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Section 1

Exposures, Premium, Losses, and Claims

This section of the study guide is intended to provide practice problems and solutions for actuarial students to accompany the pages of Basic Ratemaking cited below. Students are encouraged to read these pages before attempting the problems.


Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-1-1. A provider of workers' compensation insurance insures a company with the following staff:
3 employees earning $80000 per year.
3 employees earning $120000 per year.
6 employees earning $240000 per year.

The insurer uses annual payroll as the measure of exposure and determines that there are 60 exposures. What is the unit of exposure?

Solution S5-1-1. The total insured payroll is $2040000. Since we know that this amount of payroll constitutes 60 exposures, our unit of exposure is $2040000/60 = $34,000 per year.

Problem S5-1-2. Which of these statements is always true?
(a) Written exposures = In-force exposures
(b) Written exposures = Earned exposures
(c) Written exposures = Earned exposures + Unearned exposures
(d) Written exposures = (Earned exposures)*(Unearned exposures)
(e) Written exposures = Earned exposures - Unearned exposures

Solution S5-1-2. The correct answer is (c). Werner and Modlin (1) state the following: "Earned exposures represent the portion of the written exposures for which coverage has already been provided as of a certain point in time."

"Unearned exposures represent the portion of the written exposures for which coverage has not yet been provided as of that point in time."

As written exposures can either have coverage provided for them or not have coverage provided for them (the Aristotelian law of the excluded middle), it follows that Written exposures = Earned exposures + Unearned exposures. Clearly, then, answers (b), (d), and (e) cannot be true. Answer (a) is not true because the number of exposures that are actually at risk of loss (in-force
exposures) can be less than the number of exposures included in the policies the company wrote (written exposures).

**Problem S5-1-3.** An insurance company has written premium of $500000 and earned premium of $60000 for a single large insured. What is the unearned premium for this insured?

**Solution S5-1-3.** We use the following definitions from Werner and Modlin (1):

"**Written premium** is the total premium associated with policies that were issued during a specified period."

"**Earned premium** represents the portion of the written premium for which coverage has already been provided as of a certain point in time."

"**Unearned premium** is the portion of the written premium for which coverage has yet to be provided."

Therefore, it follows that Written premium = Earned premium + Unearned premium, so Unearned premium = Written premium - Earned premium = 500000 - 60000 = **$440,000.**

**Problem S5-1-4.** An insurance company has written premium of $500000 on 300 policies, each of which had the same premium. During the term for which the policies were written, only 250 policies were in effect. What is the in-force premium during this term?

**Solution S5-1-4.** We use the following definition from Werner and Modlin (1):

"**In-force premium** is the full-term premium for policies that are in effect at a given point in time." Since each policy has the same premium and 250 of the 300 written policies are in effect, the in-force premium is (250/300)*500000 = approximately **$416,666.67.**

**Problem S5-1-5.** What is the difference between a loss and a claim?

(a) There is no difference.
(b) A loss includes any applicable deductible, and a claim does not.
(c) A claim refers to the demand for compensation, and a loss refers to the amount of compensation.
(d) Losses require loss reserves, but claims do not.
(e) "Claims" refers to reported losses, and "losses" refers to paid losses.

**Solution S5-1-5.** The correct answer is (c) **A claim refers to the demand for compensation, and a loss refers to the amount of compensation.** This follows Werner and Modlin (2), who use "the term claim to refer to the demand for compensation, and loss to refer to the amount of compensation."
Section 2

Loss Reserves and Loss Adjustment Expenses

This section of the study guide is intended to provide practice problems and solutions to accompany the pages of Basic Ratemaking, cited below. Students are encouraged to read these pages before attempting the problems.

Source:

Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-2-1. An insurance company has reported losses of $5003, and there is a case reserve of $4030. How many losses has the insurance company paid?

Solution S5-2-1. We use the formula Reported Losses = Paid Losses + Case Reserve from Werner and Modlin (2). Thus, Paid Losses = Reported Losses - Case Reserve = 5003 - 4030 = Paid Losses = 973.

Problem S5-2-2. The following loss information pertains to an insurance company:
Case reserve = 4000;
Paid losses = 3400;
Incurred but not reported (IBNR) reserve = 3500;
Incurred but not enough reported (IBNR) reserve = 530.

Given this information, find the ultimate losses for the insurance company.

Solution S5-2-2. We use the following formula from Werner and Modlin (2):
Ultimate Losses = Reported Losses + IBNR Reserve + IBNER Reserve.
We also recall that Reported Losses = Paid Losses + Case Reserve, so
Ultimate Losses = Paid Losses + Case Reserve + IBNR Reserve + IBNER Reserve = 3400 + 4000 + 3500 + 530 = Ultimate Losses = 11430.

Problem S5-2-3. Which of these two pairs of terms refer to the same idea? More than one answer may be correct.

(a) IBNR reserve and case reserve
(b) Development on known claims and IBNER reserve
(c) IBNR reserve and IBNER reserve
(d) Paid losses and (Ultimate losses - All loss reserves)
(e) Case reserve and amount of money required to ultimately settle a claim in the future.
Solution S5-2-3. The correct answers are (b), (d), and (e).

IBNER (incurred but not reported) reserve applies to known claims and is the difference between the amount for which the claims are ultimately expected to be settled and the amount of reported losses for the claims at the time of evaluation. Werner and Modlin (2) state explicitly that the IBNER reserve is also known as development on known claims, so (b) is correct.

For (d), we recall that
Ultimate Losses = Paid Losses + Case Reserve + IBNR Reserve + IBNER Reserve, so
Ultimate Losses = Paid Losses + All loss reserves, and thus
Paid losses = Ultimate losses - All loss reserves.

For (e), a case reserve on a claim is defined as Reported Losses - Paid Losses on that claim, so it is the same as the amount of money required to ultimately settle a claim in the future.

Problem S5-2-4. Which of these can be considered allocated loss adjustment expenses (ALAE)? More than one answer may be correct.

(a) Paying a claims adjuster to go to the site of a damaged house and estimate the magnitude of damages.
(b) Paying technical support staff at the insurance company headquarters to fix the claims processing software.
(c) Paying for a lawyer to defend the insured in court on matters related to a claim.
(d) Paying a consultant to prepare a report on the company's claims handling practices.
(e) Paying the company CEO to go out to lunch with other company CEOs.

Solution S5-2-4. ALAE can only apply to payments pertaining to specific claims, where it is possible to directly identify a service as relevant to the specific claim. The only choices above that fit this criterion are the following:

(a) Paying a claims adjuster to go to the site of a damaged house and estimate the magnitude of damages.
(c) Paying for a lawyer to defend the insured in court on matters related to a claim.

Problem S5-2-5. A company's total loss adjustment expenses are twice its unallocated loss adjustment expenses (ULAE). The allocated loss adjustment expenses (ALAE) are known to be $6700. Find the total loss adjustment expenses (LAE).

Solution S5-2-5. We use the following formula from Werner and Modlin (3):

\[ \text{LAE} = \text{ALAE} + \text{ULAE} \]

We are given that \( \text{LAE} = 2 \times \text{ULAE} \).

Thus, \( \text{ALAE} = 2 \times \text{ULAE} - \text{ULAE} = \text{ULAE} \), meaning that \( \text{LAE} = \text{ALAE} + \text{ALAE} = 2 \times 6700 = 13,400 \).
Section 3

Underwriting Expenses, Insurance Company Profit, and the Fundamental Insurance Equation

This section of the study guide is intended to provide practice problems and solutions to accompany the pages of Basic Ratemaking, cited below. Students are encouraged to read these pages before attempting the problems.

Source:

Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-3-1. Which of the following are components of underwriting expenses? More than one answer may be correct.

(a) Taxes, licenses, and fees
(b) General expenses
(c) Insured losses
(d) Loss adjustment expenses
(e) Claims-related expenses
(f) Other acquisition expenses
(g) Commissions and brokerage
(h) Charitable donations of the insurance company

Solution S5-3-1. The following are the correct answers, as identified in Werner and Modlin (4):
(a) Taxes, licenses, and fees
(b) General expenses
(f) Other acquisition expenses
(g) Commissions and brokerage

Problem S5-3-2. What are the two components of insurance company profit?

(a) Underwriting profit and legal settlements
(b) Investment income and earned premium
(c) Underwriting profit and loss adjustment profit
(d) Earned premium and unearned premium
(e) Underwriting profit and investment income
(f) The money the company earned and the money the company did not earn
Solution S5-3-2. The correct answer, as identified in Werner and Modlin (5), is

(e) Underwriting profit and investment income.

Problem S5-3-3. An insurance company's underwriting profit is 3500, and its underwriting expenses are 2000. Losses are 90000, and loss adjustment expenses are 3560. Use the fundamental insurance equation to determine the amount of premium.

Solution S5-3-3. The fundamental insurance equation is

\[
\text{Premium} = \text{Losses} + \text{LAE} + \text{UW Expenses} + \text{UW Profit}. 
\]

We are given Losses = 90000, LAE = 3560, UW Profit = 3500, UW Expenses = 2000, so

\[
\text{Premium} = 90000 + 3560 + 3500 + 2000 = \text{Premium} = 99060. 
\]

Problem S5-3-4. The amount of premium is 6490, underwriting profit is 360, underwriting expense are 1000, and loss adjustment expenses are 460. Use the fundamental insurance equation to determine the amount of losses.

Solution S5-3-4. The fundamental insurance equation is

\[
\text{Premium} = \text{Losses} + \text{LAE} + \text{UW Expenses} + \text{UW Profit}. 
\]

Thus, Losses = Premium - LAE - UW Expenses - UW Profit =

\[
6490 - 460 - 1000 - 360 = \text{Losses} = 4670. 
\]

Problem S5-3-5. The amount of premium is 5460, losses are 3660, underwriting expenses are 1234, underwriting profit is 100, and allocated loss adjustment expenses are 345. Find the unallocated loss adjustment expenses using the fundamental insurance equation.

Solution S5-3-5. The fundamental insurance equation is

\[
\text{Premium} = \text{Losses} + \text{LAE} + \text{UW Expenses} + \text{UW Profit}. 
\]

We also know that LAE = ALAE + ULAE.

Thus, Premium = Losses + ALAE + ULAE + UW Expenses + UW Profit, meaning that

\[
ULAE = \text{Premium} - \text{Losses} - \text{ALAE} - \text{UW Expenses} - \text{UW Profit} = 
\]

\[
5460 - 3660 - 345 - 1234 - 100 = \text{ULAE} = 121. 
\]
Section 4

Ratemaking Principles, Frequency, Severity, and Pure Premium

This section of the study guide is intended to provide practice problems and solutions to accompany the pages of *Basic Ratemaking* cited below. Students are encouraged to read these pages before attempting the problems.

The following formulas are applied in this section:

- Frequency = (Number of Claims)/(Number of Exposures)
- Severity = (Total Losses)/(Number of Claims)
- Pure Premium = (Total Losses)/(Number of Exposures) = Frequency*Severity

**Source:**

**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-4-1.** Ratemaking is prospective. What are the implications of this fact? More than one answer may be correct.

(a) Ratemaking is used to set future rates in order to recover past costs.
(b) Ratemaking is used to estimate the expected value of future costs.
(c) Ratemaking needs to take into account likely future inflation and law changes and adjust rates accordingly.
(d) The future costs of the insurance product being rated are known in advance.
(e) Rates are estimates and cannot correspond to future costs with certainty.

**Solution S5-4-1.** The following are the correct answers, based on the discussion in Werner and Modlin (6):

(b) Ratemaking is used to estimate the expected value of future costs.

(c) Ratemaking needs to take into account likely future inflation and law changes and adjust rates accordingly.

(e) Rates are estimates and cannot correspond to future costs with certainty.
Problem S5-4-2. What which of the following are involved in obtaining overall and individual balance in ratemaking? More than one answer may be correct.
(a) Total premium for all policies written will cover the expected losses and expenses and will provide for the targeted profit.
(b) Total premium for all policies written does not need to cover expected losses, provided that individual rates are proportional to individual levels of risk.
(c) If a policy has a greater risk of loss, it should have higher associated premiums.
(d) If a policy has a greater risk of loss, it should have lower associated premiums.
(e) Risk of loss does not need to correspond to individual levels of risk, provided that the total premium for all policies written is sufficient to cover the expected losses and expenses and to provide for the targeted profit.

Solution S5-4-2. Based on the discussion in Werner and Modlin (6-7), the principle of overall and individual balance requires both that total premium be sufficient and that individuals be rated according to their risk, with greater risks receiving higher rates. Thus, the correct answers are as follows:

(a) Total premium for all policies written will cover the expected losses and expenses and will provide for the targeted profit.

(c) If a policy has a greater risk of loss, it should have higher associated premiums.

Problem S5-4-3. A provider of workers' compensation insures a company with the following staff:

3 employees earning $80000 per year.
3 employees earning $120000 per year.
6 employees earning $240000 per year.

The insurer uses an annual payroll of $34,000 as the measure of a single unit of exposure. It is observed that 3 claims were filed this year. The magnitudes of the claims were as follows:

3405, 34050, 340500.

What is the observed claim frequency?

Solution S5-4-3. The total insured payroll is $34,000 = 3*80000 + 3*120000 + 6*240000 = 2040000. The number of exposures is thus 2040000/34000 = 60. We now use the formula Frequency = (Number of Claims)/(Number of Exposures) = 3/60 = \textbf{Frequency} = 0.05.

Problem S5-4-4. A provider of workers' compensation insures a company with the following staff:

3 employees earning $80000 per year.
3 employees earning $120000 per year.
6 employees earning $240000 per year.
The insurer uses an annual payroll of $34,000 as the measure of a single unit of exposure. It is observed that 3 claims were filed this year. The magnitudes of the claims were as follows:

3405, 34050, 340500.

What is the observed claim severity?

**Solution S5-4-4.** Total losses are $3405 + 34050 + 340500 = 377955$.

We use the formula $\text{Severity} = \frac{\text{Total Losses}}{\text{Number of Claims}} = \frac{377955}{3} = \text{Severity} = 125,985$.

**Problem S5-4-5.** A provider of workers' compensation insures a company with the following staff:

3 employees earning $80000 per year.
3 employees earning $120000 per year.
6 employees earning $240000 per year.

The insurer uses an annual payroll of $34,000 as the measure of a single unit of exposure. It is observed that 3 claims were filed this year. The magnitudes of the claims were as follows:

3405, 34050, 340500.

What is the observed pure premium?

**Solution S5-4-5.** We use the formula $\text{Pure Premium} = \text{Frequency}*\text{Severity}$. From Solution S5-4-3, we know that frequency is 0.05. From Solution S5-4-4, we know that severity is 125985. Our answer is thus $0.05*125985 = \text{Pure Premium} = 6299.25$. 
Section 5

Average Premium, Loss Ratio, Loss Adjustment Expense Ratio, Underwriting Expense Ratio, and Operating Expense Ratio

This section of the study guide is intended to provide practice problems and solutions to accompany the pages of *Basic Ratemaking* cited below. Students are encouraged to read these pages before attempting the problems.

The following formulas are applied in this section:

Average Premium = (Total Premium)/(Number of Exposures)

Loss Ratio = (Total Losses)/(Total Premium) = (Pure Premium)/(Average Premium)

Loss Adjustment Expense (LAE) Ratio = (Total Loss Adjustment Expenses)/(Total Losses)

Underwriting (UW) Expense Ratio = (Total Underwriting Expenses)/(Total Premium)

Operating Expense Ratio = UW Expense Ratio + LAE/(Total Earned Premium)

Source:

Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-5-1. There are a total of 3500 insured vehicles, each of which counts as a single exposure. You know the following figures from the last year of data:
Total earned premium = 456000 (note that this is "total premium" for the purposes of this problem);

Total losses = 345600;

Total loss adjustment expenses = 80000;

Total underwriting expenses = 45290.

Calculate the average premium based on this information.
Solution S5-5-1. We use the formula Average Premium = (Total Premium)/(Number of Exposures) = 456000/3500 = **Average Premium = 130.2857143**

Problem S5-5-2. There are a total of 3500 insured vehicles, each of which counts as a single exposure. You know the following figures from the last year of data:
Total earned premium = 456000 (note that this is "total premium" for the purposes of this problem);

Total losses = 345600;
Total loss adjustment expenses = 80000;
Total underwriting expenses = 45290.

Calculate the loss ratio based on this information.

Solution S5-5-2. We use the formula Loss Ratio = (Total Losses)/(Total Premium) = 345600/456000 = **Loss Ratio = 0.7578947368**.

Problem S5-5-3. There are a total of 3500 insured vehicles, each of which counts as a single exposure. You know the following figures from the last year of data:
Total earned premium = 456000 (note that this is "total premium" for the purposes of this problem);

Total losses = 345600;
Total loss adjustment expenses = 80000;
Total underwriting expenses = 45290.

Calculate the LAE ratio based on this information.

Solution S5-5-3. We use the formula LAE Ratio = (Total Loss Adjustment Expenses)/(Total Losses) = 80000/345600 = **LAE Ratio = 0.2314814815**.

Problem S5-5-4. There are a total of 3500 insured vehicles, each of which counts as a single exposure. You know the following figures from the last year of data:
Total earned premium = 456000 (note that this is "total premium" for the purposes of this problem);

Total losses = 345600;
Total loss adjustment expenses = 80000;
Total underwriting expenses = 45290.
Calculate the UW expense ratio based on this information.

**Solution S5-5-4.** We use the formula UW Expense Ratio = (Total Underwriting Expenses)/(Total Premium) = 45290/456000 = **UW Expense Ratio = 0.0993201754.**

**Problem S5-5-5.** There are a total of 3500 insured vehicles, each of which counts as a single exposure. You know the following figures from the last year of data:
Total earned premium = 456000 (note that this is "total premium" for the purposes of this problem);
Total losses = 345600;
Total loss adjustment expenses = 80000;
Total underwriting expenses = 45290.

Calculate the operating expense ratio based on this information.

**Solution S5-5-5.** We use the formula Operating Expense Ratio = UW Expense Ratio + LAE/(Total Earned Premium) = 0.0993201754 + 80000/456000 = **Operating Expense Ratio = 0.2747587719.**
Section 6

Combined Ratio, Retention Ratio, and Close Ratio

This section of the study guide is intended to provide practice problems and solutions to accompany the pages of *Basic Ratemaking*, cited below. Students are encouraged to read these pages before attempting the problems.

The following formulas are applied in this section:

Combined Ratio = Loss Ratio + LAE/(Earned Premium) + (Underwriting Expenses)/(Written Premium)

If underwriting expenses are compared to earned premium, then

Combined Ratio = Loss Ratio + Operating Expense Ratio.

Retention Ratio = (Number of Policies Renewed)/(Number of Potential Renewal Policies).

Close Ratio = (Number of Accepted Quotes)/(Number of Quotes).

Source:

Original Problems and Solutions from The Actuary's Free Study Guide

**Problem S5-6-1.** There are a total of 3500 insured vehicles, each of which counts as a single exposure. You know the following figures from the last year of data:
Total earned premium = 456000;
Total written premium = 500000;
Total losses = 345600;
Total loss adjustment expenses = 80000;
Total underwriting expenses = 45290.

Find the combined ratio. Compare underwriting expenses to written premium in your determination. Is the insurer profitable?
Solution S5-6-1.

We use the formula Combined Ratio = Loss Ratio + LAE/(Earned Premium) + (Underwriting Expenses)/(Written Premium).

We calculate Loss Ratio = (Total Losses)/(Total Premium) = 345600/456000 = Loss Ratio = 0.7578947368.

We find LAE/(Earned Premium) = 80000/456000 = 0.1754385965.

We find (Underwriting Expenses)/(Written Premium) = 45290/500000 = 0.09058.

The combined ratio is thus 0.7578947368 + 0.1754385965 + 0.09058 = Combined Ratio = 1.023913333. The insurer is not profitable, because the combined ratio exceeds 1.

Problem S5-6-2. There are a total of 3500 insured vehicles, each of which counts as a single exposure. You know the following figures from the last year of data:
Total earned premium = 456000;
Total written premium = 500000;
Total losses = 345600;
Total loss adjustment expenses = 80000;
Total underwriting expenses = 45290.

Find the combined ratio. Compare underwriting expenses to earned premium in your determination. Is the insurer profitable?

Solution S5-6-2. We use the formula Combined Ratio = Loss Ratio + OER, where Loss Ratio, from Solution S5-6-1, is 0.7578947368.

We find Operating Expense Ratio = UW Expense Ratio + LAE/(Total Earned Premium)
= (Total Underwriting Expenses)/(Total Earned Premium) + LAE/(Total Earned Premium) = (45290 + 80000)/456000 = 0.2747587719.

Thus, Combined Ratio = 0.7578947368 + 0.2747587719 = Combined Ratio = 1.032653509. The insurer is not profitable, because the combined ratio exceeds 1.

Problem S5-6-3. Compare the combined ratio in which underwriting expenses are compared to written premium to the combined ratio in which underwriting expenses are compared to earned premium. Is one of these always at least as large as the other?

Solution S5-6-3. The formulas for these two kinds of combined ratio are as follows:
i) Combined Ratio = Loss Ratio + LAE/(Earned Premium) + (Underwriting Expenses)/(Written Premium)

ii) Combined Ratio = Loss Ratio + LAE/(Earned Premium) + (Underwriting Expenses)/(Earned Premium)

Since Written Premium = Earned Premium + Unearned Premium, so in all cases

Earned Premium ≤ Written Premium, and therefore

1/(Earned Premium) ≥ 1/(Written Premium).

Thus, a combined ratio for which no aspect differs except that a denominator of (Written Premium) has been replaced by a denominator of (Earned Premium) will be at least as large and will often be larger.

Thus, comparing underwriting expenses to earned premium always results in larger or equally large combined ratios as compared to the situation where underwriting expenses are compared to written premium.

Problem S5-6-4. An insurer insures 3450 policies. At renewal, only 2350 policies were renewed. Calculate the retention ratio.

Solution S5-6-4. We use the formula Retention Ratio = (Number of Policies Renewed)/(Number of Potential Renewal Policies) = 2350/3450 = Retention Ratio = 0.6811594203.

Problem S5-6-5. An insurer has a close ratio of 0.46. This year, the insurer gave out 460700 quotes. How many quotes were accepted?

Solution S5-6-5. We use the formula

Close Ratio = (Number of Accepted Quotes)/(Number of Quotes).

This means that (Number of Accepted Quotes) = (Close Ratio)*(Number of Quotes) = 0.46*460700 = 211922 accepted quotes.
Section 7

Rules, Rates, and Rating Algorithms in Insurance Rating Manuals

This section of the study guide is intended to provide practice problems and solutions to accompany the pages of *Basic Ratemaking*, cited below.


**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-7-1.** Which of these are functions of the *rules* in a Rating Manual? More than one answer may be correct.

(a) To present the rating algorithm.
(b) To define how to classify a risk before a rating algorithm can be applied.
(c) To display the numerical factors used in rating.
(d) To offer information about optional coverages, endorsements, and riders.
(e) To define the risks being insured.
(f) To present the detailed insurance contract.
(g) To summarize the policy forms offered to the insured.

**Solution S5-7-1.** According to Werner and Modlin (13-14), the following are functions of rules in a Rating Manual: (b) To define how to classify a risk before a rating algorithm can be applied.

(d) To offer information about optional coverages, endorsements, and riders.

(e) To define the risks being insured.

(g) To summarize the policy forms offered to the insured.

**Problem S5-7-2.** An insurance company treats policyholders who wear orange hats more favorably than other policyholders. Policyholders who wear orange hats pay 30% lower premiums. Currently, the base rate is 350 and is the rate that a policyholder who wears an orange hat would receive. The company is revising its base rate to define it as the rate charged to non-orange-hat policyholders in order to be able to offer a 30% orange hat discount (with a multiplicative discount factor of 0.7 applied to the new base rate). What is the new base rate?

**Solution S5-7-2.** The rate for orange-hat insureds is 350, which is the same as $0.7 \times \text{New Base Rate}$, meaning that New Base Rate $= 350/0.7 = 500$.

**Problem S5-7-3.** Insureds who wear green hats have their rates multiplied by 1.34 compared to the rates charged to other insureds. Which of these are possible names for the figure "1.34"?

More than one answer may be correct.

(a) An addend
(b) A relativity
(c) A rate
(d) A factor
(e) A multiplier
(f) A base

Solution S5-7-3. The adjustment to the base rate is multiplicative, so the value can be called a relativity, factor or multiplier, according to Werner and Modlin (15). An addend is the name for a value that is added to or subtracted from the base rate, and a rate factor is not the same as a rate or a base (rate). Thus, (b), (d), and (e) are correct answers.

Problem S5-7-4. Which of these statements describes base rates? More than one answer may be correct.
(a) Base rates are the same as average rates.
(b) Base rates are always set as the rates charged to the highest risks, with discounts applied for lower risks.
(c) Base rates are always set as the rates charged to the lowest risks, with surcharges applied for higher risks.
(d) The way the base rate is set is subject to insurer discretion.
(e) All expenses may sometimes be incorporated in the base rates.

Solution S5-7-4. This question is based on the discussion in Werner and Modlin (15). (a) is not true, as base rates are rarely average rates. (d) is true in that insurers can choose which risks to designate as the base risks and therefore which risks appear to receive surcharges or discounts. By implication, (b) and (c) are incorrect. (e) is true; insurance companies do sometimes incorporate all expenses in the base rates, although they do not always do this. Thus, (d) and (e) are the correct answers.

Problem S5-7-5. Which of the following can be contained in a rating algorithm? More than one answer may be correct.
(a) Maximum and minimum allowable discounts and surcharges.
(b) The empirical distribution of losses from the past.
(c) Maximum and minimum allowable premiums.
(d) The magnitudes of the base rates.
(e) Details about which risks may and may not be insured.
(f) The order in which to consider rating variables.
(g) Rules for rounding, if any.
(h) Whether rating variables are applied in an additive, multiplicative, or other fashion.
(i) Details of the insurance contract.

Solution S5-7-5. This question is based on the discussion in Werner and Modlin (15-16). The following answers are correct: (a) Maximum and minimum allowable discounts and surcharges. (c) Maximum and minimum allowable premiums. (f) The order in which to consider rating variables. (g) Rules for rounding, if any. (h) Whether rating variables are applied in an additive, multiplicative, or other fashion.
Section 8

Underwriting Guidelines and Rating Manuals in Insurance

This section of the study guide is intended to provide practice problems and solutions to accompany the pages of *Basic Ratemaking*, cited below. Students are encouraged to read these pages before attempting the problems.


**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-8-1.** Which of the following are possible functions of *underwriting guidelines*? More than one answer may be correct.

(a) To apply credits or debits where schedule rating is used and premium varies from what is established via the manual rates.

(b) To determine which company an insured will be placed in, if there are multiple companies within an insurance group.

(c) To determine whether the factors applied to the base rates will be additive or multiplicative.

(d) To specify how various risks are to be rated.

(e) To determine which risks will be accepted and which will be rejected.

(f) To determine the tier placement for various risks within an insurance company.

**Solution S5-8-1.** This question is based on the discussion in Werner and Modlin (16). The following are the correct answers.

(a) To apply credits or debits where schedule rating is used and premium varies from what is established via the manual rates.

(b) To determine which company an insured will be placed in, if there are multiple companies within an insurance group.

(e) To determine which risks will be accepted and which will be rejected.

(f) To determine the tier placement for various risks within an insurance company.

**Problem S5-8-2.** The following are the relativities associated with Amount of Insurance (AOI) on a superwidget:

<table>
<thead>
<tr>
<th>AOI</th>
<th>Relativity</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>0.24</td>
</tr>
<tr>
<td>130</td>
<td>0.27</td>
</tr>
<tr>
<td>190</td>
<td>0.35</td>
</tr>
<tr>
<td>230</td>
<td>0.42</td>
</tr>
<tr>
<td>300</td>
<td>0.50</td>
</tr>
</tbody>
</table>
600..................0.90
800..................1.00
856..................1.05
Each additional 10...0.01

Straight-line interpolation is used for any AOI that is not explicitly listed on the table

How many times more would an insured who insures a superwidget for an AOI of 950 have to pay compared to an otherwise identical insured who insures a superwidget for an AOI of 200?

**Solution S5-8-2.** The factor for an AOI of 200 will be \[0.35 + (0.42-0.35)\times(200-190)/(230-190) = 0.3675.\]
The factor for an AOI of 950 will be \[1.05 + 0.01\times(950-856) = 1.99.\]
Our answer is \[1.99/0.3675 = 5.414965986\] times.

**Problem S5-8-3.** The price of superwidget insurance varies by territory. There are 4 territories, numbered 1 through 4. The following are the territory factors in a rating manual of a company that issues superwidget insurance:

<table>
<thead>
<tr>
<th>Territory</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.35</td>
</tr>
<tr>
<td>2</td>
<td>0.43</td>
</tr>
<tr>
<td>3</td>
<td>1.00</td>
</tr>
<tr>
<td>4</td>
<td>3.03</td>
</tr>
</tbody>
</table>

The base rate is 64. What would be the rate charged to an insured who lives in territory 2?

**Solution S5-8-3.** We multiply the territory factor for territory 2 by the base rate to get \[0.43\times64 = 27.52.\]

**Problem S5-8-4.** Insureds who purchase superwidget insurance can choose one of three deductibles: 400, 900, and 1200. The following are the factors associated with each deductible amount:

<table>
<thead>
<tr>
<th>Deductible</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>1.00</td>
</tr>
<tr>
<td>900</td>
<td>0.24</td>
</tr>
<tr>
<td>1200</td>
<td>0.06</td>
</tr>
</tbody>
</table>

The base rate is 64, which also equals the premium paid by an insured who is rated at the base rate. Two otherwise identical insureds, X and Y, each insure a superwidget worth 1500. X chooses a deductible of 400, whereas Y chooses a deductible of 1200. Each insured then suffers a total loss of the superwidget. Calculate the combined payment each insured had to make (premium + deductible).
**Solution S5-8-4.** X paid 400 in deductible and $1.00 \times 64 = 64$ in premium, implying that **X paid 464**. Y paid 1200 in deductible and $0.06 \times 64 = 3.84$ in premium, implying that **Y paid 1203.84**.

**Problem S5-8-5.** The rating manual of a company offering superwidget insurance has the following three factor tables:
- The table of Amount of Insurance (AOI) factors from Problem S5-8-2;
- The table of territory factors from Problem S5-8-3;
- The table of deductible factors from Problem S5-8-4.

The base rate is 64. What rate will be charged to an insured who selects amount of insurance of 700, lives in territory 4, and selects a deductible of 900?

**Solution S5-8-5.** The following are the relevant listed AOI factors:

<table>
<thead>
<tr>
<th>AOI</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>600</td>
<td>0.90</td>
</tr>
<tr>
<td>800</td>
<td>1.00</td>
</tr>
</tbody>
</table>

We use linear interpolation to get 0.95 as the factor for AOI of 700.

Territory 4 has an associated factor of 3.03, while a deductible of 900 has associated factor of 0.24, meaning that the rate charged to the insured will be $64 \times 0.95 \times 3.03 \times 0.24 = 44.21376$. 


Section 9

Practice Problems and Solutions Pertaining to a Fictional Rating Manual for Homeowners' Insurance

The problems in this section all refer to the following excerpt from a fictional homeowners' insurance rating manual from Ecnarusni Insurance Company:

The base rate is 60.

<table>
<thead>
<tr>
<th>Amount of Insurance (AOI) Relativities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of Insurance (AOI)..............Rate Relativity</td>
</tr>
<tr>
<td>100....................................................0.35</td>
</tr>
<tr>
<td>200....................................................0.44</td>
</tr>
<tr>
<td>500....................................................0.66</td>
</tr>
<tr>
<td>1000..................................................1.00</td>
</tr>
<tr>
<td>2000..................................................1.34</td>
</tr>
<tr>
<td>4000..................................................1.75</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Territory Relativities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Territory...............Rate Relativity</td>
</tr>
<tr>
<td>1..........................0.95</td>
</tr>
<tr>
<td>2..........................0.98</td>
</tr>
<tr>
<td>3..........................0.52</td>
</tr>
<tr>
<td>4..........................1.00</td>
</tr>
<tr>
<td>5..........................1.21</td>
</tr>
</tbody>
</table>

| Protection Class / Construction Type Rating Table |
| Protection Class........Frame Construction Type........Masonry Construction Type |
| 1........................................0.55............................0.35 |
| 2........................................0.65............................0.45 |
| 3........................................0.98............................0.87 |
| 4........................................1.00............................0.96 |
| 5........................................1.16............................1.00 |
| 6........................................1.45............................1.34 |
Underwriting Tier Table
Underwriting Tier............Rate Relativity
A..................................0.45
B..................................0.76
C..................................1.00
D..................................1.45
E..................................1.84

Deductible Rating Table
Deductible.............Rate Relativity
0.............................1.00
20...........................0.95
100..........................0.75
200..........................0.45
1000.........................0.04

Miscellaneous Credits
Miscellaneous Credit........Credit Amount
Geodesic Dome Home Discount........30%
Wearing an Orange Hat Discount......20%
π-Year Claims-Free Discount............20%
Multi-Policy Discount...............5%

Increased Jewelry Coverage
Limit.............Additive
20.....................Included
40........................5
100......................10
200.....................16

Increased Liability/Medical Limits
Limit.............Additive
100/10..............Included
200/20............20
300/30............25
400/40............30

Each policy also has a policy fee of 10 added to it.

Rating Algorithm
Total Premium = All-Peril Base Rate
* AOI Relativity
* Territory Relativity
* Protection Class / Construction Type Relativity
* Underwriting Tier Relativity
* Deductible Credit
* [1.0 - Geodesic Dome Home Discount - Claims-Free Discount]
* [1.0 - Wearing an Orange Hat Discount - Multi-Policy Discount]
+ Increased Jewelry Coverage Rate
+ Increased Liability/Medical Coverage Rate
+ Policy Fee.

No rounding is to be done at all.

Source:
Chapter 2, pp. 18-23.

Original Problems and Solutions from The Actuary's Free Study Guide

**Problem S5-9-1.** An insured has the following characteristics:
- The insured has selected amount of insurance of 500.
- The insured lives in territory 4.
- The insured's house is of a frame construction type and is in Protection Class 6.
- The insured is assigned to Underwriting Tier B by the company.
- The insured has selected a deductible of 20.
- The insured owns a Geodesic Dome Home and has been free of claims for π years.
- The insured selects to cover 100 worth of jewelry and to increase liability/medical limits to 300/30.

Find the premium that Ecinarusni Insurance Company would charge to this insured.

**Solution S5-9-1.** By the rating algorithm, we do the following
Total Premium = All-Peril Base Rate (60)
* AOI Relativity (0.66)
* Territory Relativity (1.00)
* Protection Class / Construction Type Relativity (1.45)
* Underwriting Tier Relativity (0.76)
* Deductible Credit (0.95)
* [1.0 - Geodesic Dome Home Discount - Claims-Free Discount] (1-0.3-0.2 = 0.5)
* [1.0 - Wearing an Orange Hat Discount - Multi-Policy Discount] (1-0-0 = 1)
  + Increased Jewelry Coverage Rate (10)
  + Increased Liability/Medical Coverage Rate (25)
  + Policy Fee (10).
Thus, Total Premium = 60*0.66*1.00*1.45*0.76*0.95*0.5*1 + 10 + 25 + 10 = Total Premium = 65.72862.

**Problem S5-9-2.** An insured has the following characteristics:
- The insured has selected amount of insurance of 2000.
- The insured lives in territory 2.
- The insured's house is of a masonry construction type and is in Protection Class 2.
- The insured is assigned to Underwriting Tier C by the company.
- The insured has selected a deductible of 1000.
- The insured always wears an orange hat.
- The insured selects to cover 20 worth of jewelry and to increase liability/medical limits to 400/40.

Find the premium that Ecnarusni Insurance Company would charge to this insured.

Solution S5-9-2. Total Premium = All-Peril Base Rate (60)
* AOI Relativity (1.34)
* Territory Relativity (0.98)
* Protection Class / Construction Type Relativity (0.45)
* Underwriting Tier Relativity (1.00)
* Deductible Credit (0.04)
* \[1.0 - Geodesic Dome Home Discount - Claims-Free Discount\] (1-0-0 = 1)
* \[1.0 - Wearing an Orange Hat Discount - Multi-Policy Discount\] (1-0.2-0 = 0.8)
  + Increased Jewelry Coverage Rate (0)
  + Increased Liability/Medical Coverage Rate (30)
  + Policy Fee (10).

Thus, Total Premium = 60*1.34*0.98*0.45*1.00*0.04*1*0.8+0+30+10 = Total Premium = 41.1346048.

Problem S5-9-3. An insured has the following characteristics:
- The insured has selected amount of insurance of 4000.
- The insured lives in territory 3.
- The insured's house is of a masonry construction type and is in Protection Class 1.
- The insured is assigned to Underwriting Tier A by the company.
- The insured has selected a deductible of 1000.
- The insured has a Geodesic Dome Home, has always been free of claims, always wears an orange hat, and has multiple policies with the insurance company.
- The insured selects to cover 20 worth of jewelry and to have liability/medical limits of 100/10.

Find the premium that Ecnarusni Insurance Company would charge to this insured.

Solution S5-9-3. Total Premium = All-Peril Base Rate (60)

* AOI Relativity (1.75)
* Territory Relativity (0.52)
* Protection Class / Construction Type Relativity (0.35)
* Underwriting Tier Relativity (0.45)
* Deductible Credit (0.04)
* \[1.0 - Geodesic Dome Home Discount - Claims-Free Discount\] (1-0.3-0.2 = 0.5)
* \[1.0 - Wearing an Orange Hat Discount - Multi-Policy Discount\] (1-0.2-0.05 = 0.75)
  + Increased Jewelry Coverage Rate (0)
  + Increased Liability/Medical Coverage Rate (0)
  + Policy Fee (10).

Thus, Total Premium = 60*1.75*0.52*0.35*0.45*0.04*0.5*0.75+0+0+10 = Total Premium = 10.1289925.
**Problem S5-9-4.** An insured has the following characteristics:
- The insured has selected amount of insurance of 100.
- The insured lives in territory 5.
- The insured's house is of a frame construction type and is in Protection Class 6.
- The insured is assigned to Underwriting Tier E by the company.
- The insured has selected a deductible of 0.
- The insured does not qualify for any discounts.
- The insured selects to cover 200 worth of jewelry and to have liability/medical limits of 400/40.

Find the premium that Ecnarusni Insurance Company would charge to this insured.

**Solution S5-9-4.** Total Premium = All-Peril Base Rate (60)
* AOI Relativity (0.35)
* Territory Relativity (1.21)
* Protection Class / Construction Type Relativity (1.45)
* Underwriting Tier Relativity (1.84)
* Deductible Credit (1.00)
* [1.0 - Geodesic Dome Home Discount - Claims-Free Discount] (1-0-0 = 1)
* [1.0 - Wearing an Orange Hat Discount - Multi-Policy Discount] (1-0-0 = 1)
+ Increased Jewelry Coverage Rate (16)
+ Increased Liability/Medical Coverage Rate (30)
+ Policy Fee (10).

Thus, Total Premium = 60*0.35*1.21*1.45*1.84*1.00*1*1+16+30+10 = **Total Premium = 123.79388**.

**Problem S5-9-5.** Find the highest premium an insured would ever be charged under this homeowners' insurance policy.

**Solution S5-9-5.** We examine the rating manual and select the highest possible factors or addends in each category. We discern that the following are the characteristics of our hypothetical insured:
- The insured has selected amount of insurance of 4000.
- The insured lives in territory 5.
- The insured's house is of a frame construction type and is in Protection Class 6.
- The insured is assigned to Underwriting Tier E by the company.
- The insured has selected a deductible of 0.
- The insured does not qualify for any discounts.
- The insured selects to cover 200 worth of jewelry and to have liability/medical limits of 400/40.

We find the premium that Ecnarusni Insurance Company would charge to this insured:

Total Premium = All-Peril Base Rate (60)
* AOI Relativity (1.75)
* Territory Relativity (1.21)
* Protection Class / Construction Type Relativity (1.45)
* Underwriting Tier Relativity (1.84)
* Deductible Credit (1.00)
* [1.0 - Geodesic Dome Home Discount - Claims-Free Discount] (1-0-0 = 1)
* [1.0 - Wearing an Orange Hat Discount - Multi-Policy Discount] (1-0-0 = 1)
+ Increased Jewelry Coverage Rate (16)
+ Increased Liability/Medical Coverage Rate (30)
+ Policy Fee (10).
Thus, Total Premium = 60*1.75*1.21*1.45*1.84*1.00*1+16+30+10 = **Total Premium = 394.9694.**
Section 10

Practice Problems and Solutions Pertaining to a Fictional Rating Manual for Medical Malpractice Insurance

The problems in this section all refer to the following excerpt from a fictional medical malpractice insurance rating manual from Lacidem Insurance Company:

The base rate per practitioner is 500.

**Specialty Rating Table**

<table>
<thead>
<tr>
<th>Specialty</th>
<th>Rate Relativity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acupuncture</td>
<td>1.94</td>
</tr>
<tr>
<td>Homeopathy</td>
<td>0.77</td>
</tr>
<tr>
<td>Placebo Medicine</td>
<td>0.96</td>
</tr>
<tr>
<td>Doing Nothing Therapy</td>
<td>1.14</td>
</tr>
<tr>
<td>&quot;Traditional&quot; Medicine</td>
<td>2.24</td>
</tr>
<tr>
<td>Bleeding Services</td>
<td>9.92</td>
</tr>
<tr>
<td>Snake Oil Services</td>
<td>4.41</td>
</tr>
<tr>
<td>All Other Specialties</td>
<td>1.00</td>
</tr>
</tbody>
</table>

**Part-Time Status Rating Table**

<table>
<thead>
<tr>
<th>Status</th>
<th>Rate Relativity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full-time</td>
<td>1.00</td>
</tr>
<tr>
<td>Part-time</td>
<td>0.65</td>
</tr>
</tbody>
</table>

**Territory Rating Table**

<table>
<thead>
<tr>
<th>Territory</th>
<th>Rate Relativity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.95</td>
</tr>
<tr>
<td>2</td>
<td>0.98</td>
</tr>
<tr>
<td>3</td>
<td>0.52</td>
</tr>
<tr>
<td>4</td>
<td>1.00</td>
</tr>
<tr>
<td>5</td>
<td>1.21</td>
</tr>
</tbody>
</table>

**Claims-Free Discount**

The claims-free discount is 30%. To qualify for the discount, the insured must not have cumulative losses over $3400 during the past e years.

**Schedule Rating**

**Scientific Method:** A credit of up to 50% for using the Scientific Method in practicing medicine.

**Hypochondria Encouragement:** A debit of up to 30% for pandering to hypochondriacs.
**Harvesting Endangered Species:** A debit of up to 60% for using endangered species as ingredients in "medicinal" potions.

### Limit Rating Table

<table>
<thead>
<tr>
<th>Limit Option</th>
<th>Rate Relativity</th>
</tr>
</thead>
<tbody>
<tr>
<td>200K/400K</td>
<td>0.82</td>
</tr>
<tr>
<td>400K/800K</td>
<td>1.00</td>
</tr>
<tr>
<td>1M/2M</td>
<td>2.00</td>
</tr>
<tr>
<td>3M/6M</td>
<td>3.45</td>
</tr>
</tbody>
</table>

### Deductible Rating Table

<table>
<thead>
<tr>
<th>Deductible (Per Claim)</th>
<th>Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>2000</td>
<td>10%</td>
</tr>
<tr>
<td>6000</td>
<td>30%</td>
</tr>
<tr>
<td>10000</td>
<td>80%</td>
</tr>
</tbody>
</table>

### Claims-Made Maturity Factors

<table>
<thead>
<tr>
<th>Maturity</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Year</td>
<td>0.10</td>
</tr>
<tr>
<td>2nd Year</td>
<td>0.30</td>
</tr>
<tr>
<td>3rd Year</td>
<td>0.40</td>
</tr>
<tr>
<td>4th Year</td>
<td>0.70</td>
</tr>
<tr>
<td>5th Year</td>
<td>0.98</td>
</tr>
<tr>
<td>Mature</td>
<td>1.00</td>
</tr>
</tbody>
</table>

### Extended Reporting Endorsement Factors

<table>
<thead>
<tr>
<th>Maturity</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Year</td>
<td>0.80</td>
</tr>
<tr>
<td>2 Years</td>
<td>0.93</td>
</tr>
<tr>
<td>3 Years</td>
<td>1.00</td>
</tr>
<tr>
<td>4 Years</td>
<td>1.23</td>
</tr>
<tr>
<td>5 Years</td>
<td>1.53</td>
</tr>
</tbody>
</table>

### Group Credit

<table>
<thead>
<tr>
<th>Number of Practitioners</th>
<th>Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0%</td>
</tr>
<tr>
<td>2-60</td>
<td>15%</td>
</tr>
<tr>
<td>60+</td>
<td>20%</td>
</tr>
</tbody>
</table>

The final premium, including the group credit, should first be calculated for each individual practitioner and aggregated for all practitioners to determine the premium for the group policy. The minimum premium per practitioner is 300.
Rating Algorithm
Total Premium per Practitioner = Higher of
(Base Rate per Practitioner
x Specialty Relativity
x Part-time Status Relativity
x Territory Relativity
x (1.0 - Claims-free Discount)
x (1.0 +/- Schedule Rating Debit/Credit)
x Limit Relativity
x (1.0 - Deductible Credit)
x Claims-made Factor
x (1.0 - Group Credit ))
and
Minimum Premium specified in the rating manual (300).


Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-10-1. A group of 4 practitioners hires another practitioner with the following characteristics:
- The practitioner specializes in "traditional" medicine.
- The practitioner is part-time.
- The practitioner works in Territory 2.
- The practitioner had cumulative losses of $346 over the past e years.
- The practitioner does not use the Scientific Method, panders to hypochondriacs, and does not harvest endangered species.
- The practitioner selects limits of 1M/2M.
- The practitioner selects a deductible of 2000 per claim.
- The practitioner was previously covered by an occurrence policy and is applying for a claims-made policy.
Find the premium that the group will have to pay for that individual practitioner.

Solution S5-10-1. Total Premium per Practitioner = Higher of
(Base Rate per Practitioner (500)
x Specialty Relativity (2.24)
x Part-time Status Relativity (0.65)
x Territory Relativity (0.98)
x (1.0 - Claims-free Discount) (1-0.3 = 0.7)
x (1.0 +/- Schedule Rating Debit/Credit) (1 + 0.3 = 1.3)
x Limit Relativity (2.00)
x (1.0 - Deductible Credit) (1-0.1 = 0.9)
x Claims-made Factor (0.10)
x (1.0 - Group Credit )) (1-0.15 = 0.85)
and
Minimum Premium specified in the rating manual (300).

We compare 300 to
500*2.24*0.65*0.98*0.7*1.3*2.00*0.9*0.1*0.85 = 99.3322512, and we select the premium for this practitioner to be **300**.

**Problem S5-10-2.** A group of 5 practitioners currently pays the minimum possible total premium. A new practitioner is hired with the following characteristics:
- The practitioner specializes in bleeding services.
- The practitioner is full-time.
- The practitioner works in Territory 1.
- The practitioner had cumulative losses of $3460 over the past e years.
- The practitioner does not use the Scientific Method, panders to hypochondriacs, and harvests endangered species.
- The practitioner selects limits of 3M/6M.
- The practitioner selects a deductible of 0 per claim.
- The practitioner has a mature claims-made policy.

Find the total premium that the group will have to pay.

**Solution S5-10-2.** The premium for this individual practitioner is calculated as follows:

\[
\text{Total Premium per Practitioner} = \text{Higher of} \\
\quad (\text{Base Rate per Practitioner} \times 9.92) \\
\quad \times \text{Specialty Relativity} \\
\quad \times \text{Part-time Status Relativity} \\
\quad \times \text{Territory Relativity} \\
\quad \times (1.0 - \text{Claims-free Discount}) \\
\quad \times (1.0 +/- \text{Schedule Rating Debit/Credit}) \\
\quad \times \text{Limit Relativity} \\
\quad \times (1.0 - \text{Deductible Credit}) \\
\quad \times \text{Claims-made or Extended Reporting Endorsement Factor} \\
\quad \times (1.0 - \text{Group Credit}) \\
\]

Minimizing Premium specified in the rating manual (300).

We compare 300 to
500*9.92*1.00*0.95*1*1.9*3.45*1*1.00*0.85 = 26254.086. We select 26254.086 as the premium for this practitioner.

The 5 other practitioners paid the minimum premium per practitioner, or 300, for a combined premium of 1500. Thus, the total premium for the group with the new practitioner included is 1500 + 26254.086 = **27754.086**.

**Problem S5-10-3.** Find the highest premium an individual insured would ever be charged under this medical malpractice insurance policy.
Solution S5-10-3. We examine the rating manual and select the highest possible factors or addends in each category. We discern that the following are the characteristics of our hypothetical insured:
- The practitioner specializes in bleeding services.
- The practitioner is full-time.
- The practitioner works in Territory 5.
- The practitioner had cumulative losses over $3400 during the past e years.
- The practitioner does not use the Scientific Method, panders to hypochondriacs, and harvests endangered species.
- The practitioner selects limits of 3M/6M.
- The practitioner selects a deductible of 0 per claim.
- The practitioner has purchased an extended reporting endorsement for 5 years.
- The practitioner practices alone and is not a part of a group.

The premium for this individual practitioner is calculated as follows:

\[
\text{Total Premium per Practitioner} = \text{Higher of}
\]
\[
(\text{Base Rate per Practitioner} \times \text{Specialty Relativity} \times \text{Part-time Status Relativity} \times \text{Territory Relativity} \times (1 - \text{Claims-free Discount}) \times (1 + \text{Schedule Rating Debit/Credit}) \times \text{Limit Relativity} \times (1 - \text{Deductible Credit}) \times \text{Claims-made or Extended Reporting Endorsement Factor} \times (1 - \text{Group Credit}))
\]

and

Minimum Premium specified in the rating manual (300).

We compare 300 to 500*9.92*1.00*1.21*1.9*3.45*1*1.53*1 = 60190.94664. We select as the premium the higher value of 60190.94664.

Problem S5-10-4. Lacidem Insurance Company is considering eliminating the 300 minimum premium requirement on medical malpractice insurance. If it were to do so, what would be the lowest premium an individual practitioner would be able to pay?

Solution S5-10-4. We examine the rating manual and select the lowest possible factors or addends in each category. We discern that the following are the characteristics of our hypothetical insured:
- The practitioner specializes in homeopathy.
- The practitioner is part-time.
- The practitioner works in Territory 3.
- The practitioner had cumulative losses under $3400 during the past e years.
- The practitioner uses the Scientific Method, does not pander to hypochondriacs, and does not harvest endangered species.
- The practitioner selects limits of 200K/400K.
- The practitioner selects a deductible of 10000 per claim.
- The practitioner was previously covered by an occurrence policy and is applying for a claims-made policy.
- The practitioner practices as part of a group with 60 or more members.

The premium for this individual practitioner is calculated as follows:

\[
\text{Total Premium per Practitioner} = (\text{Base Rate per Practitioner (500)} \times \text{Specialty Relativity (0.77)} \times \text{Part-time Status Relativity (0.65)} \times \text{Territory Relativity (0.52)} \times (1.0 - \text{Claims-free Discount}) (1-0.3 = 0.7) \times (1.0 +/- \text{Schedule Rating Debit/Credit}) (1 - 0.5 = 0.5) \times \text{Limit Relativity (0.82)} \times (1.0 - \text{Deductible Credit}) (1-0.8 = 0.2) \times \text{Claims-made or Extended Reporting Endorsement Factor} (0.10) \times (1.0 - \text{Group Credit})) (1-0.2= 0.8)
\]

Thus, Total Premium = 500*0.77*0.65*0.52*0.7*0.5*0.82*0.2*0.10*0.8 = **Total Premium = 0.59755696**.

**Problem S5-10-5.** A company is considering purchasing insurance for a group of 35 practitioners. Without accounting for the specialty of a practitioner, the rate charged per practitioner is 6067.63575, as all other characteristics except specialty are the same for all practitioners. The company has a total budget of 250000 for this project. For which of the following 3 combinations of practitioners by specialty would the company be able to purchase insurance?

**Combination A:** 4 acupuncturists, 13 homeopaths, 3 practitioners of placebo medicine, 15 practitioners of doing nothing therapy.
**Combination B:** 1 provider of bleeding services, 3 providers of snake oil services, 31 homeopaths.
**Combination C:** 35 practitioners classified as belonging to "All Other Specialties". (These practitioners do not believe in "alternative medicine.")

**Solution S5-10-5.**

For each combination we multiply the rate per practitioner without specialty considered by the specialty rate relativity.

**For Combination A:** Combined premium is
6067.63575*(4*1.94 + 13*0.77 + 3*0.96 + 15*1.14) = 229053.2496 < 250000, so the company can afford to purchase insurance for Combination A.

For Combination B: Combined premium is 6067.63575*(1*9.92 + 3*4.41 + 31*0.77) = 285300.233 > 250000, so the company cannot afford to purchase insurance for Combination B.

For Combination C: Combined premium is 6067.63575*(35*1.00) = 212367.2513 < 250000, so the company can afford to purchase insurance for Combination C.

Thus, the company can afford to purchase insurance for Combinations A and C only.
Section 11

Practice Problems and Solutions Pertaining to a Fictional Rating Manual for Workers' Compensation Insurance

The problems in this section all refer to the following excerpt from a fictional workers' compensation insurance rating manual from Srekrow Insurance Company:

**Class Rating Table**

<table>
<thead>
<tr>
<th>Class</th>
<th>Rate per $100 of payroll</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hippopotamus trainers</td>
<td>1.35</td>
</tr>
<tr>
<td>Asteroid miners</td>
<td>3.56</td>
</tr>
<tr>
<td>Writers of actuarial study guides</td>
<td>0.45</td>
</tr>
<tr>
<td>All other workers</td>
<td>1.00</td>
</tr>
</tbody>
</table>

**Premium Credits/Debits**

<table>
<thead>
<tr>
<th>Item</th>
<th>Credits(-) or Debits(+)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presence of blue sofas</td>
<td>-2%</td>
</tr>
<tr>
<td>Presence of green sofas</td>
<td>+5%</td>
</tr>
<tr>
<td>Rounded corners on walls</td>
<td>-10%</td>
</tr>
<tr>
<td>Spikes sticking out of walls</td>
<td>+50%</td>
</tr>
</tbody>
</table>

**Expense Constant**

The expense constant is $95 per policy.

**Minimum Premium**

The minimum premium for any policy is $1000.

**Rating Algorithm**

Total Premium = Higher of

\( \left( \sum_{i=1}^{N} \frac{\text{Class rate} \times \text{Payroll for class}}{100} \right) \times (1.0 - \text{Blue Sofa Credit}) \times (1.0 + \text{Green Sofa Debit}) \times (1.0 - \text{Rounded Corners Credit}) \times (1.0 + \text{Spikes Debit}) + \text{Expense Constant} \)

and

Minimum Premium specified in the rating manual ($1000 in this example).

There is to be no rounding at any step of the algorithm.
Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-11-1. Hippopotamus Actuarial and Asteroid Mining Services employs the following individuals:

- 6 hippopotamus trainers who are paid $56000 each per year.
- 2 asteroid miners who are paid $100000 each per year.
- 9 writers of actuarial study guides who are paid $30000 each per year.

The company does not own any sofas and has ordinary sharp corners on the walls of its offices. There are also no spikes sticking out of the walls. Find the total premium that the company will have to pay to Srekrow Insurance Company to insure all of its employees.

Solution S5-11-1. We first find the manual premium or

\[ \sum_{i=1}^{N} (\text{Class rate} \times \frac{\text{Payroll for class}}{100}) \]

Here, \( N = 3 \).

For hippopotamus trainers, \( \text{Class rate} \times \frac{\text{Payroll for class}}{100} = 1.35 \times \frac{6 \times 56000}{100} = 4536 \).

For asteroid miners, \( \text{Class rate} \times \frac{\text{Payroll for class}}{100} = 3.56 \times \frac{2 \times 100000}{100} = 7120 \).

For writers of actuarial study guides, \( \text{Class rate} \times \frac{\text{Payroll for class}}{100} = 0.45 \times \frac{9 \times 30000}{100} = 1215 \).

Thus, the manual premium is \( 4536 + 7120 + 1215 = 12871 \).

Total Premium = Higher of

\[ \sum_{i=1}^{N} (\text{Class rate} \times \frac{\text{Payroll for class}}{100}) \times (1 + 0 = 1) \times (1 - 0 = 1) \times (1 + 0 = 1) \times (1 - 0 = 1) + \text{Expense Constant} (95) \]

and

Minimum Premium specified in the rating manual ($1000 in this example).

12871 + 95 = 12966 > 1000, so the premium for this policy is $12,966.

Problem S5-11-2. Hippopotamus Actuarial and Asteroid Mining Services employs the following individuals:

- 6 hippopotamus trainers who are paid $56000 each per year.
- 2 asteroid miners who are paid $100000 each per year.
- 9 writers of actuarial study guides who are paid $30000 each per year.
Previously, the company's workers' compensation insurance premium was 12966. By how much will the premium decrease if the company decides to purchase blue sofas? (Everything else remains the same.)

**Solution S5-11-2.** The manual premium remains the same at 12871 (See Solution S5-11-1), but now it is multiplied a factor of \((1 - 0.02) = 0.98\).

\[
\text{Total Premium} = \text{Higher of } \sum_{i=1}^{N} (\text{Class rate} \times \frac{\$\text{Payroll for class}}{100}) \times (12871) \times (1 - 0.02) \times (1 + 0) \times (1 - 0) \times (1 + 0) + \text{Expense Constant (95)}
\]

and

Minimum Premium specified in the rating manual ($1000 in this example).

\[
12871 \times 0.98 + 95 = 12708.58 > 1000.
\]

The premium will decrease by \(12966 - 12708.58 = \$257.42\).

**Problem S5-11-3.** A company currently employs 2 writers of actuarial study guides who are paid $40000 each per year. The company has both green and blue sofas and has rounded corners sticking out of walls. At most how many more writers of actuarial study guides can the company hire while keeping its workers' compensation insurance premium at 1000?

**Solution S5-11-3.** We first find the current manual premium. There is only one class of workers, so Manual Premium = Class rate * $Payroll for class /100 = 0.45*2*40000/100 = 360.

We multiply the manual premium by the following factors:

\( (1.0 - \text{Blue Sofa Credit}) = (1-0.02) = 0.98; \)
\( (1.0 + \text{Green Sofa Debit}) = (1+0.05) = 1.05; \)
\( (1.0 - \text{Rounded Corners Credit}) = (1-0.10) = 0.90; \)

Prior to the application of the expense constant, we thus have a value of \(360 \times 0.98 \times 1.05 \times 0.90 = 333.396\). Each employee would contribute \(333.396/2 = 166.698\) to the manual premium, adjusted by the factors above.

To 333.396 we add the expense constant of 95 and get 428.396. This is how much the company would have paid in premium if it were not for the 1000 minimum. The company can add \(1000 - 428.396 = 571.604\) to what its premium would have been without the minimum before reaching 1000.
Thus, hiring an additional \( \frac{571.604}{166.698} = 3.4289179352 \) writers of actuarial study guides would not contribute to an increase in the premium. Since writers of actuarial study guides only come in discrete units, the company can hire at most 3 more writers of actuarial study guides.

**Problem S5-11-4.** A company has the following characteristics:
There are 7 asteroid miner employees, 5 of whom get paid $46,000 per year, and 2 of whom get paid $150,000 per year.

There are also 2 "other" employees, each of whom gets paid $90,000 per year.

The company's office walls have spikes sticking out them. The company does not have any sofas or rounded corners.

Find the total premium that the company will have to pay to Srekrow Insurance Company to insure all of its employees.

**Solution S5-11-4.** We first find \( \sum_{i=1}^{N} (\text{Class rate} \times \frac{\$\text{Payroll for class}}{100}) \). Here, \( N = 2 \).

For asteroid miners, \( \text{Class rate} \times \frac{\$\text{Payroll for class}}{100} = 3.56(5 \times 46000 + 2 \times 150000)/100 = 18868 \).

For the "other" employees, \( \text{Class rate} \times \frac{\$\text{Payroll for class}}{100} = 1.00(2 \times 90000)/100 = 1800 \).

Thus, the manual premium is 18868 + 1800 = 20668.

Total Premium = Higher of
\[ \sum_{i=1}^{N} (\text{Class rate} \times \frac{\$\text{Payroll for class}}{100}) (20668) \]
\[ \times (1.0 - \text{Blue Sofa Credit}) (1 - 0 = 1) \]
\[ \times (1.0 + \text{Green Sofa Debit}) (1 + 0 = 1) \]
\[ \times (1.0 - \text{Rounded Corners Credit}) (1 - 0 = 1) \]
\[ \times (1.0 + \text{Spikes Debit}) (1 + 0.50 = 1.50) \]
\[ + \text{Expense Constant (95)} \]
and
Minimum Premium specified in the rating manual ($1000 in this example).

20668*1.50 + 95 = 31097 > 1000, so the premium for this company is $31,097.

**Problem S5-11-5.** A company has the following characteristics:
There are 7 asteroid miner employees, 5 of whom get paid $46,000 per year, and 2 of whom get paid $150,000 per year.

There are also 2 "other" employees, each of whom gets paid $90,000 per year.

The company's office walls have spikes sticking out them. The company does not have any sofas or rounded corners.
The company decides to diversify into hippopotamus training. However, it does not wish to see an increase in workers' compensation premiums as a result of doing so. To compensate for the increased payroll, the company decides to eliminate the spikes sticking out of its office walls, to purchase blue sofas, and to install rounded corners on all the walls.

Each hippopotamus trainer gets paid $50000 per year. By at most how many hippopotamus trainers could the company hire without increasing its workers' compensation premium after instituting the safety improvements above?

**Solution S5-11-5.** From Solution S5-11-4, the current premium is 31097, and the current manual premium is 20668.

With the new credits received from the safety improvements, the manual premium is multiplied by the following factors:

\[(1.0 - \text{Blue Sofa Credit}) (1 - 0.02 = 0.98);\]

\[(1.0 - \text{Rounded Corners Credit}) (1 - 0.10 = 0.90).\]

\[20668*0.98*0.90 + 95 = 18324.176 = \text{the new total premium before any new workers are hired.}\]

The company can afford to increase its premium by \[31097 - 18324.176 = 12772.824\] through hiring new hippopotamus trainers.

How much will each hippopotamus trainer cost in extra premium?
The manual premium per trainer is \(1.35*50000/100 = 675\).

Multiplying this value by the two credit factors, we get \(675*0.98*0.90 = 595.35\). This is the added cost in premium of hiring one trainer.

Thus, the company can hire at most \(12772.824/595.35 = 21.45431091\) additional trainers.

Since hippopotamus trainers only come in discrete units, the company can hire at most **21 more hippopotamus trainers.**
Section 12

Moral Hazard Versus Morale Hazard in Insurance

In insurance, the term "moral hazard" refers to the increase in frequency and/or severity of losses due to the fact that individuals who suffer the losses no longer bear their full cost.

*Ex ante moral hazard* occurs when there is an increase in the underlying risky behavior causing the loss.

*Ex post moral hazard* occurs when an individual asks the insurer to pay for more of the negative consequences of a behavior than would have otherwise been the case.

**Morale hazard** is an increase in the hazards due to a risk as the result of an individual's indifference or carelessness, brought about by the presence of insurance coverage.

**Sources:**
"Moral hazard." Wikipedia, the Free Encyclopedia.
"Morale hazard." Wikipedia, the Free Encyclopedia.

**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-12-1.** Classify the following moral hazards as either *ex ante* or *ex post*:

(a) Driving more often and more recklessly after getting car insurance.
(b) Expecting insurance to pay for repairs that one would have paid for on one's own before.
(c) Failing to exercise after getting full health insurance coverage.
(d) Holding raucous parties in an insured house.
(e) Expecting insurance to replace a roof that has been blown off by a storm.

**Solution S5-12-1.** *Ex ante* moral hazards require changes in the underlying risk-causing behavior. Thus, (a), (c), and (d) are *ex ante* moral hazards.

*Ex post* moral hazards simply entail a change in expectations about getting insurance money for what one would have previously funded oneself. Thus, (b) and (e) are *ex post* moral hazards.

**Problem S5-12-2.** Which of the following are *morale* hazards? More than one answer may be correct.

(a) Killing an individual on whom one has a life insurance policy.
(b) Vandalizing one's own car to get paid under comprehensive coverage.
(c) Allowing large vegetation to grow near one's house in a fire-prone area.
(d) Funding one's hypochondria by means of health insurance companies' money.
(e) Regularly speeding on the way to work in an insured vehicle.

**Solution S5-12-2.** Morale hazards arise out of carelessness or indifference, but not out of malicious behavior or a desire to scam the insurance company for money. Thus, only (c) and (e) are morale hazards.

**Problem S5-12-3.** Name three ways in which an insurance company could reduce moral hazard and morale hazard.

*(Note: This is a "short-answer" written question. The exam will consist of such questions, so it is best to begin practicing. Write out your answer and compare to the possible answers below. Note that other correct answers may be possible.)*

**Solution S5-12-3.** Some possibilities are as follows:

1. The company could impose a deductible on insurance policies so that each loss costs the insured something out-of-pocket.

2. The company could offer co-insurance, in which the insured pays a fraction of the costs of loss and has an incentive to minimize the magnitude of losses so as to pay a smaller absolute amount.

3. The company could offer premium discounts for features that reduce risk - such as fire extinguishers in homes or air bags in cars.

4. The company could offer discounts for not filing claims. In this way, individuals have an incentive to behave responsibly and avoid losses, as their premiums will increase if they try to claim some of the insurer's money.

5. The company could refuse to underwrite certain kinds of risks known to be particularly subject to moral/morale hazard. This places the entire burden of loss on the individuals who are refused insurance.

**Problem S5-12-4.** Why might federal disaster insurance and reconstruction aid after disasters constitute moral hazards?

**Solution S5-12-4.** Federal disaster insurance and reconstruction aid may constitute moral hazards by encouraging people to move into disaster-prone areas in the first place and to continue living there. Federal insurance is typically offered at subsidized rates, and so individuals incur lower costs than they otherwise would have in living in a particular area. When a disaster strikes, the inhabitants expect federal insurance payouts and aid for recovery, and so their out-of-pocket expected losses are lower. They have an incentive to rebuild in the same area and continue being exposed to the same natural perils. Without federal disaster insurance, insurance for comparable risks might not have been available on the private market, thereby dissuading people from living in high-risk areas altogether.
Problem S5-12-5. An insurer has found a reliable way to reduce moral hazard for all insureds through a universal approach to the way it conducts business. Which of the following would be possible consequences of this accomplishment?
(a) Insured losses would decline.
(b) The insurance company would be able to reduce premiums.
(c) The insurance company would be able to underwrite additional insureds.

Solution S5-12-5. Clearly, if moral hazard declines, so does probability of loss, so (a) is true. If expected losses are lower, premiums may be lowered, so (b) is true. Moreover, insureds who were previously unable to be underwritten because of large amounts of moral hazard risk might now qualify for the insurance because moral hazard is now reduced for all insureds. This may push some currently uninsured individuals over the acceptability threshold for getting insurance.
Section 13

Ratemaking Data Types, Policy Databases, and Claims Databases

This section of the study guide is intended to provide practice problems and solutions to accompany the pages of Basic Ratemaking, cited below. Students are encouraged to read these pages before attempting the problems.

Some of the questions here ask for short written answers based on the reading. This is meant to give the student practice in answering questions of the format that will appear on Exam 5. Students are encouraged to type their own answers first and then to compare these answers with the solutions given here. Please note that the solutions provided here are not necessarily the only possible ones.


Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-13-1. According to Werner and Modlin (36), what are the two types of internal data involved in ratemaking analysis? Give some examples of each.

Solution S5-13-1. The two types of internal data are as follows:

Risk information - including "characteristics like exposures, premium claim counts, losses, and explanatory characteristics about the policy or the claim."

Accounting information - including underwriting expenses and unallocated loss adjustment expenses (ULAE).

Problem S5-13-2. According to Werner and Modlin (37), insurance companies typically record risk information relevant to ratemaking in two databases: a policy database and a claims database. Match the following elements with the database in which they would typically be found. Note that some elements may occur in both databases.

(a) Risk identifiers, such as a vehicle number for personal auto databases
(b) Claim identifier
(c) Premium
(d) Exposure
(e) Claim characteristics
(f) Policy identifier
(g) Claimant identifier
(h) Event identifier  
(i) Claim status  
(j) Claim count  
(k) Salvage/Subrogation  
(l) Dates for the origination and termination of the policy  
(m) Loss dates  
(n) Dates for any midterm policy amendments  
(o) Characteristics of the individual risk  
(p) Paid loss  
(q) Case reserve  
(r) Allocated loss adjustment expense

**Solution S5-13-2.**

The following elements can be found in policy databases:

(a) Risk identifiers, such as a vehicle number for personal auto databases  
(c) Premium  
(d) Exposure  
(f) Policy identifier  
(l) Dates for the origination and termination of the policy  
(n) Dates for any midterm policy amendments  
(o) Characteristics of the individual risk

The following elements can be found in claim databases:

(a) Risk identifiers, such as a vehicle number for personal auto databases  
(b) Claim identifier  
(e) Claim characteristics  
(f) Policy identifier  
(g) Claimant identifier  
(h) Event identifier  
(i) Claim status  
(j) Claim count  
(k) Salvage/Subrogation  
(m) Loss dates  
(p) Paid loss  
(q) Case reserve  
(r) Allocated loss adjustment expense

**Problem S5-13-3.** You are working with the following policy database template:

Policy...Or. Eff. Date...Or. Term. Date...Tr. Eff. Date...Ded.. Terr...Wr.Ex...Wr.Prem.  
(ENTER DATA FOR EACH FIELD ABOVE.)
Meaning of abbreviations:
Or. Eff. Date = Original Effective Date
Or. Term. Date = Original Termination Date
Tr. Eff. Date = Transaction Effective Date - this is the date of the initiation or change in the policy to which the current entry pertains.
Ded. = Deductible
Terr. = Territory
Wr. Ex. = Written Exposure - this is the fraction of the policy period to which the current entry applies.
Wr. Prem. = Written Premium

An insurance company that uses this database writes 5-month policies for which it charges a premium of 150 when a deductible of 1000 is selected and a premium of 100 when a deductible of 1500 is selected.

You are aware of three policies. Policy A is in territory 4, Policy B is in territory 5, and Policy C is in territory π.

Policy A was written on October 4, 2193, with original termination date of March 4, 2194. The insured had a deductible of 1000, and the policy remained unchanged for the full term.

Policy B was written on December 2, 2193, with original termination date of May 2, 2194. The insured had a deductible of 1500. The policy was cancelled on February 2, 2194, and the insured received a pro rata refund of premium (a refund equal to the fraction of the original policy term for which the insured did not receive coverage).

Policy C was written on January 4, 2194, with original termination date of June 4, 2194. The insured had a deductible of 1000. On March 4, 2194, the insured changed the deductible to 1500, and the premium for the subsequent months of the policy changed accordingly.

Create entries in the policy database for each policy based on this information.

Solution S5-13-3. Policy A requires only one entry, as the policy did not change during the full term:

|--------|---------------|----------------|---------------|------|-------|---------|-----------|

Policy B requires two entries, one for the initiation of the policy and one for the cancellation of the policy, where a pro rata premium refund is given. The policy was canceled after two months, with three months remaining. So the written exposure is -(1-2/5) = - 3/5 = -0.6, meaning that the insurer paid the policyholder 0.6 of the original premium or 0.6*100 = 60, which corresponds to an entry of -60 under "Written Premium". Here are the two entries for Policy B:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>12/2/2193</td>
<td>5/2/2194</td>
<td>12/2/2193</td>
<td>1500</td>
<td>5</td>
<td>1.00</td>
<td>100</td>
</tr>
<tr>
<td>B</td>
<td>12/2/2193</td>
<td>5/2/2194</td>
<td>2/2/2194</td>
<td>1500</td>
<td>5</td>
<td>-0.60</td>
<td>-60</td>
</tr>
</tbody>
</table>
Policy C requires three entries, one for the initiation of the policy, one writing off the unearned portion of the policy with the old deductible, and one writing in the unearned portion of the policy with the new deductible. The latter two entries occur on the date the deductible was elected. The deductible was changed after two months, with three months remaining in the policy.

The insured had 150 \times 0.6 = 90 of the old premium written off and 100 \times 0.6 = 60 of the new premium applied to the policy. Here are the two entries for Policy C:

\[
\begin{array}{|c|c|c|c|c|c|c|c|}
\hline
\text{Policy} & \text{Or. Eff. Date} & \text{Or. Term. Date} & \text{Tr. Eff. Date} & \text{Ded.} & \text{Terr.} & \text{Wr. Ex} & \text{Wr. Prem.} \\
\hline
C & 1/4/2194 & 6/4/2194 & 1/4/2194 & 1000 & \pi & 1.00 & 150 \\
C & 1/4/2194 & 6/4/2194 & 3/4/2194 & 1000 & \pi & -0.60 & -90 \\
C & 1/4/2194 & 6/4/2194 & 3/4/2194 & 1500 & \pi & 0.60 & 60 \\
\hline
\end{array}
\]

Problem S5-13-4. An insurance company uses a claims database with the following template:

\[
\begin{array}{|c|c|c|c|c|c|c|}
\hline
\text{Policy} & \text{Cl.#} & \text{Acc.Date} & \text{Rep.Date} & \text{Tr.Date} & \text{Cl.Status} & \text{LossPaym} \\
\hline
\end{array}
\]

(ENTER DATA FOR EACH FIELD ABOVE.)

Meanings of abbreviations:
- Cl.# = Claim Number
- Acc.Date = Accident Date
- Rep.Date = Report Date
- Tr.Date = Transaction Date
- Cl.Status = Claim Status (Open or Closed)
- LossPaym = Loss Payment
- CaseRes = Case Reserve
- ALAE = Paid Allocated Loss Adjustment Expenses
- S/S = Salvage/Subrogation

For Policy A, a loss occurs on October 4, 2302, and is reported to the insurance company as Claim #1 on October 10, 2302. An initial case reserve of 50000 is estimated. There are three payments on the claim:

- On October 28, 2302, a payment of 45000 is made. The case reserve is reduced correspondingly.
- On November 30, 2302, a payment of 2300 is made to the insured. The case reserve is increased to 6000. The insurer also pays 200 in allocated loss adjustment expenses.
- On January 4, 2303, a payment of 6000 is made. The insurer also receives 4000 in salvage recovery. The claim is closed.
- On March 4, 2303, a new loss occurs. A claim (Claim #2) is immediately made, and a case reserve is estimated at 3000.
- On March 30, 2303, the insurer pays 3000 on the new claim and closes the claim.

Develop entries in the claim database associated with this policy.
Solution S5-13-4.

There are six entries in all - four for Claim #1 and two for Claim #2. Each claim has an entry corresponding to the opening date and individual entries corresponding to the dates of any payments made.

<table>
<thead>
<tr>
<th>Policy</th>
<th>CL#</th>
<th>Acc.Date</th>
<th>Rep.Date</th>
<th>Tr.Date</th>
<th>Cl.Status</th>
<th>LossPaym</th>
<th>CaseRes</th>
<th>ALAE</th>
<th>S/S</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>10/4/2302</td>
<td>10/10/2302</td>
<td>10/10/2302</td>
<td>Open</td>
<td>0</td>
<td>50000</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>A</td>
<td>1</td>
<td>10/4/2302</td>
<td>10/10/2302</td>
<td>10/28/2302</td>
<td>Open</td>
<td>45000</td>
<td>50000</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>A</td>
<td>1</td>
<td>10/4/2302</td>
<td>10/10/2302</td>
<td>11/30/2302</td>
<td>Open</td>
<td>2300</td>
<td>6000</td>
<td>200</td>
<td>0</td>
</tr>
<tr>
<td>A</td>
<td>2</td>
<td>3/4/2303</td>
<td>3/4/2303</td>
<td>3/4/2303</td>
<td>Open</td>
<td>0</td>
<td>3000</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>A</td>
<td>2</td>
<td>3/4/2303</td>
<td>3/4/2303</td>
<td>3/30/2302</td>
<td>Closed</td>
<td>3000</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Problem S5-13-5. Define salvage and subrogation. What is a benefit of salvage and subrogation for insurance companies?

Solution S5-13-5.

Salvage occurs when an insurance company sells part of the damaged property it acquired from the insured after making a claim payment for replacing that property. Revenues gained from salvage can help the insurer to partially offset the cost of the claim payment.

Subrogation occurs when a company has paid for an insured's loss and then attempts to recover damages from the third party that caused the loss. Revenues gained from subrogation can also help the insurer to partially offset the cost of the claim payment.

Note: Werner and Modlin briefly discuss salvage and subrogation on p. 40.
Section 14

Aggregation of Insurance Data

This section of the study guide is intended to provide practice problems and solutions to accompany the pages of *Basic Ratemaking*, cited below. Students are encouraged to read these pages before attempting the problems.

Some of the questions here ask for short written answers based on the reading. This is meant to give the student practice in answering questions of the format that will appear on Exam 5. Students are encouraged to type their own answers first and then to compare these answers with the solutions given here. Please note that the solutions provided here are not necessarily the only possible ones.

**Source:**

**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-14-1.** Which of the following expenses are most often tracked at the aggregate level by insurance companies? More than one answer may be correct.

(a) Allocated loss adjustment expenses  
(b) Unallocated loss adjustment expenses  
(c) Commissions on specific policies  
(d) Taxes  
(e) General expenses  
(f) Licenses

**Solution S5-14-1.** Any expense which it is difficult to assign to specific policies is typically tracked at the aggregate level. Among the options provided here, the following are difficult to assign to specific policies:

(b) Unallocated loss adjustment expenses  
(d) Taxes  
(e) General expenses  
(f) Licenses

A more detailed discussion of this issue is available in Werner and Modlin (42).

**Problem S5-14-2.** According to Werner and Modlin (42), what are the three general objectives that apply when one is aggregating data for ratemaking purposes?
Solution S5-14-2. Werner and Modlin describe the three objectives as follows:
1. Accurately match losses and premium for the policy
2. Use the most recent data available
3. Minimize the cost of data collection and retrieval.

Problem S5-14-3. Name the four common methods of data aggregation. **Hint:** Each method is called "_____ year."

Solution S5-14-3. According to Werner and Modlin (42), the four common methods of data aggregation are as follows:
1. Calendar year
2. Policy year
3. Accident year
4. Report year

Problem S5-14-4. Which of the following statements about calendar year aggregation are true? More than one answer may be correct.
(a) Calendar year aggregation considers the date when the policy was issued and the dates when claims occurred.
(b) For the calendar year aggregation method, during the 12-month period considered to be a "calendar year,"
Reported Losses = Paid Losses + Change in Reserves.
(c) The calendar year aggregation method matches the premium on a policy to the losses resulting from that policy.
(d) The calendar year aggregation method allows for data to be available quickly once the calendar year ends.
(e) The calendar year aggregation method is best used in lines of insurance where losses develop very slowly.
(f) Loss development on a claim originally made 10 years ago can affect this year's data under the calendar year aggregation method.

Solution S5-14-4. This question is based on the discussion in Werner and Modlin (43). The following answers are correct:
(b) For the calendar year aggregation method, during the 12-month period considered to be a "calendar year,"
Reported Losses = Paid Losses + Change in Reserves.
(d) The calendar year aggregation method allows for data to be available quickly once the calendar year ends.
(f) Loss development on a claim originally made 10 years ago can affect this year's data under the calendar year aggregation method.

Answer (a) is not correct; the calendar year method only considers premium and loss transactions during a calendar year; it does not matter when the original policy was issued or when a claim was made.
Answer (c) is not correct; there may be a mismatch between premium and losses on a policy if premium was paid in one calendar year and losses were paid in another.

Answer (e) is not correct; the calendar year aggregation method is best used in lines of insurance where losses develop very quickly, as this reduces the occurrence of mismatches between premiums and losses.

**Problem S5-14-5.** Which of the following statements about accident year aggregation are true? More than one answer may be correct.

(a) Accident year aggregation is also called calendar-accident year aggregation or fiscal-accident year aggregation.
(b) Accident year aggregation considers the date when the policy was issued and the dates when claims were reported.
(c) For the accident year aggregation method, Reported Losses = Paid Losses + Case Reserves, all of which apply to losses that occurred during the year.
(d) At the end of the accident year, reported losses cannot change.
(e) The accident year aggregation method requires estimates of development on known losses at the end of the year.
(f) The accident year aggregation method compares losses on accidents occurring during the year to premium earned on policies during the same year.

**Solution S5-14-5.** This question is based on the discussion in Werner and Modlin (43). The following answers are correct:

(a) Accident year aggregation is also called calendar-accident year aggregation or fiscal-accident year aggregation.
(c) For the accident year aggregation method, Reported Losses = Paid Losses + Case Reserves, all of which apply to losses that occurred during the year.
(e) The accident year aggregation method requires estimates of development on known losses at the end of the year.
(f) The accident year aggregation method compares losses on accidents occurring during the year to premium earned on policies during the same year.

Answer (b) is not correct; the accident year method considers losses for accidents that occurred in a 12-month period. The dates the policy was issued and claims were reported are not considered.

Answer (d) is not correct; reported losses can change after the end of the accident year because of development on existing losses. This implies the need to estimate such loss development.
Section 15

Insurance Data Aggregation Methods and External Insurance Data

This section of the study guide is intended to provide practice problems and solutions to accompany the pages of *Basic Ratemaking*, cited below. Students are encouraged to read these pages before attempting the problems.

Some of the questions here ask for short written answers based on the reading. This is meant to give the student practice in answering questions of the format that will appear on Exam 5. Students are encouraged to type their own answers first and then to compare these answers with the solutions given here. Please note that the solutions provided here are not necessarily the only possible ones.


**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-15-1.** Which of the following statements about policy year aggregation are true? More than one answer may be correct.

(a) Policy year aggregation is the same as calendar-accident year aggregation.
(b) Policy year aggregation is the same as underwriting year aggregation.
(c) Policy year aggregation considers the dates when claims occurred.
(d) Policy year aggregation considers the premiums and losses on all policies written during a 12-month period, irrespective of when claims were reported or paid.
(e) Only when all policies written during a 12-month period expire can fixed premium and loss data be obtained under the policy year aggregation method.
(f) For the policy year aggregation method, Reported Losses = Paid Losses + Case Reserves, all of which apply to losses that occurred during the year.
(g) Policy year aggregation provides the best match between premiums and losses.
(h) When the policy year aggregation method is used, it takes longer for data to develop than when the calendar year aggregation method or accident year aggregation method are used.

**Solution S5-15-1.** This question is based on the discussion in Werner and Modlin (43-44). The following answers are correct:

(b) Policy year aggregation is the same as underwriting year aggregation.
(d) Policy year aggregation considers the premiums and losses on all policies written during a 12-month period, irrespective of when claims were reported or paid.

(e) Only when all policies written during a 12-month period expire can fixed premium and loss data be obtained under the policy year aggregation method.

(g) Policy year aggregation provides the best match between premiums and losses.

(h) When the policy year aggregation method is used, it takes longer for data to develop than when the calendar year aggregation method or accident year aggregation method are used.

Answer (a) is incorrect, because accident year or calendar-accident year aggregation is different from policy year aggregation.

Answer (c) is incorrect, because policy year aggregation only considers whether a loss occurs on a policy written during a certain time period, not when a claim occurs on that policy.

Answer (f) is incorrect, because for the policy year aggregation method,

\[
\text{Reported Losses} = \text{Paid Losses} + \text{Case Reserves},
\]

all of which apply only to policies written in a certain 12-month period.

**Problem S5-15-2.** Which of the following statements about report year aggregation are true? More than one answer may be correct.

(a) Report year aggregation considers the dates when claims occurred.
(b) Report year aggregation considers the dates when losses were paid.
(c) Report year aggregation considers the dates when claims were reported.
(d) Report year aggregation is often used in claims-made policies for commercial lines of insurance.
(e) Report year aggregation is often used in personal lines of insurance, especially for private passenger automobile policies.

**Solution S5-15-2.** This question is based on the discussion in Werner and Modlin (44). The following answers are correct:

(c) Report year aggregation considers the dates when claims were reported.
(d) Report year aggregation is often used in claims-made policies for commercial lines of insurance.

The report year method is typically not used in personal lines of insurance, so (e) is incorrect. (a) and (b) are incorrect, because the report year method only considers when claims were reported - not when they occurred or when losses were paid.

**Problem S5-15-3.** Match the following (numbered) methods to the following (lettered) practices.
(1) Overall ratemaking analysis;
(2) Univariate classification analysis;
(3) Multivariate classification analysis.

(a) Data ought to be organized at the individual policy or risk level.
(b) Data can be aggregated and summarized using the chosen type of year (e.g. calendar year, policy year, etc.) for the overall product and location being analyzed.
(c) Data should be aggregated at the level of each variable being analyzed.

**Solution S5-15-3.** This question is based on the discussion in Werner and Modlin (44).

Data ought to be organized at the individual policy or risk level in multivariate classification analysis.

Data can be aggregated and summarized using the chosen type of year (e.g. calendar year, policy year, etc.) for the overall product and location being analyzed in overall ratemaking analysis.

Data should be aggregated at the level of each variable being analyzed in univariate classification analysis.

Thus, we have the following matches:
(1) and (c); (2) and (b); (3) and (a).

**Problem S5-15-4.** Which of the following are true about statistical plan data? More than one answer may be correct.

(a) Statistical plan data collected by state regulators are often highly summarized.
(b) Statistical plan data always only apply within the boundaries of a particular state.
(c) The Insurance Services Office (ISO) and the National Council on Compensation Insurance (NCCI) are two examples of organizations that collect and analyze statistical plan data.
(d) Statistical plan data collected by ISO and NCCI are often highly summarized.
(e) Statistical plan data are almost always confidential and only accessible to the entities that collect them.

**Solution S5-15-4.** This question is based on the discussion in Werner and Modlin (45).

The following answers are correct:
(a) Statistical plan data collected by state regulators are often highly summarized.

(c) The Insurance Services Office (ISO) and the National Council on Compensation Insurance (NCCI) are two examples of organizations that collect and analyze statistical plan data.

Answer (b) is incorrect; statistical plan data can apply to multiple states.

Answer (d) is incorrect; ISO and NCCI often collect highly detailed data at the level of individual transactions.
Answer (e) is incorrect; statistical plan data are often publicly available information and can be used by insurers in ratemaking analyses.

**Problem S5-15-5.** Name five organizations or systems that serve as sources of other aggregated industry data, as discussed in Werner and Modlin (45-46).

**Solution S5-15-5.** The five sources of other aggregated industry data are as follows:
1. The "Fast Track Monitoring System";
2. The Highway Loss Data Institute (HLDI);
3. The Insurance Research Council (IRC);
4. The Institute for Business and Home Safety (IBHS);
Section 16

Practice Questions and Solutions on the Use of Competitor Rate Filings and Third-Party Data by Insurance Companies and Criteria for Exposure Bases

This section of the study guide is intended to provide practice problems and solutions to accompany the pages of Basic Ratemaking, cited below. Students are encouraged to read these pages before attempting the problems.

Some of the questions here ask for short written answers based on the reading. This is meant to give the student practice in answering questions of the format that will appear on Exam 5. Students are encouraged to type their own answers first and then to compare these answers with the solutions given here. Please note that the solutions provided here are not necessarily the only possible ones.

Source:

Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-16-1. Which of the following statements are true about insurance company rate filings? More than one answer may be correct.
(a) Rate filings always contain confidential information that is not available to the public.
(b) Rate filings typically include actuarial justification for proposed rate changes.
(c) Some rate filings only propose changes to the base rates of an insurance company; other rate filings can also propose changes in rating differentials - such as territory-based relativities or special discounts offered.
(d) Insurance companies will always file their complete rating manual with each rate filing.
(e) Competitor rate filings can always provide useful data to insurance companies for determining their own rates.

Solution S5-16-1. This question is based on the discussion in Werner and Modlin (46-47). The following answers are correct:
(b) Rate filings typically include actuarial justification for proposed rate changes.
(c) Some rate filings only propose changes to the base rates of an insurance company; other rate filings can also propose changes in rating differentials - such as territory-based relativities or special discounts offered.
Answer (a) is incorrect, because most rate filings are publicly available in entirety.

Answer (d) is incorrect; insurers will typically file only the manual pages they intend to change with a given rate filing.

Answer (e) is incorrect; if the competitor underwrites different risks or writes insurance in an area with different perils from those faced by the insurer in question, that competitor’s data may not be particularly useful. The usefulness of competitor data presupposes fundamental similarities between the business of the insurer in question and that of the competitor.

Problem S5-16-2. Give six examples of third-party data used by some insurance companies, where the data originates from entities that are not insurance companies themselves.

Solution S5-16-2. The following are all valid examples, mentioned by Werner and Modlin (47):

1. Economic data such as trends in the Consumer Price Index (CPI) and its component indices, such as the construction cost and medical cost indices.

2. Geo-demographic data, such as U.S. census data estimating population density in a particular area or weather indices and theft indices for a particular area.

3. Credit data of individuals or corporations, used for credit-based insurance scoring in personal lines or commercial lines of insurance, respectively.

4. Records pertaining to individual drivers from the Department of Motor Vehicles.

5. Distance from a house to a fire station.

6. Type of soil for earthquake insurance.

7. OSHA inspection data for workers' compensation insurance.

8. Attributes of the hospital in which the doctor practices for medical malpractice insurance.

9. Type of owner for commercial general liability insurance.

Problem S5-16-3. List the three criteria for a good exposure base, as described by Werner and Modlin (49).

Solution S5-16-3. The three criteria for a good exposure base are as follows:

1. It should be directly proportional to expected loss.

2. It should be practical.

3. It should consider any preexisting exposure base established within the industry.
Problem S5-16-4. It has been calculated that 30 exposures for a particular line of insurance correspond to expected losses of 7000. Assume that the exposure base was selected to perfectly meet the proper criteria for a good exposure base. What is the amount of expected losses to which 95 exposures ought to correspond, all other things equal?

Solution S5-16-4. A good exposure base should be directly proportional to expected loss.

Thus, if 30 exposures correspond to expected losses of 7000, then 95 exposures should correspond to expected losses of \((95/30) \times 7000 = 22166.666666667\).

Problem S5-16-5. You have found an intuitive exposure base that you expect to be directly proportional to expected loss. What are some possible issues that might arise so as to prevent this exposure base from being practical? List three such general issues.

Solution S5-16-5. The following are all possibilities discussed in Werner and Modlin (50):

1. Measurements of the exposure base may be difficult to verify.

2. Measurements of the exposure base may be too costly to obtain.

3. The exposure base may leave open the possibility of moral hazard through insureds' dishonest manipulation of exposure information and failure to disclose accurate data.

4. The technology that would enable accurate measurement of the exposure base may not yet be available.
Section 17

Exposure Bases, Methods of Aggregating Exposures, and In-Force Exposures

This section of the study guide is intended to provide practice problems and solutions to accompany the pages of *Basic Ratemaking*, cited below. Students are encouraged to read these pages before attempting the problems.

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**Source:**

**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-17-1.** Historically, exposure base A has been used for a particular line of insurance. However, because of advances in technology, exposure base B - which more directly corresponds to expected loss - is now practical to use. However, there may still be some negative side effects due transitioning from exposure base A to exposure B. Werner and Modlin (50) discuss three of these side effects. What are they?

**Solution S5-17-1.** The three negative side effects discussed are as follows:

1. Individual insureds may encounter large premium changes due to the change in exposure base.

2. A change in the rating algorithm will be required due to the change in exposure base. This may require significant efforts to alter the rating manuals and systems.

3. Ratemaking analysis typically relies on multiple years of data. If the exposure base is changed now, data from the past will need to be adjusted to the new standard in order to make the data before the change comparable to the data after the change.

Note that none of these side effects is necessarily a reason *not* to transition to a new exposure base. They are simply the likely costs of such a transition and should be compared to the benefits.
Problem S5-17-2. Which of the following statements about composite rating are true? More than one statement may be correct.

(a) Composite rating is typically used for small personal risks.
(b) Composite rating is typically used for small commercial risks.
(c) Composite rating is typically used for large commercial risks.
(d) Composite rating is typically used when there is a single, easily measurable exposure base.
(e) Composite rating is typically used when there are multiple perils being covered, and a different exposure base is used for each aspect of coverage.
(f) Composite rating often involves the use of a proxy measure for overall change in exposure.
(g) Loss-rated composite rating is based on the individual insured's historical loss experience.
(h) Loss-rated composite rating uses rigorously standardized rating algorithms.

Solution S5-17-2. The following answers are correct:

(c) Composite rating is typically used for large commercial risks.
(e) Composite rating is typically used when there are multiple perils being covered, and a different exposure base is used for each aspect of coverage.
(f) Composite rating often involves the use of a proxy measure for overall change in exposure.
(g) Loss-rated composite rating is based on the individual insured's historical loss experience.

Small personal and commercial risks typically do not have complicated exposure bases and so do not require composite rating. Thus, (a) and (b) are incorrect. Answer (d) is incorrect, because composite rating makes no sense if there is only one exposure base that is easy to measure directly. Answer (h) is incorrect, because composite rating typically does not utilize any standard rating algorithms.

Problem S5-17-3. According to Werner and Modlin (51-52), there are two methods of aggregating exposures. What are they? Which of these methods can assign a single earned exposure to multiple time periods?

Solution S5-17-3. The two methods of aggregating exposures are the calendar year or calendar-accident year method (note that these two methods are different for aggregating loss data, but the same for aggregating exposures) and the policy year method. Of these, the calendar year method is the one that can assign a single earned exposure to multiple time periods. For instance, a policy written for a term of one year in September 2030 would have some of the earned exposure assigned to calendar year 2030, and the rest assigned to calendar year 2031. By definition, a policy is in force only during the policy year, so the policy year method always assigns the entirety of the earned exposure to the policy year in question.

Problem S5-17-4. A policy of insurance is issued on May 1, 2045. The term of the policy is one year, and it is assumed that one unit of exposure corresponds to the full policy term. Also assume that the probability of a claim is evenly distributed throughout the term of the policy. Use both the calendar year method and the policy year method to determine how many earned exposure units are allocated to each year by each method.
Solution S5-17-4. The policy is in force from May 1, 2045, to May 1, 2046. This means that, under the calendar year method, the policy is in force for 8 out of 12 months in 2045, and for 4 of 12 months in 2046. Since a full year corresponds to 1 unit of exposure, the calendar year method assigns $\frac{8}{12} = \frac{2}{3}$ units of earned exposure to calendar year 2045 and $\frac{4}{12} = \frac{1}{3}$ units of earned exposure to calendar year 2046. For the policy year method, the entirety of the earned exposure is always allocated to the year in which the policy was written, so 1 year of earned exposure is allocated to policy year 2045.

Problem S5-17-5. There are 7 policies of insurance, with the following terms and dates of issuance:
Policy A has a term of 3 years and was issued on October 1, 3046.
Policy B has a term of 5 months and was issued on October 1, 3046.
Policy C has a term of 1 year and was issued on January 1, 3047.
Policy D has a term of 9 months and was issued on April 1, 3047.
Policy E has a term of 9 months and was issued on July 1, 3047.
Policy F has a term of 1 year and was issued on July 1, 3047.
Policy H has a term of 1 year and was issued on August 1, 3047.

Each policy has one unit of exposure associated with it. Policies written for shorter time periods have a proportionally higher amount of the relevant exposure base at risk.

Calculate the difference between the number of in-force exposures on July 1, 3047 and the number of in-force exposures on July 1, 3048.

Solution S5-17-5. Since each policy corresponds to a unit of exposure, the number of in-force exposures at a given time will correspond to the number of policies that are written at or before that time and have an expiration date after that time.

On July 1, 3047, the following policies are in force: A, C, D, E, F.

B is not in force, because B expired on March 1, 3047. H is not in force, because H will only get written 1 month later on August 1, 3047.

On July 1, 3048, the following policies are in force: A, H.

C, D, E, and F have all expired on or before July 1, 3048, so they are no longer in force.

Thus, the desired difference is 5-2 = 3.
Section 18

Risk, Loss Exposures, and Hazards in Insurance

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Source:


Original Problems and Solutions from The Actuary's Free Study Guide

**Problem S5-18-1.** Nyce 2006, p. 1.6 discusses three necessary elements of loss exposures:
1. An asset exposed to loss;
2. Cause of loss (peril);

Apply these concepts to the following situation:

Amenhotep is growing spherical blue crops on his land. It is possible that a Perilous Purple Monster (PPM) will appear on his land and eat the crops. If this happens, Amenhotep has probability 0.5 of losing his entire crop (worth $60,000) and a probability of 0.5 of only losing one-tenth of his crop. Identify the elements of the loss exposure Amenhotep faces.

**Solution S5-18-1.** The elements of the loss exposure are as follows:
- **Asset exposed to loss:** The spherical blue crops owned by Amenhotep;
- **Cause of loss:** The PPM eating the crops;
- **Financial consequences of the loss:** Provided that a loss occurs, the financial consequences are either a loss of $60,000 with probability 0.5 or a loss of $10,000 with probability 0.5.

**Problem S5-18-2.** Nyce 2006, p. 1.4, describes the two elements of risk as being the following:
1. Uncertainty of outcome;  
2. Possibility of a negative outcome.

Which of the following situations exhibit risk under these criteria? More than one answer may be correct.

(a) You are given a free lottery ticket for a drawing where you have a small chance of winning $50,000,000. Otherwise, you win or lose nothing.

(b) You purchase a lottery ticket for $5 for a drawing where you have a small chance of winning $50,000,000. Otherwise, you win or lose nothing.

(c) Your friend tells you the following: "If you can spell the name of the capital of Madagascar backwards, I will give you $50. Otherwise, I will give you $25."

(d) You know with certainty that, if you go swimming, you will either be eaten by a shark or catch a contagious disease.

(e) You know with certainty that, if you go swimming, you will either be eaten by a shark or find a hidden treasure.

(f) You know with certainty that, if you go swimming, you will either be eaten by a shark.

Solution S5-18-2.

Choice (a) fails to meet the definition of risk, because there is no possibility of a negative outcome. You can win the lottery, but you cannot lose any money, and you have not even paid for the ticket.

Choice (b) meets the definition of risk, because if you do not win the $50,000,000 prize, you will have lost the purchase price of the ticket.

Choice (c) does not meet the definition of risk, because there is no possibility of a negative outcome. Irrespective of whether you answer correctly, you get some amount of money in excess of what you originally had.

Choice (d) meets the definition of risk, as the outcome is uncertain, and negative outcomes are possible. (Both of the possible outcomes are negative.)

Choice (e) meets the definition of risk, as the outcome is uncertain, and a negative outcome is possible. (There is only one negative outcome - being eaten by a shark.)

Choice (f) does not meet the definition of risk, because there is no uncertainty of outcome. If you go swimming, you will get eaten.

Thus, (b), (d), and (e) are correct answers.
**Problem S5-18-3.** Amenhotep is growing spherical blue crops on his land. It is possible that a Perilous Purple Monster (PPM) will appear on his land and eat the crops. Amenhotep has purchased PPM insurance coverage against this peril.

Nyce 2006, pp. 1.8-1.9 identifies four types of hazards that can occur in insurance:

1. Moral hazard;
2. Morale hazard;
3. Physical hazard;
4. Legal hazard.

Classify each of the following scenarios under one of the hazard categories described above.

(a) Amenhotep's spherical blue crops have genetically mutated to give off a scent that is particularly appealing to the PPM.

(b) Amenhotep, confident that insurance will pay for his losses, decides to go fishing all the time instead of looking after his crops.

(c) The Spherical Crop Regulation Authority (SCRA) issues a new bulletin, stating that PPMs must not be interfered with at any time, even when they trespass on property or eat farmers' crops.

(d) Amenhotep hires a friend to dress up as a PPM and pretend to devour the crops. In reality, the friend stores the crops inside his large costume and sells them on the market, giving the proceeds to Amenhotep. Amenhotep files a claim on his insurance policy.

(e) The courts in Amenhotep's jurisdiction have consistently found in favor of insureds in coverage disputes between the insurers and insureds. In particular, the courts have always awarded "pain and suffering" damages to insureds whose crops have been eaten by PPMs. The courts have insisted that these damages are covered under all PPM insurance policies.

**Solution S5-18-3.**

Scenario (a) poses a **physical hazard;** the scent of the mutated crops is a condition of property that increases the frequency - and possibly the severity - of losses.

Scenario (b) poses a **morale hazard;** Amenhotep is more negligent, now that he has insurance.

Scenario (c) poses a **legal hazard;** the bulletin prevents Amenhotep from interfering with the PPM whenever the PPM decides to eat Amenhotep's crops. This is likely to increase the severity of any loss that occurs.
Scenario (d) poses a **moral hazard**; Amenhotep has colluded with his friend to defraud the insurer.

Scenario (e) poses a **legal hazard**; the courts in Amenhotep's jurisdiction have ruled in such a way as to increase the likely insurance payout in the event of a loss. This makes it more costly for the insurer to offer coverage.

**Problem S5-18-4.** Nyce, on p. 1.11, classifies loss exposures into four types:

1. Property loss exposures;
2. Liability loss exposures;
3. Personnel loss exposures;

Property loss exposures can be classified as either tangible property loss exposures or intangible loss exposures. Tangible property is further divided into real property and personal property.

Apply the above classifications to each of the following situations, pertaining to Superwidgets, Inc. More than one classification may apply to each scenario.

(a) The CEO of Superwidgets, Inc. has 600 years of management experience that could not be replaced in the event of the CEO's death, retirement, or resignation.

(b) Superwidgets, Inc. owns a large and highly valuable art collection that is on display inside the corporate headquarters. The company does not plan to ever sell the collection and claims that it serves purely to enhance the employees' esthetic enjoyment of the workplace. The art is vulnerable to fire, flood, and paint-eating bugs.

(c) A branch office of Superwidgets, Inc. is the primary revenue generator for the company. The building sits on top of an earthquake fault and would be completely destroyed in the event of an earthquake.

(d) Superwidgets, Inc. owns a patent on a superwidget design that has been the blueprint for its major product. Several competitors have been alleging that the design is too simple and obvious to be patentable, and there are rumors that lawsuits may be filed, alleging illegitimate and injurious conduct on the part of Superwidgets, Inc. for holding back information that should be in the public domain.

(e) Superwidgets, Inc. uses a trade secret formula for the fuel used to power its superwidgets. The formula cannot be patented, no legal recourse exists to protect its trade secret status, and competitors will readily adopt it if its existence becomes known. This formula has thus far allowed Superwidgets, Inc. to substantially exceed its competitors in revenue and profitability.
(f) Superwidgets, Inc. markets its products to particularly sensitive consumers who will file lawsuits if the bouncing dodecahedron inside each superwidget does not bounce a sufficient number of times per minute. Each of these "nuisance lawsuits" is usually settled and constitutes a one-time expense for the company. The lawsuits do not damage the company's revenue-generating capacity or reputation, as the general public dismisses the lawsuits as being filed by cranks.

Solution S5-18-4.

Situation (a) presents both a **personnel loss exposure** (due to the possibility that the CEO might at some time no longer remain with the company) and a **net income loss exposure** (as the company's ability to generate income is likely to be hampered without the CEO's management experience).

Situation (b) presents a **tangible, personal property loss exposure** (due to the possibility that art owned by the company may be lost). There is no net income loss exposure, since the art does not contribute to the company's income generation abilities.

Situation (c) presents both a **tangible, real property loss exposure** (due to the possibility of loss to the branch office building) and a **net income loss exposure** (as the branch office is the primary revenue generator for the company, and its operations would be interrupted if its building were destroyed).

Situation (d) presents an **intangible property loss exposure** (due to the possibility of loss of the patent), a **liability loss exposure** (due to the possibility of lawsuits pertaining to the patent), and a **net income loss exposure** (due to the possibility of diminished income for the company if the patent is lost).

Situation (e) presents an **intangible property loss exposure** (due to the possibility of loss of the trade secret), and a **net income loss exposure** (due to the possibility of diminished income for the company if the trade secret is lost). There is no liability loss exposure, since no legal action is possible regarding the trade secret formula.

Situation (f) presents a **liability loss exposure** from the possibility of lawsuits filed against the company. There is no net income loss exposure, as the lawsuits are one-time losses and do not affect subsequent income of the company.

Problem S5-18-5. Nyce 2006, p. 1.17, describes some possible types of net income losses, including the following:
1. Loss of goodwill;
2. Failure to perform;
3. Missed opportunities.

Classify each of the following causes of net income loss under one of the categories listed above. Assume that the company has suffered a decrease in net income in each of these situations.
(a) Superwidgets, Inc. promises to deliver 300 superwidgets to a retailer, but only delivers 30 superwidgets due to a decimal-point error made by one of the company's employees.

(b) Despite studies that show that solid blue superwidgets have been consistently more profitable while costing no extra money to produce, Superwidgets, Inc. has continued to produce superwidgets in the traditional stripes-with-polka-dots pattern.

(c) One of the pet chickens of the CEO of Superwidgets, Inc. has run amok on a public walkway and mildly pecked 80 pedestrians. No lawsuits have been filed, but several newspaper editorials have chided Superwidgets, Inc. for irresponsible behavior toward the general public. The CEO has staunchly refused to issue an apology, alleging special pecking rights for his chickens.

(d) Superwidgets, Inc. has decided to replace customer-service representatives with automated telephone answering systems that were designed to lead consumers in circles until the consumers hang up in disgust. As a result, consumers are finding themselves practically unable to call the company with questions or complaints and are thus more reluctant to purchase superwidgets.

(e) Superwidgets, Inc. has refused to invest in a new oil-refining operation despite having the capital and expertise to do so. The CEO has stated that "Superwidgets are what we do, and we will not stray from our fundamental purpose."

(f) Superwidgets, Inc. has been consistently late on its mortgage payments for the commercial real estate it owns. As a result, no lenders are willing to make any future loans to the company.

Solution S5-18-5.

Situation (a) is an example of failure to perform.

Situation (b) is an example of missed opportunities.

Situation (c) is an example of loss of goodwill.

Situation (d) is an example of loss of goodwill.

Situation (e) is an example of missed opportunities.

Situation (f) is an example of failure to perform.
Section 19

Competition in Property and Casualty Insurance Markets

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**The Herfindahl (Herfindahl-Hirschman) Index (HHI)**

The Herfindahl Index is calculated as the sum of the squares of the market shares (expressed in decimal form) of all the firms in the market. It is a measure of market concentration. The higher the Herfindahl Index, the more concentrated the market is.

**Source:**


**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-19-1.** There are 5 insurance companies in the market in a particular region. The following are their market shares:
- A has market share of 30%.
- B has market share of 30%.
- C has market share of 20%.
- D has market share of 10%.
- E has market share of 10%.
Find the value of the Herfindahl Index (HHI) for this market.

**Solution S5-19-1.**

We take the sum of the squares of the market shares, expressed in decimal form:
\[
HHI = 0.3^2 + 0.3^2 + 0.2^2 + 0.1^2 + 0.1^2 = HHI = 0.24.
\]
Problem S5-19-2. Insurers can be classified by the products they offer. Nyce 2006, pp. 6.21-6.22, discusses the following classifications:

1. Insurers can be property-casualty insurers, life-health insurers, or multi-line insurers that sell both property-casualty and life-health products.

2. Property-casualty insurers can be personal lines insurers or commercial lines insurers.

3. Property-casualty insurers can be monoline or multi-line insurers.

Classify the following insurers using the categories mentioned above:

(a) Insurer A sells workers' compensation insurance only.

(b) Insurer B sells private passenger automobile insurance and homeowners' insurance for small properties owned by individuals.

(c) Insurer C sells only life insurance and commercial general liability insurance.

(d) Insurer D sells commercial automobile insurance and commercial inland marine insurance.

(e) Insurer E sells pet insurance and only insures cats owned by individuals.

(f) Insurer F sells only health insurance.

Solution S5-19-2.

(a) Insurer A is a **property-casualty, commercial lines, monoline insurer**.

(b) Insurer B is a **property-casualty, personal lines, multi-line insurer**.

(c) Insurer C is a **multi-line insurer** with regard to providing both property-casualty and life-health insurance but is a **commercial lines, monoline insurer** with regard to the property-casualty insurance it provides, since it provides only one kind.

(d) Insurer D is a **property-casualty, commercial lines, multi-line insurer**.

(e) Insurer E is a **property-casualty, personal lines, monoline insurer**.

(f) Insurer F is a **life-health insurer**. Since it does not provide property-casualty products, the classifications pertaining to property-casualty insurers do not apply.

Problem S5-19-3. Nyce 2006, p. 6.22, states that the "level of competition depends on the number and the size of competing insurers, the existence of insurance substitutes, the buyers' knowledge of the market, and the size and growth of the overall insurance market." For each of
the following possible changes in the homeowners' insurance market for Region X, can the change be expected to make the market more competitive or less competitive?

(a) Consumers have become more sophisticated in preventing losses to their homes, leading many to adopt the approach of retaining their losses instead of insuring them.
(b) Consumers have gotten into the habit of getting most of their insurance information from daytime soap opera television shows.
(c) Over the past 3 years, 80 new homeowners' insurers have entered the market.
(d) Due to the presence of special legal favors and barriers to entry into the market, one insurer, Generalized Insurance Co., has obtained a market share of 80%.
(e) The homeowners' insurance market in Region X has been growing at an unusually rapid rate compared to markets in other regions. This has resulted in many companies opening new branches in Region X.
(f) The government of Region X has issued a directive permitting sellers of shrimp to also provide homeowners' insurance without obtaining any additional licenses.

Solution S5-19-3.

Situation (a) is likely to increase competitiveness. If more consumers are retaining losses, then insurers will have to work harder to earn consumers' business; they will do this in part by offering more attractive coverages at more affordable prices.

Situation (b) is likely to reduce competitiveness, as daytime soap operas do not generally offer reliable information about insurance. With reduced consumer knowledge of the insurance market, consumers are more likely to acquiesce to less than ideal insurance policy terms.

Situation (c) is likely to increase competitiveness. The new entrants will compete with existing providers, which is likely to increase quality and reduce price.

Situation (d) is likely to reduce competitiveness, as there are persistent barriers to entry for competitors, and Generalized Insurance Co. has obtained an enormous market share due to special favors derived from the legal system.

Situation (e) is likely to increase competitiveness. The rapid growth of the market makes it attractive for new competitors to enter and is also likely to fuel innovation in the design and marketing of insurance.

Situation (f) increase competitiveness, as it allows a whole new group of companies to enter the market without having to overcome any legal barriers.

Problem S5-19-4. Which of the following statements are true? More than one answer may be correct.

(a) The Gramm-Leach-Bliley Act of 1999 allowed hedge funds to also provide insurance.
(b) As a result of the Gramm-Leach-Bliley Act of 1999, banks have offered more insurance products than traditional insurers.

(c) The Internet has made it considerably easier for insurers to enter new markets.

(d) In a local insurance market, it is important to consider insurers who compete in other states in order to gain an understanding of the competitiveness of the market in question.

(e) All other things being equal, it is more likely that a wealthier individual or firm will choose to retain losses rather than insure them.

(f) The increased ability to retain losses makes it possible for individuals to afford lower deductibles on insurance coverages.

Solution S5-19-4.

Answer (a) is incorrect, because the Gramm-Leach-Bliley Act applies to banks, not hedge funds.

Answer (b) is incorrect, because, despite the permissions of the Gramm-Leach-Bliley Act, banks have comprised only a small percentage of the insurance market, and are generally more interested in marketing insurance products than in developing products of their own.

Answer (c) is correct; the Internet reduces insurers' cost of establishing a traditional marketing force.

Answer (d) is incorrect; the insurers who compete in other states do not have an effect on a local insurance market unless they specifically enter that market.

Answer (e) is correct; wealthier individuals and firms can afford to retain more losses without suffering catastrophic financial consequences.

Answer (f) is incorrect; the increased ability to retain losses makes it possible for individuals to afford higher deductibles on insurance coverages, since more of the loss amount can be comfortably retained.

Thus, (c) and (e) are the correct answers.

Problem S5-19-5. According to Nyce 2006, p. 6.27, which of the following are contributing factors to the decline in the growth rate of the property-casualty insurance market in the United States after 1990? More than one answer may be correct.

(a) There has been a substantial growth in alternative risk financing tools.
(b) More stringent regulations on insurance products have prevented a lot of insurance from being offered.
(c) A lot of insurance products have been outsourced to India and China since 1990.
(d) There has been saturation of market demand for insurable products in property and casualty lines.
(e) The average annual population growth rate has declined, leading to a reduced growth in demand for insurance.
(f) Malthus was right: the increasing population growth rate and our limited resources have meant that more people are concerned with basic subsistence than with purchasing insurance.

Solution S5-19-5. The correct answers are as follows:
(a) There has been a substantial growth in alternative risk financing tools.
(d) There has been saturation of market demand for insurable products in property and casualty lines.
(e) The average annual population growth rate has declined, leading to a reduced growth in demand for insurance.

Whether or not (b) is correct is an open question and is not addressed in the text; it is also not clear whether insurance regulations have become more stringent since 1990. Choices (c) and (f) are both factually untrue. It is difficult to outsource insurance as such, since policies still need to be provided to insureds within the U.S. Moreover, the population growth rate has not been increasing, and the Malthusian conclusion would not be correct even if the population were increasing.
Section 20

Basic Supply and Demand and Some Factors Affecting Insurance Supply

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Total *written premiums*, or premiums on all policies written during a certain time period, are often used as an approximation of an insurer's liabilities. The *policyholders' surplus*, the difference between assets and liabilities, is a measure of how much capital an insurer has to pay greater-than-expected claims (Nyce 2006, p. 7.14).

Premium-to-surplus ratio = (Written premiums)/(Policyholders' surplus).

A *lower* premium-to-surplus ratio indicates greater insurer financial strength, because fewer written premiums (an estimate of liability) exist for each unit of surplus (an estimate of how much is available to pay greater-than-expected claims).

Source:


**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-20-1.** Using simple supply-and-demand analysis, determine what happens to quantity sold and price under each of the following circumstances. Assume *ceteris paribus* (all other things being equal) and a perfect neoclassical market which equilibrates instantaneously.

(a) Supply increases; demand decreases.
(b) Supply decreases; demand increases.
(c) Supply and demand both increase.
(d) Supply and demand both decrease.
Solution S5-20-1. Each of situations has an unambiguous effect on one of the two variables and an indeterminate effect on the other. Draw a supply-and-demand graph to see the effects visually. Here are the answers:

(a) Price unambiguously decreases, while quantity may increase or decrease. Quantity will increase if effect of the supply increase is greater than the effect of the demand decrease.

(b) Price unambiguously increases, while quantity may increase or decrease. Quantity will increase if effect of the demand increase is greater than the effect of the supply decrease.

(c) Quantity unambiguously increases, while price may increase or decrease. Price will increase if the increase in demand exceeds the increase in supply.

(d) Quantity unambiguously decreases, while price may increase or decrease. Price will increase if the decrease in supply exceeds the decrease in demand.

Problem S5-20-2.

Insurer A has total assets of $100 million and total written premiums of $50 million. Insurer B has total assets of $150 million and total written premiums of $120 million. The insurers are otherwise identical. Assume that no other information is available and that the insurers' liabilities have to be estimated using the information given. Using such estimates, what is the absolute value of the difference between the policyholders' surplus of A and the policyholders' surplus of B?

Solution S5-20-2. We use the formula Policyholders' Surplus = Assets - Liabilities.

Here, we are given the assets of each insurer, but we can only estimate liabilities, using total written premiums as a proxy.

Thus, we have the policyholders' surplus estimate for A as $100 million - $50 million = $50 million and the policyholders' surplus estimate for B as $150 million - $120 million = $30 million. The absolute value of the difference between the two surpluses is $20 million.

Problem S5-20-3. Insurer A has total assets of $100 million and total written premiums of $50 million. Insurer B has total assets of $150 million and total written premiums of $120 million. The insurers are otherwise identical. Assume that no other information is available and that the insurers' liabilities have to be estimated using the information given. Using such estimates, what is the premium-to-surplus ratio of each insurer? Which insurer is financially stronger, as measured by this ratio?

Solution S5-20-3. We use the formula Premium-to-surplus ratio = (Written premiums)/(Policyholders' surplus).

From Solution S5-20-2, the policyholders' surplus of A is $50 million, so the premium-to-surplus ratio for A is ($50 million)/($50 million) = 1 = premium-to-surplus ratio for A.
From Solution S5-20-2, the policyholders' surplus of B is $30 million, so the premium-to-surplus ratio for A is \((\$120\text{ million})/(\$30\text{ million}) = 4\) = **premium-to-surplus ratio for B**.

By this measure, A is financially stronger, since it has a lower premium-to-surplus ratio.

**Problem S5-20-4.** Give two examples of business practice regulation of insurance companies at the state level.

**Solution S5-20-4.** The examples mentioned by Nyce 2006, p. 7.16, include the following:
1. Regulations regarding licensing;
2. Regulations regarding policy language;
3. Regulations regarding minimum financial requirements - such as minimum capital and policyholders' surplus requirements;
4. Regulations regarding marketing practices - which can raise administrative expenses.

There are other possibilities, but any two of the above would suffice to answer the question.

**Problem S5-20-5.** Give two examples of insurance price regulation of insurance companies at the state level.

**Solution S5-20-5.**

The examples mentioned by Nyce 2006, p. 7.17, include the following:
1. Prohibitions of certain underwriting factors, such as gender, race, or income, in setting premiums.
2. Limitations on large rate increases in certain lines of insurance - such as private passenger automobile insurance or workers' compensation insurance. (Sometimes state regulators will ask that premium increases per policy renewal be limited to a certain percentage of the original premium - say, 20% or 25%.)
3. Limitations on rates charged for homeowners' insurance in areas susceptible to natural disasters.

There are other possibilities, and the rate regulation practices differ considerably among states, but any two of the above would suffice to answer the question.
Section 21

Considerations Regarding Insurance Markets and Pooling of Risk

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**Source:**

**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-21-1.** Which of the following statements are true? More than one answer may be correct.

(a) The greater an insurer's investment income, the lower its present value of future losses.
(b) The greater an insurer's investment income, the greater its present value of future losses.
(c) An insurer will more investment income can afford to charge a lower premium for the same coverage.

(d) An insurer will more investment income can afford to charge a higher premium for the same coverage, because it can afford to survive the resulting flight of consumers away from the company.
(e) The insurer may only invest its own initial capital and earned premiums; it may not invest premiums that have been collected but have not yet been earned.
(f) Using reinsurance can increase an insurer's capacity to pay future claims and assume new business.
(g) Salaries paid to employees of the insurance company are considered a part of the production costs of providing insurance.
(h) Despite regulatory price limitations on insurance, consumers are always able to find the coverage they desire at some price.
**Solution S5-21-1.** The statements above are addressed in Nyce 2006, pp. 7.15-7.17. The following statements are correct:

(a) The greater an insurer’s investment income, the lower its present value of future losses.

(c) An insurer will more investment income can afford to charge a lower premium for the same coverage.

(f) Using reinsurance can increase an insurer’s capacity to pay future claims and assume new business.

(g) Salaries paid to employees of the insurance company are considered a part of the production costs of providing insurance.

Choices (b) and (d) are the opposites of (a) and (c), respectively, and so are incorrect. Choice (e) is incorrect, because the insurer may invest premiums as soon as they are collected. Choice (h) is incorrect; price limitations may mean that some consumers cannot get the coverage they want at any price, because insurers may not offer as much coverage as there is demand for the coverage.

**Problem S5-21-2.** Which of the following statements are true? More than one answer may be correct.

(a) Demand for insureds is always the result of voluntary choices on the part of potential customers.

(b) Only governments may mandate certain types of insurance.

(c) More risk-tolerant individuals will tend to purchase less insurance, all other things being equal.

(d) A given consumer’s risk tolerance level and desire to purchase insurance are always going to be roughly the same.

(e) Insurance may be less lucrative for both individuals and organizations with highly limited financial resources and for extremely wealthy individuals and organizations.

(f) The decision regarding whether to retain losses or insure them is always made on the basis of financial considerations, where no mandates are present.

(g) By marketing new and original products, an insurer may increase the demand for insurance.

**Solution S5-21-2.** The statements above are addressed in Nyce 2006, pp. 7.17-7.20. The following statements are correct:

(c) More risk-tolerant individuals will tend to purchase less insurance, all other things being equal.
(e) Insurance may be less lucrative for both individuals and organizations with highly limited financial resources and for extremely wealthy individuals and organizations.

(g) By marketing new and original products, an insurer may increase the demand for insurance.

Choice (a) is incorrect, because both governments and private lenders often mandate the purchase of insurance that individuals would not necessarily have demanded on their own.

Choice (b) is incorrect, because private lenders often mandate the purchase of certain types of insurance (e.g. homeowners’ insurance) as a condition of the loan.

Choice (d) is incorrect, because consumers’ risk tolerance levels may change with age, wealth, and general economic circumstances.

Choice (f) is incorrect, because an insurer may attract consumers who would otherwise retain losses on the basis of a personable sales force, effective loss control services, and fast claims service.

**Problem S5-21-3.** Which of the following statements are true? More than one answer may be correct.

(a) Individuals’ casualty losses are sometimes income-tax-deductible.

(b) Individuals’ property insurance premiums are sometimes tax-deductible.

(c) If losses are tax-deductible and premiums are not tax-deductible, this gives individuals an incentive to purchase more insurance.

(d) Businesses’ casualty losses are tax-deductible at the time they are paid.

(e) Businesses’ casualty losses are tax-deductible at the time they are incurred.

(f) Businesses’ insurance premiums are tax-deductible at the time they are paid.

(g) Purchasing insurance is likely to make businesses’ after-tax earnings less stable.

**Solution S5-21-3.** The statements above are addressed in Nyce 2006, pp. 7.20-7.21. The following statements are correct:

(a) Individuals’ casualty losses are sometimes income-tax-deductible.

(d) Businesses’ casualty losses are tax-deductible at the time they are paid.

(f) Businesses’ insurance premiums are tax-deductible at the time they are paid.

Choice (b) is incorrect, because individuals’ property insurance premiums are not tax-deductible.
Choice (c) is incorrect, because if premiums are not tax-deductible but losses are, this gives individuals an incentive to retain more losses and get a deduction from their taxes for any losses incurred. This tends to motivate individuals to purchase no insurance, less insurance, or insurance with higher deductibles.

Choice (e) is incorrect, because casualty losses are tax-deductible at the time they are paid, not at the time they are incurred.

Choice (g) is incorrect, because purchasing insurance is likely to make businesses' after-tax earnings more stable - since the tax deduction for insurance premiums is spread more evenly over time, and the insurance costs are much more consistent from one year to another.

**Problem S5-21-4.** According to Nyce 2006, p. 7.21, four key issues that affect the functioning of insurance markets with regard to pricing are as follows:
1. Adverse selection;
2. Moral and morale hazard;
3. Actuarial equity vs. social equity;
4. Timing.

Each of the scenarios below pertains to one of the four issues above. Match each scenario to the issue of which it is an example.

(a) Wine Insurance Company offers coverage for a brand of wine that takes 100 years to mature. There is a risk that the wine will spoil or become contaminated during the maturation period, and the company will pay the market value of good wine for every unit of wine that gets contaminated.

(b) Data Dredging Insurance Company has proposed a new "finger-based insurance scoring" (FBIS) model, which is based on empirical studies that have been interpreted to suggest that individuals of differing finger lengths have different levels of likelihood of filing a claim. Regulators in State X disapprove the FBIS model's use in rating, arguing that individuals have little to no control over their finger length and that such discrimination would be contrary to public policy.

(c) Pi Insurance Company estimates that there is an average delay of 3.14159265 years between the time of a loss occurrence and the time of loss payment. Because the company can invest the premium in the meantime, it can afford to charge a premium that is lower than the expected value of the loss.

(d) Individual Q knows that he is a careless driver, but he has been lucky and has not had any accidents in the past. He is able to purchase an extremely low-priced automobile insurance policy.

(e) Individual Θ is lazy and does not like to work; he deliberately sets himself on fire at work so as to sustain mild injuries that nonetheless prevent him from working. He stages the fire to look
like an accident and collects a large percentage of his former salary in workers' compensation insurance benefits.

(f) An expert on earthquakes, floods, and hurricanes designs his own house to be virtually invulnerable to all of these perils. He discovers a way to construct this house at a reasonable cost, but the house is unique, and no insurer's rating plan can give enough discounts to account for its actual level of risk. Thus, the owner chooses to go without insurance, because his insurance premiums would be too expensive.

**Solution S5-21-4.** The following are the issues represented by each of these scenarios:
Scenario (a) is an example of **timing**;
Scenario (b) is an example of **actuarial equity vs. social equity**;
Scenario (c) is an example of **timing**;
Scenario (d) is an example of **adverse selection**;
Scenario (e) is an example of **moral hazard**;
Scenario (f) is an example of **adverse selection**.

**Problem S5-21-5.** In a certain neighborhood, houses are vulnerable to two types of perils - the Drill Monster (DM) and the Big Bouncy Monster (BBM). The DM lives in the ground, and it can only move vertically up or down. It has a tiny, but highly powerful drill using which it can puncture a hole inside the floor of a house and contaminate the house with a scent that requires considerable expense to remove but does not spread beyond the house. The DM cannot reproduce, and it never leaves its burrow. It is not known under which house the DM lives. The BBM is a giant sphere about the size of 12 houses that comes down at random times and destroys everything it touches. The residents are considering pooling their financial resources to pay for any losses occurring from the DM and the BBM. For which of these loss exposures in pooling most likely to reduce financial risk to each resident? For which of these loss exposures would the probability of every member paying out a positive amount be reduced by the pooling arrangement?

**Solution S5-21-5.** This question is based on the discussion of pooling in Nyce 2006, p. 7.34.

The financial risk due to the DM is more likely to be reduced because of the pooling arrangement. This is because loss exposures due to the DM are independent and uncorrelated, as a single contamination of a house by the DM does not spread to other houses. Pooling will be less effective at reducing financial risk due to the BBM, which can destroy up to 12 houses at a time - meaning that loss exposures due to the BBM are correlated.

Neither pooling arrangement would reduce the probability of paying out a positive amount for each member. Indeed, the probability of any one house being affected by one of these perils is always greater than the probability of a particular house being so affected. Thus, any given member of the pool will be more likely to pay out some amount in losses, but the average amount of the payout per individual will most likely be lower than if pooling did not exist.
Section 22

Functions and Properties of Risk Pooling and Insurance

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When there exists a pooling arrangement with n members who each have an identical expected value of losses and standard deviation of losses and for whom the losses are completely independent and uncorrelated, then the following formula holds:

\[
\text{Standard deviation of pool} = \sqrt{n} \times (\text{Standard deviation for a single member without the pooling arrangement}).
\]

The standard deviation of losses per member of the pool is

\[
\sqrt{n} \times (\text{Standard deviation for a single member without the pooling arrangement})/n = \text{Standard deviation per member of pool} = (\text{Standard deviation for a single member without the pooling arrangement})/\sqrt{n}.
\]

Pooling in which the members are identical does not change the expected value of losses per member.

Source:


Original Problems and Solutions from The Actuary’s Free Study Guide

Problem S5-22-1. Joe, Jim, and Claudius decide to pool their losses. Each of them on his own has a standard deviation of losses of $670. All losses are independent and uncorrelated. What is the standard deviation of losses for the pool?

Solution S5-22-1. Here, n, the number of members of the pool, is 3.

We use the formula Standard deviation of pool =
√(n) *(Standard deviation for a single member without the pooling arrangement) =
√(3)*670 = 1160.474041 = approximately $1160.47.

**Problem S5-22-2.** Joe, Jim, and Claudius decide to pool their losses. Each of them on his own has a standard deviation of losses of $670. All losses are independent and uncorrelated. With the pooling arrangement, what is the standard deviation of losses faced by each of them?

**Solution S5-22-2.** We use the formula Standard deviation per member of pool = (Standard deviation for a single member without the pooling arrangement)/√(n) = 670/√(3) = 386.8246804 = approximately $386.82.

**Problem S5-22-3.** Cuauhtémoc and Tim decide to pool their losses, which are completely independent and uncorrelated. Each of them has a 0.6 probability of no loss occurring, a 0.3 probability of a $10,000 loss occurring, and a 0.1 probability of a $100,000 loss occurring. Each person contributes an equal amount of money in the event of loss. What is the difference between the probability that Cuauhtémoc will not have to pay anything under the pooling arrangement and the probability that he would not have had to pay anything if he decided not to pool?

**Solution S5-22-3.** If Cuauhtémoc decided not to pool, he would pay nothing with probability 0.6, as given in the problem. Under the pooling arrangement, Cuauhtémoc would have to pay half of any of his own losses and half of any of Tim's losses. Thus, in order for him to pay nothing, both he and Tim would need to not suffer any losses. The probability of this happening is $0.6^2 = 0.36$. Thus, the desired difference is $0.36 - 0.6 = -0.24$. Note that Cuauhtémoc's probability of paying nothing is reduced considerably via the pooling arrangement.

**Problem S5-22-4.** Cuauhtémoc and Tim decide to pool their losses, which are completely independent and uncorrelated. Each of them has a 0.6 probability of no loss occurring, a 0.3 probability of a $10,000 loss occurring, and a 0.1 probability of a $100,000 loss occurring. Each person contributes an equal amount of money in the event of loss. What is the difference between the probability that Cuauhtémoc will have to pay $50,000 or more under the pooling arrangement and the probability that he would have had to pay $50,000 or more if he decided not to pool?

**Solution S5-22-4.** If Cuauhtémoc decided not to pool, the only way for him to pay $50,000 or more would be if he suffered a $100,000 loss - which would have a probability of 0.1. Under the pooling arrangement, Cuauhtémoc would have to pay half of any of his own losses and half of any of Tim's losses. Thus, if total losses are $100,000 or more, Cuauhtémoc would have to pay at least $50,000. The only way for total losses to be $100,000 or more is if either member of the pool or both of them have a $100,000 loss. This is

\[
\Pr(\text{Tim loses } $100,000) + \Pr(\text{Cuauhtémoc loses } $100,000) - \Pr(\text{Both lose } $100,000) = 0.1 + 0.1 - 0.1^2 = 0.19.
\]

Thus, the desired difference is $0.19 - 0.1 = 0.09$, meaning that Cuauhtémoc is actually at greater risk for a large payout with this pooling arrangement.
Problem S5-22-5. Which of the following statements about insurance and pooling are true? More than one answer may be correct.

(a) Pooling functions by reducing the expected frequency and severity of individual loss exposures.
(b) As the number of members in a pool increases, the standard deviation of losses per member decreases, unless the loss exposures are perfectly correlated.
(c) Pooling can reduce the expected cost of loss for every member.
(d) One advantage of pooling is that it tends to make losses per member more consistent and more predictable.
(e) Pooling does not work with correlated loss exposures.
(f) Insurance is just another name for pooling of losses. There are no substantive differences beyond the names.
(g) Insurance is a risk sharing mechanism, whereas pooling is a risk transfer mechanism.
(h) Unlike a pool, insurers typically cannot collect additional payments from the insured if actual losses happen to exceed the losses which were estimated in calculating the premium.
(i) One advantage of insurance over a pool is that an insurer typically has other resources to draw on - such as the initial capital from its investors and its retained earnings.

Solution S5-22-5. The ideas in this question are addressed in Nyce 2006, pp. 7.36-7.39.

The following statements are correct:
(b) As the number of members in a pool increases, the standard deviation of losses per member decreases, unless the loss exposures are perfectly correlated.
(d) One advantage of pooling is that it tends to make losses per member more consistent and more predictable.
(h) Unlike a pool, insurers typically cannot collect additional payments from the insured if actual losses happen to exceed the losses which were estimated in calculating the premium.
(i) One advantage of insurance over a pool is that an insurer typically has other resources to draw on - such as the initial capital from its investors and its retained earnings.

Choice (a) is incorrect, because pooling cannot reduce frequency and severity of individual losses.

Choice (c) is incorrect, because pooling does not reduce total expected loss cost, so it cannot reduce the expected loss cost for every member.

Choice (e) is incorrect; pooling works best with completely uncorrelated loss exposures, but it can also work to a lesser extent with correlated loss exposures, provided that the correlation is not perfect.

Choice (f) is incorrect; there are numerous important differences between pooling and insurance - including those discussed under the correct answers (h) and (i).

Choice (g) is incorrect; pooling is a risk sharing mechanism, whereas insurance is a risk transfer mechanism. This is one of the major differences between pooling and insurance.
Section 23

Characteristics of Ideally Insurable Loss Exposures

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Source:


Original Problems and Solutions from The Actuary’s Free Study Guide

Problem S5-23-1. Nyce 2006, p. 8.4, lists six characteristics of ideally insurable loss exposures:

1. Pure risk;
2. Fortuitous losses from the insured's standpoint;
3. Definite and measurable losses;
4. Large number of similar exposure units;
5. Independent and non-catastrophic losses;
6. Affordable premiums.

Each of the situations below does not meet one of the above criteria. Identify which characteristic is absent in each situation.
(a) A large number of houses are clustered together in a neighborhood. The Big Bouncy Monster (BBM), whose size is equivalent to that of twelve houses, can touch down on the ground at any time and will destroy anything it touches.

(b) Ms. Ψ wants to start an insurance company whose only product would be a package policy offering coverage on property damage to a particular kind of Chinese teapot, property damage liability arising from the insured's expeditions to the Moon, and pet-grooming liability. There are approximately four people in the world who would be potential customers for this kind of policy.

(c) Mr. Δ eats cookies with his tea. However, he often drops cookies into the tea and refuses to eat the wet cookies afterward. He wishes to obtain insurance coverage on his cookies, so that he would be refunded the purchase price every cookie he deems inedible.

(d) Ms. Θ wants to obtain insurance coverage against her own acts of vandalism to her hovermobile.

(e) Mr. Ω has invested money in the stock of a startup high-tech firm. He wants to purchase insurance coverage that would refund any of his losses on his investment.

(f) Mr. Ξ sometimes feels depressed and wants to purchase insurance coverage that indemnifies him for the "emotional cost" of his depression.

Solution S5-23-1.

Situation (a) lacks the characteristic of independent and non-catastrophic losses, since the BBM can destroy a large number of houses at the same time and can inflict considerable damage at once.

Situation (b) lacks the characteristic of a large number of similar exposure units, as there are not many potential insureds who would want this kind of coverage, and the exposures covered within the package policy are extremely different from one another.

Situation (c) lacks the characteristic of affordable premiums. It would be prohibitively expensive to insure frequent small losses such as Mr. Δ’s cookie drops, as the loss adjustment expenses would likely far exceed the losses.

Situation (d) lacks the characteristic of fortuitous losses from the insured's standpoint, since Ms. Θ has full control over whether she vandalizes her own hovermobile.

Situation (e) lacks the characteristic of pure risk. A stock investment is a speculative risk, with the possibility of gains for the investor.

Situation (f) lacks the characteristic of definite and measurable losses. "Emotional cost" is highly subjective, difficult to identify, and virtually impossible to measure using any external standard.
Problem S5-23-2. Fire typically poses a pure risk of loss, and the loss is fortuitous from the standpoint of the owner of the building that catches on fire. What situation poses an exception to this rule? (See Nyce 2006, p. 8.12.)

Solution S5-23-2. Fire may not be a pure risk or a cause of fortuitous loss if the owner of the building commits arson for profit. For instance, the owner may want to set fire to an obsolete or run-down building, collect insurance money, and build a structure that brings in more revenue using the proceeds. The fact that the owner set fire to the property means that the fire loss was not fortuitous; the fact that the owner may gain financially from the fire means that the risk is now speculative and is no longer pure.

Problem S5-23-3. For both the windstorm cause of loss and the flood cause of loss, explain why these causes of loss sometimes may not meet the following criteria where commercial property is concerned:

(a) Large number of similar exposure units;
(b) Independent and not catastrophic losses;
(c) Economically feasible premiums.

(See Nyce 2006, pp. 8.13-8.15.)

Solution S5-23-3.

(a) With regard to windstorms, buildings located in different areas may face substantially different loss exposures. For instance, buildings in hurricane-prone coastal states may face substantially greater windstorm loss exposures than buildings in landlocked areas. The same applies to floods. A dry area with little precipitation faces a significantly lower probability of flood than an area near a large body of water. Commercial buildings also serve a wider variety of functions that individual homes, which may make comparison of exposure units more difficult than in the case of residences owned by individual.

(b) A windstorm - especially a hurricane - can devastate an entire geographic area, destroying large amounts of property. Thus, windstorm losses can be catastrophic, and they may not be independent if the buildings affected are located in the same area. Flood losses are also geographically concentrated and so are seldom independent. Large floods may cause catastrophic losses - as happened, for instance, in New Orleans in the aftermath of Hurricane Katrina in 2005.

(c) In areas which are at a high risk for windstorms, improved catastrophe modeling may be able to more accurately evaluate that risk, leading to correspondingly higher premiums that may become economically infeasible for many insureds. Flood premiums for property and fixed locations have typically been considered economically infeasible by private insurers because of the geographically concentrated loss exposures, the potential for catastrophic damage, and the virtual certainty that a flood would occur within a given area during a longer time period (e.g. 100 years).
Problem S5-23-4. According to Nyce 2006, pp. 8.17-8.18, premises and operations liability has all six characteristics of an ideally insurable loss exposure. Products liability, however, may lack four of these characteristics. Which four are they, and why might products liability lack them?

Solution S5-23-4. The characteristics that products liability may lack in some situations are as follows:

1. **Definite and measurable losses**: The cause of the injury allegedly due to the insured's product may not always be definite; there may be several possible causes, only one of which might be the product. The loss may also not be measurable, as an injury often involves non-financial damage (e.g. pain and suffering, emotional distress, disfigurement, etc.) that is difficult to put a monetary value on.

2. **Large number of similar exposure units**: It is possible that a product may cause injuries in only rare cases - as when most users react favorably to a medicinal drug, but a small percentage of the population experiences severely negative side effects. Products liability may also arise from a customer who uses a product in an unusual fashion and thereby damages himself.

3. **Independent and non-catastrophic losses**: It is possible that a product could adversely affect large numbers of individuals and organizations, if it has been widely distributed. This could result in substantial and even catastrophic liability losses for the maker of the product.

4. **Affordable premiums**: The possibility of losses that are difficult to measure, unusual losses and dissimilar exposure units, and catastrophic losses may render premiums for products liability economically infeasible.

Problem S5-23-5. Which of the following statements about personnel loss exposures are true? More than one answer may be correct.

(a) The retirement cause of loss has typically been found to be uninsurable.
(b) The severity of a personnel cause of loss is about the same, irrespective of the member of the organization whose loss occurs.
(c) There is a wide variety of property-casualty insurance products available for personnel loss exposures.
(d) Because of the possibility of employee suicides, the death cause of loss may not be fortuitous.
(e) One characteristic that the death cause of loss sometimes may not meet is the definite and measurable nature of losses.
(f) The retirement cause of loss may not be fortuitous, because an employee can choose when to retire.
(g) The retirement cause of loss may not be fortuitous, because organizations can influence employees' retirement decisions through a variety of incentives and disincentives.
(h) One reason why the death cause of loss may not be an ideally insurable loss exposure is because it sometimes may not have a large number of similar exposure units.
(i) One reason why the death cause of loss may not be an ideally insurable loss exposure is because it often may not be independent and non-catastrophic.
Solution S5-23-5. The following answers are correct:
(a) The retirement cause of loss has typically been found to be uninsurable.

(e) One characteristic that the death cause of loss sometimes may not meet is the definite and measurable nature of losses.

(g) The retirement cause of loss may not be fortuitous, because organizations can influence employees' retirement decisions through a variety of incentives and disincentives.

(h) One reason why the death cause of loss may not be an ideally insurable loss exposure is because it sometimes may not have a large number of similar exposure units.

Choice (b) is incorrect; an organization may have key members whose death, retirement, or resignation could have a substantially more adverse impact than the loss of other employees.

Choice (c) is incorrect; property-casualty insurers typically do not insure personnel loss exposures.

Choice (d) is incorrect; an employee suicide is still a fortuitous cause of loss from the standpoint of the insured organization for which the employee works.

Choice (f) is incorrect, because an employee's choice to retire may still be fortuitous from the standpoint of the insured organization for which the employee works. Although it is true that the retirement cause of loss may not be fortuitous, the reason given is not correct in cases where the organization exerts no positive or negative influence on the employee's choice to retire.

Choice (i) is incorrect; employee deaths are independent and non-catastrophic in the vast majority of cases.
Section 24

Net Income Loss Exposures and Personal Loss Exposures

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**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-24-1.** Net income loss exposures associated with property losses exhibit five of the six characteristics of an ideally insurable loss exposure. Which one of the six characteristics might these loss exposures sometimes not exhibit? (If necessary, refer to Section 23 and to Nyce 2006, p. 8.21).

**Solution S5-24-1.** Net income loss exposures associated with property losses may sometimes not exhibit the property of being independent and non-catastrophic. For instance, if a company owns a large number of buildings in a particular town that gets struck by a windstorm, many of the buildings may be destroyed, and the damage may be catastrophic. This would greatly impair the company's ability to generate revenue in the future.

**Problem S5-24-2.** Why is no insurance offered on the market for net income loss exposures associated with liability losses? (If necessary, refer to Nyce 2006, pp. 8.21-8.22).

**Solution S5-24-2.** The time of a net income loss associated with liability is virtually impossible to determine. A liability claim against a company may do damage to its reputation and reduce its number of customers indefinitely into the future. It is not possible to objectively determine when the effect of such reputational damage has stopped being in operation. By contrast, restoration of damaged property provides a definite end time to net income losses due to property loss exposures.
**Problem S5-24-3.** Which of the following statements about personal loss exposures are true? More than one answer may be correct.

(a) Individuals may face liability loss exposures arising out of their real property, but not their personal property.
(b) Individuals may face liability loss exposures arising out of their behavior toward others.
(c) Some homeowners' insurers refuse to sell policies to individuals who own a certain kind of pet.
(d) Premises liability for individuals meets all six characteristics of an ideally insurable loss exposure.
(e) Automobile liability for individuals meets all six characteristics of an ideally insurable loss exposure.
(f) One characteristic of ideally insurable loss exposures that net income loss due to unemployment sometimes may not meet is the definite and measurable criterion.
(g) One characteristic of ideally insurable loss exposures that net income loss due to unemployment sometimes may not meet is the fortuitous nature of losses.

**Solution S5-24-3.** This question is based on the discussion in Nyce 2006, pp. 8.23-8.25.

The following answers are correct:
(b) Individuals may face liability loss exposures arising out of their behavior toward others.
(c) Some homeowners' insurers refuse to sell policies to individuals who own a certain kind of pet.
(d) Premises liability for individuals meets all six characteristics of an ideally insurable loss exposure.
(e) Automobile liability for individuals meets all six characteristics of an ideally insurable loss exposure.
(g) One characteristic of ideally insurable loss exposures that net income loss due to unemployment sometimes may not meet is the fortuitous nature of losses.

Choice (a) is incorrect; individuals may face liability loss exposures arising out of both their real property and their personal property.

Choice (f) is incorrect; net income loss due to unemployment is definite and measurable in virtually all cases, as the time of loss of employment, duration of employment, and salary/wages that the individual has lost due to unemployment are fairly easy to ascertain.

**Problem S5-24-4.** Explain how life, health, and retirement personal loss exposures might not be fortuitous. (If necessary, refer to Nyce 2006, pp. 8.25-8.26).

**Solution S5-24-4.**

From the standpoint of the individual, life loss exposures might not be fortuitous in cases where individuals commit suicide, over which they have control. Health loss exposures may not be fortuitous in cases where individuals either deliberately damage their health (moral hazard) or expose themselves to greater risk through negligent, indifferent, or careless behavior (morale
hazard) in order to collect insurance benefits. Retirement loss exposures are typically fortuitous from the standpoint of the individual, as most people can choose whether and when they will retire, as well as how much they will save for retirement.

**Problem S5-24-5.** Which of the following statements about life, health, and retirement loss exposures are true? More than one answer may be correct.

(a) Of the three loss exposures, life loss exposures are least likely to be definite and measurable.  
(b) Health insurance is typically not subject to the problem of adverse selection.  
(c) Life is generally not considered a loss exposure, except in cases of loss of life to premature death.  
(d) Losses due to retirement will necessarily be faced by all individuals who retire.  
(e) One way to reduce one's health loss exposure is to refrain from unhealthy practices, such as smoking and excessive eating.  
(f) Life loss exposures satisfy all six of the ideally insurable loss exposure characteristics only for a small minority of individuals.

**Solution S5-24-5.** This question is based on the discussion in Nyce 2006, pp. 8.26-8.27. The following answers are correct:

(c) Life is generally not considered a loss exposure, except in cases of loss of life to premature death.

(e) One way to reduce one's health loss exposure is to refrain from unhealthy practices, such as smoking and excessive eating.

Choice (a) is incorrect; of the three loss exposures, health loss exposures are least likely to be definite and measurable. It is sometimes difficult to determine when a health problem began and what the extent of its adverse impact on an individual's financial condition was and will be.

Choice (b) is incorrect; health insurance is subject to considerable adverse selection, as less healthy individuals will tend to pursue health insurance to a greater extent than healthier individuals.

Choice (d) is incorrect; if an individual has substantial savings or benefits from retirement plans, there may be no financial hardship due to retirement, in which case the individual will not face losses.

Choice (f) is incorrect; life loss exposures satisfy all six of the ideally insurable loss exposure characteristics for the majority of individuals - i.e., those who do not wish to commit suicide, do not work in especially hazardous occupations, and do not have life-threatening health conditions.
Section 25

Basic Legal Concepts Relevant to Insurance

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Problem S5-25-1. What is the difference between the civil-law system and civil law?

Solution S5-25-1. The civil-law system is defined in Nyce 2006, p. 9.3, as "a basic legal system that relies on scholarly interpretations of codes and constitutions rather than court interpretations of prior court decisions, as in common-law systems." Civil law can exist both under a civil-law system and a common-law system. It is defined in Nyce 2006, p. 9.4, as "a classification of law that applies to legal matters not governed by criminal law and that protects rights and provides remedies for breaches of duties owed to others." A civil-law system pertains to how laws are arrived at and interpreted, whereas civil law is law that applies to a certain set of matters.

Problem S5-25-2. Which of the following statements about the legal environment of insurance are true? More than one answer may be correct.

(a) The doctrine of *stare decisis* applies to civil-law systems.
(b) Some states in the U.S., such as Louisiana and California, have primarily civil-law systems.
(c) Under a common-law system, a court cannot decide a case for which there is no applicable precedent.
(d) The common-law system tends to increase the uncertainty of the law for ordinary citizens, as it is difficult for ordinary citizens to learn and understand all of the many precedents that might apply to a given situation.
(e) Common-law systems allow for evolution in law and the reversal of prior precedents.
(f) In cases pertaining to criminal law, the victims of criminal acts are responsible for bringing suit against and prosecuting the perpetrators.
(g) A misdemeanor is a crime.
(h) Summary offenses are crimes that typically result in large monetary fines and imprisonment.
(i) Most remedies under civil law consist of monetary damages for harm.

Solution S5-25-2. This question is based on the discussion in Nyce 2006, pp. 9.3-9.5. The following answers are correct:

(b) Some states in the U.S., such as Louisiana and California, have primarily civil-law systems.
(e) Common-law systems allow for evolution in law and the reversal of prior precedents.
(g) A misdemeanor is a crime.
(i) Most remedies under civil law consist of monetary damages for harm.

Choice (a) is incorrect; the doctrine of [*stare decisis*](https://en.wikipedia.org/wiki/Stare_deISIS), where courts follow earlier decisions in similar cases, applies to common-law systems.

Choice (c) is incorrect; under a common-law system, cases for where there are no applicable precedents are called "threshold cases," for which the judges examine all applicable law in order to answer new legal questions.

Choice (d) is incorrect; the common-law system tends to add certainty to the law by establishing a general consistency in court decisions. Courts typically need to furnish strong justifications for departing from precedent.

Choice (f) is incorrect; in cases pertaining to criminal law, the government, not the victims, must bring charges against the alleged perpetrators.

Choice (h) is incorrect; summary offenses are the most minor crimes. They are neither felonies nor misdemeanors, and they typically result in monetary fines and no imprisonment.

Problem S5-25-3. Which of the following statements about the legal environment of insurance are true? More than one answer may be correct.

(a) An act can either be a crime or a civil wrong; it cannot be both. Prohibitions on double jeopardy prevent an individual from enduring separate trials for the same action.
(b) A tort is a wrongful act or omission which is not a crime or a breach of contract.
(c) A tortfeasor is somebody who brings forth a lawsuit as a result of a tort.
(d) The same action can be both a tort and a breach of contract.
(e) Negligence is the most prevalent basis of property-casualty insurance claims.
(f) Typically, courts have found individuals guilty of negligence irrespective of the precautions they took to avoid damage.
(g) Negligence does not require actual damage to the plaintiff.
Solution S5-25-3. The following answers are correct:
(b) A tort is a wrongful act or omission which is not a crime or a breach of contract.
(d) The same action can be both a tort and a breach of contract.
(e) Negligence is the most prevalent basis of property-casualty insurance claims.

Note that although a tort itself is not a breach of contract, the same action may involve wrongful conduct both within and outside the scope of a contract.

Choice (a) is incorrect; it is possible for a single act be both a civil and criminal wrong, in which case separate civil and criminal trials may occur.

Choice (c) is incorrect; a tortfeasor is someone who commits a tort, not someone who sues as a result of a tort.

Choice (f) is incorrect; typically, courts have adopted the reasonably prudent person test to evaluate a defendant's behavior. If damage occurred despite reasonable precautions on the part of the defendant, then negligence may not be found.

Choice (g) is incorrect; one of the four essential elements of negligence is that the plaintiff must have suffered actual injury or damage.

Problem S5-25-4. Nyce 2006, p. 9.7, lists the four essential elements of negligence:
1. The defendant owed a legal duty of care to the plaintiff.
2. The defendant breached the duty of care owed to the plaintiff.
3. The defendant's breach of duty was the proximate cause of the plaintiff's injury or damage.
4. The plaintiff suffered actual injury or damage.

Each of the following allegations of negligence is likely to be thrown out of court because one or more of these four elements is missing. Identify the missing element(s) in each case.

(a) Mr. Λ alleges that Ms. Φ was negligent because she failed to give Mr. Λ a chocolate cake on his birthday.

(b) Mr. Π's car rammed into and completely destroyed the fence of Mr. Ψ, which Mr. Ψ wanted to get rid of for a long time. Mr. Ψ had hired a contractor to demolish the fence, and the contractor was scheduled to do so two days after the accident. Mr. Ψ informs the contractor that its services are no longer necessary and then files a negligence lawsuit against Mr. Π.

(c) In a zone where pedestrians always have the right of way, Mr. Ŷ always stopped for pedestrians while driving his car, and no pedestrians got hurt. However, Ms. Γ, a pedestrian, sues Mr. Ŷ for negligence.

(d) Mr. Q suffered a leg injury while walking outside. He tripped on a rock and fell. However, he sues Mr. İ for negligence because of a heated dispute he and Mr. İ had the previous day over Mr. İ's breach of duty of care to Mr. Q. Mr. Q claims that the dispute led him to be distracted, so that that he did not notice the rock.

(e) Mr. Σ manufactures stomping robots that are often taken out to an exhibition at the center of the city. To make sure that no people are hurt by the robots, Mr. Σ has hired guards to accompany the robots all the time and to keep away people who come too close. He has also
installed a security system in the robots which leads them to move away when a human who is not a guard gets too close. However, an extremely eager fan of the robots approaches one of them during an exhibition, pushes the guards aside, and turns off the robot's security switch - after which the robot stomps on him. The fan sues Mr. Σ for negligence.

Solution S5-25-4.

For (a), there was no legal duty of care owed to the plaintiff, as Ms. Φ was not obligated to give anyone a chocolate cake. Accordingly, there was no breach of care.

For (b), there was no actual damage to the plaintiff, who wanted the fence destroyed anyway. In fact, the plaintiff, Mr. Ψ, experienced monetary savings as a result of Mr. Π's action, since Mr. Ψ no longer had to hire the contractor.

For (c), there was no breach of duty of care by Mr. Υ, nor was there any actual damage.

For (d), any breach of duty of care that Mr. Υ might have exhibited was not the proximate cause of Mr. Q's tripping over a rock, since Mr. Q could have chosen not to walk that day or could have taken a different route.

For (e), Mr. Σ exercised reasonable care in preventing damage due to the robots, and the plaintiff flouted the extensive precautions Mr. Σ had taken. Thus, there was no breach of duty of care to the plaintiff.

Problem S5-25-5. Ms. Ξ has been actively and knowingly spreading false information about several of her former coworkers in order to prevent them from getting hired by other employers. This results in persistent unemployment for the former coworkers, who sue Ms. Ξ. Can Ms. Ξ be found guilty of negligence in this case? Why or why not?

Solution S5-25-5. Ms. Ξ cannot be found guilty of negligence in this case, because she committed an intentional tort; negligence typically involves the absence of an intention to do harm, which was clearly present in this case. Here, Ms. Ξ actively and deliberately inflicted harm on her former coworkers.

See the discussion of intentional torts in Nyce 2006, p. 9.8. This intentional tort would probably fall under the category of defamation.
Section 26

Intentional Torts, Strict Liability, and Remedies for Torts

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**Problem S5-26-1.** Which of the following statements about intentional torts and strict liability are true? More than one answer may be correct.

(a) One example of an ultrahazardous activity is keeping domesticated animals known to be unusually dangerous.
(b) Most insurance policies exclude coverage for intentional torts.
(c) Engaging in ultrahazardous activities that result in injury to others will not result in liability to others, provided that the entity engaging in the activities can show that it exercised due care in preventing injury.
(d) Battery is considered a physical tort.
(e) Defamation (e.g., libel and slander) is considered a physical tort.
(f) False arrest is considered a physical tort.
(g) Selling dangerously defective products can result in strict liability.

**Solution S5-26-1.** This question is based on the discussion in Nyce 2006, pp. 9.8-9.9. The following answers are correct:

(a) One example of an ultrahazardous activity is keeping domesticated animals known to be unusually dangerous.
(b) Most insurance policies exclude coverage for intentional torts.
(d) Battery is considered a physical tort.
(f) False arrest is considered a physical tort.
(g) Selling dangerously defective products can result in strict liability.

Choice (c) is not correct, because engaging in ultrahazardous activities can result in strict liability, where the damage itself is sufficient to cause liability - irrespective of the care taken by the party performing the action.

Choice (e) is not correct, because defamation is considered a nonphysical tort. Defaming someone does not involve the infliction of physical harm.

**Problem S5-26-2.** Which of the following statements about remedies for torts are true? More than one answer may be correct.

(a) General damages are subdivided into the categories of compensatory damages and punitive damages.
(b) Compensatory damages are subdivided into the categories of general damages and special damages.
(c) Punitive damages are a subset of compensatory damages.
(d) Punitive damages are not required to have a relationship to the actual harm suffered by an injured party.
(e) Pain and suffering damages are an example of general damages.
(f) Mental anguish damages are an example of special damages.
(g) Medical expenses incurred by the plaintiff are an example of special damages.

**Solution S5-26-2.** This question is based on the discussion in Nyce 2006, pp. 9.10.

The following answers are correct:

(b) Compensatory damages are subdivided into the categories of general damages and special damages.

(d) Punitive damages are not required to have a relationship to the actual harm suffered by an injured party.

(e) Pain and suffering damages are an example of general damages.

(g) Medical expenses incurred by the plaintiff are an example of special damages.

Choice (a) is not correct, because general damages are a subset of compensatory damages, and punitive damages are apart from compensatory damages.

Choice (c) is not correct, because punitive damages are imposed apart from compensatory damages to punish a defendant for conduct that is malicious, reckless, or deceitful.

Choice (f) is not correct, because mental anguish damages are an example of general damages.

**Problem S5-26-3.** Mr. Θ is the plaintiff in a lawsuit against Mr. Ψ, who has been accused of dumping ravenous piranhas into a stream which passes through Mr. Θ's property. The two neighbors are on good terms, and it is clear that Mr. Ψ did not intend to cause harm; he simply
wanted to get rid of the piranhas. In order to maintain good terms with Mr. Ψ, Mr. Θ does not want to make Mr. Ψ pay anything in monetary damages. What other resolution to this lawsuit might be acceptable to Mr. Θ? (See Nyce 2006, p. 9.11 for a discussion of a possibility.)

**Solution S5-26-3.** Mr. Θ could ask the court to order an injunction against Mr. Ψ to prevent Mr. Ψ from dumping piranhas into any body of water that passes through Mr. Θ's property. An injunction, according to Nyce 2006, p. 9.11, is "a court-ordered equitable remedy requiring a party to act or to refrain from acting." In this case, Mr. Θ will probably be satisfied with just the injunction and no other remedies for Mr. Ψ's tort.

**Problem S5-26-4.** Which of the following statements about remedies for torts are true? More than one answer may be correct.

(a) In some cases, states' tort reform statutes may limit the amount of special damages a plaintiff can receive.
(b) In some cases, states' tort reform statutes may limit the amount of general damages a plaintiff can receive.
(c) Punitive damages are most often awarded in ordinary negligence lawsuits.
(d) Recently, the frequency and severity of punitive damages have considerably increased.
(e) General damages are awarded to compensate victims for tangible losses that can have a clear, objective economic value associated with them.
(f) Loss of earnings from damaged property would constitute a kind of special damages.

**Solution S5-26-4.** The following answers are correct:

(b) In some cases, states' tort reform statutes may limit the amount of general damages a plaintiff can receive.

(d) Recently, the frequency and severity of punitive damages have considerably increased.

(f) Loss of earnings from damaged property would constitute a kind of special damages.

Choice (a) is not correct; tort reform statutes limit general damages, not special damages.

Choice (c) is not correct; punitive damages are most often awarded in cases in gross negligence, intentional interference, or particularly malicious conduct.

Choice (e) is not correct; general damages are awarded to compensate victims for intangible losses that do not have an easily ascertainable economic value.

**Problem S5-26-5.** A demolition company used dynamite to demolish a building. The resulting explosion, however, damaged Mr. II's nearby store so as to take it out of operation, resulting in considerable uncertainty regarding the II family's financial situation. The explosion also resulted in a loss of a limb to Mr. II's wife. Give three examples of special damages and three examples of general damages which the demolition company might be required to pay to the II family.
**Solution S5-26-5.** The following are three possible examples of special damages:
1. Medical expenses incurred by Mr. II's wife;
2. Damage to the property owed by Mr. II (i.e., the store);
3. Damages resulting from loss of earnings because Mr. II's store was damaged.

The following are three possible examples of general damages:
1. Damages for pain and suffering experienced by Mr. II's wife;
2. Damages to Mr. II for loss of consortium with his wife, as a result of her disability;
3. Damages for mental anguish due to the uncertainty of the II family's financial condition after the explosion.

(Categories of examples of general and special damages can be found in Nyce 2006, p. 9.10.)
Section 27

Distinguishing Characteristics of Insurance Policies

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Problem S5-27-1. Nyce 2006, p. 10.4, lists the following seven typical distinguishing characteristics of insurance policies:
1. Indemnity;
2. Utmost good faith;
3. Fortuitous losses;
4. Contract of adhesion;
5. Exchange of unequal amounts;
6. Conditional;
7. Nontransferable.

In each of the following seven situations, one of these conditions is absent. Identify the absent condition in each situation.

(a) Insurance Company Z offers a policy whereby the insured is entitled to full compensation for a loss, without any duties on the part of the insured that would need to be met before compensation is made.
(b) Vercingetorix, an insurance consumer, sells his automobile insurance policy to Bob.
(c) When filling out his insurance application, Montezuma Smith-Jones deliberately writes his name as "John Doe" and provides a false Social Security Number.
(d) Mr. Y pays insurance premiums every six months. If no loss occurs during these six months, he is refunded the full premium payment, with interest. If a loss does occur, the insurance
company will pay the loss amount, but Mr. Y must later pay back the loss amount, with interest, to the insurance company.

(e) Ms. Ī wants to purchase insurance against the possibility that she would commit suicide.

(f) An insurance company issues a policy that will always pay the insured $5000 for every loss, irrespective of the magnitude of the loss.

(g) Pi Insurance Company and its insured, Mr. Π, have finally concluded year-long negotiations to arrive at an insurance policy whose terms have been drafted and extensively revised by both parties.

**Solution S5-27-1.**

Situation (a) lacks the **conditional** aspect, since no duties are required of the insured in order for the insured to receive compensation.

Situation (b) lacks the **nontransferable** aspect, since an insured is selling his policy to another individual.

Situation (c) lacks the **utmost good faith** aspect, since Montezuma Smith-Jones is deliberately misrepresenting his information.

Situation (d) lacks the **exchange of unequal amounts** aspect. The parties appear not to be engaged in insurance, but rather swapping amounts of money which, when time value of money is taken into account, are equivalent.

Situation (e) lacks the **fortuitous loss** aspect, since Ms. Ī has control of whether she will commit suicide.

Situation (f) lacks the **indemnity** aspect, since most insureds will not suffer a loss of exactly $5000.

Situation (g) lacks the **contract of adhesion** aspect, since both parties contribute extensively to the drafting of the policy.

**Problem S5-27-2.** Which of the following statements about the principle of indemnity are true? More than one statement may be correct.

(a) All insurance policies strictly follow the principle of indemnity.

(b) Under a valued policy, the insurer agrees to pay a preset monetary amount for a total loss, irrespective of the market value of the insured item at the time of loss.

(c) The existence of a deductible is not consistent with the strict principle of indemnity.

(d) Where the principle of indemnity is concerned, it is permissible to disregard the insured's nonfinancial costs of loss - such as lost time and inconvenience.

(e) Multiple insurance sources of recovery are never justified, as they lead to insureds being indemnified multiple times for the same loss.

(f) The collateral source rule prohibits reducing damages to a victim who is also entitled to recover money from an insurance policy.
Solution S5-27-2. This question is based on the discussion in Nyce 2006, pp. 10.5-10.6. The following answers are correct:

(b) Under a valued policy, the insurer agrees to pay a preset monetary amount for a total loss, irrespective of the market value of the insured item at the time of loss.

(c) The existence of a deductible is not consistent with the strict principle of indemnity.

(f) The collateral source rule prohibits reducing damages to a victim who is also entitled to recover money from an insurance policy.

Choice (a) is not correct; some policies, such as valued policies, will often depart from the strict principle of indemnity and will simply pay a present amount. Likewise, policies with deductibles or limits will not compensate the insured for the full loss amount.

Choice (d) is not correct; some insurance policies do take into account such aspects of a loss as time and inconvenience lost - although many do not do so. Fully indemnifying the insured might mean compensating for some of these aspects of loss.

Choice (e) is not correct. Sometimes, as when the insured has paid an actuarially fair premium for overlapping coverage on two insurance policies, the insured might be entitled to recover twice for the same loss.

Problem S5-27-3. Give an example of how each of the following parties to an insurance contract might violate the principle of utmost good faith:

(a) An insured, if no loss occurred;

(b) An insured, if a loss occurred;

(c) An insurer, if a loss occurred.

Solution S5-27-3.

Numerous examples are possible. The following are all mentioned in Nyce 2006, p. 10.7.

(a) An insured could violate utmost good faith by filing a claim on an accident or loss that did not take place.

(b) An insured could violate utmost good faith by intentionally overstating the amount of damage resulting from an accident or loss and attempting to collect reimbursement for the inflated amount.

(c) An insurer could violate utmost good faith by failing to promptly investigate claims and/or pay legitimate claims.

Problem S5-27-4. Which of the following statements about fortuitous and non-fortuitous losses are true? More than one answer may be correct.

(a) All fortuitous losses can be covered by insurance policies.

(b) Some non-fortuitous losses are covered by certain insurance policies.

(c) If Mr. Φ might vandalize his car but does not know when he will do so, then the occurrence
would be a fortuitous loss.
(d) If Mr. Φ might accidentally slip and fall on a banana peel and injure himself, but does not know when he will do so, then the occurrence would be a fortuitous loss.
(e) If an anvil will fall out of the sky on Mr. Φ's house, and Mr. Φ knows exactly when this will happen, then the occurrence would be a fortuitous loss.
(f) "Claims-made" liability insurance policies often provide coverage for some non-fortuitous losses.

**Solution S5-27-4.** This question is based on the discussion in Nyce 2006, pp. 10.7-10.8. The following answers are correct:

(b) Some non-fortuitous losses are covered by certain insurance policies.
(d) If Mr. Φ might accidentally slip and fall on a banana peel and injure himself, but does not know when he will do so, then the occurrence would be a fortuitous loss.
(f) "Claims-made" liability insurance policies often provide coverage for some non-fortuitous losses.

Choice (a) is incorrect. Some fortuitous losses, such as inherent vice of an object (i.e. that object's tendency to perish on its own accord) or wear and tear, are typically not covered by insurance policies.

A fortuitous loss is a loss that an insured can neither intentionally inflict nor perfectly predict the timing of. Thus, (c) and (e) are not fortuitous losses. For (c), the vandalism would be an intentional act on the part of Mr. Φ, and for (e), Mr. Φ knows exactly when the loss will occur.

**Problem S5-27-5.** Which of the following statements about contracts of adhesion are true? More than one answer may be correct.

(a) Contracts of adhesion may contain ambiguities that are acceptable to both parties.
(b) With a contract of adhesion, the contract is always construed in favor of the party that drafted it.
(c) Most insurance policies involve little to no negotiation.
(d) An unsophisticated insured is more likely to have any policy ambiguity interpreted in its favor than a sophisticated insured.
(e) The size of the insured organization has no effect on whether that organization is considered a sophisticated insured. One educated private individual who has a typical personal lines insurance policy may be a more sophisticated insured than a corporation staffed by incompetents.
(f) Manuscript policies are not contracts of adhesion.
(g) The reasonable expectations doctrine might imply that a policyholder who has not been notified of changes in his renewal policy may reasonably assume that the renewal policy is offered on the same terms as the expiring policy.

**Solution S5-27-5.** This question is based on the discussion in Nyce 2006, pp. 10.9-10.10. The following answers are correct:
(a) Contracts of adhesion may contain ambiguities that are acceptable to both parties.
(c) Most insurance policies involve little to no negotiation.
(d) An unsophisticated insured is more likely to have any policy ambiguity interpreted in its favor than a sophisticated insured.
(f) Manuscript policies are not contracts of adhesion.
(g) The reasonable expectations doctrine might imply that a policyholder who has not been notified of changes in his renewal policy may reasonably assume that the renewal policy is offered on the same terms as the expiring policy.

Choice (b) is not correct. A contract of adhesion is construed against the party that drafted it.

Choice (e) is not correct. The size of an insured organization is one of the factors considered in determining whether it is a "sophisticated insured." Although an educated individual policyholder may indeed know more about insurance than the decision-makers of some corporations, the former will rarely, if ever, be considered a sophisticated insured for the purposes of determining how a contract of adhesion, such as a typical personal lines insurance policy, will be construed.
Section 28

Exchange of Unequal Amounts, Conditionality, and Restrictions on Transfer in Insurance

This section of the study guide is intended to provide practice problems and solutions to accompany the pages of *Foundations of Risk Management and Insurance*, cited below. Students are encouraged to read these pages before attempting the problems. This study guide is entirely an independent effort by Mr. Stolyarov and is not affiliated with any organization(s) to whose textbooks it refers, nor does it represent such organization(s).

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**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-28-1.** In insurance policies, what is the consideration offered by each party (the insurer and the insured)? Give an example of a situation in which the insured provides greater consideration than the insurer. Then give an example of a situation in which the insurer provides greater consideration than the insured.

**Solution S5-28-1.** This question is based on the discussion in Nyce 2006, p. 10.11.

In insurance policies, the consideration offered by the insured is the payment of premium. The consideration offered by the insurer is the indemnification of the insured in the event of a covered loss.

An example of a situation in which the insured provides greater consideration than the insurer is one in which the insured keeps paying a premium to the insurer, but no covered loss ever occurs, so the insurer is never required to make a payment.

An example of a situation in which the insurer provides greater consideration than the insured is one in which the insured pays a small premium (say, $100) for coverage and then shortly thereafter suffers a total loss of the covered property (say, a loss of $100,000), and the insurer indemnifies the insured for the entire loss.
Problem S5-28-2. Nyce 2006, p. 10.12, discusses three ways in which insurers can achieve an equitable distribution of risks costs. What are these ways, and how does each of them fulfill the goal of equitable distribution of risk costs?

Solution S5-28-2.

1. **Rating plans**: Rating plans are developed by actuaries to estimate expected loss costs and expenses for an insurance policy and to establish a premium that reflects these factors.

2. **Coinsurance**: In property insurance policies, coinsurance is a penalty for an insured who does not insure property to its full value or some proportion thereof. Coinsurance incentivizes the insured to have coverage for the entire loss exposure in question.

3. **Subrogation**: Subrogation is the insurer's recovery of payments for losses from third parties who caused those losses. Subrogation reduces the insurer's costs and facilitates payment for losses to be made by the parties responsible for those losses.

Problem S5-28-3. Insurance is often described as a conditional contract, in the sense that the insured must fulfill certain duties, such as allowing inspection of damaged property, before the insurer pays a claim. Is this always necessarily the case? If you answer affirmatively, explain why; if you answer negatively, give a counterexample.

Solution S5-28-3. This question is based on the discussion in Nyce 2006, p. 10.13.

It is not always necessarily the case that the insured has any duties to fulfill, in practice, before a claim is paid - especially when the insurer decides to waive those duties. For instance, an insurer can waive its right to inspect damaged property and simply pay the claim amount. This frequently takes place.

Problem S5-28-4. What parties typically may and what parties typically may not transfer an insurance policy to another party? Give three examples of situations in which insurance policies might be transferred.

Solution S5-28-4. This question is based on the discussion in Nyce 2006, p. 10.13.

Insurers are typically able to transfer insurance policies to other insurers, but insureds typically may not transfer insurance policies to other insureds. Three examples of situations in which insurance policies might be transferred are as follows:

1. An insurer is acquired by another insurer, and the acquired insurer transfers its book of business to the acquiring insurer.

2. An insurer sells its book of business to another insurer upon deciding to no longer do business in a particular area.
3. An insurer becomes insolvent, and the state insurance department transfers that insurer's book of business to other, more viable, insurers.

**Problem S5-28-5.** According to Nyce 2006, p. 10.14, what exception commonly exists for the rule that insurance policies are nontransferable by the insured?

**Solution S5-28-5.** For maritime insurance policies, an exception to the policy's nontransferable clause exists if ownership is transferred during a ship's voyage. It is common for seagoing vessels to change ownership while at sea. When this happens, the loss exposure does not fundamentally change until the ship reaches port. Thereafter, the new owner has to either achieve the insurer's consent for the transfer of the policy or apply for new insurance.
Section 29


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Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-29-1. Which of the following items of information are typically found in the Declarations section of an insurance policy? More than one answer may be correct.

(a) The name of the insured  
(b) The steps the insured needs to take to enforce the policy  
(c) The circumstances under which the insurer agrees to pay  
(d) The policy number  
(e) The name of the insurance agent  
(f) The definitions of terms in the policy  
(g) The address of the covered property  
(h) The dollar limits applicable to the policy  
(i) The premium amount  
(j) A list of excluded persons, places, things, or actions

Solution S5-29-1. This question is based on the discussion in Nyce 2006, pp. 11.13-11.14. The following choices are correct:  
(a) The name of the insured  
(d) The policy number  
(e) The name of the insurance agent  
(g) The address of the covered property  
(h) The dollar limits applicable to the policy  
(i) The premium amount
Choice (b) is not correct; this information is typically found in the Conditions section.
Choice (c) is not correct; this information is typically found in the Insuring Agreements section.
Choice (f) is not correct; this information is typically found in the Definitions section.
Choice (j) is not correct; this information is typically found in the Exclusions section.

**Problem S5-29-2.** Which of the following statements about the Definitions and the Insuring Agreements sections of insurance policies are true? More than one answer may be correct.

(a) The definitions typically appear toward the beginning of a personal lines policy.
(b) The definitions typically appear toward the beginning of a commercial lines policy.
(c) The definitions section is used to resolve ambiguities surrounding definitions of terms that had been used in previous policies.
(d) When a term in an insurance policy is undefined in the policy and has an everyday meaning, it is typically interpreted according to any technical meaning it may have - even though the technical meaning may diverge from the everyday meaning.
(e) Insurance policies are always based on the formal definitions of terms, and, therefore, more nebulous meanings, such as local and cultural connotations, are never considered.
(f) For every type of coverage they provide, insurance policies typically have a separate insuring agreement.
(g) The term "insuring agreement" is only used to refer to the section of the policy that introduces the coverage - not to any supplementary payments, coverage extensions, or additional coverages.
(h) Unlabeled statements within the Declarations, Exclusions, Definitions, or Conditions sections of an insurance policy can sometimes serve as insuring agreements.

**Solution S5-29-2.** This question is based on the discussion in Nyce 2006, pp. 11.14-11.19. The following choices are correct:

(a) The definitions typically appear toward the beginning of a personal lines policy.
(c) The definitions section is used to resolve ambiguities surrounding definitions of terms that had been used in previous policies.
(f) For every type of coverage they provide, insurance policies typically have a separate insuring agreement.
(h) Unlabeled statements within the Declarations, Exclusions, Definitions, or Conditions sections of an insurance policy can sometimes serve as insuring agreements.

Choice (b) is incorrect; the definitions typically appear toward the end of a commercial lines policy.
Choice (d) is incorrect; when a term in an insurance policy is undefined in the policy and has an everyday meaning, the everyday meaning is what is used in policy interpretation.
Choice (e) is incorrect; local, cultural, and trade-usage meanings of words are considered in interpreting many insurance policies.
Choice (g) is incorrect; supplementary payments, coverage extensions, or additional coverages can also be considered parts of the insuring agreements.
**Problem S5-29-3.** Which of the following statements about insuring agreements are true? More than one answer may be correct.

(a) Special-form coverage is a kind of named perils coverage.
(b) Basic-form coverage is a kind of named perils coverage.
(c) Broad-form coverage is a kind of named perils coverage.
(d) All-risks coverage requires a peril to be specifically mentioned in the policy in order for that peril to be covered.
(e) Broad-form coverage typically covers more causes of loss than basic-form coverage.
(f) Only all-risks coverage requires exclusions; named perils coverage does not have associated exclusions, because only the listed perils are covered.
(g) An exception within a definition can have the effect of restoring coverage that would otherwise be excluded.
(h) An "additional coverages" section can extend coverage to types of losses that would not otherwise be covered.

**Solution S5-29-3.** This question is based on the discussion in Nyce 2006, pp. 11.20-11.22. The following answers are correct:

(b) Basic-form coverage is a kind of named perils coverage.
(c) Broad-form coverage is a kind of named perils coverage.
(e) Broad-form coverage typically covers more causes of loss than basic-form coverage.
(g) An exception within a definition can have the effect of restoring coverage that would otherwise be excluded.
(h) An "additional coverages" section can extend coverage to types of losses that would not otherwise be covered.

Choice (a) is incorrect; special-form coverage is a kind of all-risks coverage.
Choice (d) is incorrect; all-risks coverage covers all perils that are not specifically excluded.
Choice (f) is incorrect; policies offering named perils coverage often also have exclusions, which can serve to eliminate ambiguity about what aspects of the named perils are or are not covered.

**Problem S5-29-4.** What section of an insurance policy discusses the behaviors (or lack of certain behaviors) that an insured must exhibit in order to receive payment for a covered loss? Give three examples of such behaviors or lack of behaviors.

**Solution S5-29-4.** This question is based on the discussion in Nyce 2006, p. 11.23.

The Conditions section of an insurance policy discusses the behaviors (or lack of certain behaviors) that an insured must exhibit in order to receive payment for a covered loss. Examples of such required behaviors/lack of behaviors can be any of the following:
1. Payment of premiums;
2. Prompt reporting of losses;
3. Cooperation with the insurer in legal proceedings;
4. Providing appropriate documentation for losses;
5. Refraining from interference with the insurer's right of subrogation.
**Problem S5-29-5.** Nyce 2006, p. 11.24, discusses the following six purposes of exclusions in insurance policies:
1. Eliminate coverage for uninsurable loss exposures;
2. Assist in managing moral and morale hazards;
3. Reduce likelihood of coverage duplications;
4. Eliminate coverages not needed by the typical insured;
5. Eliminate coverages requiring special treatment;
6. Assist in keeping premiums reasonable.

Each of the following exclusions can be primarily identified with one of the above purposes. Match the exclusion with the purpose it serves.

(a) A certain homeowners' insurance policy excludes coverage for the insured's intentional acts of damage to his own home.
(b) A certain personal automobile insurance policy excludes coverage on special decals and custom paint jobs.
(c) A certain insurance policy excludes coverage for losses due to war.
(d) A certain homeowners' insurance policy excludes coverage for damage to the insured's automobile.
(e) A certain homeowners' insurance policy excludes coverage for flood damage on a beachfront home. The coverage could be provided, but the likelihood of flood in the area during the next 10 years is virtually certain.
(f) A certain personal property insurance policy excludes coverage for property exhibited at a trade fair or convention.

**Solution S5-29-5.** Exclusion (a) serves primarily to **assist in managing moral and morale hazards**, as it reduces the insured's incentive to intentionally damage his home.

Exclusion (b) serves primarily to **eliminate coverages not needed by the typical insured**, since most insureds do not have special decals or custom paint jobs on their cars.

Exclusion (c) serves primarily to **eliminate coverage for uninsurable loss exposures**, since war losses typically cannot be insured.

Exclusion (d) serves primarily to **reduce likelihood of coverage duplications**, since the insured can obtain coverage for his automobile via an automobile insurance policy.

Exclusion (e) serves primarily to **assist in keeping premiums reasonable**, since the premium for coverage of a loss that is virtually certain to occur would be quite high.

Exclusion (f) serves primarily to **eliminate coverages requiring special treatment**, since property exhibited at a trade fair or convention is exposed to a variety of perils that are atypical for personal property and so would require different underwriting, loss control, and risk evaluation methods that the insurer may not be willing to undertake, except for additional premium.
Section 30

Aggregation of Written, Earned, and In-Force Exposures for Insurance Policies of Unequal Terms and the "15th of the Month" Rule

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Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-30-1. There are 7 policies of insurance, with the following terms and dates of issuance:

Policy A has a term of 3 years and was issued on October 1, 3046.
Policy B has a term of 5 months and was issued on October 1, 3046.
Policy C has a term of 1 year and was issued on January 1, 3047.
Policy D has a term of 9 months and was issued on April 1, 3047.
Policy E has a term of 9 months and was issued on July 1, 3047.
Policy F has a term of 1 year and was issued on July 1, 3047.
Policy G has a term of 1 year and was issued on August 1, 3047.

Each policy has the same exposure base at risk per unit of time, and one year is associated with one exposure unit on each policy.

For each policy, determine the number of written exposure units, as of December 31, 3049, associated with calendar years 3046, 3047, 3048, and 3049.
Solution S5-30-1. Written exposures are always assigned to the year in which the policy is issued (written) - irrespective of whether the policy term is entirely within that year. Thus, the policies that were written in 3046 will have all of their written exposure units in 3046 - and policies that were written in 3047 will have all of their written exposure units in 3047. Since 1 year of each policy corresponds to one exposure unit, n months of each policy corresponds to n/12 exposure units. No policies above were written in 3048 or 3049, so no written exposure units apply to those years. Therefore, the following are the answers:

Policy A has 36/12 exposure units = 3 written exposure units in 3046 for Policy A.
Policy B has 5/12 exposure units = 0.416666667 written exposure units in 3046 for Policy B.
Policy C has 12/12 exposure units = 1 written exposure unit in 3047 for Policy C.
Policy D has 9/12 exposure units = 0.75 written exposure units in 3047 for Policy D.
Policy E has 9/12 exposure units = 0.75 written exposure units in 3047 for Policy E.
Policy F has 12/12 exposure units = 1 written exposure unit in 3047 for Policy F.
Policy G has 12/12 exposure units = 1 written exposure unit in 3047 for Policy G.

Problem S5-30-2. There are 7 policies of insurance, with the following terms and dates of issuance:

Policy A has a term of 3 years and was issued on October 1, 3046.
Policy B has a term of 5 months and was issued on October 1, 3046.
Policy C has a term of 1 year and was issued on January 1, 3047.
Policy D has a term of 9 months and was issued on April 1, 3047.
Policy E has a term of 9 months and was issued on July 1, 3047.
Policy F has a term of 1 year and was issued on July 1, 3047.
Policy G has a term of 1 year and was issued on August 1, 3047.

Each policy has the same exposure base at risk per unit of time, and one year is associated with one exposure unit on each policy.

For each policy, determine the number of earned exposure units, as of December 31, 3049, associated with calendar years 3046, 3047, 3048, and 3049.

Solution S5-30-2.

In this situation, earned exposure units for a policy in a year are calculated by taking the number of months the policy will be in effect during that year and dividing that number by 12.

Policy A will expire on October 1, 3049. It thus lasts through the entirety of 3047 and 3048 and has one exposure unit in each of these years. It lasts for 3 months of 3046 and 9 months of 3049. Therefore, Policy A has 0.25 earned exposure units in 3046, 1 earned exposure unit in 3047, 1 earned exposure unit in 3048, and 0.75 earned exposure units in 3049.

Policy B will expire on March 1, 3047. It therefore lasts for 3 months of 3046 and 2 months of 3047. Therefore, Policy B has 0.25 earned exposure units in 3046 and 0.166666667 earned exposure units in 3047.
Policy C will expire on January 1, 3048. The entirety of its one-year term is in 3047, so **Policy C has 1 earned exposure unit in 3047.**

Policy D will expire on January 1, 3048. The entirety of its 9-month term is in 3047, so **Policy D has 0.75 earned exposure units in 3047.**

Policy E will expire on April 1, 3048. 6 months of its term are in 3047, and 3 months are in 3048. Thus, **Policy E has 0.50 earned exposure units in 3047 and 0.25 earned exposure units in 3048.**

Policy F will expire on July 1, 3048. 6 months of its term are in 3047, and 6 months are in 3048. Thus, **Policy F has 0.50 earned exposure units in 3047 and 0.50 earned exposure units in 3048.**

Policy G will expire on August 1, 3048. 5 months of its term are in 3047, and 7 months are in 3048. Thus, **Policy G has 0.416666666667 earned exposure units in 3047 and 0.58333333333 earned exposure units in 3048.**

**Problem S5-30-3.** There are 7 policies of insurance, with the following terms and dates of issuance:

- Policy A has a term of 3 years and was issued on October 1, 3046.
- Policy B has a term of 5 months and was issued on October 1, 3046.
- Policy C has a term of 1 year and was issued on January 1, 3047.
- Policy D has a term of 9 months and was issued on April 1, 3047.
- Policy E has a term of 9 months and was issued on July 1, 3047.
- Policy F has a term of 1 year and was issued on July 1, 3047.
- Policy G has a term of 1 year and was issued on August 1, 3047.

Each policy has the same exposure base at risk per unit of time, and one year is associated with one exposure unit on each policy.

Calculate the difference between the number of in-force exposures on July 1, 3047 and the number of in-force exposures on July 1, 3048.

**Solution S5-30-3.** On July 1, 3047, the following policies are in force: A, C, D, E, F.

B is not in force, because B expired on March 1, 3047. G is not in force, because G will only get written 1 month later on August 1, 3047.

On July 1, 3048, the following policies are in force: A, G.

C, D, E, and F have all expired on or before July 1, 3048, so they are no longer in force.

For each policy that is in force, the full-term number of exposures is equal to the in-force exposures.
The full-term number of exposures for each policy is the same as its number of written exposures. We can find this number for each policy in Solution S5-30-1.

For policies A, C, D, E, and F, the sum of full-term exposure units is $3 + 1 + 0.75 + 0.75 + 1 = 6.5$.

For policies A and G, the sum of full-term exposure units is $3 + 1 = 4$.

The desired difference is $6.5 - 4 = 2.5$.

**Problem S5-30-4.** There were 34 insurance policies written during the month of June 4450, 31 policies written during July 4450, and 90 policies written during August 4450. The "15th of the month" rule (described in Werner and Modlin, p. 59) is being used to estimate the issuance dates of each policy. Assume that each policy has a term of one year and the same exposure base at risk, so that each policy has one exposure unit per year. Also assume that no other insurance policies were issued. How many in-force exposures are there as of August 4, 4450?

**Solution S5-30-4.** The "15th of the month" rule assumes that a policy written in a given month was issued on the 15th day of that month. Thus, none of the August exposures contribute to the in-force exposures on August 4, since all of the August policies are assumed to be written on August 15. Hence, only the June and July exposures comprise the in-force exposures on August 4, and our answer is $34 + 31 = 65$ in-force exposure units.

**Problem S5-30-5.** There were 34 insurance policies written during the month of June 4450, 31 policies written during July 4450, and 90 policies written during August 4450. The "15th of the month" rule (described in Werner and Modlin, p. 59) is being used to estimate the issuance dates of each policy. Assume that each policy has a term of one year and the same exposure base at risk, so that each policy has one exposure unit per year. Also assume that no other insurance policies were issued. Furthermore, assume that, due to calendar reforms promulgated in the year 4356, each month has exactly 30 days. How many **earned** exposures are there as of October 1, 4450?

**Solution S5-30-5.** The "15th of the month" rule assumes that a policy written in a given month was issued on the 15th day of that month. During the latter half of that month, 1/24 of the exposure is earned. So the June policies each have $1/24$ earned exposures from June, $1/12$ from July, $1/12$ from August, and $1/12$ from September, for a total of $7/24$ earned exposures per policy. The July policies have $7/24 - 1/12 = 5/24$ earned exposures per policy. The August policies have $5/24 - 1/12 = 3/24$ earned exposures per policy.

Thus, the total number of earned exposures as of October 1, 4450, is

$$(7/24)*34 + (5/24)*31 + (3/24)*90 = 27.625$$ **earned exposures.**
Section 31

Adjustments to Historical Premium and Written Premium Aggregation for Calendar Years and Policy Years

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Source:

Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-31-1. Werner and Modlin (63) discuss three adjustments that are generally made to historical premium figures in order to estimate premium for a future policy period. What are these three adjustments, and why are they important?

Solution S5-31-1.

First adjustment: Bringing the historical premium to the rate level currently in effect.

Why it is important: Any rate changes during or after the historical period to which the premium data apply need to be reflected in the premium figures. Otherwise, the data will not be comparable to one another.

Second adjustment: Develop premium to ultimate levels if premium is still changing.

Why it is important: If current premium data are different from what ultimate premium data are likely to be, the ultimate premium data would be more relevant to premium in the future.

Third adjustment: Project the historical premium to the premium level expected in the future.
Why it is important: This adjustment "accounts for changes in the mix of business that have occurred or are expected to occur after the historical experience period" (Werner and Modlin, p. 63).

Problem S5-31-2. The adjustments discussed in Problem S5-31-1 are required for which general approach to evaluate rate adequacy? For which approach are they not required? (Werner and Modlin, p. 63)

Solution S5-31-2. The adjustments are required for the loss ratio approach, but not for the pure premium approach. Only the loss ratio approach requires an estimation of the premium that will be collected in the future.

Problem S5-31-3. You know the following information on insurance policies, each of which is one year in term length:

Policy T was issued on January 1, 3109, and the policyholder paid a premium of $671.
Policy U was issued on June 1, 3109, and the policyholder paid a premium of $123.
Policy V was issued on August 1, 3109, and the policyholder paid a premium of $870.
Policy W was issued on December 1, 3109, and the policyholder paid a premium of $1300.
Policy X was issued on February 1, 3110, and the policyholder paid a premium of $50.
Policy Y was issued on March 1, 3110, and the policyholder paid a premium of $500.
Policy Z was issued on September 1, 3110, and the policyholder paid a premium of $600.

Assume that each policy was in force until its expiration date.

Find the sum of written premium for the calendar year 3109 as of January 1, 3111.

Solution S5-31-3. Any policy written in 3109 would have all of its premium classified as written premium for 3109. Thus, the premium for policies T, U, V, and W constitutes written premium for the year 3109. This is our answer: $673 + 123 + 870 + 1300 = $2966.

Problem S5-31-4. You know the following information on insurance policies, each of which is one year in term length:

Policy T was issued on January 1, 3109, and the policyholder paid a premium of $671.
Policy U was issued on June 1, 3109, and the policyholder paid a premium of $123.
Policy V was issued on August 1, 3109, and the policyholder paid a premium of $870.
Policy W was issued on December 1, 3109, and the policyholder paid a premium of $1300.

Policy X was issued on February 1, 3110, and the policyholder paid a premium of $50.

Policy Y was issued on March 1, 3110, and the policyholder paid a premium of $500.

Policy Z was issued on September 1, 3110, and the policyholder paid a premium of $600.

Now assume that Policy U was cancelled on March 1, 3110 and that Policy W was cancelled on February 1, 3110. Also, policy Z was cancelled by the policyholder on October 1, 3110. Both policyholders received a full (pro rata) refund of unearned premium.

Find the sum of written premium for the calendar year 3110 as of January 1, 3111.

Solution S5-31-4. The written premium for the calendar year 3110 is the sum of the premiums paid for policies issued in 3110 minus the sum of the unearned premiums for the policies that were cancelled in 3110 (irrespective of when these policies were written) - as these unearned premiums were refunded to the policyholders.

The sum of the premiums paid for policies issued in 3110 is the sum of the premiums for policies X, Y, and Z: 50 + 500 + 600 = $1150.

Policy U was cancelled after 7 months, which means that 5 months of premium - i.e., 123*(5/12) = $51.25 - were unearned.

Policy W was cancelled after 2 months, which means that 10 months of premium - i.e., 1300*(10/12) = $1083.33 - were unearned.

Policy Z was cancelled after 1 month, which means that 11 months of premium - i.e., 600*(11/12) = $550 - were unearned.

Thus, the sum of written premium for the year 3110 is 1150 - 51.25 - 1083.33 - 550 = -$534.58.

Problem S5-31-5. You know the following information on insurance policies, each of which is one year in term length:

Policy T was issued on January 1, 3109, and the policyholder paid a premium of $671.

Policy U was issued on June 1, 3109, and the policyholder paid a premium of $123.

Policy V was issued on August 1, 3109, and the policyholder paid a premium of $870.

Policy W was issued on December 1, 3109, and the policyholder paid a premium of $1300.

Policy X was issued on February 1, 3110, and the policyholder paid a premium of $50.
Policy Y was issued on March 1, 3110, and the policyholder paid a premium of $500.

Policy Z was issued on September 1, 3110, and the policyholder paid a premium of $600.

Now assume that Policy U was cancelled on March 1, 3110 and that Policy W was cancelled on February 1, 3110. Also, policy Z was cancelled by the policyholder on October 1, 3110. Both policyholders received a full (pro rata) refund of unearned premium.

Find the sum of written premium for the policy year 3110 as of January 1, 3111.

**Solution S5-31-5.** The written premium for the calendar year 3110 is the sum of the premiums paid for policies issued in 3110 minus the sum of the unearned premiums for the policies that were both issued and cancelled in 3110 - as these unearned premiums were refunded to the policyholders.

**Important note:** For policy year aggregation of written premium, any policies written in years other than 3110 and cancelled in 3110 would not affect written premium in 3110, since policy year aggregation applies any premium adjustments during the term of a policy to the year in which the policy was written.

The sum of the premiums paid for policies issued in 3110 is the sum of the premiums for policies X, Y, and Z: 50 + 500 + 600 = $1150.

Of the policies issued in 3110, only Z was cancelled in 3110. Policy Z was cancelled after 1 month, which means that 11 months of premium - i.e., 600*(11/12) = $550 - were unearned.

Thus, the sum of written premium for the policy year 3110 is 1150 - 550 = **$600**.
Section 32

Aggregation of Earned Premium and In-Force Premium by Calendar Year and Policy Year

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Some of the questions here ask for short written answers based on the reading. This is meant to give the student practice in answering questions of the format that will appear on Exam 5. Students are encouraged to type their own answers first and then to compare these answers with the solutions given here. Please note that the solutions provided here are not necessarily the only possible ones.


**Original Problems and Solutions from The Actuary’s Free Study Guide**

**Problem S5-32-1.** You know the following information on insurance policies, each of which is one year in term length:

Policy T was issued on January 1, 3109, and the policyholder paid a premium of $671.

Policy U was issued on June 1, 3109, and the policyholder paid a premium of $123.

Policy V was issued on August 1, 3109, and the policyholder paid a premium of $870.

Policy W was issued on December 1, 3109, and the policyholder paid a premium of $1300.

Policy X was issued on February 1, 3110, and the policyholder paid a premium of $50.

Policy Y was issued on March 1, 3110, and the policyholder paid a premium of $500.

Policy Z was issued on September 1, 3110, and the policyholder paid a premium of $600.

Assume that each policy was in force until its expiration date.
Find the sum of *earned premium* for the *calendar* year 3109 as of January 1, 3111.

**Solution S5-32-1.** For a one-year policy, the premium earned in a calendar year is the total premium multiplied by the fraction of the year the policy was in effect.

Policy T was only in effect during 3109, so all of its premium ($671) is calendar-year earned premium for 3109.

Policy U was only in effect for 7 months of 3109, so its calendar-year earned premium for 3109 is \((7/12) \times 123 = $71.75\).

Policy V was only in effect for 5 months of 3109, so its calendar-year earned premium for 3109 is \((5/12) \times 870 = $362.50\).

Policy W was only in effect for 1 month of 3109, so its calendar-year earned premium for 3109 is \((1/12) \times 1300 = $108.33\).

The sum of earned premium for calendar year 3109 is thus \(671 + 71.75 + 362.50 + 108.33 = $1213.58\).

**Problem S5-32-2.** You know the following information on insurance policies, each of which is one year in term length:

Policy T was issued on January 1, 3109, and the policyholder paid a premium of $671.

Policy U was issued on June 1, 3109, and the policyholder paid a premium of $123.

Policy V was issued on August 1, 3109, and the policyholder paid a premium of $870.

Policy W was issued on December 1, 3109, and the policyholder paid a premium of $1300.

Policy X was issued on February 1, 3110, and the policyholder paid a premium of $50.

Policy Y was issued on March 1, 3110, and the policyholder paid a premium of $500.

Policy Z was issued on September 1, 3110, and the policyholder paid a premium of $600.

Assume that each policy was in force until its expiration date.

Find the sum of *earned premium* for the *policy* year 3109 as of January 1, 3111.

**Solution S5-32-2.** When the policy year method of aggregating premium is used and the terms of all policies written in a given year have expired, the premium for a policy is designated as earned premium for the year in which the policy was written - and any cancellations or premium refunds that occur also get assigned to the year in which the policy was written.
As of January 1, 3111, any policy written in 3109 would have all of its premium classified as earned premium for 3109. Thus, the premium for policies T, U, V, and W constitutes earned premium for the year 3109. This is our answer: $673 + 123 + 870 + 1300 = $2966.

**Problem S5-32-3.** You know the following information on insurance policies, each of which is one year in term length:

Policy T was issued on January 1, 3109, and the policyholder paid a premium of $671.

Policy U was issued on June 1, 3109, and the policyholder paid a premium of $123.

Policy V was issued on August 1, 3109, and the policyholder paid a premium of $870.

Policy W was issued on December 1, 3109, and the policyholder paid a premium of $1300.

Policy X was issued on February 1, 3110, and the policyholder paid a premium of $50.

Policy Y was issued on March 1, 3110, and the policyholder paid a premium of $500.

Policy Z was issued on September 1, 3110, and the policyholder paid a premium of $600.

How much *unearned premium* exists on this book of business as of July 1, 3110?

**Solution S5-32-3.** As of July 1, 3110, policies T and U have expired, so their premium is fully earned.

Policy V has 1 month remaining, so its unearned premium is $870*(1/12) = $72.50.

Policy W has 5 months remaining, so its unearned premium is $1300*(5/12) = $541.67.

Policy X has 7 months remaining, so its unearned premium is $50*(7/12) = $29.17.

Policy Y has 8 months remaining, so its unearned premium is $500*(8/12) = $333.33.

Policy Z has not been written yet, so it should not be considered.

The unearned premium on this book of business as of July 1, 3110, is $72.50 + $541.67 + $29.17 + $333.33 = $976.67.

**Problem S5-32-4.** You know the following information on insurance policies, each of which is one year in term length:

Policy T was issued on January 1, 3109, and the policyholder paid a premium of $671.

Policy U was issued on June 1, 3109, and the policyholder paid a premium of $123.
Policy V was issued on August 1, 3109, and the policyholder paid a premium of $870.

Policy W was issued on December 1, 3109, and the policyholder paid a premium of $1300.

Policy X was issued on February 1, 3110, and the policyholder paid a premium of $50.

Policy Y was issued on March 1, 3110, and the policyholder paid a premium of $500.

Policy Z was issued on September 1, 3110, and the policyholder paid a premium of $600.

How much in-force premium exists on this book of business as of July 1, 3110?

Solution S5-32-4. The in-force premium on a group of policies as of a given date is the sum of the full-term premiums on all policies in effect on that date. Only policies V, W, X, and Y are in effect on July 1, 3110. Thus, the in-force premium is the sum of these policies' full-term premiums: $870 + $1300 + $50 + $500 = $2720.

Problem S5-32-5. Which of the following is most commonly used to measure the impact of a rate change on an existing insurance book of business? (See Werner and Modlin, p. 69.)

(a) The in-force premium at the start of the current calendar year
(b) The earned premium for last year's policy year, as of the start of the current calendar year
(c) The unearned premium for last year's policy year, as of the start of the current calendar year
(d) The most recent in-force premium
(e) The most recent unearned premium
(f) The most recent earned premium
(g) The written premium of the most recent policy year for which all the policies have expired.

Solution S5-32-5.

The correct answer is (d) The most recent in-force premium. The in-force premium is, according to Werner and Modlin, p. 69, "the best estimate of the company's mix of business as of a given date."
Section 33

Adjusting Historical Premium to Current Rate Levels: The Extension of Exposures Method and an Introduction to the Parallelogram Method

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Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-33-1. Actuary X is analyzing rates for Δ Insurance Company. During the historical period for which Actuary X has data, rates were $890 per policy. Since then, rates were changed twice: there was a 5.6% increase, followed by a 4.3% decrease. Nothing else has changed. The best estimate of Actuary X is that the indicated rate - the rate the company ought to adopt - is $895 per policy. How much of a change should this be from the current rate?

Solution S5-33-1. This problem addresses the principle of adjusting historical premium to current rate levels. The $890 per policy is a historical figure and needs to be adjusted (multiplied) by the factors corresponding to changes in rates since that time. These factors are, respectively, $1 + 0.056 = 1.056$ and $1 - 0.043 = 0.957$. Thus, the current rate level is $890 \times 1.056 \times 0.957 = 899.42688$. The change from the current rate is thus $895/899.42688 - 1 = -0.0049218898 \approx -0.492\%$. Note that this is a rate decrease, even though the indicated rate is greater than the historical rate before the adjustments.

Problem S5-33-2. Ω Insurance Company uses a simple rating algorithm: 

\[ \text{Premium} = \text{Exposure} \times \text{Rate per Exposure} \times \text{Class Factor} + \text{Policy Fee}. \]
On November 1, 2902, the company increased its Class Factor for Class Q from 0.67 to 0.78. It also decreased its policy fee from 89 Golden Hexagons (GH) to 34 GH. Meanwhile, the rate per exposure changed from 1500 GH to 1429 GH.

Policyholder Y paid a premium of 670 GH on September 1, 2902. The company wishes to adjust this premium to the current rate level to assist in ratemaking calculations. What is the equivalent premium at the post-November 1, 2902, rate level?

**Solution S5-33-2.** We know that $670 = \text{Exposure} \times \text{Rate per Exposure} \times \text{Class Factor} + \text{Policy Fee}$.

Pre-November 1, we are given that Rate per Exposure = 1500, Class Factor = 0.67, and Policy Fee = 89. We first want to find the number of exposures:

$$670 = \text{Exposure} \times 1500 \times 0.67 + 89$$

Thus, Exposure $= (670 - 89)/(1500 \times 0.67) = \text{Exposure} = 0.5781094527$.

The new Rate per Exposure $= 1429$, the new Class Factor $= 0.78$, and the new Policy Fee $= 34$. Thus, the equivalent premium at the new rate level is $0.5781094527 \times 1429 \times 0.78 + 34 = 678.3723582 \text{ GH}$.

**Problem S5-33-3.** Which of the following statements about the *extension of exposures* method of adjusting historical premium are true? More than one answer may be correct.

(a) The extension of exposures method is less practical when used in conjunction with rating guidelines that involve some subjectivity of judgment by underwriters.
(b) The extension of exposures method is one of the less accurate current rate level methods.
(c) The extension of exposures method deals with aggregate premium quantities and does not delve into individual policy data.
(d) The main limitation of the extension of exposures method today is the significant number of calculations needed to rerate each policy.
(e) The main limitation of the extension of exposures method today is the gathering of data needed to rerate each policy.
(f) It is possible to group policy data when using the extension of exposures method, but only if the rating algorithm is so complex that using individual policy data would be impractical.

**Solution S5-33-3.** This question is based on the discussion in Werner and Modlin, pp. 71-72.

The following statements are true:
(a) The extension of exposures method is less practical when used in conjunction with rating guidelines that involve some subjectivity of judgment by underwriters.
(e) The main limitation of the extension of exposures method today is the gathering of data needed to rerate each policy.

Choice (b) is incorrect; the extension of exposures method is the most accurate current rate level method.
Choice (c) is incorrect; the extension of exposures method will virtually always involve examination of individual policy data.

Choice (d) is incorrect; the number of calculations limitation has been overcome by advances in computing power.

Choice (f) is incorrect; the simpler the rating algorithm, the more feasible it is to group policy data with the same rating characteristics for use with the extension of exposures method.

**Problem S5-33-4.** Werner and Modlin (72) give six major steps for the parallelogram method of adjusting historical rate levels to current rate levels. What are these six steps?

**Solution S5-33-4.** The following answer is cited from Werner and Modlin (72):

"1. Determine the timing and amount of the rate changes during and after the experience period and group the policies into rate level groups according to the timing of each rate change.
"2. Calculate the portion of the year's earned premium corresponding to each rate level group.
"3. Calculate the cumulative rate level index for each rate level group.
"4. Calculate the weighted average cumulative rate level index for each year.
"5. Calculate the on-level factor as the ratio of the current cumulative rate level index and the average cumulative rate level index for the appropriate year.
"6. Apply the on-level factor to the earned premium for the appropriate year."

**Problem S5-33-5.** Give two ways in which the parallelogram method of adjusting historical rate levels to current rate levels is less accurate than the extension of exposures method.

**Solution S5-33-5.** There are more than two possible answers. The following are some of the aspects discussed by Werner and Modlin (72):

1. The parallelogram method is undertaken on a group of policies, whereas the extension of exposures method analyzes individual policy data.

2. The parallelogram method assumes that premium is written evenly throughout the time period in question, whereas the extension of exposures method considers when premium was actually written.

3. The parallelogram method involves adjusting an aggregated historical premium by an average factor, whereas the extension of exposures method involves adjusting the premium for each policy by the rate changes that would apply to that particular policy and only then aggregating the results.

4. The parallelogram method does not calculate exact rates, whereas the extension of exposures method does.

Other answers are possible.
Section 34

Application of the Parallelogram Method for Adjusting Historical Premium to Current Rate Levels

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Source:

Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-34-1. Total earned premium in the year 4067 was 6700 Golden Hexagons (GH). Total earned premium in the year 4068 was 6630 GH. Total earned premium in the year 4069 was 5640 GH. There were three rate changes during this time period:
On August 1, 4067, the average rate level was increased by 12%.
On March 1, 4068, the average rate level was decreased by 46%.
On January 1, 4069, the average rate level was increased by 6.5%.
Assume that one-year policies were written at an even rate throughout each year. Use the parallelogram method to find the fraction of earned premium in calendar year 4068 that corresponds to policies which were written before the rate change of March 1, 4068, took effect.

Solution S5-34-1. First, we need to find the fraction of earned premium in calendar year 4068 that corresponds to policies which were written after the rate change of March 1, 4068, took effect. To do this, we can, following Werner and Modlin (83), draw a graph with time (t) on the horizontal axis and percent of policy earned (p) on the vertical axis. The policies written on March 1, 4068, would be represented by a diagonal line corresponding to p = 0 at t = March 1, 4068, and to p = 100 at t = March 1, 4069. At t = January 1, 4069, p will be (10/12)*100 = 83.3333333%. If we consider the t axis to be denominated in months and the p axis to be
denominated in percentage points of policy earned, then the area of the rectangle corresponding to calendar year 4068 is $12 \times 100 = 1200$. The area of the triangle corresponding to the policies written after March 1, 4068, is $(1/2) \times 10 \times 83.33333333 = 416.666666667$. The fraction of the rectangle occupied by such policies is $416.666666667/1200 = 0.3472222222222$, implying that the fraction of the rectangle occupied by pre-March 1, 4068, policies is $1 - 0.3472222222222 = 0.6527777777778$.

**Problem S5-34-2.** Total earned premium in the year 4067 was 6700 Golden Hexagons (GH). Total earned premium in the year 4068 was 6630 GH. Total earned premium in the year 4069 was 5640 GH. There were three rate changes during this time period: On August 1, 4067, the average rate level was increased by 12%. On March 1, 4068, the average rate level was decreased by 46%. On January 1, 4069, the average rate level was increased by 6.5%.

Assume that one-year policies were written at an even rate throughout each year. Use the parallelogram method to find the fraction of earned premium in calendar year 4068 that corresponds to policies which were written before the rate change of March 1, 4068, took effect, but after the rate change of August 1, 4067, took effect.

**Solution S5-34-2.** From Solution S5-34-2, we know that the fraction of the rectangle corresponding to calendar year 4068 occupied by pre-March 1, 4068, policies is $0.6527777777778$. We first want to find the part of this area occupied by pre-August 1, 4067, policies. To do this, we can, following Werner and Modlin (83), draw a graph with time (t) on the horizontal axis and percent of policy earned (p) on the vertical axis. The policies written on August 1, 4067 would have $p = (5/12) \times 100 = 41.66666667$ at $t = January 1, 4067$. They will expire on August 1, 4068. So the area in calendar year 4068 corresponding to these policies is that of an upper-left-hand-corner triangle with height of $100 - 41.66666667 = 58.333333333\%$ and horizontal length of 8 months. This area is $(1/2) \times 8 \times 58.333333333 = 233.33333333$. Since the area of the CY 4068 rectangle is 1200, the area corresponding to pre-August 1, 4067, policies is $233.33333333/1200 = 0.19444444444$ of the rectangle. The rest of the pre-March 1, 4068, area is comprised of post-August 1, 4067, but pre-March 1, 4068, policies. This is our desired answer: $0.6527777777778 - 0.19444444444 = 0.458333333333 = 11/24$.

**Problem S5-34-3.** Total earned premium in the year 4067 was 6700 Golden Hexagons (GH). Total earned premium in the year 4068 was 6630 GH. Total earned premium in the year 4069 was 5640 GH. There were three rate changes during this time period: On August 1, 4067, the average rate level was increased by 12%. On March 1, 4068, the average rate level was decreased by 46%. On January 1, 4069, the average rate level was increased by 6.5%.

Assume that one-year policies were written at an even rate throughout each year. Assuming that the initial rate level index (pre August 1, 4067) is 1, what is the average rate level index for calendar year 4068? Use the parallelogram method.

**Solution S5-34-3.** We want to calculate the cumulative rate level indices after each rate change pertinent to CY 4068 data.
Post-August 1, 4067, and pre-March 1, 4068, the cumulative rate level index is $1 \times 1.12 = 1.12$.

Post-March 1, 4068 and pre-January 1, 4069, the cumulative rate level index $1.12 \times (1 - 0.46) = 0.6048$.

From Solutions S5-34-1 and S5-34-2, we know that $0.19444444444 = 7/36$ of CY 4068 policies are pre-August 1, 4067, $0.458333333333 = 11/24$ of CY 4068 policies are post-August 1, 4067, and pre-March 1, 4068, and $0.3472222222222 = 25/72$ of CY 4068 policies are post-March 1, 4068. These are the factors by which the corresponding cumulative rate level indices should be multiplied to get the average rate level index for CY 4068:

$$1 \times (7/36) + 1.12 \times (11/24) + 0.6048 \times (25/72) = 0.91777777778.$$ 

**Problem S5-34-4.** Total earned premium in the year 4067 was 6700 Golden Hexagons (GH). Total earned premium in the year 4068 was 6630 GH. Total earned premium in the year 4069 was 5640 GH. There were three rate changes during this time period:
- On August 1, 4067, the average rate level was increased by 12%.
- On March 1, 4068, the average rate level was decreased by 46%.
- On January 1, 4069, the average rate level was increased by 6.5%.

Assume that one-year policies were written at an even rate throughout each year. What is the calendar-year 4068 earned premium, brought to the 4069 rate level? Use the parallelogram method.

**Solution S5-34-4.** The factor by which the calendar-year 4068 earned premium of 6630 would need to be multiplied to be brought to the 4069 rate level is equal to

$$(\text{Current Cumulative Rate Level Index})/(\text{Average Rate Level Index for Historical Period}).$$

From Solution S5-34-3, we know that Average Rate Level Index for Historical Period = 0.917777777778.

Post-March 1, 4068 and pre-January 1, 4069, the cumulative rate level index is 0.6048.

The current cumulative rate index is the post-January 1, 4069, cumulative rate index:

$$0.6048 \times 1.065 = 0.644112 = \text{Current Cumulative Rate Level Index}.$$ 

Thus, the factor needed is $0.644112/0.917777777778 = 0.7018169492$, and the CY 4068 earned premium, adjusted to current rate levels, is $6630 \times 0.7018169492 = 4653.046373$ GH.

**Problem S5-34-5.** Total earned premium in the year 4067 was 6700 Golden Hexagons (GH). Total earned premium in the year 4068 was 6630 GH. Total earned premium in the year 4069 was 5640 GH. There were three rate changes during this time period:
- On August 1, 4067, the average rate level was increased by 12%.
- On March 1, 4068, the average rate level was decreased by 46%.
- On January 1, 4069, the average rate level was increased by 6.5%.
Assume that one-year policies were written at an even rate throughout each year. What is the total earned premium during calendar year 4069, brought to current (post-January 1, 4069) rate levels? Use the parallelogram method.

**Solution S5-34-5.** For CY 4069, half the policies during the calendar year are written after January 1, 4069, while half are written before. Of the half written before January 1, 4069, some were written before March 1, 4068. It is useful to find this fraction first. To do this, we can, following Werner and Modlin (83), draw a graph with time (t) on the horizontal axis and percent of policy earned (p) on the vertical axis. The policies written on March 1, 4068 would have p = (10/12)*100 = 83.333333333 at t = January 1, 4069. This means that in the rectangle corresponding to CY 4069, the area of the triangle corresponding to such policies written before March 1, 4068, would be in the upper-left-hand-corner of the rectangle and would have height 100 - 83.333333333 = 16.666666667 and horizontal length 2 months, for an area of

\[
(1/2)*16.6666667*2 = 16.666666667. 
\]

The corresponding fraction of the rectangle (for is 16.6666667/1200 = 0.0138888889. Thus, the fraction of the rectangle corresponding to policies written after March 1, 4068, but before January 1, 4069, would be 0.5 - 0.0138888889 = 0.48611111111.

We multiply these fractions by the cumulative rate indices corresponding to the time periods in question:

\[
0.0138888889*1.12 + 0.48611111111*0.6048 + 0.5*0.644112 = 0.6316115556. 
\]

This is the average rate level index for CY 4069. To bring the CY 4069 earned premium to current rate levels, we would need to multiply it by a factor of

\[
\frac{\text{Current Cumulative Rate Level Index}}{\text{Average Rate Level Index for Historical Period}} = \frac{0.644112}{0.6316115556} = 1.019791349, \text{ getting a result of } 5640*1.019791349 = 5751.623206 \text{ GH.}
\]
Section 35

Policy-Year Calculations Using the Parallelogram Method

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Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-35-1. Total earned premium in the policy year 4067 was 8000 Golden Hexagons (GH). Total earned premium in the policy year 4068 was 13400 GH. Total earned premium in the policy year 4069 was 6640 GH. There were three rate changes during this time period:
On August 1, 4067, the average rate level was increased by 12%.
On March 1, 4068, the average rate level was decreased by 46%.
On January 1, 4069, the average rate level was increased by 6.5%.

Assume that one-year policies were written at an even rate throughout each year. Use the parallelogram method to find the fraction of earned premium in policy year 4068 that corresponds to policies which were written before the rate change of March 1, 4068, took effect.

Solution S5-35-1. Applying the parallelogram method to policy years is easier than applying it to calendar years. All policies written in 4068 are assigned to policy year 4068, and all policies written in other years are not. Thus, we only need to concern ourselves with policies written from January 1, 4068 and before March 1, 4068. If one considers policy year 4068 to be represented by a parallelogram, then each "policy month" can be represented as a 1/12 "slice" of that parallelogram - a parallelogram of 1/12 the length of each of the horizontal sides but otherwise the same. Thus, each policy month corresponds to 1/12 the area of the policy year, and the fraction of earned premium corresponding to pre-March 1, 4068, policies is 2/12 = 1/6.
Problem S5-35-2. Total earned premium in the policy year 4067 was 8000 Golden Hexagons (GH). Total earned premium in the policy year 4068 was 13400 GH. Total earned premium in the policy year 4069 was 6640 GH. There were three rate changes during this time period: On August 1, 4067, the average rate level was increased by 12%. On March 1, 4068, the average rate level was decreased by 46%. On January 1, 4069, the average rate level was increased by 6.5%.

Assume that one-year policies were written at an even rate throughout each year. Assuming that the initial rate level index (pre August 1, 4067) is 1, what is the average rate level index for policy year 4068? Use the parallelogram method.

Solution S5-35-2. We want to calculate the cumulative rate level indices after each rate change pertinent to PY 4068 data. Post-August 1, 4067, and pre-March 1, 4068, the cumulative rate level index is $1 \times 1.12 = 1.12$. Post-March 1, 4068 and pre-January 1, 4069, the cumulative rate level index $1.12 \times (1 - 0.46) = 0.6048$.

These are the only two rate level indices relevant to PY 4068. From Solution S5-35-1, the fraction of the policy year's earned premium corresponding to pre-March 1, 4068, policies is 1/6, and therefore, the fraction corresponding to post-March 1, 4068, policies is 5/6.

Hence, the average rate level index for PY 4068 is $(1/6) \times 1.12 + (5/6) \times 0.6048 = 0.69066666667$.

Problem S5-35-3. Total earned premium in the policy year 4067 was 8000 Golden Hexagons (GH). Total earned premium in the policy year 4068 was 13400 GH. Total earned premium in the policy year 4069 was 6640 GH. There were three rate changes during this time period: On August 1, 4067, the average rate level was increased by 12%. On March 1, 4068, the average rate level was decreased by 46%. On January 1, 4069, the average rate level was increased by 6.5%.

Assume that one-year policies were written at an even rate throughout each year. What is the policy-year 4068 earned premium, brought to the 4069 rate level? Use the parallelogram method.

Solution S5-35-3. The factor by which the policy-year 4068 earned premium of 13400 would need to be multiplied to be brought to the 4069 rate level is equal to

$\text{(Current Cumulative Rate Level Index)} / \text{(Average Rate Level Index for Historical Period)}$.

From Solution S5-34-2, we know that Average Rate Level Index for Historical Period = 0.69066666667.

Post-March 1, 4068 and pre-January 1, 4069, the cumulative rate level index is 0.6048.

The current cumulative rate index is the post-January 1, 4069, cumulative rate index: $0.6048 \times 1.065 = 0.644112 = \text{Current Cumulative Rate Level Index}$.
Thus, the factor needed is 0.644112/0.69066666667 = 0.9325945946, and the PY 4068 earned premium, adjusted to current rate levels, is 13400*0.9325945946 = **12496.76757 GH**.

**Problem S5-35-4.** Total earned premium in the policy year 4067 was 8000 Golden Hexagons (GH). Total earned premium in the policy year 4068 was 13400 GH. Total earned premium in the policy year 4069 was 6640 GH. There were three rate changes during this time period:

- On August 1, 4067, the average rate level was increased by 12%.
- On March 1, 4068, the average rate level was decreased by 46%.
- On January 1, 4069, the average rate level was increased by 6.5%.

Assume that one-year policies were written at an even rate throughout each year. What is the total earned premium during policy years 4067, 4068, and 4069, brought to current (post-January 1, 4069) rate levels? Use the parallelogram method.

**Solution S5-35-4.** We already know from Solution S5-35-4 that the PY 4068 on-level earned premium is 12496.76757 GH. In PY 4069, all the policies written are at current rate levels, since no further rate changes were implemented after January 1, 4069. Thus, the PY 4069 on-level earned premium is exactly as given: 6640 GH. What remains is to find the PY 4067 on-level earned premium.

There are two rate level indices for PY 4067 - the original index of 1, which is in effect until August 1, or 7/12 of the policy year. The post-August 1, 4067, index of 1.12 is in effect for the remaining 5/12 of the policy year. Thus, the average historical rate level index for PY 4067 is \[1 \times \frac{7}{12} + 1.12 \times \frac{5}{12} = 1.05\].

The on-level factor needed is

\[
\text{(Current Cumulative Rate Level Index)/(Average Rate Level Index for Historical Period)} = \frac{0.644112}{1.05} = 0.61344.
\]

Thus, the PY 4067 on-level earned premium is 0.61344*8000 = **4907.52**.

The answer is the sum of the on-level earned premiums for the three policy years:

\[4907.52 + 12496.76757 + 6640 = \mathbf{24044.28757 \text{ GH}}\].

**Problem S5-35-5.** Consider six-month insurance policies that are written at an even rate throughout the year. There is a rate increase of 7% on July 1, 3356. Assuming that 1 is the original rate level index, what is the average rate level index for policy year 3356?

**Solution S5-35-5.** Policy year X incorporates all policies written in year X. The shape of the parallelogram representing a policy year for six-month policies will be different from the shape of a parallelogram representing a policy year for one-year policies. The diagonal sides of the parallelogram will be twice as steep, as policies expire sooner, and the last policy of the policy year will expire 6 months after the end of the corresponding calendar year. What does not change, however, is that policies written during n months of the year correspond to n/12 of the parallelogram. Therefore, policies written after July 1, 3356, comprise half of the earned premium for PY 3356. Therefore, the average rate level index for PY 3356 is simply

\[(1/2)*1 + (1/2)*1.07 = \mathbf{1.035}.
\]
Section 36

Calculations Using the Parallelogram Method when Some Rate Changes Are Applied to Already Written Insurance Policies

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Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-36-1. Earned premium in calendar year 5777 was 9000 Golden Hexagons (GH). Earned premium in calendar year 5778 was 10000 GH. The insurer in question writes one-year policies.

There were two rate changes during this time period:

On July 1, 5777, the insurer increased its rates by 10%.

On September 1, 5777, because of the passage of the Radical Rate Reduction Act of 5777, all rates - including the rates of existing policies, were reduced by 20%.

Assume that one-year policies were written at an even rate throughout each year. Use the parallelogram method to find the fraction of earned premium in calendar year 5777 that corresponds to policies which were written after July 1, 5777 - before the September 1 law change took effect.
**Solution S5-36-1.** Let calendar year 5777 be a rectangle of horizontal length \( t = 12 \) (in months) and height \( p = 100 \) (in percentage points). Then the area of this rectangle is 1200. To represent the dividing line pertaining to the July 1, 5777, rate change, we can draw a diagonal time from \( t = July 1, 5777, \) and \( p = 0 \) to \( t = January 1, 5778, \) and \( p = 50 \). To represent the dividing line pertaining to the September 1, 5777, rate change, we just draw a vertical line starting at \( t = September 1, 5777, \) and \( p = 0 \) - since this rate change applies to all policies, not just policies written after September 1.

We can divide the parallelogram into four areas:
(a) The area corresponding to earned premium on policies which were written prior to July 1, 5777 - before the September 1 law change took effect.

(b) The area corresponding to earned premium on policies which were written prior to July 1, 5777 - after the September 1 law change took effect.

(c) The area corresponding to earned premium on policies which were written after July 1, 5777 - before the September 1 law change took effect.

(d) The area corresponding to earned premium on policies which were written after July 1, 5777 - after the September 1 law change took effect.

To find (c), we note that at September 1, policies written on July 1 will have been in force for 2 months, meaning that they will be \( 2/12 = 16.6666666667\% \) to expiration. This is represented graphically by the legs of the right triangle which forms the boundaries of area (c). This triangle has horizontal length 2 months and height 16.6666666667 percentage points, and therefore an area of \( (1/2)*2*16.6666666667 = 16.6666666667 \). The corresponding fraction of the rectangle representing CY 5777 is 16.6666666667/1200 = \( 0.013888888889 = 1/72 \).

**Problem S5-36-2.** Earned premium in calendar year 5777 was 9000 Golden Hexagons (GH). Earned premium in calendar year 5778 was 10000 GH. The insurer in question writes one-year policies.

There were two rate changes during this time period:

On July 1, 5777, the insurer increased its rates by 10%.

On September 1, 5777, because of the passage of the Radical Rate Reduction Act of 5777, all rates - including the rates of existing policies, were reduced by 20%.

Assume that one-year policies were written at an even rate throughout each year. Use the parallelogram method to find the fraction of earned premium in calendar year 5777 that corresponds to policies which were written after July 1, 5777 - after the September 1 law change took effect.

**Solution S5-36-2.** From Solution S5-36-1, we recall how we structured the graphic solution to this problem:
Let calendar year 5777 be a rectangle of horizontal length \( t = 12 \) (in months) and height \( p = 100 \) (in percentage points). Then the area of this rectangle is 1200. To represent the dividing line pertaining to the July 1, 5777, rate change, we can draw a diagonal time from \( t = July 1, 5777, \) and \( p = 0 \) to \( t = January 1, 5778, \) and \( p = 50 \). To represent the dividing line pertaining to the September 1, 5777, rate change, we just draw a vertical line starting at \( t = September 1, 5777, \) and \( p = 0 \) - since this rate change applies to all policies, not just policies written after September 1.

We can divide the parallelogram into four areas:
(a) The area corresponding to earned premium on policies which were written prior to July 1, 5777 - before the September 1 law change took effect.
(b) The area corresponding to earned premium on policies which were written prior to July 1, 5777 - after the September 1 law change took effect.
(c) The area corresponding to earned premium on policies which were written after July 1, 5777 - before the September 1 law change took effect.
(d) The area corresponding to earned premium on policies which were written after July 1, 5777 - after the September 1 law change took effect.

In Solution S5-36-1, we found that \((c) = 16.666666667\).

We wish the find the fraction of the rectangle corresponding to area (d).

It is easiest to first find \((c) + (d)\), which is simply the area corresponding to policies written after July 1, 5777. This is the area of a triangle with base 6 months and height 50 percentage points. This area is \((1/2)*6*50 = 150\).

To find \((d)\), we take \((c) + (d) - (c) = 150 - 16.666666667 = 133.333333333\).

The fraction of the rectangle (d) represents is \(133.333333333/120 = 0.11111111111 = 1/9\).

**Problem S5-36-3.** Earned premium in calendar year 5777 was 9000 Golden Hexagons (GH). Earned premium in calendar year 5778 was 10000 GH. The insurer in question writes one-year policies.

There were two rate changes during this time period:

On July 1, 5777, the insurer increased its rates by 10%.

On September 1, 5777, because of the passage of the Radical Rate Reduction Act of 5777, all rates - including the rates of existing policies, were reduced by 20%.

Assume that one-year policies were written at an even rate throughout each year. Use the parallelogram method to find the fraction of earned premium in calendar year 5777 that
corresponds to policies which were written prior to July 1, 5777 - before the September 1 law change took effect.

**Solution S5-36-3.** From Solution S5-36-1, we recall how we structured the graphic solution to this problem:

Let calendar year 5777 be a rectangle of horizontal length \( t = 12 \) (in months) and height \( p = 100 \) (in percentage points). Then the area of this rectangle is 1200. To represent the dividing line pertaining to the July 1, 5777, rate change, we can draw a diagonal time from \( t = July 1, 5777, \) and \( p = 0 \) to \( t = January 1, 5778, \) and \( p = 50 \). To represent the dividing line pertaining to the September 1, 5777, rate change, we just draw a vertical line starting at \( t = September 1, 5777, \) and \( p = 0 \) - since this rate change applies to all policies, not just policies written after September 1.

We can divide the parallelogram into four areas:
(a) The area corresponding to earned premium on policies which were written prior to July 1, 5777 - before the September 1 law change took effect.

(b) The area corresponding to earned premium on policies which were written prior to July 1, 5777 - after the September 1 law change took effect.

(c) The area corresponding to earned premium on policies which were written after July 1, 5777 - before the September 1 law change took effect.

(d) The area corresponding to earned premium on policies which were written after July 1, 5777 - after the September 1 law change took effect.

In Solution S5-36-1, we found that (c) = 16.666666667.

In Solution S5-36-2, we found that (d) = 133.33333333.

We are interested in finding area (a).

The relevant area that we can find most directly is area (a) + (c), which is simply the rectangle corresponding to all the calendar months prior to September 1, 5777. The area of this rectangle is \( 8 \times 100 = 800 \).

Thus, \( (a) = (a) + (c) - (c) = 800 - 16.666666667 = 783.333333333 \).
The fraction of the CY 5777 rectangle corresponding to area (a) is \( 783.333333333/1200 = 0.652777777778 = 47/72 \).

**Problem S5-36-4.** Earned premium in calendar year 5777 was 9000 Golden Hexagons (GH). Earned premium in calendar year 5778 was 10000 GH. The insurer in question writes one-year policies.

There were two rate changes during this time period:
On July 1, 5777, the insurer increased its rates by 10%.

On September 1, 5777, because of the passage of the Radical Rate Reduction Act of 5777, all rates - including the rates of existing policies, were reduced by 20%.

Assume that one-year policies were written at an even rate throughout each year. What is the average historical rate level index for calendar year 5777? Use the parallelogram method.

**Solution S5-36-4.** In Solutions S5-36-1 through S5-36-3, we have divided the rectangle corresponding to CY 5777 into four areas:

(a) The area corresponding to earned premium on policies which were written prior to July 1, 5777 - before the September 1 law change took effect.

(b) The area corresponding to earned premium on policies which were written prior to July 1, 5777 - after the September 1 law change took effect.

(c) The area corresponding to earned premium on policies which were written after July 1, 5777 - before the September 1 law change took effect.

(d) The area corresponding to earned premium on policies which were written after July 1, 5777 - after the September 1 law change took effect.

We found that the fraction of the rectangle corresponding to (a) is 47/72, the fraction corresponding to (c) is 1/72, and the fraction corresponding to (d) = 1/9. Thus, the fraction corresponding to (b) is 1 - 47/72 - 1/72 - 1/9 = 2/9.

The rate level associated with (a) is 1, since policies in (a) are prior to either of the rate changes.

The rate level associated with (b) is 0.80, since only the legally mandated rate reduction of 20% applies to these policies.

The rate level associated with (c) is 1.10, since only the company's rate increase of 10% applies.

The rate level associated with (d) is 1.10*0.80 = 0.88, since both of the rate changes apply.

The average historical rate level index is therefore 1*(47/72) + 0.80*(2/9) + 1.10*(1/72) + 0.88*(1/9) = 0.94361111111111.

**Problem S5-36-5.** Earned premium in calendar year 5777 was 9000 Golden Hexagons (GH). Earned premium in calendar year 5778 was 10000 GH. The insurer in question writes one-year policies.

There were two rate changes during this time period:

On July 1, 5777, the insurer increased its rates by 10%.
On September 1, 5777, because of the passage of the Radical Rate Reduction Act of 5777, all rates - including the rates of existing policies, were reduced by 20%.

Assume that one-year policies were written at an even rate throughout each year. An actuary in the year 5780 is studying earned premium data from calendar years 5777 and 5778. No new rate changes have occurred, besides the two mentioned above. What is the total earned premium from those two calendar years, brought to current rate levels?

**Solution S5-36-5.** Based on the average historical rate level index of 0.94361111111, found in Solution S5-36-4, we can find the on-level earned premium for CY 5777 by multiplying the historical earned premium of 9000 by a factor of

\[
\frac{\text{Current Cumulative Rate Level Index}}{\text{Average Rate Level Index for Historical Period}}
\]

where the current cumulative rate level index is \(1.10 * 0.80 = 0.88\), taking both rate changes into account.

Thus, the on-level CY 5777 earned premium is \(9000 * \frac{0.88}{0.94361111111111} = 8393.288195\).

We will also want to find the average rate level index for CY 5778. All policies in CY 5778 are affected by the September 1, 5777, legally mandated rate change. However, not all policies in CY 5778 were written after July 1, 5777. The upper-left-hand corner of the rectangle corresponds to policies that were written before July 1, 5777. This is a triangular area bounded by a diagonal line extending from \(t = \text{January 1, 5778}\) and \(p = 50\) to \(t = \text{July 1, 5778}\) and \(p = 100\).

This area is therefore \((1/2)*50*6 = 150\), and is thus \(150/1200 = 1/8\) of the CY 5778 rectangle. The associated rate level index is simply 0.80, since the July 1, 5777, 10% rate increase does not apply to these policies.

Hence, the average historical rate level index for CY 5778 is \(0.80*(1/8) + 0.88*(7/8) = 0.87\).

To bring the historical earned premium of 10000 for CY 5778 to current rate levels, we will need to multiply it by

\[
\frac{\text{Current Cumulative Rate Level Index}}{\text{Average Rate Level Index for Historical Period}} = \frac{0.88}{0.87},
\]

producing a result of \(10000 * 0.88/0.87 = 10114.94253\).

The sum of the on-level CY 5777 and CY 5778 earned premiums is \(8393.288195 + 10114.94253 = 18508.23072 \text{ GH.}\)
Section 37

Premium Trends, Exposure Trends, One-Step Trending, and Two-Step Trending

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Problem S5-37-1. Due to the Federal Reserve's enormous expansions of the money supply, the annual rate of inflation in 2010 and every year thereafter is 20%. Assume that there was no inflation in 2009. On February 1, 2010, X Insurance Company increased its rates by 6%. On December 1, 2011, the company decreased its rates by 9%. Earned premium for X Insurance Company's book of business in calendar year 2009 was $90,000. Bring this premium to the premium level which exists as of January 1, 2012.

Solution S5-37-1. Here, to bring the premium on level, we need to consider not just the company's rate changes, but also the inflation trend. Assume a starting premium level index of 1 in 2009. Each year, 20% inflation will cause the premium level index to be multiplied by a factor of 1.2. Here, this should be done twice, to account for inflation in 2010 and 2011. In addition, the company's two rate changes correspond to factors of 1.06 and 1-0.09 = 0.91, by which the premium level index should be multiplied. On January 1, 2012, the new premium level index is 1.2*1.2*1.06*0.91 = 1.389024, which means that the on-level CY 2009 premium is

90000*1.389024 = $125,012.16.

Problem S5-37-2. Company Γ has just purchased Company Δ. Both companies have never changed their rates before and, in their premiums and exposures, have hitherto experienced unchanging underlying conditions. Company Γ's book of business has 4890 historical earned exposures and has a total historical earned premium of $1,860,000. Company Δ's book of
business has 9000 historical earned exposures and has a total historical earned premium of $426,000. Assuming that nothing else changes in the future, by what factor will Company Γ’s pre-acquisition premium need to be multiplied in order to be brought to post-acquisition levels?

**Solution S5-37-2.** Prior to acquisition, Company Γ has an average rate of

\[
\frac{\text{Earned Premium}}{\text{Earned Exposures}} = \frac{1860000}{4890} = 380.3680982.
\]

After acquisition of Company Δ, Company Γ has an average rate of \( \frac{(1860000+426000)}{(4890+9000)} = 164.5788337 \). The factor by which the average rate changes is thus \( \frac{164.5788337}{380.3680982} = 0.4326830628 \).

**Problem S5-37-3.** Actuary A is using Π Insurance Company's written premium and written exposure data to estimate average annual premium trends. All written premium data have been brought to the relevant current rate level. The actuary has the following data:

- Year 5361, Quarter 1: Written premium = 34259; Written exposures = 135.
- Year 5361, Quarter 2: Written premium = 36269; Written exposures = 145.
- Year 5361, Quarter 3: Written premium = 33267; Written exposures = 112.
- Year 5361, Quarter 4: Written premium = 42829; Written exposures = 133.
- Year 5362, Quarter 1: Written premium = 46201; Written exposures = 137.
- Year 5362, Quarter 2: Written premium = 44444; Written exposures = 111.
- Year 5362, Quarter 3: Written premium = 47356; Written exposures = 122.
- Year 5362, Quarter 4: Written premium = 42219; Written exposures = 138.

Four percentage estimates of annual changes in premium can be estimated from the above data. What are these four changes?

**Solution S5-37-3.** To estimate the annual premium level changes from quarterly data, it is necessary to divide the average written premium for Quarter X in Year Y by the average written premium for Quarter X in Year (Y-1) - i.e., the same quarter of the previous year. We are given 8 quarters of data, so we can estimate the change from any Quarter X of 5361 to the corresponding Quarter X of 5362. Here, average written premium is

\[
\frac{\text{Written premium}}{\text{Written exposures}}.
\]

Thus, from Quarter 1 of 5361 to Quarter 1 of 5362, the following was the percent change in average written premium:

\[
(42829/133)/(34259/135) - 1 = 0.2689525413 = \text{26.89525413}\%\text{change from Quarter 1 of 5361 to Quarter 1 of 5362.}
\]

From Quarter 2 of 5361 to Quarter 2 of 5362, the following was the percent change in average written premium:

\[
(44444/111)/(32629/145) - 1 = 0.779321385 = \text{77.9321385}\%\text{change from Quarter 2 of 5361 to Quarter 2 of 5362.}
\]

From Quarter 3 of 5361 to Quarter 3 of 5362, the following was the percent change in average written premium:
From Quarter 4 of 5361 to Quarter 4 of 5362, the following was the percent change in average written premium:

\[
\frac{42219/138}{42829/133} - 1 = -0.0499585307 = -4.99585307\% \text{ change from Quarter 4 of 5361 to Quarter 4 of 5362.}
\]

**Problem S5-37-4.** Actuary B uses one-step trending to estimate the premium trend for the book of business of Standardized Insurance Company, which consists entirely of one-year policies. B knows that in calendar year (CY) 2135, the earned premium was 4600 Golden Hexagons (GH). He estimates that the average annual premium growth is 3%. No other relevant changes that would affect the premium level have occurred between 2135 and 2140. B is trying to adjust the CY 2135 earned premium to the level at which it would need to be in order to accurately estimate the rate need for policy year (PY) 2140. What is this adjusted CY 2135 earned premium?

**Solution S5-37-4.** As discussed by Werner and Modlin, p. 83, the average written date for premium earned in a calendar year is the beginning of the year - i.e., January 1. The average written date for premium earned in a policy year is the middle of the year - i.e., June 30. Between the average written date for premium earned in CY 2135 - January 1, 2135 - and the average written date for premium earned in PY 2140 - June 30, 2140 - there are 5.5 years. Thus, the trend factor by which the CY 2135 earned premium would need to be multiplied is 1.03^{5.5} = 1.176534687, resulting in an adjusted earned premium of 4600*1.176534687 = 5412.059562 GH.

**Problem S5-37-5.** Actuary C uses two-step trending to estimate the premium trend for the book of business of Generalized Insurance Company, which consists entirely of one-year policies.

C knows that in calendar year (CY) 2222, the average earned premium was 3160 Golden Hexagons (GH). The average written premium for the latest available quarter, Quarter 3 of 2224, is 3536 GH. Thereafter, C estimates that the premium trend was 4% per year. No other relevant changes that would affect the premium level have occurred between 2222 and 2229. B is trying to adjust the CY 2222 earned premium to the level at which it would need to be in order to accurately estimate the rate need for policy year (PY) 2229. What is this adjusted CY 2222 earned premium?

**Solution S5-37-5.** Two-step trending involves selecting a current trend factor based on available data and a projected trend factor for time periods for which data are not yet available. The current trend factor applies to the time until Quarter 3 of 2224 and is equal to 3536/3160 = 1.118987342. Now we need to determine the length of time over which the projected premium trend factor would apply. The midpoint of Quarter 3 of a year occurs on August 15, with 4.5 months remaining in the year.
As discussed by Werner and Modlin, p. 83, the average written date for premium earned in a calendar year is the beginning of the year - i.e., January 1. The average written date for premium earned in a policy year is the middle of the year - i.e., June 30. Thus, the average written date for premium earned in PY 2229 is June 30, 2229. From August 15, 2224, to June 30, 2229, there are $4 + 1-1.5/12 = 4.875$ years. Thus, the projected premium trend factor is $1.04^{4.875} = 1.210702751$.

The factor needed to adjust the CY 2222 earned premium to the current rate level is thus $1.11897342*1.210702751 = 1.354761053$, leading to the adjusted premium of $1.354761053*3160 = \textbf{4281.044927 GH}$.
Section 38

Analyzing Loss Data by Calendar Year, Accident Year, and Policy Year

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**Source:**

**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-38-1.** An actuary is examining loss data pertaining to Accident Year 3602, as of November 1, 3604.

(a) What is the *accounting period* pertaining to these data?
(b) What is the *valuation date* pertaining to these data?
(c) There are two ways to describe these data in terms of number of months relative to Accident Year 3602. What are these two ways?

**Solution S5-38-1.** This question is based on the discussion in Werner and Modlin, p. 90. The following are the correct answers:

(a) The accounting period is **Accident Year 3602**. This is the period *to which* the losses pertain.

(b) The valuation date is **November 1, 3604**. This is the date from whose vantage point the actuary is examining the loss data. Because accident-year data can change after the end of the time period to which they refer, it is possible for data as of a later time period to be different from data as of the end of the accident year in question.

(c) The two ways to describe these data in terms of number of months relative to Accident Year 3602 are **Accident Year 3602 as of 34 months** and **22 months after the close of Accident Year 3602**.
Year 3602. The difference in the number of months is accounted for by the fact that the first description incorporates the months comprising the year 3602, whereas the second description excludes these months.

Problem SS-38-2. Actuary Q is analyzing two insurance policies and transactions pertaining to them. The relevant data are given below.

**Policy A:**

**Effective date:** March 1, 2030.

**Date of occurrence of first loss:** October 2, 2030.

**Report date of first loss:** November 5, 2030.

**Transactions on first loss:**
On November 5, 2030, a case reserve of $5460 was established on the loss. Nothing was paid yet.

On November 15, 2030, a payment of $300 was made, and the case reserve was revised to $5300.

On January 4, 2031, a payment of $800 was made, and the case reserve was revised to $4000.

On October 30, 2031, a payment of $3000 was made, and the case reserve was revised to $950.

On February 4, 2032, a payment of $670 was made, and the claim was closed.

**Policy A:**

**Date of occurrence of second loss:** January 17, 2031

**Report date of second loss:** March 9, 2031

**Transactions on second loss:** On March 9, 2031, a case reserve of $6000 was established on the loss. In addition to the case reserve, a payment of $9000 was made.

On October 9, 2031, a payment of $5000 was made, and the case reserve was revised to $2000.

On January 19, 2032, a payment of $2000 was made, and the claim was closed.

**Policy B:**

**Effective date:** May 20, 2031

**Date of occurrence of loss:** December 30, 2031
Report date of loss: January 4, 2032

Transactions on loss: On January 4, 2032, a case reserve of $7000 was established on the loss nothing was paid yet.

On January 5, 2033, a payment of $8000 was made, and the claim was closed.

What are the Calendar Year 2030 reported losses?

Solution S5-38-2. The Calendar Year 2030 reported losses are equal to the sum of losses paid in 2030 and the ending reserve (sum of case reserves) on December 31, 2030.

Only one loss occurred in 2030 or earlier. In 2030, a payment of $300 was made on this loss, and the year ended with a case reserve of $5300. Thus, Calendar Year 2030 reported losses are 300 + 5300 = $5600.

Problem S5-38-3. Actuary Q is analyzing two insurance policies and transactions pertaining to them. The relevant data are given below.

Policy A:

Effective date: March 1, 2030.

Date of occurrence of first loss: October 2, 2030.

Report date of first loss: November 5, 2030.

Transactions on first loss: On November 5, 2030, a case reserve of $5460 was established on the loss. Nothing was paid yet.

On November 15, 2030, a payment of $300 was made, and the case reserve was revised to $5300.

On January 4, 2031, a payment of $800 was made, and the case reserve was revised to $4000.

On October 30, 2031, a payment of $3000 was made, and the case reserve was revised to $950.

On February 4, 2032, a payment of $670 was made, and the claim was closed.

Policy A:

Date of occurrence of second loss: January 17, 2031

Report date of second loss: March 9, 2031
**Transactions on second loss:** On March 9, 2031, a case reserve of $6000 was established on the loss. In addition to the case reserve, a payment of $9000 was made.

On October 9, 2031, a payment of $5000 was made, and the case reserve was revised to $2000.

On January 19, 2032, a payment of $2000 was made, and the claim was closed.

**Policy B:**

**Effective date:** May 20, 2031

**Date of occurrence of loss:** December 30, 2031

**Report date of loss:** January 4, 2032

**Transactions on loss:** On January 4, 2032, a case reserve of $7000 was established on the loss nothing was paid yet.

On January 5, 2033, a payment of $8000 was made, and the claim was closed.

What are the Calendar Year 2031 reported losses?

**Solution S5-38-3.** The Calendar Year 2031 reported losses are equal to the sum of losses paid in 2031 and the ending reserve (sum of case reserves) on December 31, 2031, minus the beginning reserve in 2031 ($5300).

All three of the losses occurred either before or during 2031. But the loss on Policy B was not reported in 2031, so no payments or reserves were made.

The first loss on policy A had payments of $800 and $3000 made on it, and had an ending case reserve of $950. This means that this loss's contribution to CY 2031 reported losses is $800 + $3000 + $950 = $4750.

The second loss on policy A had payments of $9000 and $5000 made on it, and had an ending case reserve of $2000. This means that this loss's contribution to CY 2031 reported losses is $9000 + $5000 + $2000 = $16000.

Thus the total CY 2031 reported losses are $4750 + $16000 - $5300 = $15,450.

**Problem S5-38-4.** Actuary Q is analyzing two insurance policies and transactions pertaining to them. The relevant data are given below.

**Policy A:**

**Effective date:** March 1, 2030.
Date of occurrence of first loss: October 2, 2030.

Report date of first loss: November 5, 2030.

Transactions on first loss:  
On November 5, 2030, a case reserve of $5460 was established on the loss. Nothing was paid yet.

On November 15, 2030, a payment of $300 was made, and the case reserve was revised to $5300.

On January 4, 2031, a payment of $800 was made, and the case reserve was revised to $4000.

On October 30, 2031, a payment of $3000 was made, and the case reserve was revised to $950.

On February 4, 2032, a payment of $670 was made, and the claim was closed.

Policy A:

Date of occurrence of second loss: January 17, 2031

Report date of second loss: March 9, 2031

Transactions on second loss: On March 9, 2031, a case reserve of $6000 was established on the loss. In addition to the case reserve, a payment of $9000 was made.

On October 9, 2031, a payment of $5000 was made, and the case reserve was revised to $2000.

On January 19, 2032, a payment of $2000 was made, and the claim was closed.

Policy B:

Effective date: May 20, 2031

Date of occurrence of loss: December 30, 2031

Report date of loss: January 4, 2032

Transactions on loss: On January 4, 2032, a case reserve of $7000 was established on the loss nothing was paid yet.

On January 5, 2033, a payment of $8000 was made, and the claim was closed.

What are the Accident Year 2031 reported losses, as of December 31, 2032?
**Solution S5-38-4.** Accident year considers when a loss occurred, irrespective of when it was reported or paid. The two losses that occurred in 2031 are the second loss on Policy A and the loss on Policy B. Thus, Accident Year 2031 reported losses, as of December 31, 2032, are the cumulative amounts paid for these two losses through December 31, 2032, plus the case reserve on these claims. Only the Policy B loss was open on December 31, 2032, with a case reserve of $7000. Nothing was paid on that loss yet. The second loss on Policy A was closed, and had cumulative payments of $9000 + $5000 + $2000 = $16000 on it. Thus, the Accident Year 2031 reported losses, as of December 31, 2032, are $7000 + 16000 = **$23,000**.

**Problem S5-38-5.** Actuary Q is analyzing two insurance policies and transactions pertaining to them. The relevant data are given below.

**Policy A:**

**Effective date:** March 1, 2030.

**Date of occurrence of first loss:** October 2, 2030.

**Report date of first loss:** November 5, 2030.

**Transactions on first loss:**
On November 5, 2030, a case reserve of $5460 was established on the loss. Nothing was paid yet.

On November 15, 2030, a payment of $300 was made, and the case reserve was revised to $5300.

On January 4, 2031, a payment of $800 was made, and the case reserve was revised to $4000.

On October 30, 2031, a payment of $3000 was made, and the case reserve was revised to $950.

On February 4, 2032, a payment of $670 was made, and the claim was closed.

**Policy A:**

**Date of occurrence of second loss:** January 17, 2031

**Report date of second loss:** March 9, 2031

**Transactions on second loss:** On March 9, 2031, a case reserve of $6000 was established on the loss. In addition to the case reserve, a payment of $9000 was made.

On October 9, 2031, a payment of $5000 was made, and the case reserve was revised to $2000.

On January 19, 2032, a payment of $2000 was made, and the claim was closed.
Policy B:

Effective date: May 20, 2031

Date of occurrence of loss: December 30, 2031

Report date of loss: January 4, 2032

Transactions on loss: On January 4, 2032, a case reserve of $7000 was established on the loss nothing was paid yet.

On January 5, 2033, a payment of $8000 was made, and the claim was closed.

What are the Policy Year 2030 reported losses, as of December 31, 2032?

Solution S5-38-5. Policy year considers when the policies in question were written. Policy A was written in 2030, whereas Policy B was written in 2031. Thus, only Policy A data - for both losses - applies to Policy Year 2030. By December 31, 2032, both claims on Policy A were closed, so the case reserve estimate for them is $0. The cumulative payments on the first claim were $300 + $800 + $3000 + $670 = $4770.

The cumulative payments on the second claim were $9000 + $5000 + $2000 = $16000.

The total Policy Year 2030 reported losses, as of December 31, 2032, are therefore $4770 + $16000 = $20,770.
Section 39

Catastrophe and Excess Losses

This section of the study guide is intended to provide practice problems and solutions to accompany the pages of *Basic Ratemaking*, cited below. Students are encouraged to read these pages before attempting the problems. This study guide is entirely an independent effort by Mr. Stolyarov and is not affiliated with any organization(s) to whose textbooks it refers, nor does it represent such organization(s).

Some of the questions here ask for short written answers based on the reading. This is meant to give the student practice in answering questions of the format that will appear on Exam 5. Students are encouraged to type their own answers first and then to compare these answers with the solutions given here. Please note that the solutions provided here are not necessarily the only possible ones.

**Source:**

**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-39-1.** Non-catastrophe losses in a past year were $56,000. To trend losses from that year to their ultimate level, it is necessary to multiply them by a factor of 1.04. A model also estimates catastrophe losses in each future year to be $46,000. Assuming that nothing else changes, what are the total losses that can be expected for a future year?

**Solution S5-39-1.** This question is based on the discussion in Werner and Modlin, p. 93, which states that non-catastrophe losses must be trended and developed to ultimate *before* modeled catastrophe losses are added to them. Thus, the non-catastrophe expected future losses are $56000 \times 1.04 = $58,240$, and total losses are $58240 + 46000 = $104,240$.

**Problem S5-39-2.** An insurer offers the following policy limits on the hot-air-balloon insurance policies it issues: $30,000, $100,000, and $500,000. The following are the individual losses experienced in a year within the insurer's book of business:

- $60,000
- $56,000
- $400,000
- $23,000
- $120,000
- $4,000
Using the basic limit approach, what are the total shock loss amounts for this particular year? (That is, what is the total amount that would be excluded from consideration if shock losses were capped using the basic limit approach?)

**Solution S5-39-2.** The basic limit approach caps all losses at the amount of the lowest limit offered by the insurer and then considers shock loss amounts to be those loss amounts in excess of the cap. Here, this limit is $30,000. The sum of the shock losses here is the sum of the amounts of the loss above $30,000 for each policy where the loss amount exceeds $30,000. The $23,000 and $4,000 losses do not have a shock component. Thus, we have the following answer:

\[(60000 - 30000) + (56000 - 30000) + (400000 - 30000) + (120000 - 30000) = 516,000\]

**Problem S5-39-3.** An insurer offers the following policy limits on the hot-air-balloon insurance policies it issues: $30,000, $100,000, and $500,000. The following are the individual losses experienced in a year within the insurer's book of business:

$60,000
$56,000
$400,000
$23,000
$120,000
$4,000

To estimate the shock losses for this book of business, Actuary Ξ assumes that losses follow an exponential distribution with mean 67000 and caps all losses at the 95th percentile of this distribution. What would be the total shock loss amounts using this capping approach?

**Relevant property of exponential distributions:** \(F(x) = 1 - e^{-x/\theta}\), where \(\theta\) is the mean.

**Solution S5-39-3.**

Let \(x\) be the 95th percentile of the exponential distribution in question.

\[0.95 = 1 - e^{-x/67000} \quad \rightarrow \quad 0.05 = e^{-x/67000}\]

\[-x/67000 = \ln(0.05) \quad \rightarrow \quad x = -67000*\ln(0.05) = 200714.0623.\] This means that shock losses are those losses that exceed $200,714.06. Only the $400,000 loss does so, and therefore, the shock loss amount is $400000 - 200714.06 = $199,285.94.

**Problem S5-39-4.** Accident Year 2090 has reported losses of $600,000 and 17 excess claims, with the excess loss threshold being set at $5,000. The total amount of the excess claims (from the ground up) is $130,000. What is the Excess Ratio for Accident Year 2090?

**Solution S5-39-4.** The Excess Ratio is the ratio of excess losses to non-excess losses.
Total ground-up excess losses are $130,000. Of these, the non-excess amount is equal to number of claims multiplied by the excess loss threshold: $17 \times 5000 = $85,000. Thus, the losses in excess of the threshold are $130000 - 85000 = $45,000. Non-excess losses are therefore $600000 - 45000 = 555000$, and so the Excess Ratio is $45000/550000 = 0.081818181818 = 8.1818181818\%$

**Problem S5-39-5.** The following kinds of losses can (at least potentially) be analyzed via either non-modeled catastrophe analysis or modeled catastrophe analysis. Identify the kind of analysis that would be most suitable for each kind of loss.

(a) Earthquakes  
(b) Hail storms  
(c) Tornadoes in a high-frequency tornado area, such as the Midwestern United States  
(d) Major hurricanes  
(e) Meteorites that reach the Earth

**Solution S5-39-5.** This question is based on the discussion in Werner and Modlin, p. 97. Losses that occur with some regularity can be analyzed via non-modeled catastrophe analysis, which considers past loss data to develop a catastrophe provision. However, losses that are sporadic and of extremely high severity might not be effectively analyzed even by examining several decades of past data. Based on this distinction, the following matches are correct:

(a) Earthquakes - Modeled catastrophe analysis  
(b) Hail storms - Non-modeled catastrophe analysis  
(c) Tornadoes in a high-frequency tornado area, such as the Midwestern United States - Non-modeled catastrophe analysis  
(d) Major hurricanes - Modeled catastrophe analysis  
(e) Meteorites that reach the Earth - Modeled catastrophe analysis
Section 40

Changes in Insurer Losses Due to Reinsurance and Changes in Coverage or Benefit Levels

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Source:

Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-40-1. X Insurance Company enters into a proportional reinsurance arrangement with Y Reinsurance Company, with the proportion of premium ceded being 30%. During policy year 2067, X Insurance Company collected $600,000 in premium and had $400,000 of losses. What is the difference between the premium ceded to Y Reinsurance Company and the loss ceded to Y Reinsurance Company under this arrangement?

Solution S5-40-1. This question is based on the discussion in Werner and Modlin, p. 98. Under a proportional reinsurance arrangement, the proportion of premium ceded is the same as the proportion of losses; here, this proportion is 30%. Thus, the difference between premium ceded and losses ceded is just 30% of the difference between premium and losses:

\[0.3 \times (600000 - 400000) = \$60,000.\]

Problem S5-40-2. Θ Insurance Company enters into a catastrophe excess-of-loss reinsurance agreement with Λ Reinsurance Company, where Λ will cover 64% of total losses in excess of $500,000, up to $900,000. The reinsurance premium charged for this coverage is $200,000 per policy year. During policy year 3705, the following individual losses occurred within Θ's book of business:
What is the difference between the amount of losses ceded to $\Lambda$ and the amount of reinsurance premium paid to $\Lambda$ by $\Theta$? Did $\Theta$ make money on this reinsurance arrangement?

**Solution S5-40-2.** This question is based on the discussion of catastrophe excess-of-loss reinsurance in Werner and Modlin, p. 98.

Total losses for $\Theta$'s book of business during this policy year are

$$60000 + 360000 + 900000 + 76800 + 560000 = 1956800,$$

clearly in excess of $900,000. Thus, reinsurance will pay $64\%$ of $400,000$, which is the entire difference between $900,000$ and $500,000$. That is, reinsurance will pay $0.64 \times 400000 = 256000$, meaning that the difference between losses ceded and reinsurance premium is $256000 - 200000 = 56000$. Thus, $\Theta$ made money on this reinsurance arrangement.

**Problem S5-40-3.** In an alternate universe, $\Theta$ Insurance Company enters into a per-risk excess-of-loss reinsurance agreement with $\Lambda$ Reinsurance Company, where $\Lambda$ will cover $32\%$ of any individual loss in excess of $500,000$, up to $900,000$, for five specified risks. The reinsurance premium charged for this coverage is $200,000$ per policy year. During policy year 3705, the following individual losses for the five risks in question occurred within $\Theta$'s book of business:

- $60,000$
- $360,000$
- $900,000$
- $76,800$
- $560,000$

What is the difference between the amount of losses ceded to $\Lambda$ and the amount of reinsurance premium paid to $\Lambda$ by $\Theta$? Did $\Theta$ make money on this reinsurance arrangement?

**Solution S5-40-3.** This question is based on the discussion of per-risk excess-of-loss reinsurance in Werner and Modlin, p. 98. The only losses in excess of $500,000$ here are the $900,000$ loss and the $560,000$ loss. Thus, the reinsurer will pay $32\%$ of $(900000 - 500000) + (560000 - 500000) = 460000$. $0.32 \times 460000 = 147200$, meaning that the difference between losses ceded and reinsurance premium is $147200 - 200000 = -52800$. Thus $\Theta$ lost money on this reinsurance arrangement.

**Problem S5-40-4.** In policy year 4530, Limitless Insurance Company did not have policy limits on its policies and paid out the following amounts in claims:

- $60,000$
- $360,000$
- $900,000$
- $76,800$
- $560,000$

What is the difference between the amount of losses ceded to $\Lambda$ and the amount of reinsurance premium paid to $\Lambda$ by $\Theta$? Did $\Theta$ make money on this reinsurance arrangement?
56,000 Golden Hexagons (GH)
45,000 GH
43,000 GH
34,000 GH
12,000 GH

On January 1, 4531, Limitless Insurance Company was acquired by Limits, Ltd., which promptly proceeded to impose a limit of 40,000 GH on each policy. Assuming that the underlying empirical loss distribution can be expected to remain the same in policy year 4531, what is the percentage effect of this change on the projected losses that would be paid out by the company?

Solution S5-40-4. This question is based on the discussion of changes in coverage limits in Werner and Modlin, p. 99.

In PY 4530, the total losses paid out by the company were $56000 + 45000 + 43000 + 34000 + 12000 = 190000. In PY 4531, the three largest losses above are capped at 40000, making the total payout 40000*3 + 34000 + 12000 = 166000. The percentage change is 100*(166000/190000 - 1) = -12.63157895%.

Problem S5-40-5. In a particular state, the statutorily mandated workers' compensation benefit is 57% of the pre-injury wage. A change in the law increases the benefit to 93% of the pre-injury wage. Actuary Q also estimated that this increase in the benefit would result in claimants being more reluctant to return to work after an injury, and that the effect of this increased reluctance would be to increase losses for the insurer by 6% per worker of what the loss amount would have been without the incentive change. Before the change in law, an insurer's workers' compensation losses were $235,000. What can this insurer's losses be expected to be after the change in the law, assuming that no other factors change?

Solution S5-40-5. This question is based on the discussion of workers' compensation benefit changes in coverage limits in Werner and Modlin, pp. 99-100. Without the incentive change, the change in law would only result in an increase in losses by a factor of 0.93/0.57 = 1.631578947. The added incentive not to return to work inflates losses by an additional factor of 1.06, leading to a total factor of 1.631578947*1.06 = 1.729473684, by which losses are inflated, leading to an expected loss of 235000*1.631578947 = $406,426.32.
Section 41

Calculations Pertaining to Workers' Compensation Insurance Benefit Levels

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Source:

Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-41-1. You are given the following information:
The state average weekly wage (SAWW) is $1100.

The compensation rate for an injured worker is 80% of the worker's pre-injury wage.

The state-mandated minimum indemnity benefit is 80% of the SAWW, and the maximum indemnity benefit is 120% of the SAWW. Assume that all of the workers below get injured. What will be the total amounts in benefits received by workers subject to the minimum benefit?

Ratio to SAWW......Number of Workers......Total Weekly Wages
Less than 25%..........................2............................$430
25%-50%................................12...........................$3600
50%-75%..............................12.........................$7500
75%-100%............................19.........................$15000
100%-125%............................18.........................$21000
125%-150%............................13.........................$21000
>150%....................................13.........................$80000

Solution S5-41-1. We first consider how many workers would be subject to the minimum benefit. These are workers who would otherwise be entitled to less than 80% of the SAWW in
benefits. Since the compensation rate is 80% of the pre-injury wage, the largest percentage of the SAWW that workers who are subject to the minimum benefit would earn before injury is $0.8/0.8 = 1 = 100\%$. So, the $2 + 12 + 12 + 19 = 45$ workers who earn below 100\% of the SAWW will be subject to the minimum benefit of $1100*0.8 = 880$, and these workers combined would receive $880*45 = \$39,600$.

**Problem S5-41-2.** You are given the following information:
The state average weekly wage (SAWW) is $1100.

The compensation rate for an injured worker is 80\% of the worker's pre-injury wage.

The state-mandated minimum indemnity benefit is 80\% of the SAWW, and the maximum indemnity benefit is 120\% of the SAWW. Assume that all of the workers below get injured.

What will be the total amounts in benefits received by workers subject to the maximum benefit?

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<thead>
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<td>13</td>
<td>$80000</td>
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</table>

**Solution S5-41-2.** We consider how many workers would be subject to the maximum benefit. These are workers who would otherwise be entitled to more than 120\% of the SAWW in benefits, which corresponds to a pre-injury wage level of at least $1.2/0.8 = 1.5 = 150\%$ of the SAWW. Thus, 13 workers are subject to the maximum benefit, which is $1.2*1100 = 1320$, leading to a total payout for these workers of $13*1320 = \$17,160$.

**Problem S5-41-3.** You are given the following information:
The state average weekly wage (SAWW) is $1100.

The compensation rate for an injured worker is 80\% of the worker's pre-injury wage.

The state-mandated minimum indemnity benefit is 80\% of the SAWW, and the maximum indemnity benefit is 120\% of the SAWW. Assume that all of the workers below get injured.

What will be the total amounts in benefits received by all these workers?

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</table>
**Solution S5-41-3.** In Solution S5-41-1 and Solution S5-41-2, we already determined that the 45 workers earning less than 100% of the SAWW will receive $39,600 in benefits, while the 13 workers earning more than 150% of the SAWW will receive $17,160 in benefits. The combined wages of the workers earning between 100% and 150% of the SAWW are $21000 + $21000 = $42000. Because the compensation rate is 80% of the pre-injury wage, these workers will receive 0.8 * $42000 = $33,600, leading to a total of $39600 + $33600 + $17160 = $90,360 in benefits.

**Problem S5-41-4.** You are given the following information:
The state average weekly wage (SAWW) is $1100.

The compensation rate for an injured worker is 80% of the worker's pre-injury wage.

The state-mandated minimum indemnity benefit is 80% of the SAWW, and the maximum indemnity benefit is 120% of the SAWW.

A new law increases the minimum indemnity benefit to 100% of the SAWW.

Assume that all of the workers below get injured. What will be the total amounts in benefits received by all these workers under the new benefit structure?

<table>
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</tr>
<tr>
<td>25%-50%</td>
<td>12</td>
<td>$3600</td>
</tr>
<tr>
<td>50%-75%</td>
<td>12</td>
<td>$7500</td>
</tr>
<tr>
<td>75%-100%</td>
<td>19</td>
<td>$15000</td>
</tr>
<tr>
<td>100%-125%</td>
<td>18</td>
<td>$21000</td>
</tr>
<tr>
<td>125%-150%</td>
<td>13</td>
<td>$21000</td>
</tr>
<tr>
<td>&gt;150%</td>
<td>13</td>
<td>$80000</td>
</tr>
</tbody>
</table>

**Solution S5-41-4.** The new change affects the number of workers receiving the minimum benefit, but does not affect the number of workers receiving the maximum benefit, of which the total payout remains at $17,160 (from Solution S5-41-2). A worker whose benefit is 100% of the SAWW would have received 1 / 0.8 = 1.25 = 125% of the SAWW prior to injury. This means that the number of workers receiving the minimum benefit under the new structure has grown from 45 to 45 + 18 = 63, each of whom receives the $1100 SAWW as a benefit, leading to a total payout of 63 * $1100 = $69,300. The remaining workers, those earning between 125% and 150% of the SAWW, will receive $21000 * 0.8 = $16,800 in benefits, resulting in total benefits of $69300 + $16800 + $17160 = $103,260.

**Problem S5-41-5.** You are given the following information:
The state average weekly wage (SAWW) is $1100.

The compensation rate for an injured worker is 80% of the worker's pre-injury wage.

The state-mandated minimum indemnity benefit is 80% of the SAWW, and the maximum indemnity benefit is 120% of the SAWW.
A new law increases the minimum indemnity benefit to 100% of the SAWW.

Assume that all of the workers below get injured. What is the direct effect (percentage decrease or increase) on the benefit level because of this change in law? Assume that nothing else changes.

**Ratio to SAWW......Number of Workers......Total Weekly Wages**

<table>
<thead>
<tr>
<th>Ratio to SAWW</th>
<th>Number of Workers</th>
<th>Total Weekly Wages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 25%</td>
<td>2</td>
<td>$430</td>
</tr>
<tr>
<td>25%-50%</td>
<td>12</td>
<td>$3600</td>
</tr>
<tr>
<td>50%-75%</td>
<td>12</td>
<td>$7500</td>
</tr>
<tr>
<td>75%-100%</td>
<td>19</td>
<td>$15000</td>
</tr>
<tr>
<td>100%-125%</td>
<td>18</td>
<td>$21000</td>
</tr>
<tr>
<td>125%-150%</td>
<td>13</td>
<td>$21000</td>
</tr>
<tr>
<td>&gt;150%</td>
<td>13</td>
<td>$80000</td>
</tr>
</tbody>
</table>

**Solution S5-41-5.** In Solution S5-41-3, we found that the total benefits prior to the law change were $90,360; after the law change, they would be $103,260. The percentage change is simply $100\times(103260/90360 - 1) = \text{an increase of 14.2762284\%}$. 


Section 42

Analysis of Insurance Losses Using the Parallelogram Method and Age-to-Age Development Factors

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Source:

Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-42-1. Law X requires all workers' compensation insurance benefits to increase by 7% above what their levels would have been in the absence of the law. The law takes effect on May 1, 2060, and applies only to insurance policies written after that date. Assume that all insurance policies have annual terms and that losses are spread evenly throughout any given year. What is the adjustment factor by which losses for the second quarter of accident year 2060 must be multiplied in order to be brought to the post-Law-X level? Use the parallelogram method.

Solution S5-42-1. We can consider each calendar or accident year to be a rectangle of horizontal length $t = 12$ months and height $p = 100$ percent - representing the proportion of a given policy that has expired. Each accident quarter is one-fourth of this rectangle, having length 3 months and height 100 percent. We can draw a diagonal line from point $(t = May 1, 2060, and p = 0\%)$ to point $(t = May 1, 2061, and p = 100\%)$. This line represents policies that were written on May 1, 2060. These policies and all policies thereafter are post-Law-X. The second quarter of AY 2060 is concluded on July 1, 2060, which on our diagonal line corresponds to $p = 2/12 = 1/6 = 16.66666667\%$. Thus, the area of the triangle representing the proportion of the second quarter of AY 2060 (AQ2 2060) that is affected by the law change is $(1/2)*2*16.66666667 = 16.66666667$, out of a total area of $3*100 = 300$, representing the entirety of AQ2 2060. The corresponding
The proportion is 16.66666667/300 = 1/18, meaning that 17/18 of the policies in effect during AQ2 2060 are not affected by the law change.

If 1 is the loss level index before the law change, then 1.07 is the loss level index after the law change. The average loss level index during AQ2 2060 is therefore 1.07*(1/18) + 1*(17/18) = 1.003888889. The adjustment factor we desire can be obtained via the following formula: Adjustment = (Current Loss Level)/(Average Loss Level of Historical Period). The current loss level is the post-Law-X level of 1.07, so the adjustment factor is 1.07/1.003888889 = 1.065855008.

**Problem S5-42-2.** Law X requires all workers' compensation insurance benefits to increase by 7% above what their levels would have been in the absence of the law. The law takes effect on May 1, 2060, and applies only to insurance policies written after that date. Assume that all insurance policies have annual terms and that losses are spread evenly throughout any given year. What is the adjustment factor by which losses for the second quarter of policy year 2060 must be multiplied in order to be brought to the post-Law-X level? Use the parallelogram method.

**Solution S5-42-2.** The parallelogram method is easier to use on policy year data because policy year is defined to consider the time at which policies are written, and so the lines separating policy years and quarters are (in the case of annual policies) parallel to the lines representing policies written at certain specified dates. The diagonal line representing policies written on May 1, 2060, splits the parallelogram corresponding to the second quarter of policy year 2060 (PQ2 2060) into two sections. The first section is 1/3 of the PQ2 2060 parallelogram and represents the policies written between April 1 and May 1, 2060. The rest of the policies, 2/3 of PQ2 2060, were written between May 1 and July 1, 2060.

If 1 is the loss level index before the law change, then 1.07 is the loss level index after the law change. The average loss level index during PQ2 2060 is therefore 1*(1/3) + 1.07*(2/3) = 1.046666667. The adjustment factor we desire can be obtained via the following formula: Adjustment = (Current Loss Level)/(Average Loss Level of Historical Period). The current loss level is the post-Law-X level of 1.07, so the adjustment factor is 1.07/1.046666667 = 1.022292994.

**Problem S5-42-3.** Law Y requires all workers' compensation insurance benefits to increase by 7% above what their levels would have been in the absence of the law. The law takes effect on May 1, 2060, and applies to all losses thereafter, irrespective of when the corresponding insurance policies were written. Assume that all insurance policies have annual terms and that losses are spread evenly throughout any given year. What is the adjustment factor by which losses for the second quarter of accident year 2060 must be multiplied in order to be brought to the post-Law-Y level? Use the parallelogram method.

**Solution S5-42-3.** Even though the parallelogram method is being used, no actual parallelograms apply to this situation. The law change applies to all losses after May 1, 2060, irrespective of when policies were written. This can be diagrammatically represented as a vertical line at t = May 1, 2060. Since we are analyzing losses on an accident year basis, the vertical line simply
divides the rectangle representing AQ2 2060 into two areas; the smaller area, comprising 1/3 of AQ2060, denotes losses occurring before the law change. 2/3 of the losses in AQ2 2060 will occur after the law change.

If $I$ is the loss level index before the law change, then $1.07$ is the loss level index after the law change. The average loss level index during PQ2 2060 is therefore $I*(1/3) + 1.07*(2/3) = 1.0466666667$. The adjustment factor we desire can be obtained via the following formula:

$$\text{Adjustment} = \frac{\text{Current Loss Level}}{\text{Average Loss Level of Historical Period}}.$$ 

The current loss level is the post-Law-Y level of $1.07$, so the adjustment factor is $1.07/1.0466666667 = 1.022292994$.

Note that policy-year analysis of policy-based loss level changes will result in the same answer as accident-year analysis of accident-based loss level changes.

**Problem S5-42-4.** Law Y requires all workers' compensation insurance benefits to increase by 7% above what their levels would have been in the absence of the law. The law takes effect on May 1, 2060, and applies to all losses thereafter, irrespective of when the corresponding insurance policies were written. Assume that all insurance policies have annual terms and that losses are spread evenly throughout any given year. What is the adjustment factor by which losses for the second quarter of policy year 2060 must be multiplied in order to be brought to the post-Law-Y level? Use the parallelogram method.

**Solution S5-42-4.** In the diagram for this problem, the parallelograms represent policy years (and policy quarters) of data, and a vertical line at $t = May 1, 2060$, represents the law change. The diagonal line representing the beginning of PQ2 2060 (beginning at $t = April 1, 2060$, and $p = 0\%$, ending at $t = April 1, 2061$, and $p = 100\%$) intersects the vertical line at $p = 1/12 = 8.33333333\%$. The vertical line and the diagonal line form a triangle pertaining to losses in PQ2 2060 that took place before the effective date of Law Y. The area of this triangle is $(1/2)*1*8.33333333 = 8.33333333$, out of the area of 300 corresponding to the parallelogram representing PQ2 2060 (a policy quarter parallelogram has the same area as an accident quarter rectangle). The corresponding fraction is $8.33333333/300 = 1/36$ - meaning that $1/36$ of losses in PQ2 2060 that took place before the law change, and $35/36$ of losses took place after the law change.

If $I$ is the loss level index before the law change, then $1.07$ is the loss level index after the law change. The average loss level index during PQ2 2060 is therefore $(1/36)*I + (35/36)*1.07 = 1.0680555556$. The adjustment factor we desire can be obtained via the following formula:

$$\text{Adjustment} = \frac{\text{Current Loss Level}}{\text{Average Loss Level of Historical Period}}.$$ 

The current loss level is the post-Law-Y level of $1.07$, so the adjustment factor is $1.07/1.0680555556 = 1.001820546$.

**Problem S5-42-5.** For a certain kind of "long-tailed" loss that occurred in Accident Year 2052, you have the following information:

As of 12 months, total losses were $56,000.  
As of 24 months, total losses were $65,700.
As of 36 months, total losses were $87,000.
As of 48 months, total losses were $90,000.
As of 60 months, total losses were $102,000.

From the information above, it is possible to calculate four age-to-age development factors. Find the factors and specify the time periods to which each factor pertains.

**Solution S5-42-5.**

An age-to-age development factor for the time period $X$ through $Y$ is found via the expression 

$$\frac{\text{Losses at time } Y}{\text{Losses at time } X}.$$ 

The factor for **months 12-24** is thus $\frac{65700}{56000} = 1.173214286$.

The factor for **months 24-36** is $\frac{87000}{65700} = 1.324200913$.

The factor for **months 36-48** is $\frac{90000}{87000} = 1.034482759$.

The factor for **months 48-60** is $\frac{102000}{90000} = 1.1333333333$. 

Section 43

Loss Development, Age-to-Ultimate Development Factors, and Calculations of Loss Trends

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Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-43-1. Loss development is most often positive for a given loss (i.e., reported losses tend to increase over time). However, there are situations in which loss development can be negative (i.e., reported losses decrease as they approach their ultimate amount). Describe two reasons for which loss development can be negative.

Solution S5-43-1. This question is based on the discussion in Werner and Modlin, p. 106. There are three situations described in that discussion:

1. **Salvage**: The insurer pays for a total loss on the damaged property and then takes possession of the property. Thereafter, the insurer sells the damaged property and recovers some of the amount it paid. This reduces the insurer's net payment on the loss.

2. **Subrogation**: The insurer pays for a loss for which a third party is responsible; then the insurer seeks indemnification from the responsible third party. Successful subrogation will mean that the insurer gets a reduction in net payment on the loss.

3. **Early case reserve estimate too high**: If the insurer or the insurer's claim adjuster sets the case reserve on a claim too high, later events may lead to a downward revision of this estimate, leading to negative loss development.
**Problem S5-43-2.** For a certain kind of "long-tailed" loss that occurred in Accident Year 2052, you have the following information:

As of 12 months, total losses were $56,000.
As of 24 months, total losses were $65,700.
As of 36 months, total losses were $87,000.
As of 48 months, total losses were $90,000.
As of 60 months, total losses were $102,000.

The chain ladder method of estimating loss development is used, and it is assumed that no further changes in total losses occurred after 60 months.

From the information above, it is possible to calculate five age-to-ultimate development factors. Find the factors and specify the time periods to which each factor pertains.

**Solution S5-43-2.** Before we calculate age-to-ultimate development factors, we need to find the age-to-age development factors whose multiplication will enable us to obtain the age-to-ultimate factors. An age-to-age development factor for the time period $X$ through $Y$ is found via the expression

\[
\frac{\text{Losses at time } Y}{\text{Losses at time } X}.
\]

The factor for months 12-24 is thus $65700/56000 = 1.173214286$.

The factor for months 24-36 is $87000/65700 = 1.324200913$.

The factor for months 36-48 is $90000/87000 = 1.034482759$.

The factor for months 48-60 is $102000/90000 = 1.1333333333$.

The five age-to-ultimate factors are from each of the times listed to ultimate (i.e., 12 months to ultimate, 24 months to ultimate, etc.). From time $X$ to ultimate, the age-to-ultimate factor is the product of all the age-to-age factors applicable to that time range.

Thus, the **60-months-to-ultimate factor** is simply 1, since no further loss development occurs after 60 months.

The **48-months-to-ultimate factor** is the (48-60) factor, multiplied by the (60-ultimate) factor, i.e., $1.1333333333*1 = 1.1333333333$.

The **36-months-to-ultimate factor** is the (36-48) factor, multiplied by the (48-ultimate) factor, i.e., $1.034482759*1.1333333333 = 1.172413793$.

The **24-months-to-ultimate factor** is the (24-36) factor, multiplied by the (36-ultimate) factor, i.e., $1.324200913*1.172413793 = 1.552511415$. 

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The 12-months-to-ultimate factor is the (12-24) factor, multiplied by the (24-ultimate) factor, i.e., $1.173214286 \times 1.552511415 = 1.821428572$.

**Problem S5-43-3.** For a certain kind of "long-tailed" loss that occurred in Accident Year 2052, you have the following information:

- As of 12 months, total losses were $56,000.
- As of 24 months, total losses were $65,700.
- As of 36 months, total losses were $87,000.
- As of 48 months, total losses were $90,000.
- As of 60 months, total losses were $102,000.

The chain ladder method of estimating loss development is used, and it is assumed that no further changes in total losses occurred after 60 months.

Age-to-ultimate factors on the basis of these data were calculated in Solution S5-43-2. These factors are then applied to subsequent years' data, which is analyzed on accident year basis as of January 1, 2058. All that is known about the subsequent years' losses are the reported losses as of January 1, 2058:

- 2053 reported losses as of January 1, 2058, are $53,000.
- 2054 reported losses as of January 1, 2058, are $52,000.
- 2055 reported losses as of January 1, 2058, are $92,000.
- 2056 reported losses as of January 1, 2058, are $85,000.
- 2057 reported losses as of January 1, 2058, are $45,000.

Using the assumptions above, find the total estimated ultimate losses for the years 2053 through 2057.

**Solution S5-43-3.** From Solution S5-43-2, we have the following age-to-ultimate development factors:

- (60-ultimate): 1
- (48-ultimate): 1.1333333333
- (36-ultimate): 1.172413793
- (24-ultimate): 1.552511415
- (12-ultimate): 1.821428572

60 months have passed between the beginning of accident year (AY) 2053 and January 1, 2058, so we multiply AY 2053 reported losses by the (60-ultimate) factor of 1, resulting in estimated ultimate AY 2053 losses being $53,000 \times 1 = 53,000$.

48 months have passed between the beginning of accident year (AY) 2054 and January 1, 2058, so we multiply AY 2054 reported losses by the (48-ultimate) factor of 1.1333333333, resulting in estimated ultimate AY 2054 losses being $52,000 \times 1.1333333333 = 58,933.33$. 


36 months have passed between the beginning of accident year (AY) 2055 and January 1, 2058, so we multiply AY 2055 reported losses by the (36-ultimate) factor of 1.172413793, resulting in estimated ultimate AY 2055 losses being 92000*1.172413793 = $107,862.07.

24 months have passed between the beginning of accident year (AY) 2056 and January 1, 2058, so we multiply AY 2056 reported losses by the (24-ultimate) factor of 1.552511415, resulting in estimated ultimate AY 2056 losses being 85000*1.552511415 = $131,963.47.

12 months have passed between the beginning of accident year (AY) 2057 and January 1, 2058, so we multiply AY 2057 reported losses by the (12-ultimate) factor of 1.821428572, resulting in estimated ultimate AY 2057 losses being 45000*1.821428572 = $81,964.29.

The sum of the estimated ultimate losses for these five years is $53,000 + $58,933.33 + $107,862.07 + $131,963.47 + $81,964.29 = $433,723.16.

**Problem S5-43-4.** You have the following loss data:
For the year ending during the first quarter of 2350 (Q1 2350), there were 766,000 earned exposures, 46,000 claims, and $15,331,551 in losses.

For the year ending during the second quarter of 2350 (Q2 2350), there were 341,000 earned exposures, 26,000 claims, and $6,801,800 in losses.

For the year ending during the third quarter of 2350 (Q3 2350), there were 443,138 earned exposures, 32,020 claims, and $8,889,123 in losses.

For the year ending during the fourth quarter of 2350 (Q4 2350), there were 500,000 earned exposures, 47,831 claims, and $7,000,012 in losses.

For the year ending during the first quarter of 2351 (Q1 2351), there were 871,124 earned exposures, 61,000 claims, and $15,159,012 in losses.

For the year ending during the second quarter of 2351 (Q2 2351), there were 124,000 earned exposures, 8,000 claims, and $2,442,400 in losses.

What is the annual percent change in loss frequency, measured as of the end of Q1 2351?

**Solution S5-43-4.** Here, Frequency = (Number of Claims)/(Number of Earned Exposures).

For Q1 2351, frequency is \( \frac{61000}{871124} = 0.0700244741 \). This should be compared to frequency one year ago, during the year ending during Q1 2350. This frequency is \( \frac{46000}{776000} = 0.0592783505 \). The annual percent change in frequency is therefore \( 100 \times (0.0700244741/0.0592783505 - 1) = +18.12824331\% \).

**Problem S5-43-5.** You have the following loss data on closed claims:
For the year ending during the first quarter of 2350 (Q1 2350), there were 766,000 earned exposures, 46,000 claims, and $15,331,551 in losses.
For the year ending during the second quarter of 2350 (Q2 2350), there were 341,000 earned exposures, 26,000 claims, and $6,801,800 in losses.

For the year ending during the third quarter of 2350 (Q3 2350), there were 443,138 earned exposures, 32,020 claims, and $8,889,123 in losses.

For the year ending during the fourth quarter of 2350 (Q4 2350), there were 500,000 earned exposures, 47,831 claims, and $7,000,012 in losses.

For the year ending during the first quarter of 2351 (Q1 2351), there were 871,124 earned exposures, 61,000 claims, and $15,159,012 in losses.

For the year ending during the second quarter of 2351 (Q2 2351), there were 124,000 earned exposures, 8,000 claims, and $2,442,400 in losses.

What is the annual percent change in pure premium, measured as of the end of Q2 2351?

**Solution S5-43-5.** Although pure premium can be calculated as (Frequency)*(Severity), we can also take a more direct approach and consider pure premium as

\[
\text{(Amount of Total Losses)} / \text{(Number of Earned Exposures)}.
\]

For the year ending Q2 2351, pure premium is thus \(2442400/124000 = 19.69677419\). For the year ending Q2 2350, pure premium is \(6801800/341000 = 19.94662757\). The annual percent change in pure premium is therefore

\[
100 \times (19.69677419 / 19.94662757 - 1) = -1.252609603\%.
\]
Section 44

Calculations of Loss Trends in Insurance – Part 2

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Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-44-1. By fitting exponential models to observed loss data, an actuary has estimated that loss frequency changed by +6% during time period X, while loss severity changed by -8% during the same time period. What is the percentage change in pure premium during time period X?

Solution S5-44-1. Since Pure Premium = (Frequency)*(Severity), it follows that (Factor by which pure premium changed) = (Factor by which frequency changed)*(Factor by which severity changed). The factor by which frequency changed is 1.06; the factor by which severity changed is 0.92. Thus, the factor by which pure premium changed is 1.06*0.92 = 0.9752. The corresponding pure premium percentage change is 100*(0.9752 - 1) = -2.48%.

Problem S5-44-2. An actuary is attempting to trend historical losses to current levels. The losses to be trended are from calendar-accident year (CAY) 3540. The rates which the actuary is developing would take effect for all new policies written on or after January 1, 3556. The actuary determines that the annual loss trend is -2%. The insurance company in question writes annual policies. Determine the trend factor by which historical losses would need to be multiplied in order to be brought to current levels in the actuary's ratemaking analysis.

Solution S5-44-2. This question is based on the discussion in Werner and Modlin, p. 112. To determine the trend period, we need to consider the midpoint of CAY 3540, which is where the loss data are taken from. This midpoint is June 30, 3540, i.e., halfway through the calendar year.
This is the beginning of our trend period. The end of our trend period is the midpoint of policy year (PY) 3556, which occurs on December 31, 3556, since losses on PY 3556 policies will continue to occur until December 31, 3557. Between June 30, 3540, and December 31, 3556, there are 16.5 years. Thus, our trend factor is $(1 - 0.02)^{16.5} = 0.716523187$.

**Problem S5-44-3.** An actuary is attempting to trend historical losses to current levels. The losses to be trended are from calendar-accident year (CAY) 3540. The rates which the actuary is developing would take effect for all new policies written on or after January 1, 3556. The actuary determines that the annual linear loss trend is +54.3 Golden Hexagons (GH). The insurance company in question writes annual policies. Determine the trend addend by which historical losses would need to be adjusted in order to be brought to current levels in the actuary's ratemaking analysis.

**Solution S5-44-3.** This question is based on the discussion in Werner and Modlin, p. 112. To determine the trend period, we need to consider the midpoint of CAY 3540, which is where the loss data are taken from. This midpoint is June 30, 3540, i.e., halfway through the calendar year. This is the beginning of our trend period. The end of our trend period is the midpoint of policy year (PY) 3556, which occurs on December 31, 3556, since losses on PY 3556 policies will continue to occur until December 31, 3557. Between June 30, 3540, and December 31, 3556, there are 16.5 years. For a linear trend, the annual trend is simply multiplied by the term length and added to (or subtracted from) historical losses. Here, the addend is $54.3 \times 16.5 = +895.95 \text{ GH}$.

**Problem S5-44-4.** An actuary is attempting to trend historical losses to current levels. The losses to be trended are from calendar-accident year (CAY) 3540. The rates which the actuary is developing would take effect for all new policies written on or after January 1, 3556. The actuary is using a two-step loss trending method. The latest loss data available are from CAY 3549; for this period, the actuary estimates the annual loss trend to be +6%. Thereafter, the actuary estimates the annual loss trend to be -3%. Determine the trend factor by which historical losses would need to be multiplied in order to be brought to current levels in the actuary's ratemaking analysis.

**Solution S5-44-4.** This question is based on the discussion in Werner and Modlin, pp. 112-113. We need to determine the trend period for each of the two steps of this method. For the first step, the trend period is from the midpoint of CAY 3540 (June 30, 3540) to the midpoint of CAY 3549 (June 30, 3549) - i.e., 9 years. For the second step, the trend period is from June 30, 3549, to the midpoint of PY 3556 (December 31, 3556) - i.e., 7.5 years. Thus, our trend factor is $(1.06)^9 \times (1-0.03)^{7.5} = 1.344438047$.

**Problem S5-44-5.** According to Werner and Modlin, p. 113, what is one fundamental, possibly incorrect assumption entailed in using calendar-year data for the measurement of loss trends?

**Solution S5-44-5.** The fundamental assumption is that the insurer's book of business has not significantly changed in size during the time period for which data are considered. If the book of business size has changed, there may be an overestimation or underestimation of the loss trend if calendar year data are used. This problem arises because losses from older accident years may possibly be matched with exposures from the year in question.
Section 45

Trends Pertaining to Total Limits Losses, Basic Limits Losses, and Excess Losses

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**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-45-1.** Losses on each claim are censored at a basic limit of $56,000. The following losses occurred on specific claims:

i) $67,000  
ii) $34,000  
iii) $51,000  
iv) $152,000  
v) $356,000

Every total limits loss is subject to a +15% severity trend. Determine the basic limits losses and the excess losses for each of the claims above.

**Solution S5-45-1.** The basic limits losses are the losses that are capped at the basic limit (here, at $56,000). The excess losses on any claim are that portion of losses that exceeds the basic limit. For any loss amount $X > 56000$, the excess losses are $X - 56000$. We thus have the following answer:

i) Basic limits loss: **$56,000**; Excess loss: **$11,000**;  
ii) Basic limits loss: **$34,000**; Excess loss: **$0**;  
iii) Basic limits loss: **$51,000**; Excess loss: **$0**;
iv) Basic limits loss: $56,000; Excess loss: $96,000; 
v) Basic limits loss: $56,000; Excess loss: $300,000.

Problem S5-45-2. Losses on each claim are censored at a basic limit of $56,000. The following losses occurred on specific claims:

i) $67,000  
ii) $34,000  
iii) $51,000  
iv) $152,000  
v) $356,000  

Every total limits loss is subject to a +15% severity trend.

Determine the trend (percentage change) applicable to the basic limits losses for each of the claims above.

Solution S5-45-2. The basic limits losses will only change if the initial total limits losses are below the basic limit. Only claims ii) and iii) are below the basic limit. Thus, for claims i), iv), and v), the trend applicable to the basic limits losses is 0%. The loss amount for claim ii) will increase to 34000*1.15 = $39,100. This is still below the basic limit, so the entire +15% change applies to the basic limits loss. The loss amount for claim iii) will increase to 51000*1.15 = $58,650, which would be capped at the basic limit of $56,000 - leaving an excess loss of $2,650. Thus, the change in the basic limits loss pertaining to claim iii) is 100*(56000/51000 - 1) = +9.803921569%. Our answers are as follows:

i) 0%  
ii) +15%  
iii) +9.803921569%  
iv) 0%  
v) 0%  

Problem S5-45-3. Losses on each claim are censored at a basic limit of $56,000. The following losses occurred on specific claims:

i) $67,000  
ii) $34,000  
iii) $51,000  
iv) $152,000  
v) $356,000  

Every total limits loss is subject to a +15% severity trend.

Determine the trend (percentage change) applicable to the excess losses for each of the claims above.
**Solution S5-45-3.** The loss amount for claim ii) will increase to $34000*1.15 = $39,100. This is still below the basic limit, so there are no excess losses before or after the change. For claim iii), the excess loss changes from $0 to $51000*1.15 - 56000 = $2,650. This is not quantifiable in percentage terms; all we can say is that there is now an excess loss, where there was not one before. For claim i), the original excess loss, per Solution S5-45-1, was $11,000. The new excess loss is $67000*1.15 - 56000 = $21,050, implying a percentage change of $100*(21050/11000 - 1) = +91.3636363636\%$. For claim iv), the original excess loss, per Solution S5-45-1, was $96,000. The new excess loss is $152000*1.15 - 56000 = $118,800, implying a percentage change of $100*(118800/96000 - 1) = +23.75\%$. For claim v), the original excess loss, per Solution S5-45-1, was $300,000. The new excess loss is $356000*1.15 - 56000 = $353,400, implying a percentage change of $100*(353400/300000 - 1) = +17.8\%$. Our answers are as follows:

i) +91.3636363636\%
ii) No excess losses exist before or after the total limits loss trend is considered.
iii) Excess losses exist after the total limits loss trend is considered.
iv) +23.75\%
v) +17.8\%

**Problem S5-45-4.** Losses on each claim are censored at a basic limit of $56,000. The following losses occurred on specific claims:

i) $67,000
ii) $34,000
iii) $51,000
iv) $152,000
v) $356,000

Every total limits loss is subject to a +15\% severity trend.

Determine the trend (percentage change) applicable to the basic limits losses for the aggregation of the claims above. (It is possible to assume, for instance, that these claims represent the claims in a small insurer's entire book of business.)

**Solution S5-45-4.** From Solution S5-45-1, we have the following information before the application of the +15\% severity trend to total limits losses:

i) Basic limits loss: $56,000;
ii) Basic limits loss: $34,000;
iii) Basic limits loss: $51,000;
iv) Basic limits loss: $56,000;
v) Basic limits loss: $56,000;

The total basic limits losses here are the sum of the above: $253,000.

On the basis of Solution S5-45-2, we have the following information after the application of the +15\% severity trend to total limits losses:
i) Basic limits loss: $56,000;
ii) Basic limits loss: $39,100;
iii) Basic limits loss: $56,000;
iv) Basic limits loss: $56,000;
v) Basic limits loss: $56,000;

The total basic limits losses here are the sum of the above: $263,100.
The percentage change is therefore $100 \times \left( \frac{263100}{253000} - 1 \right) = \boxed{+3.99209486\%}.$

**Problem S5-45-5.** Losses on each claim are censored at a basic limit of $56,000. The following losses occurred on specific claims:

i) $67,000
ii) $34,000
iii) $51,000
iv) $152,000
v) $356,000

Every total limits loss is subject to a +15% severity trend.

Determine the trend (percentage change) applicable to the excess losses for the aggregation of the claims above.

**Solution S5-45-5.** From Solution S5-45-1, we have the following information before the application of the +15% severity trend to total limits losses:

i) Excess loss: $21,050;
ii) Excess loss: $0;
iii) Excess loss: $2,650;
iv) Excess loss: $96,000;
v) Excess loss: $300,000.

The total excess losses here are the sum of the above: $407,000.

On the basis of Solution S5-45-3, we have the following information after the application of the +15% severity trend to total limits losses:

i) Excess loss: $11,000;
ii) Excess loss: $0;
iii) Excess loss: $0;
iv) Excess loss: $118,800;
v) Excess loss: $353,400.

The total excess losses here are the sum of the above: $483,200.

The percentage change is therefore $100 \times \left( \frac{483200}{407000} - 1 \right) = \boxed{+18.72235872\%}.$
Section 46

Comparisons of Various Types of Loss Trends in Insurance and Simple Methods of Estimating Unallocated Loss Adjustment Expenses

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Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-46-1. Which of the following statements are true if there is a positive loss severity trend? More than one answer may be correct:
(a) The basic limits trend is always greater than or equal to the total limits trend.
(b) The basic limits trend is always greater than or equal to the excess losses trend.
(c) The total limits trend is always greater than or equal to the basic limits trend.
(d) The total limits trend is always greater than or equal to the excess losses trend.
(e) The excess losses trend is always greater than or equal to the basic limits trend.
(f) The excess losses trend is always greater than or equal to the total limits trend.

Solution S5-46-1. This question is based on the discussion in Werner and Modlin, p. 115, where the following inequality is given for cases of positive severity trend:
Basic Limits Trend ≤ Total Limits Trend ≤ Excess Losses Trend.

Thus, the following answers are correct:
(c) The total limits trend is always greater than or equal to the basic limits trend.
(e) The excess losses trend is always greater than or equal to the basic limits trend.
(f) The excess losses trend is always greater than or equal to the total limits trend.
Problem S5-46-2. Which of the following statements are true if there is a negative loss severity trend? More than one answer may be correct:
(a) The basic limits trend is always greater than or equal to the total limits trend.
(b) The basic limits trend is always greater than or equal to the excess losses trend.
(c) The total limits trend is always greater than or equal to the basic limits trend.
(d) The total limits trend is always greater than or equal to the excess losses trend.
(e) The excess losses trend is always greater than or equal to the basic limits trend.
(f) The excess losses trend is always greater than or equal to the total limits trend.

Solution S5-46-2. This question is based on the discussion in Werner and Modlin, p. 115, where the following inequality is given for cases of negative severity trend:
Excess Losses Trend ≤ Total Limits Trend ≤ Basic Limits Trend.
Thus, the following answers are correct:
(a) The basic limits trend is always greater than or equal to the total limits trend.
(b) The basic limits trend is always greater than or equal to the excess losses trend.
(d) The total limits trend is always greater than or equal to the excess losses trend.

Problem S5-46-3. According to Werner and Modlin, p. 115, what three types of trends are considered in the projection of pure premiums into the forecast period when an actuary is developing a pure premium rate level indication?

Solution S5-46-3. The three trends are as follows, as stated in Werner and Modlin, p. 115:
1. Changes in the likelihood of a claim happening;
2. Changes in the average cost of claims;
3. Changes in the level of exposure.

Problem S5-46-4. An actuary is aware of the following loss and loss adjustment expense data for calendar years 4310, 4311, 4312, and 4313. Recall that ALAE stands for allocated loss adjustment expenses, and ULAE stands for unallocated loss adjustment expenses.

CY 4310: Paid Loss and ALAE: 4120 Golden Hexagons (GH); Paid ULAE: 456 GH.
CY 4311: Paid Loss and ALAE: 3333 GH; Paid ULAE: 900 GH.
CY 4312: Paid Loss and ALAE: 5640 GH; Paid ULAE: 1230 GH.
CY 4313: Paid Loss and ALAE: 4210 GH; Paid ULAE: 426 GH.

Find the ULAE ratio for each year and the ULAE Factor that could be derived from considering the data above and applied via multiplication to paid loss and ALAE data for subsequent years.

Solution S5-46-4. For each year, the ULAE ratio is (Paid ULAE)/(Paid Loss and ALAE)
For CY 4310, the ULAE ratio is 456/4120 = 0.1106796117.
For CY 4311, the ULAE ratio is 900/3333 = 0.2700270027.
For CY 4312, the ULAE ratio is 1230/5640 = 0.2180851064.
For CY 4313, the ULAE ratio is 426/4210 = 0.1011876485.
The total ULAE ratio is \((\text{Sum of all Paid ULAE})/(\text{Sum of all Paid Loss and ALAE}) =\)

\[(456 + 900 + 1230 + 426)/(4120 + 3333 + 5640 + 4210) = 0.17407386.\]

The ULAE factor is \((1 + (\text{Total ULAE Ratio})) = 1.17407386.\)

**Problem S5-46-5.** An actuary is aware of the following loss and loss adjustment expense data for calendar years 4310, 4311, 4312, and 4313. Recall that ALAE stands for allocated loss adjustment expenses, and ULAE stands for unallocated loss adjustment expenses.

- **CY 4310:** Paid Loss and ALAE: 4120 Golden Hexagons (GH); Paid ULAE: 456 GH.
- **CY 4311:** Paid Loss and ALAE: 3333 GH; Paid ULAE: 900 GH.
- **CY 4312:** Paid Loss and ALAE: 5640 GH; Paid ULAE: 1230 GH.
- **CY 4313:** Paid Loss and ALAE: 4210 GH; Paid ULAE: 426 GH.

You also know that paid losses and ALAE in CY 4314 were 7387 GH.

(a) Using a ULAE Factor derived from considering the data above and applied via multiplication to paid loss and ALAE data for subsequent years, find the estimated total ULAE pertaining to CY 4314.

(b) According to the discussion in Werner and Modlin, p. 119, what inherent assumption must be made about ULAE to use this method?

(c) Why might actual unallocated loss adjustment expenses for CY 4314 be higher than the amount that is estimated via this method? Hint: Look at the magnitude of the losses and ALAE for CY 4314 and compare them to the figures from earlier years.

**Solution S5-46-5.** (a) In Solution S5-46-4, we found that the ULAE factor is 1.17407386 and the ULAE ratio is 0.17407386. To find just the estimated ULAE in CY 4314, we multiply the paid losses and ALAE for that year by the ULAE ratio. We get \(0.17407386\times 7387 = 1285.883604\) GH.

(b) According to the discussion in Werner and Modlin, p. 119, this method "inherently assumes that ULAE trend and develop at the same rate as loss plus ALAE."

(c) The paid losses and ALAE for CY 4314 appear to be substantially higher than for earlier years, suggesting that a catastrophic event may have occurred. Werner and Modlin, p. 119, discuss this possibility and comment that it is possible for unallocated loss adjustment expenses to be unusually high (in excess of the average ratio that would be observed in the absence of catastrophes) for catastrophic losses - for instance, because the company might need to establish temporary offices in the area affected by the catastrophe.
Section 47

Risk Management Steps, the Law of Large Numbers, Types of Insurers, and Insurance Functions

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**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-47-1.** Six steps in the risk management process are mentioned by Myhr and Markham, p. 1.5:

1. Identify loss exposures.
2. Analyze loss exposures.
3. Examine the feasibility of risk management techniques.
4. Select the most appropriate techniques.
5. Implement the risk management techniques.
6. Monitor results and make changes as needed.

Business X is implementing a risk management process. The following steps (not necessarily in sequence) have been taken by employees of Business X. Match each situation below to the corresponding step in the risk management process.

(a) The management of Business X decides that the risk of falling anvils will be controlled by putting an extremely thick rubber padding over the roof of the business's main office, while the risk of infestation by worms wearing ninja costumes will be controlled by installing automatic...
spray-painting devices that would paint any ninja costume pink and cause any malicious worms to cower away in shame.

(b) The risk-management department of Business X conducts a detailed study of expected losses from falling anvils and worms wearing ninja costumes.

(c) During the course of six months, Business X installs rubber padding over the roof of its main office to protect against falling anvils and also installs an automatic spray-painting system to deter worms who wear ninja costumes.

(d) Inspectors hired by Business X determine that it stands to suffer the most losses from falling anvils and from infestation by worms wearing ninja costumes.

(e) After collecting data for a year, analysts from Business X determine that the rubber padding recently installed over the roof of its main office helped neutralize 85% of all falling anvils, but branch offices were still subject to roughly the same amount of falling anvil damage. The management of Business X decides to also install rubber padding on the roofs of branch offices. It has also been determined that worms wearing ninja costumes are deterred by pink spray paint only 50% of the time, whereas competitors who have used neon orange spray paint managed to get a 70% success rate. The management of Business X decides to try neon orange spray paint next year.

(f) Business X commissions studies to compare and contrast the effects of five alternative risk management techniques that have been suggested to prevent and reduce losses due to falling anvils and infestation by worms wearing ninja costumes.

Solution S5-47-1.

Situation (a) is an example of step 4: selecting the most appropriate techniques.
Situation (b) is an example of step 2: analyzing loss exposures.
Situation (c) is an example of step 5: implementing the risk management techniques.
Situation (d) is an example of step 1: identifying loss exposures.
Situation (e) is an example of step 6: monitoring results and make changes as needed.
Situation (f) is an example of step 3: examining the feasibility of risk management techniques.

Problem S5-47-2. Actuary Ω decides to develop rates for automobile insurance on the basis of the following data:
- 63 colonists driving moon rovers in calendar year 2060 have experienced an average annual cost of losses of $3500 per driver.
- 12 drivers of sport utility vehicles in Taiwan in calendar year 2031 have experienced an average annual cost of losses of $3500 per driver.
- 14 operators of wheelbarrows in California in calendar year 2055 have experienced an average annual cost of losses of $3500 per wheelbarrow operator.

Actuary Ω alleges that, on the basis of the law of large numbers, he can reasonably assume that the average cost for the drivers insured by Insurance Company Y will be $3500 per year per driver. In what manner has he misapplied the law of large numbers?

Solution S5-47-2. This question is based on the discussion in Myhr and Markham, p. 1.5, where the law of large numbers is defined as a "mathematical principle stating that as the number of similar but independent exposure units increases, the relative accuracy of predictions about
future outcomes (losses) also increases." The exposure units analyzed by Actuary Ω are probably independent, but they are far from being similar. Drivers of moon rovers are not comparable to operators of wheelbarrows in California, and the years from which the data were taken differ considerably as well. The $3500 average annual per-driver loss from the three groups of drivers is thus much more likely to be a result of coincidence than information that can be relied on to make future projections.

**Problem S5-47-3.** Myhr and Markham, pp. 1.6-1.10, discuss the following different types of insurers:

1. Stock insurance companies
2. Lloyd's
3. Insurance exchanges
4. Mutual insurance companies
5. Reciprocal exchanges
6. Fraternal organizations
7. Pools
8. Government insurers

Each of the following is an attribute unique to one of these types of insurers and explicitly discussed by Myhr and Markham, pp. 1.6-1.10. Match each attribute to the type of insurer to which it pertains.

(a) The policyholders of these entities elect a board of directors that appoints officers to manage the company.
(b) One of these entities is the principal provider of flood insurance in the United States.
(c) These nonprofit entities are owned by its policyholders and managed by an attorney-in-fact, which can be a for-profit organization.
(d) These entities combine a lodge or social function with their insurance function.
(e) These entities are owned by their stockholders, who elect a board of directors to oversee the company's operations.
(f) These entities consist of several insurers, not otherwise related, that join together to insure loss exposures that individual insurers are unwilling to insure.
(g) Members of these entities belong to syndicates and delegate day-to-day operations to the syndicate manager.
(h) All of the insurance pertaining to this entity is written on behalf of individual members, whose personal fortunes back the insurance.

**Solution S5-47-3.**

(a) pertains to 4. Mutual insurance companies.
(b) pertains to 8. Government insurers.
(c) pertains to 5. Reciprocal exchanges.
(d) pertains to 6. Fraternal organizations.
(e) pertains to 1. Stock insurance companies.
(f) pertains to 7. Pools.
(g) pertains to 3. Insurance exchanges.
(h) pertains to 2. Lloyd's.

**Problem S5-47-4.** Myhr and Markham, pp. 1.26-1.29, discuss the following functions of insurers:

1. Marketing
2. Underwriting
3. Claims
4. Loss control
5. Reinsurance
6. Actuarial
7. Investments
8. Information technology

Each of the following is a description that pertains primarily to one of the functions above and is explicitly discussed by Myhr and Markham, pp. 1.26-1.29. Match each description to the function to which it pertains.

(a) Calculating insurance rates, developing rating plans, and estimating loss reserves;
(b) Determining whether applications received meet the insurer's guidelines;
(c) Providing the infrastructure that supports the insurer's internal and external communications, as well as its rating, statistical, and claim payment functions;
(d) Transferring to another entity some of the insurer's potential financial consequences of certain loss exposures;
(e) Informing potential consumers about the insurer's products and services;
(f) Facilitating improved loss prevention and loss reduction;
(g) Earning returns on policyholders' premiums before the premium money is used to pay for losses;
(h) Fulfilling the insurer's contractual promises to policyholders.

**Solution S5-47-4.**

(a) is primarily an example of the actuarial function (6).
(b) is primarily an example of the underwriting function (2).
(c) is primarily an example of the information technology function (8).
(d) is primarily an example of the reinsurance function (5).
(e) is primarily an example of the marketing function (1).
(f) is primarily an example of the loss control function (4).
(g) is primarily an example of the investments function (7).
(h) is primarily an example of the claims function (3).

**Problem S5-47-5.** Myhr and Markham, pp. 1.30-1.31, discuss common ways in which the actuarial department of an insurer needs to interact with other departments. Describe some of possible ways in which the actuarial department would work with each of the following departments:
(a) Underwriting

(b) Marketing

(c) Claims

**Solution S5-47-5.**

(a) The actuarial department may work with the underwriting department in preparing the insurance rates and rating plans that the underwriting department subsequently uses and in preparing statistical information used to evaluate the underwriting department's performance. (Myhr and Markham 2004, pp. 1.30-1.31).

(b) "In determining rates and rating plans, the actuarial department must also consider the views of the marketing department about the acceptability of rates in the marketplace" (Myhr and Markham 2004, pp. 1.30-1.31).

(c) "The actuarial department is responsible for developing loss reserves for the insurer's Annual Statement. Consequently, it must maintain contact with the claim department, because the case reserves that the claim department establishes are an important element in establishing statement reserves" (Myhr and Markham 2004, pp. 1.30-1.31).

Other answers are possible, depending on the structure and functions of various insurers.
Section 48

Independent Agents and Brokers in Insurance

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Original Problems and Solutions from The Actuary’s Free Study Guide

Problem S5-48-1. Which of the following statements about independent insurance agents and brokers are true? More than one answer may be correct.

(a) Independent agents are employees of the multiple insurers whom they typically represent.
(b) Independent agents and brokers own the expirations of the policies they place with insurers and other producers.
(c) Most agency contracts do not clearly state that independent agents and brokers own the expirations of insurance policies; rather, this is assumed as a matter of custom.
(d) A flat commission on all business submitted is one way in which independent agents and brokers are typically compensated.
(e) A substantial advance fixed payment, which is not based on the volume and profitability of business submitted by the agent or broker and which suffices to pay the salary of the agent/broker for the time period in question, is one way in which independent agents and brokers are typically compensated.
(f) A contingent or profit-sharing commission based on meeting goals related to volume or profit is one way in which independent agents and brokers are typically compensated.
(g) Independent producers, such as independent agents and brokers, often provide risk management advice to their customers.

Solution S5-48-1. This question is based on the discussion in Myhr and Markham, p. 3.7. The following answers are correct:

(b) Independent agents and brokers own the expirations of the policies they place with insurers and other producers.
(d) A flat commission on all business submitted is one way in which independent agents and brokers are typically compensated.
(f) A contingent or profit-sharing commission based on meeting goals related to volume or profit
is one way in which independent agents and brokers are typically compensated. (g) Independent producers, such as independent agents and brokers, often provide risk management advice to their customers.

Statement (a) is false because independent agents are independent contractors, not employees of the insurers they represent. Statement (c) is false because the agents'/brokers' ownership of policy expirations is clearly stated in most agency contracts; however, even if it is not stated, it may still exist as a matter of custom or law. Statement (e) is false; typical payments to agents and brokers are typically dependent on the volume of business submitted, and are often dependent on the profitability of such business.

**Problem S5-48-2.** Which of the following statements about national and regional brokers are true? More than one answer may be correct.

(a) Personal lines insureds are part of the typical target market for national and regional brokers.
(b) Large commercial lines insureds are part of the typical target market for national and regional brokers.
(c) Insureds who desire specialized coverage or a particular type of coverage for multiple locations are part of the typical target market for national and regional brokers.
(d) As compensation, national and regional brokers only receive commissions and no fees.
(e) As compensation, national and regional brokers only receive fees and no commissions.
(f) As compensation, national and regional brokers can receive both commissions and fees.
(g) The compensation received by national and regional brokers is subject to regulation in the various states in which these entities operate.

**Solution S5-48-2.** This question is based on the discussion in Myhr and Markham, p. 3.9. The following answers are correct:

(b) Large commercial lines insureds are part of the typical target market for national and regional brokers.
(c) Insureds who desire specialized coverage or a particular type of coverage for multiple locations are part of the typical target market for national and regional brokers.
(f) As compensation, national and regional brokers can receive both commissions and fees.
(g) The compensation received by national and regional brokers is subject to regulation in the various states in which these entities operate.

Choices (d) and (e) cannot be correct if (f) is correct. Choice (a) is not correct, because small personal lines insureds typically purchase their insurance directly from the insurer or through independent or exclusive agents, not through brokers.

**Problem S5-48-3.** Which of the following statements about independent agent networks are true? More than one answer may be correct.

(a) Independent agent networks can operate on a local scale.
(b) Independent agent networks can operate on a national scale.
(c) Independent agent networks typically take over ownership of the member agencies and have a rigorous top-down corporate command structure.
(d) One of the benefits an independent agent network can offer to its members is the generation of additional sales income.
(e) One of the benefits an independent agent network can offer to its members is the reduction in the official number of competitors on the market, leading to higher profits for each remaining competitor.
(f) One of the benefits an independent agent network can offer to its members is expertise in financial planning services.
(g) One of the benefits an independent agent network can offer to its members is the ability for agents to also be brokers with regard to the same insured.

**Solution S5-48-3.** This question is based on the discussion in Myhr and Markham, p. 3.9. The following answers are correct:

(a) Independent agent networks can operate on a local scale.
(b) Independent agent networks can operate on a national scale.
(d) One of the benefits an independent agent network can offer to its members is the generation of additional sales income.
(f) One of the benefits an independent agent network can offer to its members is expertise in financial planning services.

Choice (c) is not correct, because independent agent networks typically allow agents-members to keep their independence and ownership of their agencies.
Choice (e) is not correct, because independent agent networks do nothing to reduce the number of competitors; instead, they are a means for existing agencies to collaborate with one another.
Choice (g) is not correct, because it would be a conflict of interest for the same individual to serve as an agent (representing an insurer) and a broker (representing an insured) for the same insured - and this is the case irrespective of whether the individual is a member of an agent network.

**Problem S5-48-4.** Which of the following statements about managing general agents (MGAs) are true? More than one answer may be correct.

(a) MGAs serve as substitutes for producers who sell insurance.
(b) MGAs serve as substitutes for insurers in performing investment and actuarial functions.
(c) MGAs serve as intermediaries between insurers and producers who sell insurance.
(d) An MGA is typically a subsidiary of either an insurer or an insurance producer.
(e) A single MGA most commonly represents several insurers.
(f) MGAs can serve as de facto branch offices for insurers.
(g) MGAs' activities are not regulated in most states.

**Solution S5-48-4.** This question is based on the discussion in Myhr and Markham, p. 3.10. The following answers are correct:

(c) MGAs serve as intermediaries between insurers and producers who sell insurance.
(e) A single MGA most commonly represents several insurers.
(f) MGAs can serve as de facto branch offices for insurers.

Choices (a) and (b) are not correct; MGAs may perform some of the functions of insurers and producers, but they are typically not substitutes for either. While MGAs do collaborate with insurers on a variety of insurance functions, actuarial and investment functions are typically not among those.
Choice (d) is not correct; MGAs are typically independent firms that contract with insurers and producers.
Choice (g) is not correct; most states regulate MGAs' contracts and activities.

**Problem S5-48-5.** Which of the following statements about excess and surplus lines (E&S) brokers are true? More than one answer may be correct.

(a) Most states require a reasonable effort to place coverage with an admitted insurer before coverage can be placed through E&S insurers.
(b) Most E&S insurers deal directly with the producer who wants to place coverage with an E&S insurer.
(c) Most E&S insurers deal with the producer who wants to place coverage with an E&S insurer through an intermediary - the E&S broker.
(d) One advantage for producers of using E&S brokers is that E&S brokers have extensive access to excess and surplus lines insurers.
(e) E&S brokers are useful in placing coverage for typical personal lines loss exposures that would also be written in the admitted market.
(f) E&S brokers are useful in placing coverage for loss exposures that require a tailored insurance program.
(g) One of the functions of E&S brokers is to help evaluate the financial security of an E&S insurer.

**Solution S5-48-5.** This question is based on the discussion in Myhr and Markham, pp. 3.10-3.11. The following answers are correct:

(a) Most states require a reasonable effort to place coverage with an admitted insurer before coverage can be placed through E&S insurers.
(c) Most E&S insurers deal with the producer who wants to place coverage with an E&S insurer through an intermediary - the E&S broker.
(d) One advantage for producers of using E&S brokers is that E&S brokers have extensive access to excess and surplus lines insurers.
(f) E&S brokers are useful in placing coverage for loss exposures that require a tailored insurance program.
(g) One of the functions of E&S brokers is to help evaluate the financial security of an E&S insurer.

Choice (b) cannot be correct if choice (c) is correct. Choice (e) is not correct, because if a coverage can readily be placed on the admitted market, placing it with excess and surplus lines insurers is typically not permitted.
Section 49

Exclusive Agents, Direct Writers, Excess and Surplus Lines Brokers, Agency Premium Billing, and General Functions of Insurance Producers

This section of the study guide is intended to provide practice problems and solutions to accompany the pages of Insurance Operations, Regulation, and Statutory Accounting, cited below. Students are encouraged to read these pages before attempting the problems. This study guide is entirely an independent effort by Mr. Stolyarov and is not affiliated with any organization(s) to whose textbooks it refers, nor does it represent such organization(s).

Some of the questions here ask for short written answers based on the reading. This is meant to give the student practice in answering questions of the format that will appear on Exam 5. Students are encouraged to type their own answers first and then to compare these answers with the solutions given here. Please note that the solutions provided here are not necessarily the only possible ones.


Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-49-1. Which of the following statements about the typical responsibilities of excess and surplus lines (E&S) brokers to comply with state regulations are true? More than one answer may be correct.

(a) As E&S brokers are not insurers, they are not subject to insurance regulations and codes.
(b) E&S brokers are typically required to maintain records of each insurance transaction and provide them to state insurance regulators upon request.
(c) E&S brokers must typically maintain a surety bond in a certain minimum amount; this amount is virtually always a fixed figure and is not dependent on the amount of business transacted by the E&S broker.
(d) If an E&S broker receives an application for insurance, he/she may, under most state laws, place coverage immediately, without regard for whether that application was previously submitted to standard/admitted insurers.
(e) E&S brokers are typically required to have both a general property-casualty license and a surplus lines license within the state in which they operate.
(f) In the notice that E&S brokers are required to provide to insureds, it must be stated that the
insurer with whom coverage is being placed is subject to guaranty fund protection.

(g) E&S brokers are responsible for remitting taxes on premiums collected to the appropriate state agency.

**Solution S5-49-1.** This question is based on the discussion in Myhr and Markham, p. 3.12. The following answers are correct:

(b) E&S brokers are typically required to maintain records of each insurance transaction and provide them to state insurance regulators upon request.

(e) E&S brokers are typically required to have both a general property-casualty license and a surplus lines license within the state in which they operate.

(g) E&S brokers are responsible for remitting taxes on premiums collected to the appropriate state agency.

Choice (a) is not correct; E&S brokers are subject to many insurance regulations and codes, since they place business with insurers.

Choice (c) is not correct; the minimum surety bond amount required is typically a percentage or portion of the insurance transacted by the E&S broker within a given time period, such as a year.

Choice (d) is not correct; according to Myhr and Markham, p. 3.12, the "E&S broker must have proof that the application for insurance was rejected by standard insurers; proof is frequently in the form of an affidavit that cites the insurers who rejected the application, the date of rejection, and the name of a contact at each rejecting insurer."

Choice (f) is not correct; in the notice that E&S brokers are required to provide to insureds, it must be stated that the insurer with whom coverage is being placed is not subject to guaranty fund protection, which is the case for all states except New Jersey. In New Jersey, state-specific requirements would apply.

**Problem S5-49-2.** Which of the following statements pertaining to the exclusive agency marketing system in insurance are true? More than one answer may be correct.

(a) Exclusive agents can be compensated by salary.
(b) Exclusive agents can be compensated by commission.
(c) Commissions paid by insurers to exclusive agents typically do not depend on whether the business being placed is new business or renewal business.
(d) Exclusive agents are mostly limited to selling policies of a single insurer.
(e) Sometimes exclusive agents may place coverage with other insurers, if the company which the agents represent does not offer the product or service that a customer requires.
(f) Just like independent agents, exclusive agents most often own the expirations of the insurance policies which they transact.
(g) If an insurer's agency contract with an exclusive agency specifies that the agency will own
the expirations of the insurance policies which they transact, and the contract is terminated, the expirations will typically continue to be owned by the agency.

**Solution S5-49-2.** This question is based on the discussion in Myhr and Markham, pp. 3.12-3.13. The following answers are correct:

(a) Exclusive agents can be compensated by salary.
(b) Exclusive agents can be compensated by commission.
(d) Exclusive agents are mostly limited to selling policies of a single insurer.
(e) Sometimes exclusive agents may place coverage with other insurers, if the company which the agents represent does not offer the product or service that a customer requires.

Choice (c) is not correct; insurers typically pay exclusive agents a higher commission rate for new business than for renewal business. This serves as an incentive to attract new business.

Choice (f) is not correct; most exclusive agents do not own the expirations of insurance policies; rather, the insurer retains this ownership.

Choice (g) is not correct; if an insurer's agency contract with an exclusive agency specifies that the agency will own the expirations of the insurance policies which they transact, and the contract is terminated, the ownership of the expirations will typically revert to the insurer.

**Problem S5-49-3.** Which of the following statements pertaining to the direct writer marketing system in insurance are true? More than one answer may be correct.

(a) The direct writer system uses sales agents that are employees of the insurers for which they sell coverage.
(b) Because the direct writer system uses employees of insurers to sell coverage, it is not common for commissions to be paid to the sales agents under this system.
(c) Sales agents in the direct writer system perform extensive administrative functions for their employers.
(d) Direct writer producers can be both employees and independent contractors.
(e) Direct writer producers do not typically have ownership of insurance policy expirations.
(f) Direct writer producers are similar to exclusive agents in terms of the limitations on which insurers they may represent.
(g) Direct writer producers are essentially the same as managing general agents (MGAs).

**Solution S5-49-3.** This question is based on the discussion in Myhr and Markham, p. 3.13. The following answers are correct:

(a) The direct writer system uses sales agents that are employees of the insurers for which they sell coverage.
(e) Direct writer producers do not typically have ownership of insurance policy expirations.
(f) Direct writer producers are similar to exclusive agents in terms of the limitations on which insurers they may represent.
Choice (b) is not correct; sales agents under the direct writer system are often compensated via salaries, commission, or a combination of both.

Choice (c) is not correct; sales agents under the direct writer system are typically relieved of administrative responsibilities by their employers.

Choice (d) is not correct; direct writer producers are employees and not independent contractors.

Choice (g) is not correct; managing general agents are intermediaries between insurers and independent producers, whereas direct writer producers are employees of the insurers which they represent.

Problem S5-49-4. Myhr and Markham, p. 3.15, discuss three methods, widely used by agencies of insurance producers, for transmitting premiums to the insurer:

1. The item basis
2. The statement basis
3. The account current basis

Each of the following situations below represents the application of one of these methods. Match the situation to the method of which it is an example. Also specify, for each situation, what would happen if the premium is not received from the insured by the agency by the premium's due date. Would the agency need to forward the premium to the insurer anyway?

(a) An insured pays a premium to the agency before its due date. As soon as the agency receives the premium, it forwards the premium to the insurer.
(b) Once every specified time period, the agency prepares a statement, wherein the premiums due to the insurer are shown. The agency then subtracts from those premiums the commissions due to the agency and forwards the remaining amount to the insurer.
(c) The insurer periodically sends the agency a bill showing how much premium is due for a given time period. After receiving the bill, the agency forwards the required amount of premium to the insurer.

Solution S5-49-4.

Situation (a) is an example of 1. the item basis. Under this method, the agency is not required to forward to the insurer premium that has not yet been received from the insured.

Situation (b) is an example of 3. the account current basis. Under this method, the agency is required to forward to the insurer premium at regular intervals, even if it has not yet been received from the insured.

Situation (c) is an example of 2. the statement basis. Under this method, the agency is required to forward to the insurer premium at regular intervals, even if it has not yet been received from the insured.
Problem S5-49-5. Give the specified number of examples for how many insurance producers are involved in each of the following functions:

(a) Customer service (give 3 examples);
(b) Claim handling (give 2 examples);
(c) Consulting (give 1 example).

Solution S5-49-5. This question is based on the discussion in Myhr and Markham, pp. 3.16-3.17. The following possible answers are provided in the text, but other answers may be possible:

(a) The following customer service functions are often performed by producers of insurance:

1. Independent agents/brokers often personalize insurance packages.
2. Direct writers often take endorsement requests over the phone.
3. Direct writers often provide coverage quotes.
4. Direct writers often transfer policyholders who have had losses to the claims department.
5. Producers can respond to billing inquiries.
6. Producers can perform customer account reviews.
7. Producers can engage in field underwriting (e.g., obtaining loss reports, motor vehicle reports, insurance credit scores, and other information).
8. Producers need to be able to respond to questions from policyholders about existing and additional coverages.
9. Producers "facilitate contacts between policyholders and insurer personnel, including premium auditors and loss control representatives."

(b) The following claim handling functions are often performed by producers of insurance:

1. Many insureds will contact the producer first when a claim occurs.
2. The producers often need to transfer insureds to the claim department or to obtain some basic information about the loss from the insured and later relay this information to the insurer.
3. Many producers have insurer authorization to adjust small claims. Most often, this authorization only pertains to first-party liability claims, but it sometimes also extends to third-party liability claims.

(c) The following consulting functions are often performed by producers of insurance:

1. Many producers offer consulting services in exchange for a fee. These services can be offered to insureds, or, less frequently, to non-insureds or prospects.
Section 50

General Underwriting Purposes, Functions, and Information in Insurance

This section of the study guide is intended to provide practice problems and solutions to accompany the pages of *Insurance Operations, Regulation, and Statutory Accounting*, cited below. Students are encouraged to read these pages before attempting the problems. This study guide is entirely an independent effort by Mr. Stolyarov and is not affiliated with any organization(s) to whose textbooks it refers, nor does it represent such organization(s).

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Source:


Original Problems and Solutions from The Actuary's Free Study Guide

**Problem S5-50-1.** Which of the following statements about underwriting authority and general underwriting concepts are true? More than one answer may be correct:

(a) Specialty insurers - such as providers of aviation insurance, livestock mortality insurers, or surety bonds - tend to centralize underwriting authority.

(b) When a producer or managing general agent (MGA) is given underwriting authority by the insurer, this typically comes with a lower commission rate, because the producer or MGA is essentially buying the right to underwrite policies at its discretion.

(c) For potential policyholders who require high limits of insurance, the insurance producer is more likely to have independent underwriting authority.

(d) Centralized and decentralized underwriting authority both ultimately serve the same essential purpose of underwriting, in terms of evaluating what loss exposures will be insured, at what prices, and under what conditions.

(e) The primary purpose of underwriting is to develop and maintain a profitable book of business for the insurer.

(f) A "book of business" refers only to the *entirety* of policies an insurer has in force. Any subgroup of these policies is called a "chapter of business".

(g) Careful underwriting procedures can minimize the phenomenon of adverse selection, which
is the phenomenon by which the individuals whose probability of loss is greatest are also the most likely to purchase insurance.

**Solution S5-50-1.** This question is based on the discussion in Myhr and Markham, p. 4.4. The following answers are correct:

(a) Specialty insurers - such as providers of aviation insurance, livestock mortality insurers, or surety bonds - tend to centralize underwriting authority.

(d) Centralized and decentralized underwriting authority both ultimately serve the same essential purpose of underwriting, in terms of evaluating what loss exposures will be insured, at what prices, and under what conditions.

(e) The primary purpose of underwriting is to develop and maintain a profitable book of business for the insurer.

(g) Careful underwriting procedures can minimize the phenomenon of adverse selection, which is the phenomenon by which the individuals whose probability of loss is greatest are also the most likely to purchase insurance.

Choice (b) is not correct; when a producer or managing general agent (MGA) is given underwriting authority by the insurer, this typically comes with a higher commission rate and a larger percentage of profits shared with the producer or MGA. This is because, by underwriting policies, the producer or MGA would be doing additional valuable work in place of the insurer.

Choice (c) is not correct; for potential policyholders who require high limits of insurance, the insurance producer is less likely to have independent underwriting authority. The potential policyholders are likelier to be referred to the insurer's underwriter(s), because writing higher limits of coverage entails greater risk.

Choice (f) is not correct; a "book of business" can refer to all the policies an insurer has in force, or to some subgroup of those policies.

**Problem S5-50-2.** Myhr and Markham, p. 4.4, describe six steps in the underwriting process:

1. Evaluating loss exposures
2. Determining underwriting alternatives
3. Selecting an underwriting alternative
4. Determining the appropriate premium
5. Implementing the underwriting decision
6. Monitoring the loss exposures

Each of the scenarios below pertains to an underwriter evaluating an application from Insured Φ, who has requested insurance on a valuable wooden figurine. Each scenario also pertains to one of the underwriting steps above. Match each scenario to the underwriting step it represents.

(a) The underwriter considers three options for how to treat Insured Φ's application:
1) Reject the application altogether as an unacceptable risk;
2) Accept the application, but charge Insured Φ a premium twice the standard level, to compensate for the unusually high level of risk involved;
3) Accept the application, but require Insured Φ to purchase a bulletproof reinforced glass case with an attached alarm system. The figurine would need to be kept within this case, which the underwriter expects would deter would-be thieves and prevent termites from getting to the figurine.

(b) The underwriter issues an insurance policy to Insured Φ on his figurine and requires the insured to pay the standard premium for such a policy, which the insured pays in full. The policy contains a manuscript endorsement, which establishes, as a condition of the policy, that Insured Φ must purchase a bulletproof reinforced glass case with an attached alarm system, in which the figurine would be kept.

(c) The underwriter's analysis shows that Insured Φ's figurine is most vulnerable to theft and to termites. In conducting the analysis, the underwriter used historical data pertaining to similar wooden figurines as well as theft and termite infestation statistics pertaining to Insured Φ's geographical area. The underwriter concludes that the current loss exposures are too risky for the insurer to accept at the standard premium level.

(d) The underwriter decides that Insured Φ will be charged the standard premium, provided that he purchases a bulletproof reinforced glass case with an attached alarm system, in which the figurine would be kept.

(e) Every year the insurance policy is in force, the underwriter works with an inspector and arranges for the inspector to visit Insured Φ's home and verify that the wooden figurine is being kept in a bulletproof reinforced glass case. The Insured is also required to submit monthly photographs of the figurine within the case, to demonstrate that the case has not been broken or sold.

(f) The underwriter decides that Insured Φ's application for insurance on the wooden figurine would be accepted, but that Insured Φ would be required to purchase a bulletproof reinforced glass case with an attached alarm system. The figurine would need to be kept within this case.

**Solution S5-50-2.**

Scenario (a) is an instance of step 2. Determining underwriting alternatives.

Scenario (b) is an instance of step 5. Implementing the underwriting decision.

Scenario (c) is an instance of step 1. Evaluating loss exposures.

Scenario (d) is an instance of step 4. Determining the appropriate premium.

Scenario (e) is an instance of step 6. Monitoring the loss exposures.

Scenario (f) is an instance of step 3. Selecting an underwriting alternative.
Problem S5-50-3. Which of the following statements about underwriting are true? More than one answer may be correct.

(a) It is typically simpler for direct writers and exclusive agents, as opposed to independent agents, to follow the explicit underwriting guidelines of the insurer they represent right away when evaluating a policyholder's application.
(b) Independent agents face the added challenge of matching their applicants for insurance with the insurers that would best serve those applicants' needs.
(c) ACORD applications are applications independently developed by each insurer in order to facilitate the maximal ability to evaluate applicants' adherence to insurer-specific underwriting guidelines.
(d) Underwriters should only consider objective information, based on recorded facts that can be verified, when evaluating an insurance application. Subjective information, based on opinions or personal impressions, should always be disregarded as irrelevant.
(e) External information, which comes from sources other than the insurer's in-house services, is often less economical and more time-consuming to access than internal information.
(f) Underwriters often use reports by independent inspectors or by loss control personnel to discover facts about an insured's safety record and physical condition (for a business or residence).
(g) Government records, such as criminal and civil court records, records of bankruptcy filings, and motor vehicle records, are protected by privacy laws and therefore may not be accessed by private insurance underwriters, even though this information might be useful in the underwriting process.

Solution S5-50-3. This question is based on the discussion in Myhr and Markham, pp. 4.6-4.7. The following answers are correct:

(a) It is typically simpler for direct writers and exclusive agents, as opposed to independent agents, to follow the explicit underwriting guidelines of the insurer they represent right away when evaluating a policyholder's application.
(b) Independent agents face the added challenge of matching their applicants for insurance with the insurers that would best serve those applicants' needs.
(e) External information, which comes from sources other than the insurer's in-house services, is often less economical and more time-consuming to access than internal information.
(f) Underwriters often use reports by independent inspectors or by loss control personnel to discover facts about an insured's safety record and physical condition (for a business or residence).

Choice (c) is not correct; ACORD applications are standardized applications developed by insurance industry committees.

Choice (d) is not correct; underwriters can usefully consider subjective information, provided that they recognize the possibility of bias contained in such information and try to supplement it with objective information and an evaluation of possible biases.

Choice (g) is not correct; the government records mentioned in the statement are typically accessible to private insurance underwriters. Privacy laws generally do not prohibit such access.
**Problem S5-50-4.** Myhr and Markham, p. 4.7, discuss financial rating services and the information they can provide to underwriters.

(a) Provide four examples of either financial rating services that underwriters use or other financial information that is typically accessible to underwriters.

(b) Provide two examples of the useful information that using financial rating services can provide to underwriters.

**Solution S5-50-4.**

(a) The four examples mentioned by Myhr and Markham, p. 4.7, are as follows:

1. Dun & Bradstreet (D&B)
2. Standard & Poor's
3. TRW
4. The 10-K form, filed with the Securities and Exchange Commission (SEC)

Other valid examples are possible.

(b) The following useful information is mentioned by Myhr and Markham, p. 4.7:

1. "Data on the credit ratings of individual business, together with industry averages for comparison."
2. Verification of an applicant's financial statements and "an overall picture of the applicant's financial status."
3. "Financial ratios used to evaluate a firm's liquidity, profitability, and debt structure."

Other valid examples are possible.

**Problem S5-50-5.** Which of the following statements about information available to underwriters are true? More than one answer may be correct.

(a) Field marketing personnel should not serve in the role of inspectors; this presents a conflict of interest.
(b) Data on the causes and dates of losses can give useful information about the seasonality of particular losses.
(c) Producers, managing general agents (MGAs), and sales managers can, at times, provide some of the same information as field marketing personnel.
(d) Premium auditors, by examining the policyholder's books, can only provide information about numerical figures of premium. A separate inspection is always required to identify possible moral or morale hazards.
(e) A claim file review can identify insureds who are making small claims that most people would attribute to normal wear and tear.
(f) Long-term results of a producer's field underwriting activity are not a reliable measure of producer performance, because producers can make proper underwriting decisions but still face a run of bad luck.
(g) Insurers typically do not consider the mix of business a producer submits to them, provided that the business has not yet resulted in unusually detrimental loss ratios.

Solution S5-50-5. This question is based on the discussion in Myhr and Markham, pp. 4.7-4.10. The following answers are correct:

(b) Data on the causes and dates of losses can give useful information about the seasonality of particular losses.

(c) Producers, managing general agents (MGAs), and sales managers can, at times, provide some of the same information as field marketing personnel.

(e) A claim file review can identify insureds who are making small claims that most people would attribute to normal wear and tear.

Choice (a) is not correct; field marketing personnel are sometimes useful in providing simplified inspection reports. There is no conflict of interest, since both field marketing personnel and inspectors would be working in the interest of the insurer.

Choice (d) is not correct; premium auditors' visits can often identify possible moral and morale hazards.

Choice (f) is not correct; while bad luck is certainly possible, long-term results tend to give at least an initial idea of how well a producer is performing. These should be considered along with other relevant measures and information.

Choice (g) is not correct; insurers often have criteria for the mix of business they wish to have, based on evaluations of how risky that mix of business can be expected to be in the future.
Section 51

General Insurance Underwriting Considerations and Procedures

This section of the study guide is intended to provide practice problems and solutions to accompany the pages of *Insurance Operations, Regulation, and Statutory Accounting*, cited below. Students are encouraged to read these pages before attempting the problems. This study guide is entirely an independent effort by Mr. Stolyarov and is not affiliated with any organization(s) to whose textbooks it refers, nor does it represent such organization(s).

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**Source:**


**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-51-1.** Myhr and Markham, p. 4.10, state that the three alternatives open to an underwriter are as follows:
1. Accept the submission as is.
2. Reject the submission.
3. Make a counteroffer to accept the submission, subject to certain modification.

If the underwriter selects alternative 3 above, what are the four major types of modifications that the underwriter could require?

**Solution S5-51-1.** According to Myhr and Markham, p. 4.10, the underwriter could do the following:

"1. Require loss control measures;

"2. Change insurance rates, rating plans, or policy limits;
Problem S5-51-2. What are the differences among experience rating, schedule rating, and retrospective rating? Define each term and state the elements that are unique to each rating approach.

Solution S5-51-2. This question is based on the discussion in Myhr and Markham, pp. 4.11-4.12. Here are the definitions of each term, as given by these authors:

**Experience rating** is "a ratemaking technique that adjusts the insured's premium for the upcoming policy period, based on the insured's experience for the current period."

**Schedule rating** is "a rating plan that awards debits and credits based on specific categories, such as the care and condition of the premises or the training and selection of employees."

**Retrospective rating** is "a ratemaking technique that adjusts the insured's premium for the current policy period, based on the insured's loss experience during the current period; paid losses or incurred losses may be used to determine loss experience."

The differences can be encapsulated as follows:

Experience rating develops the premium for time period X on the basis of the experience from time period (X-1). Also, an experience rating plan "uses three years of past loss experience, when available, and a credibility factor based on the size of the policyholder's premium to determine the modification. In comparison to other rating plans, experience rating has a formal methodology that must be applied without discrimination to all submissions that must meet experience-rating eligibility requirements" (Myhr and Markham, p. 4.11).

Retrospective rating develops the premium for time period X on the basis of the experience from time period X. Premiums are adjusted at the end of time period X; the insured incurs an additional premium charge or receives a refund on the basis of experience from period X. Retrospective rating "is an individual experience modification program" (Myhr and Markham, p. 4.12), and only current-year experience, as opposed to experience from past years, is used.

Schedule rating is not dependent on actual loss experience per se, but rather on conditions deemed by the underwriter to contribute to more or less favorable loss experience. The underwriter uses a combination of judgment and the insurance company's stated policies to decide what credits or debits to apply to the insured's premium based on the underwriter's evaluation of the insured's physical premises and practices.

Problem S5-51-3. Myhr and Markham, p. 4.13, discuss factors that need to be considered in making an underwriting decision. List five of these factors.
Solution S5-51-3. The following factors are explicitly mentioned by Myhr and Markham, p. 4.13:
1. Loss exposures contemplated in the insurance rate;
2. Loss control measures;
3. The insured's commitment to loss prevention;
4. Amount of underwriting authority required;
5. Presence of supporting business;
6. Mix of business;
7. Producer relationships;
8. Regulatory restrictions.

Other valid answers may be possible, depending on the loss exposure being underwritten.

Problem S5-51-4. Myhr and Markham, p. 4.16, discuss three steps that are involved in implementing an underwriting decision. What are these three steps? For each step, name one more specific course of action that might be required.

Solution S5-51-4. The three steps, in general, are as follows:
1. Communicating the decision;
2. Putting coverage into effect;
3. Recording information for accounting, statistical, and monitoring purposes.

For step 1, the following courses of action are possible:

i. If the underwriter decides to accept the submission with modification, he or she needs to communicate the reasons clearly to the producer and the applicant; "the applicant must agree to accept or implement the modifications" (Myhr and Markham, p. 4.16).

ii. "If the underwriter decides to reject the application, he or she must communicate the rejection to the producer in a positive way to preserve their long-term relationship. Underwriters must provide clear and logical reasons why the particular applicant does not meet the insurer's underwriting requirements" (Myhr and Markham, p. 4.16).

For step 2, the following courses of action are possible:

i. Issuing a binder;
ii. Sending a policy worksheet to the policywriting department;
iii. Preparing certificates of insurance.

For step 3, the following courses of action are possible:

i. Entering data about the policyholder's "location, limits, coverages, price modifications, and class of business" (Myhr and Markham, p. 4.16).
ii. Coding data so as to make it available for purposes of ratemaking, statutory reporting, financial accounting, and book-of-business evaluations.
iii. Using the data to "monitor the account, to trigger renewals, and to flag situations requiring special attention" (Myhr and Markham, p. 4.16).
Other answers are possible, depending on the situation in question.

**Problem S5-51-5.** Which of the following statements about monitoring loss exposures are true? More than one statement may be correct.

(a) An underwriter should distribute his resources properly so as to enable a thorough and constant monitoring of all existing individual policies, while he continues to underwrite new business.

(b) Changes in policies or the occurrence of losses on policies provide a good opportunity for an underwriter to monitor loss exposures.

(c) Premium audits, when they occur, usually accompany a renewal policy and occur simultaneously with it.

(d) Underwriters should try to obtain first-hand knowledge from insurer personnel who were involved in any premium audits of the insured.

(e) Monitoring primarily pertains to individual policies, and not to the insurer's entire book of business. Monitoring the entire book of business would be a prohibitively costly task.

(f) A poor loss ratio for a particular class of business indicates overly restrictive underwriting guidelines for that class of business.

(g) It is possible for one large loss to distort a loss ratio.

(h) Good underwriting decisions will always lead to good underwriting results.

**Solution S5-51-5.** This question is based on the discussion in Myhr and Markham, pp. 4.17-4.18. The following statements are correct:

(b) Changes in policies or the occurrence of losses on policies provide a good opportunity for an underwriter to monitor loss exposures.

(d) Underwriters should try to obtain first-hand knowledge from insurer personnel who were involved in any premium audits of the insured.

(g) It is possible for one large loss to distort a loss ratio.

Choice (a) is not correct; it is too large a task for most underwriters to continually monitor all existing policies; rather, most monitoring is done when there are policy changes, losses, premium audits, or other circumstances that bring attention to the policies in question.

Choice (c) is not correct; premium audits typically lag behind renewal policies by a few months.

Choice (e) is not correct; monitoring can be usefully done both for individual policies and at an aggregate level, for a book of business.

Choice (f) is not correct; overly restrictive underwriting is unlikely to lead to a poor loss ratio; overly permissive underwriting or inadequate rates, however, might.

Choice (h) is not correct; a major loss might not be anticipated even by the best underwriting practices. Over the long run, however, more competent underwriters will tend to develop a book of business that performs more favorably.
Section 52

General Underwriting Purposes, Functions, and Information in Insurance – Part II

This section of the study guide is intended to provide practice problems and solutions to accompany the pages of *Insurance Operations, Regulation, and Statutory Accounting*, cited below. Students are encouraged to read these pages before attempting the problems. This study guide is entirely an independent effort by Mr. Stolyarov and is not affiliated with any organization(s) to whose textbooks it refers, nor does it represent such organization(s).

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**Source:**

**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-52-1.** Myhr and Markham, pp. 4.19-4.20, discuss the differences between *line underwriters* and *staff underwriters*. Define each kind of underwriter and give two examples of responsibilities that would be performed by each.

**Solution S5-52-1.**
A *line underwriter* is an "underwriter who is primarily responsible for implementing the steps in the underwriting process" (Myhr and Markham, p. 4.19).

The following are two examples of line underwriters' activities, provided by Myhr and Markham, p. 4.19:
"1. Assisting with determining appropriate coverage;
"2. Providing service to producers and policyholders."

A *staff underwriter* is an"underwriter who is usually located in the home office and who assists underwriting management with making and implementing underwriting policy" (Myhr and Markham, p. 4.19).
The following are examples of staff underwriters' activities, provided by Myhr and Markham, p. 4.20:

"1. Researching the market;
"2. Researching and developing coverages;
"3. Evaluating underwriting experience;
"4. Reviewing and revising rating plans;
"5. Formulating underwriting policy;
"6. Developing underwriting guides;
"7. Conducting underwriting audits;
"8. Assisting with education and training."

Any two of the above would suffice as an answer.

**Problem S5-52-2.** Myhr and Markham, pp. 4.20-4.21, mention four issues of the insurance market which staff underwriters, along with actuarial and marketing departments, research. List three of these four issues.

**Solution S5-52-2.** The following four issues are explicitly mentioned by Myhr and Markham, pp. 4.20-4.21:

"1. Effect of adding or deleting entire types of business;
"2. Effect of expanding into additional states or retiring from states presently serviced;
"3. Optimal product mix (the composition of the book of business, such as the percentage of premium generated by general liability or workers' compensation policies);
"4. Premium volume goals."

Any three of the above would suffice as an answer.

**Problem S5-52-3.** Myhr and Markham, p. 4.22, mention four constraints to which underwriting is subject:
1. Financial capacity;
2. Regulation;
3. Personnel and physical resources;
4. Reinsurance.

Each of the situations below is an example of one of these four constraints. For each situation, identify the constraint it exemplifies.

(a) Insurers in virtually every state must obtain licenses to write insurance for every specific type of insurance.
(b) If an insurer wishes to transfer a loss exposure to an external entity, it may not be able to do this if it uses certain manuscript forms judged by the external entity to be too risky.
(c) An insurer has an obsolete information infrastructure and has not updated its computer systems in 10 years, therefore being unable to promptly meet consumer demand for its products.
(d) An insurer might decide to altogether stop writing a certain class of business if the loss
experience has been such that the rates are shown to be inadequate for the insurer to continue to exist if it continued to write the business.
(e) Insurers are subject to periodic market conduct examinations that determine whether or not the insurers deviated, in actual practice, from filed and approved rates and forms.
(f) An insurer's resources might be wiped out by a major catastrophic loss.
(g) An insurer may not be able to pursue writing aviation insurance if it does not have specially trained underwriters who are specifically familiar with this kind of insurance.

Solution S5-52-3.

All of the situations in this question are discussed in Myhr and Markham, pp. 4.22-4.24.

Situation (a) is an example of constraint 2. Regulation.
Situation (b) is an example of constraint 4. Reinsurance.
Situation (c) is an example of constraint 3. Personnel and physical resources.
Situation (d) is an example of constraint 1. Financial capacity.
Situation (e) is an example of constraint 2. Regulation.
Situation (f) is an example of constraint 1. Financial capacity.
Situation (g) is an example of constraint 3. Personnel and physical resources.

Problem S5-52-4. Which of the following statement about underwriting guides are true? More than one answer may be correct.

(a) Line underwriters typically develop underwriting guides.
(b) Staff underwriters typically develop underwriting guides.
(c) Once developed, an underwriting guide is expected to function throughout the insurer's existence as a complete and comprehensive document, requiring no future updates.
(d) The purpose of underwriting guides is to develop consistent and uniform guidelines for underwriting selection decisions throughout the geographic regions in which an insurer operates.
(e) The purpose of underwriting guides is to help an insurer distinguish acceptable geographic locations of insureds from unacceptable ones.
(f) If a loss exposure is classified as "worse than average" via an underwriting guide, this necessarily means that the loss exposure will be judged as being unacceptable to the insurer.
(g) Desirable methods of monitoring the underwriting decision are often incorporated into underwriting guides.

Solution S5-52-4. This question is based on the discussion in Myhr and Markham, p. 4.24. The following answers are correct:

(b) Staff underwriters typically develop underwriting guides.
(d) The purpose of underwriting guides is to develop consistent and uniform guidelines for underwriting selection decisions throughout the geographic regions in which an insurer operates.
(g) Desirable methods of monitoring the underwriting decision are often incorporated into underwriting guides.
Choice (a) is not correct; typically, underwriting guides are developed by staff underwriters to communicate information and practices to line underwriters.

Choice (c) is not correct; it is typically necessary for staff underwriters to periodically update underwriting guides based on changing external circumstances and internal policies.

Choice (e) is not correct, since the correct choice (d) states that underwriting guides help underwriters make uniform decisions throughout all the territories in which the insurer does business.

Choice (f) is not correct; some insurers even specialize in writing "worse than average" risks.

**Problem S5-52-5.** Myhr and Markham discuss underwriting audits and the use of statistical data by underwriters on p. 4.28.

(a) Define what an *underwriting audit* is.

(b) List three aspects on which a typical underwriting audit might focus.

(c) Name three ways by which statistical data analyzed by underwriters are often classified.

**Solution S5-52-5.**

(a) An *underwriting audit* is a "process in which members of an insurer's home office underwriting department examine files to see whether underwriters in branch or regional offices are following underwriting guidelines" (Myhr and Markham, p. 4.28).

(b) The following aspects on which underwriting audits focus are mentioned by Myhr and Markham, p. 4.28:

1. Proper documentation;
2. Adherence to procedure, classification, and rating practices;
3. Conformity of selection decisions to the underwriting guide and bulletins.

(c) The following classifications of statistical data are mentioned by Myhr and Markham, p. 4.28:

1. Data by type of insurance;
2. Data by class of business;
3. Data by size of loss exposure;
4. Data by territory.

Any three of the above would suffice as an answer. Other valid answers may also be possible.
Section 53

Construction and Occupancy Considerations Pertaining to Fire Risk

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Source:


Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-53-1. Six construction classes are identified by Myhr and Markham, p. 5.4:

Class 6: Fire-resistive construction;
Class 5: Modified fire-resistive construction;
Class 4: Masonry noncombustible construction;
Class 3: Noncombustible construction;
Class 2: Joisted masonry construction;
Class 1: Frame construction.

Give the definition of each type of construction.

Solution S5-53-1. The following definitions can all be found in Myhr and Markham, pp. 5.4-5.6:

Fire-resistive construction: "Construction that incorporates load-bearing members and that has a fire-resistance rating of at least two hours."
Modified fire-resistant construction: "Construction that has load-bearing members and columns of masonry or reinforced concrete construction and that has a fire-resistance rating of one to two hours."

Masonry noncombustible construction: "Masonry construction or construction that includes exterior walls of fire-resistant construction with a fire-resistance rating of not less than one hour."

Noncombustible construction: "A building of noncombustible construction has exterior walls, roof, and floor constructed of and supported by metal or noncombustible materials such as gypsum. Although these buildings are noncombustible, they are not fire-resistant."

Joisted masonry construction: "Construction that has load-bearing exterior walls made of brick, adobe, concrete, gypsum, stone, tile, or similar materials; that has floors and roofs of combustible materials; and that has a fire-resistance rating of at least one hour."

Frame construction: "Construction that has load-bearing components made of wood or other combustible materials."

Problem S5-53-2. Myhr and Markham, p. 5.8, mention eight important factors that should be considered with regard to the age of a building. Provide three of these factors.

Solution S5-53-2. The following factors are mentioned by Myhr and Markham, p. 5.8:
1. "A different building code might have been in effect when the building was constructed. Consequently, the building might lack protective features and systems generally considered essential today."
2. "Complying with current building codes might increase the cost of making repairs after a loss."
3. "Heating, cooling, electrical, and fire protection systems might be obsolete."
4. "The building might have been intended for a different occupancy and might not be suitable for its current use."
5. "Conversion and remodeling might have created concealed spaces in which could burn undetected and spread rapidly."
6. "Alterations and repairs made over the years might have left unprotected openings in vertical and horizontal firestops."
7. "The building's condition might have deteriorated for numerous reasons, including normal wear and tear, hard use, or lack of maintenance."
8. "The value of an older building might be difficult to determine, especially if the builder used construction techniques and materials that are no longer available."

Any three of the above answers would suffice.

Problem S5-53-3. Define the following elements of a building's structure, discussed by Myhr and Markham, p. 5.10:
(a) Fire division;
(b) Fire wall;
Solution S5-53-3. The following definitions are provided by Myhr and Markham, p. 5.10:

(a) **Fire division:** "A section of a structure so well protected that fire cannot spread from that section to another, or vice versa."

(b) **Fire wall:** "A wall that resists the spread of fire by serving as a fire-resistive barrier."

(c) **Parapet:** "A vertical extension of a fire wall that extends above a roofline."

(d) **Fender wall:** "An extension of a fire wall through an outer wall."

Problem S5-53-4. Myhr and Markham, pp. 5.12-5.13, define and discuss six occupancy categories. What are the six categories, and what are the defining features of each?

Solution S5-53-4. The six occupancy categories, as discussed by Myhr and Markham, pp. 5.12-5.13, are as follows:

1. **Habitation:** This category includes apartments, hotels, motels, and nursing homes.
2. **Office:** This category encompasses buildings used for office occupancy; these buildings may have unusual features, including heliports and restaurants. Typically, this is a low-hazard category, as buildings within it contain materials of relatively limited combustibility.
3. **Institution:** This category includes schools, churches, hospitals, and government property—with the exception of habitational property owned and operated by government entities. Special-purpose facilities, such as police stations, fire stations, and prisons, are also included under this category.
4. **Mercantile:** This category includes businesses that buy or sell merchandise at the wholesale or retail level. Examples include grocery stores, clothing stores, department stores, hardware stores, and specialty shops.
5. **Service:** This category includes businesses that perform a service or activity for a customer, instead of creating a product. Examples include dry cleaners and auto service stations.
6. **Manufacturing:** This category includes businesses that convert raw stock into finished products. Examples include steel manufacturers and pasta manufacturers. Depending on the item being manufactured, the hazards can vary dramatically within this category.

Problem S5-53-5. Myhr and Markham, pp. 5.13-5.14, state that three characteristics of building contents that underwriters should evaluate are 1) ignition sources, 2) combustibility, and 3) damageability.

(a) Give two examples of potential ignition sources.

(b) Give three examples of highly combustible materials.

(c) What else besides the ability to burn would damageability encompass?

Solution S5-53-5.

(a) The following four potential ignition sources are discussed by Myhr and Markham, pp. 5.13-5.14:
1. "Friendly fires that escape containment;"
2. "Friction that generates enough heat to ignite nearby combustible material;"
3. "Electricity that produces sparks or heat that can ignite exposed combustibles;"
4. Exothermic chemical reactions that produce heat sufficient to cause ignition.

Any two of the above answers suffice. Other valid answers may be possible.

(b) The following categories of highly combustible materials are discussed by Myhr and Markham, p. 5.14:
1. "Light combustible materials such as thin plywood, shingles, shavings, paper, cotton, and other fibers;"
2. "Combustible dusts such as those produced when refinishing bowling alley lanes or refining flour;"
3. "Flammable liquids;"
4. "Combustible gases such as hydrogen;"
5. "Materials subject to spontaneous combustion;"

Any three of the above answers suffice. Other valid answers may be possible.

(c) Other considerations pertaining to damageability include the ability of property to be damaged by smoke or by water used in putting out a fire.
Section 54

Occupancy Hazards, Fire Protection Classes, Fire Prevention, and Fire Detection

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Source:


Original Problems and Solutions from The Actuary's Free Study Guide

**Problem S5-54-1.** Myhr and Markham, pp. 5.15-5.16, discuss four general sources of occupancy hazards. What are these sources? For each source, give one specific example of how the source could contribute to fire-related damage.

**Solution S5-54-1.** The four sources of occupancy hazards, discussed by Myhr and Markham, pp. 5.15-5.16, are as follows:

"1. Housekeeping practices;"
"2. Heating equipment;"
"3. Electrical equipment;"
"4. Smoking."

The following **housekeeping practices** could be hazardous:

i. Uncollected litter: paper, oily items, packing materials, discarded smoking materials, accumulation of greasy soot in vents and flues;

ii. Improper storage: non-separation of materials that react with one another, combustible containers, oily materials in confined spaces;

iii. Improper disposal: dangerous incineration of waste on the insured's premises.
The following **heating equipment** could be hazardous:

i. Burners and heating elements;
ii. The equipment itself and pipes, ducts, and flues leading from it;
iii. Wood-burning stoves and salamanders (portable heaters).

The following **electrical equipment** could be hazardous:

i. Electrical equipment that is used carelessly;
ii. Electrical equipment that is improperly installed;
iii. Electrical equipment that is poorly maintained.

The following are examples of how **smoking** could be hazardous:

i. Cigarettes and cigars themselves could cause a fire;
ii. Matches used to light the cigars/cigarettes could cause a fire.

**Problem S5-54-2.** Myhr and Markham, p. 5.16, discuss the difference between *special hazards of the class* and *special hazards of the risk*. For each of the following situations, state whether the situation describes a special hazard of the class or a special hazard of the risk.

(a) The buildings owned by Ajax the tobacco manufacturer suffer roof damage because Ajax likes to skateboard on top of their roofs.
(b) A cheesecake factory owner receives a premium increase based on the insurance company's data, which show that the frequency of rodent infestations in cheesecake factories has increased in recent years.
(c) An explosives manufacturer has an added risk of explosion in his factory, in excess of the risk experienced by plastic toy manufacturers.
(d) A cheesecake factory owner receives a premium increase because he has purchased a custom-built cheesecake-making machine that cooks all cheesecakes over a tall open flame.
(e) The only manufacturer of Fuel Y in Country X receives a premium increase because of the flammability of Fuel Y.

**Solution S5-54-2.** According to Myhr and Markham, p. 5.16, *special hazards of the class* are "hazards that are typical for the class of loss exposures." *Special hazards of the risk* are "hazards that are created by the activities of a particular business and that are not typical of other businesses with which it would be classed."

Accordingly, (a) and (d) describe *special hazards of the risk*, because these situations pertain to unique characteristics of the business in question, not to characteristics that other similar businesses might also exhibit. Situations (b), (c), and (e) describe *special hazards of the class*, because other businesses engaged in similar kinds of work are also likely to have the same hazardous characteristics.

**Problem S5-54-3.** The American Association of Insurance Services (AAIS) has three public protection classifications: Protected, Partially Protected, and Unprotected. These classifications
are described by Myhr and Markham, p. 5.17. For each of the following buildings, what would be the public protection classification?

(a) A building that is within 500 feet of a fire hydrant and is within 10 road miles of a responding fire department.
(b) A building that is within 500 feet of a fire hydrant and is within 4 road miles of a responding fire department.
(c) A building that is within 1100 feet of a fire hydrant and is within 10 road miles of a responding fire department.
(d) A building that is within 1100 feet of a fire hydrant and is within 4 road miles of a responding fire department.
(e) A building that is within 2200 feet of a fire hydrant and is within 4 road miles of a responding fire department.
(f) A building that is within 20 feet of a fire hydrant and is within 6 road miles of a responding fire department.

Solution S5-54-3. The following definitions of the three AAIS public protection classifications are given by Myhr and Markham, p. 5.17:

"Protected: Building is located within 1000 feet of a fire hydrant and is within five road miles of a responding fire department.

"Partially Protected: Building is located more than 1000 feet of a fire hydrant and is within five road miles of a responding fire department.

"Unprotected: Building is located in an area that is classified as neither protected nor partially protected."

Note that any building located more than 5 road miles from a responding fire department is considered Unprotected. Any building located within 5 road miles from a responding fire department is considered either Protected or Partially Protected.

Accordingly, the following are the answers:

(a) is Unprotected.
(b) is Protected.
(c) is Unprotected.
(d) is Partially Protected.
(e) is Partially Protected.
(f) is Unprotected.

Problem S5-54-4. Give two examples of ways in which building owners can take measures to prevent fires.

Solution S5-54-4. This question is based on the discussion in Myhr and Markham, p. 5.18, where the following possibilities are mentioned:
1. Controlling heat sources via reduction or elimination thereof;
2. Using substitutes for certain dangerous heating techniques - e.g., using hot water instead of open flames;
3. Separating fuel and heat;
4. Controlling arson;
5. Controlling the use of mobile heat sources.

Any two of the above answers would suffice. Other valid answers may be possible.

**Problem S5-54-5.** Myhr and Markham, pp. 5.18-5.20, discuss five major fire detection systems. Give a brief description of each system.

**Solution S5-54-5.** The five types of major detection systems mentioned by Myhr and Markham, pp. 5.18-5.20, are as follows:

1. A guard service with a clock system: "A clock system verifies that the guard makes regular rounds. Guards carry devices that time-mark their routes through the premises" (Myhr and Markham, p. 5.19).

2. A private patrol system: "In many areas, business and industry associations provide private patrol services as a member benefit. A guard visits each business several times during the night to ensure that all doors and windows are secure and that fire has not broken out" (Myhr and Markham, p. 5.19).

3. Smoke and heat detectors: "Most smoke detectors perform independently, sounding an alarm only at the location of the detected smoke. More advanced systems connect the smoke detectors so that all the alarms sound simultaneously... Heat detectors can be operated independently of suppression devices but are most frequently combined with devices like automatic sprinkler systems. Heat detectors are slow to activate, which makes them less desirable than smoke detectors" (Myhr and Markham, p. 5.19).

4. An automatic local alarm: A local fire alarm system is "a detection system, triggered by smoke or heat, that sounds a gong, siren, or another audible alert inside or outside the building" (Myhr and Markham, p. 5.19).

5. A central station alarm or remote station system: A central station system is "a private detection service that monitors the systems of multiple businesses and/or residences and that calls appropriate authorities or dispatches its own personnel when an alarm is activated" (Myhr and Markham, p. 5.19).
Section 55

Fire Sprinkler Systems and External Fire Loss Exposures

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**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-55-1.** Myhr and Markham, p. 5.21, discuss various sprinkler systems. Give a definition of each of the following sprinkler systems:
(a) Automatic sprinkler systems;
(b) Wet pipe sprinkler systems;
(c) Dry pipe sprinkler systems;
(d) Pre-action sprinkler systems;
(e) Deluge sprinkler systems.

**Solution S5-55-1.** The following definitions are provided by Myhr and Markham, p. 5.21:
(a) **Automatic sprinkler systems** are "Fire sprinkler systems with a series of interconnected valves and pipes with sprinkler heads. Each sprinkler head usually contains a heat-sensing element that responds individually to the heat generated by a fire."
(b) **Wet pipe sprinkler systems** are "Automatic fire sprinkler systems with pipes that always contain water under pressure, which is released immediately when a sprinkler head opens."
(c) **Dry pipe sprinkler systems** are "Automatic fire sprinkler systems with pipes that contain compressed air or another inert gas that holds a valve in the water line shut until an open sprinkler head releases the gas and allows water to flow through the previously dry pipe to the sprinkler head."
(d) **Pre-action sprinkler systems** are "Automatic fire sprinkler systems with automatic valves"
controlled by smoke or heat detectors."
(e) **Deluge sprinkler systems** are "Automatic fire sprinkler systems with valves that remain open and that are controlled by an automatic fire detection device, such as a smoke or heat detector."

**Problem S5-55-2.** Name four factors that influence the severity of an exposure fire in an exposing building. (An exposing building is "one that significantly increases the possibility of fire in the insured building". An exposure fire is a "fire that erupts in an exposing building". These definitions and a discussion of the factors influencing exposure fires can be found in Myhr and Markham, pp. 5.22-5.23.)

**Solution S5-55-2.** The following twelve factors are mentioned by Myhr and Markham, pp. 5.22-5.23:
1. The intensity of the exposure fire;
2. The duration of the intensity fire;
3. "Type of construction of the exposing (adjacent) and exposed (insured) buildings";
4. "Height and width of the exposure fire";
5. "Openings in the exterior walls of the exposing and exposed buildings";
6. "Type of combustible contents in the exposure fire";
7. "Protection for openings in the walls of the exposed building";
8. "Interior finish of the exposing and exposed buildings";
9. "Distance between the exposing and exposed building";
10. "Shielding effects of noncombustible construction between the exposing and exposed buildings";
11. "Wind direction and velocity at the time of the fire";
12. "Public and private fire protection".

Any four of the above answers will suffice. Other valid answers may be possible.

**Problem S5-55-3.** Name four ways in which the probability that an external fire will spread to an insured property can be reduced. If necessary, refer to Myhr and Markham, p. 5.23.

**Solution S5-55-3.** This question is based on the discussion in Myhr and Markham, p. 5.23, where the following preventative measures/characteristics are mentioned:
1. Fire walls;
2. Fire doors;
3. Special barriers;
4. Parapets;
5. Clear space between buildings;
6. Good water supply;
7. Quick response from the fire department;
8. Internal automatic sprinkler systems;
9. External automatic sprinkler systems;

Any four of the above answers will suffice. Other valid answers may be possible.
**Problem S5-55-4.** Name six specific ways in which the loss exposure between two buildings can be reduced. If necessary, refer to Myhr and Markham, p. 5.23.

**Solution S5-55-4.** This question is based on the discussion in Myhr and Markham, p. 5.23, where the following preventative measures/characteristics are specifically mentioned:
1. "Complete automatic sprinkler system protection";
2. "Blank walls of noncombustible materials facing the exposure";
3. "Barrier walls (self-supporting) between the insured building and the exposure";
4. "Extension of exterior masonry walls to form parapets or fender walls";
5. "Automatic outside water curtains for combustible walls";
6. "Elimination of openings by filling them with construction equivalent to the wall";
7. "Glass block panels in openings";
8. "Wired glass in steel-sash windows (fixed or automatic closing) in openings";
9. "Automatic or deluge sprinklers outside over openings";
10. "Automatic (rolling steel) fire shutters on openings";
11. "Automatic fire doors on door openings";
12. "Automatic fire dampers on wall openings".

Any six of the above answers will suffice. Other valid answers may be possible.

**Problem S5-55-5.** Based on the discussion of multiple-occupancy loss exposures in Myhr and Markham, p. 5.24, answer the following questions:

(a) What is a multiple-occupancy loss exposure?
(b) What fundamental aspect of multiple-occupancy loss exposures would require them to be treated differently from single-occupancy loss exposures?
(c) What are two major considerations that underwriters take into account when evaluating multiple-occupancy buildings?

**Solution S5-55-5.**

(a) A multiple-occupancy loss exposure arises from a building where "persons other than the policyholder own or control portions of the fire division that contains the insured property" (Myhr and Markham, p. 5.24).

(b) With a multiple-occupancy loss exposure, the occupancy hazards of persons and businesses other than the policyholder, who occupy the same building, can result in an increased risk for the policyholder and correspondingly greater insurance risk. For instance, if the insured property is separated from other occupancies by a combustible wall, it is possible for a fire from a non-insured property to spread to the insured property (Myhr and Markham, p. 5.24).

(c) When evaluating multiple-occupancy buildings, underwriters consider 1) "the occupancy class of the other occupants" and 2) "the amount of protection available against fire originating in exposing occupancies" - such as whether there is a noncombustible wall, or whether there is vulnerability due to fire because of the presence of a continuous attic for the whole fire division or of fire-prone drywall partitions (Myhr and Markham, p. 5.24).
Section 56

Coinsurance Requirements for Property Insurance and the Fire, Lightning, Explosion, and Windstorm Causes of Loss

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**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-56-1.** A property insurer has a coinsurance clause, which requires the insured to purchase insurance of at least 80% of the property's insurance value in order to avoid a penalty. If the insurer does not insure up to the required amount, then the insurer only pays the fraction of any loss that is equal to the fraction of the required amount of insurance that the policyholder owns. Assume that the policyholder has purchased insurance with a limit of $460,000 and has suffered a loss of $100,000. At the time of loss, the value of the insured property was ascertained as being $800,000. How much will the insurance company pay the policyholder?

**Solution S5-56-1.** This question is based on the discussion in Myhr and Markham, pp. 5.24-5.25.

The amount of insurance the insured needed to have purchased to avoid the coinsurance penalty is 80% of $800,000, or $640,000. The insured only purchased $460,000 of insurance, or $460000/640000 = 0.71875 of the required amount. Thus, he will only get 0.71875*100000 = $71,875 of his loss paid for by the insurer.

**Problem S5-56-2.**
(a) In evaluating the risk of fire, underwriters use the COPE model. What does the COPE acronym stand for?
(b) With regard to a cause of loss, what is the amount subject?

(c) With regard to a cause of loss, what is the probable maximum loss (PML)?

(d) Which of these is always greater than or equal to the other: the amount subject or the PML?

**Solution S5-56-2.** This question is based on the discussion in Myhr and Markham, p. 5.26.

(a) COPE stands for Construction, Occupancy, Protection, and Exposure -- the four factors used to analyze the fire cause of loss.

(b) The amount subject is the "total value exposed to loss at any one location from any one event" (Myhr and Markham, p. 5.26).

(c) The probable maximum loss (PML) is "an estimate of the largest likely loss" (Myhr and Markham, p. 5.26).

(d) The amount subject is always greater than or equal to the PML. The amount subject is the total value exposed to loss, whereas the PML is an estimate of what the greatest loss is likely to be. Sometimes, actual losses can exceed the PML, as when a building that was not expected to ever suffer a total loss actually suffers such a loss. But the total value of the building - the amount subject - would not be exceeded even if a total loss occurred.

**Problem S5-56-3.** Which of the following statements about lightning damage are true? More than one answer may be correct.

(a) Insurance policies that cover property on land and in a fixed location have in virtually all cases paired coverage for lightning with coverage for fire.

(b) Lightning damage can only accompany fire damage; this is why the two coverages have historically been paired together.

(c) The insured property's plumbing system is particularly vulnerable to lightning.

(d) The insured property's electrical system is particularly vulnerable to lightning.

(e) With current technology, it is possible to completely prevent lightning damage.

(f) If the power lines entering a building have an external surge protector, it would be redundant to employ interior surge protectors on such equipment as computers within the building.

(g) The probability of lightning damage can be reduced by lightning rods.

**Solution S5-56-3.** This question is based on the discussion in Myhr and Markham, pp. 5.26-5.27. The following answers are correct:

(a) Insurance policies that cover property on land and in a fixed location have in virtually all cases paired coverage for lightning with coverage for fire.

(d) The insured property's electrical system is particularly vulnerable to lightning.

(g) The probability of lightning damage can be reduced by lightning rods.

Choice (b) is not correct; lightning damage can and does occur independently of fire damage.

Choice (c) is not correct; there is no reason for why plumbing systems would be more vulnerable to lightning than most other building components.

Choice (e) is not correct; lightning damage cannot (yet) be completely prevented, but there are many effective ways of reducing loss frequency and loss severity.
Choice (f) is not correct; some particularly intricate types of equipment, such as computers, should have their own interior surge protectors, even if an exterior surge protector is present.

**Problem S5-56-4.**
(a) What is a combustion explosion?
(b) What are two effective methods for preventing combustion explosions?
(c) What are two effective methods of minimizing damage from combustion explosions that occur?
(d) What is a pressure explosion?
(e) Give three examples of pressure vessels that are vulnerable to pressure explosion.

**Solution S5-56-4.** This question is based on the discussion of explosions in Myhr and Markham, pp. 5.27-5.28.

(a) A combustion explosion is an "explosion caused by a fire that develops so rapidly that gases expand violently and explode. Combustion explosions occur when a flammable cloud of dust, vapor, mist, or gas encounters an ignition source" (Myhr and Markham, p. 5.27).

(b) The following two effective methods for preventing combustion explosions are discussed by Myhr and Markham, p. 5.27:
1. Limiting the amount of fuel in the atmosphere;
2. Restricting the supply of oxygen that reaches the fuel.

(c) The following two effective methods of minimizing damage from combustion explosions that occur are discussed by Myhr and Markham, p. 5.27:
1. Venting, which relieves pressure on the building itself and directs the force of the explosion away from susceptible property;
2. "Isolating the potential source of an explosion by placing spaces or barriers between the source and the property that might be damaged".

(d) A pressure explosion "occurs when a container bursts because it cannot contain internal pressure" (Myhr and Markham, pp. 5.27-5.28).

(e) Some examples of pressure vessels that are vulnerable to pressure explosion, discussed by Myhr and Markham, p. 5.28, are as follows:
1. Water heaters;
2. Tanks;
3. Boilers;
4. Process equipment in manufacturing occupancies;
5. Fired kettles.
Any three of the above answers would suffice.

**Problem S5-56-5.** Which of the following statements about the windstorm cause of loss are true? More than one answer may be correct.
(a) Windstorm is a greater potential cause of loss for commercial properties than for personal properties.
(b) Windstorm is a greater potential cause of loss for personal properties than for commercial properties.
(c) The outer walls and roof of a building are the key determinants of whether that building withstands windstorm damage.
(d) Most windstorm damage actually results from wind-driven rain.
(e) Windstorm losses typically simultaneously affect large numbers of insureds.
(f) One way for an insurer to restrict its windstorm loss exposures is to focus only on one area or a few proximate areas where the insurer has thoroughly studied the history of wind damage - and to restrict the writing of coverage to that area.
(g) It is possible to take routine measures to largely immunize property against tornado damage; this includes lowering awnings and making sure that any patio furniture is securely protected.

Solution S5-56-5. Myhr and Markham, pp. 5.28-5.30. The following answers are correct:

(b) Windstorm is a greater potential cause of loss for personal properties than for commercial properties.
(c) The outer walls and roof of a building are the key determinants of whether that building withstands windstorm damage.
(e) Windstorm losses typically simultaneously affect large numbers of insureds.

Choice (a) cannot be correct if choice (b) is correct.

Choice (d) is not correct; most windstorm damage results from the effects of high wind on exposed property.

Choice (f) is not correct; the best way to minimize the impact of windstorm losses on an insurer's book of business is for the insurer to diversify geographically, so that a windstorm in one location would not be as damaging to the insurer's book of business overall. Concentrating business in a single area is probably the worst possible course of action.

Choice (g) is not correct; while the measures suggested can reduce some tornado damage, they are by no means guarantees that no damage will occur. Typically, there is little that property owners can do to be absolutely sure that a tornado will not devastate their property.
Section 57

Losses Due to Hail, Vandalism, Earthquakes, Water, and Other Perils

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**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-57-1.** Which of the following statements about hail damage are true? More than one answer may be correct.

(a) Virtually all destructive hail falls during violent thunderstorms.
(b) Damage to personal residences constitutes almost 80 percent of all hail losses.
(c) Wooden frame structures within a building are particularly susceptible to hail damage.
(d) Roofing materials are particularly susceptible to hail damage.
(e) Aluminum siding is particularly susceptible to hail damage.
(f) Hail damage can be easily prevented by purchasing special protective coverings over buildings and crops.
(g) It is possible to develop an underwriting strategy that minimizes the insurer's hail-related losses by restricting the writing of business in areas that have been historically susceptible to hailstorms.

**Solution S5-57-1.** This question is based on the discussion in Myhr and Markham, p. 5.30. The following answers are correct:

(a) Virtually all destructive hail falls during violent thunderstorms.
(d) Roofing materials are particularly susceptible to hail damage.
(e) Aluminum siding is particularly susceptible to hail damage.
(g) It is possible to develop an underwriting strategy that minimizes the insurer's hail-related
losses by restricting the writing of business in areas that have been historically susceptible to hailstorms.

Choice (b) is not correct; nearly 80 percent of all hail losses are damage to crops.

Choice (c) is not correct; the internal structure of a building is less vulnerable to hail than external elements like roofs and siding.

Choice (f) is not correct; with present technology, there are few viable measures that can prevent hail damage.

**Problem S5-57-2.** Which of the following statements about damage due to vandalism and malicious mischief are true? More than one answer may be correct.

(a) Vandalism is more common in rural areas than in urban areas.
(b) Vandalism is more likely to be committed by individuals between the ages of 25 and 40 than by members of any other age group.
(c) Schools can be particular targets for vandalism.
(d) Nursing homes can be particular targets for vandalism.
(e) Vacant property tends to attract vandals.
(f) Vandalism tends to produce losses that are relatively infrequent, but quite severe when they occur.
(g) Vandalism tends to produce losses that are quite frequent, but typically not severe when they occur.
(h) Vandalism losses are typically neither frequent nor severe.
(i) Of the two underwriting concerns for vandalism, frequency is a greater concern than severity.
(j) Of the two underwriting concerns for vandalism, severity is a greater concern than frequency.

**Solution S5-57-2.** This question is based on the discussion in Myhr and Markham, p. 5.31. The following answers are correct:

(c) Schools can be particular targets for vandalism.
(e) Vacant property tends to attract vandals.
(h) Vandalism losses are typically neither frequent nor severe.
(i) Of the two underwriting concerns for vandalism, frequency is a greater concern than severity.

Choice (a) is not correct; vandalism is more common in urban areas than in rural areas.

Choice (b) is not correct; vandalism is more likely to be committed by children and young adults than by members of any other age group.

Choice (d) is not correct; vandals generally do not target institutions that primarily cater to the elderly; they tend to target institutions where there is a high concentration of young people.

Choices (f) and (g) cannot be correct if choice (h) is correct. Likewise, choice (j) cannot be correct if choice (i) is correct.
Problem S5-57-3. The following questions pertain to water damage.
(a) Name two types of water damage against which many homeowners' insurance policies provide coverage.
(b) What typically causes the types of water damage in part (a)? Name two possible sources.
(c) Name one type of water damage against which most homeowners' insurance policies do not provide coverage. Briefly, what is the rationale for excluding it?
(d) In the United States, what entity does often provide coverage for the type of water damage in part (c)?
(e) What are six kinds of the type of water damage in part (c), as discussed by Myhr and Markham, p. 5.33?

Solution S5-57-3.

(a) Two types of water damage against which many homeowners' insurance policies provide coverage are as follows, according to Myhr and Markham, p. 5.32:

1. Accidental discharge, overflow, or leakage of water;
2. Steam from plumbing, heating, and cooling systems.

(b) The two possible sources of the water damage types in part (a) are as follows, according to Myhr and Markham, p. 5.32:

1. Poor maintenance;
2. Flat roofs, where water can soak through the roof covering.

(c) Flood is a type of water damage against which most homeowners' insurance policies do not provide coverage. This is because flood losses tend to be catastrophic.

(d) In the United States, the National Flood Insurance Program (NFIP), a part of the Federal Emergency Management Administration (FEMA), is the largest underwriter of flood insurance.

(e) The six types of floods, as discussed by Myhr and Markham, p. 5.33, are as follows:

1. Riverine floods that "occur when rivers, streams, and other watercourses rise and overflow their banks";
2. Tidal floods that "arise from high tides, frequently driven by high winds offshore, and from tropical storms making landfall or passing closely offshore";
3. Wind floods that "occur whenever a strong wind holds back a large body of water from its normal drainage course and raises the water level";
4. Backwater floods that are caused by "rising water levels downstream" that "prevent drainage upstream";
5. **Floods due to ice jams** that are caused when an ice jam blocks the flow of water and then breaks suddenly and causes flooding downstream;

6. **Accidental floods** that "are caused by the failure of flood control systems," such as dam breakage or blocked floodgates.

**Problem S5-57-4.** The following questions pertain to earthquake damage.

(a) What are the three major earthquake underwriting considerations, discussed by Myhr and Markham, p. 5.34?

(b) What is the most seismically active area in the United States?

(c) Name one category of soil upon which buildings are superior at withstanding earthquake damage.

(d) Name one category of soil upon which buildings do not withstand earthquake damage well.

(e) What kind of stresses do earthquakes cause - horizontal stresses or vertical stresses? What kinds of stresses are most buildings designed to bear?

(f) Classify the following kinds of construction into types that typically withstand earthquake damage well and types that typically do not withstand earthquake damage well:

   (i) Joisted masonry construction;
   (ii) Frame construction;
   (iii) Brick facing;
   (iv) Stone veneer;
   (v) Tile roofs;
   (vi) Tilt slab construction;
   (vii) Fire-resistive construction.

**Solution S5-57-4.**

(a) The three major earthquake underwriting considerations, discussed by Myhr and Markham, p. 5.34, are as follows:

"1. Areas of earthquake activity;
2. Soil conditions;
3. Building design and construction."

(b) "The Pacific Coast from Alaska to California is the most seismically active area in the United States" (Myhr and Markham, p. 5.34). 90 percent of U. S. earthquakes occur in California and western Nevada.

(c) Buildings on **consolidated soil**, such as limestone and certain kinds of clay, are superior at withstanding earthquake damage (Myhr and Markham, p. 5.34).

(d) Buildings on **unconsolidated soil**, such as sand, gravel, silt, and certain other kinds of clay, are inferior at withstanding earthquake damage. Also, buildings on **filled land**, particularly unconsolidated filled land, are particularly vulnerable during an earthquake (Myhr and Markham, p. 5.34).
(e) Earthquakes cause **horizontal stresses**, whereas most buildings are designed to bear **vertical stresses** (Myhr and Markham, p. 5.34).

(f) This question is based on the discussion in Myhr and Markham, pp. 5.34-5.36.

The following types of construction typically **withstand earthquake damage well**:

(ii) Frame construction;
(vii) Fire-resistive construction.

The following types of construction typically **do not withstand earthquake damage well**:

(i) Joisted masonry construction;
(iii) Brick facing;
(iv) Stone veneer;
(v) Tile roofs;
(vi) Tilt slab construction;

**Problem S5-57-5.**
(a) List three common causes of building collapse.
(b) Name five other causes of loss, against which property insurance often exists, that have not been discussed in this section or in Sections 53-57 of this study guide.

**Solution S5-57-5. (a)** According to Myhr and Markham, p. 5.36, the following are common causes of building collapse:
1. Weight of ice, snow, or sleet;
2. Defective design or construction;
3. Deterioration;
4. Weight of people, personal property, or water;
5. Rain water accumulating on flat roofs when drains are blocked;
6. The cumulative effect of vibration.

Any three of the above answers would suffice. Other valid answers may be possible.

**Solution S5-57-5. (b)** According to Myhr and Markham, p. 5.37, the following are additional causes of loss against which property insurance sometimes protects:
1. Riot and civil commotion;
2. Sprinkler leakage;
3. Sinkhole collapse;
4. Mine subsidence;
5. Volcanic action;
6. Terrorism;
7. Theft.

Any five of the above answers would suffice. Other valid answers may be possible.
Section 58

Concepts Pertaining to Legal Liability and Commercial Liability Insurance

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Source:


Original Problems and Solutions from The Actuary's Free Study Guide

**Problem S5-58-1.** Myhr and Markham, p. 6.5, discuss the difference between an invitee, a licensee, and a trespasser. Classify each of the following persons into one of these three categories:

(a) A contractor doing work on a person's house;

(b) A guest to a party at a person's house;

(c) A home robber;

(d) A customer who enters a store;

(e) A police officer who enters a home because of a possible threat to the owner;

(f) A visitor to an open exhibition at a museum.

(g) A person who enters a store just to look around, without the intention of buying anything.

**Solution S5-58-1.**

An invitee is "a person who enters the premises for the owner's or the occupant's financial benefit" (Myhr and Markham, p. 6.5). This is the case even if no transaction ultimately occurs (as in the case of a customer who does not buy anything). Any member of the public who enters premises open to the public is also an invitee. A licensee is "any other person who enters the premises with permission" (Myhr and Markham, p. 6.5), where the premises would not be
legitimately accessible without such permission. A trespasser is someone who enters the premises without permission. Accordingly, the following are the answers:

Person (a) is an invitee;
Person (b) is a licensee;
Person (c) is a trespasser;
Person (d) is an invitee;
Person (e) is a licensee;
Person (f) is an invitee;
Person (g) is an invitee.

Problem S5-58-2. Give three examples of relationships where one party might assume vicarious liability for the actions of another party.

Solution S5-58-2. The following five examples of relationships exhibiting vicarious liability are given by Myhr and Markham, p. 6.5:

1. A principal-agent relationship;
2. An employer-employee relationship;
3. A parent-child relationship;
4. A contractual relationship;
5. A partnership.
Any three of the above answers would suffice.

Problem S5-58-3. Name the five liability coverages that are encompassed under commercial general liability insurance.

Solution S5-58-3. This question is based on the discussion in Myhr and Markham, p. 6.7. The following are the five coverages that are included in commercial general liability insurance policy:

1. Premises and operations liability;
2. Personal and advertising injury liability;
3. Premises medical payments liability;
4. Contractual liability;
5. Products and completed operations liability.

Problem S5-58-4. Myhr and Markham, p. 6.9, discuss three kinds of physical hazards pertaining to premises and operations liability loss exposures:

1. Common hazards;
2. Special hazards of the class;
3. Special hazards of the risk.

Classify each of the following hazards as one of the above types.
(a) Explosion risk at a dynamite factory;
(b) Poor lighting;
(c) Defective electrical equipment;
(d) Toxic chemicals involved in the manufacture of a kind of pesticide;
(f) Congested aisles;
(g) Uneven stairs;
(h) The presence of an experimental water slide inside an amusement park;
(j) An angry pit bull whom the owner keeps on the premises of a department store as a mascot.

**Solution S5-58-4.** Common hazards can occur at any premises, irrespective of the type of business involved. The following are examples of common hazards:

(b) Poor lighting;
(c) Defective electrical equipment;
(f) Congested aisles;
(g) Uneven stairs.

Special hazards of the class occur because of a type of activity common to an entire class of businesses. The following are examples of special hazards of the class:

(a) Explosion risk at a dynamite factory;
(d) Toxic chemicals involved in the manufacture of a kind of pesticide.

Special hazards of the risk are not commonly encountered in businesses of a similar sort; they are, rather, particular to the operation in question. The following are examples of special hazards of the risk:

(h) The presence of an experimental water slide inside an amusement park;
(j) An angry pit bull whom the owner keeps on the premises of a department store as a mascot.

**Problem S5-58-5.** Which of the following statements about the loss exposures of contractors are true? More than one answer may be correct.

(a) Contractors typically have large premises loss exposures, but small operations loss exposures.
(b) Contractors typically have small premises loss exposures, but large operations loss exposures.
(c) Contractors typically have both large premises loss exposures and large operations loss exposures.
(d) Under common law, a person who hires an independent contractor to do work is liable for that contractor's acts.
(e) Courts have ruled in some cases that independent contractors are *de facto* employees.
(f) With proper delegation of responsibility, a business can exempt itself from vicarious liability arising out of the selection of independent contractors.
(g) Commercial general liability insurance typically provides coverage for an insured's liability for the actions of contractors and subcontractors.
(h) If a contractor which hires subcontractors is being insured, and the subcontractors fail to
provide proof of their own insurance, then the insurer will typically refuse to continue to insure the contractor and will cancel that contractor's policy.

**Solution S5-58-5.** This question is based on the discussion in Myhr and Markham, pp. 6.9-6.11. The following answers are correct:

**(b)** Contractors typically have small premises loss exposures, but large operations loss exposures.

**(e)** Courts have ruled in some cases that independent contractors are *de facto* employees.

**(g)** Commercial general liability insurance typically provides coverage for an insured's liability for the actions of contractors and subcontractors.

Choices (a) and (c) cannot be correct if choice (b) is correct.

Choice (d) is not correct; under common law, individuals typically have immunity for the actions of independent contractors.

Choice (f) is not correct; some vicarious liability, particularly arising from the selection of independent contractors, cannot be readily delegated away.

Choice (h) is not correct; in the situation described, the insurer will typically charge the contractor a premium equivalent to what would have been charged if the subcontractors were the contractor's employees.
Section 59

Personal and Advertising Injury Loss Exposures, Premises Medical Payments Loss Exposures, Hold-Harmless Agreements, and Products Liability Loss Exposures

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Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-59-1. Which of the following statements about personal and advertising injury loss exposures are true? More than one answer may be correct.

(a) Coverage for personal and advertising injury is excluded from most commercial general liability insurance policies, unless it is included via an endorsement.
(b) Insurance underwriters typically do not evaluate personal and advertising injury loss exposures closely, except in special cases where such losses are likely to occur frequently.
(c) Infringement of copyright is an example of personal and advertising injury.
(d) Bodily injury inflicted during an automobile accident is an example of personal and advertising injury.
(e) Wrongful arrest is an example of personal and advertising injury.
(f) Libel and slander are examples of personal and advertising injury.
(g) Commercial general liability policies typically exclude personal and advertising injury coverage for businesses that engage in advertising as a primary occupation.
Solution S5-59-1. This question is based on the discussion in Myhr and Markham, p. 6.11. The following answers are correct:

(b) Insurance underwriters typically do not evaluate personal and advertising injury loss exposures closely, except in special cases where such losses are likely to occur frequently.

(c) Infringement of copyright is an example of personal and advertising injury.

(e) Wrongful arrest is an example of personal and advertising injury.

(f) Libel and slander are examples of personal and advertising injury.

(g) Commercial general liability policies typically exclude personal and advertising injury coverage for businesses that engage in advertising as a primary occupation.

Choice (a) is not correct; coverage for personal and advertising injury is included in most commercial general liability insurance policies, unless it is excluded via an endorsement.

Choice (d) is not correct; bodily injury in an automobile accident is not included under personal and advertising injury.

Problem S5-59-2. The following questions pertain to premises medical payments loss exposures.

(a) Do underwriters typically provide premises medical payments coverage on a stand-alone basis? If not, with what category of loss exposures are premises medical payments loss exposures typically identified?

(b) For what does premises medical payments coverage provide payment?

(c) What legal liability must exist on the policyholder's part in order for premises medical payments coverage to apply in a particular situation?

Solution S5-59-2. This question is based on the discussion in Myhr and Markham, pp. 6.11-6.12. The following answers are correct:

(a) Underwriters typically do not provide premises medical payments coverage on a stand-alone basis; rather, premises medical payments loss exposures are typically identified as a subset of premises and operations loss exposures.

(b) Premises medical payments coverage pays for "medical expenses of persons other than the insured who are injured on the policyholder's premises or because of the policyholder's operations" (Myhr and Markham, p. 6.12).

(c) There is no requirement that the policyholder must be liable in order for premises medical payments coverage to apply in a particular situation.

Problem S5-59-3. (a) What is a hold-harmless agreement? What are the two parties to a hold-harmless agreement called?

(b) What are two limitations of hold-harmless agreements?
Solution S5-59-3. This question is based on the discussion in Myhr and Markham, p. 6.12. The following answers are correct:

(a) A hold-harmless agreement is a contractual provision where one party, the indemnitor, assumes the legal liability of the other party, the indemnitee.

(b) The following two limitations of hold-harmless agreements are discussed by Myhr and Markham, p. 6.12:

1. Often, the parties to a hold-harmless agreement assume that the indemnitor takes on the entire liability of the indemnitee and that the indemnitor's liability insurance policy will protect both parties from losses due to liability. However, some aspects of certain hold-harmless agreements fall entirely outside the scope of liability insurance.

2. Some courts have not upheld hold-harmless agreements, on the grounds that they are vague and that extremely broad transfers of liability violate public policy.

Problem S5-59-4. Identify and briefly describe the three sources of products liability.

Solution S5-59-4. This question is based on the discussion in Myhr and Markham, p. 6.13. The following sources of products liability are mentioned there:

1. Breach of warranty: "Source of liability based on laws that protect consumers who purchase products that do not perform as expected" (Myhr and Markham, p. 6.13).

2. Negligence: This often arises out of a failure of the product's manufacturer to give adequate warning about potential dangers of the product.

3. Strict liability: This "is the most common basis for products liability suits; it imposes liability on any person who produces an unreasonably dangerous product" (Myhr and Markham, p. 6.13).

Problem S5-59-5. Give five examples of questions that underwriters ask in examining products liability loss exposures.

Solution S5-59-5. The following questions are identified by Myhr and Markham, p. 6.14:

1. "What are the product's inherent hazards?"
2. "What representations or promises are made to the consumer in the sales material and advertising?"
3. "Do technical manuals for complex products accurately reflect the safety precautions required in the product's assembly and repair?"
4. "Does the product's packaging adequately protect the product so that it will operate properly when used?"
5. "Are the instructions easy to read and understand?"
6. "Does the product's warranty overstate the capability of the product?"
7. "Are loss control efforts introduced into the product's design and production phases?"
8. "Is a complaint-handling system in place to identify flaws and prevent injury and damage?"
9. "Are quality-control checks incorporated into the product's manufacture?"
10. "Are accurate records kept of products and components so that defective products can be identified and recalled?"
11. "Have product lines changed to increase the inherent hazards?"
12. "What is the applicant's position in the channel of distribution?"
13. "Who is the product's ultimate consumer?"

Any five of the above suffice as an answer. Other valid answers may be possible.
Section 60

Completed Operations Loss Exposures, Professional Liability Insurance, Personal Liability Insurance, and Laws Pertaining to Automobile Insurance

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Source:


Original Problems and Solutions from The Actuary's Free Study Guide

**Problem S5-60-1.** The following questions pertain to completed operations loss exposures:

(a) Give three examples of activities that involve completed operations loss exposures.

(b) Are businesses with premises loss exposures or businesses with operations loss exposures more likely to have completed operations loss exposures?

(c) Give three examples of considerations underwriters use when evaluating completed operations loss exposures.

**Solution S5-60-1.** This question is based on the discussion in Myhr and Markham, pp. 6.14-6.15.

(a) The following examples of activities that involve completed operations loss exposures are mentioned by Myhr and Markham, p. 6.14:
1. Construction;  
2. Service;  
3. Repair;  

Any three of the above suffice as an answer. Other valid answers may be possible.

(b) Businesses with **operations loss exposures** more likely to have completed operations loss exposures. What is known as "operations" loss exposures can also be referred to as loss exposures for work in progress. When this work is completed, the business can continue to have completed operations loss exposures - for instance, arising from a house that was built by a construction contractor or a product made by a manufacturer.

(c) The following examples of considerations underwriters use when evaluating completed operations loss exposures are mentioned by Myhr and Markham, p. 6.15:

1. Quality of workmanship;  
2. Quality of equipment;  
3. Supervision of employees;  
4. Technical skill found within the business;  
5. Reputation of the business;  
6. Experience found within the business;  
7. Type of business performed;  
8. Frequency of potential losses;  

Any three of the above answers suffice. Other valid answers may be possible.

**Problem S5-60-2.** The following questions pertain to professional liability insurance:

(a) Give three examples of different kinds of professional liability insurance.

(b) Give two examples of loss exposures typically covered by professional liability insurance.

**Solution S5-60-2.** This question is based on the discussion in Myhr and Markham, p. 6.16.

(a) The following kinds of professional liability insurance are mentioned by Myhr and Markham, p. 6.16:

1. Medical professional liability (medical malpractice) insurance;  
2. Errors and omissions insurance for accountants, attorneys, insurance agents, brokers, and other professionals;  
3. Directors' and officers' liability insurance;  
4. Fiduciary liability insurance;  
5. Employment practices liability insurance.
Any three of the above answers suffice. Other valid answers may be possible.

(b) The following examples of loss exposures typically covered by professional liability insurance are mentioned by Myhr and Markham, p. 6.16:

1. Mistakes;
2. Errors or omissions in rendering professional service;
3. Wrongful acts.

Any two of the above answers suffice. Other valid answers may be possible.

Problem S5-60-3. You are aware of two policies of professional liability insurance. Each covers the same perils. Policy A is written on an occurrence basis and has a term from January 1, 2302, to January 1, 2304. Policy B is written on a claims-made basis and has the same term: from January 1, 2302, to January 1, 2304, with a retroactive date of January 1, 2301. Suppose that the following losses from covered perils occurred:

(a) A loss occurs on March 3, 2300. A claim on the loss is submitted on June 5, 2303.
(b) A loss occurs on October 30, 2303. A claim on the loss is submitted on May 4, 2305.
(c) A loss occurs on November 1, 2302. A claim on the loss is submitted on January 3, 2303.
(d) A loss occurs on January 11, 2301. A claim on the loss is submitted on October 15, 2302.

Under which policies would each loss be covered, if these insurance policies applied to the insured?

Solution S5-60-3. Myhr and Markham, p. 6.16, discuss the difference between occurrence coverage and claims-made coverage. Under a policy that offers occurrence coverage, a loss must have taken place within the policy term in order to be covered. Under claims-made coverage, a claim must have been made within the policy term, and the loss must have occurred after the retroactive date of the policy.

Loss (a) would not be covered under Policy A, because the loss occurred prior to the term of the policy. It would also not be covered under Policy B, because the loss occurred prior to the retroactive date of the policy. Thus, Loss (a) would not be covered by either policy.

Loss (b) would be covered by Policy A, because the loss occurred within the term of the policy. However, the loss would not be covered by Policy B, because the claim was submitted after the policy term had ended. Thus, Loss (b) would be covered by Policy A, but not by Policy B.

Loss (c) would be covered by Policy A, because the loss occurred within the term of the policy. The loss would also be covered by Policy B, because the claim was submitted within the policy term. Thus, Loss (c) would be covered by both Policy A and Policy B.

Loss (d) would not be covered by Policy A, because the loss occurred prior to the term of the policy. However, it would be covered by Policy B, because the loss occurred after the retroactive date, and the claim was submitted within the policy term. Thus, Loss (d) would be covered by Policy B, but not by Policy A.
Problem S5-60-4. The following questions pertain to personal liability loss exposures:

(a) What is an attractive nuisance?

(b) Give three examples of common hazards on the premises of a personal residence.

(c) How is personal liability insurance typically provided?

Solution S5-60-4.

(a) An attractive nuisance is a "potentially harmful object or structure so inviting or interesting to children that it would lure them onto someone's premises" (Myhr and Markham, p. 6.19).

(b) The following examples of common hazards on the premises of a personal residence are mentioned by Myhr and Markham, p. 6.19:

1. Uneven sidewalks;
2. Icy sidewalks;
3. Poorly maintained steps;
4. Poorly maintained porches;
5. Poorly lighted hallways;
6. Large sliding glass doors without a way to call attention to the glass.

Any three of the above answers suffice. Other valid answers may be possible.

(c) Personal liability insurance is typically provided as part of a homeowner's insurance policy or another package that includes property insurance. It is seldom sold alone; when it is, it is sold for a relatively low premium (Myhr and Markham, pp. 6.18-6.19).

Problem S5-60-5. List four kinds of laws that some regulatory jurisdictions have developed in an attempt to ensure that financial resources are available to compensate auto accident victims.

Solution S5-60-5. The following examples of such laws are provided by Myhr and Markham, p. 6.21:

1. Financial responsibility laws;
2. Compulsory auto liability insurance laws;
3. Laws providing for shared market mechanisms (e.g., residual markets, state funds, etc.);
4. Mandatory uninsured motorists' coverage;
5. No-fault automobile laws;
6. Restrictions on cancellations and nonrenewals.

Any four of the above answers suffice. Many states do not have one or more of the above types of laws. Other valid answers may be possible.
Section 61

Personal Automobile and Commercial Automobile Loss Exposures

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**Source:**


**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-61-1.** Myhr and Markham, pp. 6.22-6.23, discuss four types of residual market mechanisms. Name and briefly describe each type.

**Solution S5-61-1.** The following types of residual market mechanisms are discussed by Myhr and Markham, pp. 6.22-6.23:

1. **Automobile insurance plans:** These plans, also known as *assigned risk plans*, assign drivers to insurers who are members of the plan. Each insurer is typically required to accept the risks assigned to it.

2. **Joint underwriting associations:** "Joint underwriting associations (JUAs) operate as insurers. They appoint servicing insurers to handle all insurer functions. State law usually requires all insurers that write auto coverage to participate in a JUA. JUA profits and losses are evenly distributed among insurers based on their voluntary market share" (Myhr and Markham, p. 6.23).

3. **Reinsurance facilities:** This arrangement requires insurers to accept all applicants with a valid driver's license. However, for high-risk applicants, "the underwriter has the option of assigning
the driver's premiums and losses to the reinsurance facility. The profits or losses on those policies are shared evenly among all insurers” (Myhr and Markham, p. 6.23).

4. **State funds:** This is a state-run organization that functions as a residual market insurer. It collects premiums, pays claims, and can be self-sustaining.

**Problem S5-61-2.**

(a) What are typical coverages required by no-fault automobile laws in some states? Give two examples.

(b) How might an injured party's right to sue be affected by no-fault automobile laws in some states?

**Solution S5-61-2.**

(a) The following typical coverages required by no-fault automobile laws in some states are discussed by Myhr and Markham, p. 6.24:

1. First-party medical coverage for automobile accident victims;
2. Loss of earnings coverage for automobile accident victims;
3. Survivors' benefits;
4. Funeral benefits;
5. Payment for replacement services required by the injured party.

Any two of the above answers suffice. Other valid answers may be possible.

(b) Some restrictions on the insured's right to sue are a result of many no-fault automobile laws, which are intended to reduce lawsuits arising out of automobile accidents. Some states allow insureds to waive their rights to sue in most circumstances, in exchange for a lower premium (Myhr and Markham, p. 6.23).

**Problem S5-61-3.** List five factors commonly considered by underwriters in evaluating personal automobile loss exposures.

**Solution S5-61-3.** The following factors are mentioned by Myhr and Markham, p. 6.25:

1. Age of operator;
2. Age of automobile;
3. Type of automobile;
4. Automobile use;
5. Driving record;
6. Territory;
7. Gender;
8. Marital status;
9. Occupation;
10. Personal characteristics;
11. Physical condition of driver;
12. Safety equipment;
13. Credit-based insurance scores (used by many insurers - but highly controversial).

Any five of the above answers suffice. Other valid answers may be possible, depending on the practices of specific insurers.

**Problem S5-61-4.** The following questions pertain to commercial automobile loss exposures.

(a) Why is considering the weight of the vehicle particularly important for commercial vehicles?

(b) The ISO Commercial Lines Manual (CLM) separates trucks and tractor-trailers into three categories based on their use. What are these three categories, and what are the criteria for membership in each?

(c) Which of the categories in part (b) receives the lowest rate? Which receives the highest rate? Why?

(d) Give three reasons for why truckers operated over longer distances may have more severe accidents than locally operated trucks.

(e) Myhr and Markham, pp. 6.31-6.32, discuss seven special industry classifications, or secondary classifications, of commercial vehicles. Name and define four of these classifications.

**Solution S5-61-4.**

(a) Considering the weight of the vehicle is particularly important for commercial vehicles because many commercial vehicles are extremely heavy - such as large trucks and tractor-trailer rigs - and often travel at high speeds. If an accident occurs, these vehicles are more likely to cause severe damage. Larger vehicles are also harder to navigate in heavy traffic or on small streets; this increases the likelihood of loss (Myhr and Markham, p. 6.30).

(b) The three categories in the ISO CLM are as follows:

1. **Service use:** This category describes "vehicles that are used principally to transport personnel or material to job sites. These vehicles are often driven to job sites at the start of a shift and remain there until the shift is over" (Myhr and Markham, p. 6.30).

2. **Retail use:** This category describes vehicles that are "used primarily for deliveries to and pickups from households" (Myhr and Markham, p. 6.31).

3. **Commercial use:** This category describes vehicles that are classified as neither "Service use" nor "Retail use".
(c) **Service use** vehicles receive the **lowest rate**, because they are typically driven to the job site and remain there until the end of the applicable shift; this means that they are used less during the course of the day. **Retail use** vehicles receive the **highest rate**, because they are typically driven throughout the day, along unfamiliar routes, and on demanding schedules.

(d) The following three reasons are given by Myhr and Markham, p. 6.31:
1. "A driver who operates a truck over long distances might not be as familiar with the route and its hazards as are drivers who operate trucks locally."
2. "Long-distance driving is more likely to be more strictly scheduled. If drivers are rushing to meet a delivery deadline, resulting fatigue and excessive speeds can increase accident frequency."
3. "Because long-haul trucks are large and usually travel at high speeds, they are typically involved in more severe accidents than trucks used within a city or town."

Other valid reasons may be possible.

(e) The following special industry classifications are described by Myhr and Markham, pp. 6.31-6.32:

1. **Truckers**: "Vehicles used to transport the goods or materials of others; this does not include moving household goods, office furniture, or fixtures and supplies."
2. **Food delivery**: "Vehicles that wholesale food distributors and food manufacturers use to transport raw and finished products."
3. **Specialized delivery**: "Delivery vehicles such as armored cars or autos for delivering film, magazines or newspapers, mail and parcel post, and similar items."
4. **Waste disposal**: "Vehicles transporting waste material for disposal or resale."
5. **Farmers**: "Vehicles owned by farmers and used in farming operations."
6. **Dump and transit mix trucks and trailers**: "Vehicles that have no other appropriate classification and that have an incidental dumping operation."
7. **Contractors**: "All vehicles used by contractors, other than dump trucks."

Any four of the above items suffice as answers.

**Problem S5-61-5.** Give three examples of useful information that an insurer can gather from a loss control report pertaining to commercial automobile loss exposures.

**Solution S5-61-5.** The following examples of useful information are discussed by Myhr and Markham, pp. 6.32-6.33:

1. The policyholder's accident record;
2. Small losses that are not directly reported to insurers because of high commercial automobile deductibles;
3. Frequency of theft and vandalism losses;
4. Location of losses.

Any three of the above answers suffice. Other valid answers may also be possible.
Section 62

Underwriting Considerations Pertaining to Workers' Compensation Insurance

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**Source:**


**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-62-1.** The following questions pertain to workers' compensation insurance and employers' liability insurance.

(a) List three types of benefits made available under workers' compensation insurance.

(b) What does employers' liability insurance cover?

(c) Does a standard workers' compensation / employers' liability insurance policy cover all perils not specifically excluded or only those perils that are specifically listed?

**Solution S5-62-1.**

(a) The following four types of benefits made available under workers' compensation insurance are mentioned by Myhr and Markham, p. 6.33:

1. Death benefits;
2. Disability income;
3. Medical expense;
4. Rehabilitation expense.
Any three of the above answers would suffice.

(b) Employers' liability insurance covers "employers for their legal liability to an employee for bodily injury arising out of and in the course of employment that is not covered under the workers' compensation law" (Myhr and Markham, p. 6.34).

(c) A standard workers' compensation / employers' liability insurance policy covers all perils not specifically excluded.

Problem S5-62-2.

(a) Describe two types of on-premises hazards considered by underwriters of workers' compensation insurance.

(b) According to Myhr and Markham, p. 6.36, what are the three elements of an off-premises hazard?

Solution S5-62-2.

(a) The following two types of on-premises hazards are described by Myhr and Markham, p. 6.35:

1. **Housekeeping:** This hazard concerns "the physical layout of the workplace, its cleanliness, and its operating efficiency. Housekeeping includes not only tidiness but also machinery arrangement, aisle placement and adequacy, stair cleanliness, and freight-elevator opening and stair marking" (Myhr and Markham, p. 6.35).

2. **Maintenance:** This hazard concerns the condition of the plant and machinery, and whether these are kept in good working order.

(b) The following three elements of off-premises hazards are discussed by Myhr and Markham, p. 6.36:

1. The duration of travel;
2. The mode of transportation;
3. The hazards at remote job sites.

Problem S5-62-3.

(a) What are professional employer organizations (PEOs)?

(b) What important question does the existence of PEOs raise with regard to workers' compensation insurance?

(c) How do most workers' compensation laws and standard workers' compensation insurance policies address the treatment of uninsured subcontractors of a contractor?
Solution S5-62-3. These questions are based on the discussion in Myhr and Markham, pp. 6.37-6.38:

(a) PEOs are vendors who lease employees to firms.

(b) The question the existence of PEOs raises is that of "who employs these workers, the leasing company or the firm that hires them" (Myhr and Markham, p. 6.37). This is an important question to address when payrolls are segregated to develop experience modifications and collect statistical data.

(c) "Most workers' compensation laws hold a contractor responsible for workers' compensation benefits to employees of its uninsured subcontractors. The standard workers' compensation policy automatically insures this loss exposure" (Myhr and Markham, p. 6.38).

Problem S5-62-4. The following questions pertain to the Occupational Safety and Health Act of 1970:

(a) What entity enforces this act?

(b) Under this act, when may safety inspectors enter working premises to inspect the premises, equipment, and environment?

(c) Once an employer receives written notice of a violation of the act, how long does the employer have to notify the Department of Labor that the action taken under the act will be contested?

(d) How does the act define a recordable case?

(e) What information could OSHA safety logs and inspections provide to workers' compensation insurance underwriters?

Solution S5-62-4. These questions are based on the discussion in Myhr and Markham, p. 6.39.

(a) The Department of Labor enforces the Occupational Safety and Health Act of 1970.

(b) Under the act, safety inspectors may enter working premises to perform inspections "at any reasonable time" (Myhr and Markham, p. 6.39).

(c) Once an employer receives written notice of a violation of the act, the employer has 15 days to notify the Department of Labor that the action taken under the act will be contested.

(d) The act defines a recordable case as "one involving an occupational death; occupational illness; or occupational injury involving loss of consciousness, restriction of work or motion, transfer to another job, or medical treatment (other than first aid)" (Myhr and Markham, p. 6.39).
(e) OSHA safety logs and inspections can provide workers' compensation insurance underwriters with information regarding "types of losses, loss frequency, and loss duration in terms of lost workdays." It "can also be used to verify other loss information submitted with the insurance application" (Myhr and Markham, p. 6.39).

Problem S5-62-5.

(a) Define maritime loss exposures in the context of workers' compensation insurance.

(b) Name the two principal U. S. federal laws that address on-the-job injuries for maritime occupations.

(c) What potential "gray areas" of coverage can arise because benefits pertaining to many marine occupations are addressed by federal laws, whereas most workers' compensation benefits are addressed by state laws?

(d) Give three examples of ways in which a workers' compensation residual market can be structured.

Solution S5-62-5.

(a) Maritime loss exposures are loss exposures "related to occupations involving work on vessels while at sea or in close proximity to bodies of water, such as on docks, on piers, or in terminals" (Myhr and Markham, p. 6.39).

(b) The two principal U. S. federal laws that address on-the-job injuries for maritime occupations are the United States Longshore and Harbor Workers' (USL&HW) Compensation Act and the Merchant Marine Act (Jones Act) (Myhr and Markham, p. 6.40).

(c) If an individual who does not regularly work on a vessel on water boards such a vessel and is injured in the course of doing work there, it is sometimes not clear whether federal laws or state laws apply. The injured party will often seek benefits under federal laws, because these benefits are typically greater.

(d) The following examples of ways in which a workers' compensation residual market can be structured are provided by Myhr and Markham, p. 6.41:

1. Monopolistic state funds;
2. Competitive state funds;
3. Joint underwriting associations (JUAs);
4. Assigned risk plans;
5. Reinsurance pools.

Any three of the above answers suffice. Other valid answers may be possible.
Section 63

Basics of Insurance Claims and Property Claim Adjusting

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**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-63-1.** Which of the following statements about claims in insurance are true? More than one answer may be correct.

(a) For many insureds, the insurer's claim adjusters are the only insurer representatives with whom the insureds have contact after the policy has been issued.

(b) If a claim goes to trial, the claim adjuster typically manages the insurer's defense counsel.

(c) Insurer claim offices are usually centralized in one location so as to enable rapid coordination among the various offices.

(d) Independent adjusters are best used for small, routine claims, on which the insurer should not expend the time and resources of its specialized internal staff.

(e) Many insurers employ independent adjusters as a part of their normal business operations.

(f) Higher levels of claim settlement authority are typically granted to insurer employees and representatives on the basis of seniority - i.e., length of time spent with the company.
(g) The claim adjustment process for property and liability claims focuses on essentially the same attributes.

**Solution S5-63-1.** This question is based on the discussion in Myhr and Markham, pp. 8.40-8.41. The following answers are correct:

(a) For many insureds, the insurer's claim adjusters are the only insurer representatives with whom the insureds have contact after the policy has been issued.

(b) If a claim goes to trial, the claim adjuster typically manages the insurer's defense counsel.

(e) Many insurers employ independent adjusters as a part of their normal business operations.

Choice (c) is not correct; insurer claim offices are typically located in close proximity to policyholders, so as to enable easier provision of service.

Choice (d) is not correct; independent adjusters are often used for complex claims that require specialized expertise. Some independent adjusters may specialize in handling certain types of claims for which the insurer lacks internal expertise.

Choice (f) is not correct; higher levels of claim settlement authority are typically granted to insurer employees on the basis of responsible use of authority that had already been granted. Experience with the company may be a factor that is considered, but strict seniority considerations are seldom used.

Choice (g) is not correct; there are considerable differences in the claim adjustment process between property claims and liability claims. Property losses are primarily objective and relatively straightforward to quantify. The largest component of liability losses is subjective - e.g., losses due to "pain and suffering" and similar harms.

**Problem S5-63-2.** List four questions that a property claim adjuster would need to answer in handling virtually any property claim.

**Solution S5-63-2.** Six such questions are mentioned by Myhr and Markham, p. 9.3:

1. "Who has an insurable interest in, and who is insured with respect to, damaged property?"
2. "What property is insured under a policy, where is it insured, and during what time period?"
3. "Against what causes of loss does the insurance protect?"
4. "What is the dollar amount of the loss?"
5. "What are the insured's duties after a loss?"
6. "What procedures must the adjuster follow to settle the claim?"

Any four of the above suffice as an answer. Other valid answers may also be possible.

**Problem S5-63-3.** Define the following kinds of interest in property:

(a) Sole ownership;
(b) Joint ownership;
(c) Tenancy by entireties;
(d) Ownership in common.

(e) Name three kinds of interests in property, aside from ownership interest, which can exist.

**Solution S5-63-3.**

(a) **Sole ownership** is a situation where the "owner has complete interest in the property" (Myhr and Markham, p. 9.4).

(b) **Joint ownership** is "a form of ownership in which two or more owners have an indivisible interest in property" (Myhr and Markham, p. 9.4).

(c) **Tenancy by entireties** is "a form of joint tenancy ownership in which the co-owners are husband and wife, and when one spouse dies, property is passed to the surviving spouse" (Myhr and Markham, p. 9.4).

(d) **Ownership in common** is "a form of ownership in which two or more owners each have an identifiable fractional interest in property" (Myhr and Markham, p. 9.4).

(e) The following three non-ownership interests in property are mentioned by Myhr and Markham, pp. 9.4-9.5:

1. **Lessees of property**, who "have an interest in the use of property for the life of the lease" (Myhr and Markham, p. 9.4).

2. **Custodians of property**: This group includes bailees, warehouse employees, and carriers. They "have an interest in the property to the extent of their fees and for their legal liability for the property's safe return to its owner" (Myhr and Markham, p. 9.4).

3. **Security interests**, where the secured party is most often "a creditor of the property owner" (Myhr and Markham, p. 9.5).

**Problem S5-63-4.**

(a) What two questions must a claim adjuster address when handling claims that involve a landlord-tenant relationship?

(b) Generally, what entities are the only ones entitled to make a claim under a property insurance policy?

(c) What are **loss payees**?

**Solution S5-63-4. (a)** When handling claims that involve a landlord-tenant relationship, a claim adjuster must address the following two questions, discussed by Myhr and Markham, p. 9.6:
1. "What are the parties' respective interests in the property under the lease?"

2. "What rights does each party have under the applicable insurance policy in question?"

(b) As discussed by Myhr and Markham, p. 9.7, generally, only the following parties are entitled to make a claim under a property insurance policy:

1. The "first named insured" or "named insured";
2. A spouse of the "named insured";
3. A legal representative of the named insured, in the event of said insured's death.

(c) Loss payees are "parties, such as owners of leased office equipment, who do not have any rights greater than or independent of the policyholder, but whose names must be included on any claim settlement check" (Myhr and Markham, p. 9.7).

Problem S5-63-5.

(a) What is a fixture?

(b) What three questions can adjusters ask to determine whether a fixture gets classified as real property or personal property?

(c) Name three courses of action that a claim adjuster should always take before denying a claim.

Solution S5-63-5.

(a) A fixture is "personal property that has become attached to and part of real property" (Myhr and Markham, p. 9.8).

(b) The following three questions regarding the classification of fixtures are discussed by Myhr and Markham, p. 9.8:

1. "How permanently attached to the real property is the fixture?"
2. "Is the fixture well-adapted to the real property?"
3. "What was the intent of the owner?"

(c) The following three courses of action with regard to claim denials are mentioned by Myhr and Markham, p. 9.8:

1. The adjuster should check the exact policy language.
2. The adjuster should provide a plausible and verifiable explanation to the insured for why the claim has been denied.
3. The adjuster should provide the claim denial in writing to the insured.

There may be other courses of action that are advisable in all circumstances; these would also constitute valid answers.
Section 64

Indirect Losses to Property, Verification of Property Losses, Intentional Property Losses, Replacement Cost, and Actual Cash Value

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Source:


Original Problems and Solutions from The Actuary's Free Study Guide

**Problem S5-64-1.**

(a) What is the most important type of indirect loss to property?

(b) Which kinds of insurance policies typically cover the type of indirect loss in part (a), and which kinds of insurance policies sometimes do not cover this loss?

(c) What needs to happen to trigger coverage for the indirect loss in part (a), when such coverage exists?

(d) Give three examples of nonphysical losses to property. Are these losses covered by most insurance policies?

**Solution S5-64-1.** This question is based on the discussion by Myhr and Markham, p. 9.9, of covered causes of loss for property insurance.
(a) The most important type of indirect loss to property is **loss of use** of the property.

(b) A typical **homeowners' insurance policy** typically** covers loss of use**; on the other hand, **commercial property insurance policies** sometimes do not cover loss of use, unless such coverage is explicitly purchased by the insured.

(c) A **direct physical loss to property** needs to occur in order to trigger coverage for loss of use.

(d) The following examples of nonphysical losses to property are mentioned by Myhr and Markham, p. 9.9:
1. Obsolescence;
2. Loss of market;
3. Investment loss;

Any three of the above suffice as answers. Other valid answers may be possible. Most insurance policies **do not cover** nonphysical losses.

**Problem S5-64-2.**

(a) Name two causes of loss to property which are typically easy to verify.

(b) Name two causes of loss to property which are often difficult to verify.

(c) Name three exclusions for which it is often difficult to separate excluded losses from non-excluded losses.

**Solution S5-64-2.**

(a) **Fire** and **windstorm** losses to property are typically easy to verify (Myhr and Markham, p. 9.9). Other valid answers may be possible.

(b) The following causes of loss to property, which are often difficult to verify, are mentioned by Myhr and Markham, p. 9.10:
1. Water damage;
2. Collapse;
3. Theft;
4. Vandalism.

Any two of the above suffice as an answer. Other valid answers may be possible.
The following four difficult exclusions are mentioned by Myhr and Markham, p. 9.10:

1. Gradual causes of loss;
2. Ordinance or law;
3. Faulty design, construction, or material;
4. Intentional acts of the insured.

Any three of the above suffice as an answer. Other valid answers may be possible.

Problem S5-64-3.

(a) What is the most common type of intentionally caused loss?

(b) To prove that the type of loss in part (a) actually occurred and was caused by the insured, what three facts must a claim adjuster demonstrate?

(c) What are two possible motives for this type of intentionally caused loss?

Solution S5-64-3. This question is based on the discussion of intentional acts of the insured in Myhr and Markham, p. 9.13.

(a) The most common type of intentionally caused loss is **loss due to fire, i.e., arson**.

(b) To prove that the insured committed arson, the claim adjuster must demonstrate the following, according to Myhr and Markham, p. 9.13:

1. "An incendiary fire (one that has been set intentionally);"
2. "A motive on the insured's part;"
3. "Opportunity on the insured's part".

(c) The following possible motives for arson caused by the insured are discussed by Myhr and Markham, p. 9.13:

1. **Financial motives:** The insured might be better off with vacant land and the insurance money than with an intact building.
2. **Irrational motives:** Anger toward a business partner, spouse, or other individual who would be worse off if the building were destroyed.

Other valid answers may be possible.

Problem S5-64-4. Mr. Ξ has purchased an insurance policy on his Superwidget, Mark X, which he purchased in the year 2310 for 6000 Golden Hexagons (GH). In the year 2315, a total loss to the superwidget occurs. Since that time, Superwidget, Mark X, has been discontinued and replaced by Superwidget, Mark Y, which has similar functionality. The market price of Superwidget, Mark Y, in 2315 is 7800 GH. The insurance company also calculates that, because
of obsolescence and wear and tear, Mr. Ξ's former superwidget experienced 2300 GH of depreciation. How much will Mr. Ξ receive from the insurer if:

(a) The insurance is provided on a replacement cost basis?
(b) The insurance is provided on an actual cash value basis?

Solution S5-64-4. This question is based on the discussion of replacement cost and actual cash value in Myhr and Markham, pp. 9.15-9.19.

(a) Replacement cost is the cost to replace a destroyed item with either another instance of that item or an item of like kind and quality. Here, Superwidget, Mark Y, appears to be of similar kind and quality to Superwidget, Mark X. Moreover, replacement cost is the cost to replace at the time of loss, and, in most cases, does not take into account the item's original purchase price. Thus, the replacement cost in this case is the market price of Superwidget, Mark Y, in 2315: 7800 GH.

(b) In most cases, (Actual Cash Value) = (Replacement Cost) - (Depreciation). Here, replacement cost is 7800 GH, and depreciation is estimated at 2300 GH. Thus, compensation provided on an actual cash value basis would be 7800 - 2300 = 5500 GH.

Problem S5-64-5. Give three examples of considerations that a thorough estimate of replacement cost for damaged or destroyed property should take into account. Briefly describe what these considerations are and what aspects of them should be taken into account.

Solution S5-64-5. The following five considerations with regard to replacement cost are discussed by Myhr and Markham, p. 9.16:

1. **Specifications:** "What must be done, including whether to repair or replace the property, the exact type of materials, and the quantity of materials in exact dimensions or count."

2. **Materials:** "Material prices are based on prevailing material costs for projects similar to what is required by the policyholder's loss."

3. **Labor:** How much time is required to complete the project that would replace the damaged/destroyed property. It is generally considered fair to determine the cost of labor by multiplying the time required by published "standard" work rates.

4. **Overhead:** "The contractor's fixed costs of doing business or fixed specific costs attributable to the job. Examples include office space, telephones, permits, and job site offices."

5. **Profit:** Profit is typically calculated as a percentage of total other costs, as virtually every contractor will include some provision for profit in the price it charges to repair/replace the damaged/destroyed property."
Section 65

Replacement Cost, Actual Cash Value, Depreciation, Agreed Amounts, Stated Amounts, and Policyholder Duties in the Event of Insured Losses

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**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-65-1.** Insurers typically do not want to pay the replacement cost of property until the property has been repaired or replaced. What are two ways which insurers typically pursue to provide reimbursement for replacement cost to an insured?

**Solution S5-65-1.** This question is based on the discussion in Myhr and Markham, p. 9.17. The following are two ways in which insurers typically reimbursement for replacement cost:

1. Pay the insured the actual cash value once it is determined, and then pay the remaining amount of full replacement cost when repair or replacement is complete.
2. Gradually pay out amounts of money as repairs/replacements are completed, until the full replacement cost amount is paid.

**Problem S5-65-2.**
(a) What are the two main causes of depreciation?
(b) Name two situations in which the formula (Actual Cash Value) = (Replacement Cost) - (Depreciation) might not be appropriate.
(c) Briefly describe two alternative approaches some courts have used to define actual cash value.

Solution S5-65-2. This question is based on the discussion of depreciation in Myhr and Markham, pp. 9.17-9.19.

(a) The two main causes of depreciation are physical wear and tear and obsolescence.

(b) The following three examples for situations in which the formula (Actual Cash Value) = (Replacement Cost) - (Depreciation) might not be appropriate are mentioned by Myhr and Markham, p. 9.18:

1. Antiques which cannot be reproduced;
2. Buildings that feature construction methods which are no longer used;
3. Property that has appreciated in value, instead of depreciating.

Any two of the above suffice as an answer. Other valid answers may be possible.

(c) The following two alternative approaches some courts have used to define actual cash value are mentioned by Myhr and Markham, pp. 9.18-9.19:

1. Fair market value: What an item would sell for on the secondary market.
2. The broad evidence rule: A rule that requires "adjusters to consider all pertinent factors, including physical wear and tear, obsolescence, market value, and any other relevant factors" (Myhr and Markham, p. 9.19).

Problem S5-65-3. A property insurance policy has a coinsurance requirement, whereby the full value of the loss is only paid if the property is insured to 75% of its full value at the time of loss. The amount of insurance purchased by the insured is $125,000. The property has suffered a loss of $48,000. The full value of the property at the time of loss is $300,000. There is a $10,000 deductible applied to any losses that occur.

(a) How much will the insurer pay if the deductible is applied before the coinsurance penalty?
(b) How much will the insurer pay if the coinsurance penalty is applied before the deductible?
(c) Which approach - the approach of part (a) or the approach of part (b) - is the default approach that adjusters should use unless the insurance policy explicitly states otherwise?

Solution S5-65-3. This question is based on the discussion of the application of deductibles and coinsurance penalties in Myhr and Markham, p. 9.19:

(a) We apply the deductible to the loss first: $48,000 - $10,000 = $38,000. This is the amount to which the coinsurance penalty will be applied. The amount of insurance needed to avoid the penalty is 0.75*300000 = $225,000. Thus, the insurer will pay only 125000/225000 = 5/9 of any covered loss amount. In this case, the insurer will pay (5/9)*380000 = $21,111.11.
We apply the coinsurance penalty - a multiplicative factor of $5/9$ - to the loss amount of $48,000$: $48000 \times (5/9) = 26666.67$. Now we subtract the deductible: $26666.67 - 10000 = 16,666.67$, which is what the insurer will pay if the coinsurance is applied first.

(c) Applying the deductible before the coinsurance penalty is the default approach. It should be used unless the insurance policy states otherwise. This approach is also always more favorable to the insured.

Problem S5-65-4. (a) If property is insured for a stated amount, how much is the insured entitled to at the time of loss?
(b) If property is insured for an agreed amount, how much is the insured entitled to at the time of loss?
(c) What kinds of property are typically more likely to be insured for an agreed amount, as opposed to a stated amount?

Solution S5-65-4. This question is based on the discussion of stated amounts and agreed amounts in Myhr and Markham, pp. 9.19-9.20:

(a) If property is insured for a stated amount, the insured, in the event of loss, is entitled to the least amount of the following three values: "(1) the property's actual cash value, (2) the cost to repair or replace the property, (3) the applicable amount of insurance" (Myhr and Markham, p. 9.20).

(b) If property is insured for an agreed amount, the insured, in the event of loss, is entitled to either of the following:
1. The insurer's restoration of the property to its pre-loss condition.
2. The insurer's payment of the agreed amount.

(c) Property that is extremely difficult or impossible to replace is more likely to be insured for an agreed amount. This includes valuable papers and fine arts (Myhr and Markham, p. 9.20).

Problem S5-65-5. Name four typical duties of the policyholder in the event of loss, as specified in insurance policies.

Solution S5-65-5. The following policyholder duties in the event of loss are discussed by Myhr and Markham, pp. 9.21-9.24:

1. Providing prompt notice;
2. Protecting property;
3. Assisting with the loss adjustment process;
4. Providing proof of loss;
5. Submitting to examination under oath.

Any four of the above suffice as an answer. Other valid answers may be possible.
Section 66

Waiver, Estoppel, Reservations of Rights, Salvage, and Subrogation in Insurance Claims

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**Source:**


**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-66-1.**

(a) What are three possible courses of action available to adjusters when they receive a new claim?

(b) Give three reasons for why claim adjusters should perform complete files of information pertaining to the claim.

**Solution S5-66-1.**

(a) The following three courses of action are discussed by Myhr and Markham, p. 9.24:

1. "Accept the policyholder's word and settle the claim accordingly."
2. "Employ experts to investigate the claim or refer it to an SIU" (special investigative unit).
3. "Personally investigate the claim."
(b) The following reasons for why claim adjusters should perform complete files of information pertaining to the claim are discussed by Myhr and Markham, p. 9.25:

1. To justify settlement payments;
2. To audit claim procedures and claim-handling quality;
3. To enable transfer of cases among adjusters;
4. To provide satisfactory information to state insurance regulators;
5. To provide satisfactory information to reinsurers.

Any three of the above suffice as answers. Other valid answers may be possible.

**Problem S5-66-2.**

(a) Define *waiver*.

(b) Define *estoppel*.

(c) How might estoppel exist in cases where there was no waiver?

(d) Why are the concepts of waiver and estoppel important with regard to the actions of claim adjusters?

**Solution S5-66-2.**

(a) **Waiver** is "the voluntary and intentional relinquishment of a right," which can be "expressed explicitly or implied by conduct" (Myhr and Markham, p. 9.26).

(b) **Estoppel** is "a relinquishment of a right" that "results when someone's words or behavior cause another to rely, to his or her detriment, on those words or behavior. Estoppel bars the first party from asserting any rights inconsistent with his or her words or behavior" (Myhr and Markham, p. 9.26).

(c) Estoppel when there is no waiver can be "based on thoughtless, unintentional action on which the other party relies" to that party's detriment (Myhr and Markham, p. 9.26).

(d) Courts have ruled that adjusters have the authority to waive conditions within insurance contracts. Thus, if a course of action is prescribed by an insurance policy, the adjuster's statements to the contrary can constitute a waiver and/or estoppel of that course of action. Estoppel can occur if an adjuster continues to adjust a claim once an issue has been discovered that would prevent coverage from applying (Myhr and Markham, p. 9.26).

**Problem S5-66-3.**

(a) What do nonwaiver agreements and reservation of rights letters accomplish?
(b) What is the substantive difference between a nonwaiver agreement and a reservation of rights letter?

(c) Once a nonwaiver agreement or reservation of rights letter has been issued, what course of action must the adjuster take in addressing any outstanding coverage issues? What will happen if the adjuster fails to take this course of action?

**Solution S5-66-3.** This question is based on the discussion of nonwaiver agreements and reservation of rights letters in Myhr and Markham, pp. 9.26-9.29.

(a) Nonwaiver agreements and reservation of rights letters enable a claim adjuster to continue to investigate a claim without guaranteeing that insurer will make payment or provide coverage simply because the investigation continues to occur. These documents enable the insurer to later deny payment for the claim if there are legitimate reasons for why coverage should not be provided.

(b) A nonwaiver agreement is reached between the insurer and the insured; it is arrived at bilaterally. A reservation of rights letter is sent unilaterally by the insurer to the insured. A reservation of rights letter may also be more specific; it can tell "the policyholder about any specific problems, such as property or causes of loss that appear not to be covered or the policyholder's failure to perform any duties after a loss or to comply with other policy conditions" (Myhr and Markham, p. 9.26). In other respects, the two documents have the same content.

(c) "Once either a nonwaiver agreement or a reservation of rights letter has been issued, the adjuster must promptly resolve the coverage issue and must inform the policyholder. Should the adjuster fail to resolve the coverage issue and proceed to settle the claim, the claim payment constitutes a waiver, and the insurer is estopped from raising coverage issues again" (Myhr and Markham, pp. 9.26-9.29).

**Problem S5-66-4.**

(a) If an insurer has "totaled" a damaged item of property - i.e., paid the full value of the property - what right has the insured waived?

(b) What do adjusters typically do with regard to salvage of property? Why do they make this choice?

(c) What can an insurer do when an insured wishes to attempt to sell damaged covered property?

**Solution S5-66-4.** This question is based on the discussion of salvage in Myhr and Markham, p. 9.29.

(a) The insured can no longer salvage the property that has been "totaled". The property reverts to the insurer, and the insurer then has the option to recover some money by salvaging the property.
(b) Adjusters typically sell or consign the property to be salvaged to professional salvage companies. They do this because the "markets for salvaged property are specialized, variable, and irregular", and the insurer's personnel may not have the expertise to compete these markets (Myhr and Markham, p. 9.29).

(c) An insurer can consult a professional salvage company to receive an estimate of the percentage of original value that the damaged property has retained. The insurer can then offer a claim settlement equal to the original value of the property minus the salvage value. If the insured wishes to sell the property, the insured will likely accept this reduced settlement (Myhr and Markham, p. 9.29).

Problem S5-66-5.

(a) What is the role of the claim adjuster in handling a claim that has been subrogated?

(b) When a claim has been subrogated and the party responsible for the loss has liability insurance, what system can the two insurers use to settle the dispute without litigation?

(c) What is the upper limit of the claim amount which can be handled by the system in part (b).

Solution S5-66-5. This question is based on the discussion of subrogation in Myhr and Markham, p. 9.29.

(a) "Handling a claim involving potential subrogation is no different for an adjuster than handling any other claim, except that the adjuster must be especially thorough in establishing and documenting the cause of loss and might put the responsible party on notice of the liability claim" (Myhr and Markham, p. 9.29).

(b) When a claim has been subrogated and the party responsible for the loss has liability insurance, the two insurers can use the "nationwide arbitration system operated by Arbitration Forums, Inc." (Myhr and Markham, p. 9.29). This system offers faster and less expensive dispute resolution than the court system. It is also possible for the claim adjusters of the respective insurers to reach a settlement prior to arbitration.

(c) The upper limit of the claim amount which can be handled by the nationwide arbitration system of Arbitration Forums, Inc. is $100,000.
Section 67

Basics of Liability Claim Adjusting

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**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-67-1.**

(a) On what actions do liability claim adjusters spend most of their time and effort?

(b) Who is the claimant in a liability claim?

(c) Which kind of liability claim is more common - a claim for bodily injury or a claim for property damage?

(d) According to Myhr and Markham, p. 10.4, what are the four steps in the process of adjusting liability claims?

**Solution S5-67-1.**

(a) Liability claim adjusters "spend most of their time and effort investigating and evaluating the legal aspects of liability and damages" (Myhr and Markham, p. 10.3).

(b) In a liability claim, the claimant is a third party with a claim *against* the insured. This claim arises from the allegation that the insured is liable for damages to the third party (Myhr and Markham, p. 10.3).
(c) A liability claim for **bodily injury** is more common than a liability claim for property damage.

(d) According to Myhr and Markham, p. 10.4, the four steps in the liability claim adjusting process are as follows:
1. Determining coverage;
2. Determining legal liability;
3. Determining damages;
4. Negotiating and settling the claim.

**Problem S5-67-2.**

(a) If a liability claim occurs, what aspect of the claim itself (not of the insurance policy language) determines whether coverage applies? What part of that aspect is irrelevant?

(b) What should a claim adjuster do if a part of a liability claim is clearly not covered by the insurance policy?

(c) Why do insurers typically pay the entire settlement of a liability claim, even when parts of that claim are clearly not covered under the policy?

(d) What should a claim adjuster do if there exists a significant possibility that the entire liability claim is not covered by the insurance policy?

**Solution S5-67-2.** This question is based on the discussion in Myhr and Markham, p. 10.5.

(a) What determines whether coverage applies for a liability claim are the **allegations of the claimant**. If the allegations are that the insured is liable in a manner that is covered by the insurance policy, then coverage applies. What is irrelevant is **whether or not the allegations are true**; coverage would apply even for groundless allegations of liability.

(b) If a part of a liability claim is clearly not covered by the insurance policy, the claim adjuster must explain to the insured why this part is not covered and refer to the relevant policy provisions in the explanation. "The adjuster must explain that the insurer will continue handling the claim but that the insured might have to contribute to an eventual settlement or judgment" (Myhr and Markham, p. 10.5).

(c) Insurers typically pay the entire settlement of a liability claim, even when parts of that claim are clearly not covered under the policy, because when liability claims are settled, the basis of liability for each aspect of the settlement is seldom specified, and so it is known how the settlement amount is attributed to the various covered and non-covered aspects of the claim (Myhr and Markham, p. 10.5).
(d) If there exists a significant possibility that the *entire* liability claim is not covered by the insurance policy, the adjuster must explain to the insured in writing why there exist doubts with regard to coverage. The adjuster should also explain his course of action - which is typically a further investigation. Based on the facts of this investigation, the adjuster can deny coverage. The insured would be informed if coverage is found to apply, as well as if it is found not to apply (Myhr and Markham, p. 10.5).

**Problem S5-67-3.**

(a) What is a declaratory judgment action?
(b) What are two possible disadvantages of filing a declaratory judgment action?

**Solution S5-67-3.** This question is based on the discussion of declaratory judgment actions in Myhr and Markham, pp. 10.5-10.6.

(a) A **declaratory judgment action** is a court's declaration of the rights of the parties in a dispute, but not a determination of which party's case is actually valid. Declaratory judgment actions determine issues of coverage - i.e., what is covered under the applicable insurance policy - but not issues of liability - i.e., whether the third-party claimant's allegations against the insured are actually legitimate.

(b) The following possible disadvantages of filing a declaratory judgment action are mentioned by Myhr and Markham, p. 10.6:

1. Declaratory judgments are expensive and often generate tens of thousands of dollars in legal costs. They are therefore not suitable for addressing small or moderate claims.

2. Declaratory judgment actions sometimes take as long to obtain as court decisions on other cases. This defeats their purpose.

3. If a declaratory judgment action is unsuccessful, it "complicates the defense of the underlying action" (Myhr and Markham, p. 10.6).

Any two of the above suffice as an answer. Other valid answers may also be possible.

**Problem S5-67-4.**

(a) What term do attorneys typically use to refer to what insurers would call "bodily injury" claims?

(b) Why should adjusters not deny coverage without further investigation for lawsuits where only injunctions and no monetary damages are sought?

(c) Name three kinds of claims that are clearly not covered by liability insurance for bodily injury or property damage.
Solution S5-67-4. This question is based on the discussion in Myhr and Markham, p. 10.6.

(a) "Bodily injury" claims in insurance are typically called "personal injury" claims by attorneys.

(b) Lawsuits where only an injunction is sought may be concerned with ongoing bodily injury; the injunction is then intended to stop further injury. Alternatively, such lawsuits may involve an attempt to stop interference with the use of property. "Because loss of use of property is included within the definition of 'property damage,' a lawsuit based on such alleged damage might be covered" (Myhr and Markham, p. 10.6).

(c) The following kinds of claims are clearly not covered by liability insurance for bodily injury or property damage, according to Myhr and Markham, p. 10.6:

1. "Lawsuits alleging breach of contract resulting only in financial harm";
2. "Lawsuits alleging financial fraud";
3. Regulatory fines;
4. Minor criminal fines.

Problem S5-67-5.

(a) What two questions must liability claim adjusters answer in order to determine whether the intentional acts exclusion applies?

(b) What two kinds of allegations by the third-party claimant make it difficult for the insurer to apply the intentional acts exclusion?

Solution S5-67-5. This question is based on the discussion of intentional acts by Myhr and Markham, p. 10.7.

(a) In order to determine whether the intentional acts exclusion applies, liability claim adjusters must answer the following questions (Myhr and Markham, p. 10.7):
1. "Did the insured intend the result of his or her action or merely intend to commit the action without contemplating the injurious outcome?"
2. "Can intentional acts be excluded when the claimant also alleges negligence or strict liability on the insured's part?"

The following can also be a valid answer:
3. "Is the insured liable for the intentional acts of an agent or servant, if the insured is vicariously liable?"

(b) Allegations by the third-party claimant of (1) negligence and/or (2) strict liability make it difficult for the insurer to apply the intentional acts exclusion, because this would render at least a part of the claim to be covered. When even a part of the claim is covered, the insurer is obligated to defend the insured (Myhr and Markham, p. 10.7).
Section 68

Coverage, Investigation, and Defenses for Liability Insurance Claims

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Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-68-1.
(a) Provide examples of three kinds of situations in which liability insurers might end up having to provide coverage for actions pertaining to breaches of contractual obligations.  
(b) Do typical liability insurance policies provide coverage for "property damage to another's property that has been damaged while in the insured's care, custody, or control or while the insured was working on it" (Myhr and Markham, p. 10.8)?  
(c) Do typical liability insurance policies provide coverage for "property damage to the insured's work itself, or to property that the insured has sold or given away" (Myhr and Markham, p. 10.9)?  
(d) Do typical liability insurance policies provide coverage for "consequential bodily injury and damage to another's property" (Myhr and Markham, p. 10.9)?

Solution S5-68-1.

(a) Myhr and Markham, p. 10.8, discuss the following examples of situations in which liability insurers might end up having to provide coverage for actions pertaining to breaches of contractual obligations:

1. Even if the breach of contract itself is not covered, the consequences of said breach might be covered.
2. Some insurance policies may explicitly insure for certain kinds of breach of contract, either via a statement to this effect or via an exception to the contractual exclusion.

3. Claims of negligence or strict liability might be combined with claims of contractual breach; in that case, the insurer is often obligated to defend the insured against the entire claim.

(b) Typical liability insurance policies do not provide coverage for "property damage to another's property that has been damaged while in the insured's care, custody, or control or while the insured was working on it" (Myhr and Markham, p. 10.8).

(c) Typical liability insurance policies do not provide coverage for "property damage to the insured's work itself, or to property that the insured has sold or given away" (Myhr and Markham, p. 10.9).

(d) Typical liability insurance policies do indeed provide coverage for "consequential bodily injury and damage to another's property" (Myhr and Markham, p. 10.9).

Problem S5-68-2. List six items of information that a claim adjuster should obtain when they are relevant to investigating a liability claim.

Solution S5-68-2. The following items relevant to a liability claim adjuster's investigation are discussed by Myhr and Markham, pp. 10.9-10.10:

1. The potential claimants' names;
2. The potential claimants' addresses;
3. The potential claimants' telephone numbers;
4. A statement of each claimant's account of the accident;
5. A statement of the insured's account of the accident;
6. Statements from witnesses;
7. Police reports;
8. Photographs of accident scenes;
9. Diagrams of accident scenes;
10. Products or objects involved in claims.

Any six of the above suffice as an answer. Other valid answers may also be possible.

Problem S5-68-3. Which of the following statements are true? More than one answer may be correct.

(a) Convicted criminals are an exception to the requirement in liability insurance policies that anyone seeking coverage for a claim must cooperate with the insurer.

(b) The desire to protect their Fifth Amendment rights often prevents individuals accused of crimes from fully cooperating with an insurer.
(c) Criminal cases typically take much less time to move through the court system than civil cases.

(d) In cases of possible criminal liability, the adjuster should never wait until the conclusion of the criminal case; he should attempt to obtain the cooperation of the insured(s) and claimant(s) as soon as possible, or else the insurer would waive the right to receive such cooperation.

(e) When there is an alleged breach of contract, the liability claim adjuster needs only to review the provisions of the insurance policy which explicitly mention breach of contract and any relevant exclusions or exceptions.

(f) One potential defense against a breach of contract claim is that the precondition for the insured's contractual obligations did not occur.

(g) One potential defense against a breach of contract claim is that the claimant breached the contract first.

(h) When hold-harmless agreements are not particularly specific, courts have tended to interpret them broadly as possible, transferring as much liability as could be consistent with the letter of the agreements.

(i) Courts have sometimes invalidated hold-harmless agreements that contain ambiguous language.

Solution S5-68-3. This question is based on the discussion of criminal liability and contractual liability by Myhr and Markham, p. 10.12. The following answers are correct:

(b) The desire to protect their Fifth Amendment rights often prevents individuals accused of crimes from fully cooperating with an insurer.

(c) Criminal cases typically take much less time to move through the court system than civil cases.

(f) One potential defense against a breach of contract claim is that the precondition for the insured's contractual obligations did not occur.

(g) One potential defense against a breach of contract claim is that the claimant breached the contract first.

(i) Courts have sometimes invalidated hold-harmless agreements that contain ambiguous language.

Choice (a) is not correct; convicted criminals are also required to cooperate with the insurer in order to receive coverage.
Choice (d) is not correct; the adjuster can often fruitfully wait until the conclusion of a criminal case before requiring that the insured cooperate. This can be done to prevent the insured's cooperation from infringing on the insured's desire for Fifth Amendment protections.

Choice (e) is not correct; when there is an alleged breach of contract, the liability claim adjuster needs to review the entire applicable policy. Allegations of breach of contract could be coupled with allegations of negligence or statutory liability that may be covered under the policy.

Choice (h) is not correct; when hold-harmless agreements are not particularly specific, courts have tended to interpret them quite narrowly.

**Problem S5-68-4.**

(a) Name one kind of statutory violation that causes bodily injury and property damage and for which coverage is excluded from the typical liability insurance policy.

(b) Regarding vicarious liability, what is the most important issue for liability claim adjusters to address?

**Solution S5-68-4.**

(a) One kind of statutory violation that causes bodily injury and property damage and for which coverage is excluded from the typical liability insurance policy is mentioned by Myhr and Markham, p. 10.13. It is **intentional dumping of pollutants**. Other valid answers may also be possible.

(b) Regarding vicarious liability, is the most important issue for liability claim adjusters to address is "the scope of employment or agency" (Myhr and Markham, p. 10.13). The principal or employer is only liable for the actions of the agent or employee to the extent that those actions were performed within the scope of the relevant agency or employment relationship.

**Problem S5-68-5.** Briefly discuss three possible defenses to liability claims.

**Solution S5-68-5.** The following possible defenses to liability claims are mentioned by Myhr and Markham, pp. 10.13-10.14:

1. **Absence of Negligence:** The claimant's failure to prove that negligence on the insured's part occurred.
2. **Comparative or contributory negligence:** Some aspect of the claimant's fault contributing to the claimant's bodily injury.
3. **Assumption of risk:** The claimant's voluntary assumption of a risk when the claimant had adequate knowledge of that risk's existence.
4. **Statute of limitations:** The expiration of the time limit within which the claimant could have legitimately filed a lawsuit.

Any three of the above suffice as an answer. Other valid answers may also be possible.
Section 69

Damages and Settlements in Liability Insurance Claims

This section of the study guide is intended to provide practice problems and solutions to accompany the pages of Insurance Operations, Regulation, and Statutory Accounting, cited below. Students are encouraged to read these pages before attempting the problems. This study guide is entirely an independent effort by Mr. Stolyarov and is not affiliated with any organization(s) to whose textbooks it refers, nor does it represent such organization(s).

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Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-69-1.

(a) Name three outside parties on which liability claim adjusters might rely to receive information that would be of use in estimating damages.

(b) Name two kinds of documents that are often used in proving damages in bodily injury liability claims.

(c) Name two kinds of documents that are often used in proving damages in property damage liability claims.

(d) What unscientific approach is often used by liability claim adjusters to estimate general damages (i.e., damages for pain and suffering, loss of consortium, disfigurement, etc., which are difficult to precisely measure).

Solution S5-69-1. This question is based on the discussion of damages in liability claims by Myhr and Markham, p. 10.15.

(a) The following outside parties are mentioned by Myhr and Markham, p. 10.15:
For bodily injury estimates:
1. Doctors

For property damage estimates:
2. Appraisers
3. Contractors
4. Repairers

For financial factors:
5. Accountants
6. Economists

Any three of the above suffice as an answer. Other valid answers may be possible.

(b) The following documents, often used in proving damages in bodily injury liability claims, are mentioned by Myhr and Markham, p. 10.15:

1. Medical reports and bills;
2. Hospital records;
3. Employer information.

Any two of the above suffice as an answer. Other valid answers may be possible.

(c) The following documents, often used in proving damages in property damage liability claims, are mentioned by Myhr and Markham, p. 10.15:

1. Repair estimates;
2. Actual bills for repair and rental.

Other valid answers may be possible.

(d) The "multiple-of-specials" approach is often used by liability claim adjusters to estimate general damages. Either the entire likely amount of special damages or just the medical special damages would be multiplied by some factor to arrive at the general damages. This factor is often considerably greater than 1 (Myhr and Markham, p. 10.15).

Problem S5-69-2.

(a) What are future damages?

(b) Person Z has lost a spouse in a car accident for which someone else is liable. Should Person Z pursue a survival action or a wrongful death action?

(c) Person Q was hurt in a car accident for which someone else is liable. Subsequently, Person Q incurred considerable medical costs to receive treatment as a result of the accident. Then Person
Q died of a cause unrelated to the accident. Person Q's son, Q II, wishes to recover Q's medical expenses from the liable party. Should Q II pursue a survival action or a wrongful death action?

(d) What condition allows for the largest amount of recovery in wrongful death actions?

**Solution S5-69-2.**

(a) **Future damages** are "damages that can be expected to continue into the future", "such as future medical expenses, future lost earnings, and future pain and suffering" (Myhr and Markham, p. 10.18).

For (b), (c), and (d), the questions are based on the following definitions expressed in Myhr and Markham, p. 10.18:

A **survival action** is a "legal cause of action that existed for the deceased before his or her death."

A **wrongful death action** is a "legal cause of action that exists for the survivor of the deceased."

(b) Person Z should pursue a **wrongful death action** for loss of companionship; if Person Z had any manner of financial dependency on the deceased spouse, this would increase the amount Z could recover.

(c) Q II should pursue a **survival action**, since Q II is only seeking to recover medical expenses that Q would have been able to recover had Q still lived.

(d) The wrongful death actions that tend to receive the largest recoveries apply to situations where **financial dependency** on the deceased individual was present - as, for instance, in cases where children depended on their parents or one spouse depended on another (Myhr and Markham, p. 10.19).

**Problem S5-69-3.** Which of the following considerations are relevant in settling third-party property damage liability claims? More than one answer may be correct.

(a) Coinsurance
(b) Depreciation
(c) Possible legal expenses
(d) Arbitration possibilities
(e) Special sublimits
(f) The property owner's own negligence
(g) Deductibles

**Solution S5-69-3.** The following considerations are relevant in settling third-party property damage liability claims, according to Myhr and Markham, pp. 10.19-10.20:

(b) Depreciation
(c) Possible legal expenses
Problem S5-69-4.

(a) What purpose does the insurer's right to litigate serve?

(b) Why is settling a liability claim often in the insured's best interest?

(c) Why does the insurer have a duty to settle the claim when its value approaches or exceeds the insured's policy limit?

(d) What might a court do if an insurer unreasonably rejected a settlement which was at or close to the applicable policy limit?

Solution S5-69-4.

(a) The insurer's right to litigate serves the purpose of protecting the insurer "against frivolous, fraudulent, or unfounded claims" (Myhr and Markham, p. 10.20).

(b) It is often in the insured's best interest to settle a liability claim, because even successful trials are stressful to the parties involved. A settlement prevents the insured from being sued and protects the insured against the vicissitudes of a trial (Myhr and Markham, p. 10.20).

(c) When the value of a claim approaches or exceeds the insured's policy limit, the insurer has the duty to settle a claim because of the potential conflict of interest that arises in this situation. The insured would be liable for any damages in excess of the policy limit. If the insurer chooses to litigate the case, then the insurer has little to lose beyond the policy limit but has much to gain in terms of reducing the insurer's own payment. The insured would, in any case, need to pay damages that exceed the policy limit (Myhr and Markham, pp. 10.20-10.21).

(d) If an insurer unreasonably rejected a settlement which was at or close to the applicable policy limit, the court might require the insurer to pay any damages in excess of the policy limit for which a verdict has been rendered (Myhr and Markham, p. 10.21).

Problem S5-69-5. Which of the following statements about negotiations of liability claims are true? More than one answer may be correct.

(a) Insurers typically feel the pressure to negotiate liability claims more strongly than do claimants.
(b) Claimants who are extremely likely to win at trial will typically prefer to litigate rather than to settle.
(c) Most claimants greatly overestimate what they could recover from a trial verdict.
(d) The attorneys of most claimants make more money per unit of time by settling claims instead of litigating them.
(e) Insurers stand to lose much more from an adverse verdict than most claimants, because the
insurer's reputation would be tarnished by a trial that generated a lot of negative publicity for the insurer.

(f) Court cases can frequently make or break the professional reputations of the attorneys involved in them.

(g) Insurers monitor the number of claims that go to litigation and reward adjusters for having a higher number of such claims.

Solution S5-69-5. This question is based on the discussion of pressures to negotiate liability claims by Myhr and Markham, p. 10.21. The following answers are correct:

(a) Insurers typically feel the pressure to negotiate liability claims more strongly than do claimants.

(d) The attorneys of most claimants make more money per unit of time by settling claims instead of litigating them.

(f) Court cases can frequently make or break the professional reputations of the attorneys involved in them.

Choice (b) is not correct; even claimants who are likely to win at trial will often prefer to settle.

Choice (c) is not correct; most claimants underestimate the damages they could recover.

Choice (e) is not correct; claimants typically have many fewer financial resources than do insurers and can also be emotionally devastated by an adverse verdict in court. For insurers, most individual adverse verdicts can be absorbed without substantial damage.

Choice (g) is not correct; insurers reward adjusters for having fewer claims go into litigation.
Section 70

Negotiations, Settlements, and Litigation for Liability Insurance Claims

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**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-70-1.** Which of the following statements about negotiation strategies in liability claim settlements are true? More than one answer may be correct.

(a) Negotiations typically begin with the claimant's attorney demanding a specific amount of money.

(b) The negotiation process is typically a simple exchange of offers and counteroffers that does not involve extensive discussion between the claimant's attorney and the claim adjuster.

(c) If a claimant is not represented by an attorney, it will typically be more difficult for an offer close to the claimant's first expectation to be accepted. Having an attorney greatly enhances the bargaining power of the claimant and can often motivate the adjuster to accept the attorney's initial demands.

(d) If a claimant is not represented by an attorney, the adjuster will typically make the first settlement offer.

(e) Willingness to negotiate a settlement is considered a weakness on the part of the party that initiates negotiations; it is seen as a sign that this party's case may not be strong enough to withstand a trial.

(f) Every claim adjuster only has the authority to settle a claim up to a specified dollar limit; thereafter, it is necessary to obtain authority from claim personnel at higher levels.

(g) In making an initial settlement offer, the adjuster should offer as low a value as possible, even if an intelligent evaluation of the claim would suggest that this low value is unreasonable.
Solution S5-70-1. This question is based on the discussion of negotiation strategies in liability claim settlements by Myhr and Markham, p. 10.22. The following answers are correct:

(a) Negotiations typically begin with the claimant's attorney demanding a specific amount of money.

(d) If a claimant is not represented by an attorney, the adjuster will typically make the first settlement offer.

(f) Every claim adjuster only has the authority to settle a claim up to a specified dollar limit; thereafter, it is necessary to obtain authority from claim personnel at higher levels.

Choice (b) is not correct; negotiations will often involve discussions between the adjuster and the claimant's attorney in an attempt to reach a mutually acceptable settlement.

Choice (c) is not correct; adjusters are more likely to make realistic initial offers with unrepresented claimants, knowing that such claimants are typically not familiar or comfortable with the negotiation process.

Choice (e) is not correct; negotiation in liability claim settlements is the norm. Willingness to negotiate intelligently can be a strength and is rarely, if ever, considered a weakness by the other party.

Choice (g) is not correct; if an adjuster grossly undervalues a claim in his offer, this can discredit the adjuster and make it more difficult for him to reach a reasonable claim settlement.

Problem S5-70-2.

(a) How is payment for liability claim settlements usually made?

(b) What is a structured settlement?

(c) Describe a situation in which a structured settlement would be especially useful.

(d) Why are structured settlements sometimes attractive to insurers?

Solution S5-70-2. This question is based on the discussion of settlement techniques in Myhr and Markham, p. 10.23.

(a) Payment for liability claim settlements are usually made as a single lump sum.

(b) A structured settlement is an "agreement in settlement of a lawsuit involving specific payments made over a period of time."

(c) A structured settlement would be especially useful in the following cases:

1. If the recipient of the settlement can be expected to incur "regular damages into the future";
2. If the recipient of the settlement cannot be expected to "effectively manage a lump-sum payment".

(d) Structured settlements are sometimes attractive to insurers because, for the same dollar amount of ultimate settlement, there is a lower present value, since some of the settlement does not have to be paid right away but is deferred into the future. These obligations can be funded by the insurer's purchase of annuities.

Problem S5-70-3.

(a) What is an *advance payment*?

(b) What is one purpose of an advance payment, from an insurer's perspective?

(c) What must the recipient of advance payment do?

(d) What is a *walk-away settlement*?

(e) For what kinds of claims are walk-away settlements most appropriate?

(f) Name two advantages that insurers cite for using walk-away settlements.

Solution S5-70-3. This question is based on the discussion of settlement techniques in Myhr and Markham, p. 10.23.

(a) An *advance payment* is a "payment made to a claimant following a loss to cover the immediate expenses resulting from that loss."

(b) One purpose of an advance payment, from an insurer's perspective, would be to discourage the claimant from hiring an attorney. Other valid answers may be possible.

(c) The recipient of an advance payment "must sign a receipt acknowledging payments and that the advance payments count toward final settlement."

(d) A *walk-away settlement* is a "settlement that involves lump-sum payments made by insurers to settle claims and that does not require a release from the claimant."

(e) Walk-away settlements are most appropriate for *small claims*.

(f) According to Myhr and Markham, p. 10.23, the following three advantages of walk-away settlements are cited by insurers:

1. They promote excellent public relations;

2. They enhance assertive claim handling;
3. They encourage claimants not to sue the insurer;

4. If claimants do sue the insurer, the insurer will receive credit for the money it paid in the walk-away settlements.

Any two of the above suffice as an answer. Other valid answers may be possible.

**Problem S5-70-4.**

(a) Why are claims that are litigated to a conclusion so important, even though they comprise only a small fraction of all claims?

(b) What factors might make it difficult for a liability claim to be settled? Give two examples.

**Solution S5-70-4.**

(a) Claims that are litigated to a conclusion are important because the verdicts pertaining to those claims can set a precedent for how courts would rule in other situations as well. The nature of the relevant legal precedents can greatly influence how negotiations and claim settlements proceed (Myhr and Markham, p. 10.24).

(b) The following two examples of factors that might make it difficult for a liability claim to be settled are given by Myhr and Markham, p. 10.25:

1. Plaintiffs or defendants may be unreasonable and make either unreasonably high or unreasonably low settlement offers.

2. There may be multiple codefendants that all insist that they are not liable and so refuse to settle.

3. The claim may be frivolous, fraudulent, or meritless.

Any two of the above suffice as an answer. Other valid answers may also be possible.

**Problem S5-70-5.**

(a) What rights does an insurer obtain in combination with its duty to defend the insured under a liability policy? Give two examples.

(b) If an attorney has been hired by an insurer to defend an insured, what should that attorney never be instructed to do?

(c) For a complex claim in which the claimant has made several allegations which are clearly not covered under the defendant's liability insurance policy, along with several allegations that are or may be covered, what is the extent of the insurer's duty to defend? What right does the insured always have?
Solution S5-70-5.

(a) The insurer's duty to defend comes with the following rights, according to Myhr and Markham, p. 10.25:

1. The right to select the defense attorney;

2. The right to "unilaterally decide to settle or to continue a claim's defense";

3. The right to direct the defense attorney "as long as the insured is not financially exposed to the claim".

Any two of the above suffice as an answer. Other valid answers may also be possible.

(b) If an attorney has been hired by an insurer to defend an insured, that attorney "should never be used to advise the insurer on coverage issues in the same case" (Myhr and Markham, p. 10.26).

(c) The insurer must typically **defend the insured against the entire claim** even if the allegations of the plaintiff pertaining to only a part of the claim are covered. The insured always has the right to **hire another attorney representing the insured, at the insured's expense**.
Section 71

Stages of a Lawsuit, Legal Expense Controls, and Alternative Dispute Resolution

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Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-71-1.

(a) Describe the two ways in which a lawsuit can be initiated.

(b) What must the defendant do, usually within 20 to 30 days, after being informed of the plaintiff's allegations?

(c) What is the initial stage of a lawsuit called? What entities typically provide the first papers in this stage?

**Solution S5-71-1.**

(a) According to Myhr and Markham, p. 10.26, a lawsuit can be initiated either via a **summons** - a "legal document issued by the clerk of the court requiring the sheriff or another officer to notify the person named that an action has commenced against him or her and that he or she must answer the complaint" - or a **complaint** - a "document listing what the defendant has done to harm the plaintiff and the amount of money the plaintiff wants to recover."

(b) The defendant is required to provide an **answer** - a "document that responds to the plaintiff's allegations and that can include defenses to the complaint" (Myhr and Markham, p. 10.26).
(c) The initial stage of a lawsuit is called the **pleadings** and entails "formal written statements of the facts and claims of each party to a lawsuit" (Myhr and Markham, p. 10.26). A court officer, such as a sheriff, sheriff’s deputy, or U. S. marshal, will typically present the initial papers of the pleadings to the parties in the lawsuit.

**Problem S5-71-2.**
(a) What is the *discovery* stage of a lawsuit?
(b) What is the difference between *interrogatories* and *depositions*?
(c) In a lawsuit, what is the most expensive and time-consuming form of discovery?
(d) What other two elements, besides interrogatories and depositions, might the discovery stage of a lawsuit involve?

**Solution S5-71-2.**

(a) *Discovery* is a "pretrial exchange of all relevant information between the plaintiff and defendant" or "the formal process by which each party obtains the evidence and information known to the other parties" (Myhr and Markham, p. 10.27).

(b) *Interrogatories* are "specific written questions or requests raised by one party to a lawsuit that the opposing party must answer in writing", whereas a *deposition* is a "a series of oral questions and answers that are recorded by a court reporter" (Myhr and Markham, p. 10.27). Interrogatories are answered in writing, whereas depositions are answered orally.

(c) *Depositions* are the most expensive and time-consuming form of discovery in a lawsuit (Myhr and Markham, p. 10.27).

(d) The following other possible elements of the discovery stage of a lawsuit are mentioned by Myhr and Markham, p. 10.27:

1. Requests for documents;
2. Requests for admission: "written statements that the receiving party must either accept or dispute";
3. A right of inspection;
4. A right of medical examination.

Any two of the above suffice as an answer. Other valid answers may also be possible.

**Problem S5-71-3.**
(a) In a lawsuit, what is a *motion*?
(b) At what stages of a lawsuit can motions be made?
(c) What is a *motion for summary judgment*?

**Solution S5-71-3.**

(a) A *motion* is "a formal request to the court for a decision or ruling" (Myhr and Markham, p. 10.27).
(b) A motion can be filed at any stage of the lawsuit, from the time it is initiated to the time that it is appealed (Myhr and Markham, p. 10.27).

(c) A motion for summary judgment is a motion "in which the moving party asks the court to decide the case in its favor, usually after only pleadings or discovery has been completed and before trial. A motion for summary judgment is essentially an argument that no real issues exist and that, as a matter of law, the moving party is entitled to judgment" (Myhr and Markham, p. 10.27).

Problem S5-71-4.
(a) In a jury trial, what is the role of the judge with respect to the jury?
(b) What are the only aspects of a case that can be heard on appeal?
(c) Name two techniques that liability insurers use to control legal expenses.

Solution S5-71-4.
(a) In a jury trial, "the judge explains to the jury the relevant law and explains what factual issues the jury must resolve" (Myhr and Markham, p. 10.27).

(b) On appeal, the only aspects of a case that can be heard are alleged errors of law - such as misstatements of the law by the judge or presentation of inadmissible evidence. Issues of fact may not be disputed (Myhr and Markham, p. 10.28).

(c) The following techniques used by liability insurers to control legal expenses are mentioned by Myhr and Markham, p. 10.28:

1. Using only specific preapproved firms to defend liability lawsuits. These firms typically work at a lower hourly rate;
2. Requiring "monthly or quarterly bills on active cases." These bills would typically show a highly detailed breakdown of expenses;
3. Requiring law firms to submit budgets or quote fixed prices for a case.
4. Requiring adjusters to "preapprove all depositions or motions".
5. Settling cases before a lawsuit can even emerge.

Any two of the above suffice as an answer. Other valid answers may also be possible.

Problem S5-71-5. The following six types of alternative dispute resolution (ADR) are discussed by Myhr and Markham, pp. 10.28-10.30:

1. Negotiation;
2. Mediation;
3. Arbitration;
4. Appraisal;
5. Mini-trial = summary jury trial;
Each of the following characteristics pertain to one of the six types of ADR above. Match the characteristic to the type of ADR to which it pertains.

(a) A procedure in which the amount of covered loss is determined by the insurer and the insured each choosing a representative; thereafter, the two representatives may select an umpire who would resolve differences between their estimates.
(b) A referee assists the parties in dispute in reaching a mutually agreeable settlement.
(c) Before the parties to a lawsuit actually go to trial, they discuss the case with the judge who will be presiding over it and attempt one final time to reach an agreement that would render the trial unnecessary.
(d) A disinterested third party acts as a judge and reaches a decision regarding the dispute, which may or may not be binding.
(e) Direct communication between the insurer and the claimant or claimant's representatives in an attempt to settle the claim and prevent a lawsuit.
(f) Representatives of each side in a dispute offer an abbreviated version of their case to a panel whose decisions may or may not be binding. The rules and procedures used in this method of ADR are often the same as those of conventional courts.

**Solution S5-71-5.**

Characteristic (a) pertains to 4. Appraisal.

Characteristic (b) pertains to 2. Mediation.

Characteristic (c) pertains to 6. Pretrial settlement conference.

Characteristic (d) pertains to 3. Arbitration.

Characteristic (e) pertains to 1. Negotiation.

Characteristic (f) pertains to 5. Mini-trial = summary jury trial.
Section 72

Treatment of Expenses in Ratemaking and the All Variable Expense Method

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Equation 72.1 is the fundamental insurance equation, transformed to determine average premium:

\[ P^* = \frac{L^- + E^-L + E^-F}{1 - V - QT} \]

Definitions of variables:
- \( E^-F \): Fixed expense per policy
- \( E^-L \): Average expected loss adjustment expense per policy
- \( L^- \): Average expected loss per policy
- \( P^* \): Average premium per policy
- \( Q_T \): Company-selected profit provision as a fraction of premium
- \( V \): Variable expense as a fraction of premium

Source:

Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-72-1. An insurance company has determined the following:

- The average expected loss per policy is $700.
- The average expected loss adjustment expense per policy is $78.
- The fixed expense per policy is $30.
- For each dollar of premium collected, 24 cents cover expenses that vary with the premium.
- The company has selected a profit provision of 2% of premium.
Using this information and the fundamental insurance equation, determine the average amount of premium that the company will need to charge.

**Solution S5-72-1.** We use Equation 72.1: $P^- = (L^- + E^-_L + E^-_F)/(1 - V - Q_T)$.
Here, $L^- = 700$, $E^-_L = 78$, $E^-_F = 30$, $V = 0.24$, and $Q_T = 0.02$. Thus, our answer is $P^- = (700 + 78 + 30)/(1 - 0.24 - 0.02) = 1091.891892 = \$1091.89$.

**Problem S5-72-2.** Werner and Modlin, p. 123, discuss the following categories of underwriting expense:

1. Commissions and brokerage  
2. Other acquisition expenses  
3. Taxes, licenses, and fees  
4. General expenses.

Match each of the following items to the category within which it would be included. It is also possible that some of these items belong to category 5. None of the above.

(a) Costs of media advertisements  
(b) Investment income expenses  
(c) Premium taxes  
(d) Actuarial salaries  
(e) Payments to agents based on predetermined volume goals  
(f) Building maintenance  
(g) Costs of mailings to prospective insureds  
(h) Federal income taxes  
(i) Payments to brokers based on loss ratios of business generated  
(j) Licensing fees  
(k) Salaries of non-commissioned sales employees

**Solution S5-72-2.**

The following items belong to category 1. **Commissions and brokerage**:

(e) Payments to agents based on predetermined volume goals  
(i) Payments to brokers based on loss ratios of business generated

The following items belong to category 2. **Other acquisition expenses**:

(a) Costs of media advertisements  
(g) Costs of mailings to prospective insureds  
(k) Salaries of non-commissioned sales employees

The following items belong to category 3. **Taxes, licenses, and fees**:

(c) Premium taxes
(j) Licensing fees

The following items belong to category 4. General expenses:

(d) Actuarial salaries
(f) Building maintenance

The following items belong to category 5. None of the above:

(b) Investment income expenses
(h) Federal income taxes

Problem S5-72-3. You know the following data about a large commercial insurer's book of business:

In the year 2350, expenses were 53600 Golden Hexagons (GH), and written premium was 360000 GH.
In the year 2351, expenses were 46000 GH, and written premium was 400000 GH.
In the year 2352, expenses were 50000 GH, and written premium was 380000 GH.

Use the All Variable Expense Method to determine the following:
(a) The variable expense percentage for each year.
(b) The selected variable expense percentage, based on a 3-year average of variable expenses.
(c) The estimated expenses in the year 2353, if written premium is 560000 GH.

Solution S5-72-3. (a) The All Variable Expense Method assumes that all expenses are variable expenses. The variable expense percentage for each year is (Expenses)/(Written Premium).

For 2350, this percentage is 53600/360000 = 14.88888889%.
For 2351, this percentage is 46000/400000 = 11.5%.
For 2352, this percentage is 50000/380000 = 13.15789474%.

(b) The three-year average variable expense percentage is equal to
(Sum of expenses during the three years)/(Sum of written premium during the three years) =
(53600 + 46000 + 50000)/(360000 + 400000 + 380000) = 13.12280702%.

(c) The estimated expenses in the year 2353, if written premium is 560000 GH, are
13.12280702% of the written premium, or 560000*0.1312280702 = 73487.7193 GH.

Problem S5-72-4. This question pertains to the All Variable Expense Method.

(a) What determines whether written premium or earned premium is used in the denominator of the variable expense percentage calculation?
(b) When will the use of written premium versus earned premium have a material impact on the variable expense percentage calculation?
Solution S5-72-4. This question is based on the discussion in Werner and Modlin, pp. 124-125.

(a) If expenses are mostly incurred at the beginning of the policy - as is the case for expenses such as commissions - then written premium should be used. If expenses are mostly incurred gradually over the lifetime of the policy - as is the case for overhead and salaries - then earned premium should be used.

(b) If the company is substantially growing or shrinking, then the use of written premium versus earned premium have a material impact on the variable expense percentage calculation. If the company is growing, written premium will be higher than earned premium. If the company is shrinking, written premium will be lower than earned premium.

Problem S5-72-5. An insurance company has determined the following:

The average expected loss per policy is $700.
The average expected loss adjustment expense per policy is $78.
The fixed expense per policy is $30.
For each dollar of premium collected, 24 cents cover expenses that vary with the premium.
The company has selected a profit provision of 2% of premium.

Now consider a policy for which the true loss and loss adjustment expense cost, known to the company, is $500.

(a) What would be the premium on this policy if it were rated correctly?
(b) What would be the premium on this policy if it were rated according to the All Variable Expense Method?
(c) By what percentage and in what direction is the answer in (b) different from the answer in (a)?

Solution S5-72-5.

(a) We use Equation 72.1, applied to the particular policy: \( P^- = (L + E_L^- + E_F^-)/(1 - V - Q_T) \).
Here, \( L + E_L^- = 500, E_F^- = 30, V = 0.24, \) and \( Q_T = 0.02 \). Thus, our answer is \( P^- = (500 + 30)/(1 - 0.24 - 0.02) = 716.2162162 = \$716.22 \).

(b) From Solution S5-72-1, we know that the average premium for this book of business is 1091.891892. The percentage of this that the fixed expense constitutes is \( 30/1091.891892 = 2.74752475% \). This gets incorporated into the variable expense under the All Variable Expense Method, leading the variable expense percentage to be \( 24% + 2.74752475% = 26.74752475% \).

Now we can find the premium: \( P^- = (L + E_L^-)/(1 - V - Q_T) = (500)/(1-0.2674752475 - 0.02) = 701.7300076 = \$701.73 \).

(c) The premium in part (b) is too low. The percentage difference from the premium in part (a) is \( 701.7300076/716.2162162 - 1 = -0.0202260271 = -2.0260271% \).
Section 73

The Premium-Based Projection Method and the Exposure-Based Projection Method for Expenses in Insurance Ratemaking

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Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-73-1. You know the following data about a large commercial insurer's book of business:

In the year 2350, expenses were 53600 Golden Hexagons (GH), and written premium was 360000 GH.
In the year 2351, expenses were 46000 GH, and written premium was 400000 GH.
In the year 2352, expenses were 50000 GH, and written premium was 380000 GH.

Use the Premium-Based Projection Method, with the assumption that fixed expenses constitute 30% of all expenses, to determine the following:

(a) The fixed expense percentage of written premium for each year.
(b) The variable expense percentage of written premium for each year.
(c) The selected fixed expense percentage of written premium, based on a 3-year average of fixed expenses.
(d) The selected variable expense percentage of written premium, based on a 3-year average of variable expenses.
(e) The projected average premium for 2353 is 300 GH. What is the projected fixed expense per exposure for 2353?
Solution S5-73-1.

(a) The Premium-Based Projection Method designates a certain percentage of expenses as fixed expenses, and the rest as variable expenses. Here, the percentage of expenses comprised of fixed expenses is 30%.

For 2350, the fixed expense percentage of written premium is $0.3 \times \frac{53600}{360000} = 4.466667\%$.

For 2351, the fixed expense percentage of written premium is $0.3 \times \frac{46000}{400000} = 3.45\%$.

For 2352, the fixed expense percentage of written premium is $0.3 \times \frac{50000}{380000} = 3.947368\%$.

(b) Here, the percentage of expenses comprised of variable expenses is 100% - 30% = 70%.

For 2350, the variable expense percentage of written premium is $0.7 \times \frac{53600}{360000} = 10.42222222\%$.

For 2351, the variable expense percentage of written premium is $0.7 \times \frac{46000}{400000} = 8.05\%$.

For 2352, the variable expense percentage of written premium is $0.7 \times \frac{50000}{380000} = 9.21052632\%$.

(c) The three-year fixed expense percentage is (Sum of estimated fixed expenses)/(Sum of written premium for the three years) =

$0.3 \times (\frac{53600 + 46000 + 50000}{360000 + 400000 + 380000}) = 3.93684211\%$.

(d) The three-year variable expense percentage is (Sum of estimated variable expenses)/(Sum of written premium for the three years) = $0.7 \times (\frac{53600 + 46000 + 50000}{360000 + 400000 + 380000}) = 9.18596491\%$.

(e) We use the formula (Fixed Expense Per Exposure) = (Fixed Expense Ratio)* (Projected Average Premium). We know that Projected Average Premium = 300, and, from part (c), Fixed Expense Ratio = 0.0393684211. Thus, (Fixed Expense Per Exposure) = 0.0393684211*300 = 11.81052633 GH.

Problem S5-73-2. Discuss three situations in which distortions might arise when one is using the Premium-Based Percentage Method.

Solution S5-73-2. The following situations are mentioned by Werner and Modlin, p. 129:

1. Rate changes after the historical period from which the data were taken: If rates increased after the historical period, then the Premium-Based Projection Method will overstate fixed expenses. If rates decreased after the historical period, then the Premium-Based Projection Method will understate fixed expenses.
2. **Changes in average premium after the historical period from which the data were taken:**
If average premium increased after the historical period, then the Premium-Based Projection Method will overstate fixed expenses. If average premium decreased after the historical period, then the Premium-Based Projection Method will understate fixed expenses.

3. **Application of countrywide fixed expense ratios to specific states:** Fixed expenses will be overestimated in states with higher-than-average premium and underestimated in states with lower-than-average premium.

**Problem S5-73-3.** An insurance company has determined the following:
The average expected loss per policy is $700.

The average expected loss adjustment expense per policy is $78.

The fixed expense per policy is $30.

For each dollar of premium collected, 24 cents cover expenses that vary with the premium.

The company has selected a profit provision of 2% of premium.

Now consider a policy for which the true loss and loss adjustment expense cost, known to the company, is $500.

The premium on this policy, if it were rated correctly, is $716.2162162 = $716.22.

(a) What would be the premium on this policy if it were rated according to the Premium-Based Projection Method?
(b) By what percentage and in what direction is the answer in (a) different from the true premium?

**Solution S5-73-3.**

(a) The average premium on this policy is

\[ P^- = \frac{L^- + E^-_L + E^-_F}{1 - V - Q_T}. \]

Here, \( L^- = 700, E^-_L = 78, E^-_F = 30, V = 0.24, \) and \( Q_T = 0.02. \)

Thus, \( P^- = \frac{700 + 78 + 30}{1 - 0.24 - 0.02} = 1091.891892. \)

The fixed expense percentage according to the Premium-Based Projection Method can be expressed as a percentage of average premium: \( 30/1091.891892 = 2.74752475\%. \)

If the true premium on this policy is $716.2162162, then the fixed expense would be estimated as \( 0.0274752475\times716.2162162 = 19.6782178. \)

The estimated premium for the policy in question is then

\[ P^- = \frac{L^- + E^-_L + E^-_F}{1 - V - Q_T}. \]
\[
\frac{500 + 19.6782178}{1 - 0.24 - 0.02} = 702.2678619 = \textbf{702.27}.
\]

(b) The premium in part (a) is too low. The percentage difference from the true premium is
\[
\frac{702.2678619}{716.2162162} - 1 = -0.0194750607 = -1.94750607\%.
\]

**Problem S5-73-4.** You know the following data about a large commercial insurer's book of business:

In the year 2350, expenses were 53600 Golden Hexagons (GH), and written premium was 360000 GH. There were 4600 earned exposures.

In the year 2351, expenses were 46000 GH, and written premium was 400000 GH. There were 5000 earned exposures.

In the year 2352, expenses were 50000 GH, and written premium was 380000 GH. There were 4500 earned exposures.

Use the *Exposure-Based Projection Method*, with the assumption that fixed expenses constitute 30% of all expenses, to determine the following:

(a) The selected variable expense percentage of written premium, based on a 3-year average of variable expenses.

(b) The fixed expense per exposure for each year.

(c) The fixed expense per exposure, based on a 3-year average of fixed expenses.

(d) The projected average premium for 2353 is 300 GH. What is the projected fixed expense ratio for 2353?

**Solution S5-73-4.**

(a) Variable expenses under the Exposure-Based Projection Method are calculated in the exact same way as under the Premium-Based Projection Method:

The three-year variable expense percentage is \( \frac{(\text{Sum of estimated variable expenses})}{(\text{Sum of written premium for the three years})} = 0.7*(53600 + 46000 + 50000)/(360000 + 400000 + 380000) = 9.18596491\%. \)

(b) For 2350, the fixed expense per exposure is \( 0.3*53600/4600 = 3.495652174 \text{ GH} \).

For 2351, the fixed expense per exposure is \( 0.3*46000/5000 = 2.76 \text{ GH} \).

For 2352, the fixed expense per exposure is \( 0.3*50000/4500 = 3.333333333 \text{ GH} \).

(c) For the three years, the fixed expense per exposure is \( (\text{Sum of fixed expenses})/(\text{Sum of exposures}) = 0.3*(53600 + 46000 + 50000)/(4600 + 5000 + 4500) = 3.182978723 \text{ GH} \).
(d) We use the formula (Projected Fixed Expense Ratio) = (Average Projected Fixed Expense Per Exposure)/(Projected Average Premium) = 3.182978723/300 = 0.0106099291 = 1.06099291%.

Problem S5-73-5. Briefly discuss three possible shortcomings of the Exposure-Based Projection Method.

Solution S5-73-5. The following possible shortcomings of the Exposure-Based Projection Method are mentioned by Werner and Modlin, pp. 131-132:

1. Actuarial judgment is still most often required to split total expenses into fixed and variable portions.

2. The Exposure-Based Projection Method allocates fixed expenses to each state on the basis of the number of exposures in that state. However, there could be location-dependent variations in average fixed expense.

3. So-called fixed expenses can actually vary on the basis of certain characteristics - such as whether business is new or renewal.

4. Considerations pertaining to economies of scale can increase or decrease average fixed expenses. Judgment is often required to estimate future changes based on economies of scale.
Section 74

Trending of Fixed Expenses, Reinsurance Costs, and Treatment of Profit in Insurance Ratemaking

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Source:

Original Problems and Solutions from The Actuary's Free Study Guide

**Problem S5-74-1.** It is known that the average fixed expense per policy was $56 in calendar year (CY) 2021. The annual inflation rate during the next several years is 32%. It is assumed that the fixed expense is incurred at the onset of the policy. An actuary uses this information to trend the fixed expenses for policy year (PY) 2026. What is the trended fixed expense per policy for PY 2026?

**Solution S5-74-1.** According to Werner and Modlin, p. 133, "Expenses that are incurred at the inception of the policy should be trended from the average date that the policies were written in the historical period to the average written date in the projection period."

The average written date for a calendar year is the midpoint of that year. For CY 2021, the average written date is therefore June 30, 2021. Likewise, the average written date for a policy year is also the midpoint of the year. In the case of PY 2026, the midpoint is June 30, 2026. This means that the fixed expenses must be trended for five years of inflation, leading the trended fixed expense to be $56 \times 1.32^5 = 224.4189986 = \$224.42$.

**Problem S5-74-2.** It is known that the average fixed expense per policy was $56 in calendar year (CY) 2021. The annual inflation rate during the next several years is 32%. It is assumed that the
fixed expense is incurred evenly throughout the policy period. An actuary uses this information to trend the fixed expenses for policy year (PY) 2026. What is the trended fixed expense per policy for PY 2026?

Solution S5-74-2. According to Werner and Modlin, p. 133, "expenses that are incurred evenly throughout the policy period should be trended from the average date the policies were earned in the historical period to the average earned date in the projection period."

The average written date for a calendar year is the midpoint of that year. For CY 2021, the average written date is therefore June 30, 2021. For a policy year, the average earned date is the beginning of the next calendar year. That is, for PY 2026, the average earned date of the policies is January 1, 2027; because, if policies are written evenly throughout the year, half the premium from all the policies will have been earned by that date. This means that the fixed expenses must be trended for 5.5 years of inflation, leading the trended fixed expense to be $6 \times 1.325^{5.5} = 257.8366493 = \$257.84.$

Problem S5-74-3.

(a) With what kinds of reinsurance is it typically unnecessary to consider reinsurance costs in ratemaking analysis? With what kinds of reinsurance is it often proper to consider reinsurance costs?

(b) In general terms, how are projected losses and projected premiums affected by taking reinsurance costs into account?

Solution S5-74-3. This question is based on the discussion of reinsurance costs by Werner and Modlin, p. 134.

(a) In ratemaking analysis, it is typically unnecessary to consider reinsurance costs for proportional reinsurance, where the primary insurer cedes the same fraction of premium and losses to the reinsurer. On the other hand, it is often proper to consider reinsurance costs for non-proportional reinsurance, where the reinsurer agrees to assume responsibility for some predetermined portion of losses, typically in excess of a certain amount. For instance, with catastrophe excess-of-loss reinsurance, the reinsurer might cover a certain proportion of losses in excess of a certain amount from a given occurrence. The primary insurer does not necessarily cede to the reinsurer the same fraction of premium as it cedes of losses.

(b) If reinsurance costs are taken into account, projected losses must be reduced by the amount of "expected non-proportional reinsurance recoveries." Projected premiums must be reduced "by the amount to be ceded to the reinsurer" (Werner and Modlin, p. 134).

Problem S5-74-4. Insurer Q lost $6002 on its investments in the year 2103 and earned an underwriting profit of $6310. Insurer Q collected $16000 in premium and incurred $5500 in losses and $2500 in loss adjustment expenses.

(a) What was Insurer Q's total profit in the year 2103?
(b) What were Insurer Q's underwriting expenses in the year 2103?

**Solution S5-74-4.**

(a) We use the formula Total Profit = Investment Income + Underwriting Profit.

Here, investment income is negative: -6002, so Total Profit = -6002 + 6310 = $308.

(b) We use the formula UW Profit = Premium - Losses - LAE - UW Expenses, rearranging the formula thus: UW Expenses = Premium - Losses - LAE - UW Profit = 16000 - 5500 - 2500 - 6310 = $1690.

**Problem S5-74-5.** Insurer Z estimates that 9% of its expenses are variable expenses and 3% are fixed expenses. It also has a target profit provision of 10%.

(a) What is Insurer Z's variable permissible loss ratio (VPLR)?

(b) What is Insurer Z's total permissible loss ratio (PLR)?

**Solution S5-74-5.**

(a) We use the formula VPLR = 1 - (Variable Expense%) - (Target Profit%) = 1 - 0.09 - 0.10 = 0.81 = 81%.

(b) We use the formula PLR = 1 - (Total Expense%) - (Target Profit%) = 1 - 0.09 - 0.03 - 0.10 = 0.78 = 78%.
Section 75

The Pure Premium Method and the Loss Ratio Method in Insurance Ratemaking

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The Pure Premium Method

Under the Pure Premium Method, the following equation can be used to determine the indicated average rate per exposure:

**Formula 75.1:**

Indicated Average Rate =

\[
\frac{((\text{Pure Premium (including LAE)}) + (\text{Fixed Underwriting Expense Per Exposure}))/}{(1 - \text{Variable Expense Ratio} - \text{Target Profit Percentage})}. 
\]

The symbolic expression of this formula is as follows:

**Formula 75.2:**

\[
P'_1 = \frac{(L + E^-_L + E^-_F)}{(1 - V - QT)}
\]

We can also express this result as **Formula 75.3:**

\[
P'_1 = \frac{((L + E_L + E_F)/X)/(1 - V - QT)}.
\]

**Definitions of variables:**

- \(E_F\): Total fixed expense
- \(E^-_F\): Fixed expense per exposure
- \(E_L\): Total loss adjustment expense
- \(E^-_L\): Average loss adjustment expense per exposure
- \(L\): Total incurred losses
- \(L^-\): Average loss per exposure
- \(P'_1\): Indicated average rate
The Loss Ratio Method

Under the Loss Ratio Method, the following equation can be used to determine the indicated rate change:

Formula 75.3:

\[(\text{Indicated Change Factor}) = \frac{\text{Loss & LAE Ratio} + \text{Fixed Expense Ratio}}{1 - \text{Variable Expense Ratio} - \text{Target Underwriting Profit \%}}.\]

The symbolic expression of this formula is as follows:

Formula 75.4:

\[(\text{Indicated Change Factor}) = \frac{(L + E_L)/PC + F}{1 - V - QT}.\]

Formula 75.5:

\[(\text{Indicated Change}) = \frac{(L + E_L)/PC + F}{1 - V - QT} - 1.\]

Definitions of variables:
- \(E_L\): Total loss adjustment expense
- \(F\): Fixed expense ratio
- \(L\): Total incurred losses
- \(PC\): Total earned premium
- \(QT\): Company-selected profit provision as a fraction of premium
- \(V\): Variable expense as a fraction of premium

Note that the Loss Ratio Method can only be used to evaluate experience for an insurance program that is already in place.

Under the Loss Ratio Method, \(Q_C\), the expected profit percentage, assuming current rates, can be expressed as follows:

Formula 75.6:

\[Q_C = 1 - \frac{(L + E_L) + F}{PC} - V.\]

Source:
Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-75-1. In calendar year 2501, Insurance Company Ω had 67000 Golden Hexagons (GH) in incurred losses, 9600 GH in loss adjustment expenses, and 4300 GH in fixed expenses. The company selected a variable expense provision of 10% and a profit provision of 4%. The company had 3680 earned exposures, and all expenses are compared to earned exposures. Using the pure premium method, what is the indicated average rate?

Solution S5-75-1. We use Formula 75.3: \( P_I = \frac{(L + EL + EF)}{X}(1 - V - QT) \), where \( L = 67000 \), \( EL = 9600 \), \( EF = 4300 \), \( X = 3680 \), \( V = 0.1 \), and \( QT = 0.04 \). Thus, \( P_I = \frac{(67000 + 9600 + 4300)}{3680}(1 - 0.1 - 0.04) = P_I = 25.5624368 \text{ GH} \).

Problem S5-75-2. In calendar year 2310, Insurance Company Ψ had an average loss per exposure of 90 Golden Hexagons (GH). Loss adjustment expenses were 53 GH per exposure, and fixed expenses were 1 GH per exposure. The company selected a variable expense provision of 23% and a profit provision of 2%. Using the pure premium method, what is the indicated average rate?

Solution S5-75-2. We use the Formula 75.2: \( P_I = \frac{(L' + EL' + EF')}{(1 - V - QT)} \), where \( L' = 90 \), \( EL' = 53 \), \( E_F' = 1 \), \( V = 0.23 \), and \( QT = 0.02 \). Thus, \( P_I = \frac{(90 + 53 + 1)}{(1 - 0.23 - 0.02)} = P_I = 192 \text{ GH} \).

Problem S5-75-3. In calendar year 2344, Insurance Company Σ had a total of 54440 Golden Hexagons (GH) in losses and 2400 GH in loss adjustment expenses. The company also earned 80000 GH of premium; rate levels have not changed since that time. The company estimates that its fixed expense ratio is 4%, and that its variable expense ratio is 19%. The company selects a profit provision of 5%. Using the loss ratio method, find the following:

(a) The indicated rate change factor;
(b) The indicated rate change.

Solution S5-75-3.

(a) We use Formula 75.4: (Indicated Change Factor) = \( \frac{(L + EL + EF)}{(PC + F)}(1 - V - QT) \). Here, \( L = 54440 \), \( EL = 2400 \), \( PC = 80000 \), \( F = 0.04 \), \( V = 0.19 \), and \( QT = 0.05 \). Thus, (Indicated Change Factor) = \( \frac{(54440 + 2400) - 80000 + 0.04}{(1 - 0.19 - 0.05)} = 0.7505/0.76 = 0.9875 \).

(b) The indicated rate change is, by Formula 75.5, (Indicated Change Factor) - 1 = 0.9875 - 1 = -0.0125 = -1.25%.

Problem S5-75-4. In calendar year 2550, Insurance Company Π had a total of 4270 Golden Hexagons GH in losses, 3260 GH in loss adjustment expenses, and 460 GH in fixed expenses. The company earned 10000 GH of premium. The company's variable expense provision is 20%. Assume that rate levels have not changed since 2550 and that all expenses are being compared to earned premium for the purpose of determining expense ratios.
(a) What is the company's profit percentage for calendar year 2550?
(b) What is the indicated rate change, if the company seeks to earn 5% profit?

Solution S5-75-4.

(a) We use Formula 75.6: \( Q_C = 1 - ((L + E_L + E_F)/P_C) - V \). Here, \( L = 4270 \), \( E_L = 3260 \), \( E_F = 460 \), \( P_C = 10000 \), and \( V = 0.2 \). Thus, \( Q_C = 1 - (4270 + 3260 + 460)/10000 - 0.2 = 0.001 = 0.1\% \).

(b) We use Formula 75.5: \( (\text{Indicated Change}) = ((L + E_L)/P_C + F)/(1 - V - Q_T) - 1 \), where \( Q_T = 0.05 \). Here, \( F \) is the fixed expense ratio, or \( 460/10000 \).

Thus, \( (\text{Indicated Change}) = ((4270 + 3260 + 460)/10000)/(1 - 0.2 - 0.05) - 1 = 0.0653333333 = a +6.53333333\% \text{ increase.} \)

Problem S5-75-5. The following questions pertain to comparisons between the Pure Premium Method and the Loss Ratio Method:

(a) Which of these methods requires premium to be at current rate levels?
(b) Which of these methods always produces a higher rate indication than the other?
(c) Which of these methods requires clearly defined exposures?
(d) Which of these methods works better if data regarding premium are not available?
(e) Which of these methods is preferable for rating most commercial general liability (CGL) insurance products?
(f) Which of these methods must be used for a new line of business (if the actuary does not wish to rely on judgment alone)?

Solution S5-75-5. This problem is based on the discussion in Werner and Modlin, pp. 143-144.

(a) The Loss Ratio Method requires premium to be at current rate levels.

(b) This is a trick question. Neither method produces a higher rate indication than the other, since the two methods are mathematically equivalent, if executed correctly using comparable, accurate, and consistent data.

c) The Pure Premium Method requires clearly defined exposures.

(d) The Pure Premium Method works better if data regarding premium are not available.

e) The Loss Ratio Method is preferable for rating most commercial general liability (CGL) insurance products, because the Pure Premium Method requires clearly defined exposures, and it is extremely difficult to identify what an exposure is for a CGL product, since such a broad variety of coverages is being provided.

(f) The Pure Premium Method must be used for a new line of business.
Section 76
Criteria for Selecting Underwriting and Rating Variables in Insurance

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**Source:** Werner, Geoff and Claudine Modlin. *Basic Ratemaking*. Casualty Actuarial Society. 2009. Chapter 9, pp. 147-156.

**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-76-1.** Werner and Modlin, p. 152, discuss the following *statistical criteria* for selecting rating variables:

1. Statistical significance;
2. Homogeneity;
3. Credibility.

In the following situations, one of these criteria is lacking. Identify the missing criterion:

(a) Variable Θ was selected on the basis of data from 12 personal lines insurance policies.
(b) Variable Δ contains a class consisting of 30% highly risk-averse and careful drivers and 70% of reckless and risk-seeking drivers.
(c) For the particular classes in Variable Φ, the loss experience results are close to one another in a manner that could be explained by sheer random variation.
(d) The loss experience suitable for analyzing the predictive efficacy of Variable Ω varies dramatically from year to year, and analyzing multiple years of data is required to make an accurate determination.
(e) It is possible to separate a class of Variable Γ into three categories, each of which will have different expected loss ratios.
(f) For the particular classes in Variable \( \Psi \), the loss experience results are different from one another, but are also quite volatile, such that the entire range of possible results for a given class can be close to the entire range of observed results for the variable itself.

**Solution S5-76-1.**

In situation (a), the missing criterion is **3. Credibility**.

In situation (b), the missing criterion is **2. Homogeneity**.

In situation (c), the missing criterion is **1. Statistical Significance**.

In situation (d), the missing criterion is **3. Credibility**.

In situation (e), the missing criterion is **2. Homogeneity**.

In situation (f), the missing criterion is **1. Statistical Significance**.

**Problem S5-76-2.** Werner and Modlin, p. 153, discuss the following operational criteria for selecting rating variables:

1. Objectivity;
2. Inexpensiveness;
3. Verifiability.

In the following situations, one or more of these criteria are lacking. Identify the missing criterion:

(a) A variable measuring the quality of the insured's political views is being proposed.
(b) A variable measuring the insured's grades on high school biology papers is being proposed. The variable, to be implemented, requires the insurer to contact the insured's high school biology teacher and obtain documentation of the grades the insured received.
(c) A variable measuring the gustatory qualities of an insured's cooking is being proposed.
(d) A variable measuring the insured's "goodness of intention" is being proposed.
(e) A variable is being proposed, which relies on the insured's monthly reports regarding the number of times during the month that the insured abstained from jumping on one foot while wearing an orange shoe, despite the temptation to do so being present.
(f) A variable is being proposed, which would require the insurer to conduct biweekly counseling sessions with the insured, on the basis of which the insurer would develop recommendations that the insured would implement in protecting the insured property or preventing liability losses. Those insureds who consistently attend the counseling sessions would receive a premium discount.

**Solution S5-76-2.**

In situation (a), the missing criterion is **1. Objectivity**.

In situation (b), the missing criterion is **2. Inexpensiveness**.

In situation (c), the missing criterion is **1. Objectivity**.

In situation (d), the missing criteria are **1. Objectivity** and **3. Verifiability**.

In situation (e), the missing criterion is **3. Verifiability**.

In situation (f), the missing criterion is **2. Inexpensiveness**.
Problem S5-76-3. Werner and Modlin, p. 153, discuss the following social criteria for selecting rating variables:

1. Affordability;
2. Causality;
3. Controllability;
4. Privacy concerns.

In the following situations, one or more of these criteria may be in question. Identify the possibly missing criteria:

(a) A variable is used, where customers of private passenger automobile insurance are being charged different rates based on the age at which they began to study geometry.

(b) A homeowners' insurance rating plan includes the use of a camera that monitors the manner in which the insured uses kitchen equipment, in an effort to identify behaviors that might increase the risk of fire.

(c) An insurer's statistical analysis indicates that insureds from Group Q have loss ratios that are 10 times greater than average. Group Q has 20 members, and the insurer decides to surcharge members of this group in accordance with the indicated difference in loss experience.

(d) Credit-based insurance scoring is used to partially determine an insured's premium on the basis of aspects of the insured's credit history.

(e) Insureds who are just beginning to drive are being charged a much higher premium than insureds who have been driving for one year.

Solution S5-76-3.
In situation (a), the possibly missing criteria are 2. Causality and 3. Controllability.
In situation (b), the possibly missing criterion is 4. Privacy concerns.
In situation (c), the possibly missing criterion is 1. Affordability.
In situation (d), the possibly missing criterion is 2. Causality.
In situation (e), the possibly missing criterion is 1. Affordability.

Problem S5-76-4. Werner and Modlin, p. 155, discuss legal criteria for the selection of rating variables. List three types of legal criteria that an insurer should take into account when establishing a rating variable within a particular state.

Solution S5-76-4. The following legal criteria should be taken into account:

1. Statutory requirements for rates - e.g., the requirement that rates not be "excessive, inadequate, or unfairly discriminatory";

2. Regulations that specify which rating variables are or are not permitted;
3. Differences in requirements between what variables may be considered in rating and what variables may be considered in underwriting;

4. Requirements regarding the manner in which a rating variable must be filed with regulatory authorities in order to be used;

5. The manner in which the state's executive branch interprets insurance statutes and regulations.

Any three of the above suffice as an answer. Other valid answers may also be possible.

**Problem S5-76-5.** Werner and Modlin, p. 156, mention typical rating or underwriting variables used for the following common insurance products:

1. Personal Automobile Insurance;
2. Homeowners' Insurance;
3. Workers' Compensation Insurance;
4. Commercial General Liability Insurance;
5. Medical Malpractice Insurance;

For each of the following variables, identify the insurance products where the variable is commonly used. A given variable may apply to more than one product.

(a) Limit of Liability;
(b) Occupation Class Code;
(c) Territory;
(d) Age of Home;
(e) Driver Age;
(f) Construction Type;
(g) Driver Class;
(h) Driver Gender;
(i) Amount of Insurance;
(j) Specialty;
(k) Model Year.

**Solution S5-76-5.**

(a) Limit of Liability is used for **Commercial General Liability Insurance**, **Medical Malpractice Insurance**, and **Commercial Automobile Insurance**. It is also used in **Personal Automobile Insurance** (e.g., with regard to limits for bodily injury liability coverage).

(b) Occupation Class Code is used for **Workers' Compensation Insurance**.

(c) Territory is used for **Commercial General Liability Insurance**, **Medical Malpractice Insurance**, and **Commercial Automobile Insurance**. It is also used in **Personal Automobile Insurance**.
(d) Age of Home is used for **Homeowners' Insurance**.

(e) Driver Age is used for **Personal Automobile Insurance**.

(f) Construction Type is used for **Homeowners' Insurance**.

(g) Driver Class is used for **Commercial Automobile Insurance**. It is also used in **Personal Automobile Insurance**, where "Driver Class" is sometimes defined as a combination of age, gender, and marital status, for instance.

(h) Driver Gender is used for **Personal Automobile Insurance**.

(i) Amount of Insurance is used for **Homeowners' Insurance**.

(j) Specialty is used for **Medical Malpractice Insurance**.

(k) Model Year is used for **Personal Automobile Insurance**.
Section 77

The Pure Premium Approach for Determining Relativities Pertaining to Specific Insurance Rating Variables

This section of the study guide is intended to provide practice problems and solutions to accompany the pages of *Basic Ratemaking*, cited below. Students are encouraged to read these pages before attempting the problems. This study guide is entirely an independent effort by Mr. Stolyarov and is not affiliated with any organization(s) to whose textbooks it refers, nor does it represent such organization(s).

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The Pure Premium Approach for Specific Rating Variables

Let $R_1$ by a rating variable. Let $R_{1i}$ be the rating factor (relativity) associated with subgroup $i$ of $R_1$. Let $B$ be the base rate. Then the rate for subgroup $i$ of $R_1$ is as follows:

**Formula 77.1:** \[ \text{Rate}_i = R_{1i} \times B. \]

Let $R_{1i}$ be the *indicated* rating factor (relativity) associated with subgroup $i$ of $R_1$. Let $\text{Rate}_{1i}$ be the *indicated* rate for subgroup $i$ of $R_1$. Let $B_1$ be the *indicated* base rate. Then the following formula holds:

**Formula 77.2:** \[ R_{1i} = \frac{\text{Rate}_{1i}}{B_1}. \]

Now we make the following assumptions, per Werner and Modlin, p. 158:

**Assumption Set 77.3:**

1. There are no fixed expenses;
2. All policies have the same underwriting expenses. The percentage comprised of underwriting expenses (which are all variable) is $V$;
3. All policies have the same profit provisions. The percentage profit provision selected by the company is $Q_T$.

If these assumptions are true, then the following formula holds:
**Formula 77.4:** \( R_{1,i} = \frac{(L^- + E^-_L)_i}{(L^- + E^-_L)B} \).

Here, \((L^- + E^-_L)_i\) is the pure premium (including loss adjustment expenses) for subgroup \(i\) of \(R_1\), whereas \((L^- + E^-_L)B\) is the pure premium (including loss adjustment expenses) for the class on the basis of which the base rate was established.

**Source:**

**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-77-1.** The base rate for an insurance program is $360. It is determined that subgroup \(q\) of Variable \(Ψ\) is, on an overall basis, 0.6 times as risky as the base class, and a relativity has been assigned to this subgroup accordingly.

(a) What is the rate for subgroup \(q\) of Variable \(Ψ\)?

(b) If the indicated base rate were $380, what would be the new rate for subgroup \(q\) of Variable \(Ψ\)?

**Solution S5-77-1.**

(a) We use Formula 77.1: \( \text{Rate}_1 = R_1B \). Here, \(R_1 = 0.6\), and \(B = 360\), and so our answer is \(0.6 \times 360 = 216\).

(b) We use Formula 77.2: \( R_{1,i} = \frac{(\text{Rate}_{1,i})B_i}{R_{1,i}} \), which is equivalent to \( \text{Rate}_{1,i} = \frac{(R_{1,i}B_i)}{R_{1,i}} \), where \(R_{1,i} = 0.6\) and \(B_i = 380\). Thus, our answer is \( \text{Rate}_{1,i} = 0.6 \times 380 = 228\).

**Problem S5-77-2.** In this problem, Assumption Set 77.3 holds. Insurance Company \(Π\) experienced losses of $36 per exposure and loss adjustment expenses of $12 per exposure in calendar year 2024. In the same year, for every exposure in subgroup \(z\) of Variable \(Ξ\), the company experienced losses of $19 per exposure and loss adjustment expenses of $10 per exposure. Based on this information, what is the indicated relativity pertaining to subgroup \(z\) of Variable \(Ξ\)?

**Solution S5-77-2.** We use Formula 77.4: \( R_{1,i} = \frac{(L^- + E^-_L)_i}{(L^- + E^-_L)B} \). Here, \((L^- + E^-_L)_B = 36 + 12 = 48\), whereas \((L^- + E^-_L)_i = 19 + 10 = 29\). Our answer is thus \( R_{1,i} = \frac{29}{48} = 0.6041666667\).

**Problem S5-77-3.** In this problem, Assumption Set 77.3 holds. You are given the following information pertaining to an insurer's book of business in calendar year 2030:
Variable \(X\) is being used to classify insureds into three categories: a, b, and c.

There are 390 exposures in category a, and total losses and loss adjustment expenses (LAE) for category a are $120,125.
There are 350 exposures in category b, and total losses and LAE for category b are $123,012.
There are 500 exposures in category c, and total losses and LAE for category c are $230,234.
Assume that the same loss trend and loss development applies to each category.

(a) What is the indicated pure premium for category a?

(b) What is the indicated pure premium for category b?

(c) What is the indicated pure premium for category c?

(d) What is the indicated overall pure premium?

Solution S5-77-3.

(a) For category a, the indicated pure premium is (Losses and LAE)/(Number of exposures) = 120125/390 = 308.0128205 = \$308.01.

(b) For category b, the indicated pure premium is (Losses and LAE)/(Number of exposures) = 123012/350 = 351.4628571 = \$351.46.

(c) For category c, the indicated pure premium is (Losses and LAE)/(Number of exposures) = 230234/500 = 460.468 = \$460.47.

(d) The indicated overall pure premium is (Total losses and LAE)/(Total number of exposures) = (120125 + 123012 + 230234)/(390 + 350 + 500) = 381.7524194 = \$381.75.

Problem S5-77-4. In this problem, Assumption Set 77.3 holds. You are given the following information pertaining to an insurer's book of business in calendar year 2030:
Variable X is being used to classify insureds into three categories: a, b, and c.

There are 390 exposures in category a, and total losses and loss adjustment expenses (LAE) for category a are $120,125.

There are 350 exposures in category b, and total losses and LAE for category b are $123,012.

There are 500 exposures in category c, and total losses and LAE for category c are $230,234.

Assume that the same loss trend and loss development applies to each category.

(a) What is the indicated relativity for category a?

(b) What is the indicated relativity for category b?
(c) What is the indicated relativity for category c?

**Solution S5-77-4.** In Solution S5-77-3, we calculated the overall indicated pure premium and the indicated pure premiums by category. For each category, by Formula 77.4, the indicated relativity is equal to (Indicated pure premium by category)/(Overall indicated pure premium).

(a) The indicated relativity for category a is 308.0128205/381.7524194 = 0.80683921.

(b) The indicated relativity for category b is 351.4628571/381.7524194 = 0.9206565283.

(c) The indicated relativity for category c is 460.468/381.7524194 = 1.206195368.

**Problem S5-77-5.** Explain how the univariate Pure Premium Method is subject to distortions when one uses it to calculate the relativities associated with subgroups of specific rating variables.

**Solution S5-77-5.** The univariate Pure Premium Method implicitly assumes that exposure within each subgroup of a particular variable (e.g., Variable A) is uniformly distributed within each subgroup with respect to characteristics of all other variables within the insurer's rating structure (e.g., Variables B, C, etc.). However, if some variables are correlated with others, then performing a univariate Pure Premium Method analysis on each variable would result in "double-counting" (or "multiple-counting") of the effects of certain variables.
Section 78

The Loss Ratio Approach for Determining Relativities Pertaining to Specific Insurance Rating Variables

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The Loss Ratio Approach for Specific Rating Variables

Let R1 by a rating variable. Let R1C,i be the current rating factor (relativity) associated with subgroup i of R1. Let R1I,i be the indicated rating factor (relativity) associated with subgroup i of R1. Let P^C,i be the current average premium for subgroup i of R1. Let B be the base class, on the basis of which the base rate is established. Let P^C,B be the current average premium for the base class. Then the following formulas hold:

Formula 78.1:
R1C,i = (P^C,i)/(P^C,B)

Formula 78.2:
Indicated Differential Change =
(R1I,i)/(R1C,i) = (Loss & LAE Ratio for i)/(Loss & LAE Ratio for B).


Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-78-1. The current relativity associated with subgroup z of rating variable Q is 1.23. The current average premium for the base class is $421. For the base class, the average loss and loss adjustment expenses per exposure are $208. For subgroup z, the average loss and loss adjustment expenses per exposure are $230.
(a) What is the current average premium for subgroup z?
(b) Assuming that the current average premium for subgroup z is also the indicated average
premium for this subgroup, what is the indicated relativity for subgroup z?

Solution S5-78-1.

(a) We use Formula 78.1: \( R_{1C,i} = \frac{(P_{C,i})}{(P_{C,B})} \rightarrow (R_{1C,i}) \times (P_{C,B}) = (P_{C,i}). \)
Here, \( P_{C,B} = 421 \), and \( R_{1C,i} = 1.23 \). Thus, \( (P_{C,i}) = 421 \times 1.23 = \$517.83 \).

(b) We use Formula 78.2: \( \frac{(R_{1i})}{(R_{1C,i})} = \frac{(Loss \ & \ LAE \ Ratio \ for \ i)}{(Loss \ & \ LAE \ Ratio \ for \ B)} \),
rearranging it thus: \( (R_{1i}) = (R_{1C,i}) \times \frac{(Loss \ & \ LAE \ Ratio \ for \ i)}{(Loss \ & \ LAE \ Ratio \ for \ B)} \).
Here, \( R_{1C,i} = 1.23 \). We find \( (Loss \ & \ LAE \ Ratio \ for \ subgroup \ z) = \frac{230}{517.83} = 0.4441612112 \).
We find \( (Loss \ & \ LAE \ Ratio \ for \ B) = \frac{208}{421} = 0.4940617577 \).
Thus, \( (R_{1i}) = 1.23 \times 0.4441612112/0.4940617577 = 1.105769231 \).

Problem S5-78-2.

An insurance company uses rating variable N, with three subgroups: d, e, and f. It analyzes data
from calendar year 2090 to determine the indicated relatiivities for each of these subgroups.

For subgroup d, the earned premium at the current rate level is $43100. The incurred losses &
loss adjustment expenses (LAE) are $23000. The current relativity for this subgroup is 0.90.

For subgroup e, the earned premium at the current rate level is $60000. The incurred losses &
loss adjustment expenses (LAE) are $50000. The current relativity for this subgroup is 1.25.

For subgroup f, the earned premium at the current rate level is $20000. The incurred losses &
loss adjustment expenses (LAE) are $5000. The current relativity for this subgroup is 0.40.

(a) What is the Loss & LAE ratio for subgroup d?
(b) What is the Loss & LAE ratio for subgroup e?
(c) What is the Loss & LAE ratio for subgroup f?
(d) What is the overall Loss & LAE ratio for this book of business?

Solution S5-78-2.

(a) The Loss & LAE ratio for subgroup d is \( (Losses \ and \ LAE)/(Earned \ Premium) = \frac{23000}{43100} = 0.5336426914 \).

(b) The Loss & LAE ratio for subgroup e is \( (Losses \ and \ LAE)/(Earned \ Premium) = \frac{50000}{60000} = 0.8333333333 \).

(c) The Loss & LAE ratio for subgroup f is \( (Losses \ and \ LAE)/(Earned \ Premium) = \frac{5000}{20000} = 0.25 \).
(d) The overall Loss & LAE ratio is \((\text{Sum of Losses and LAE})/(\text{Sum of Earned Premium}) = (23000 + 50000 + 5000)/(43100 + 60000 + 20000) = 0.6336311942.\)

**Problem S5-78-3.** An insurance company uses rating variable N, with three subgroups: d, e, and f. It analyzes data from calendar year 2090 to determine the indicated relativities for each of these subgroups.

For subgroup d, the earned premium at the current rate level is $43100. The incurred losses & loss adjustment expenses (LAE) are $23000. The current relativity for this subgroup is 0.90.

For subgroup e, the earned premium at the current rate level is $60000. The incurred losses & loss adjustment expenses (LAE) are $50000. The current relativity for this subgroup is 1.25.

For subgroup f, the earned premium at the current rate level is $20000. The incurred losses & loss adjustment expenses (LAE) are $5000. The current relativity for this subgroup is 0.40.

(a) What is the indicated relativity change factor for subgroup d?
(b) What is the indicated relativity change factor for subgroup e?
(c) What is the indicated relativity change factor for subgroup f?

**Solution S5-78-3.** In Solution S5-78-2, we calculated loss and LAE ratios for each subgroup and overall. For each subgroup, the indicated relativity change factor is equal to

\[(\text{Loss and LAE ratio for the subgroup})/(\text{Overall loss and LAE ratio}).\]

(a) \((\text{Loss and LAE ratio for subgroup d})/(\text{Overall loss and LAE ratio}) = 0.5336426914/0.6336311942 = 0.8421976322.\)

(b) \((\text{Loss and LAE ratio for subgroup e})/(\text{Overall loss and LAE ratio}) = 0.833333333/0.6336311942 = 1.31517094.\)

(c) \((\text{Loss and LAE ratio for subgroup f})/(\text{Overall loss and LAE ratio}) = 0.25/0.6336311942 = 0.3945512821.\)

**Problem S5-78-4.** An insurance company uses rating variable N, with three subgroups: d, e, and f. It analyzes data from calendar year 2090 to determine the indicated relativities for each of these subgroups.

For subgroup d, the earned premium at the current rate level is $43100. The incurred losses & loss adjustment expenses (LAE) are $23000. The current relativity for this subgroup is 0.90.

For subgroup e, the earned premium at the current rate level is $60000. The incurred losses & loss adjustment expenses (LAE) are $50000. The current relativity for this subgroup is 1.25.

For subgroup f, the earned premium at the current rate level is $20000. The incurred losses & loss adjustment expenses (LAE) are $5000. The current relativity for this subgroup is 0.40.
(a) What is the indicated relativity for subgroup d?
(b) What is the indicated relativity for subgroup e?
(c) What is the indicated relativity for subgroup f?

**Solution S5-78-4.** In Solution S5-78-3, we calculated the indicated relativity change factor for each subgroup. For each subgroup, the indicated relativity change is equal to

\[(\text{Current relativity}) \times (\text{Indicated relativity change factor})\].

(a) For subgroup d,
\[(\text{Indicated relativity}) = (\text{Current relativity for d}) \times (\text{Indicated relativity change factor for d}) = 0.90 \times 0.8421976322 = \textbf{0.757977869}.\]

(b) For subgroup e,
\[(\text{Indicated relativity}) = (\text{Current relativity for e}) \times (\text{Indicated relativity change factor for e}) = 1.25 \times 1.31517094 = \textbf{1.643963675}.\]

(c) For subgroup f,
\[(\text{Indicated relativity}) = (\text{Current relativity for f}) \times (\text{Indicated relativity change factor for f}) = 0.40 \times 0.3945512821 = \textbf{0.1578205128}.\]

**Problem S5-78-5.**

(a) Why might the loss ratio approach produce indicated relativities closer to the true relativities than those produced by the pure premium approach?

(b) How might the loss ratio approach still produce distortions from the true relativities?

**Solution S5-78-5.** This problem is based on the discussion in Werner and Modlin, pp. 162-163.

(a) The loss ratio approach might produce indicated relativities closer to the true relativities than those produced by the pure premium approach because, while the pure premium approach assumes that, within each subgroup of the variable being analyzed (e.g., Variable A), there is a uniform distribution of exposures among the other variables (e.g., Variables B, C, etc.), the loss ratio approach relies on the premium within each subgroup of the variable. This enables some consideration, within each subgroup of Variable A, of the fact that exposures by Variables B, C, etc., are not necessarily uniformly distributed within said subgroup, since differences in other variables may result in differences in premium for each subgroup of A.

(b) The loss ratio approach relies on adjusting the current relativities by a multiplicative factor to arrive at the indicated relativities. If the current relativities vary substantially from the true relativities, there will be greater inaccuracy in the indicated relativities. When the current relativities are the true relativities, however, the loss ratio approach will produce correct results.
Section 79

The Adjusted Pure Premium Approach for Determining Relativities Pertaining to Specific Insurance Rating Variables

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The Adjusted Pure Premium Approach for Specific Rating Variables

The Pure Premium Approach, discussed in Section 77, can be adjusted via a weighting of exposures by subgroup of the rating variable being considered, such that the outcome is equivalent to that of the Loss Ratio Approach discussed in Section 78.

For instance, the number of earned exposures in each subgroup of Variable A might be multiplied by a subgroup-specific adjustment factor, based on the average relativity for that subgroup with respect to a different rating variable or set of variables (e.g., Variables B, C, etc.).

This is easiest to illustrate via application, as will be done via the problems in this section.

**Source:**

**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-79-1.** In this problem, Assumption Set 77.3 holds. You are given the following information pertaining to an insurer's book of business in calendar year 2030: Variable X is being used to classify insureds into three categories: a, b, and c.

There are 390 exposures in category a, and total losses and loss adjustment expenses (LAE) for category a are $120,125.
There are 350 exposures in category b, and total losses and LAE for category b are $123,012.

There are 500 exposures in category c, and total losses and LAE for category c are $230,234.

Assume that the same loss trend and loss development applies to each category.

There is another rating variable being used: Variable Q. Exposures in each category of Variable X are not uniformly distributed with respect to Variable Q. There are three categories for Variable Q: g, h, and i.

An actuary makes the following determinations in an attempt to account for the effect of Variable Q:

The exposures in category g should be adjusted by a relativity of 1.02.
The exposures in category h should be adjusted by a relativity of 0.89.
The exposures in category i should be adjusted by a relativity of 0.66.

The following is the distribution of exposures by Variables X and Q:

Category g of Variable Q has 20 exposures in category a, 40 exposures in category b, and 300 exposures in category c.

Category h of Variable Q has 190 exposures in category a, 200 exposures in category b, and 50 exposures in category c.

Category i of Variable Q has 180 exposures in category a, 110 exposures in category b, and 150 exposures in category c.

Per category of Variable X, what is the adjustment factor that the actuary needs to apply to the number of exposures to account for the effect of the distribution of exposures with respect to Variable Q? Give an answer for (a) category a, (b) category b, and (c) category c.

Solution S5-79-1.

(a) Category a of X has 390 total exposures: 20 exposures in category g of Q, 190 exposures in category h of Q, and 180 exposures in category i of Q. The adjustment factor needed is a weighted average of the relativities for each category in Q:

\[
\frac{20 \times 1.02 + 190 \times 0.89 + 180 \times 0.66}{390} = 0.7905128205.
\]

(b) Category b of X has 350 total exposures: 40 exposures in category g of Q, 200 exposures in category h of Q, and 110 exposures in category i of Q. The adjustment factor needed is a weighted average of the relativities for each category in Q:

\[
\frac{40 \times 1.02 + 200 \times 0.89 + 110 \times 0.66}{350} = 0.8325714286.
\]
(c) Category c of X has 500 total exposures: 300 exposures in category g of Q, 50 exposures in category h of Q, and 150 exposures in category i of Q. The adjustment factor needed is a weighted average of the relativities for each category in Q:

\[
\frac{300 \times 1.02 + 50 \times 0.89 + 150 \times 0.66}{500} = 0.899.
\]

**Problem S5-79-2.** This problem has the same conditions as Problem S5-79-1.

(a) How many adjusted exposures are there for category a?

(b) How many adjusted exposures are there for category b?

(c) How many adjusted exposures are there for category c?

(d) How many adjusted exposures are there overall?

**Solution S5-79-2.** For each category, (Number of adjusted exposures) = (Number of actual exposures)*(Category-specific relativity for adjusting exposures). In Solution S5-79-1, we found, for each category of X, the category-specific relativity for adjusting the exposures.

(a) For category a, (Number of adjusted exposures) = 390*0.7905128205 = 308.3.

(b) For category b, (Number of adjusted exposures) = 350*0.8325714286 = 291.4.

(c) For category b, (Number of adjusted exposures) = 500*0.899 = 449.5.

(d) The overall number of adjusted exposures is the sum of the adjusted exposures per category: 308.3 + 291.4 + 449.5 = 1049.2.

**Problem S5-79-3.** This problem has the same conditions as Problem S5-79-1.

(a) What is the indicated pure premium for category a?

(b) What is the indicated pure premium for category b?

(c) What is the indicated pure premium for category c?

(d) What is the indicated overall pure premium?

**Solution S5-79-3.**

(a) For category a, the indicated pure premium is (Losses and LAE)/(Number of adjusted exposures) = 120125/308.3 = 389.6367175 = $389.64.

(b) For category b, the indicated pure premium is (Losses and LAE)/(Number of adjusted exposures) = 123012/291.4 = 422.1413864 = $422.14.
(c) For category c, the indicated pure premium is \( \frac{\text{Losses and LAE}}{\text{Number of adjusted exposures}} = \frac{230234}{449.5} = 512.20 \). 

(d) The indicated overall pure premium is \( \frac{\text{Sum of Losses and LAE}}{\text{Sum of adjusted exposures}} = \frac{120125 + 123012 + 230234}{1049.2} = 451.17 \).

**Problem S5-79-4.** This problem has the same conditions as Problem S5-79-1.

(a) What is the indicated relativity for category a?

(b) What is the indicated relativity for category b?

(c) What is the indicated relativity for category c?

**Solution S5-79-4.** In Solution S5-79-3, we calculated the overall indicated pure premium and the indicated pure premiums by category. For each category, the indicated relativity is equal to \( \frac{\text{Indicated pure premium by category}}{\text{Overall indicated pure premium}} \).

(a) For category a, the indicated relativity is \( \frac{389.6367175}{451.1732749} = 0.8636077073 \).

(b) For category b, the indicated relativity is \( \frac{422.1413864}{451.1732749} = 0.9356524642 \).

(c) For category c the indicated relativity is \( \frac{512.2002225}{451.1732749} = 1.135262772 \).

**Problem S5-79-5.** The adjusted pure premium approach produces results equivalent to those of the loss ratio approach. If one wanted to obtain such results, in what situations would it be necessary to use the adjusted pure premium approach instead of the loss ratio approach?

**Solution S5-79-5.** This question is based on the discussion in Werner and Modlin, p. 163.

It would be necessary to use the adjusted pure premium approach instead of the loss ratio approach in situations where it is not possible to obtain premium at current rate levels for every category of the rating variable in question. The loss ratio approach requires premium to be at current levels, whereas the adjusted pure premium approach does not consider premium directly.
Section 80

The Minimum Bias Procedure for Two Rating Variables and Two Categories Per Variable

This section of the study guide is intended to provide practice problems and solutions to accompany the pages of *Basic Ratemaking*, cited below. Students are encouraged to read these pages before attempting the problems. This study guide is entirely an independent effort by Mr. Stolyarov and is not affiliated with any organization(s) to whose textbooks it refers, nor does it represent such organization(s).

Some of the questions here ask for short written answers based on the reading. This is meant to give the student practice in answering questions of the format that will appear on Exam 5. Students are encouraged to type their own answers first and then to compare these answers with the solutions given here. Please note that the solutions provided here are not necessarily the only possible ones.

Steps in the Minimum Bias Procedure for Two Rating Variables and Two Categories per Variable

The minimum bias procedure is an iterative technique that endeavors to account for possible correlations between multiple rating variables in an insurer's rating structure. Here, we will work with a simple case of the minimum bias procedure, applicable to a multiplicative insurance rating structure.

Assume that there are two rating variables, X and Y, each with two categories, x₁ and x₂ and y₁ and y₂, respectively.

Assume that we also know the pure premium and number of exposures for each of the possible combinations of categories of these variables, i.e., (x₁, y₁), (x₁, y₂), (x₂, y₁), (x₂, y₂).

Let B be some assumed base rate.

Then the following are the steps in the Minimum Bias Procedure for determining the relativities pertaining to the categories for these two variables:

1. Select one of the variables - here, variable X. Set category x₂ to have a relativity of 1.

2. Set category x₁ to have a relativity of (Pure premium for x₁)/(Pure premium for x₂).

3. Set up the following equation:
(Pure premium for \((x_1, y_1)\))*(Exposures for \((x_1, y_1)\)) + (Pure premium for \((x_2, y_1)\))*(Exposures for \((x_2, y_1)\)) = B*(Exposures for \((x_1, y_1)\))*(Relativity for \(x_1\))*(Relativity for \(y_1\)) + B*(Exposures for \((x_2, y_1)\))*(Relativity for \(x_2\))*(Relativity for \(y_1\)).

Solve this equation for (Relativity for \(y_1\)).

4. Set up the following equation:

(Pure premium for \((x_1, y_2)\))*(Exposures for \((x_1, y_2)\)) + (Pure premium for \((x_2, y_2)\))*(Exposures for \((x_2, y_2)\)) = B*(Exposures for \((x_1, y_2)\))*(Relativity for \(x_1\))*(Relativity for \(y_2\)) + B*(Exposures for \((x_2, y_2)\))*(Relativity for \(x_2\))*(Relativity for \(y_2\)).

Solve this equation for (Relativity for \(y_2\)).

5. Now it will be necessary to recalculate (Relativity for \(x_1\)) and (Relativity for \(x_2\)) on the basis of the values of (Relativity for \(y_1\)) and (Relativity for \(y_2\)) found in steps 3 and 4.

Set up the following equation:

(Pure premium for \((x_1, y_1)\))*(Exposures for \((x_1, y_1)\)) + (Pure premium for \((x_1, y_2)\))*(Exposures for \((x_1, y_2)\)) = B*(Exposures for \((x_1, y_1)\))*(Relativity for \(x_1\))*(Relativity for \(y_1\)) + B*(Exposures for \((x_1, y_2)\))*(Relativity for \(x_1\))*(Relativity for \(y_2\)).

Solve this equation for (Relativity for \(x_1\)).

6. Set up the following equation:

(Pure premium for \((x_2, y_1)\))*(Exposures for \((x_2, y_1)\)) + (Pure premium for \((x_2, y_2)\))*(Exposures for \((x_2, y_2)\)) = B*(Exposures for \((x_2, y_1)\))*(Relativity for \(x_2\))*(Relativity for \(y_1\)) + B*(Exposures for \((x_2, y_2)\))*(Relativity for \(x_2\))*(Relativity for \(y_2\)).

Solve this equation for (Relativity for \(x_2\)).

7. Now it will be necessary to recalculate (Relativity for \(x_1\)) and (Relativity for \(x_2\)) on the basis of the values of (Relativity for \(y_1\)) and (Relativity for \(y_2\)) found in steps 5 and 6.

The recalculation of relativities will need to continue until the next iteration produces a result that is substantively identical to that of the previous iteration. This iteration process stabilizes at relativities that reasonably reflect the interaction between the two variables.

8. After the stabilized relativities have been calculated, it is typical to normalize these relativities by setting one category of each variable (here, \(x_2\) for \(X\) and \(y_2\) for \(Y\)) to equal 1. Then, the other category's relativity (here, the relativities of \(x_1\) for \(X\) and \(y_1\) for \(Y\)) will be the ratio

\[
\frac{\text{Non-normalized relativity for } x_1}{\text{Non-normalized relativity for } x_2} \text{ or } \frac{\text{Non-normalized relativity for } y_1}{\text{Non-normalized relativity for } y_2}.
\]
9. If normalization has been done, the base rate $B$ needs to be adjusted as follows:

$\text{(New } B\text{)} = (\text{Original } B)* (\text{Non-normalized relativity for } x_2)* (\text{Non-normalized relativity for } y_2)$.


**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-80-1.** Assume that there are two rating variables, $X$ and $Y$, each with two categories, $x_1$ and $x_2$ and $y_1$ and $y_2$, respectively.

Assume that we also know the pure premium and number of exposures for each of the possible combinations of categories of these variables, i.e., $(x_1, y_1)$, $(x_1, y_2)$, $(x_2, y_1)$, $(x_2, y_2)$.

Combination $(x_1, y_1)$ has 356 exposures and $430$ of pure premium.
Combination $(x_1, y_2)$ has 462 exposures and $221$ of pure premium.
Combination $(x_2, y_1)$ has 636 exposures and $500$ of pure premium.
Combination $(x_2, y_2)$ has 300 exposures and $800$ of pure premium.
The assumed base rate is $200$.

Begin a minimum bias procedure as follows: Set category $x_2$ to have a starting ("seed") relativity of $1$. What would be the starting ("seed") relativity for category $x_1$?

**Solution S5-80-1.** The starting relativity for category $x_1$ would be $(\text{Pure premium for } x_1)/(\text{Pure premium for } x_2)$.

We are given pure premium by combinations of categories for each variable. To figure out $(\text{Pure premium for } x_1)$, we need to perform an exposure-weighting of pure premiums for combination $(x_1, y_1)$ and combination $(x_1, y_2)$:

$((\text{Pure premium for } (x_1, y_1))*(\text{Exposures for } (x_1, y_1)) + (\text{Pure premium for } (x_1, y_2))*(\text{Exposures for } (x_1, y_2)))/(\text{Total exposures for } x_1) =$

$(430*356 + 221*462)/(356 + 462) = (\text{Pure premium for } x_1) = 311.9584352$.

A similar exposure-weighting of pure premiums can be performed for combination $(x_2, y_1)$ and combination $(x_2, y_2)$ to get $(\text{Pure premium for } x_2)$:

$((\text{Pure premium for } (x_2, y_1))*(\text{Exposures for } (x_2, y_1)) + (\text{Pure premium for } (x_2, y_2))*(\text{Exposures for } (x_2, y_2)))/(\text{Total exposures for } x_1) =$

$(500*636 + 800*300)/(636 + 300) = (\text{Pure premium for } x_2) = 596.1538462$.

Our starting relativity for category $x_1$ is $(\text{Pure premium for } x_1)/(\text{Pure premium for } x_2) = 311.9584352/596.1538462 = 0.5232851171$. 


**Problem S5-80-2.** Assume that there are two rating variables, X and Y, each with two categories, \( x_1 \) and \( x_2 \) and \( y_1 \) and \( y_2 \), respectively.

Assume that we also know the pure premium and number of exposures for each of the possible combinations of categories of these variables, i.e., \( (x_1, y_1) \), \( (x_1, y_2) \), \( (x_2, y_1) \), \( (x_2, y_2) \).

Combination \( (x_1, y_1) \) has 356 exposures and $430 of pure premium.
Combination \( (x_1, y_2) \) has 462 exposures and $221 of pure premium.
Combination \( (x_2, y_1) \) has 636 exposures and $500 of pure premium.
Combination \( (x_2, y_2) \) has 300 exposures and $800 of pure premium.
The assumed base rate is $200.

Continue the minimum bias procedure from Problem S5-80-1 by determining the first iteration of relativities for \( y_1 \) and \( y_2 \).

**Solution S5-80-2.** Per Solution S5-80-1, the seed relativities we will use for \( x_1 \) and \( x_2 \) are 0.5232851171 and 1, respectively. We apply the following formula:

\[
(P\text{ure premium for } (x_1, y_1))*(\text{Exposures for } (x_1, y_1)) + (P\text{ure premium for } (x_2, y_1))*(\text{Exposures for } (x_2, y_1)) = B*(\text{Exposures for } (x_1, y_1))*(\text{Relativity for } x_1)*(\text{Relativity for } y_1) + B*(\text{Exposures for } (x_2, y_1))*(\text{Relativity for } x_2)*(\text{Relativity for } y_1).
\]

Substituting known values, the equation becomes the following:

\[
430*356 + 500*636 = 200*356*0.5232851171*(\text{Relativity for } y_1) + 200*636*1*(\text{Relativity for } y_1) \rightarrow 471080 = 164457.9003*(\text{Relativity for } y_1) \rightarrow \frac{471080}{164457.9003} = (\text{Relativity for } y_1) = 2.864441289.
\]

We now apply the following formula:

\[
(P\text{ure premium for } (x_1, y_2))*(\text{Exposures for } (x_1, y_2)) + (P\text{ure premium for } (x_2, y_2))*(\text{Exposures for } (x_2, y_2)) = B*(\text{Exposures for } (x_1, y_2))*(\text{Relativity for } x_1)*(\text{Relativity for } y_2) + B*(\text{Exposures for } (x_2, y_2))*(\text{Relativity for } x_2)*(\text{Relativity for } y_2).
\]

Substituting known values, the equation becomes the following:

\[
221*462 + 800*300 = 200*462*0.5232851171*(\text{Relativity for } y_2) + 200*300*(\text{Relativity for } y_2) \rightarrow 342102 = 108351.5448*(\text{Relativity for } y_2) \rightarrow 342102/108351.5448 = (\text{Relativity for } y_2) = 3.157333849.
\]

**Problem S5-80-3.** Assume that there are two rating variables, X and Y, each with two categories, \( x_1 \) and \( x_2 \) and \( y_1 \) and \( y_2 \), respectively.
Assume that we also know the pure premium and number of exposures for each of the possible combinations of categories of these variables, i.e., \((x_1, y_1), (x_1, y_2), (x_2, y_1), (x_2, y_2)\).

Combination \((x_1, y_1)\) has 356 exposures and $430 of pure premium.
Combination \((x_1, y_2)\) has 462 exposures and $221 of pure premium.
Combination \((x_2, y_1)\) has 636 exposures and $500 of pure premium.
Combination \((x_2, y_2)\) has 300 exposures and $800 of pure premium.
The assumed base rate is $200.

Continue the minimum bias procedure from Problem S5-80-2 by determining the second iteration of relativities for \(x_1\) and \(x_2\).

Solution S5-80-3. Per Solution S5-80-2, the relativities we will use for \(y_1\) and \(y_2\) are 2.864441289 and 3.157333849, respectively. We apply the following formula:

\[
(Pure\ premium\ for\ (x_1, y_1))*(Exposures\ for\ (x_1, y_1)) + (Pure\ premium\ for\ (x_1, y_2))*(Exposures\ for\ (x_1, y_2)) = B*(Exposures\ for\ (x_1, y_1))*(Relativity\ for\ x_1)*(Relativity\ for\ y_1) + B*(Exposures\ for\ (x_1, y_2))*(Relativity\ for\ x_1)*(Relativity\ for\ y_2).
\]

Substituting known values, the equation becomes the following:

\[
430*356 + 221*462 = 200*356*2.864441289*(Relativity\ for\ x_1) + 200*462*3.157333849*(Relativity\ for\ x_1) \rightarrow \\
255182 = 296351.3771*(Relativity\ for\ x_1) \rightarrow \\
255182/296351.3771 = (Relativity\ for\ x_1) = 0.8610791773.
\]

We now apply the following formula:

\[
(Pure\ premium\ for\ (x_2, y_1))*(Exposures\ for\ (x_2, y_1)) + (Pure\ premium\ for\ (x_2, y_2))*(Exposures\ for\ (x_2, y_2)) = B*(Exposures\ for\ (x_2, y_1))*(Relativity\ for\ x_2)*(Relativity\ for\ y_1) + B*(Exposures\ for\ (x_2, y_2))*(Relativity\ for\ x_2)*(Relativity\ for\ y_2).
\]

Substituting known values, the equation becomes the following:

\[
500*636 + 800*300 = 200*636*2.864441289*(Relativity\ for\ x_2) + 200*300*3.157333849*(Relativity\ for\ x_2) \rightarrow \\
558000 = 553796.9629*(Relativity\ for\ x_2) \rightarrow 558000/553796.9629 = (Relativity\ for\ x_2) = 1.007589491.
\]

Problem S5-80-4. Assume that there are two rating variables, \(X\) and \(Y\), each with two categories, \(x_1\) and \(x_2\) and \(y_1\) and \(y_2\), respectively.
Assume that we also know the pure premium and number of exposures for each of the possible combinations of categories of these variables, i.e., \((x_1, y_1), (x_1, y_2), (x_2, y_1), (x_2, y_2)\).

Combination \((x_1, y_1)\) has 356 exposures and $430 of pure premium.
Combination \((x_1, y_2)\) has 462 exposures and $221 of pure premium.
Combination \((x_2, y_1)\) has 636 exposures and $500 of pure premium.
Combination \((x_2, y_2)\) has 300 exposures and $800 of pure premium.
The assumed base rate is $200.

Suppose that the relativities for \(x_1\) and \(x_2\) and \(y_1\) and \(y_2\) from Solutions S5-80-3 and S5-80-2, respectively, were accepted as the relativities that would be used in the insurer's rating structure - even though further iterations of the minimum bias procedure might produce more accurate relativities. If this decision were made, what would be the normalized relativities, assuming that the second category of each variable were treated as the base category?

**Solution S5-80-4.** Since \(x_2\) and \(y_2\) are our base categories, it follows, by definition, that \((\text{Relativity for } x_2) = (\text{Relativity for } y_2) = 1\).

We find \((\text{Relativity for } x_1) = (\text{Non-normalized relativity for } x_1)/(\text{Non-normalized relativity for } x_2) = 0.8610791773/1.007589491 = (\text{Relativity for } x_1) = 0.8545932494\).

We find \((\text{Relativity for } y_1) = (\text{Non-normalized relativity for } y_1)/(\text{Non-normalized relativity for } y_2) = 2.864441289/3.157333849 = (\text{Relativity for } y_1) = 0.9072342128\).

**Problem S5-80-5.** Assume that there are two rating variables, \(X\) and \(Y\), each with two categories, \(x_1\) and \(x_2\) and \(y_1\) and \(y_2\), respectively.

Assume that we also know the pure premium and number of exposures for each of the possible combinations of categories of these variables, i.e., \((x_1, y_1), (x_1, y_2), (x_2, y_1), (x_2, y_2)\).

Combination \((x_1, y_1)\) has 356 exposures and $430 of pure premium.
Combination \((x_1, y_2)\) has 462 exposures and $221 of pure premium.
Combination \((x_2, y_1)\) has 636 exposures and $500 of pure premium.
Combination \((x_2, y_2)\) has 300 exposures and $800 of pure premium.
The assumed base rate is $200.

Suppose that the normalization in Problem S5-80-4 has been done. What would be the adjusted base rate, as a consequence of the normalization?

**Solution S5-80-5.** The adjusted base rate is \((\text{New B}) = (\text{Original B})*(\text{Non-normalized relativity for } x_2)*(\text{Non-normalized relativity for } y_2) = 200*1.007589491*3.157333849 = 636.2592812 = $636.26\).
Section 81

Multivariate Classification Ratemaking Methods and Basic Principles of Generalized Linear Models

This section of the study guide is intended to provide practice problems and solutions to accompany the pages of *Basic Ratemaking*, cited below. Students are encouraged to read these pages before attempting the problems. This study guide is entirely an independent effort by Mr. Stolyarov and is not affiliated with any organization(s) to whose textbooks it refers, nor does it represent such organization(s).

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Source:

Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-81-1. Name three advantages of multivariate classification ratemaking methods over univariate methods.

Solution S5-81-1. The following advantages of multivariate classification ratemaking methods are discussed by Werner and Modlin, pp. 171-172.

1. Multivariate methods "consider all rating variables simultaneously and automatically adjust for exposure correlations between rating variables."
2. Multivariate methods "allow for the nature of the random process" and are able, in many cases, to largely extract the "signal" (systematic patterns in the data) from the "noise" (unsystematic patterns).
3. Multivariate methods "produce model diagnostics, additional information about the certainty of results and the appropriateness of the model fitted."
4. Multivariate methods "allow consideration of the interaction, or interdependency, between two or more rating variables."

Any three of the above suffice as an answer. Other valid answers may also be possible.
Problem S5-81-2. What is the difference between an *exposure correlation* and a *response correlation* (interaction)?

Solution S5-81-2. Exposure correlation refers to the uneven distribution of categories of one rating variable within the categories of another variable. An interaction occurs "when the effect of one variable varies according to the levels of another" (Werner and Modlin, p. 172). In exposure correlation, one variable does not have to affect the other; there just needs to be an uneven distribution of exposures such that a univariate analysis will be distorted. In response correlation, one variable influences the other.

Problem S5-81-3.

(a) Which two assumptions of linear models (LMs) do generalized linear models (GLMs) remove?

(b) In GLMs, what does a *link function* accomplish?

(c) According to Werner and Modlin, p. 173, what are the three steps needed to solve a GLM?

Solution S5-81-3. This question is based on the discussion in Werner and Modlin, p. 173.

(a) GLMs remove the assumptions of **normality** (i.e., that the underlying random variable follows a Normal distribution) and of **constant variance** (i.e., that the variance of the error term $\varepsilon$ is always the same throughout the distribution of the underlying random variable).

(b) A link function enables the modeler "to define the relationship between the expected response variable (e.g., claim severity) and the linear combination of the predictor variables (e.g., age of home, amount of insurance, etc.)" (Werner and Modlin, p. 173).

(c) The following three steps needed to solve a GLM are given by Werner and Modlin, p. 173:

1. "Supply a modeling dataset with a suitable number of observations of the response variable and associated predictor variables to be considered for modeling."

2. "Select a link function to define the relationship between the systematic and random components."

3. "Specify the distribution of the underlying random process, typically a member of the exponential family of distributions (e.g., normal, Poisson, gamma, binomial, inverse Gaussian); this is done by specifying the mean and the variance of the distribution, the latter being a function of the mean."

Problem S5-81-4. Give three reasons for why GLMs typically analyze *loss cost* data, as opposed to *loss ratio* data.
Solution S5-81-4. The following reasons for why GLMs typically analyze loss cost data instead of loss ratio data are given by Werner and Modlin, p. 173:

1. "Modeling loss ratios requires premiums to be adjusted to current rate level at the granular level, and that can be practically difficult."

2. "Experienced actuaries have an a priori expectation of frequency and severity patterns (e.g., youthful drivers have higher frequencies). In contrast, the loss ratio patterns are dependent on the current rates. Thus, the actuary can better distinguish the signal from the noise when building models."

3. "Loss ratio models become obsolete when rates and rating structures are changed."

4. "There is no commonly accepted distribution for modeling loss ratios."

Any three of the above suffice as an answer. Other valid answers may also be possible.

Problem S5-81-5. An actuary developing rates for a insurance product that protects homeowners from anvils falling from the sky uses territory, amount of insurance, and roof age as rating variables. The actuary makes the observation that the univariate (one-way) relativity for Territory Q is significantly higher than the GLM-indicated relativity. Assuming that the GLM was properly set up, which of the following scenarios could account for this observation?

(a) Territory Q consists primarily of smaller homes that would suffer less total damage if an anvil were to fall on them.

(b) Territory Q was populated earlier than most territories and so contains predominantly older homes where the roofs have not been reinforced to protect against falling anvils.

(c) The univariate analysis failed to capture the considerable risk-aversion of homeowners in Territory Q, which was taken into account by the GLM.

(d) Territory Q is predominantly inhabited by more reckless homeowners who jump on their roofs regularly, making them more vulnerable to anvil damage.

(e) None of the above scenarios could account for this observation.

Solution S5-81-5.

The correct answer is (b). A GLM considers the effects of a given variable in the context of all the other variables. So the higher univariate relativity for Territory Q suggest that the univariate analysis attributed to a home's presence in Territory Q risk characteristics that were in fact due to another factor, such as greater roof age. A GLM, by distinguishing the effect of territory from the effect of roof age, would produce a lower relativity for Territory Q, compared to the relativity obtained via the univariate analysis.
Answer (a) is not correct; if it were, the GLM-indicated relativities would be higher than the univariate relativities for Territory Q, since the smaller home size (and, by implication, smaller amount of insurance) would have somewhat reduced the visible "signal" from territory-based phenomena.

Answer (c) is not correct; if homeowners in Territory Q are indeed more risk-averse than elsewhere, both the univariate analysis and the GLM would have captured this. The two analyses are presumably based on the same underlying data, and the risk-aversion of homeowners would be difficult to disentangle from the territory variable and to identify as a separate variable (as there are few objective, independently verifiable measures of risk-aversion).

Answer (d) is not correct, since the recklessness of homeowners is not a separate rating variable, and so its effects would not be disentangled from the effects of territory by a GLM. GLMs can provide information regarding interactions among variables that have been defined, but they cannot account for interactions within a variable (i.e., what, aside from age of room and amount of insurance in this model, would explain why Territory Q has a relativity that differs in a certain way from the relativities of the other territories).
Section 82

Basics of GLM Diagnostics, Validation, and Factor Analysis

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Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-82-1.
(a) For generalized linear models (GLMs), what does the standard error diagnostic measure?
(b) Place values of Variable X, in sequence from lowest to highest, on the horizontal axis of a graph and indicated relativities for Variable X on the vertical axis. Which of the following results with respect to GLM indications and standard error would be most effective in demonstrating that higher values of Variable X correspond to a higher risk of risk of insurance loss?

(i) The curve connecting the points on the graph indicated by the GLM is positively sloped and has wide bands around it, corresponding to ± 2 standard errors.
(ii) The curve connecting the points on the graph indicated by the GLM is negatively sloped and has wide bands around it, corresponding to ± 2 standard errors.
(iii) The curve connecting the points on the graph indicated by the GLM is positively sloped and has narrow bands around it, corresponding to ± 2 standard errors.
(iv) The curve connecting the points on the graph indicated by the GLM is negatively sloped and has narrow bands around it, corresponding to ± 2 standard errors.

Solution S5-82-1.

(a) The standard error provides a measurement of confidence around the indicated GLM values. ± 2 standard errors from the GLM indication are akin to a 95% confidence interval estimate (Werner and Modlin, p. 176).
(b) The correct answer is (iii) The curve connecting the points on the graph indicated by the GLM is positively sloped and has narrow bands around it, corresponding to ±2 standard errors. This indicates that there is an indication that higher values of Variable X correspond to a higher risk of insurance loss, and that there is a substantial degree of confidence in this result, as the equivalent of a 95% confidence interval is quite narrow.

Problem S5-82-2.
(a) For generalized linear models (GLMs), what does the deviance diagnostic measure?
(b) Name three examples of deviance diagnostics.
(c) Describe a practical diagnostic pertaining to GLMs that is neither an instance of standard error measurement nor of deviance.

Solution S5-82-2. This question is based on the discussion in Werner and Modlin, p. 177.

(a) The deviance diagnostic measures "how much the fitted values differ from the observations." It is frequently used to evaluate whether it would be useful to include additional variables in the model.

(b) Four examples of deviance diagnostics are (1) the Chi-Square test, (2) the F-test, (3) the Akaike Information Criteria (AIC), and (4) the Bayesian Information Criteria (BIC).

(c) A practical diagnostic pertaining to GLMs is the comparison of results for individual years to see how well the model performs from one year to the next and whether the model is a reliable predictor of subsequent years' data. One can be more confident in a model's predictive abilities if it continues to largely reflect observed results for many years.

Problem S5-82-3.
(a) What is a holdout sample of data, and how can it be used in GLM validation?

(b) If the model's treatment of certain variables is a result of over-fitting, how would the holdout sample reflect this? What flaw in the model's design does the existence of over-fitting suggest?

(c) If the model's treatment of certain variables is a result of under-fitting, how would the holdout sample reflect this? What flaw in the model's design does the existence of under-fitting suggest?

Solution S5-82-3. This question is based on the discussion in Werner and Modlin, p. 178.

(a) A holdout sample of data consists of historical data taken from the same time period as the data used in the development of the model; however, data in the holdout sample are not used in creating the model itself. Rather, they are used to test the model once it has been created, to see whether the model can accurately predict the distribution of data within the holdout sample. If the model's prediction corresponds closely to the actual composition of the holdout sample, then this constitutes evidence in support of the model's predictive power.
(b) If there is substantial over-fitting in the model, then the observed distribution of data in the holdout sample will differ substantially from the distribution of data predicted by the model. Over-fitting indicates that the modeler mistook "noise" within the data sample used to develop the model for "signal" - i.e., for systematic trends in the data. Since the same "noise" is unlikely to be reflected in other data samples, a substantial disparity will occur between model results and the actual holdout sample.

(c) The disparity between the model's predictions and the holdout sample results will not be as great if there is under-fitting; indeed, an under-fitted model might accurately predict the distribution of the variables in question within the holdout sample, as well as in future time periods. However, there will be less substance to the prediction than might be hoped for, as an under-fitted model has difficulty explaining what is responsible for differential experience within the data.

**Problem S5-82-4.** Name three aspects of GLM development that are still the responsibility of the individual actuary, no matter what sophisticated programs and other tools are at that actuary's disposal.

**Solution S5-82-4.** The following aspects of actuarial responsibility with regard to GLM development are discussed by Werner and Modlin, p. 180:

1. "Ensuring data is adequate for the level of detail of the classification ratemaking analysis (avoiding what is known as the GIGO principle: Garbage In, Garbage Out)"
2. "Identifying when anomalous results dictate additional exploratory analysis"
3. "Reviewing model results in consideration of both statistical theory and business application"
4. "Developing appropriate methods to communicate model results in light of a company's ratemaking objectives (e.g., policyholder dislocation, competitive position)"
5. Addressing IT constraints;
6. Addressing the insurer's marketing objectives;
7. Addressing regulatory requirements.

Any three of the above suffice as an answer. Other valid answers may be possible.

**Problem S5-82-5.** What is the purpose of factor analysis? How does it accomplish this purpose?

**Solution S5-82-5.** This question is based on the discussion of factor analysis by Werner and Modlin, pp. 180-181.

The purpose of factor analysis is to reduce the number of variables (parameter estimates) in a model such as a GLM. If two variables exhibit an exposure correlation or an interaction, factor analysis proceeds by determining the relationship between the variables (for instance, via a regression procedure) and then combining the two variables into a single variable that accounts for this relationship. The benefit of factor analysis is that the model utilizes fewer correlated variables and that each variable will convey information that does not overlap to as great an extent with the information conveyed by the other variables.
Section 83

The Role of Data Mining Techniques and External Data in Enhancing Generalized Linear Models in Insurance

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Source:

Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-83-1.

(a) What is the purpose of *cluster analysis*?

(b) With what kinds of rating variables is cluster analysis most frequently used?

Solution S5-83-1. This problem is based on the discussion of cluster analysis by Werner and Modlin, p.181.

(a) The purpose of cluster analysis is "to combine small groups of similar risks into larger homogeneous categories or 'clusters.'" This enables the variables based on the resulting clusters to be more easily incorporated into generalized linear models (GLMs), since there are fewer variables and more data that would be relevant to each variable.

(b) Cluster analysis is most frequently used with rating variables pertaining to *geography*, where small geographic areas, such as zip codes, with similar experience might be grouped into a single cluster.
Problem S5-83-2.

(a) What does the acronym CART stand for?

(b) How does CART work? (Briefly describe just the basics.)

(c) Name one purpose that CART can help actuaries accomplish.

Solution S5-83-2. This problem is based on the discussion of CART by Werner and Modlin, p.181.

(a) The acronym CART stands for **Classification and Regression Trees**.

(b) CART employs classification trees based on if-then logical conditions. For instance, variable X can be the initial variable being examined. If variable X has value a, then variable Y is examined; if variable X has value b, then variable Z is examined, which may or not be the same variable as Y. The "tree" is formed with each option within a variable leading to a separate "branch" of the tree. The order in which variables are examined may depend on the "branches" of the tree that are being followed.

(c) According to Werner and Modlin, p.181, CART can help 1) "identify the strongest list of initial variables", 2) "determine how to categorize each variable", and 3) "detect interactions between variables." Any of the above items suffices as an answer. Other valid answers may also be possible.

Problem S5-83-3.

(a) What does the acronym MARS stand for?

(b) How does MARS work? (Briefly describe just the basics.)

(c) Name one purpose that MARS can help actuaries accomplish.

Solution S5-83-3. This problem is based on the discussion of MARS by Werner and Modlin, p.181.

(a) The acronym MARS stands for the **Multivariate Adaptive Regression Spline**.

(b) MARS is an algorithm that "operates as a multiple piecewise linear regression where each breakpoint defines a region for a particular linear regression equation" (Werner and Modlin, p.181).

(c) According to Werner and Modlin, p.181, MARS can help 1) "select breakpoints for categorizing continuous variables" and 2) "detect interactions between variables." Any of the above items suffices as an answer. Other valid answers may also be possible.
Problem S5-83-4.

(a) Briefly describe the basics of what neural networks do.

(b) What element of good models have neural networks often been criticized as lacking?

(c) Name one purpose that a neural network can help actuaries accomplish.

Solution S5-83-4. This problem is based on the discussion of neural networks by Werner and Modlin, p.182.

(a) Neural networks employ training algorithms that are applied to test data and that are able to "learn" the data's structure.

(b) Neural networks have been criticized as lacking transparency. Neural networks use extremely sophisticated and complex algorithms, which are not always easily communicable to all parties who need to know about how the model works.

(c) A neural network's results can be fed into a GLM and can identify areas within the GLM that might need improvement - such as taking account of a missing interaction (Werner and Modlin, p.182).

Problem S5-83-5. Name three kinds of external data that insurers have increasingly come to use after GLMs have been adopted.

Solution S5-83-5. The following external data types are discussed by Werner and Modlin, p. 182:

1. "Geo-demographics (e.g., population density of an area, average length of homeownership in an area)"

2. "Weather (e.g., average rainfall or number of days below freezing of a given area)"

3. "Property characteristics (e.g., square footage of a home or business, quality of the responding fire department"

4. "Information about insured individuals or businesses (e.g., credit information, occupation)."

Any three of the above suffice as an answer. Other valid answers may also be possible.
Section 84

Attributes of Territorial Ratemaking in Insurance

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Source:

Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-84-1.

(a) According to Werner and Modlin, p. 185, what are the two steps of the territorial ratemaking process?

(b) Describe two main challenges of the territorial ratemaking process.

Solution S5-84-1.

(a) According to Werner and Modlin, p. 185, the two steps of the territorial ratemaking process are as follows:
1. "Establishing territorial boundaries";
2. "Determining rate relativities for the territories".

(b) According to Werner and Modlin, p. 185, two main challenges of the territorial ratemaking process are as follows:
1. Location is often strongly correlated with other rating variables, such as amount of insurance (based on the value of a house), and this significantly distorts any univariate analysis of territorial experience.
2. If small geographic units are analyzed as part of a company's territorial analysis, the problem
of high-dimensionality arises; this is essentially the scarcity of data in each individual territorial unit.

**Problem S5-84-2.**
(a) Name three kinds of geographical units that are used by many insurers in classifying territories for rating purposes.

(b) For each of your answers in part (a), name an advantage and a disadvantage involved in using the geographical unit.

(c) Actual experience by territory reflects both signal and noise components. The signal components can be geographic or non-geographic. List two possible non-geographic signal components and two possible geographic signal components.

**Solution S5-84-2.** This problem is based on the discussion in Werner and Modlin, p. 186, of defining the geographic unit.

(a) Three kinds of geographical units that are used by many insurers in classifying territories for rating purposes are (1) **zip codes/postal codes**, (2) **counties**, and (3) **census blocks**. Other valid answers may also be possible.

(b) 1. **Zip codes/postal codes** are the most readily available of the territorial units, but they also change over time.
2. **Counties** typically do not change over time and are also readily available, but they are quite large and include many heterogeneous risks.
3. **Census blocks** typically do not change over time, "but require a process to map insurance policies to the census blocks" (Werner and Modlin, p. 186).

(c) The following signal components are mentioned by Werner and Modlin, p. 186:

**Geographic signal components:**
1. Density of population;
2. Weather indices;

**Non-geographic signal components:**
1. Age of house;
2. Amount of insurance;
3. Number of employees.

The non-geographic components may vary by territory but are not dependent on the territory as such; they are still reflected in the signal given by actual experience.

Any two items from each category would suffice as an answer. Other valid answers may also be possible.
Problem S5-84-3.

(a) What are two major disadvantages of using univariate techniques in developing a geographic estimator for each unit used in territorial ratemaking?

(b) How does the development of a multivariate model such as a generalized linear model (GLM) help overcome these disadvantages?

Solution S5-84-3. This problem is based on the discussion in Werner and Modlin, p. 186

(a) The following are the two major disadvantages of univariate techniques in developing a geographic estimator:

1. The univariate techniques reflect both the signal and the noise components of actual experience. This is particularly important when the geographic units used are small, such that there is substantial volatility in the limited experience data for each unit.

2. The univariate estimator is often biased because of the correlation between location and non-geographic factors.

(b) Multivariate models can help overcome the disadvantages from part (a) as follows:

1. A multivariate model's design can enable it to isolate the noise from the signal if it is not over-fitted or under-fitted to the observed data.

2. Because non-geographic predictors are incorporated into a multivariate model, the model can capture and identify interactions between geographic and non-geographic variables that are defined within the model. If the geographic variables within the model do not fully capture the signal, then there will also be some geographic residual variation in the observed experience.

Problem S5-84-4.

(a) Describe distance-based spatial smoothing.

(b) Name one advantage and one disadvantage of distance-based spatial smoothing.

(c) Describe adjacency-based spatial smoothing.

(c) Name one advantage and one disadvantage of adjacency-based spatial smoothing.

Solution S5-84-4.

(a) Distance-based spatial smoothing weights "the information from one geographic unit with the information from all nearby geographic units based on the distance from the primary unit and some measure of credibility. The influence of nearby areas is deemed to diminish with increasing distance" (Werner and Modlin, p. 187).
(b) Distance-based spatial smoothing "has the advantage of being easy to understand and implement" (Werner and Modlin, p. 187). Its disadvantages include the implicit assumption that the same amount of distance corresponds to the same effect of risk, irrespective of differences between geographical areas - e.g., urban versus rural areas. Another disadvantage is that natural geographic boundaries are not taken into account by this method.

(c) Adjacency-based spatial smoothing "weights the information from one geographic unit with the information estimators of rings of adjacent units (i.e., immediately adjacent units get more weight than the units adjacent to adjacent units, etc)" (Werner and Modlin, p. 187).

(d) Adjacency-based spatial smoothing can more effectively account for urban versus rural differences and differences based on natural or artificial geographic boundaries than can distance-based spatial smoothing. It is still vulnerable to over-smoothing by the actuary; by using this technique, or any smoothing technique, the actuary runs the risk of concealing actual geographically based variation that meaningfully affects loss experience (Werner and Modlin, p. 187).

**Problem S5-84-5.**
(a) Complete the following statement by filling in the blanks: "The purpose of clustering in territorial ratemaking is to maximize heterogeneity ______ groups and to minimize heterogeneity ______ groups."
(b) Briefly discuss how quartile methods of clustering work.
(c) Werner and Modlin, p. 188, discuss the following three similarity methods of clustering:
   1. Average linkage method;
   2. Centroid method;

Match each feature below to the method that exhibits that feature:
(i) Clusters that have the same number of observations are produced.
(ii) Clusters with smaller variances are joined.
(iii) Outliers are identified with relative ease.

**Solution S5-84-5.** This problem is based on the discussion of clustering by Werner and Modlin, p. 188.

(a) "The purpose of clustering in territorial ratemaking is to maximize heterogeneity between groups and to minimize heterogeneity within groups."

(b) Quartile methods of clustering "create clusters based on either equal numbers of observations (such as geographic units) or equal weights (such as exposure)" (Werner and Modlin, p. 188).

(c) Feature (i) is characteristic of 3. Ward's clustering method.
Feature (ii) is characteristic of 1. Average linkage method.
Feature (iii) is characteristic of 2. Centroid method.
Section 85

Increased Limits Ratemaking for Single Limits with Uncensored Losses

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Let B be the base rate. Let H be a limit of liability that is different from the basic (default) limit of liability. Then the following formula holds:

**Formula 85.1:**

\[
\text{Rate at Limit } H = (\text{ILF for Limit } H) \times B
\]

Here, (ILF for Limit H) is the *increased limit factor* associated with Limit H. The following formulas apply for determining the ILF:

**Formula 85.2:**

\[
\text{Indicated ILF (H)} = \frac{(L^- + E^-_L)_H}{(L^- + E^-_L)_B}.
\]

Here, \((L^- + E^-_L)_H\) is the pure premium associated with Limit H, and \((L^- + E^-_L)_B\) is the pure premium associated with the basic limit.

**Formula 85.3:**

\[
\text{Indicated ILF (H)} = \frac{(\text{Frequency}_H \times \text{Severity}_H)}{(\text{Frequency}_B \times \text{Severity}_B)}.
\]

If frequency does not depend on the limit of liability chosen, then the following formula applies:

**Formula 85.4:**

\[
\text{Indicated ILF (H)} = \frac{\text{Severity}_H}{\text{Severity}_B}.
\]
The losses for Limit H have to be limited at H, and the losses for the basic limit have to be limited at the basic limit. The concept of limited average severity (LAS) describes losses limited in this way. Another way to express Formula 85.4 is the following:

Indicated ILF (H) = LAS(H)/LAS(B).

**Source:**

**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-85-1.** The following is known about losses in the book of business of Insurer Z during calendar year 2033:

There were 435 claims with a size of loss under $50,000. The total reported losses for these claims were $20,227,500.

There were 316 claims with a size of loss between $50,000 and $100,000. The total reported losses for these claims were $28,400,000.

There were 121 claims with a size of loss between $100,000 and $500,000. The total reported losses for these claims were $27,104,000.

There were 8 claims with a size of loss in excess of $500,000. The total reported losses for these claims were $6,230,000.

The basic limit for an insurance policy issued by Insurer Z in this book of business is $50,000. What is the limited average severity (LAS) associated with this basic limit?

**Solution S5-85-1.** First, we add together the number of claims: 435 + 316 + 121 + 8 = 880 claims. We do not cap the reported losses for the 435 claims which had losses under $50,000. For the other 445 claims, we cap the loss per claim at $50,000; this total capped loss amount is 445*50000 = $22,250,000. Our LAS associated with the basic limit is

\[
\text{LAS}(50000) = \frac{\text{Total reported losses capped at } 50,000 \text{ per claim}}{\text{Total number of claims}} = \frac{22,250,000 + 20,227,500}{880} = \text{LAS}(50000) = $48,269.89.
\]

**Problem S5-85-2.** The following is known about losses in the book of business of Insurer Z during calendar year 2033:

There were 435 claims with a size of loss under $50,000. The total reported losses for these claims were $20,227,500.
There were 316 claims with a size of loss between $50,000 and $100,000. The total reported losses for these claims were $28,400,000.

There were 121 claims with a size of loss between $100,000 and $500,000. The total reported losses for these claims were $27,104,000.

There were 8 claims with a size of loss in excess of $500,000. The total reported losses for these claims were $6,230,000.

The basic limit for an insurance policy issued by Insurer Z in this book of business is $50,000. What is the limited average severity (LAS) associated with an increased limit of $500,000?

**Solution S5-85-2.** There are 435 + 316 + 121 + 8 = 880 total claims. We do not cap the reported losses for the 435 + 316 + 121 = 872 claims which had losses under $500,000. Each of the 8 claims with a size of loss in excess of $500,000 will be capped at $500,000 per claim. The capped amount for these eight claims is 8*500000 = $4,000,000.

Our LAS(500000) =

(Total reported losses capped at $500,000 per claim)/(Total number of claims) =

($20,227,500 + $28,400,000 + $27,104,000 + $4,000,000)/880 = 90603.97727 = \text{LAS}(500000) = \$90,603.98.$

**Problem S5-85-3.** The following is known about losses in the book of business of Insurer Z during calendar year 2033:

There were 435 claims with a size of loss under $50,000. The total reported losses for these claims were $20,227,500.

There were 316 claims with a size of loss between $50,000 and $100,000. The total reported losses for these claims were $28,400,000.

There were 121 claims with a size of loss between $100,000 and $500,000. The total reported losses for these claims were $27,104,000.

There were 8 claims with a size of loss in excess of $500,000. The total reported losses for these claims were $6,230,000.

The basic limit for an insurance policy issued by Insurer Z in this book of business is $50,000. Assume that loss frequency does not vary on the basis of the policy limit selected by the insured. What should be the increased limit factor (ILF) associated with a limit of $500,000?
Solution S5-85-3. We use Formula 85.4: Indicated ILF (H) = LAS(H)/LAS(B). From Solution S5-85-1, \( LAS(50000) = 48269.88636 \). From Solution S5-85-2, \( LAS(500000) = 90603.97727 \). Our answer is thus \( \frac{LAS(500000)}{LAS(50000)} = \frac{90603.97727}{48269.88636} = \text{ILF}(500000) = 1.877029016 \).

Problem S5-85-4. The following is known about losses in the book of business of Insurer Z during calendar year 2033:

There were 435 claims with a size of loss under $50,000. The total reported losses for these claims were $20,227,500.

There were 316 claims with a size of loss between $50,000 and $100,000. The total reported losses for these claims were $28,400,000.

There were 121 claims with a size of loss between $100,000 and $500,000. The total reported losses for these claims were $27,104,000.

There were 8 claims with a size of loss in excess of $500,000. The total reported losses for these claims were $6,230,000.

The basic limit for an insurance policy issued by Insurer Z in this book of business is $50,000. The base rate for this policy is $316. What is the rate associated with a limit of $500,000?

Solution S5-85-4. We use Formula 85.1: Rate at Limit H = (ILF for Limit H)*B. From Solution S5-85-3, \( \text{ILF}(500000) = 1.877029016 \). Thus, the rate for a limit of $500,000 is \( 1.877029016 \times 316 = 593.1411689 = \$593.14 \).

Problem S5-85-5. For the book of business of Insurer Q, it is observed that loss frequency at the basic limit of $20,000 is 0.043, and loss severity is at $10,216. Loss frequency at the limit of $100,000 is 0.033, and loss severity is $30,231. According to this information, what should be the increased limit factor associated with the limit of $100,000?

Solution S5-85-5. We use Formula 85.3:

\[
\text{Indicated ILF (H)} = \frac{(\text{Frequency}_H)(\text{Severity}_H)}{(\text{Frequency}_B)(\text{Severity}_B)}.
\]

Indicated ILF (100000) = \( \frac{(0.033)(30231)}{(0.043)(10216)} = \text{Indicated ILF (100000)} = 2.270999891 \).
Section 86

Increased Limits Ratemaking for Single Limits with Censored Losses

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Source:

Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-86-1. Insurance Company F's data for losses in calendar year 2040 are censored at the policy limits. That is, if a loss is in excess of the limits of the applicable policy, the excess amount is not known. What is known is the following:
The basic limit offered by the company is $20,000.

There were 500 claims pertaining to policies with limits of $20,000. The total reported losses for these claims were $6,172,500.

There were 813 claims pertaining to policies with limits of $50,000. Of these, 213 claims were under $20,000, and the total loss amount for these claims was $3,104,688, whereas 600 claims were between $20,000 and $50,000, and the total loss amount for these claims was $20,807,400.

There were 135 claims pertaining to policies with limits of $100,000. Of these, 12 claims were under $20,000, and the total loss amount for these claims was $105,528. 49 of these claims were between $20,000 and $50,000, and the total loss amount for these claims was $1,409,289. 74 of these claims were between $50,000 and $100,000, and the total loss amount for these claims was $5,331,108.

What is the limited average severity (LAS) pertaining to the basic limit of $20,000?
Solution S5-86-1. With LAS pertaining to the smallest possible limit, LAS can be calculated in the relatively straightforward fashion demonstrated in Section 85. We use reported losses for the claims up to $20,000, and we censor all the other claims at $20,000.

The $500 + 213 + 12 = 725$ claims up to $20,000 constitute $6,172,500 + 3,104,688 + 105,528 = 9,382,716$ of reported losses.

The remaining claims will be censored at $20,000; there are $600 + 49 + 74 = 723$ such claims. Thus, the total censored loss amount for these is $20,000*723 = 14,460,000$.

The numerator of the LAS calculation will thus be $9,382,716 + 14,460,000 = 23,842,716$.

The denominator of the LAS calculation is the total number of claims, since all claims are being considered for calculating the LAS pertaining to the smallest possible limit: $725 + 723 = 1448$ claims. Thus, $\text{LAS}(20000) = 23,842,716/1448 = 16465.96409 = \$16,465.96$.

Problem S5-86-2. Insurance Company F's data for losses in calendar year 2040 are censored at the policy limits. That is, if a loss is in excess of the limits of the applicable policy, the excess amount is not known. What is known is the following:
The basic limit offered by the company is $20,000.

There were 500 claims pertaining to policies with limits of $20,000. The total reported losses for these claims were $6,172,500.

There were 813 claims pertaining to policies with limits of $50,000. Of these, 213 claims were under $20,000, and the total loss amount for these claims was $3,104,688, whereas 600 claims were between $20,000 and $50,000, and the total loss amount for these claims was $20,807,400.

There were 135 claims pertaining to policies with limits of $100,000. Of these, 12 claims were under $20,000, and the total loss amount for these claims was $105,528. 49 of these claims were between $20,000 and $50,000, and the total loss amount for these claims was $1,409,289. 74 of these claims were between $50,000 and $100,000, and the total loss amount for these claims was $5,331,108.

What is the limited average severity (LAS) pertaining to the layer between $20,000 and $50,000, if one considers only the claims for which positive loss amounts can be found within that layer? (Note that this is not the same as LAS pertaining to the limit of $50,000, as it excludes from consideration policies that have a $20,000 limit.)

Solution S5-86-2. We cannot consider claims for policies with a $20,000 limit, since those claims are not within the layer between $20,000 and $50,000. We consider claims for which the size of reported loss is between $20,000 and $50,000; there are $600 + 49 = 649$ such claims, with total reported losses of $20,807,400 + 1,409,289 = 22,216,689$. From this amount, we subtract the amount of each claim that is under $20,000, i.e., $649*20000 = 12,980,000$. The difference is
$22,216,689 - $12,980,000 = $9,236,689. We also need to consider claims in excess of $50,000; each such claim contributes the maximum possible amount to the layer between $20,000 and $50,000, i.e., $50,000 - $20,000 = $30,000. There are 74 such claims, so their contribution to the excess layer is 74*30000 = $2,220,000. The total numerator for the LAS calculation is thus $9,236,689 + $2,220,000 = $11,456,689. The denominator for the LAS calculation is 649 + 74 = 723 claims. Thus, LAS for the layer between $20,000 and $50,000 is $11,456,689/723 = 15846.04288 = $15,846.04

Problem S5-86-3. Insurance Company F’s data for losses in calendar year 2040 are censored at the policy limits. That is, if a loss is in excess of the limits of the applicable policy, the excess amount is not known. What is known is the following:

The basic limit offered by the company is $20,000.

There were 500 claims pertaining to policies with limits of $20,000. The total reported losses for these claims were $6,172,500.

There were 813 claims pertaining to policies with limits of $50,000. Of these, 213 claims were under $20,000, and the total loss amount for these claims was $3,104,688, whereas 600 claims were between $20,000 and $50,000, and the total loss amount for these claims was $20,807,400.

There were 135 claims pertaining to policies with limits of $100,000. Of these, 12 claims were under $20,000, and the total loss amount for these claims was $105,528. 49 of these claims were between $20,000 and $50,000, and the total loss amount for these claims was $1,409,289. 74 of these claims were between $50,000 and $100,000, and the total loss amount for these claims was $5,331,108.

What is the limited average severity (LAS) pertaining to the limit of $50,000?

Solution S5-86-3. We know from Solution S5-86-1 that LAS(20000) = 16465.96409. We also know from Solution S5-86-2 that LAS(Layer between 20000 and 50000) = 15846.04288. We cannot, however, simply add these two values together to get LAS(50000). Rather, LAS(Layer between 20000 and 50000) needs to be adjusted for the fact that, of the claims pertaining to policies with limits of $50,000 and $100,000, the claims where losses were under $20,000 were not used. 723 claims were used in determining LAS(Layer between 20000 and 50000). However, there were 813 + 135 = 948 total claims pertaining to policies with limits of $50,000 and $100,000. Thus, LAS(Layer between 20000 and 50000) would need to be adjusted by a factor of (723/948); the adjusted LAS for this layer is (723/948)*15846.04288 = 12085.11498; this is the figure we add to LAS(20000). Thus, LAS(50000) = 16465.96409 + 12085.11498 = 28551.07907 = LAS(50000) = $28,551.08.

Problem S5-86-4. Insurance Company F’s data for losses in calendar year 2040 are censored at the policy limits. That is, if a loss is in excess of the limits of the applicable policy, the excess amount is not known. What is known is the following:

The basic limit offered by the company is $20,000.
There were 500 claims pertaining to policies with limits of $20,000. The total reported losses for these claims were $6,172,500.

There were 813 claims pertaining to policies with limits of $50,000. Of these, 213 claims were under $20,000, and the total loss amount for these claims was $3,104,688, whereas 600 claims were between $20,000 and $50,000, and the total loss amount for these claims was $20,807,400.

There were 135 claims pertaining to policies with limits of $100,000. Of these, 12 claims were under $20,000, and the total loss amount for these claims was $105,528. 49 of these claims were between $20,000 and $50,000, and the total loss amount for these claims was $1,409,289. 74 of these claims were between $50,000 and $100,000, and the total loss amount for these claims was $5,331,108.

What is the limited average severity (LAS) pertaining to the layer between $50,000 and $100,000, if one considers only the claims for which positive loss amounts can be found within that layer?

**Solution S5-86-4.** Here, only policies with a limit of $100,000 (the highest possible limit in this scenario) can be used to determine LAS pertaining to the layer between $50,000 and $100,000. There were 74 claims between $50,000 and $100,000, and the total loss amount for these claims was $5,331,108. From this, we subtract $50,000 from the amount of each loss:

\[ 5331108 - 74 \times 50000 = 1,631,108. \]

This will be the numerator of our LAS calculation. The denominator is the number of claims: 74. Thus, LAS for this layer is $1,631,108/74 = 22042 = $22,042.00.

**Problem S5-86-5.** Insurance Company F's data for losses in calendar year 2040 are censored at the policy limits. That is, if a loss is in excess of the limits of the applicable policy, the excess amount is not known. What is known is the following:

The basic limit offered by the company is $20,000.

There were 500 claims pertaining to policies with limits of $20,000. The total reported losses for these claims were $6,172,500.

There were 813 claims pertaining to policies with limits of $50,000. Of these, 213 claims were under $20,000, and the total loss amount for these claims was $3,104,688, whereas 600 claims were between $20,000 and $50,000, and the total loss amount for these claims was $20,807,400.

There were 135 claims pertaining to policies with limits of $100,000. Of these, 12 claims were under $20,000, and the total loss amount for these claims was $105,528. 49 of these claims were between $20,000 and $50,000, and the total loss amount for these claims was $1,409,289. 74 of these claims were between $50,000 and $100,000, and the total loss amount for these claims was $5,331,108.

What is the limited average severity (LAS) pertaining to the limit of $100,000.
**Solution S5-86-5.** From Solution S5-86-3, we know that \( \text{LAS}(50000) = 28551.07907 \). From Solution S5-86-4, we know that \( \text{LAS}(\text{Layer between 50000 and 100000}) = 22042 \). The latter figure needs to be adjusted to account for the number of claims under $50,000, pertaining to the limit of $100,000. There were 135 total claims pertaining to the limit of $100,000, of which 74 were in excess of $50,000. Our adjustment factor is thus \((74/135)\), and the adjusted \( \text{LAS}(\text{Layer between 50000 and 100000}) = (74/135) \times 22042 = 12082.28148 \). Therefore, \( \text{LAS}(100000) = 28551.07907 + 12082.28148 = 40633.36055 \) = \( \text{LAS}(100000) = $40,633.36 \).
Section 87

Calculations of Increased Limit Factors Using Continuous Loss Distributions and Basic Calculations of Deductible Relativities and Loss Elimination Ratios

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Let \( f(x) \) be a continuous distribution of losses. Let \( B \) be the basic limit, and let \( H \) be a different, higher limit. Let \( \text{LAS}(H) \) and \( \text{LAS}(B) \) denote the limited average severities at \( H \) and \( B \), respectively. Let \( \text{ILF}(H) \) denote the increased limit factor at \( H \). Then, the following formulas hold:

**Formula 87.1:**

\[
\text{LAS}(H) = \int_0^H x f(x) \, dx + H \frac{\int_H^\infty f(x) \, dx}{\int_0^\infty f(x) \, dx}.
\]

**Formula 87.2:**

\[
\text{ILF}(H) = \frac{\text{LAS}(H)}{\text{LAS}(B)} = \frac{\int_0^H x f(x) \, dx + H \frac{\int_H^\infty f(x) \, dx}{\int_0^\infty f(x) \, dx}}{\int_0^B x f(x) \, dx + B \frac{\int_B^\infty f(x) \, dx}{\int_0^\infty f(x) \, dx}}.
\]

Let \( (L^- + E^-_L)_B \) be the pure premium at the base rate and no deductible. Let \( (L^- + E^-_L)_D \) be the pure premium when a deductible amount of \( D \) is applied. Then the following formula holds:

**Formula 87.3:**

\[
\text{Indicated Deductible Relativity for } D = \frac{(L^- + E^-_L)_D}{(L^- + E^-_L)_B}.
\]

Let \( \text{LER}(D) \) be the loss elimination ratio associated with deductible \( D \), i.e., the proportion of losses eliminated by the existence of deductible \( D \). Then the following formulas hold:
Formula 87.4:

\[ \text{LER}(D) = \frac{(L^- + E^-_L)_B - (L^- + E^-_L)_D}{(L^- + E^-_L)_B} \]

Formula 87.5:

Indicated Deductible Relativity for \( D = 1 - \text{LER}(D) \).


Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-87-1. Losses follow an exponential distribution with mean 631. The basic limit for an insurance policy is 400. What is the limited average severity at the limit of 631?

Relevant property of exponential distributions: \( f(x) = \frac{1}{\theta}e^{-x/\theta} \), where \( \theta \) is the mean of the distribution.

Solution S5-87-1. We use Formula 87.1: \( \text{LAS}(H) = \left( \int_0^H x f(x) dx + H \int_H^\infty f(x) dx \right) \). Here, \( H = 631 \) and \( \theta = 631 \). Thus, \( \text{LAS}(H) = \left( \int_0^{631} \frac{x}{631} e^{-x/631} dx + 631 \int_{631}^\infty e^{-x/631} dx \right) \). We find \( 631 \left( \frac{1}{631} \right) e^{-x/631} dx = \frac{631}{631} e^{-x/631} dx = (631) e^{-x/631} \). We can also find \( \int_0^{631} \frac{x}{631} e^{-x/631} dx \) using the Tabular Method of Integration by Parts:

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<th>Signs</th>
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<tr>
<td>+</td>
<td>x</td>
<td>(1/631)e^{-x/631}</td>
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<tr>
<td>-</td>
<td>1</td>
<td>-e^{-x/631}</td>
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<tr>
<td>+</td>
<td>0</td>
<td>631e^{-x/631}</td>
</tr>
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Thus, \( \int_0^{631} \frac{x}{631} e^{-x/631} dx = (-xe^{-x/631} - 631e^{-x/631}) \bigg|_0^{631} = -631e^{-1} - 631e^{-1} + 0 + 631 = 631 - 1062e^{-1} \).

We add the results of the two integrals together to get \( 631 - 1062e^{-1} + 631e^{-1} = 631 - 631e^{-1} = \text{LAS}(631) = 398.8680726 \).

Problem S5-87-2. Losses follow an exponential distribution with mean 631. The basic limit for an insurance policy is 400. What is the limited average severity at the basic limit?

Relevant property of exponential distributions: \( f(x) = \frac{1}{\theta}e^{-x/\theta} \), where \( \theta \) is the mean of the distribution.

Solution S5-87-2. \( \text{LAS}(B) = \left( \int_0^B x f(x) dx + B \int_B^\infty f(x) dx \right) \). Here, \( B = 400 \) and \( \theta = 631 \). Thus, \( \text{LAS}(400) = \left( \int_0^{400} \frac{x}{631} e^{-x/631} dx + 400 \int_{400}^{631} e^{-x/631} dx \right) \).

\( \int_0^{400} \frac{x}{631} e^{-x/631} dx = (-xe^{-x/631} - 631e^{-x/631}) \bigg|_0^{400} = -400e^{-400/631} - 631e^{-400/631} + 0 + 631 = 631 - 1031e^{-1} \).
\[ 400 \int_{400}^{\infty} \left( \frac{1}{631} e^{-x/631} \right) dx = -400 e^{-x/631} \bigg|_{400}^{\infty} = 400 e^{400/631} \cdot \infty = 400 e^{400/631}. \] The sum of the two integrals is \( \text{LAS}(400) = 631 - 1031 e^{-400/631} + 400 e^{-400/631} = 631 - 631 e^{-400/631} = \text{LAS}(400) = 296.247504. \)

**Problem S5-87-3.** Losses follow an exponential distribution with mean 631. The basic limit for an insurance policy is 400. What is the increased limit factor (ILF) associated with a limit of 631?

**Solution S5-87-3.** We use Formula 87.2: \( \text{ILF}(H) = \frac{\text{LAS}(H)}{\text{LAS}(B)} \), where \( H = 631 \), and \( B = 400 \). From Solution S5-87-1, we know that \( \text{LAS}(631) = 398.8680726 \). From Solution S5-87-2, we know that \( \text{LAS}(400) = 296.247504 \). Thus, \( \text{ILF}(631) = \frac{398.8680726}{296.247504} = \text{ILF}(631) = 1.346301462. \)

**Problem S5-87-4.** Assume that the pure premium at the base rate with no deductible is $562. The pure premium with a deductible of $100 is $333.

(a) What is the indicated relativity associated with the deductible of $100?

(b) What is the loss elimination ratio associated with the deductible of $100?

**Solution S5-87-4.**

(a) We use Formula 87.3: \( \text{Indicated Deductible Relativity for } D = (L^- + E^L)/D) / (L^- + E^L)B \). Here, \( (L^- + E^L)D = 333 \), and \( (L^- + E^L)B = 562 \), so the indicated relativity is \( 333/562 = 0.5925266904. \)

(b) We use Formula 87.4: \( ((L^- + E^L)B - (L^- + E^L)D) / (L^- + E^L)B = (562-333)/562 = 0.4074733096. \)

**Problem S5-87-5.**

(a) The loss elimination ratio associated with a deductible of $500 is 0.64. What is the indicated relativity associated with this deductible?

(b) Continuing from part (a), the pure premium associated with a deductible of $500 is $230. The pure premium associated with a deductible of $1000 is $130. What is the indicated relativity associated with a deductible of $1000?

**Solution S5-87-5.**

(a) We use Formula 87.5: \( \text{Indicated Deductible Relativity for } D = 1 - \text{LER}(D) = 1 - 0.64 = 0.36 \). 

(b) We can calculated the indicated relativity going from a deductible of $500 to a deductible of $1000; this is also the ratio of the pure premiums in each case: \( 130/230 = 0.5652173913. \) To get the indicated relativity when going from no deductible, we multiply this result by the relativity for the $500 deductible: \( 0.36 \times 0.5652173913 = 0.2034782609. \)
Section 88

Calculation of Loss Elimination Ratios Using Observed Data

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Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-88-1. You have the following data from Insurance Company G during Calendar Year 2032:

There were 346 claims with losses under $200; the total ground-up losses for these claims were $48,786.
There were 800 claims with losses between $200 and $400; the total ground-up losses for these claims were $264,800.
There were 436 claims with losses between $400 and $800; the total ground-up losses for these claims were $242,852.
There were 600 claims with losses over $800; the total ground-up losses for these claims were $930,000.

Based on these observed data, what would be the total losses eliminated if a deductible of $400 were applied to all policies?

Solution S5-88-1. With a $400 deductible, all losses of a size under $400 would be eliminated completely. This corresponds to $48,786 + 264,800 = $313,586 eliminated. Also, for losses in excess of $400, $400 per loss would be eliminated. This applies to $400 / $400 = 1036 claims; thus, $400*1036 = $414,400 would be eliminated in this way. The total amount eliminated would be $313,586 + $414,400 = $727,986.
Problem S5-88-2. You have the following data from Insurance Company G during Calendar Year 2032:

There were 346 claims with losses under $200; the total ground-up losses for these claims were $48,786.
There were 800 claims with losses between $200 and $400; the total ground-up losses for these claims were $264,800.
There were 436 claims with losses between $400 and $800; the total ground-up losses for these claims were $242,852.
There were 600 claims with losses over $800; the total ground-up losses for these claims were $930,000.

Based on these observed data, what would be the loss elimination ratio (LER) if a deductible of $400 were applied to all policies?

Solution S5-88-2. LER = (Losses eliminated)/(Total losses). In Solution S5-88-1, we found that (Losses eliminated) = $727,986. Total ground-up losses are 48786 + 264800 + 242852 + 930000 = $1,486,438. Thus, LER(400) = $727,986/$1,486,438 = 0.4897520112.

Problem S5-88-3. Which of the following data can be used to determine the loss elimination ratio associated with moving from a $1000 deductible to a $2500 deductible? More than one answer may be possible.

(a) Data from policies with no deductible;
(b) Data from policies with a $100 deductible;
(c) Data from policies with a $500 deductible;
(d) Data from policies with a $1000 deductible;
(e) Data from policies with a $2000 deductible;
(f) Data from policies with a $2500 deductible;
(g) Data from policies with a $5000 deductible;
(h) Data from policies with a $10000 deductible.

Solution S5-88-3. This question is based on the discussion in Werner and Modlin, p. 198. Data from policies with deductibles lower than the deductibles in question can be used to determine loss elimination ratios. Here, only data from policies with $1000 or lower deductibles can be used. Thus, the following data can be used:

(a) Data from policies with no deductible;
(b) Data from policies with a $100 deductible;
(c) Data from policies with a $500 deductible;
(d) Data from policies with a $1000 deductible.

Problem S5-88-4. You are given the following loss data from Insurance Company T in calendar year 2046. Assume that each individual loss exceeds $1000.
The company had 142 claims on policies with no deductible, for which the reported losses were $315,132.
The company had 411 claims on policies with a $500 deductible, for which the reported losses were $600,500.
The company had 126 claims on policies with a $1000 deductible, for which the reported losses were $431,123.
The company had 80 claims on policies with a $2000 deductible, for which the reported losses were $86,320.

Based on the observed data, what would be the total amount of losses eliminated by moving from a $500 deductible to a $1000 deductible?

**Solution S5-88-4.** Only policies with no deductible or a deductible of $500 can be analyzed, because only for these policies the loss amounts between $500 and $1000 for each individual claim are known. Because each individual loss exceeds $1000, the losses eliminated for the 142 + 411 = 553 claims on policies with a deductible of $500 or less would be (1000 - 500)*553 = $276,500 as a result of moving from a deductible of $500 to a deductible of $1000.

**Problem S5-88-5.** You are given the following loss data from Insurance Company T in calendar year 2046. Assume that each individual loss exceeds $1000.

The company had 142 claims on policies with no deductible, for which the reported losses were $315,132.
The company had 411 claims on policies with a $500 deductible, for which the reported losses were $600,500.
The company had 126 claims on policies with a $1000 deductible, for which the reported losses were $431,123.
The company had 80 claims on policies with a $2000 deductible, for which the reported losses were $86,320.

Based on the observed data, what would be the loss elimination ratio associated with moving from a $500 deductible to a $1000 deductible?

**Solution S5-88-5.** Again, we can only analyze policies with no deductible or a deductible of $500. LER = (Losses eliminated)/(Total losses). In Solution S5-88-4, we found that (Losses eliminated) = $276,500. Total losses on the claims for policies with deductibles of $500 or under were $315,132 + $600,500 = $915,632. Thus, our loss elimination ratio is $276,500/$915,632 = LER = 0.3019772136.
Section 89

Calculations of Loss Elimination Ratios Using Continuous Loss Distributions and Considerations Pertaining to Expenses in Workers' Compensation Ratemaking

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If the underlying loss distribution f(x) is continuous, then the following formulas apply with respect to determining the loss eliminated by application of deductible D and the loss elimination ratio (LER) associated with D.

Formula 89.1:

Loss eliminated by application of deductible D = \( \int_0^D x f(x) \, dx + D \int_D^\infty f(x) \, dx \).

Formula 89.2:

LER(D) = \( \frac{\int_0^D x f(x) \, dx + D \int_D^\infty f(x) \, dx}{\int_0^\infty x f(x) \, dx} \).

Note that the integral \( \int_0^\infty x f(x) \, dx \) corresponds to the unlimited expected loss, i.e., the mean of the distribution with function f(x).


Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-89-1. Losses follow an exponential distribution with mean 631. What would be the loss eliminated by the application of a deductible of 300?
Relevant property of exponential distributions: \( f(x) = (1/\theta) e^{-x/\theta} \), where \( \theta \) is the mean of the distribution.

Solution S5-89-1. We use Formula 89.1: Loss eliminated by application of deductible \( D = 0^D \int x * f(x) * dx + D^\infty \int f(x) * dx \). Here, \( D = 300 \), and \( \theta = 631 \). Thus, we need to find

\[
0^{300} \int x (1/631) e^{-x/631} * dx + 300 \int^{\infty} (1/631) e^{-x/631} * dx.
\]

We find \( 300 \int^{\infty} (1/631) e^{-x/631} * dx = \frac{300}{631} \int^{\infty} (300/631) e^{-x/631} * dx = (-300/631 e^{-x/631}) \bigg|_{300}^{\infty} = 300 e^{-300/631} \). We can also find \( 0^{300} \int (1/631) e^{-x/631} * dx \) using the Tabular Method of Integration by Parts:

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<tr>
<td>+</td>
<td>x</td>
<td>( 1/631 e^{-x/631} )</td>
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<td>1</td>
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Thus, \( 0^{300} \int (x/631) e^{-x/631} * dx = (-xe^{-x/631} - 631e^{-x/631}) \bigg|_{0}^{300} = -300e^{-300/631} - 631e^{-300/631} + 0 + 631 = 631 - 931e^{-300/631} \). The sum of the two integrals is \( 631 - 931e^{-300/631} + 300e^{-300/631} = 631 - 631e^{-300/631} \).

Loss eliminated = 238.7615105.

Problem S5-89-2. Losses follow an exponential distribution with mean 631. What would be the loss elimination ratio associated with the application of a deductible of 300?

Relevant property of exponential distributions: \( f(x) = (1/\theta) e^{-x/\theta} \), where \( \theta \) is the mean of the distribution.

Solution S5-89-2. We use Formula 89.2:

\[
LER(D) = \frac{\int^{\infty} x * f(x) * dx + D^\infty \int f(x) * dx}{\int^{\infty} x * f(x) * dx}.
\]

In Solution S5-89-1, we found that \( \int^{\infty} x * f(x) * dx + D^\infty \int f(x) * dx \), the loss eliminated, is equal to 238.7615105. \( \int^{\infty} x * f(x) * dx \) is the mean of the loss distribution, i.e., 631. Thus, 238.7615105/631 = LER(200) = 0.378385912.

Problem S5-89-3. Insurer behaviors may differ on the basis of deductible amounts chosen. Describe two kinds of insurer behavior that a simple loss elimination ratio approach to analyzing the effects of deductibles will not take into account.

Solution S5-89-3. This question is based on the discussion in Werner and Modlin, p. 200. The following two behaviors are possible:

1. Insurers with higher deductibles may be less likely to report certain kinds of losses. For instance, an insured with a $5000 deductible will be less likely to report a $5100 loss than an insured with a $1000 deductible, because the insured with a $5000 deductible would receive a $100 payment for the loss, but would also likely receive a premium increase associated with having filed a claim.
2. Lower-risk insureds will more often choose higher deductibles. This can make high-deductible policies more profitable to insurers than a simple loss elimination ratio analysis would suggest.

**Problem S5-89-4.** When determining expense provisions, many commercial lines insurers use the All Variable Expense Approach, which assumes that all expenses vary with the premium. This approach tends to undercharge smaller accounts and overcharge larger accounts. What are three ways in which workers' compensation insurers have attempted to compensate for this deficiency in the All Variable Expense Approach?

**Solution S5-89-4.** This question is based on the discussion in Werner and Modlin, p. 201. The following three ways are mentioned there:

1. Calculating a variable expense provision that only applies to the first $X$ of standard premium, which is premium before premium discounts and expense constants are applied;

2. Charging an expense constant to all risks, which accounts for fixed costs.

3. Applying a premium discount to policies that have premium exceeding a certain threshold.

**Problem S5-89-5.** A workers' compensation insurer insures large accounts and small accounts. Large accounts have a earned premium of $531,013 and losses of $310,000. Small accounts have earned premium of $31,002 and losses of $26,504. There are 123 large accounts and 321 small accounts. The insurer wishes to charge an additional loss constant to each small account so that the target loss ratio for the small accounts is equal to the observed loss ratio for the large accounts. What should be the loss constant per small account?

**Solution S5-89-5.** This question is inspired by the example accompanied by Table 11.11 in Werner and Modlin, p. 201.

The loss ratio on the large accounts is \(\frac{\text{Losses}}{\text{Earned Premium}} = \frac{310000}{531013} = 0.5837898507\).

To achieve this target loss ratio on the small accounts, a premium of

\[
\frac{\text{Losses on Small Accounts}}{\text{Target Loss Ratio}} = \frac{26504}{0.5837898507} = 45399.89855 \text{ would need to be collected.}
\]

The shortfall with respect to the current premium is 45399.89855 - 31002 = 14397.89855. Assuming that this amount is distributed evenly throughout the 321 small accounts, the loss constant per small account would be 14397.89855/321 = 44.85326653 = $44.85.
Section 90

Calculations Pertaining to Coinsurance Requirements and Penalties in Property Insurance

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Let a be the coinsurance apportionment ratio.
Let c be the required coinsurance percentage.
Let e be the coinsurance penalty.
Let F be the amount of insurance selected by the insured, i.e., the face value of the insurance policy being purchased.
Let L be the amount of a loss, after the relevant deductible has been applied to it.
Let V be the value of the property being insured.

Then the following formulas hold:

**Formula 90.1:**
\[ a = \min\left(\frac{F}{cV}, 1\right) \]

**Formula 90.2:**
\[ I = \frac{L*F}{cV}, \text{ where } I \leq F \text{ and } I \leq L. \]

**Formula 90.3:**
\[ e = L - I \text{ if } L \leq F; \]
\[ e = F - I \text{ if } F < L < cV; \]
\[ e = 0 \text{ if } cV \leq L. \]

**Source:**
Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-90-1. Assume that the value of a property being insured is $316,000 at the time of loss. The applicable insurance policy has a required coinsurance percentage of 65%. The insured has purchased $165,000 of insurance on the property. A $30,000 deductible applies to the policy. A loss of $165,000 occurs.

(a) What is the coinsurance apportionment ratio?
(b) What is the amount the insured will receive from the insurer as compensation for the loss?
(c) What is the coinsurance penalty applicable to this situation?

Solution S5-90-1.

(a) We use Formula 90.1: \( a = \min(F/(cV), 1) \). Here, \( F = 165000 \), \( c = 0.65 \), and \( V = 316000 \). Thus, \( F/(cV) = 165000/(0.65*316000) = a = 0.8033106134 \).

(b) We use Formula 90.2: \( I = L*F/(cV) \). We already know that \( F/(cV) = 0.8033106134 \). Furthermore, \( L = 165000 - 30000 = 135000 \) (to account for the deductible). Thus, \( I = 135000*0.8033106134 = 108446.9328 = $108,446.93 \).

(c) We use Formula 90.3. Here, \( L < F \), so \( e = L - I = 135000 - 108446.9328 = 26553.06719 = $26553.07 \).

Problem S5-90-2. Assume that the value of a property being insured is $316,000 at the time of loss. The applicable insurance policy has a required coinsurance percentage of 65%. The insured has purchased $165,000 of insurance on the property. A $30,000 deductible applies to the policy. A loss of $215,000 occurs.

(a) What is the amount the insured will receive from the insurer as compensation for the loss?
(b) What is the coinsurance penalty applicable to this situation?

Solution S5-90-2. (a) We use Formula 90.2: \( I = L*F/(cV) \). We already know from Solution S5-90-1(a) that \( F/(cV) = 0.8033106134 \). Furthermore, \( L = 215000 - 30000 = 185000 \). Thus, \( I = 185000*0.8033106134 = 148612.4635 = $148,612.46 \).

(b) We use Formula 90.3. Here, \( cV = 0.65*316000 = $205,400 \), so \( F < L < cV \), which means that \( e = F - I = 165000 - 148612.4635 = 16387.5365 = $16,387.54 \).

Problem S5-90-3. Assume that the value of a property being insured is $316,000 at the time of loss. The applicable insurance policy has a required coinsurance percentage of 65%. The insured has purchased $165,000 of insurance on the property. A $30,000 deductible applies to the policy. A loss of $285,000 occurs.

(a) What is the amount the insured will receive from the insurer as compensation for the loss?
(b) What is the coinsurance penalty applicable to this situation?
Solution S5-90-3.

(a) We use Formula 90.2: \( I = L \times F/(cV) \). We already know from Solution S5-90-1(a) that \( F/(cV) = 0.8033106134 \). However, \( L = 285000 - 30000 = 255000 \), and I would at first glance appear to be \( 255000 \times 0.8033106134 = 204844.2064 \). However, the amount the insured receives cannot be greater than the face value of the policy, which is $165,000 in this case, so the insured will receive $165,000.

(b) We use Formula 90.3. Here, \( L > cV \), so \( e = 0 \). There is no coinsurance penalty.

Problem S5-90-4. Assume that the value of a property being insured is $316,000 at the time of loss. The applicable insurance policy has a required coinsurance percentage of 65%. The insured has purchased $165,000 of insurance on the property. A $30,000 deductible applies to the policy. What will be the loss amount for which the maximum magnitude of coinsurance penalty would apply?

Solution S5-90-4. This question is inspired by Table 11.16, displayed by Werner and Modlin on p. 208. The maximum magnitude of coinsurance penalty would apply if the otherwise covered amount of the loss (i.e., the actual loss minus the deductible) were equal to the face value of the policy. This would occur if an absolute loss amount of $165,000 + $30,000 = $195,000 occurred. For such a loss amount, the entire $165,000 of the covered loss would be multiplied by the coinsurance apportionment ratio of 0.8033106134 to arrive at the amount the insured will receive as compensation, leading to the greatest possible magnitude of coinsurance penalty. For higher loss amounts, the difference between the face value of the policy and the amount to which the insured is entitled will diminish in a linear fashion until reaching zero for a loss equal to \( cV = 0.65 \times 316000 = $205,400 \).

Problem S5-90-5. Assume that the value of a house is $100,000, and possible loss amounts for that house are uniformly distributed from 0 to 100000. Assume that the frequency of losses is 4%.

(a) What would be the rate per $1000 of insurance if this house were insured to value?

(b) What would be the rate per $1000 of insurance if this house were insured to $60,000?

Solution S5-90-5.

(a) The mean severity of loss here is $50,000, based on the uniform distribution given. Thus, the pure premium is (Frequency)*(Severity) = 0.04*50000 = $2000. The amount of insurance is $100,000, so the rate per $1000 is (2000/100000)*1000 = $20.  

(b) For every loss above $60,000, the insured would receive $60,000 in compensation. The mean of the truncated uniform loss distribution would be \( 0.6 \times ((60000 - 0)/2) + 0.4 \times 60000 = \$42,000 \). Thus, the pure premium is (Frequency)*(Severity) = 0.04*42000 = $1680. The amount of insurance is $60,000, so the rate per $1000 is (1680/60000)*1000 = $28.
Section 91

Rate Calculations for Property Insurance and Considerations Pertaining to Insurance to Value

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We define the following variables in the context of a property insurance policy:

\[ f = \text{frequency of loss}; \]
\[ F = \text{face value of policy (amount of insurance purchased)}; \]
\[ L = \text{amount of loss after the deductible has been applied}; \]
\[ s(L) = \text{probability of loss of a given size (severity distribution)}; \]
\[ V = \text{maximum possible loss (may be unlimited)}; \]

For a discrete distribution of losses, the following formula holds:

**Formula 91.1:**

\[
\text{Rate} = \frac{(f*(\sum_{L=1}^{F} L*s(L))) + F*(1 - \sum_{L=1}^{F} s(L))}{F}.
\]

For a continuous distribution of losses, the following formula holds:

**Formula 91.2:**

\[
\text{Rate} = \frac{(\int_{0}^{F} (L*s(L)*dL) + F*(1 - \int_{0}^{F} s(L)*dL))}{F}.
\]

Original Problems and Solutions from The Actuary's Free Study Guide

**Problem S5-91-1.** Assume that the face value of insurance under consideration is $200,000. The frequency of loss is 2%. The severity distribution is discrete, with the following characteristics, on the basis of observed data:

\[
\begin{align*}
Pr(L = 5000) &= 0.2; \\
Pr(L = 25000) &= 0.2; \\
Pr(L = 50000) &= 0.4; \\
Pr(L = 100000) &= 0.1; \\
Pr(L = 250000) &= 0.1.
\end{align*}
\]

What is the rate for this situation?

**Solution S5-91-1.** We use Formula 91.1:

\[
\text{Rate} = \frac{f \sum (L \cdot s(L)) + F(1 - \sum s(L))}{F}.
\]

Here, \( f = 0.02 \), and \( F = 200000 \).

We find \( \sum (L \cdot s(L)) = 5000 \cdot 0.2 + 25000 \cdot 0.2 + 50000 \cdot 0.4 + 100000 \cdot 0.1 = 36000 \).

We find \( \sum s(L) = 0.2 + 0.2 + 0.4 + 0.1 = 0.9 \).

Thus, \( F(1 - \sum s(L)) = 200000 \cdot (1 - 0.9) = 20000 \).

Thus, \( \text{Rate} = (0.02 \cdot (36000 + 20000) / 200000) = \text{Rate} = 0.0056 \text{ per dollar of coverage}. \)

**Problem S5-91-2.** Assume that the face value of insurance under consideration is $200,000. The frequency of loss is 2%. The severity distribution is exponential with mean 50000. What is the rate for this situation?

**Relevant properties of exponential distributions:** The probability density function is \( f(x) = \frac{1}{\theta} e^{-x/\theta} \), where \( \theta \) is the mean of the distribution. The survival function is \( S(x) = e^{-x/\theta} \).

**Solution S5-91-2.** We use Formula 91.2:

\[
\text{Rate} = \frac{f \int (L \cdot s(L)) dL + F(1 - \int s(L) dL)}{F}.
\]

Here, \( f = 0.02 \), and \( F = 200000 \).

\[
1 - \int s(L) dL = 1 - \int_{0}^{200000} s(L) dL \text{ is, here, the survival function at 200000 of the exponential distribution with mean 50000. This is } S(200000) = e^{-200000/50000} = e^{-4} = 0.0183156389. \text{ This is the proportion of possible losses that will be in excess of the policy's face value.}
\]

We also find \( \int (L \cdot s(L)) dL = \int_{0}^{200000} (x/50000) e^{-x/50000} dx. \)
We use the Tabular Method of Integration by Parts:

\[
\begin{array}{c|c|c|c|c|c|c|c|c}
\text{Signs} & u & \text{...} & dv & + & \text{...} & x & \text{...} & (1/50000)e^{-x/50000} \\
- & 1 & \text{...} & -e^{-x/50000} & + & 0 & 50000e^{-x/50000} \\
\end{array}
\]

Thus, 
\[
0 \int_{200000}^{\infty} \frac{x}{50000} e^{-x/50000} \, dx =\left[ -xe^{-x/50000} - 50000e^{-x/50000} \right]_{0}^{200000} = -200000e^{-4} - 50000e^{-4} + 50000.
\]

The numerator of our formula for the rate is thus

\[
0.02*(-200000e^{-4} - 50000e^{-4} + 50000 + 200000e^{-4})/200000 = (1000 - 1000e^{-4})/200000 = (1- e^{-4})/200 = \$0.0049084218 \text{per dollar of coverage}.
\]

**Problem S5-91-3.**
(a) Fill in the blanks in the following sentence, given the options suggested:
"For a right-skewed loss distribution, corresponding to a preponderance of large losses, as the policy face value increases, the rate will _______ (decrease, increase, stay constant) at a ________ (decreasing, increasing, constant) rate."

(b) Fill in the blanks in the following sentence, given the options suggested:
"For a left-skewed loss distribution, corresponding to a preponderance of small losses, as the policy face value increases, the rate will _______ (decrease, increase, stay constant) at a ________ (decreasing, increasing, constant) rate."

(c) Fill in the blanks in the following sentence, given the options suggested:
"For a uniform loss distribution, as the policy face value increases, the rate will _______ (decrease, increase, stay constant) at a ________ (decreasing, increasing, constant) rate."

**Solution S5-91-3.** This question is based on the discussion by Werner and Modlin, p. 209. The following answers are correct:

(a) "For a right-skewed loss distribution, corresponding to a preponderance of large losses, as the policy face value increases, the rate will decrease at an increasing rate."

(b) "For a left-skewed loss distribution, corresponding to a preponderance of small losses, as the policy face value increases, the rate will decrease at a decreasing rate."

(c) "For a uniform loss distribution, as the policy face value increases, the rate will decrease at a constant rate."

**Problem S5-91-4.** Briefly describe two insurer initiatives designed to encourage insurance to value.

**Solution S5-91-4.** The following insurer initiatives, designed to encourage insurance to value, are described by Werner and Modlin, p. 209:
1. **Guaranteed replacement cost (GRC) coverage**, which allows replacement cost to exceed the policy limit, but only if the property is fully insured to value. This is most often capped at some percentage greater than 100% of the policy limit (for instance 125% of the policy limit).

2. **Sophisticated property estimation tools**, which can consider more aspects of an insured's home than was previously possible.

Other valid answers may also be possible.

**Problem S5-91-5.** From the insurer's perspective (disregarding the insured's possible interest in having complete coverage in the event of a total loss to a property and disregarding higher premiums collected as a result of insurance to value), what is a motivation for encouraging insurance to value?

**Solution S5-91-5.** This question is based on the discussion in Werner and Modlin, p. 205.

If the insurer assumes that all properties are insured to value, but some properties are actually not insured to value, then the insurer will charge the underinsured properties a lower rate than would be adequate to cover the exposure. (Mathematically, it can be shown that the rate per monetary unit of coverage is higher for underinsured properties than for otherwise identical properties that are fully insured.) This is because the insurer will charge the underinsured properties the same rate as properties that are insured to value are charged. A coinsurance penalty is an attempt by many insurers to mitigate the effect of this rate inadequacy.
Section 92

Basics of Classical Credibility, Bühlmann Credibility, and Bayesian Analysis of Credibility

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Source:

Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-92-1. You know the following information:

An actuary establishes a full credibility standard such that it is desired that the observed value be within ± 2% of the true value 85% of the time.

Claim occurrence follows a Poisson distribution, all exposures are homogeneous, and no variation exists in the claim costs.

Based on 346 claims, the observed pure premium is $533.

The complement of credibility - based on data external to the situation - is $316 for pure premium.

What is the number of claims needed to attain full credibility?

Use the Normal Distribution Table in the set of Exam 4 / C Tables as necessary.
**Solution S5-92-1.** We use the formula $E(Y) = \left(\frac{zp}{2}/k\right)^2$. Here, $k = 0.02$, and $p = 1 - 0.85 = 0.15$, meaning that $p/2 = 0.075$. Thus, $E(Y) = \left(\frac{z_{0.075}}{0.02}\right)^2$. We find $z_{0.075}$ using the Normal Distribution Table. This is the $z$ value for which the entry in the table is closest to $1 - 0.075 = 0.925$. The closest value to this is $1.44$ (with standard normal cumulative distribution function $\Phi(z) = 0.9251$). Thus,

$$E(Y) = \left(\frac{1.44}{0.02}\right)^2 = 5184$$

**claims needed for full credibility.**

**Problem S5-92-2.** You know the following information:

An actuary establishes a full credibility standard such that it is desired that the observed value be within ± 2% of the true value 85% of the time.

Claim occurrence follows a Poisson distribution, all exposures are homogeneous, and no variation exists in the claim costs.

Based on 346 claims, the observed pure premium is $533.

The complement of credibility - based on data external to the situation - is $316 for pure premium.

What is the credibility-weighted pure premium, according to classical (limited fluctuation) credibility theory?

**Solution S5-92-2.** To find the credibility of the observed data, we use the square root rule, where

$$Z = \text{Credibility} = \sqrt{\frac{\text{Number of claims observed}}{\text{Full credibility standard}}} = \sqrt{\frac{346}{5184}} = 0.2583482672.$$ 

Thus, we can apply the formula

$$(\text{Credibility-weighted pure premium}) = Z \times (\text{Observed Pure Premium}) + (1-Z) \times (\text{Complement of Credibility}) = 0.2583482672 \times 533 + (1-0.2583482672) \times 316 = 372.061574 = \$372.06.$$ 

**Problem S5-92-3.** You know the following information:

Based on 260 claims, the observed pure premium is $376.

The prior mean pure premium estimated by the actuary is $400.

The expected value of the process variance (EVPV) is 146.

The variance of the hypothetical means (VHM) is 3.

What is the credibility-weighted pure premium, according to Bühlmann (least squares) credibility theory?
Solution S5-92-3.

First, we find Bühlmann's $K = \frac{\text{EVPV}}{\text{VHM}} = \frac{146}{3} = 48.6666667$.

To find the credibility of the data, we use the formula $Z = \frac{N}{N + K}$, where $N$ is the number of observations (here, 260):

$Z = \frac{260}{260 + 48.6666667} = 0.8423326134$.

Thus, we can apply the formula

$\text{(Credibility-weighted pure premium)} = Z \times \text{Observed Pure Premium} + (1-Z) \times \text{Complement of Credibility} = 0.8423326134 \times 376 + (1-0.8423326134) \times 400 = 379.7840173 = $379.78.

Problem S5-92-4. Which of the following statements are true regarding the Bühlmann credibility formula? More than one answer may be correct.

(a) It is assumed that the risk process and risk parameters do not shift over time.
(b) There is a number of observations that can result in full credibility being granted to the observed data.
(c) It is assumed that as the number of observations $N$ increases, the variance of hypothetical means (VHM) of the sum of these observations also increases.
(d) It is assumed that as the number of observations $N$ increases, the variance of expected value of the process variance (EVPV) of the sum of these observations decreases.
(e) The major challenge of the Bühlmann approach is the determination of EVPV and VHM.
(f) The major challenge of the Bühlmann approach is the determination of the complement of credibility.
(g) The "square root rule" applies to Bühlmann credibility.

Solution S5-92-4. This question is based on the discussion by Werner and Modlin, pp. 213-219.

The following answers are correct:

(a) It is assumed that the risk process and risk parameters do not shift over time.
(c) It is assumed that as the number of observations $N$ increases, the variance of hypothetical means (VHM) of the sum of these observations also increases.
(e) The major challenge of the Bühlmann approach is the determination of EVPV and VHM.

Choice (f) cannot be correct if choice (e) is correct. Choices (b) and (g) apply to classical credibility but not to Bühlmann credibility. Choice (d) is incorrect: it is assumed that as the number of observations $N$ increases, the variance of expected value of the process variance (EVPV) of the sum of these observations increases.

Problem S5-92-5. Which of the following statements about Bayesian analysis of credibility are true? More than one answer may be correct.
(a) Bayesian analysis is typically more complex to apply in practice than classical credibility analysis.

(b) Like classical credibility and Bühlmann credibility, Bayesian analysis of credibility requires a calculation of a credibility factor $Z$, which is then applied to the observed value of the quantity in question.

(c) In Bayesian analysis, a crucial assumption is that the prior estimate of the quantity in question remains constant.

(d) In Bayesian analysis, the prior estimate of the quantity in question changes to reflect new information.

(e) In Bayesian analysis, new information is added to the prior estimate via further observations of empirical data, beyond the observed data originally given.

(f) In Bayesian analysis, new information is added to the prior estimate via Bayes's Theorem.

(g) The Bühlmann credibility estimate corresponds to the weighted least-squares line associated with the Bayesian estimate.

**Solution S5-92-5.** This question is based on the discussion of Bayesian analysis by Werner and Modlin, p. 220.

The following answers are correct:

(a) Bayesian analysis is typically more complex to apply in practice than classical credibility analysis.

(d) In Bayesian analysis, the prior estimate of the quantity in question changes to reflect new information.

(f) In Bayesian analysis, new information is added to the prior estimate via Bayes's Theorem.

(g) The Bühlmann credibility estimate corresponds to the weighted least-squares line associated with the Bayesian estimate.

Choice (b) is not correct; Bayesian analysis does not require an explicit calculation of $Z$; rather, the prior estimate is adjusted according to new information via the use of Bayes's theorem. This means that choice (c) is also not correct, as the whole point of Bayesian analysis is to adjust the prior estimate. Choice (e) is not correct; Bayes's theorem does not depend on the injection of new empirical data in order to be applied to existing data.
Section 93

Methods for Determining Complements of Credibility

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Source:

Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-93-1. The following characteristics of a desirable complement of credibility are mentioned by Werner and Modlin, p. 232:
1. Accuracy;
2. Lack of bias;
3. Statistical independence from the base statistic;
4. Availability;
5. Ease of computation;
6. Logical relationship to the base statistic.

In each of the following scenarios, one of the above qualities is absent. Identify the quality that is clearly missing.
(a) The experience to which the credibility factor Z is being applied constitutes 60% of the experience considered in the complement of credibility.
(b) The complement of credibility is consistently close to the observed experience to which the
(c) Experience from aviation insurance is used to develop a complement of credibility to experience from private passenger automobile insurance.
(d) The expected value of the complement of credibility is the expected value of the observed experience to which the credibility factor \( Z \) is being applied, but there is a large variance to the data pertaining to the complement of credibility.
(e) The calculation of the complement of credibility requires extremely complex formulas that have been developed internally to an insurance company, are deemed by the company to be proprietary and confidential, and are only permitted to be used by one highly trained actuary/statistician.
(f) A complement of credibility is used to evaluate loss data for homeowners’ insurance. The data pertaining to the complement of credibility apply to an exotic class of insurance for which no losses occur during most years, and for which loss data are irregularly compiled and inadequately retained.

**Solution S5-93-1.**

Scenario (a) is an instance of the absence of characteristic 3. Statistical independence from the base statistic.

Scenario (b) is an instance of the absence of characteristic 2. Lack of bias.

Scenario (c) is an instance of the absence of characteristic 6. Logical relationship to the base statistic.

Scenario (d) is an instance of the absence of characteristic 1. Accuracy.

Scenario (e) is an instance of the absence of characteristic 5. Ease of computation and possibly of characteristic 4. Availability, particularly with regard to parties external to the company.

Scenario (f) is an instance of the absence of characteristic 4. Availability.

**Problem S5-93-2.** Actuaries sometimes use the experience of a larger group (here, \( X \)) that includes the group being considered (here, \( Y \)) to develop a complement of credibility to the experience of \( Y \).

(a) Briefly describe two advantages of this approach.

(b) Briefly describe two problems that might arise with this approach.

**Solution S5-93-2.** This problem is based on the discussion by Werner and Modlin, p. 222-223.

(a) The following are some advantages of this approach:

1. The experience of \( X \) is likely to have a lower process variance than the experience of \( Y \).
2. Data for X will typically be readily available, if data for Y is available.

3. There is, in most cases, a logical relationship between the data for Y and the data for X.

4. A complement of credibility based on X will typically be easy to compute.

5. The problem of the dependence of the experience of X on the experience of Y might be addressed by considering only the experience in X except the experience of Y in developing the complement of credibility; this is only possible if Y does not constitute a major fraction of X.

Any two of the above suffice as answers. Other valid answers may be possible.

(b) The following are some problems that might arise with this approach:

1. The experience of X is likely to be a biased estimator of the experience of Y.

2. If the experience of Y comprises a large fraction of the experience of X, then X would not be statistically independent from Y.

Other valid answers may be possible.

Problem S5-93-3. To find a complement of credibility to the loss cost experience of a particular group (here, A), an actuary can use the loss costs of a larger related group (here, B) (call this Approach 2) instead of using the loss costs of a larger group that includes the group being rated (here, C) (call this Approach 1).

(a) What is a major advantage of Approach 2 over Approach 1?

(b) What is a major weakness of Approach 2? How might that weakness be mitigated?

Solution S5-93-3. This problem is based on the discussion by Werner and Modlin, p. 223-224.

(a) Since, unlike C, B does not include A, the experience of C is most likely independent from the experience of A. Approach 2 is thus more likely than Approach 1 to produce a complement of credibility that is independent to the data to which the credibility factor (Z) is being applied.

(b) A major weakness of Approach 2 is that the complement of credibility is likely to be biased. The bias arises in that the experience of B is likely to consistently diverge from the experience of A in some way. To mitigate this bias, it might be possible to adjust the experience of B to match the exposure to loss in group A. This would require a comparison of exposures between group A and group B.

Problem S5-93-4. To find a complement of credibility to the loss cost experience of a particular group (here, A), an actuary can use the loss costs of a larger related group (here, B). Consider a situation in which the actuary uses an indicated rate change for B and applies it to present rates. It is known that the current loss cost of group A is $360, the current average loss cost of group B
is $376, and the indicated loss cost for group B is $463. What should be the complement of credibility using this approach?

**Solution S5-93-4.** This problem is based on the discussion by Werner and Modlin, p. 224. We use the formula

\[ C = \text{(Current Loss Cost of Subject Experience)} \times \frac{\text{(Larger Group Indicated Loss Cost)}}{\text{(Larger Group Current Average Loss Cost)}} \]

\[ = 360 \times \frac{463}{376} = 443.2978723 = C = $443.30. \]

**Problem S5-93-5.**

(a) In what kinds of situations is Harwayne's Method for determining a complement of credibility most often used?

(b) What are two possible disadvantages of Harwayne's Method?

**Solution S5-93-5.** This problem is based on the discussion by Werner and Modlin, p. 225-226.

(a) Harwayne's Method is most often used when the subject experience (to which the credibility factor Z is being applied) has a significantly different distribution from that of the related experience (which is used for determining the complement of credibility).

(b) Two possible disadvantages of Harwayne's Method are that (1) the necessary computations can be complicated and time-consuming and (2) it may be more difficult to explain the relationship of the complement of credibility to the subject experience, as a result of the computational complexity.

Quantitative applications of Harwayne's Method will be covered in Section 94 of the study guide.
Section 94

Methods for Finding Complements of Credibility: Harwayne's Method and the Use of Competitors' Rates

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Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-94-1. You are given the following information:

There are three classes used for rating: X, Y, and Z.
There are three states: J, K, and L.

In State J:
There are 420 exposures for class X, and the pure premium for class X is $333.
There are 550 exposures for class Y, and the pure premium for class Y is $215.
There are 150 exposures for class Z, and the pure premium for class Z is $761.

In State K:
There are 120 exposures for class X, and the pure premium for class X is $412.
There are 163 exposures for class Y, and the pure premium for class Y is $125.
There are 600 exposures for class Z, and the pure premium for class Z is $800.

In State L:
There are 636 exposures for class X, and the pure premium for class X is $312.
There are 642 exposures for class Y, and the pure premium for class Y is $200.
There are 120 exposures for class Z, and the pure premium for class Z is $620.
Apply the first steps of Harwayne's method for finding the complement of credibility for the experience of class X of State J as follows:

(a) Find the average pure premium for State J.
(b) Find the average pure premium for State K, based on the exposure distribution for State J.
(c) Find the average pure premium for State L, based on the exposure distribution for State J.

Solution S5-94-1.

(a) The average pure premium for State J is the exposure-weighted average of the pure premiums by class: \( \frac{420 \times 333 + 550 \times 215 + 150 \times 761}{420 + 550 + 150} = 332.375 = \$332.38. \)
(b) We retain the exposure weights from State J but apply them to State K pure premium data: \( \frac{420 \times 412 + 550 \times 125 + 150 \times 800}{420 + 550 + 150} = 323.0267857 = \$323.07. \)
(c) We retain the exposure weights from State J but apply them to State L pure premium data: \( \frac{420 \times 312 + 550 \times 200 + 150 \times 620}{420 + 550 + 150} = \$298.25. \)

Problem S5-94-2. You are given the following information:

There are three classes used for rating: X, Y, and Z.
There are three states: J, K, and L.

In State J:
There are 420 exposures for class X, and the pure premium for class X is $333.
There are 550 exposures for class Y, and the pure premium for class Y is $215.
There are 150 exposures for class Z, and the pure premium for class Z is $761.

In State K:
There are 120 exposures for class X, and the pure premium for class X is $412.
There are 163 exposures for class Y, and the pure premium for class Y is $125.
There are 600 exposures for class Z, and the pure premium for class Z is $800.

In State L:
There are 636 exposures for class X, and the pure premium for class X is $312.
There are 642 exposures for class Y, and the pure premium for class Y is $200.
There are 120 exposures for class Z, and the pure premium for class Z is $620.

Continue the application of Harwayne's method for finding the complement of credibility for the experience of class X of State J as follows:

(a) Develop an adjustment factor \( F_K \) for the experience from State K.
(b) Develop an adjustment factor \( F_L \) for the experience from State L.

Solution S5-94-2.

(a) We find \( F_K \) by dividing the average pure premium for State J by the average pure premium for State K, based on the exposure distribution for State J. We found the former figure to be
332.375 in Solution S5-94-1(a), and we found the latter figure to be 323.0267857 in Solution S5-94-1(b). Thus, $F_K = 332.375/323.0267857 = 1.02893944$.

(b) We find $F_L$ by dividing the average pure premium for State J by the average pure premium for State L, based on the exposure distribution for State J. We found the former figure to be 332.375 in Solution S5-94-1(a), and we found the latter figure to be 298.25 in Solution S5-94-1(c). Thus, $F_L = 332.375/298.25 = 1.114417435$.

**Problem S5-94-3.** You are given the following information:

There are three classes used for rating: X, Y, and Z. 
There are three states: J, K, and L.

**In State J:**
There are 420 exposures for class X, and the pure premium for class X is $333.
There are 550 exposures for class Y, and the pure premium for class Y is $215.
There are 150 exposures for class Z, and the pure premium for class Z is $761.

**In State K:**
There are 120 exposures for class X, and the pure premium for class X is $412.
There are 163 exposures for class Y, and the pure premium for class Y is $125.
There are 600 exposures for class Z, and the pure premium for class Z is $800.

**In State L:**
There are 636 exposures for class X, and the pure premium for class X is $312.
There are 642 exposures for class Y, and the pure premium for class Y is $200.
There are 120 exposures for class Z, and the pure premium for class Z is $620.

Continue the application of Harwayne's method for finding the complement of credibility for the experience of class X of State J as follows:

(a) Find the adjusted pure premium for class X of State K, based on the adjustment factor $F_K$, which adjusts for differences in experience from State J.

(b) Find the adjusted pure premium for class X of State L, based on the adjustment factor $F_L$, which adjusts for differences in experience from State J.

**Solution S5-94-3.**

(a) From Solution S5-94-2(a), $F_K = 1.02893944$. For class X in State K, the pure premium is $412. The adjusted pure premium is thus $412 \times 1.02893944 = 423.9230493 = 423.92$.

(b) From Solution S5-94-2(b), $F_L = 1.114417435$. For class X in State L, the pure premium is $412. The adjusted pure premium is thus $412 \times 1.114417435 = 347.6982397 = 347.70$.

**Problem S5-94-4.** You are given the following information:
There are three classes used for rating: X, Y, and Z. There are three states: J, K, and L.

**In State J:**
There are 420 exposures for class X, and the pure premium for class X is $333. There are 550 exposures for class Y, and the pure premium for class Y is $215. There are 150 exposures for class Z, and the pure premium for class Z is $761.

**In State K:**
There are 120 exposures for class X, and the pure premium for class X is $412. There are 163 exposures for class Y, and the pure premium for class Y is $125. There are 600 exposures for class Z, and the pure premium for class Z is $800.

**In State L:**
There are 636 exposures for class X, and the pure premium for class X is $312. There are 642 exposures for class Y, and the pure premium for class Y is $200. There are 120 exposures for class Z, and the pure premium for class Z is $620.

Complete the application of Harwayne's method for finding the complement of credibility for the experience of class X of State J by developing a combined adjusted pure premium for State K and State L, weighted by the class X exposures in each state. This will be the complement of credibility in this situation.

**Solution S5-94-4.** In State K, there are 120 exposures in class X, and, according to Solution S5-94-3(a), the adjusted pure premium is 423.9230493. In State L, there are 636 exposures in class X, and, according to Solution S5-94-3(b), the adjusted pure premium is 347.6982397. Thus, the exposure-weighted adjusted pure premium that will serve as the complement of credibility is

$$(120 \times 423.9230493 + 636 \times 347.6982397)/(120 + 636) = 359.7974158 = \$359.80.$$

**Problem S5-94-5.** Some insurers use complements of credibility based on competitors' rates.

(a) Briefly discuss two likely advantages of this approach.

(b) Briefly discuss two likely disadvantages of this approach.

**Solution S5-94-5.** This question is based on the discussion in Werner and Modlin, pp. 227-228.

(a) The following are some possible advantages of this approach:

1. Competitors' rates are likely to produce a complement of credibility that is independent of the subject experience analyzed by the company.

2. If the competitors have more exposures than a small and/or new insurer that is using this method, then the complement of credibility is likely to have less process error.

3. The calculations for this approach are often straightforward.
4. This approach is relatively easy communicate with regard to the complement of credibility having a logical relationship to the subject experience.

Any two of the above suffice as an answer. Other valid answers may be possible.

(b) The following are some possible disadvantages of this approach:

1. Competitors' rates may reflect marketing considerations and/or regulatory constraints that are specific to the competitors and may not apply to the company that is using the competitors' data. This may reduce the accuracy of the complement of credibility.

2. Competitors may have different underwriting and claim practices than the company that is using the competitors' data. This may introduce bias to the complement of credibility.

3. Data from competitors may be time-consuming and difficult to obtain.

Any two of the above suffice as an answer. Other valid answers may be possible.
Section 95

Using Trended Present Rates in Finding the Complement of Credibility, Statistical Methods in Multivariate Classification Analysis, and the Challenges of Excess Insurance Ratemaking

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Some of the questions here ask for short written answers based on the reading. This is meant to give the student practice in answering questions of the format that will appear on Exam 5. Students are encouraged to type their own answers first and then to compare these answers with the solutions given here. Please note that the solutions provided here are not necessarily the only possible ones.

The following formulas apply when using the method of *trended present rates* in determining a complement of credibility C:

**Formula 95.1:** $C$ for the rate = $(\text{Present Rate}) \times (\text{Trend}) \times (\text{Previously Indicated Loss Cost}) / (\text{Loss Cost Implemented with Last Review})$.

**Formula 95.2:** $C$ for the indicated rate change = $((\text{Loss Trend}) \times (1 + \text{Prior % Indication})) / ((\text{Premium Trend}) \times (1 + \text{Prior % Rate Change}))$.


**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-95-1.** An actuary is using the method of trended present rates to find a complement of credibility to the observed loss experience. The present rate for the insurance company in question is $146. The loss cost that was implemented with the last review one year ago was $120, based on an indication of $130. The annual trend by which the rate should be adjusted is 7%. What is the complement of credibility for the rate according to the method of trended present rates?
Solution S5-95-1. We use Formula 95.1: \( C = (\text{Present Rate}) \times (\text{Trend}) \times (\text{Previously Indicated Loss Cost}) / (\text{Loss Cost Implemented with Last Review}) = 146 \times 1.071 \times (130/120) = 169.2383333 = C = $169.24. \)

Problem S5-95-2. An actuary is using the method of trended present rates to find a complement of credibility to the observed loss experience. The last rate change by the company occurred 4.5 years ago, where the rates increased by +3%, based on an indication of +6%. The annual premium trend for the company is +5%, while the annual loss trend is +2%. Assume that a new review of the company's rates is being undertaken today, and the actuary wants to find a complement of credibility for the indicated rate change. What is the complement of credibility for the indicated rate change according to the method of trended present rates?

Solution S5-95-2. We use Formula 95.2: \( C = ((\text{Loss Trend}) \times (1 + \text{Prior % Indication})) / ((\text{Premium Trend}) \times (1 + \text{Prior % Rate Change})). \) Since 4.5 have elapsed, each annual trend should be taken to the power of 4.5: \( C = (1.02^{4.5} \times 1.06) / (1.05^{4.5} \times 1.03) = 0.9032699611 \) - i.e., a 9.67300389% decrease.

Problem S5-95-3.

(a) Name two advantages of the method of trended present rates for finding a complement of credibility.

(b) Name one possible disadvantage of the method of trended present rates for finding a complement of credibility.

Solution S5-95-3. This problem is based on the discussion by Werner and Modlin, p. 227.

(a) The following are advantages of this method:

1. The resulting complement is unbiased due to the unbiased nature of pure trended loss costs.
2. The data for this approach are readily available.
3. The calculations for this approach are straightforward.
4. This approach is relatively easy to communicate.

Any two of the above suffice as answers. Other valid answers may be possible.

(b) A disadvantage of this method might arise if there is overlap between the time periods for the subject experience and for the historical data used in developing the complement of credibility. This would lead rise to the problem of non-independence of the complement of credibility from the subject experience. Another possible disadvantage is that, if the historical data under consideration are sparse, the process variance of the historical loss costs might be too high, and the complement of credibility might not be accurate. Other valid answers may be possible.

Problem S5-95-4. Statistical methods are used with multivariate classification analysis to determine if the multivariate model developed is relevant to the data being analyzed.
(a) Name three kinds of statistical diagnostics that are used for this purpose.

(b) Are the results of multivariate classification analysis typically credibility-weighted with other actuarial estimates?

**Solution S5-95-4.** This question is based on the discussion by Werner and Modlin, p. 232.

(a) The following statistical diagnostics are often used with multivariate classification analysis:

1. Standard errors of the parameter estimates;
2. Standardized deviance tests (such as the Chi-Square test and the F-test);
3. Consistency of model results over time;
4. Diagnostics that identify the overall appropriateness of the model assumptions (such as deviance residual plots and leverage plots).

Any three of the above suffice as an answer. Other valid answers may be possible.

(b) The results of multivariate classification analysis are not typically credibility-weighted with other actuarial estimates, which tend to be univariate estimates and are thus are not likely to bring added accuracy to the results of a multivariate analysis.

**Problem S5-95-5.** Briefly describe three problems associated with developing a complement of credibility pertaining to ratemaking for excess insurance (i.e., insurance that only applies to excess layers, below which another insurance policy provides coverage).

**Solution S5-95-5.** This question is based on the discussion of excess ratemaking by Werner and Modlin, p. 228. The following are some frequent problems:

1. There are very few claims in the excess layers, so loss cost data for losses below the attachment point of the insurance would often need to be considered in developing a complement of credibility.

2. In some excess insurance lines, loss development might be especially slow. This is truest of excess liability insurance.

3. Loss experience when just the excess layers are considered is typically subject to different (mostly higher) inflation than total loss experience when total limits of coverage are considered.

Section 96 of the study guide will address some specific techniques for finding complements of credibility to use in excess ratemaking.
Section 96

Finding Complements of Credibility in Excess Insurance Ratemaking Using Increased Limit Factors, Lower Limits Analysis, and Limits Analysis

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Some of the questions here ask for short written answers based on the reading. This is meant to give the student practice in answering questions of the format that will appear on Exam 5. Students are encouraged to type their own answers first and then to compare these answers with the solutions given here. Please note that the solutions provided here are not necessarily the only possible ones.

The following formulas pertain to methods in excess insurance ratemaking for finding the complement of credibility $C$.

**Method of Increased Limit Factors**

*Formula 96.1:*

$$C = L^-A \times (IL_{A+L}/IL_A - 1)$$

**Meaning of Variables:**

$A$ = the attachment point of the excess insurance
$L$ = the limit of liability of the excess insurance
$IL_A$ = the increased limit factor associated with attachment point $A$
$IL_{A+L}$ = the increased limit factor associated with the sum of attachment point $A$ and the excess insurer's limit of liability $L$
$L^-A$ = The loss cost capped at the attachment point $A$.

**Method of Lower Limits Analysis**

*Formula 96.2:*

$$C = L^-d \times (IL_{A+L} - IL_A)/IL_d$$
Meaning of Variables:

A = the attachment point of the excess insurance
L = the limit of liability of the excess insurance
d = A lower limit than the attachment point
L\_d = The loss cost capped at the limit d
ILF\_d = the increased limit factor associated with the lower limit d
ILF\_A = the increased limit factor associated with attachment point A
ILF\_{A+L} = the increased limit factor associated with the sum of attachment point A and the excess insurer's limit of liability L

Method of Limits Analysis

Formula 96.3:
\[ C = (LR) \sum_{d \geq A} (P_d \cdot (ILF_{\min(d, A+L)} - ILF_A) / ILF_d) \]

Meaning of Variables:

A = the attachment point of the excess insurance
L = the limit of liability of the excess insurance
d = A higher limit than the attachment point
LR = Total loss ratio
P\_d = Total premium for policies with limit d
ILF\_d = the increased limit factor associated with the lower limit d
ILF\_{A+L} = the increased limit factor associated with the sum of attachment point A and the excess insurer's limit of liability L
ILF_{\min(d, A+L)} = the smaller of ILF\_d and ILF\_{A+L}.

Source:

Original Problems and Solutions from The Actuary's Free Study Guide

**Problem S5-96-1.** An excess insurance policy has an attachment point of $200,000, and the excess insurer's limit of liability under the policy is $100,000. It is known that the loss cost for losses capped at $200,000 is $136. The increased limit factor associated with a ground-up limit of $200,000 is 1.34. The increased limit factor associated with a ground-up limit of $300,000 is 1.59. An actuary seeks to develop a complement of credibility for data pertaining to the excess insurance policy. Find this complement of credibility using the method of increased limit factors.

**Solution S5-96-1.** We apply Formula 96.1: 
\[ C = L^- A \cdot \sum (P_d \cdot (ILF_{A+L} / ILF_A - 1)) \]
Here, A = 200000, L = 100000, so A + L = 300000. L\_A = L\_200000 = 136, and ILF\_A = ILF\_200000 = 1.34, while ILF\_{A+L} = ILF\_300000 = 1.59. Our answer is thus 136*(1.59/1.34 - 1) = 25.37313433 = C = $25.37.

**Problem S5-96-2.** An excess insurance policy has an attachment point of $200,000, and the excess insurer's limit of liability under the policy is $100,000. It is known that the loss cost for
losses capped at $50,000 is $86. The increased limit factor associated with a ground-up limit of $50,000 is 1.02. The increased limit factor associated with a ground-up limit of $200,000 is 1.34. The increased limit factor associated with a ground-up limit of $300,000 is 1.59. An actuary seeks to develop a complement of credibility for data pertaining to the excess insurance policy. Find this complement of credibility using the method of lower limits analysis.

Solution S5-96-2. We apply Formula 96.2: $C = L_d^{-1} \frac{(ILF_{A+L} - ILF_A)}{ILF_d}$.
Here, $d = 50000$, $A = 200000$, $L = 100000$, so $A + L = 300000$. $L_A = L_{200000} = 136$, while $ILF_{A+L} = ILF_{300000} = 1.59$. $L_d = L_{50000} = 86$, and $ILF_d = ILF_{50000} = 1.02$. Our answer is thus $86 \times (1.59 - 1.34)/1.02 = 21.07843137 = C = 21.08$.

Problem S5-96-3. An excess insurance policy has an attachment point of $200,000$, and the excess insurer's limit of liability under the policy is $100,000$. Ground-up insurance data is available for policies with limits of $50,000$, $150,000$, $200,000$, $250,000$, $300,000$, and $700,000$.

The loss ratio pertaining to this data is uniformly 80%.

The total premium associated with policies with $50,000$ limits is $1,230,132$.
The total premium associated with policies with $150,000$ limits is $2,888,120$.
The total premium associated with policies with $200,000$ limits is $1,348,102$.
The total premium associated with policies with $250,000$ limits is $1,366,776$.
The total premium associated with policies with $300,000$ limits is $902,319$.
The total premium associated with policies with $700,000$ limits is $120,211$.

You also know all the increased limit factors (ILFs) for each limit:

The ILF for $50,000$ is 1.00.
The ILF for $150,000$ is 1.85.
The ILF for $200,000$ is 2.03.
The ILF for $250,000$ is 2.43.
The ILF for $300,000$ is 2.76.
The ILF for $700,000$ is 3.66.

An actuary is using data about loss amounts from the layer between $200,000$ and $300,000$ to develop a complement of credibility to the excess insurance data. The method of limits analysis is being used.

(a) For policies with limits of $50,000$, what is the percentage of losses in the desired layer?
(b) For policies with limits of $150,000$, what is the percentage of losses in the desired layer?
(c) For policies with limits of $200,000$, what is the percentage of losses in the desired layer?
(d) For policies with limits of $250,000$, what is the percentage of losses in the desired layer?
(e) For policies with limits of $300,000, what is the percentage of losses in the desired layer?

(f) For policies with limits of $700,000, what is the percentage of losses in the desired layer?

Solution S5-96-3.

(a) Policies with limits of $50,000 cannot have losses in the layer between $200,000 and $300,000, since those losses exceed the policy limits. Thus, the percentage of losses for those policies that are within the layer is 0%.

(b) Policies with limits of $150,000 cannot have losses in the layer between $200,000 and $300,000, since those losses exceed the policy limits. Thus, the percentage of losses for those policies that are within the layer is 0%.

(c) Here, \( d = 200,000 = A = 200,000 \), so our percentage, based on Formula 96.3, is

\[
\frac{\text{ILF}_{\text{min}(d, A+L)} - \text{ILF}_A}{\text{ILF}_d} = \frac{\text{ILF}_d - \text{ILF}_A}{\text{ILF}_d} = \frac{0}{0} = 0\%.
\]

(d) Here, \( d = 250,000 > A = 200,000 \), so our percentage, based on Formula 96.3, is

\[
\frac{\text{ILF}_{\text{min}(d, A+L)} - \text{ILF}_A}{\text{ILF}_d} = \frac{(2.43 - 2.03)\%}{2.43\%} = 0.1646090535 = 16.46090535\%.
\]

(e) Here, \( d = 300,000 = A + L = 300,000 \), so our percentage, based on Formula 96.3, is

\[
\frac{\text{ILF}_{\text{min}(d, A+L)} - \text{ILF}_A}{\text{ILF}_d} = \frac{(2.76 - 2.03)\%}{2.76\%} = 0.2644927536 = 26.44927536\%.
\]

(f) Here, \( d = 700,000 > A + L = 300,000 \), so our percentage, based on Formula 96.3, is

\[
\frac{\text{ILF}_{\text{min}(d, A+L)} - \text{ILF}_A}{\text{ILF}_d} = \frac{(2.76 - 2.03)\%}{3.66\%} = 0.1994535519 = 19.94535519\%.
\]

Problem S5-96-4. An excess insurance policy has an attachment point of $200,000, and the excess insurer's limit of liability under the policy is $100,000. Ground-up insurance data is available for policies with limits of $50,000, $150,000, $200,000, $250,000, $300,000, and $700,000.

The loss ratio pertaining to this data is uniformly 80%.

The total premium associated with policies with $50,000 limits is $1,230,132.
The total premium associated with policies with $150,000 limits is $2,888,120.
The total premium associated with policies with $200,000 limits is $1,348,102.
The total premium associated with policies with $250,000 limits is $1,366,776.
The total premium associated with policies with $300,000 limits is $902,319.
The total premium associated with policies with $700,000 limits is $120,211.

You also know all the increased limit factors (ILFs) for each limit:
The ILF for $50,000 is 1.00.
The ILF for $150,000 is 1.85.
The ILF for $200,000 is 2.03.
The ILF for $250,000 is 2.43.
The ILF for $300,000 is 2.76.
The ILF for $700,000 is 3.66.

An actuary is using data about loss amounts from the layer between $200,000 and $300,000 to develop a complement of credibility to the excess insurance data. The method of limits analysis is being used.

(a) What is the magnitude of the expected loss, associated with policies with $250,000 limits, that will be in the desired layer?

(b) What is the magnitude of the expected loss, associated with policies with $300,000 limits, that will be in the desired layer?

(c) What is the magnitude of the expected loss, associated with policies with $700,000 limits, that will be in the desired layer?

Solution S5-96-4. In Solution S5-96-3, we calculated each of the \((\text{ILF}_{\text{min}(d, A+L)} - \text{ILF}_A)/\text{ILF}_d)\) components in Formula 96.3, as applicable to this situation. This problem asks us to calculate the \(\text{LR} \cdot \text{P}_d \cdot (\text{ILF}_{\text{min}(d, A+L)} - \text{ILF}_A)/\text{ILF}_d\) component for each policy limit amount. To do this, we multiply the corresponding percentage obtained in Solution S5-96-3 by the loss ratio of 0.8 and the total premium for the policies with the limits in question.

(a) The portion of losses in the desired layer from policies with $250,000 limits is 0.1646090535. The total premium associated with all policies with such limits is $1,366,776. Thus, the expected loss that will be in the desired layer is \(0.8 \times 1366776 \times 0.1646090535 = 179986.96\) = $179,986.96.

(b) The portion of losses in the desired layer from policies with $300,000 limits is 0.2644927536. The total premium associated with all policies with such limits is $902,319. Thus, the expected loss that will be in the desired layer is \(0.8 \times 902319 \times 0.2644927536 = 190925.47\) = $190,925.47.

(c) The portion of losses in the desired layer from policies with $700,000 limits is 0.1994535519. The total premium associated with all policies with such limits is $120,211. Thus, the expected loss that will be in the desired layer is \(0.8 \times 120211 \times 0.1994535519 = 19181.21\) = $19,181.21.

Problem S5-96-5. An excess insurance policy has an attachment point of $200,000, and the excess insurer's limit of liability under the policy is $100,000. Ground-up insurance data is available for policies with limits of $50,000, $150,000, $200,000, $250,000, $300,000, and $700,000.

The loss ratio pertaining to this data is uniformly 80%.
The total premium associated with policies with $50,000 limits is $1,230,132.
The total premium associated with policies with $150,000 limits is $2,888,120.
The total premium associated with policies with $200,000 limits is $1,348,102.
The total premium associated with policies with $250,000 limits is $1,366,776.
The total premium associated with policies with $300,000 limits is $902,319.
The total premium associated with policies with $700,000 limits is $120,211.

You also know all the increased limit factors (ILFs) for each limit:

- The ILF for $50,000 is 1.00.
- The ILF for $150,000 is 1.85.
- The ILF for $200,000 is 2.03.
- The ILF for $250,000 is 2.43.
- The ILF for $300,000 is 2.76.
- The ILF for $700,000 is 3.66.

An actuary is using data about loss amounts from the layer between $200,000 and $300,000 to
develop a complement of credibility to the excess insurance data. The method of limits analysis
is being used. What is the complement of credibility using this method?

**Solution S5-96-5.** We apply Formula 96.3:

\[ C = (LR) \sum_{d \geq A} (P_d \cdot (\text{ILF}_{\text{min}(d, A+L)} - \text{ILF}_A) / \text{ILF}_d). \]

In Solution S5-96-4, we found each of the individual components \(P_d \cdot LR \cdot (\text{ILF}_{\text{min}(d, A+L)} - \text{ILF}_A) / \text{ILF}_d\) of this summation. These components are 179986.963, 190925.4695, and
19181.20874. Their sum is 390093.6142 = \(C = \$390,093.61\). Note that this is the complement of
credibility for total losses.
Section 97


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The following formulas pertain to methods in excess insurance ratemaking for finding the complement of credibility, C.

**Method of Fitted Curves**

Let $f(x)$ be the probability density function of a continuous distribution of losses which is fitted to the observed loss experience.

**Formula 97.1**

$$\text{% of Losses in Layer (A, A + L) = (}_A^{A+L}(x*f(x)*dx) + _{A+L}^{\infty}(A+L)*f(x)*dx)/(_{-\infty}^{\infty}x*f(x)*dx)$$

Note that $(\int_{-\infty}^{\infty}x*f(x)*dx)$ is the expected value of the distribution with density function $f(x)$.


**Original Problems and Solutions from The Actuary’s Free Study Guide**

**Problem S5-97-1.** An excess insurance policy has an attachment point of $200,000, and the excess insurer’s limit of liability under the policy is $100,000. Ground-up insurance data is
available for losses; the data are fitted to an exponential distribution with mean $60,000. Total losses are $5,310,013. From that distribution, what is the percentage of expected losses that are in the layer from $200,000 to $300,000?

**Relevant property of exponential distributions:** \( f(x) = \frac{1}{\theta}e^{-x/\theta} \), where \( \theta \) is the mean of the distribution.

**Solution S5-97-1.** We use Formula 97.1:

\[
\% \text{ of Losses in Layer } (A, A + L) = \left( \int_{A}^{A+L} x f(x) \, dx + \int_{A+L}^{\infty} (A+L) f(x) \, dx \right) / \left( \int_{-\infty}^{\infty} x f(x) \, dx \right).
\]

Here, \( A = \$200,000 \), and \( L = \$100,000 \). Moreover, \( f(x) = (1/60000)e^{-x/60000} \), where \( \int_{-\infty}^{\infty} x f(x) \, dx = 60000 \) is the mean of the exponential distribution.

We find the numerator of the formula:

\[
\left( \int_{200000}^{300000} x e^{-x/60000} \, dx + \int_{300000}^{\infty} (300000) e^{-x/60000} \, dx \right).
\]

We find \( \int_{300000}^{\infty} (300000) e^{-x/60000} \, dx = 300000 e^{-5} \).

We find \( \int_{200000}^{300000} x e^{-x/60000} \, dx \) using the **Tabular Method of Integration by Parts**:

<table>
<thead>
<tr>
<th>Signs</th>
<th>u</th>
<th>dv</th>
</tr>
</thead>
<tbody>
<tr>
<td>+.....</td>
<td>x</td>
<td>(1/60000) e^{-x/60000}</td>
</tr>
<tr>
<td>-.....</td>
<td>1</td>
<td>-e^{-x/60000}</td>
</tr>
<tr>
<td>+.....</td>
<td>0</td>
<td>60000 e^{-x/60000}</td>
</tr>
</tbody>
</table>

Thus:

\[
\left( xe^{-x/60000} - 60000 e^{-x/60000} \right) \Bigg|_{200000}^{300000} = -300000 e^{-5} - 600000 e^{-5} + 2000000 e^{-10/3} + 60000 e^{-10/3} = 2600000 e^{-10/3} - 360000 e^{-5}.
\]

The sum of the two integrals we found is \( 300000 e^{-5} + 2600000 e^{-10/3} - 360000 e^{-5} = 2600000 e^{-10/3} - 60000 e^{-5} = 8870.96145 \).

The percentage of the losses in the layer (200000, 300000) is thus \( 8870.96145/60000 = 0.1478493575% \).

**Problem S5-97-2.** An excess insurance policy has an attachment point of $200,000, and the excess insurer's limit of liability under the policy is $100,000. Ground-up insurance data is available for losses; the data are fitted to an exponential distribution with mean $60,000. Total losses are $5,310,013. From that distribution, what is the magnitude of expected losses that are in the layer from $200,000 to $300,000?
Solution S5-97-2. The magnitude of expected losses in the layer from $200,000 to $300,000 is equal to the total losses multiplied by the percentage of losses in that layer (which we found to be 14.78493575% in Solution S5-97-1): 5310013*0.1478493575 = 785082.0104 = $785,082.01. This would be our complement of credibility to the observed total loss data pertaining to the excess insurance policies in question.

Problem S5-97-3. Consider the following four approaches to finding complements of credibility in excess insurance ratemaking (the first three of which were discussed in Section 96):

1. The method of increased limit factors;
2. The method of lower limits analysis;
3. The method of limits analysis;
4. The method of fitted curves.

(a) Which of these methods typically requires the most computational complexity?

(b) Which of these methods typically produces a complement of credibility which is the most logically related to the excess layer data being analyzed?

(c) Which of these approaches requires the assumption that the loss ratio does not vary by the limit of insurance chosen?

(d) Which of these approaches is most biased toward losses that occur in smaller ground-up amounts than would be applicable to the excess insurance policy under consideration?

(e) Which of these approaches requires data that have not been truncated below the attachment point of the excess insurance?

(f) Which of these approaches is typically used by reinsurers who do not have access to an insurer's full loss distribution?

Solution S5-97-3. This question is based on the evaluation of the four methods by Werner and Modlin, pp. 229-232.

(a) The method of fitted curves typically requires the most computational complexity.
(b) The method of fitted curves typically produces a complement of credibility which is the most logically related to the excess layer data being analyzed.
(c) The method of limits analysis requires the assumption that the loss ratio does not vary by the limit of insurance chosen.
(d) The method of lower limits analysis is most biased toward losses that occur in smaller ground-up amounts than would be applicable to the excess insurance policy under consideration.
(e) The method of increased limit factors requires data that have not been truncated below the attachment point of the excess insurance.
(f) The method of limits analysis is typically used by reinsurers who do not have access to an insurer's full loss distribution.
Problem S5-97-4. Insurer Q is currently charging all insureds of Class X a premium of $361. The insurer is considering implementing a more refined classification system, which Class X being split into three subclasses: 1, 2, and 3.

There are currently 4126 risks of subclass 1, whose total projected losses and expenses are $1,320,320.
There are currently 8000 risks of subclass 2, whose total projected losses and expenses are $2,800,000.
There are currently 1333 risks of subclass 3, whose total projected losses and expenses are $533,200.

(a) What is the current percentage of profit the company is achieving on subclass 1?
(b) What is the current percentage of profit the company is achieving on subclass 2?
(c) What is the current percentage of profit the company is achieving on subclass 3?
(d) What is the current percentage of profit the company is achieving overall?

Solution S5-97-4.

(a) For subclass 1, per risk, the projected losses and expenses are $1,320,320/4126 = $320.

The current rate per risk is $361. The difference is the profit per risk: 361 - 320 = $41. As there are 4126 risks, this translates to a total profit of 41*4126 = $169,166. The total premium charged for this subclass is 361*4126 = $1,489,486, so the profit percentage is $169,166/$1,489,486 = 0.1135734072 = 11.35734072%.

(b) For subclass 2 per risk, the projected losses and expenses are $2,800,000/8000 = $350.

The current rate per risk is $361. The difference is the profit per risk: 361 - 350 = $11. As there are 8000 risks, this translates to a total profit of 11*8000 = $88,000. The total premium charged for this subclass is 361*8000 = $2,888,000, so the profit percentage is $88,000/$2,888,000 = 0.0304709141 = 3.04709141%.

(c) For subclass 3 per risk, the projected losses and expenses are $533,200/1333 = $400.

The current rate per risk is $361. The difference is the profit per risk: 361 - 400 = -$39. As there are 1333 risks, this translates to a total profit of -39*1333 = -$51,987, i.e., a loss. The total premium charged for this subclass is 361*1333 = $481,213, so the profit percentage is -51,987/481,213 = -0.108033241 = -10.8033241%.

(d) The overall profit percentage is the sum of the profits for each risk class, divided by the sum of total premiums charged to each risk class:

($169,166 + $88,000 - $51,987)/($1,489,486 + $2,888,000 + $481,213) = 0.0422292058 = 4.22292058%. 

Problem S5-97-5. Insurer Q is currently charging all insureds of Class X a premium of $361. The insurer is considering implementing a more refined classification system, which Class X being split into three subclasses: 1, 2, and 3.

There are currently 4126 risks of subclass 1, whose total projected losses and expenses are $1,320,320.
There are currently 8000 risks of subclass 2, whose total projected losses and expenses are $2,800,000.
There are currently 1333 risks of subclass 3, whose total projected losses and expenses are $533,200.

(a) The company wishes to change the overall premium charged to each subclass of risk so that it achieves the same profitability over each subclass and maintains the same historical percentage of profitability. What should be the premium charged per risk in each of the subclasses?

(b) Assume that this change results in a 20% increase in insureds of subclass 1, a 4% decrease in insureds of subclass 2, and a 15% decrease in insureds of subclass 3. What is the maximum transition cost the company could incur for this rating change while still at worst not losing any money on net from the change? (Assume that the risk-free interest rate is 0%, so the time value of money is not an issue.)

Solution S5-97-5.

(a) From Solution S5-97-4(d), the overall profit percentage is 4.22292058%. The rate charged to each subclass should be (Loss and Expense Cost)/(1- Profit Percentage).

For subclass 1, the rate charged should thus be $320/(1-0.0422292058) = 334.1091131 = $334.11.
For subclass 2, the rate charged should thus be $350/(1-0.0422292058) = 365.4318425 = $365.43.
For subclass 3, the rate charged should thus be $400/(1-0.0422292058) = 417.6363914 = $417.64.

(b) From Solution S5-97-4, the total profit currently being earned is ($169,166 + $88,000 - $51,987) = $205,179.

The new number of subclass 1 exposures will be 4126*1.20 = 4951.2, rounded down to 4951.
The new number of subclass 2 exposures will be 8000*(1-0.04) = 7680.
The new number of subclass 3 exposures will be 1333*(1-0.15) = 1133.05, rounded down to 1133.

The total premium collected will be 4951*334.11 + 7680*365.43 + 1133*417.64 = $4,933,867.13. Of that, 4.22292058% is profit, meaning that total profit will be $4,933,867.13*0.0422292058 = 208352.5612 = $208,352.56. For the company to at least break even, the maximum possible transition costs would be (Anticipated profit) - (Current profit) = $208,352.56 - $205,179 = 3173.561197 = $3173.56.
Section 98

Formulas for Competitive Comparisons and Measurements of Performance for Insurers

This section of the study guide is intended to provide practice problems and solutions to accompany the pages of Basic Ratemaking, cited below. Students are encouraged to read these pages before attempting the problems. This study guide is entirely an independent effort by Mr. Stolyarov and is not affiliated with any organization(s) to whose textbooks it refers, nor does it represent such organization(s).


Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-98-1. You know the following information:

Customer A is paying a premium of $231 for insurance with Company Q. If this customer were insured with Company Z, the customer's premium would be $413.

Customer B is paying a premium of $151 for insurance with Company Q. If this customer were insured with Company Z, the customer's premium would be $123.

Customer C is paying a premium of $135 for insurance with Company Q. If this customer were insured with Company Z, the customer's premium would be $323.

Customer D is paying a premium of $500 for insurance with Company Q. If this customer were insured with Company Z, the customer's premium would be $400.

Customer E is paying a premium of $240 for insurance with Company Q. If this customer were insured with Company Z, the customer's premium would be $200.

Assume that these are the only customers whose characteristics are used to compare competitive positions among insurers. From the standpoint of Company Q, what is the company's percent competitive position for each customer with respect to Company Z, in terms of premium? Assume, for the purposes of this problem, that a higher percent competitive position is more favorable to Company Q.

Solution S5-98-1. This question is based on the discussion in Werner and Modlin, p. 243. The lower Company Q's overall premium is relative to Company Z, the greater Company Q's competitive position. We have two choices for the formula for percent competitive position:
Choice a: \((\text{Competitor Premium})/(\text{Company Premium}) - 1\)
Choice b: \((\text{Company Premium})/(\text{Competitor Premium}) - 1\)

Since a higher percent is more favorable to Company Q, it would follow that Competitor Premium should be in the numerator. Thus, we select the formula in Choice a.

**Competitive position for Customer A:** \((\text{Competitor Premium})/(\text{Company Premium}) - 1 = \frac{413}{231} - 1 = 0.7878787878 = +78.7878787878\%\).

**Competitive position for Customer B:** \((\text{Competitor Premium})/(\text{Company Premium}) - 1 = \frac{123}{151} - 1 = -0.1854304636 = -18.54304636\%\).

**Competitive position for Customer C:** \((\text{Competitor Premium})/(\text{Company Premium}) - 1 = \frac{323}{135} - 1 = 1.392592593 = +139.2592593\%\).

**Competitive position for Customer D:** \((\text{Competitor Premium})/(\text{Company Premium}) - 1 = \frac{400}{500} - 1 = -0.2 = -20\%\).

**Competitive position for Customer E:** \((\text{Competitor Premium})/(\text{Company Premium}) - 1 = \frac{200}{240} - 1 = -0.166666667 = -16.666666667\%\).

**Problem S5-98-2.** You know the following information:

Customer A is paying a premium of $231 for insurance with Company Q. If this customer were insured with Company Z, the customer's premium would be $413.

Customer B is paying a premium of $151 for insurance with Company Q. If this customer were insured with Company Z, the customer's premium would be $123.

Customer C is paying a premium of $135 for insurance with Company Q. If this customer were insured with Company Z, the customer's premium would be $323.

Customer D is paying a premium of $500 for insurance with Company Q. If this customer were insured with Company Z, the customer's premium would be $400.

Customer E is paying a premium of $240 for insurance with Company Q. If this customer were insured with Company Z, the customer's premium would be $200.

Assume that these are the only customers whose characteristics are used to compare competitive positions among insurers. From the standpoint of Company Q, what is the company's overall percent competitive position with respect to Company Z, in terms of premium? Assume, for the purposes of this problem, that a higher percent competitive position is more favorable to Company Q.

**Solution S5-98-2.** As in Solution S5-98-1, we use the formula
(Competitor Premium)/(Company Premium) - 1. However, this time, we compare the overall premium that each company would charge to all of these five customers:

\[
\frac{413 + 123 + 323 + 400 + 500}{231 + 151 + 135 + 500 + 240} - 1 = 0.399363564 = +39.9363564\%.
\]

**Problem S5-98-3.** You know the following information:

Customer A is paying a premium of $231 for insurance with Company Q. If this customer were insured with Company Z, the customer's premium would be $413.

Customer B is paying a premium of $151 for insurance with Company Q. If this customer were insured with Company Z, the customer's premium would be $123.

Customer C is paying a premium of $135 for insurance with Company Q. If this customer were insured with Company Z, the customer's premium would be $323.

Customer D is paying a premium of $500 for insurance with Company Q. If this customer were insured with Company Z, the customer's premium would be $400.

Customer E is paying a premium of $240 for insurance with Company Q. If this customer were insured with Company Z, the customer's premium would be $200.

Assume that these are the only customers whose characteristics are used to compare competitive positions among insurers. Also assume that customers only care about the amount of premium, and each customer will choose the insurer that charges the lower premium to that customer.

(a) From the standpoint of Company Z, what is the company's *win percentage* with respect to Company Q?

(b) At the next renewal period, what will be Company Q's *retention ratio*, with respect to these five insureds?

**Solution S5-98-3.** This question is based on the discussion in Werner and Modlin, pp. 243, 247.

(a) We use the formula (% Win) = (Number of Risks Meeting Criteria (e.g., Premium Lower than Competitor ))/(Total Number of Risks).

Here, there are 5 risks. Of these, only 2 (A and C) are charged a lower premium by Q than they would be charged by Z. The others (B, D, and E) would receive a lower premium from Z, and Z can expect to win them over. Thus, for Z, (% Win) = 3/5 = 60%.

(b) We use the formula (Retention Ratio) = (Number of Policies Renewed)/(Total Number of Potential Renewal Policies). Since only A and C are charged a lower premium by Q than they
would be charged by Z, only those customers will renew with Q, and so Q's retention ratio will be $2/5 = 40\%$.

**Problem S5-98-4.** Insurer Y had 1350 policies at the beginning of year 2113. During 2113, the insurer issued 43120 quotes and had a close ratio of 20%. With respect to policies that were in force at the beginning of 2113, the insurer had a retention ratio of 60%. What percent policy growth was experienced by Insurer Y during 2113?

**Solution S5-98-4.** This question is based on the discussion in Werner and Modlin, pp. 246-249.

Three formulas are relevant:

\[
\text{(\% Policy Growth)} = \frac{\text{(Policies at End of Period)}}{\text{(Policies at Onset of Period)}} - 1
\]

\[
\text{(Retention Ratio)} = \frac{\text{(Number of Policies Renewed)}}{\text{(Total Number of Potential Renewal Policies)}}
\]

\[
\text{(Close Ratio)} = \frac{\text{(Number of Accepted Quotes)}}{\text{(Total Number of Quotes)}}
\]

The original 1350 policies had a retention ratio of 60%, meaning that 60\% of those policies, or $1350 \times 0.6 = 810$ policies were renewed.

Of the 43120 issued quotes, 20\% or $0.2 \times 43120 = 8624$ quotes resulted in policies being issued. Thus, at the end of year 2113, the insurer had $810 + 8624 = 9434$ policies, compared to 1350 policies at the beginning of 2113.

Thus, \[
\text{(\% Policy Growth)} = \frac{9434}{1350} - 1 = 5.988148148 = +598.8148148\%.
\]

**Problem S5-98-5.** An insurer performs a persistency analysis ("lifetime value analysis") for two types of insureds, K and L.

An insured of type K has an 80\% probability of renewing after the first year, a 60\% probability of renewing after the second year, and a 90\% probability of renewing after the third year. The premium charged to this insured starts at $1000 during the first year and decreases by 10\% each year. The expected loss cost for this insured starts at $500 during the first year and increases by 20\% each year.

An insured of type L has a 90\% probability of renewing after the first year, a 95\% probability of renewing after the second year, and a 70\% probability of renewing after the third year. The premium charged to this insured starts at $600 during the first year and decreases by 5\% each year. The expected loss cost for this insured starts at $600 during the first year and decreases by 30\% each year.

Assume that there are no fixed expenses for insurance policies and that the risk-free interest rate is 0\%.
Over a four-year time period, what is the insurer's expected profit from each insured? Which insured can be expected to bring more profit to the insurer?

**Solution S5-98-5.** This question is based on the discussion in Werner and Modlin, pp. 253-254.

We consider the insured of type K.

During year 1, the insurer's expected profit from this insured is \(1000 - 500 = 500\) dollars.

During year 2, the insurer's expected profit from this insured is \(1000 \times 0.9 - 500 \times 1.2 = 300\) dollars.

During year 3, the insurer's expected profit from this insured is \(1000 \times 0.9^2 - 500 \times 1.2^2 = 90\) dollars.

During year 4, the insurer's expected profit from this insured is \(1000 \times 0.9^3 - 500 \times 1.2^3 = -135\) dollars.

During the first year, we assume that the insured will remain with the insurer with a probability of 1.

After the first year, there is a 0.8 probability that the insured will remain with the insurer.

After the second year, there is a 0.8 \times 0.6 = 0.48 probability that the insured will remain with the insurer.

After the third year, there is a 0.8 \times 0.6 \times 0.7 = 0.336 probability that the insured will remain with the insurer.

Thus, the expected profit from the insured of type K is

\[1 \times 500 + 0.8 \times 300 + 0.48 \times 90 + 0.336 \times (-135) = 737.84\] dollars.

We consider the insured of type L.

During year 1, the insurer's expected profit from this insured is \(600 - 600 = 0\) dollars.

During year 2, the insurer's expected profit from this insured is \(600 \times 0.95 - 600 \times 0.7 = 150\) dollars.

During year 3, the insurer's expected profit from this insured is \(600 \times 0.95^2 - 600 \times 0.7^2 = 247.50\) dollars.

During year 4, the insurer's expected profit from this insured is \(600 \times 0.95^3 - 600 \times 0.7^3 = 308.625\) dollars.

During the first year, we assume that the insured will remain with the insurer with a probability of 1.

After the first year, there is a 0.9 probability that the insured will remain with the insurer.

After the second year, there is a 0.9 \times 0.95 = 0.855 probability that the insured will remain with the insurer.

After the third year, there is a 0.9 \times 0.95 \times 0.7 = 0.5985 probability that the insured will remain with the insurer.

Thus, the expected profit from the insured of type L is

\[1 \times 0 + 0.9 \times 150 + 0.855 \times 247.50 + 0.5985 \times 308.625 = 531.32\] dollars.

**An insured of type K will bring the insurer more profit over the four-year period.**
Section 99

Elements of a Personal Automobile Insurance Policy – Part 1

This section of the study guide is intended to provide practice problems and solutions to accompany the pages of Personal Insurance, cited below. Students are encouraged to read these pages before attempting the problems. This study guide is entirely an independent effort by Mr. Stolyarov and is not affiliated with any organization(s) to whose textbooks it refers, nor does it represent such organization(s).

Some of the questions here ask for short written answers based on the reading. This is meant to give the student practice in answering questions of the format that will appear on Exam 5. Students are encouraged to type their own answers first and then to compare these answers with the solutions given here. Please note that the solutions provided here are not necessarily the only possible ones.


Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-99-1. List six elements that would be included on the declarations page of a personal automobile insurance policy.

Solution S5-99-1. This question is based on the discussion in Personal Insurance, pp. 3.4-3.7. The following elements are typically included on the declarations page of a personal automobile insurance policy:

1. Name of insurer;
2. Name and address of policyholder (named insured);
3. Policy period;
4. Description of insured automobiles;
5. Schedule of coverages, describing the coverages that apply to the policy and the limits that apply to each coverage;
6. List of applicable endorsements;
7. Name of lender, loss payee, or lienholder, if any;
8. Garage location of the insured automobile;
9. Rating information (e.g., any applicable credits and discounts);
10. Signature of the insurer's authorized legal representative.

Any six of the above suffice as an answer. Other valid answers may also be possible.
Problem S5-99-2. Which of the following entities will typically be classified as "you" within the language of a personal automobile insurance policy? More than one answer may be possible.

(a) The named insured's ward or foster child;
(b) The named insured's de facto spouse who is not legally related to the named insured;
(c) The named insured's legal spouse who lives with the named insured;
(d) The named insured;
(e) The named insured's legal spouse who has lived apart from the named insured for over a year;
(f) The named insured's legal spouse who is the named insured on another insurance policy.

Solution S5-99-2. This question is based on the discussion in Personal Insurance, pp. 3.8-3.10. The following answers are correct:

(c) The named insured's legal spouse who lives with the named insured;
(d) The named insured.

The person in choice (b) is not officially a "spouse" or a "family member" of the named insured. The person in choice (a) will most likely be considered a "family member", but will not be encompassed within the definition of "you". Choices (e) and (f) are situations in which most personal automobile insurance policies would exclude coverage for a spouse of the named insured and would exclude that spouse from the definition of "you".

Problem S5-99-3. Mr. Θ has bodily injury liability coverage under a typical personal automobile insurance policy. The policy limit for the coverage is $200,000. Mr. Θ is found to be at fault for an accident where the total bodily injury damages are $180,000. Because the case takes a long time to try in court, the plaintiff is also awarded prejudgment interest of $50,000. The insurer, under its obligation to defend Mr. Θ, incurs expenses of $560,000. How much will be paid as a result of this accident by (a) the insurer and (b) Mr. Θ?

Solution S5-99-3. This question is based on the discussion in Personal Insurance, pp. 3.12-3.13.

(a) In a typical personal automobile insurance policy, the payment of prejudgment interest is considered part of the award for damages, whereas the costs to defend the insured are considered to be in addition to the policy limits. Thus, the insurer will pay Mr. Θ's entire defense costs, as well as the damages and prejudgment interest up to $200,000. Since damages and prejudgment interest owed by Mr. Θ are $180,000 + $50,000 = $230,000, the insurer will pay $200,000 of this amount, in addition to $560,000 in defense costs, for a total of $760,000.

(b) Since damages and prejudgment interest owed by Mr. Θ are $180,000 + $50,000 = $230,000, and the insurer will pay $200,000 of this amount, Mr. Θ will need to pay the difference, $30,000.

Problem S5-99-4.

(a) Name four classes of entities to which the liability part of a personal automobile insurance policy would typically provide coverage.
(b) Name five types of supplementary payments that the liability part of a personal automobile insurance policy would typically cover.

Solution S5-99-4. This question is based on the discussion in *Personal Insurance*, pp. 3.13-3.15.

(a) The following are four classes of entities to which the liability part of a personal automobile insurance policy would typically provide coverage (*Personal Insurance*, p. 3.13):

1. The named insured and the named insured's family members;
2. "Any person using the named insured's covered auto";
3. "Any person or organization legally responsible for the acts of a covered person while using a covered auto";
4. "Any person or organization legally responsible for the named insured's or family member's use of any automobile or trailer."

(b) The following are five types of supplementary payments that the liability part of a personal automobile insurance policy would typically cover:

1. Cost of bail bonds (bail bond premiums) - up to some small amount, such as $250 - when such a cost is "required because of an accident that results in bodily injury or property damage covered by the policy" (*Personal Insurance*, p. 3.14).
2. Premiums on appeal bonds (bonds that guarantee that, if an appeal is lost, the insured will pay the costs of the original judgment and the appeal) and bonds to release attachments on an insured's property. (An attachment may be placed on the insured's property by a plaintiff during legal proceedings.)
3. Interest accruing after a judgment (postjudgment interest).
4. Loss of earnings resulting from the insured's attendance at trials - up to some amount per day, such as $200.
5. "Other reasonable expenses incurred at the insurer's request" (*Personal Insurance*, p. 3.15).

Problem S5-99-5. Name five typical exclusions of coverage under the liability part of a personal automobile insurance policy.

Solution S5-99-5. This question is based on the discussion in *Personal Insurance*, pp. 3.15-3.18. Coverage is typically excluded for the following:

1. Intentional injury inflicted by the insured;
2. "Property owned or transported by the insured";
3. "Property rented to, used by, or in the case of the insured";
4. "Bodily injury to an employee of an insured who is injured during the course of employment";
5. "Public or livery conveyance" - i.e., the use of the insured's vehicle to carry people or property indiscriminately and for a fee;
6. "Garage business use" - which is typically covered under a commercial automobile policy;
7. Other business use - use of any commercial vehicles, except for in a business such as farming or ranching
8. "Vehicles used without reasonable belief of being entitled" to do so;
9. Bodily injury liability losses that are also covered under a nuclear energy liability policy;
10. "Vehicles with fewer than four wheels or designed for off-road use";
11. "Any vehicle, other than a covered auto, owned by the named insured or made available for the named insured's regular use";
12. Any vehicle, other than a covered auto, owned by a family member of the named insured or made available for that family member's regular use;
13. Vehicles used in racing.

Any five of the above suffice as an answer. Other valid answers may also be possible.
Section 100

Elements of a Personal Automobile Insurance Policy – Part 2

This section of the study guide is intended to provide practice problems and solutions to accompany the pages of *Personal Insurance*, cited below. Students are encouraged to read these pages before attempting the problems. This study guide is entirely an independent effort by Mr. Stolyarov and is not affiliated with any organization(s) to whose textbooks it refers, nor does it represent such organization(s).

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**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-100-1.** With regard to bodily injury and property damage coverages, a personal automobile insurance policy provides split limits denoted, via the standard convention, as $40/$90/$60. An insured with this policy is found to be 100% at fault for accident in which the damages to Person A are $25,000, the damages to Person B are $56,000, and the damages to Person C are $30,000. The damage to the vehicle with which the insured collides is $36,000. How much will the insurance company pay on behalf of the insured?

**Solution S5-100-1.** This question is based on the discussion in *Personal Insurance*, p. 3.18.

Split liability limits are denoted via the standard convention in terms of thousands of dollars, and in the order of (per person bodily injury limit)/(per accident bodily injury limit)/(per accident property damage limit). Thus, this policy will pay at most $40,000 for bodily injury to any individual, at most $90,000 for bodily injury from any accident, and at most $60,000 for property damage from any accident.

We consider what the payout would be on a per-person basis. On this basis, the company would pay $25,000 for Person A and $30,000 for Person C, since each of these amounts is less than $40,000. However, the company would only pay $40,000 for Person B, since the costs of B's injuries exceed that amount. Yet we find that the sum of these three values is 25000 + 40000 + 30000 = $95,000 > $90,000, which is the per-accident limit. Thus, the company will only pay $90,000 - its per-accident limit. The company will also pay $36,000 in property damage costs,
since this is under the property damage limit of $60,000. This means that the insurer's total payout will be 90000 + 36000 = $126,000.

**Problem S5-100-2.** An insured has a typical personal automobile policy from State X, with policy limits of $15/$30/$10 - which are the minimum required limits for liability coverages in State X. The minimum required limits for liability coverages in State Y are $20/$40/$15. During a trip in State Y, the insured injures an individual in a motor vehicle accident, and the total cost of damages for that injury is $17,000. How much will the insured's policy pay for this accident? Why?

**Solution S5-100-2.** This problem is based on the discussion in *Personal Insurance*, p. 3.19.

The insured's policy will pay the full amount of the loss - $17,000 - because, when one state requires higher minimum liability limits than the insured's home state, a typical personal automobile policy written in the home state will automatically provide coverage at the higher minimum limits for an accident that occurs in the state requiring those higher limits.

**Problem S5-100-3.** Insured Q has two personal automobile policies - A and B - on the same vehicle. Policies A and B cover the same perils, and each policy stipulates pro rata sharing of damages with other applicable insurance policies. Policy A has a limit of $200,000, and policy B has a limit of $50,000. A completely covered peril occurs, and the damages are $36,000. How much will Policy A pay?

**Solution S5-100-3.** This problem is based on the discussion in *Personal Insurance*, p. 3.20.

The formula given there with respect to pro rata sharing of damages is as follows:

\[
(\text{Insurer's share of damages}) = \frac{(\text{Amount of damages}) \times (\text{Limit of liability on that insurer's policy})}{(\text{Total limits of liability on all applicable policies})}
\]

Here, thus formula leads to the following result: \((36000)\times(200000)/(200000 + 50000) = 28,800\).

**Problem S5-100-4.** Person X is driving a vehicle owned by Person Y with Y's permission. Person X hits a pedestrian and inflicts bodily injuries for which damages are determined to be $56,000. In court, Person X is found to be fully responsible for this accident; Person Y is found to have no liability. Because the case takes a long time to try, prejudgment interest of $20,000 accumulates. The costs of defending Person X in court total $40,000. Person X's personal automobile policy provides liability coverages with split limits of $15/$30/$10, and Person Y's personal automobile policy provides liability coverages with split limits of $50/$100/$50. Both policies are typical in the "other insurance" provisions they contain. It is determined that the accident is a covered peril under both policies. For this incident, how much will be paid by the following entities?

(a) Person Y's insurer;
(b) Person X's insurer;
(c) Person X;
(d) Person Y.
Solution S5-100-4. This question is modeled after the discussion in *Personal Insurance*, pp. 3.20-3.26.

(a) A typical personal automobile insurance policy will consider itself to provide excess coverage over any other applicable insurance *for a vehicle now owned by the named insured*. Here, Person X did not own the vehicle, and so Person X's coverage is excess, while Person Y's coverage is primary. As the primary insurer, Y's insurer will pay Y's defense costs of $40,000.

Total damages and prejudgment interest for this incident are $56,000 + $20,000 = $76,000.

Y's insurer will thus pay up to its policy limit of $50,000 for damages and prejudgment interest, *in addition* to the defense costs of $40,000, which are outside policy limits. Y's insurer will thus pay a total of $90,000.

(b) After Y's insurer makes its payment, the damages/prejudgment interest remaining to be paid are $76,000 - $50,000 = $26,000. X's insurer - the excess insurer here - has liability for only $15,000 of this amount - up to the per-person limit. Thus, X's insurer will pay $15,000.

(c) After both insurers have made their payments, $26,000 - $15,000 = $11,000 remains to be paid in damages/prejudgment interest. Since X was found fully liable for the accident, X will pay the entire $11,000.

(d) Y will pay $0, since Y is found to not be liable for the accident.

**Problem S5-100-5.** Many insurers use the DICE method to determine if an insurance policy covers a loss. For each step of the DICE method, name one specific situation where the personal automobile policy might be found to exclude coverage under its liability part.

Solution S5-100-5. This question is based on the discussion in *Personal Insurance*, pp. 3.24-3.26.

There are many answers possible for this question, so this answer will serve as an illustrative example. DICE stands for "Declarations, Insuring agreement, Conditions, Exclusions" - the four aspects of the insurance policy to be considered via this method. Here are possible situations in which each of these aspects would exclude coverage:

1. **Declarations:** The loss occurred at a time before or after the policy term.
2. **Insuring agreement:** The accident for which coverage is sought might be an accident for which the insured is found not to be liable (in this case, the insurer might still have to pay the costs of defending the insured in court), or the lawsuit is not even brought against any individual who would qualify as an insured under the policy.
3. **Conditions:** The insured might not have provided prompt notice of loss to the insurer, allowing the insurer to exclude coverage.
4. **Exclusions:** Any of a number of exclusions in the personal automobile policy might apply. For instance, the insured might be covered under a nuclear energy liability policy or might have intentionally caused the damage. In either case, coverage would be excluded.
Section 101

Elements of a Personal Automobile Insurance Policy – Part 3

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**Source:**

**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-101-1.**

(a) Name the types of expenses payable under the medical payments coverage of a typical personal automobile insurance policy.

(b) An insured is found to be 75% at fault for an accident. The insured also incurs medical expenses of $5000 as a result of the accident. The insured's personal automobile policy offers medical payments coverage up to a limit of $10000 per person for each accident. How much of this insured's medical expenses will the insurer pay for?

(c) Name the two types of persons covered under the medical payments coverage of a typical personal automobile insurance policy.

**Solution S5-101-1.** This problem is based on the discussion in *Personal Insurance*, pp. 3.28-3.29.

(a) Expenses typically payable under medical payments coverage include expenses for "medical, surgical, X-ray, dental, and funeral services" (*Personal Insurance*, p. 3.28).
(b) The insurer will pay for $5000 of the insured's medical expenses, because medical payments coverage applies without regard to fault, and the expenses are less than the limit of liability for this coverage.

(c) The two types of persons covered under the medical payments coverage of a typical personal automobile insurance policy are (1) the named insured and "family members" as defined in the policy and (2) any other person that occupies a covered automobile, during the course of that occupation.

**Problem S5-101-2.** Name five situations for which medical payments coverage would be excluded under a typical personal automobile insurance policy.

**Solution S5-101-2.** This problem is based on the discussion in *Personal Insurance*, pp. 3.29-3.31. The following situations are ones in which coverage would typically be excluded:

1. Motorized vehicles with fewer than 4 wheels;

2. "Public or livery conveyance" - i.e., the use of the insured's vehicle to carry people or property indiscriminately and for a fee;

3. Use of the vehicle as a residence or premises;

4. "Injury during the course of employment" - covered under a workers' compensation policy;

5. "Other vehicles owned by the insured or available for the insured's regular use" - these are vehicles that are not covered vehicles under the policy;

6. Other vehicles owned by family members of the insured or available for those family members' regular use - these are vehicles that are not covered vehicles under the policy;

7. "Vehicles used without reasonable belief of being entitled" to do so;

8. "Vehicles used in the business of an insured" - may be covered under a commercial automobile insurance policy;

9. "Bodily injury from nuclear weapons or war";

10. Nuclear radiation;

11. Injuries sustained while occupying any vehicle used for racing.

Any five of the above suffice as an answer. Other valid answers may also be possible.

**Problem S5-101-3.** Amenhotep is driving his vehicle with Joe as his passenger. Both are injured in an accident. The cost of treating Amenhotep's injuries is $1,400. The cost of treating Joe's injuries is $12,700. Amenhotep's personal automobile policy has typical medical payments.
coverage with a limit of $8,000. Joe's personal automobile policy has typical medical payments coverage with a limit of $6,000.

(a) How much will Amenhotep's insurer pay as a result of this accident?

(b) How much will Joe's insurer pay as a result of this accident?

(c) Assume that Amenhotep and Joe were struck by an uninsured motorist and that Joe also has uninsured motorists coverage with a per-person limit of $25,000. How much will Joe be able to recover under this coverage, once the insurer has made all payments under the medical payments coverage?

Solution S5-101-3. This problem is based on the discussion in *Personal Insurance*, pp. 3.31-3.32.

(a) Because both individuals have typical medical payments coverage, Joe's coverage will be considered excess over Amenhotep's, since Joe was occupying a non-owned vehicle at the time of the accident. Thus, Amenhotep's coverage is primary. Since medical payments limits of liability are per-person, Amenhotep's insurer will pay $1,400 for Amenhotep's expenses, and $8,000 for Joe's expenses - up to its per-person limit for Joe. Thus, Amenhotep's insurer will pay a total of $9,400.

(b) After Amenhotep's insurer pays, there remain expenses of the amount of $12,700 - $9,400 = $3,300. Since these expenses are less than Joe's per-person medical payments limit, Joe's insurer will pay the entire $3,300.

(c) Joe would recover $0 under uninsured motorists coverage, because a typical personal automobile insurance policy would contain a clause prohibiting duplicate recovery for the same losses that are covered under both medical payments coverage and uninsured motorists coverage.

Problem S5-101-4.

(a) The uninsured motorists coverage of a typical personal automobile policy is designed to pay for injuries caused by which three types of drivers?

(b) Which three types of persons are considered insureds under the uninsured motorists coverage of a typical personal automobile policy?

Solution S5-101-4. This problem is based on the discussion in *Personal Insurance*, pp. 3.40-3.41.

(a) Uninsured motorists coverage is designed to pay for injuries caused by (1) at-fault uninsured motorists, (2) hit-and-run drivers, and (3) drivers whose insurers are insolvent.

(b) The following three types of persons are considered insureds under the uninsured motorists coverage of a typical personal automobile policy (*Personal Insurance*, p. 3.41):
1. "The named insured and family members";
2. "Any other person occupying a covered auto";
3. "Any person legally entitled to recover damages because of bodily injury to a person described in 1 or 2".

**Problem S5-101-5.** Which of the following statements are true regarding the uninsured motorists (UM) coverage of a typical personal automobile insurance policy? More than one statement may be correct.

(a) UM coverage pays only for compensatory damages, not punitive damages.
(b) UM coverage pays only for punitive damages, not compensatory damages.
(c) UM coverage pays for both compensatory and punitive damages.
(d) In some states, the bodily injury damage covered under UM coverage is subject to a small deductible.
(e) UM coverage would still necessarily apply if a hit-and-run driver is later identified and found to be insured, before the insurer offering UM coverage has made a payment on the claim.
(f) If no bodily injury liability policy or bond applies to a vehicle involved in an accident, that vehicle would be considered an "uninsured vehicle" for the purposes of UM coverage.
(g) If an individual is injured by a vehicle to which no insurance applies and which is owned by an uninsured "family member", the injury would be covered under UM coverage.
(h) Injuries caused by a vehicle owned by a governmental entity are typically not covered under UM coverage.

**Solution S5-101-5.** This problem is based on the discussion in *Personal Insurance*, pp. 3.40-3.42. The following answers are correct:

(a) UM coverage pays only for compensatory damages, not punitive damages.

(f) If no bodily injury liability policy or bond applies to a vehicle involved in an accident, that vehicle would be considered an "uninsured vehicle" for the purposes of UM coverage.

(h) Injuries caused by a vehicle owned by a governmental entity are typically not covered under UM coverage.

Choices (b) and (c) cannot be correct in choice (a) is correct. Choice (d) is not correct; in some states, UM coverage also covers some property damage, subject, perhaps, to a small deductible. UM coverage for bodily injury is not subject to a deductible. Choice (e) is not correct; the vehicle operated by the hit-and-run driver may not meet the definition of an "uninsured vehicle" if the hit-and-run driver is later found to have sufficient applicable insurance. Choice (g) is not correct; if an individual is injured by a vehicle to which no insurance applies and which is owned by an uninsured "family member", the injury would not be covered under UM coverage.
Section 102

Elements of a Personal Automobile Insurance Policy – Part 4

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**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-102-1.** Name five situations for which uninsured motorists (UM) coverage would be excluded under a typical personal automobile insurance policy.

**Solution S5-102-1.** This problem is based on the discussion in *Personal Insurance*, pp. 3.42-3.43. The following situations are ones in which coverage would typically be excluded:

1. A vehicle owned by an insured but not covered under the policy in question;
2. A vehicle owned by the named insured but which has primary UM coverage on another policy;
3. A "claim settlement that prejudices the insurer's right of recovery" - i.e., a settlement made by the insured without the insurer's consent and that hinders the insurer's ability to recover via subrogation the amounts of money it pays to the insured;
4. "Public or livery conveyance" - i.e., the use of the insured's vehicle to carry people or property indiscriminately and for a fee;
5. "Vehicles used without reasonable belief of being entitled" to do so;
6. A situation in which there would be a direct or indirect benefit to any insurer or self-insurer under a workers' compensation law or a disability benefits law;
7. Punitive damages - UM coverage only pays for compensatory damages.

**Problem S5-102-2.** State Q requires that all vehicles be insured under bodily injury liability and property damage liability coverages for the split limits of $10/$20/$5, denoted via the standard
convention. Assume that Insured Z wants to purchase insurance at the required minimum limits, and also wants uninsured motorists (UM) coverage added to his policy. Insured Z does not provide any further clarification regarding UM coverage, but also requests medical payments (MP) coverage with a per-person, per-accident limit of $5000.

(a) Assume that Insured Z is driving his vehicle and is struck by a completely uninsured at-fault driver. Insured Z incurs costs due to bodily injury of $16,000. How much will he be reimbursed under his UM coverage, if he only files a claim under the UM coverage?

(b) Assume that, in the situation in part (a) above, Insured Z files a claim under both his MP coverage and his UM coverage. It is determined that the injuries would qualify for reimbursement under each coverage. How much will Insured Z be reimbursed in total?

(c) Assume that, in the situation in part (a) above, Insured Z was actually simultaneously driving two vehicles that he owned. (Insured Z was using a special teleportation device which enabled him to rapidly shift back and forth between the two vehicles in time to make decisions relevant to the control of those vehicles - or so he hoped. Doing this is considered perfectly legal in State Q.) Insured Z argues that, because he purchased UM coverage on both of those vehicles and because both vehicles were involved in the accident, he should be reimbursed twice the amount he would have received if only one of his vehicles were involved in the accident. Is he correct? Why or why not?

Solution S5-102-2. This problem is based on the discussion in Personal Insurance, p. 3.44.

(a) By default (unless the insured requests otherwise and pays the corresponding higher premium), if UM coverage is requested on the policy, we assume that UM policy limits are set at the same level as the minimum bodily injury (BI) liability limits required by state law. Here, the minimum required BI limits are $10,000 per person and $20,000 per accident. These are, correspondingly, the UM limits on the policy, since Insured Z did not specify otherwise. Thus, Insured Z will be reimbursed $10,000 out of his total expenses of $16,000.

(b) A typical personal automobile policy prohibits both UM and MP coverages for reimbursing the insured twice for the same loss. Consider, first, Insured Z's MP coverage, which would pay him $5,000 of his costs due to his injury. The part of the costs for which the $5,000 paid cannot be reimbursed again under UM coverage. However, there are also $16000 - 5000 = $11,000 of costs that MP coverage did not pay for. The UM coverage will cover $10,000 out of those costs, up to Insured Z's per-person limit for this coverage. Thus, Insured Z will be reimbursed $15,000 out of his total expenses of $16,000.

(c) Insured Z is not correct in his argument, because a typical personal automobile insurance policy contains, with respect to UM coverage, a provision prohibiting the "stacking" of payments where a policy covers more than one vehicle owned by the named insured. The provisions states that the limits shown on the policy are the most that will be paid, irrespective of how many vehicles are covered by the policy or involved in the accident.
**Problem S5-102-3.** (a) Mr. Epsilon is driving his vehicle, which is insured under two policies for UM coverage. Policy A provides a per-person limit of $40,000, while Policy B provides a per-person limit of $30,000. Both policies are typical personal automobile insurance policies and are otherwise identical. An at-fault, uninsured, hit-and-run driver strikes Mr. Epsilon's vehicle and causes $50,000 of bodily injury damage. How much will Mr. Epsilon recover from the two insurers combined?

**Solution S5-102-3.** This question is based on the discussion in *Personal Insurance*, p. 3.44.

The description of UM coverage under a typical personal automobile insurance policy contains a provision that, if two or more policies provide UM coverage for the same event, the most that can be paid is the highest applicable UM limit of any one policy. In this case, the highest applicable UM limit of any one policy is $40,000, so Mr. Epsilon can only recover **$40,000**.

**Problem S5-102-4.** Ms. Delta is driving Ms. Gamma's vehicle with her permission. Ms. Gamma has UM coverage under Policy G with a per-person limit of $60,000. Ms. Delta has two typical personal automobile policies which offer UM coverage: Policy C offers coverage with a per-person limit of $90,000, whereas Policy D offers coverage with a per-person limit of $150,000. Except for their limits of coverage, policies G, C, and D are identical. Ms. Delta, while driving Ms. Gamma's vehicle, is struck by an uninsured at-fault motorist who causes $120,000 in bodily injury damages to Ms. Delta. How much will be paid for these damages to Ms. Delta under the following policies?

(a) Policy G;
(b) Policy C;
(c) Policy D.

**Solution S5-102-4.** This question is based on the discussion in *Personal Insurance*, p. 3.45. Note that the entire damages of $120,000 will be paid by the combination of insurers, because $120,000 is not greater than the highest UM limit on any applicable insurance policy, which is $150,000.

(a) Because Ms. Delta was operating a non-owned vehicle, the UM coverage under her policies is excess over other applicable insurance. In this case, Ms. Gamma's Policy G offers primary coverage. Since Ms. Delta's damages exceed Policy G's limit of $60,000, **$60,000 will be paid under Policy G**.

(b) After $60,000 is paid under Policy G, $60,000 in damages remain to be paid under policies C and D. This amount is within the limit of coverage of each policy. There is nothing to suggest that one should be prioritized over the other. Thus, there will be pro-rata sharing of damages between the two policies, based on their limits. Under Policy C, \(60000 \times (90000)/(90000 + 150000) = \$22,500\) will be paid.

(c) After $60,000 is paid under Policy G, $60,000 in damages remain to be paid under policies C and D. There is nothing to suggest that one should be prioritized over the other. Thus, there will
be pro-rata sharing of damages between the two policies, based on their limits. Under Policy C, 
\[
60000 \times (150000)/(90000 + 150000) = 37,500
\]
will be paid.

**Problem S5-102-5.** Mr. Ψ carries bodily injury (BI) and underinsured motorists (UIM) coverage
on his vehicle, with a per-person limit of $300,000. Mr. Ψ's vehicle is struck by a 100% at-fault
motorist who carries bodily injury liability insurance with a per-person limit of $50,000. The
accident causes bodily injury damage to Mr. Ψ, for which the cost is $125,000. How much will
be paid under the following coverages?

(a) The at-fault motorist's BI coverage;
(b) Mr. Ψ's BI coverage;
(c) Mr. Ψ's UIM coverage.

**Solution S5-102-5.**

(a) The at-fault motorist *does* have some bodily injury liability insurance to cover part of the
damages. This insurance will pay up to its limits before any UIM coverage applies. Thus,
because the damages to Mr. Ψ are $125,000 > $50,000, the at-fault motorist's BI coverage will
pay $50,000.

(b) Mr. Ψ's BI coverage will pay $0, since Mr. Ψ is not at fault for the accident, and BI coverage
only pays for the damages owed by and the cost to defend the *insured*. There are no defense
costs specified for this problem.

(c) Mr. Ψ's UIM coverage will pay the difference between Mr. Ψ's damages (if they are less than
his UIM limit, which they are) and the at-fault motorist's BI limit. Here, the difference is 125000
- 50000 = $75,000.
Section 103

Elements of a Personal Automobile Insurance Policy – Part 5

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**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-103-1.** For each of the following situations involving underinsured motorists (UIM) coverage, identify whether coverage would apply under the limits trigger and under the damages trigger.

(a) Injured motorist's damages: $300,000; Injured motorist's UIM limit: $100,000; At-fault motorist's bodily injury liability (BI) limit: $50,000

(b) Injured motorist's damages: $100,000; Injured motorist's UIM limit: $300,000; At-fault motorist's BI limit: $50,000

(c) Injured motorist's damages: $50,000; Injured motorist's UIM limit: $300,000; At-fault motorist's BI limit: $100,000

(d) Injured motorist's damages: $50,000; Injured motorist's UIM limit: $100,000; At-fault motorist's BI limit: $300,000

(e) Injured motorist's damages: $100,000; Injured motorist's UIM limit: $50,000; At-fault motorist's BI limit: $300,000

(f) Injured motorist's damages: $300,000; Injured motorist's UIM limit: $50,000; At-fault motorist's BI limit: $100,000
Solution S5-103-1. This problem is based on the discussion in *Personal Insurance*, p. 3.47.

Under the limits trigger, coverage applies when the at-fault motorist carries BI limits that are less than the UIM limits of the injured motorist. Thus, **coverage under the limits trigger would apply in situations (a), (b), and (c).**

Under the damages trigger, coverage applies when the injured motorist incurs damages that are greater than the at-fault motorist's BI limits. Thus, **coverage under the damages trigger would apply in situations (a), (b), and (f).**

Problem S5-103-2. Mr. and Mrs. X each have their own underinsured motorists (UIM) coverage under separate policies. Mr. X's UIM coverage has a per-person limit of $40,000. Mrs. X's UIM coverage has a per-person limit of $60,000. Mrs. X is struck by an at-fault motorist whose bodily injury liability (BI) per-person limit is $15,000. Mrs. X incurs $80,000 in damages.

(a) How much would Mrs. X recover under any applicable policies if stacking of policy limits is allowed?

(b) How much would Mrs. X recover under any applicable policies if stacking of policy limits is not allowed?

Solution S5-103-2. Coverage for Mrs. X under the UIM policy applies under both the limits trigger and the damages trigger, since the at-fault motorist's limits are lower than both Mrs. X's UIM limits and her damages.

(a) The at-fault motorist's policy will pay up to its limit of $15,000. Subsequently, because stacking of policy limits is allowed, Mrs. X can recover under her and her husband's policy, up to a combined limit of $40,000 + $60,000 = $100,000. This will suffice to pay her remaining damages of $80,000 - $15,000 = $65,000. This means that Mrs. X will recover a total of $80,000.

(b) The at-fault motorist's policy will pay up to its limit of $15,000. Subsequently, because stacking of policy limits is not allowed, Mrs. X can only recover under her own policy, and not that of her husband. Thus, she will recover up to her policy limit of $60,000, meaning that her total recovery will be $75,000.

Problem S5-103-3. Identify the following types of damage to a vehicle as being covered by either collision coverage, "other than collision" (OTC or comprehensive) coverage, or neither.

(a) Damage due to breakage of glass;
(b) Damage due to a windstorm;
(c) Damage due to an accident for which the driver is not at fault;
(d) Damage due to an accident for which the driver is at fault;
(e) Damage due to war;
(f) Damage due to the vehicle hitting a tree;
(g) Damage due to riot or civil commotion;
(h) Damage due to the act of an occupant of a neighboring car opening that car’s door and damaging the insured vehicle;
(i) Damage due to flood;
(j) Damage to the tires of a vehicle while the vehicle was used on the road;
(k) Damage that results solely in electrical failure within the vehicle.

**Solution S5-103-3.** This question is based on the discussion in *Personal Insurance*, pp. 4.4-4.8.

Situation (a) would be covered under **OTC coverage**; if the breakage is due to a collision, it can also be covered under collision coverage.

Situation (b) would be covered under **OTC coverage**.

Situation (c) would be covered under **collision coverage**.

Situation (d) would be covered under **collision coverage**.

Situation (e) would **not be covered under either coverage**.

Situation (f) would be covered under **collision coverage**.

Situation (g) would be covered under **OTC coverage**.

Situation (h) would be covered under **collision coverage**.

Situation (i) would be covered under **OTC coverage**.

Situation (j) would **not be covered under either coverage**.

Situation (k) would **not be covered under either coverage**.

**Problem S5-103-4.** Mr. Λ owns two vehicles. Vehicle A has collision coverage with a deductible of $200 and "other than collision" (OTC) coverage with a deductible of $100. Vehicle B has collision coverage with a deductible of $400 and OTC coverage with a deductible of $500. Vehicle C has collision coverage with a deductible of $900 and OTC coverage with a deductible of $600.

During a particularly unfortunate day, Mr. Λ accidentally rams Vehicle A into Vehicle B. Vehicle A suffers damage to its glass windows, which would require $1500 to repair. Vehicle B suffers damage of $1800 to its side doors. At the same time, a cow falls out of the sky on Vehicle C, causing $2000 in damage. Assuming that Mr. Λ files claims under all coverages under which he is eligible to receive reimbursement, how much will Mr. Λ recover from his insurer as a result of this accident?

**Solution S5-103-4.** This question is based on the discussion in *Personal Insurance*, pp. 4.4-4.5.
It is important to keep the following facts in mind:

1. Whenever collision or OTC coverage applies to multiple vehicle, the deductible is only applied once, but it is the highest deductible of those multiple vehicles.

2. Glass breakage due to a collision can be covered under both collision coverage and OTC coverage, so both collision and OTC deductibles may apply.

Damage to Vehicles A and B are covered under collision coverage. Of the two, Vehicle B has the higher collision deductible of $400, so this deductible would apply.

Because glass breakage can also be covered under OTC coverage, damage to Vehicle B is also covered under OTC coverage. Damage to Vehicle C is only covered under OTC coverage. The higher OTC deductible of $600 for Vehicle C would apply.

Total cost of damage to Mr. Λ is 1500 + 1800 + 2000 = $5300. Of this amount, Mr. Λ will pay 400 + 600 = $1000 in the form of deductibles, meaning that he will receive $4300 from his insurer.

**Problem S5-103-5.** Under which of the following situations would an automobile not owned by the insured be covered under the physical damage coverages of a typical personal automobile policy? More than one choice may be correct.

(a) One-time borrowing of another person's vehicle;
(b) Everyday borrowing of another person's vehicle;
(c) Use of an employer's vehicle that is furnished for employees' regular use;
(d) Use of a vehicle as a temporary substitute for an owned vehicle that is out of normal use.

**Solution S5-103-5.** This question is based on the discussion in *Personal Insurance*, p. 4.5.

In the following situations, damage to the automobile would be covered under physical damage coverages:

(a) One-time borrowing of another person's vehicle;

(d) Use of a vehicle as a temporary substitute for an owned vehicle that is out of normal use.

In situations (b) and (c), physical damage coverages would not apply, because the definition of a "non-owned auto" under said coverages excludes non-owned vehicles that are operated regularly by the insured.
Section 104

Elements of a Personal Automobile Insurance Policy – Part 6

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**Source:**

**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-104-1.** Mr. Y has a personal automobile policy which provides coverage for transportation expenses in the event his insured vehicle is disabled due to a covered physical damage loss. There is a two-day waiting period specified, and the maximum the insurer will pay is $30 per day, up to a maximum of $1000 for transportation expenses resulting from each covered loss. Mr. Y's deductible for collision coverage is $500, and his deductible for "other than collision" (OTC) coverage is $200. Mr. Y's insured vehicle collides with a cow, which, in a fit of anger, decides to steal the vehicle and drive it away. The vehicle is missing for 6 days, whereafter it is found, and it is also discovered that the cow has significantly damaged the interior of the vehicle. It takes another 10 days to repair the damage. In the meantime, Mr. Y incurs expenses of $800 renting a car. How much will Mr. Y be reimbursed for transportation expenses by his insurer?

**Solution S5-104-1.** This question is based on the discussion in *Personal Insurance*, p. 4.6.

Transportation expenses are not subject to a deductible, so whether the loss is covered under collision or OTC coverage is not material to obtaining the desired result (the loss is probably covered under OTC coverage). Mr. Y incurred transportation expenses of $800 over 16 days, which amounts to $800/16 = $50 per day. But he can only be reimbursed up to $30 per day. Moreover, the two-day waiting period at the beginning of the 16 days reduces the number of days for which he will be reimbursed to 14. Thus, his total reimbursement for transportation expenses will be ($30/day)*(14 days) = $420.
Problem S5-104-2. Name five situations where the physical damage coverages of a typical personal automobile insurance policy would not apply.

Solution S5-104-2. This question is based on the discussion in Personal Insurance, p. 4.7-4.9. The following are all typical exclusions to the physical damage coverages of a typical personal automobile insurance policy:

1. "Public or livery conveyance" - i.e., the use of the insured's vehicle to carry people or property indiscriminately and for a fee;
2. "Damage 'due and confined' to wear and tear, freezing, mechanical or electrical breakdown or failure, and road damage to tires";
3. Damage due to war;
4. Damage due to radioactive contamination;
5. Damage to electronic equipment that is not permanently installed in the covered vehicle;
6. Damage to media and accessories that are not part of the vehicle;
7. Confiscation or destruction of the vehicle by governmental authorities;
8. "Physical damage loss to a trailer, camper, or motor home that is not shown on the declarations";
9. "Vehicles used without reasonable belief of being entitled" to do so;
10. Damage to radar and laser detection equipment;
11. "Loss to any custom furnishings or equipment in or on any pickup or van";
12. "Loss to a nonowned auto maintained or used " in a garage business;
13. Vehicles used in racing;
14. "Loss to, or loss of use of, a rental auto if the rental agreement includes a damage waiver or if applicable state law precludes the rental company from recovering from the insured for the loss."

Any five of the above suffice as an answer. Other valid answers may also be possible.

Problem S5-104-3. Mr. Q has a physical damage coverage on a trailer that he keeps in his living room as a decorative object. His collision deductible is $700, and his "other than collision" (OTC) deductible is $300. The trailer attracts the attention of a thief and is stolen during a break-in into Mr. Q's house. The trailer is never found and is declared a total loss. This loss is also found to be covered under Mr. Q's physical damage coverage and Mr. Q's homeowner's insurance, which has a sublimit of liability of $1,500 for trailers. It is estimated that the actual cash value (ACV) of the trailer was $2,200. Assume that Mr. Q wants to purchase a replacement trailer for $3,000. How much will be paid for this trailer by the following entities?

(a) Mr. Q's automobile insurer;
(b) Mr. Q's homeowners' insurer;
(c) Mr. Q.

Solution S5-104-3. This question is based on the discussion in Personal Insurance, p. 4.10.

(a) The automobile insurer's liability is limited to the actual cash value of the trailer, or $2,200. Because there are multiple sources of recovery, there is a pro rata sharing of losses between those sources based on the applicable limits. The homeowners' insurer has a limit of liability of
$1,500 with respect to the trailer. The automobile insurer is thus only liable for $2200 \times (2200)/(2200 + 1500) = 1308.108108 = $1,308.11, of which Mr. Q must pay $300 of his OTC deductible (since theft is covered under OTC coverage, not collision coverage), meaning that Mr. Q's automobile insurer will pay $1008.11.

(b) On the basis of pro rata sharing of losses, Mr. Q's homeowners' insurer will pay $2200 \times (1500)/(2200 + 1500) = 891.8918919 = $891.89. There is no deductible applicable to this situation in the case of the coverage afforded by Mr. Q's homeowner's policy.

(c) Mr. Q has received from the two insurers $1008.108108 + 891.8918919 = $1,900. If he wishes to purchase the $3,000 trailer, he will have to pay the difference. Thus, Mr. Q will pay $1,100.

Problem S5-104-4.

(a) Name three general duties that an insured would have under a typical personal automobile policy in the event of a loss.

(b) Name two specific duties that an insured would have under the uninsured motorists coverage of a typical personal automobile policy in the event of a loss.

(c) Name two specific duties that an insured would have under the physical damage coverages of a typical personal automobile policy in the event of a loss.

Solution S5-104-4. This question is based on the discussion in Personal Insurance, pp. 4.19-4.21.

(a) The following are general duties that an insured would have under a typical personal automobile policy in the event of a loss:

1. Providing prompt notice to the insurer;
2. Cooperating with the insurer;
3. Submitting to the insurer notices or legal documents connected with the accident or loss;
4. Submitting to a physical examination at the insurer's expense, if requested to do so by the insurer;
5. Agreeing to examination under oath, if requested to do so by the insurer;
6. Authorizing release of medical records related to the claim, if requested to do so by the insurer;
7. Submitting proof of loss - "a statement of facts about a loss for which the insured is making a claim" (Personal Insurance, p. 4.20).

Any three of the above suffice as an answer. Other valid answers may also be possible.

(b) The following are specific duties that an insured would have under the uninsured motorists coverage of a typical personal automobile policy in the event of a loss:
1. Notifying the police promptly if a hit-and-run driver was involved in the accident;
2. Submitting to the insurer the legal documentation related to any suit against an uninsured motorist.

(c) The following are specific duties that an insured would have under the physical damage coverages of a typical personal automobile policy in the event of a loss:

1. Preventing further loss to the vehicle;
2. Notifying the police promptly in the event of theft;
3. Permitting inspection and appraisal.

Any two of the above suffice as an answer. Other valid answers may also be possible.

Problem S5-104-5.

(a) Name three kinds of changes during the policy term which may result in an adjustment to the premium for a personal automobile insurance policy?

(b) Mr. Φ has suffered a loss of $6,000 due to an at-fault motorist. Mr. Φ's insurer paid Mr. Φ the full $6,000 for the loss, and Mr. Φ was also able to obtain $2,000 from the at-fault motorist through a private agreement. How much will Mr. Φ be able to recover in total?

Solution S5-104-5. This question is based on the discussion in *Personal Insurance*, pp. 4.21-4.22.

(a) The following changes during the policy term may result in an adjustment to the premium for a personal automobile insurance policy:

1. Changes in the use, type, and number of insured vehicles;
2. Changes in the operators using the insured vehicles;
3. Changes in the place where the insured vehicles are principally garaged;
4. Changes in the coverages provided, the limits of liability, and the deductibles.

Any three of the above suffice as an answer. Other valid answers may also be possible.

(b) Mr. Φ will be able to recover $6,000, which is the amount of his loss. The insurer is entitled to subrogate against the at-fault motorist in order to recover all or part of its payment, and a typical personal automobile policy would require the insured to cooperate with the subrogation effort. The $2,000 from the at-fault motorist would be paid by Mr. Φ to the insurer, which may choose to attempt to recover the remaining $4,000 from the at-fault motorist.
Section 105

Elements of Typical Homeowners' Insurance Policies – Part 1

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**Source:**

**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-105-1.** *Personal Insurance*, pp. 5.4-5.5, discusses the following typical homeowners' insurance coverage forms: HO-2, HO-3, HO-4, HO-5, HO-6, and HO-8.

Match each of the following form names to the correct form numbers. To achieve the greatest benefit from this problem, try to solve it from memory.

(a) Special Form
(b) Unit-Owners' Form
(c) Modified Coverage Form
(d) Broad Form
(e) Contents Broad Form
(f) Comprehensive Form

**Solution S5-105-1.**

(a) Special Form = HO-3
(b) Unit-Owners' Form = HO-6
(c) Modified Coverage Form = HO-8
(d) Broad Form = HO-2
(e) Contents Broad Form = HO-4
(f) Comprehensive Form = HO-5
Problem S5-105-2. *Personal Insurance*, pp. 5.4-5.5, discusses the following typical homeowners' insurance coverage forms: HO-2, HO-3, HO-4, HO-5, HO-6, and HO-8. For each of the following situations, identify the coverage form that would be most appropriate.

(a) Mr. Ω rents an apartment and would like insurance that would cover damage to his computers and furniture;
(b) Mr. Ψ lives in a historic home that would be extremely expensive to rebuild but whose market value is close to that of surrounding newer homes.
(c) Mr. Σ would like the broadest coverage available on both his house and its contents.
(d) Mr. Λ lives in a condominium community, where the condominium association takes care of the grounds and a lot of the building exteriors. He would like coverage on his personal property and other loss exposures pertaining to his condominium ownership;
(e) Mrs. Ξ wants to pay as low a premium as possible on her home insurance, but specifically wants coverage for losses due to fires, windstorms, and riots.
(f) Ms. Γ wants coverage for her home from more than just a list of named perils; however, she also does not want to pay the highest premium that she would pay if she selected the broadest possible coverage.

Solution S5-105-2.

(a) Mr. Ω should get coverage under the **HO-4**: Contents Broad Form.
(b) Mr. Ψ should get coverage under the **HO-8**: Modified Coverage Form.
(c) Mr. Σ should get coverage under the **HO-5**: Comprehensive Form.
(d) Mr. Λ should get coverage under the **HO-6**: Unit-Owners' Form.
(e) Mrs. Ξ should get coverage under the **HO-2**: Broad Form.
(f) Ms. Γ should get coverage under the **HO-3**: Special Form.

Problem S5-105-3.

(a) Name three factors that would typically affect the base premium for a homeowner's insurance policy.

(b) Name two factors that may result in adjustments to the base premium for a homeowner's insurance policy.

(c) Name two factors on the basis of which final adjustments may be made to the premium for a homeowner's insurance policy.

Solution S5-105-3. This problem is based on the discussion in *Personal Insurance*, pp. 5.6-5.8.

(a) The following factors frequently affect the base premium for a homeowner's insurance policy:

1. Location of the home;
2. Public protection class (numbered from 1 to 10, with 1 being the best rating; this value reflects the home's proximity to the nearest responding fire department and the adequacy of the water
supply in the home's vicinity);
3. Construction factors (e.g., whether the home is of frame or masonry construction);
4. Coverage amount (i.e., how much coverage the insured requests);
5. Policy form used (e.g., an HO-5 would cost more than an HO-3, which would cost more than
an HO-2, all other things being equal).

Any three of the above suffice as an answer. Depending on any particular insurer's rating
structure, other valid answers may also be possible.

(b) The following factors may result in adjustments to the base premium for a homeowner's
insurance policy:

1. Endorsements that provide special credits or additional coverage;
2. Homes of unusual construction type - e.g., houses of superior construction;
3. Adjustments due to higher or lower deductibles than the default deductible level.

Any two of the above suffice as an answer. Depending on any particular insurer's rating
structure, other valid answers may also be possible.

(c) The following factors may result in final adjustments being made to the premium for a
homeowner's insurance policy:

1. The insured's claim history;
2. The property's claim history;
3. The insured's credit-based insurance score (controversial in many states and prohibited in a
few);
4. Package policy credits/discounts - given to insureds who have multiple policies with the same
insurer.

Any two of the above suffice as an answer. Depending on any particular insurer's rating
structure, other valid answers may also be possible.

Problem S5-105-4.

(a) In addition to the named insured, what other three classes of persons fall under the definition
of an "insured" within HO-3 homeowners' insurance policies?

(b) Name three criteria, any of which can be met in order for a location to be classified as
"residence premises" under HO-3 homeowners' insurance policies.

Solution S5-105-4. This problem is based on the discussion in Personal Insurance, p. 5.11.

(a) The following three classes of persons fall under the definition of an "insured" within HO-3
homeowners' insurance policies:
1. "Relatives who are residents of the named insured's household";
2. "Other persons under the age of 21 in the care of a named insured or a resident relative";
3. "A full-time student who lives away from home but resided in the household before leaving to attend school".

(b) Any of the following criteria can be met in order for a location to be considered as "residence premises":

1. "The 1-to-4-family dwelling where the named insured resides in at least one of the units";
2. "That part of any other building (such as an apartment building) where the named insured resides";
3. "Other structures and grounds at that location".

Problem S5-105-5. Personal Insurance, p. 5.12, discusses the following coverages available under HO-3 homeowners' insurance policies: A, B, C, D, E, and F. Match each of the following coverage names to the correct letter denoting the coverage. To achieve the greatest benefit from this problem, try to solve it from memory.

(i) Medical Payments to Others
(ii) Personal Property
(iii) Personal Liability
(iv) Other Structures
(v) Dwelling
(vi) Loss of Use

Solution S5-105-5.

(i) Medical Payments to Others = Coverage F.
(ii) Personal Property = Coverage C.
(iii) Personal Liability = Coverage E.
(iv) Other Structures = Coverage B.
(v) Dwelling = Coverage A.
(vi) Loss of Use = Coverage D.
Section 106

Elements of Typical Homeowners' Insurance Policies – Part 2

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**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-106-1.** Mr. Π's HO-3 homeowner's insurance policy has a Coverage A limit of $200,000, a Coverage B limit that is 10% of the Coverage A limit, a Coverage C limit that is 50% of the Coverage A limit, and a Coverage D limit that is 30% of the Coverage A limit.

Mr. Π suffers a loss that includes the following components:
1. A $160,000 loss to his house;
2. A $25,000 loss to his tool shed next to his house;
3. A $40,000 loss to personal property in his house;
4. $70,000 of financial loss because the house was not fit to live in for some time.

How much will Mr. Π be reimbursed in total by the insurer under this policy?

**Solution S5-106-1.** This question is based on the discussion on p. 5.13 of *Personal Insurance*.

The limit for each coverage is independent of the amount paid under any other coverage.

The $160,000 loss to Mr. Π's house is covered under Coverage A and is less than the Coverage A limit, so the insurer will pay the full amount of the loss.
Mr. Π's Coverage B limit is 10% of his Coverage A limit and is thus $20,000. His loss to his tool shed next to his house is covered under Coverage B, but only $20,000 of the $25,000 loss will be reimbursed to him.

Mr. Π's Coverage C limit is 50% of his Coverage A limit and is thus $100,000. His $40,000 loss to his personal property is covered under Coverage C and is less than the Coverage C limit, so the insurer will pay the full amount of the loss.

Mr. Π's Coverage D limit is 30% of his Coverage A limit and is thus $60,000. His financial loss because the house was not fit to live in is covered under Coverage D, but only $60,000 of the $70,000 loss will be reimbursed to him.

Thus, Mr. Π will be reimbursed a total of $160,000 + $20,000 + $40,000 + $60,000 = $280,000.

**Problem S5-106-2.** For each of the following structures, identify whether it will be covered under Coverage A: Dwelling, under Coverage B: Other Structures, or under neither coverage of an HO-3 homeowner's insurance policy.

(a) A gatehouse on the insured's property, which the insured has converted into a commercial lemonade stand
(b) A deck attached to the insured's house
(c) A tool shed on the insured's property, containing tools for use in the insured's house
(d) A barn on the insured's property, connected to the insured's house by a fence
(e) The garage within the insured's house
(f) A stack of roof tiles that the insured keeps in the backyard of his house and intends to use for the repair of his roof
(g) A cottage on the insured's property, which is rented by another individual who does not reside in the insured's house
(h) A private garage on the insured's property, which is rented by another individual who does not reside in the insured's house
(i) Land on the insured's residence premises

**Solution S5-106-2.** This question is based on the discussion on p. 5.14 of *Personal Insurance.*

(a) A gatehouse on the insured's property, which the insured has converted into a commercial lemonade stand **will not be covered under either coverage.**
(b) A deck attached to the insured's house **will be covered under Coverage A.**
(c) A tool shed on the insured's property, containing tools for use in the insured's house, **will be covered under Coverage B.**
(d) A barn on the insured's property, connected to the insured's house by a fence, **will be covered under Coverage B.**
(e) The garage within the insured's house **will be covered under Coverage A.**
(f) A stack of roof tiles that the insured keeps in the backyard of his house and intends to use for the repair of his roof **will be covered under Coverage A.**
(g) A cottage on the insured's property, which is rented by another individual who does not reside in the insured's house, **will not be covered under either coverage.**
(h) A private garage on the insured's property, which is rented by another individual who does not reside in the insured's house, will be covered under Coverage B.

(j) Land on the insured's residence premises will not be covered under either coverage.

Problem S5-106-3.

(a) Name three situations in which Coverage C: Personal Property of an HO-3 homeowner's insurance policy will provide coverage for personal property, other than the insured's personal property located at the insured's residence.

(b) Name a situation in which Coverage C: Personal Property of an HO-3 homeowner's insurance policy will provide coverage for personal property with only a small percentage (e.g., 10%) of the Coverage C limit being applicable.

Solution S5-106-3. This problem is based on the discussion on p. 5.15 of Personal Insurance.

(a) Coverage C will provide coverage for the following:
1. The insured's personal property anywhere in the world;
2. Property borrowed and used by the insured;
3. "Personal property owned by others while it is on the residence premises," if the named insured requests coverage for this property after a loss;
4. "Damage or loss of personal property owned by a guest or residence employee while the property is in any residence occupied by the insured," if the named insured requests coverage for this property after a loss;
5. The insured's property that has been moved to another residence, for 30 days after the insured begins moving from one principal residence to another;
6. Personal property being moved from the insured's residence "because the house is being repaired, renovated, or rebuilt and is not fit to live in or store property in";
7. "Property kept by an insured in a self-storage warehouse".

Any three of the above suffice as an answer. Other valid answers may also be possible.

(b) Coverage C: Personal Property will provide coverage for personal property with only a small percentage (e.g., 10%) of the Coverage C limit being applicable in situations where property is located at a residence other than the residence listed on the declarations page. This does not apply if the residence premises are being repaired, rebuilt, or renovated and are not fit to store property in or live in. Moreover, this does not apply during the 30-day period in which an insured is moving from one principal residence to another.

Problem S5-106-4. List ten types of property that might be subject to special sublimits under Coverage C: Personal Property in HO-3 homeowners' insurance policies.

Solution S5-106-4. This question is based on the discussion on p. 5.16 of Personal Insurance.

Special sublimits often apply to the following:
1. Money;
2. Precious metals;
3. Gift cards and other stored value cards;
4. Securities;
5. Documents and records - including the cost to research and replace lost information;
6. Stamps;
7. "Watercraft, including trailers, equipment, and motors";
8. Trailers not used with watercraft;
9. Jewelry (only if stolen);
10. Furs (only if stolen);
11. Firearms and related items (only if stolen);
12. Silverware, goldware, platinumware, and pewterware (only if stolen);
13. "Property on the residence premises used primarily for any business purpose";
14. "Electronic apparatus and accessories equipped to be operated by power from a motor vehicle, while in or upon a motor vehicle";
15. "Electronic apparatus equipped to be operated by power from a motor vehicle, used primarily for business while away from the residence premises but not in or upon a motor vehicle".

Any ten of the above suffice as an answer. Depending on the particular insurance policy, other valid answers may also be possible.

Problem S5-106-5. List five types of personal property for which no coverage is typically provided under Coverage C: Personal Property of an HO-3 homeowner's insurance policy.

Solution S5-106-5. This question is based on the discussion on p. 5.17 of Personal Insurance.

The following types of personal property are typically excluded from coverage under Coverage C:

1. Aircraft;
2. Hovercraft;
3. Animals;
4. Articles insured elsewhere;
5. Motor vehicles that need to be registered, including parts and "electronic equipment that operates solely from the vehicle's electrical system while in the vehicle";
6. "Property of roomers and boarders unrelated to the insured";
7. "Property in an apartment rented to others";
8. "Property rented or held for rental to others off the residence premises";
9. Business data in electronic or paper form;
10. Credit card or electronic funds transfer card;
11. Water or steam.

Any five of the above suffice as an answer. Depending on the particular insurance policy, other valid answers may also be possible.
Section 107

Elements of Typical Homeowners' Insurance Policies – Part 3

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**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-107-1.** What three coverages are grouped under Coverage D: Loss of Use within HO-3 homeowners' insurance policies? Name and define these coverages.

**Solution S5-107-1.** This question is based on the discussion in *Personal Insurance*, pp. 5.17-5.18.

Coverage D: Loss of Use encompasses the following three coverages:

1. **Additional living expense** - applies to any necessary *increase* in expenses that enables a family to maintain its former standard of living if the house is not fit to live in.

2. **Fair rental value** - applies to any part of a residence that is rented out to others and is not fit to live in, resulting in loss of rental income.

3. **Loss of use due to civil authority** - applies if the owner's property is not actually damaged, but civil authorities prohibit its use because of extensive damage to nearby properties.

**Problem S5-107-2.** *Personal Insurance*, pp. 5.18-5.20, discusses 12 additional coverages available under HO-3 homeowners' insurance policies:
1. Debris Removal
2. Reasonable Repairs
3. Trees, Shrubs, and Other Plants
4. Fire Department Charge
5. Property Removed
6. Credit Card, Electronic Fund Transfer Card or Access Device, Forgery, and Counterfeit Money
7. Loss Assessment
8. Collapse
9. Glass or Safety Glazing Material
10. Landlord's Furnishings
11. Ordinance or Law
12. Grave Markers

(a) For each of these coverages, identify whether the coverage creates an additional limit.

(b) For each of these coverages, identify whether the deductible applies to the total loss from a covered event.

(c) For each of these coverages, state whether either (i) another loss from a covered peril must occur for the coverage to apply, (ii) the loss in question must be due to a covered peril, but another covered loss need not occur, (iii) there must be a threat of a covered peril but an actual peril need not occur, or (iv) there are no requirements vis-à-vis covered perils, and the loss in question is covered on the basis of its own nature.

Solution S5-107-2.

(a) Of these coverages, the following create an additional limit:

1. Debris Removal
3. Trees, Shrubs, and Other Plants
4. Fire Department Charge
6. Credit Card, Electronic Fund Transfer Card or Access Device, Forgery, and Counterfeit Money
7. Loss Assessment
11. Ordinance or Law

For the other coverages, no additional limit is created.

(b) For the following coverages, the deductible applies to the total loss from a covered event:

1. Debris Removal
2. Reasonable Repairs
3. Trees, Shrubs, and Other Plants
5. Property Removed
9. Glass or Safety Glazing Material
10. Landlord's Furnishings
11. Ordinance or Law
12. Grave Markers

For the other coverages, no deductible applies.

(c) (i) For the following coverages, another loss from a covered peril must occur for the coverage to apply:

1. Debris Removal
2. Reasonable Repairs
7. Loss Assessment (there must be loss from a covered peril to the property of the association, but not necessarily to the property of the insured)
11. Ordinance or Law

(ii) For the following coverages, the loss in question must be due to a covered peril, but another covered loss need not occur:

8. Collapse
9. Glass or Safety Glazing Material

(iii) For the following coverages, there must be a threat of a covered peril but an actual peril need not occur:

4. Fire Department Charge
5. Property Removed

(iv) For the following coverages, there are no requirements vis-à-vis covered perils, and the loss in question is covered on the basis of its own nature:

3. Trees, Shrubs, and Other Plants
6. Credit Card, Electronic Fund Transfer Card or Access Device, Forgery, and Counterfeit Money
10. Landlord's Furnishings
12. Grave Markers

Problem S5-107-3. Name seven perils that are typically excluded from coverage under Coverage A: Dwelling and Coverage B: Other Structures within an HO-3 homeowner's insurance policy.

Solution S5-107-3. This question is based on the discussion in Personal Insurance, pp. 5.21-5.23. The following exclusions typically exist for Coverage A and Coverage B:

1. Collapse - excluded as a cause, but collapse from other covered causes of loss is covered;
2. "Freezing of a plumbing, heating, air conditioning or sprinkler system, or a household
appliance";
3. "Freezing, thawing, pressure, or weight of water or ice";
4. Theft of construction materials;
5. "Vandalism and malicious mischief to vacant dwellings";
6. Mold, fungus, and wet rot - unless the problem in question is hidden and the loss results from "an accidental leak of water or steam" from certain sources;
7. "Smoke from agricultural smudging or industrial operations";
8. Pollutants;
9. Settling of the dwelling;
10. Animals;
11. Natural deterioration.

Any seven of the above suffice as an answer. Other valid answers may also be possible.

**Problem S5-107-4.** Explain the manner of application of the water damage coverage exception to exclusions for certain kinds of coverage under Coverage A and Coverage B of HO-3 homeowners' insurance policies.

**Solution S5-107-4.** This question is based on the discussion in *Personal Insurance*, pp. 5.23-5.24.

The water damage exception applies when water or steam is accidentally discharged from any of the following:

1. A plumbing system;
2. A heating system;
3. An air conditioning system;
4. A sprinkler system;
5. A "household appliance on the residence premises";
6. A storm drain;
7. "Water, steam or sewer pipe off the residence premises".

Damage by the water to the building and to other structures is covered in such cases. The cost of repairs to the building and other structures is also covered. *However*, the damage to the damaged appliance or system itself (i.e., the damage to the source of the water) would not be covered.

**Problem S5-107-5.** What is the fundamental difference between the manner in which coverage is provided (i) under Coverage A and Coverage B of an HO-3 policy and (ii) under Coverage C of an HO-3 policy? (Note that this question is asking not *what*, in particular, is covered, but *how* these coverage parts treat the issue of the applicability of coverage.)

**Solution S5-107-5.** Coverage A: Dwelling and Coverage B: Other Structures provide *open perils* coverage, meaning that coverage is provided for every peril that is not specifically listed as being excluded. Coverage C: Personal Property provides *named perils* coverage, meaning that *only* the perils specifically listed are covered.
Section 108

Elements of Typical Homeowners' Insurance Policies – Part 4

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Source:

Original Problems and Solutions from The Actuary's Free Study Guide

**Problem S5-108-1.** Name ten named perils that are typically covered under Coverage C: Personal Property of an HO-3 homeowner's insurance policy.

**Solution S5-108-1.** This question is based on the discussion in *Personal Insurance*, pp. 5.25-5.27. The following named perils are typically covered under Coverage C:

1. Fire or lightning;
2. Windstorm or hail;
3. Explosion;
4. Riot or civil commotion;
5. Aircraft;
6. Vehicles;
7. Smoke;
8. Vandalism or malicious mischief;
9. Theft;
10. Falling objects;
11. Weight of ice, snow, or sleet;
12. "Accidental discharge or overflow of water or steam";
13. "Sudden and accidental tearing apart, cracking, burning, or bulging";
14. Freezing - "if the insured has taken reasonable precautions to maintain the heat or has shut off and drained the system or appliances";
15. "Sudden and accidental discharge from artificially generated electrical current";
16. Volcanic eruption.

Any ten of the above suffice as an answer.

**Problem S5-108-2.**

(a) List the nine exclusions that would apply to all coverages under Section I of a typical HO-3 homeowner's insurance policy.

(b) List the three exclusions that would specifically apply to Coverage A: Dwelling and Coverage B: Personal Property of a typical HO-3 homeowner's insurance policy.

**Solution S5-108-2.** This question is based on the discussion in *Personal Insurance*, pp. 5.27-5.34.

(a) The following nine exclusions would apply to all coverages under Section I of a typical HO-3 homeowner's insurance policy:

1. Ordinance or Law;
2. Earth Movement;
3. Water Damage;
4. Power Failure;
5. Neglect;
6. War;
7. Nuclear Hazard;
8. Intentional Loss;

(b) The following three exclusions would specifically apply to Coverage A: Dwelling and Coverage B: Personal Property of a typical HO-3 homeowner's insurance policy:

1. Weather conditions;
2. "Acts or decisions of any person, group, organization, or governmental body";
3. Faulty workmanship.

**Problem S5-108-3.**

(a) What are the two purposes of the Insurable Interest and Limit of Liability condition in Section I of a typical HO-3 homeowner's insurance policy?

(b) Name five duties that an insured may have pursuant to the Your Duties After Loss condition in Section I of a typical HO-3 homeowner's insurance policy.

**Solution S5-108-3.** This question is based on the discussion in *Personal Insurance*, pp. 5.35-5.36.
(a) The following are the two purposes of the Insurable Interest and Limit of Liability condition in Section I of a typical HO-3 homeowner's insurance policy:

1. To limit the maximum payments for any single loss to the relevant limits shown on the declaration page.
2. To limit "loss payment to any insured to the extent of that insured's insurable interest in the property at the time of the loss".

(b) The following are the duties that an insured may have pursuant to the Your Duties After Loss condition in Section I of a typical HO-3 homeowner's insurance policy:

1. Giving prompt notice of loss to the insurer;
2. Notifying the policy if the loss is by theft;
3. Notifying the credit card company, electronic fund transfer (EFT) company, or access device company, if the loss involves a credit card, EFT device, or access device;
4. Protecting the property from further damage;
5. Cooperating with the insurer;
6. Preparing an inventory of damaged personal property;
7. Verifying the loss - including allowing an insurer to make copies of documents and to submit to examination under oath, if requested to do so;
8. Signing a sworn proof of loss;

Any five of the above suffice as an answer.

Problem S5-108-4.

(a) Under the Loss Settlement condition in Section I of a typical HO-3 homeowner's insurance policy, losses to personal property under Coverage C are settled on the basis of the lesser of which of two amounts?

(b) Mr. Σ's chair was destroyed in a fire and is a covered loss under Coverage C of his homeowner's insurance policy. No deductible applies to the loss. It would cost $200 to purchase an identical chair at today's market price. 12 years ago, the chair cost $500 and was depreciated using the straight-line method, assuming that the useful life of the chair is 18 years. How much will Mr. Σ be reimbursed for the chair?

Solution S5-108-4. This question is based on the discussion in Personal Insurance, p. 5.37.

(a) Under the Loss Settlement condition in Section I of a typical HO-3 homeowner's insurance policy, losses to personal property under Coverage C are settled on the basis of the lesser of

1. Actual cash value (ACV) of the damaged items at the time of the loss and
2. The cost to repair or replace the damaged items.

(b) It is given that the replacement cost of the chair is $200. Since the chair is depreciated in a straight-line fashion, it incurs the same dollar amount of depreciation per year. The annual
depreciation is $500/(18 \text{ years}) = 27.8888888. After 12 \text{ years} have passed, there are 6 \text{ years} left for the chair to depreciate, so the actual \text{ cash value} of the chair prior to its destruction was $27.8888888 \times 6 = 166.66666667 < 200, \text{ so the insurer will pay Mr. } \Sigma \text{ $166.67} - \text{ the } \text{ACV of the chair.}

\textbf{Problem S5-108-5.} Mrs. Ω owns a set of three statuettes made by the same sculptor. The statuettes are more valuable together than they are individually. The statuettes are insured by Mrs. Ω under Coverage C: \text{Personal Property} of an HO-3 homeowner's insurance policy. The following information is known:

A single statuette in Mrs. Ω's possession would have an actual \text{cash value} (ACV) of $500. Any two statuettes in Mrs. Ω's possession would have a combined ACV of $1500. All three statuettes in Mrs. Ω's possession would have a combined ACV of $5000.

The sculptor of the statuettes is able to make exact reproductions of each statuette, and doing this would always cost $3000 per statuette.

(a) What would the insurer do if all three statuettes were lost due to a covered loss?

(b) What would the insurer do if two of the three statuettes were lost due to a covered loss?

(c) What would the insurer do if one of the statuettes were lost due to a covered loss?

\textbf{Solution S5-108-5.} This question is based on the discussion in \textit{Personal Insurance}, pp. 5.37, 5.39. The policy conditions that would apply here would be \text{Loss Settlement}, as well as \text{Loss to a Pair or Set}.

\textbf{(a)} In this case, the \text{Loss Settlement} condition applies, as if the set of statuettes were a single unit. The insurer would pay the lesser of ACV and replacement cost. Here, the ACV of the statuettes is $5000, whereas the replacement cost for all three is $3000 \times 3 = $9000, so the insurer would pay $5000 to Mrs. Ω.

\textbf{(b)} Here, the \text{Loss to a Pair or Set} condition applies, and the insurer would have the choice of either replacing the missing statuettes (at a cost of $2 \times 3000 \times 3 = $6000) or paying Mrs. Ω the difference between the ACV of the entire set and the ACV of the remaining statuette (at a cost of $5000 - 500 = $4500). Since $4500 < 6000, the insurer would pay $4500 to Mrs. Ω.

\textbf{(c)} Here, the \text{Loss to a Pair or Set} condition applies, and the insurer would have the choice of either replacing the missing statuette (at a cost of $3000) or paying Mrs. Ω the difference between the ACV of the entire set and the ACV of the remaining two statuettes (at a cost of $5000 - 1500 = $3500). Since $3000 < 3500, the insurer would replace Mrs. Ω's missing statuette. The information given suggests that the insurer would hire the original sculptor and pay the sculptor $3000.
Section 109

Elements of Typical Homeowners' Insurance Policies – Part 5

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**Source:**

**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-109-1.**

(a) Under the Appraisal condition of a typical HO-3 homeowner's insurance policy, how is a determination of the amount of the loss made if the insurer and the insured disagree?

(b) Under the Appraisal condition of a typical HO-3 homeowner's insurance policy, who pays the various entities involved in the appraisal process?

**Solution S5-109-1.** This problem is based on the discussion in *Personal Insurance*, p. 5.39.

(a) If the insurer and insured disagree as to the amount of the loss, under the Appraisal condition, each party will select its own appraiser, and the appraisers will prepare independent estimates of the amount of the loss. If the two appraisers disagree, they would submit their disagreement to an umpire. Any decision reached by two of these three individuals will determine the official amount of the loss.

(b) The insurer and the insured each pay the costs of the appraiser they hire. The cost of the umpire is shared between the insurer and the insured.

**Problem S5-109-2.** Mr. Omicron's chair is covered under a warranty that will pay for any loss to the chair of up to $300. Mr. Omicron also has two HO-3 homeowners' insurance policies. Policy
X has a deductible of $500 and a Coverage C: Personal Property limit of $50,000. Policy Y has a deductible of $200 and a Coverage C: Personal Property limit of $100,000.

When Mr. Omicron's chair was destroyed by a windstorm, it was determined that the chair was in fact a valuable collectible item with an actual cash value of $30,000.

(a) How much will Mr. Omicron be reimbursed for the loss of the chair under Policy X?

(b) How much will Mr. Omicron be reimbursed for the loss of the chair under Policy Y?

Solution S5-109-2. This problem is based on the discussion in Personal Insurance, p. 5.40.

The relevant policy conditions here are the Service Agreement and Other Insurance conditions. The Service Agreement condition states that the HO-3 policy is excess over any applicable service plan or warranty. Thus, the warranty will pay Mr. Omicron $300, and the remaining amount of the loss: $29,700, is the only amount that even needs to be considered with regard to reimbursements under the insurance policies.

(a) The Other Insurance condition specifies that losses between two applicable insurance policies will be shared proportionally according to those policies' limits.

For Policy X, the reimbursable loss will be 29700*(50000/(50000 + 150000)) = $9,900. From this, the deductible of $500 is subtracted, meaning that Policy X will reimburse Mr. Omicron in the amount of $9,400.

(b) The Other Insurance condition specifies that losses between two applicable insurance policies will be shared proportionally according to those policies' limits.

For Policy Y, the reimbursable loss will be 29700*(100000/(50000 + 150000)) = $19,800. From this, the deductible of $200 is subtracted, meaning that Policy Y will reimburse Mr. Omicron in the amount of $19,600.

Problem S5-109-3.

(a) Under a typical HO-3 homeowner's insurance policy, in what situations may an insured bring a legal suit against the insurer?

(b) Mrs. Ψ's lamp is destroyed in a fire, and Mrs. Ψ files a claim for the lamp under her HO-3 policy, hoping to get reimbursed the actual cash value of the lamp, for which she can purchase a new table instead. However, instead of receiving monetary compensation, Mrs. Ψ receives from her insurer a lamp that is identical to the lamp that was destroyed. Upset, Mrs. Ψ alleges that the insurer has violated the terms of the policy. Is she correct?

Solution S5-109-3. This problem is based on the discussion in Personal Insurance, pp. 5.40-5.41.
(a) Under a typical HO-3 homeowner's insurance policy, an insured may only bring a legal suit against the insurer if (1) the insured has complied with all policy provisions and (2) action on the suit is started no more than two years after the loss occurred.

(b) Mrs. Ψ is not correct. The Our Option condition of a typical HO-3 homeowner's insurance policy gives the insurer the ability to choose whether to reimburse the insured for the damaged property, or to repair or replace the property.

Problem S5-109-4.

(a) Mr. Retsim owns a house which is completely destroyed in a fire. He was reimbursed by the insurer for the actual cash value of the house under his HO-3 homeowner's insurance policy. He does not want to clean up the debris left over from the fire, and he does not want to incur the liability of children playing in the rubble. Thus, he reasons that because the insurer paid him for a total loss, the insurer now necessarily owns the property, and Mr. Retsim can walk away with no further obligations. Is he correct?

(b) What rights would a mortgagee have under a typical mortgage clause in an HO-3 homeowner's insurance policy?

Solution S5-109-4. This problem is based on the discussion in Personal Insurance, p. 5.41.

(a) Mr. Retsim is not correct. The Abandonment of Property condition of a typical HO-3 homeowner's insurance policy explicitly states that the insurer is not required to take responsibility for a property that the insured abandons, even if the insurer has paid for a total loss to that property.

(b) Under a typical mortgage clause in an HO-3 homeowner's insurance policy, the mortgagee has the following right:

1. The right to have payment for a loss be made jointly to the mortgagee and the insured;

2. The right to collect from the insurer the mortgagee's insurable interest in the property if the insurer denies the insured's loss;

3. The right to receive notice of policy cancellation or nonrenewal a specified number of days before said cancellation or nonrenewal would take effect.

Problem S5-109-5.

(a) A nuclear power plant accident results in a fire that damages Mr. Δ's house. Mr. Δ has a typical HO-3 homeowner's insurance policy, but his insurer denies him coverage for the loss, referring to the nuclear hazard exclusion in the policy. Mr. Δ contests this decision and argues that he actually has coverage for the loss. Is he correct?
(b) Mr. Onaclov's HO-3 homeowner's insurance policy covers his dwelling up to a limit of $400,000. His deductible is $1000. There is no coinsurance penalty. There are five volcanic eruptions in short succession:

Eruption 1 causes $50,000 in damage to Mr. Onaclov's house.

Eruption 2 occurs 5 hours after Eruption 1 and causes $200,000 in damage to the house.

Eruption 3 occurs 50 hours after Eruption 1 and causes $200,000 in damage to the house.

Eruption 4 occurs 100 hours after Eruption 1 and causes $70,000 in damage to the house.

Eruption 5 occurs 123 hours after Eruption 1 and causes $50,000 in damage to the house.

How much will Mr. Onaclov receive from the insurer?

Solution S5-109-5. This problem is based on the discussion in *Personal Insurance*, p. 5.42-5.43.

(a) Mr. Δ is correct. The Nuclear Hazard Clause in a typical HO-3 homeowner's insurance policy specifically state that there exists coverage for direct losses from a fire that results from a nuclear hazard.

(b) According to the Volcanic Eruption Period condition of a typical HO-3 homeowner's insurance policy, multiple volcanic eruptions within a single 72-hour period are considered to be one eruption for the purposes of applying coverage limits and deductibles. The first three eruptions occurred within a 72-hour period and so are considered one eruption. Likewise, Eruptions 4 and 5 occurred within a 72-hour period of one another and so are considered one eruption.

For Eruptions 1, 2, and 3, the total loss is $50,000 + $200,000 + $200,000 = $450,000. Of this amount, Mr. Onaclov only receives coverage up to the limit of $400,000, minus the deductible of $1000 - a total of $399,000.

For Eruptions 4 and 5, the total loss is $70,000 + $50,000 = $120,000, minus the deductible of $1000 - a total of $119,000.

Thus, Mr. Onaclov will be reimbursed $399,000 + $119,000 = $518,000.
Section 110

Elements of Typical Homeowners' Insurance Policies – Part 6

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**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-110-1.** Under Coverage E: Personal Liability of a typical HO-3 homeowner's insurance policy (or any of the other HO forms), which persons are considered to be insureds?

**Solution S5-110-1.** This question is based on the discussion in *Personal Insurance*, p. 6.5. The following persons are considered to be insureds under Coverage E:

1. The policyholder (named insured) and the policyholder's spouse (or domestic partner, in some states), if the spouse/domestic partner resides in the same household;
2. Relatives of the named insured/spouse/domestic partner who reside in the same household;
3. "Residents of the household who are under the age of 21 and in the case of the named insured or resident relatives";
4. "A full-time student who resided in the household before moving out to attend school";
5. "Any person or organization legally responsible for animals or watercraft that are covered by the policy and owned by" any person in items 1-3 above;
6. "Anyone employed by a person defined" in items 1-3 above, "with respect to any motor vehicle covered by the policy";
7. "Other persons using any vehicle covered by the policy on an insured location, with the consent of the named insured or spouse," or domestic partner in some states.

**Problem S5-110-2.** (a) Under Coverage E: Personal Liability of a typical HO-3 homeowner's insurance policy (or any of the other HO forms), what is considered an "occurrence"?
(b) Under Coverage E: Personal Liability of a typical HO-3 homeowner's insurance policy (or any of the other HO forms), which individuals are considered to be "residence employees" who are covered for bodily injury and property damage liability?

**Solution S5-110-2.** This problem is based on the discussion in *Personal Insurance*, p. 6.6.

(a) Under Coverage E: Personal Liability of a typical HO-3 homeowner's insurance policy (or any of the other HO forms), an "occurrence" is "an accident, including continuous or repeated exposure to substantially the same general harmful conditions" (*Personal Insurance*, p. 6.6). The event in question can be sudden, gradual, or continuous, provided that it is fortuitous.

(b) Under Coverage E: Personal Liability of a typical HO-3 homeowner's insurance policy (or any of the other HO forms), a "residence employee" is a "person whose duties relate to the insured's residence" (*Personal Insurance*, p. 6.6). Not every person who is employed by the insured within the insured's house is a "residence employee"; the duties of a "residence employee" must involve "maintaining or using the household premises or performing domestic or household services" (*Personal Insurance*, p. 6.6).

**Problem S5-110-3.**

(a) What is the rationale behind Coverage F: Medical Payments to Others of a typical HO-3 homeowner's insurance policy (or any of the other HO forms), given that the same policy also covers bodily injury liability?

(b) What are the conditions under which Coverage F: Medical Payments to Others of a typical HO-3 homeowner's insurance policy (or any of the other HO forms) would apply?

**Solution S5-110-3.** This problem is based on the discussion in *Personal Insurance*, pp. 6.6-6.7.

(a) Coverage F: Medical Payments to Others will apply when the insured may not have a clear liability for an injury to another individual but may feel a moral obligation to pay for the costs of that injury. Coverage F provides a small limit (typically $1,000) for medical payments to others, under which payments for injuries will be made without consideration of fault.

(b) The following are the conditions under which Coverage F: Medical Payments to Others would apply (*Personal Insurance*, p. 6.7):

1. "The injury occurs to a person who has the insured's permission to be at the insured's location";
2. "The injured person is away from the insured location, and bodily injury arises out of a condition at the insured location or on property immediately adjoining the insured's location";
3. "A person is injured while away from the insured location by an activity performed by an insured";
4. "A person is injured away from the insured location by an insured's residence employee who, while off the insured premises and in the course of his or her employment for the insured, causes bodily injury";
5. "An individual is injured by an animal owned by or in the care of an insured while off the insured premises."

**Problem S5-110-4.**
(a) What four types of claim expenses are covered under the Claims Expenses additional coverage in Section II of a typical HO-3 homeowner's insurance policy (or any of the other HO forms)?
(b) Describe the situations covered under the First Aid Expenses additional coverage in Section II of a typical HO-3 homeowner's insurance policy (or any of the other HO forms).

**Solution S5-110-4.** This problem is based on the discussion in *Personal Insurance,* p. 6.8.

(a) The following four types of claim expenses are covered under the Claims Expenses additional coverage in Section II:

1. Expenses incurred by the insurer - such as legal representation during the course of a claim or suit;
2. Premium on any bonds required in defending a suit, but not in excess of the policy's Coverage E: Personal Liability limit;
3. "Reasonable expenses" if the insurer requires the insured's assistance in investigating or defending a claim or suit;
4. Postjudgment interest - interest on a judgment made against the insured that accumulates before the judgment is paid.

(b) The First Aid Expenses additional coverage applies to situations where the insured has incurred expenses because of rendering first aid to others for any bodily injury covered under the policy.

**Problem S5-110-5.**
(a) In what way is the Damage to Property of Others additional coverage in Section II of a typical HO-3 homeowner's insurance policy (or any of the other HO forms) analogous to Coverage F: Medical Payments to Others?
(b) Under what situations does the Damage to Property of Others additional coverage in Section II of a typical HO-3 homeowner's insurance policy (or any of the other HO forms) not apply? List three types of such situations.
(c) Describe the situations covered under the Loss Assessment additional coverage in Section II of a typical HO-3 homeowner's insurance policy (or any of the other HO forms).

**Solution S5-110-5.**

(a) The Damage to Property of Others additional coverage will pay for small amounts of property damage caused by an insured (up to a limit such as $1,000), regardless of legal liability or fault, in a manner analogous to how Coverage F: Medical Payments to Others will pay for small bodily injury costs regardless of legal liability or fault.
(b) The Damage to Property of Others additional coverage will not apply to any of the following situations (Personal Insurance, p. 6.9):

1. The damage is intentional and caused by an insured aged 13+ years;
2. The damaged property is owned by an insured;
3. The damaged property is owned by or rented to a resident of the named insured's household or a tenant of an insured;
4. "The damage arises out of a business engaged in by an insured";
5. "The damage is a result of an act or omission in connection with premises (other than an insured location) that the insured owns, rents, or controls";
6. "The damage arises out of the ownership, maintenance, or use of any motor vehicle, watercraft, aircraft, or hovercraft" other than an off-road recreational vehicle that is not owned by an insured and not required to be registered.

Any three of the above suffice as an answer. Other valid answers may be possible.

(c) The Loss Assessment additional coverage in Section II pays up to a small limit (e.g., $1,000) for an insured's share of a loss assessment that is charged by a property owners' association or a corporation because of the following losses (Personal Insurance, p. 6.9):

1. "Bodily injury or property damage that is not excluded under Section II of the homeowners' policy";
2. "Liability that results from an act of an elected and unpaid director, officer, or trustee".
Section 111

Elements of Typical Homeowners' Insurance Policies – Part 7

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**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-111-1.**

(a) Under the Motor Vehicle Liability exclusion in Section II of a typical HO-3 homeowner's insurance policy (or any of the other HO forms), what are the five types of excluded vehicles?

(b) Name five kinds of motor vehicle liability loss exposures that *would* be covered under Section II of a typical HO-3 homeowner's insurance policy (or any of the other HO forms).

**Solution S5-111-1.** This problem is based on the discussion in *Personal Insurance*, pp. 6.12-6.13.

(a) The following types of vehicles are excluded under Section II (*Personal Insurance*, p. 6.12):

1. Vehicles that the law requires to be registered on public roads or property;
2. Vehicles involved in organized racing;
3. Vehicles rented to others;
4. Vehicles used to carry cargo or persons for a charge;
5. Vehicles "used for any business purpose, except for motorized golf carts used on a golf course".
(b) The following types of motor vehicle liability loss exposures would be covered under Section II (Personal Insurance, p. 6.13):

1. "Motor vehicle in dead storage on an insured location";
2. "Motor vehicle used solely to service an insured's residence";
3. "Motor vehicle designed for assisting people who are handicapped";
4. "Motorized vehicle designed for recreational use off public roads and not owned by an insured";
5. "Motorized vehicle designed for recreational use off public roads and owned by an insured and on an insured location";
6. "Motorized golf cart, not capable of exceeding 25 miles per hour, owned by an insured, used to play golf on a golf course, or legally used within a private residential association";
7. "Trailer not towed by, hitched to, or carried on a motor vehicle".

Any five of the above items suffice as an answer.

Problem S5-111-2.

(a) Under the Watercraft Liability exclusion in Section II of a typical HO-3 homeowner's insurance policy (or any of the other HO forms), what are the four types of excluded watercraft?

(b) What are the only types of aircraft not excluded under the Aircraft Liability exclusion in Section II of a typical HO-3 homeowner's insurance policy (or any of the other HO forms)?

Solution S5-111-2. This problem is based on the discussion in Personal Insurance, pp. 6.13-6.16.

(a) The following types of watercraft are excluded under Section II (Personal Insurance, p. 6.14):

1. Watercraft involved in organized racing;
2. Watercraft rented to others;
3. Watercraft used to carry cargo or persons for a charge;
4. Watercraft used for any business purpose.

(b) The only types of aircraft not excluded under the Aircraft Liability exclusion in Section II are hobby aircraft and model airplanes (Personal Insurance, p. 6.16).

Problem S5-111-3. For each of the following exclusions, identify whether the exclusion applies only to Coverage E: Personal Liability, only to Coverage F: Medical Payments, or to both Coverage E and Coverage F of a typical HO-3 homeowner's insurance policy (or any of the other HO forms).

(a) Communicable Disease
(b) Loss Assessment and Contractual Liability
(c) War
(d) Residence Employee Off Premises
(e) Bodily Injury to an Insured
(f) Expected or Intended Injury
(g) Business
(h) Injury to Residents

Solution S5-111-3. This problem is based on the discussion in Personal Insurance, pp. 6.16-6.22.

The following Section II exclusions apply only to Coverage E:

(b) Loss Assessment and Contractual Liability
(e) Bodily Injury to an Insured

The following Section II exclusions apply only to Coverage F:

(d) Residence Employee Off Premises
(h) Injury to Residents

The following Section II exclusions apply to both Coverage E and Coverage F:

(a) Communicable Disease
(c) War
(f) Expected or Intended Injury
(g) Business

Problem S5-111-4.

(a) What are four types of activities that are not excluded under the Business exclusion applicable to Section II of a typical HO-3 homeowner's insurance policy (or any of the other HO forms)?

(b) What three types of common rental situations are not excluded under the Business exclusion applicable to Section II of a typical HO-3 homeowner's insurance policy (or any of the other HO forms)?

Solution S5-111-4. This problem is based on the discussion in Personal Insurance, pp. 6.17-6.18.

(a) The following four types of activities that are not excluded under the Business exclusion applicable to Section II (Personal Insurance, p. 6.17):

1. "Activities for which the insured received $2,000 or less during the year preceding the policy period";
2. Volunteer activities;
3. "Home daycare services not involving compensation, but possibly involving an exchange of
services"; 
4. "Home daycare services rendered to a relative".

(b) The following three types of common rental situations are not excluded under the Business exclusion applicable to Section II (*Personal Insurance*, pp. 6.17-6.18):

1. "Rental of an insured location on an occasional basis" - if the location is only used as a residence;
2. "Rental of part of an insured location as a residence... as long as the occupying family takes no more than two roomers or boarders in a single-family unit";
3. "Rental of part of an insured location... if it is used only as an office or a school, studio, or private garage."

**Problem S5-111-5.**

(a) Section II of a typical HO-3 homeowner's insurance policy (or any of the other HO forms) excludes coverage for liability due to most contracts. What are the two types of contracts for which coverage may be provided, if it is not excluded elsewhere in the policy?

(b) For what two situations would coverage *not be excluded* to a residence employee of the insured under Coverage F: Medical Payments of a typical HO-3 homeowner's insurance policy (or any of the other HO forms)?

**Solution S5-111-5.** This problem is based on the discussion in *Personal Insurance*, pp. 6.20-6.22.

(a) Coverage under Section II may be provided for the following two types of contracts (*Personal Insurance*, p. 6.20):

1. "Contracts relating to the ownership, maintenance, or use of an insured location";
2. "Liability of others assumed by the named insured before an accident occurs".

(b) Coverage F would not exclude coverage for the following situations (*Personal Insurance*, p. 6.22):

1. "The residence employee is away from the insured location, but is working" in some capacity for the insured;
2. "The residence employee is on the insured location". Note that this situation does not require the residence employee to be working.
Section 112

Insurance Non-Pricing Changes and Rating Changes Aimed at Achieving Rate Adequacy

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Source:

Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-112-1. If an insurance company's current rates are not adequate to pay for expected losses, expenses, and the company's profit provision, name four non-pricing solutions that the company can implement in an attempt to correct this. (Assume that the company may not change its rates.)

Solution S5-112-1. This question is based on the discussion in Werner and Modlin, pp. 259-260.

The following are non-pricing solutions for inadequate rates:

1. Reducing the marketing budget (this reduces expenses);

2. Reducing staff levels (this reduces expenses);

3. Imposing more stringent underwriting requirements (this may reduce losses to a greater extent than premium would be reduced);

4. Non-renewing particularly risky policies (this may reduce losses to a greater extent than premium would be reduced);
5. Narrowing or excluding coverage for previously covered perils (this may reduce losses payable by the insurer);

6. Instituting superior loss control procedures (this may reduce losses);

7. Reducing the company's profit provision and waiting until the external situation improves.

Any four of the above suffice as an answer. Other valid answers may also be possible.

**Problem S5-112-2.** An insurance company has a policy fee built into its rating algorithm. The average fixed expense per policy is $70. The company also has a profit provision of 7% and variable expenses of 20% of premium. Based on the information above, what should be the magnitude of the policy fee charged by the company?

**Solution S5-112-2.** This question is based on the discussion in Werner and Modlin, p. 262. The variable expense percentage and profit percentage are distributed throughout all components of the rate, including the fixed policy fee. This is expressed by Werner and Modlin via the formula \( A_P = \frac{E_F}{1.0 - V - QT} \), where \( A_P \) is the policy fee, \( E_F \) is the fixed expense amount, \( V \) is the variable expense percentage, and \( QT \) is the profit percentage. Here, \( A_P = \frac{70}{1 - 0.2 - 0.07} = 95.89041096 = \$95.89 \).

**Problem S5-112-3.** An insurance company uses the premium-based projection method, under which it estimates fixed expenses as being 5% of the premium for a policy. The projected average premium per exposure is $440, and the company's variable expense percentage is 18%. The company has also selected a profit provision of 6%. An insurance company has a policy fee built into its rating algorithm. Based on the information above, what should be the magnitude of the policy fee charged by the company?

**Solution S5-112-3.** This question is based on the discussion in Werner and Modlin, pp. 262-263. Where the premium-based projection method is used, the formula \( A_P = \frac{E_F}{1.0 - V - QT} \) still applies, but \( E_F \) must be estimated as \( (\text{Fixed Expense Ratio}) \times (\text{Average Premium Per Exposure}) = 0.05 \times 440 = \$22 \) in this case. Here, \( V = 0.18 \), and \( QT = 0.06 \). Thus, \( A_P = 22/(1 - 0.18 - 0.06) = 28.94736842 = \$28.95 \).

**Problem S5-112-4.** An insurance company is using the extension of exposures method to change its base rate in order to achieve an average premium of $600. The company's rating structure incorporates a fixed policy fee of $50. To begin the determination of what the base rate should be, the company uses a "seed" base rate of $200.

The company's current book of business contains 5 insureds, for whom the amounts of premium, if the "seed" base rate were used, would be as follows: $400, $500, $215, $736, $121.

Using the extension of exposures method, what should the company's proposed base rate be?

**Solution S5-112-4.** This question is based on the discussion in Werner and Modlin, pp. 263-265.
Using the "seed" base rate, the average premium would be \((400 + 500 + 215 + 736 + 121)/5 = 394.4\). The company wishes to achieve an average premium of $600.

We use the formula \(B_P = B_S^*\left(\frac{P_P - A_P}{P_S - A_P}\right)\), where \(B_P\) is the desired base rate, \(B_S\) is the "seed" base rate, \(P_P\) is the desired average premium, \(P_S\) is the average premium given the "seed" base rate, and \(A_P\) is the fixed policy fee. Thus, here, \(B_P = 200*(600 - 50)/(394.4 - 50) = 319.3960511\).

**Problem S5-112-5.** An insurance company is using the loss ratio method to achieve an average premium decrease of 8% from its current average premium of $900. The company's rating structure incorporates a fixed policy fee of $120. To begin the determination of what the base rate should be, the company uses a "seed" base rate of $400.

The company's current book of business contains 4 insureds, for whom the amounts of premium, if the "seed" base rate were used, would be as follows: $801, $410, $610, $1243.

Using the extension of exposures method, what should the company's proposed base rate be?

**Solution S5-112-5.** This question is based on the discussion in Werner and Modlin, p. 267.

Using the "seed" base rate, the average premium would be \((801 + 410 + 610 + 1243)/4 = $766\).

The company desires to decrease its average premium to \(900*(1 - 0.08) = $828\).

\(B_P = B_S^*\left(\frac{P_P - A_P}{P_S - A_P}\right)\), where \(B_P\) is the desired base rate, \(B_S\) is the "seed" base rate, \(P_P\) is the desired average premium, \(P_S\) is the average premium given the "seed" base rate, and \(A_P\) is the fixed policy fee. Thus, here, \(B_P = 400*(828 - 120)/(766 - 120) = 438.3900929\).
Section 113

The Approximated Average Rate Differential Method of Establishing Base Rates for Insurance Rating Plans

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Source:

Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-113-1. Insurance Company Ξ has a rating plan that involves a $65 fixed policy fee, a "color of roof" rating variable C - where a surcharge factor of 1.2 is used for a green roof, whereas all other roofs receive a factor of 1 - and a "raspberry jam" discount J, where an insured receives a 20% discount for eating raspberry jam. The company wishes to set a base rate so as to achieve an average premium of $310.

The following information is known about the insurer's book of business:

There are 23146 insureds who have a green roof.
There are 135600 insureds who have a non-green roof.
There are 31519 insureds who eat raspberry jam.
There are 127227 insureds who do not eat raspberry jam.

Use the approximated average rate differential method to find the approximated average rate differential $S^P_{\theta}$ for this book of business.
Solution S5-113-1. This problem is based on the discussion in Werner and Modlin, pp. 267-269. The approximated average rate differential is the product of the weighted-average rate differentials for each of the variables.

For variable C, the weighted-average rate differential is 
\[(1.2*23146 + 1*135600)/(23146 + 135600) = 1.02916105.\]

For variable J (which is a discount - so the raspberry-jam-eating population gets assigned a factor of 1 - 0.2 = 0.8), the weighted-average rate differential is 
\[(0.8*31519 + 1*127227)/(31519 + 127227) = 0.9602900231.\]

\(S^-_p\) is the product of these weighted-average rate differentials for the individual variables: 
\[1.02916105*0.9602900231 = S^-_p = 0.9882930884.\]

Problem S5-113-2. Insurance Company \(\Xi\) has a rating plan that involves a $65 fixed policy fee, a "color of roof" rating variable C - where a surcharge factor of 1.2 is used for a green roof, whereas all other roofs receive a factor of 1 - and a "raspberry jam" discount J, where an insured receives a 20% discount for eating raspberry jam. The company wishes to set a base rate so as to achieve an average premium of $310.

The following information is known about the insurer's book of business:

There are 23146 insureds who have a green roof.
There are 135600 insureds who have a non-green roof.
There are 31519 insureds who eat raspberry jam.
There are 127227 insureds who do not eat raspberry jam.

Use the approximated average rate differential method to find the base rate \(B^-_p\) that the company would propose under this method.

Solution S5-113-2. This problem is based on the discussion in Werner and Modlin, pp. 267-269. We use the formula \(B^-_p = ((P^-_p - A_p)/S^-_p)\), where \(P^-_p\) is the desired average premium, \(A_p\) is the fixed policy fee, \(S^-_p\) is the approximated average rate differential. Here, \(P^-_p = 310\), \(A_p = 65\), and \(S^-_p = 0.9882930884\) (from Solution S5-113-1). Thus, 
\[B^-_p = ((310 - 65)/0.9882930884) = B^-_p = 247.9021688.\]

Problem S5-113-3. Why is the approximated average rate differential method less accurate than the extension of exposures method in determining a proposed base rate?

Solution S5-113-3. This problem is based on the discussion in Werner and Modlin, p. 270.

The approximated average rate differential method less accurate than the extension of exposures method in determining a proposed base rate because the average rate differential method fails to take into account the possible distributional bias between variables. Calculating an average rate differential for each variable and then multiplying such average rate differentials together assumes that the variables are completely independent from one another and that there is no
interaction or exposure correlation between them. In reality, insureds from a particular class of variable X might also be more or less likely to be in a particular class of variable Y, and thus this assumption of independence may not reflect reality.

**Problem S5-113-4.** Insurance Company Λ has a rating plan that involves a $120 fixed policy fee, a "keychain" rating variable K - where insureds who own more than five keychains receive a surcharge factor of 1.04, whereas all others receive a factor of 1 - and a "computer game" discount G, where an insured receives an 11% discount for playing computer games regularly. The company wishes to set a base rate so as to achieve an average premium of $424. With this rate revision, it is also decreasing the keychain surcharge factor to 1.03 and decreasing the computer game discount to 9%.

The company's book of business is distributed by premium in the following ways:

- $31,513,000 of premium is paid by insureds who own five or more keychains.
- $134,246,000 of premium is paid by insureds who own fewer than five keychains.
- $123,124,000 of premium is paid by insureds who play computer games.
- $42,635,000 of premium is paid by insureds who do not play computer games.

Use the approximated average rate differential method to find the approximated average rate differential $S_p$ for this book of business.

**Solution S5-113-4.** This problem is based on the discussion in Werner and Modlin, pp. 270-271.

The approximated average rate differential is the product of the weighted-average rate differentials for each of the variables.

Here, to find the weighted-average rate differentials for each variable, it is necessary to adjust the premium for each class of each variable to what the premium would be had that class been charged the base rate. This is accomplished by first dividing the premium for a particular class by the rate differential applicable to that class.

For variable K, the following facts hold:

For the class of insureds who own five or more keychains, the premium at the base rate is $31513000/1.04 = 30300961.54$.

For the class of insureds who own fewer than five keychains, the premium is already at the base rate and so is $134,246,000$.

Now we find the weighted-average rate differential for variable K, using the company's proposed differentials: $(1.03*30300961.54 + 1*134246000)/(30300961.54 + 134246000) = 1.005524434$.

For variable G, the following facts hold:
For the class of insureds who play computer games (and receive an 11% discount), the premium at the base rate is $138,341,573.

For the class of insureds who do not play computer games, the premium is already at the base rate and so is $42,635,000.

Now we find the weighted-average rate differential for variable G, *using the company's proposed differentials*: 
\[
\frac{138,341,573 \times 0.91 + 42,635,000 \times 1}{138,341,573 + 42,635,000} = 0.9312024682.
\]

\(S^-\) is the product of these weighted-average rate differentials for the individual variables:
\[
1.005524434 \times 0.9312024682 = S^- = 0.9363468348.
\]

**Problem S5-113-5.** Insurance Company Λ has a rating plan that involves a $120 fixed policy fee, a "keychain" rating variable K - where insureds who own more than five keychains receive a surcharge factor of 1.04, whereas all others receive a factor of 1 - and a "computer game" discount G, where an insured receives an 11% discount for playing computer games regularly. The company wishes to set a base rate so as to achieve an average premium of $424. With this rate revision, it is also decreasing the keychain surcharge factor to 1.03 and decreasing the computer game discount to 9%.

The company's book of business is distributed by premium in the following ways:

- $31,513,000 of premium is paid by insureds who own five or more keychains.
- $134,246,000 of premium is paid by insureds who own fewer than five keychains.
- $123,124,000 of premium is paid by insureds who play computer games.
- $42,635,000 of premium is paid by insureds who do not play computer games.

Use the approximated average rate differential method to find the base rate \(B^-\) that the company would propose under this method.

**Solution S5-113-5.** This problem is based on the discussion in Werner and Modlin, pp. 270-271. We use the formula \(B^- = ((P^- - A_P)/S^-)\), where \(P^-\) is the desired average premium, \(A_P\) is the fixed policy fee, \(S^-\) is the approximated average rate differential. Here, \(P^- = 424\), \(A_P = 120\), and \(S^- = 0.9363468348\) (from Solution S5-113-4). Thus, \(B^- = (424-120)/0.9363468348 = B^- = 324.6660198\).
Section 114

The Approximated Change in Rate Differential Method of Establishing Base Rates for Insurance Rating Plans

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Source:

Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-114-1. Insurance Company Λ has a rating plan that involves a $120 fixed policy fee, a "keychain" rating variable K - where insureds who own more than five keychains receive a surcharge factor of 1.04, whereas all others receive a factor of 1 - and a "computer game" discount G, where an insured receives an 11% discount for playing computer games regularly. The company's current average premium is $400. The company wishes to set a base rate so as to increase average premium by 6%. With this rate revision, it is also decreasing the keychain surcharge factor to 1.03 and decreasing the computer game discount to 9%.

The company's book of business is distributed by premium in the following ways:

$31,513,000 of premium is paid by insureds who own five or more keychains.
$134,246,000 of premium is paid by insureds who own fewer than five keychains.
$123,124,000 of premium is paid by insureds who play computer games.
$42,635,000 of premium is paid by insureds who do not play computer games.

Use the approximated change in average rate differential method to find the approximated change in average rate differential \((1 + \Delta S)\) pertaining to this rating change.
Solution S5-114-1. This question is based on the discussion in Werner and Modlin, pp. 271-273.

We first need to find the proposed average differential change for each of the two variables. We consider variable K.

The class of insureds who own 5 or more keychains is receiving a differential change of $1.03/1.04 = 0.9903846154$.

The class of insureds who own fewer than 5 keychains is receiving a differential change of 1 (since the factor for this class is not changing).

The average rate differential change for this variable would be the differential changes for each class, weighted by current premium per class:

$\frac{31513000 \times 0.9903846154 + 134246000 \times 1}{31513000 + 134246000} = 0.9981719869$.

We consider variable G.

The class of insureds who play computer games is receiving a differential change of

$\frac{1-0.09}{1-0.11} = 1.02247191$.

The class of insureds who do not play computer games is receiving a differential change of 1 (since the factor for this class is not changing).

The average rate differential change for this variable would be the differential changes for each class, weighted by current premium per class:

$\frac{123124000 \times 1.02247191 + 42635000 \times 1}{123124000 + 42635000} = 1.016691893$.

The total approximated change in the average rate differential is the product of the variable-specific rate differential changes: $0.9981719869 \times 1.016691893 = (1 + \Delta_s) = 1.014833367$.

Problem S5-114-2. Insurance Company Λ has a rating plan that involves a $120 fixed policy fee, a "keychain" rating variable K - where insureds who own more than five keychains receive a surcharge factor of 1.04, whereas all others receive a factor of 1 - and a "computer game" discount G, where an insured receives an 11% discount for playing computer games regularly. The company's current average premium is $400. The company wishes to set a base rate so as to increase average premium by 6%. With this rate revision, it is also decreasing the keychain surcharge factor to 1.03 and decreasing the computer game discount to 9%.

The company's book of business is distributed by premium in the following ways:

$31,513,000 of premium is paid by insureds who own five or more keychains.
$134,246,000 of premium is paid by insureds who own fewer than five keychains.
$123,124,000 of premium is paid by insureds who play computer games.
$42,635,000 of premium is paid by insureds who do not play computer games.

Use the approximated change in average rate differential method to find the change in the base rate \((1 + \Delta_B)\) needed to achieve the desired average premium change.

**Solution S5-114-2.** This question is based on the discussion in Werner and Modlin, pp. 271-273.

We use the formula

\[
(1 + \Delta_B) = \frac{(1 + \Delta)*P_C - A_P}{(P_C - A_C)(1 + \Delta_S)},
\]

where \(\Delta\) is the overall desired average premium change, \(P_C\) is the current average premium, \(A_C\) is the current policy fee, \(A_P\) is the proposed policy fee, and \((1 + \Delta_S)\) is the approximated average change in rate differential.

Here, \(A_C = A_P = 120\), \(\Delta = 0.06\), \(P_C = 400\), and \((1 + \Delta_S) = 1.014833367\) (from Solution S5-114-1). Thus, \((1 + \Delta_B) = 1.069844884\).

**Problem S5-114-3.** Insurance Company Ξ has a rating plan that involves a $65 fixed policy fee, a "color of roof" rating variable \(C\), where a surcharge factor of 1.2 is used for a green roof, whereas all other roofs receive a factor of 1, and a "raspberry jam" discount \(J\), where an insured receives a 20% discount for eating raspberry jam. The company's current average premium is $300. The company wishes to set a base rate so as to increase average premium by 3.33333333%. With this rating change, the company is also proposing to increase the surcharge factor for green roofs to 1.3, to decrease the factor for all other roofs to 0.8, and to increase the raspberry jam discount to 25%.

The following information is known about the insurer's book of business:

- There are 23146 insureds who have a green roof.
- There are 135600 insureds who have a non-green roof.
- There are 31519 insureds who eat raspberry jam.
- There are 127227 insureds who do not eat raspberry jam.

Use the approximated change in average rate differential method to find the approximated change in average rate differential \((1 + \Delta_S)\) pertaining to this rating change.

**Solution S5-114-3.** This question is based on the discussion in Werner and Modlin, pp. 273-275.

Here, we have an exposure distribution rather than a premium distribution. But the essential method is the same as if we had a premium distribution, except the differentials for each variable are weighted by exposures.

We consider variable \(C\).

For the class of insureds who have a green roof, the rate differential change is \(1.3/1.2 = 1.083333333\).
For the class of insureds who do not have a green roof, the rate differential change is 0.8/1 = 0.8.

The exposure-weighted average rate differential change for variable C is thus
\[
(1.08333333\times23146 + 0.8\times135600)/(23146 + 135600) = 0.8413114871.
\]

We consider variable J.

For the class of insureds who eat raspberry jam, the rate differential change is \((1-0.25)/(1-0.2) = 0.9375\).

For the class of insureds who eat raspberry jam, the differential change is 1 (since the factor for this class is not changing).

The exposure-weighted average rate differential change for variable J is thus
\[
(0.9375\times31519 + 1\times127227)/(31519 + 127227) = 0.9875906322.
\]

The total approximated change in the average rate differential is the product of the variable-specific rate differential changes:
\[
(1 + \Delta_S) = 0.8308713434.
\]

**Problem S5-114-4.** Insurance Company Ξ has a rating plan that involves a $65 fixed policy fee, a "color of roof" rating variable C - where a surcharge factor of 1.2 is used for a green roof, whereas all other roofs receive a factor of 1 - and a "raspberry jam" discount J, where an insured receives a 20% discount for eating raspberry jam. The company's current average premium is $300. The company wishes to set a base rate so as to increase average premium by 3.33333333%. With this rating change, the company is also proposing to increase the surcharge factor for green roofs to 1.3, to decrease the factor for all other roofs to 0.8, and to increase the raspberry jam discount to 25%.

The following information is known about the insurer's book of business:

There are 23146 insureds who have a green roof.
There are 135600 insureds who have a non-green roof.
There are 31519 insureds who eat raspberry jam.
There are 127227 insureds who do not eat raspberry jam.

Use the approximated change in average rate differential method to find the change in the base rate \((1 + \Delta_B)\) needed to achieve the desired average premium change.

**Solution S5-114-4.** This question is based on the discussion in Werner and Modlin, pp. 273-275.

We use the formula
\[
(1 + \Delta_B) = ((1 + \Delta)\times P_C - A_P)/((P_C - A_C)*(1 + \Delta_S)),\] where \(\Delta\) is the overall desired average premium change, \(P_C\) is the current average premium, \(A_C\) is the current policy fee, \(A_P\) is the proposed policy fee, and \((1 + \Delta_S)\) is the approximated average change in rate differential.
Here, $A_C = A_P = 65$, $\Delta = 0.033333333$, $P_{-C} = 300$, and $(1 + \Delta_S) = 0.8308713434$ (from Solution S5-114-1). Thus, $(1 + \Delta_B) = \frac{(1.03333333*300 - 65)/((300 - 65)*0.8308713434)}{1 + \Delta_B} = 1.25477091$.

Problem S5-114-5. Insurance Company Φ has a book of business that contains five insureds. The company imposes a minimum premium requirement of $100. Without the minimum premium requirement, the following are the amounts of premium the insureds would pay under the company's current rating structure: $240, $31, $512, $89, $800. The company does not charge any policy fees.

By what offset factor would any base rate adjustment made by the company need to be multiplied in order to take into account the effect of the minimum premium requirement?

Solution S5-114-5. This question is based on the discussion in Werner and Modlin, p. 275.

The company's total premium without a minimum premium requirement would be $(240 + 31 + 512 + 89 + 800) = 1672$. The company's total premium with a minimum premium requirement would be $(240 + 100 + 512 + 100 + 800) = 1752$. Because the minimum premium requirement increases the premium from what would otherwise be collected, the required offset factor would need to reverse the effect of that increase when base rate changes are considered. Thus, the offset factor would be $1672/1752 = 0.9543378995$. 
Section 115

Considerations Pertaining to Insurance Rate Dislocations, Rate Transitions, and New Rating Selections

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Source:

Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-115-1. Insurance Company Π wishes to implement a rating change but wishes to limit the effect on Territory 3 to a 15% increase. Under the proposed rating changes, without any cap being taken into consideration, the following would be the case:

In Territory 1, premium would increase from $31,135 to $32,241.
In Territory 2, premium would decrease from $43,120 to $41,768.
In Territory 3, premium would increase from $23,012 to $30,128.

What should be the base rate adjustment factor that the company should implement along with the cap in order for the cap to not affect the overall change in rates?

Solution S5-115-1. This problem is based on the discussion in Werner and Modlin, p. 276. We use the formula (Base Rate Adjustment) = 1 + (Premium Above Cap)/(Premium from All Non-Capped Levels). Here, Territories 1 and 2 are uncapped in their changes, and the premium we consider for these territories is the current premium. The sum of current premium for these two territories is $31,135 + $43,120 = $74,435.
For Territory 3 premium to increase by 15%, the resulting premium would be $23,012 \times 1.15 = 26,463.80. Thus, the premium above the cap would be $30,128 - 26,463.8 = 3,664.2. Our base rate adjustment is thus \(1 + \frac{3664.2}{74435} = (\text{Base Rate Adjustment}) = 1.049226842\).

**Problem S5-115-2.** Insurance Company II wishes to implement a rating change but wishes to limit the effect on Territory 3 to a 15% increase. Under the proposed rating changes, without any cap being taken into consideration, the following would be the case:

- In Territory 1, premium would increase from $31,135 to $32,241.
- In Territory 2, premium would decrease from $43,120 to $41,768.
- In Territory 3, premium would increase from $23,012 to $30,128.

What should be the differential adjustment factor that the company should apply to the proposed relativity for Territory 3 in order to achieve the desired limitation of the rate increase to 15%?

**Solution S5-115-2.** This problem is based on the discussion in Werner and Modlin, pp. 276-277. We use the formula

\[(\text{Differential Adjustment}) = \frac{(1 + \%\text{Cap})}{(1 + \text{Uncapped Total Change}) \times (\text{Base Rate Adjustment})}.\]

From Solution S5-115-1, we know that the base rate adjustment is 1.049226842. The percent of the cap for Territory 3 is 15%. The uncapped total change for Territory 3 is \(\frac{30,128}{23,012} - 1 = 0.309229967\).

Thus, \((\text{Differential Adjustment}) = \frac{1.15}{(1.309229967 \times 1.049226842)} = (\text{Differential Adjustment}) = 0.8371677901\).

**Problem S5-115-3.** An insurer implements the following rating changes to an entirely multiplicative rating plan:

- The base rate increases by 40%.
- The multiplicative factor for adding a new vehicle to the policy changes from 1.03 to 1.15.
- The multiplicative factor for receiving a traffic ticket changes from 1.1 to 1.2.

The insurer implements a premium transition rule such that no insured will receive a premium increase of more than 15% per year, until the full increase aimed at by the rating change is achieved. This cap only applies to the rating changes above, and not to other possible changes pertaining to the policy.

The following applies to Insured E:

- Year 1: There are no changes to the policy.
- Year 2: Insured E adds a new vehicle to the policy.
- Year 3: Insured E receives a traffic ticket.
- Year 4: Insured E purchases a stuffed toy llama, which subjects him to the "stuffed toy llama surcharge" factor of 1.04.
For each of the four years, what percentage premium increase will Insured E receive?

**Solution S5-115-3.** This problem is based on the discussion in Werner and Modlin, p. 278.

In Year 1, only the base rate change of 40% is relevant. This change is capped at 15%, leaving $\frac{1.4}{1.15} - 1 = 0.2173913043 = 21.73913043\%$ of an increase to be applied over subsequent periods.

In Year 2, the addition of the new vehicle is relevant. The old 1.03 factor would apply irrespective of this rate change, so the only aspect of the change that is subject to the cap is the $\frac{1.15}{1.03} - 1 = 0.116504854 = 11.6504854\%$ that results from this filing. The total change that is subject to capping is thus $1.16504854 \times 1.2173913043$ (to account for the base rate change left over from the prior year) = 1.359223301. With the 15% cap being applied, the carried-over change is $1.359223301 / 1.15 - 1 = 0.181933051 = 18.19333051\%$. The actual Year 2 increase will be $1.15 \times 1.03 = 1.1845 \rightarrow +18.45\%$.

In Year 3, the traffic ticket is relevant. The old 1.1 factor would apply irrespective of this rate change, so the only aspect of the change that is subject to the cap is the $\frac{1.2}{1.1} - 1 = 0.0909090909 = 9.09090909\%$ that results from this filing. The total change that is subject to capping is thus $0.909090909 \times 1.181933051$ (to account for the change left over from the prior year) = 1.289381787. With the 15% cap being applied, the carried-over change is $1.289381787 / 1.15 - 1 = 0.1212015542 = 12.12015542\%$. The actual Year 3 increase will be $1.15 \times 1.1 = 1.265 \rightarrow +26.5\%$.

In Year 4, the full stuffed toy llama surcharge of 1.04 applies, because it was not affected by the rating changes in question. Moreover, the entire 12.12015542% change, carried over from prior years, falls within the 15% cap for Year 4. Thus, the total Year 4 increase will be $1.04 \times 1.1212015542 = 1.166049616 \rightarrow +16.6049616\%$.

Thus, the following changes apply over the four years:

- Year 1: +15%
- Year 2: +18.45%
- Year 3: +26.5%
- Year 4: +16.6049616%

**Problem S5-115-4.** Insurance Company X is initiating a new program, for which it will be primarily using the rates of its competitor, Insurance Company Q, which has a permissible loss ratio of 0.71, with several adjustments. Insurance Company X is willing to take a lower profit percentage (5%, as opposed to Q's 8%), but also has a commission percentage that is higher by 4%. Because Insurance Company X is confident that it has the best personnel in the industry, it estimates that its loss costs will be 10% lower on average. By what factor should Company X adjust Company Q's base rates in developing base rates of its own? Neither company has any fixed expenses or fixed expense provisions in its rates.

**Solution S5-115-4.** This problem is based on the discussion in Werner and Modlin, pp. 279-280.
First, we consider the expenses and profit, which will change the company's permissible loss ratios. Company X's permissible loss ratio will be lower by 8%-5% = 3%, because it will take a lower profit percentage. However, the permissible loss ratio will also be higher by 4% because of higher commissions. The net difference is 4%-3% = 1%, meaning that Company X's permissible loss ratio will be 0.71 + 0.01 = 0.72, and the adjustment factor for expenses/profit should thus be 0.72/0.71 = 1.014084507. This should be multiplied by 1 - 0.1 = 0.9, which reflects the savings that Company X expects over Company Q on losses. Thus, the appropriate base rate adjustment factor is 1.014084507*0.9 = 0.9126760563.

**Problem S5-115-5.** Name five elements that a ratemaking actuary may need to communicate with respect to a rate change that affects existing insurance policies.

**Solution S5-115-5.** This problem is based on the discussion in Werner and Modlin, pp. 280-281.

The following elements may be necessary to communicate with respect to a rate change that affects existing insurance policies:

1. The assumptions involved in proposing the change;
2. The specific selections pertaining to the change;
3. Impact on the company's competitive position, volume, and profitability;
4. Policyholder dislocation as a result of the change;
5. Rates of risk conversion and retention as a result of the change;
6. Comparisons of actual versus expected results (once the rate change has been in effect for some time).

Any five of the above suffice as an answer. Other valid answers may also be possible.
Section 116

A Fictional Commercial Insurance Experience Rating Plan

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Source:

Original Problems and Solutions from The Actuary's Free Study Guide

All of the questions in this section apply to the following hypothetical example:

Insurance Company Σ writes commercial general liability insurance and employs an experience rating plan based on the following formula:

\[ CD = Z \times \frac{(AER-EER)}{EER}, \]

where

- \( CD \) = credit or debit percentage;
- \( Z \) = credibility assigned to the data of the risk;
- \( AER \) = actual experience ratio;
- \( EER \) = expected experience ratio.

Manuel's Manual Manual Manufacturing, a company, owned by Manuel, that employs workers to write study manuals by hand, is the insured under this program. The credibility of its data is 32%, and the expected experience ratio is 0.723. The historical loss and loss adjustment expense trend has been calculated to be an increase of 5% per year. Also, it is expected that approximately 20% of all losses that occur in a given year are reported in that year. Every subsequent year, another 20% of those losses become reported, until 100% of the losses are reported. Experience from the past two policy periods is used to determine any credits or debits applicable to the policy. The policy is written on an occurrence basis, and the current policy
period is the entire year of 2102. For this year, the manual premium is $43,140, subject to any experience rating adjustments.

All historical data are evaluated as of January 1, 2102, and all losses for a given year are assumed to occur at a point in time on January 1 of that year (for instance, all 2101 losses are assumed to occur on January 1, 2101).

The following information is known:

During the years 2100 and 2101, Manuel's Manual Manual Manufacturing has had total reported actual losses and allocated loss adjustment expenses (ALAE) of $210,120.

The annual loss and ALAE cost underlying the insurer's current manual rates is $220,150.

**Problem S5-116-1.** What are the total "company subject loss and ALAE costs" - i.e., the total manual loss and ALAE costs, as applicable to the historical experience period?

**Solution S5-116-1.** This question is based on the discussion in Werner and Modlin, pp. 286-288. Loss and ALAE costs within the historical period must be detrended, i.e., adjusted for the reverse of the loss and ALAE trend that applies when going forward in time. The annual trend factor here is 1.05, so the annual detrend factor is 1/1.05. Thus, the manual loss and ALAE costs applicable to 2101 are 220150*(1/1.05), and the manual loss and ALAE costs applicable to 2100 are 220150*(1/1.05^2). Together, the "company subject loss and ALAE costs" are

\[
220150 \times \left( \frac{1}{1.05} + \frac{1}{1.05^2} \right) = 409349.2063 = \$409,349.21
\]

**Problem S5-116-2.** What are the total expected unreported losses and ALAE for the historical experience period, as of the start of 2102?

**Solution S5-116-2.** This question is based on the discussion in Werner and Modlin, pp. 286-288.

If 20% of losses/ALAE for a given year are reported in the first year, and 20% are reported in each year thereafter, then, as of the start of 2102, 80% of year 2101 losses/ALAE are unreported, and 60% of year 2100 losses/ALAE are unreported.

The way to calculate the expected unreported losses is via the following formula:

\[
\text{(Expected Unreported Losses)} = (\text{Detrended Expected Loss & ALAE Costs}) \times (\text{Expected Experience Ratio}) \times (\text{Expected Percentage of Losses Unreported}).
\]

For 2100, \( (\text{Expected Unreported Losses}) = (220150 \times (1/1.05^2)) \times 0.723 \times 0.60 = 86622.28571 \).

For 2101, \( (\text{Expected Unreported Losses}) = (220150 \times (1/1.05)) \times 0.723 \times 0.80 = 121271.2 \).

Thus, the total expected unreported losses are \( 86622.28571 + 121271.2 = 207893.4857 = \$207,893.49 \).
**Problem S5-116-3.** What are the projected ultimate losses and ALAE for the historical experience period?

**Solution S5-116-3.** This question is based on the discussion in Werner and Modlin, pp. 286-288.

The projected ultimate losses and ALAE for the historical experience period are the actual reported losses and ALAE, plus the expected unreported losses and ALAE.

The actual reported losses and ALAE are given as $210,120.

The expected unreported losses and ALAE are $207,893.49, based on Solution S5-116-2.

The projected ultimate losses and ALAE for the historical experience period are thus $210,120 + $207,893.49 = $418,013.49.

**Problem S5-116-4.** What is the company's actual experience ratio (AER) for the historical period?

**Solution S5-116-4.** This question is based on the discussion in Werner and Modlin, pp. 286-288.

AER here is calculated as (Projected Ultimate Losses and ALAE) / ("Company Subject" Loss and ALAE Costs). From Solution S5-116-1, the "Company Subject" Loss and ALAE Costs are $409,349.21, whereas the Projected Ultimate Losses and ALAE are $418,013.49. Thus, AER = 418013.49/409349.21 = AER = 1.021165976.

**Problem S5-116-5.** How much actual premium will the company pay for coverage in the year 2102?

**Solution S5-116-5.** This question is based on the discussion in Werner and Modlin, pp. 286-288.

Now that we found AER to be 1.021165976 in Solution S5-116-4, we can calculate the credit or debit using the formula CD = Z*(AER-EER)/EER. Here, Z = 0.32, and EER = 0.723. Thus, CD = 0.32*(1.021165973 - 0.723)/0.723 = 0.1319683436. This is the premium debit - i.e., the percentage by which the actual premium will be in excess of the manual premium of $43,140. The actual premium is thus 43140*1.1319683436 = 48833.1134 = $48,833.11.
Section 117

A Fictional Workers' Compensation Insurance Experience Rating Plan

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**Source:**

**Original Problems and Solutions from The Actuary's Free Study Guide**

All of the questions in this section apply to the following hypothetical example:

Insurance Company Φ writes workers' compensation insurance and employs an experience rating plan based on the following formula:

\[ M = \frac{(Z_P*A_P + (1 - Z_P)*E_P + Z_E*A_E + (1 - Z_E)*E_E)}{E}, \]

where

- \( M \) is the multiplicative experience modification factor, applied to the manual premium;
- \( A_P \) denotes the actual primary losses;
- \( A_E \) denotes the actual excess losses;
- \( E_P \) denotes the expected primary losses;
- \( E_E \) denotes the expected excess losses;
- \( E \) denotes the total expected losses (\( E = E_P + E_E \));
- \( Z_P \) denotes the credibility of actual primary loss data;
- \( Z_E \) denotes the credibility of actual excess loss data.

Manuel's Manual Manual Manufacturing, a company, owned by Manuel, that employs workers to write study manuals by hand, is the insured under this program. The credibility of its primary loss data is 70%, and the credibility for its excess loss data is 25%.
Experience from the past two policy periods is used to determine any modification to the manual premium applicable to the policy. The current policy period is the entire year of 2102. For this year, the manual premium is $12,012, subject to any experience rating adjustments.

The primary loss limit is considered to be $4,000.

It is also known that the loss elimination ratio (LER) at the primary loss limit is 0.45.

In 2100, there were two workers' compensation claims pertaining to Manuel's Manual Manual Manufacturing. Claim A had reported losses of $31,000, and Claim B had reported losses of $3,125. In 2100, the payroll of Manuel's Manual Manual Manufacturing was $502,204, and the expected loss cost per $100 of payroll was 5.54.

In 2101, there were three workers' compensation claims pertaining to Manuel's Manual Manual Manufacturing. Claim C had reported losses of $5,312, Claim D had reported losses of $1,111, and Claim F had reported losses of $1,011. In 2100, the payroll of Manuel's Manual Manual Manufacturing was $505,506, and the expected loss cost per $100 of payroll was 3.31.

**Problem S5-117-1.** What are the total actual primary losses (AP) and the total actual excess losses (AE) for the historical experience period?

**Solution S5-117-1.** For each claim during the historical experience period, the primary loss is that portion of the loss which is less than $4,000.

For Claim A, the claim amount is $31,000, of which $4,000 is primary and $27,000 is excess.
For Claim B, the claim amount is $3,125, of which $3,125 is primary.
For Claim C, the claim amount is $5,312, of which $4,000 is primary and $1,312 is excess.
For Claim D, the claim amount is $1,111, of which $1,111 is primary.
For Claim F, the claim amount is $1,011, of which $1,011 is primary.

The total actual primary losses are 4000 + 3125 + 4000 + 1111 + 1011 = AP = $13,247.

The total actual excess losses are 27000 + 1312 = AE = $28,312.

**Problem S5-117-2.** What are the total expected losses (E) for the historical experience period?

**Solution S5-117-2.** Expected losses are determined by multiplying payroll by the expected loss cost per unit of payroll. We note that the unit of payroll is $100, so we will express payroll in hundred-dollars rather than in single dollars.

In 2100, payroll was 5022.04 hundred-dollars, and the expected loss cost per unit was 5.54. Thus, expected losses for 2100 are 5022.04*5.54 = 27822.1016.

In 2101, payroll was 5055.06 hundred-dollars, and the expected loss cost per unit was 3.31. Thus, expected losses for 2100 are 5055.06*3.31 = 16732.2486.
Thus, total expected losses for these two years are $27822.1016 + 16732.2486 = 44554.3502 = E = $44,554.35$.

**Problem S5-117-3.** What are the total *expected* primary losses ($E_P$) and the total *expected* excess losses ($E_E$) for the historical experience period?

**Solution S5-117-3.** In Solution S5-117-2, we found that the total expected losses ($E$) for the historical experience period are $44554.3502$. To split total expected losses into primary and excess components, we apply the loss elimination ratio (LER) at the primary loss limit, given as $0.45$. Total expected losses, multiplied by this LER, give us the expected primary losses: $0.45 \times 44554.3502 = E_P = 20049.45759$. The remainder of total expected losses constitutes the expected excess losses: $44554.3502 - 20049.45759 = E_E = 24504.89261$.

Thus, $E_P = $20,049.46$ and $E_E = $24,504.89$.

**Problem S5-117-4.** What is the experience modification factor pertaining to Manuel's Manual Manual Manufacturing?

**Solution S5-117-4.** We apply the formula $M = (Z_P \times A_P + (1 - Z_P) \times E_P + Z_E \times A_E + (1 - Z_E) \times E_E)/E$, where

- $A_P = 13247$ (Solution S5-117-1);
- $A_E = 28312$ (Solution S5-117-1);
- $E_P = 20049.45759$ (Solution S5-117-3);
- $E_E = 24504.89261$ (Solution S5-117-3);
- $E = 44554.3502$ (Solution S5-117-2);
- $Z_P = 0.7$ (given);
- $Z_E = 0.25$ (given).

Thus, $M = (0.7 \times 13247 + 0.3 \times 20049.45759 + 0.25 \times 28312 + 0.75 \times 24504.89261)/44554.3502 = M = 0.9144877336$.

**Problem S5-117-5.** What is the premium that Manuel's Manual Manual Manufacturing will have to pay for the year 2102?

**Solution S5-117-5.** The actual premium is the manual premium, multiplied by the experience modification factor $M$, which we found in Solution S5-117-4 to be $0.9144877336$. The manual premium is given as $12,012$. Thus, the actual premium will be $12012 \times 0.9144877336 = 10984.82666 = $10,984.83$. 


Section 118

A Fictional Commercial Insurance Composite Rating Plan

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**Source:**

**Original Problems and Solutions from The Actuary's Free Study Guide**

All of the questions in this section apply to the following hypothetical example:

Insurance Company Δ writes commercial general liability insurance and on large, complex risks that are loss-rated via a composite rating plan. Marcus's Macroscopic Microscopes, a company, owned by Marcus, that manufactures giant microscopes, is the insured under this plan.

The experience period on the basis of which the rate is developed is the prior two years. The current policy period is the entire year of 2102.

For 2100, Marcus's Macroscopic Microscopes had reported bodily injury liability losses and allocated loss adjustment expenses of $315,125 and reported property damage liability losses and allocated loss adjustment expenses of $125,160. Total receipts from operations in 2100 were $31,124,160.

For 2101, Marcus's Macroscopic Microscopes had reported bodily injury liability losses and allocated loss adjustment expenses of $123,929 and reported property damage liability losses and allocated loss adjustment expenses of $231,250. Total receipts from operations in 2101 were $25,612,000.
All historical data are evaluated as of January 1, 2102, and all losses for a given year are assumed to occur at a point in time on January 1 of that year (for instance, all 2101 losses are assumed to occur on January 1, 2101).

The annual trend for losses and allocated loss adjustment expenses (ALAE) is -4%.

The annual trend for loss exposures is +6%. The exposure unit is $1000 of receipts from operations.

The expected loss and ALAE ratio is 65%.

The 12-month-to-ultimate bodily injury loss development factor is 1.45.

The 12-month-to-ultimate property damage loss development factor is 1.15.

The 24-month-to-ultimate bodily injury loss development factor is 1.23.

The 24-month-to-ultimate property damage loss development factor is 1.03.

**Problem S5-118-1.** For the historical experience period, what are the total trended ultimate losses and ALAE for Marcus's Macroscopic Microscopes?

**Solution S5-118-1.** The historical incurred losses and ALAE must be developed to ultimate and trended to current levels. The annual loss trend factor is $1 - 0.04 = 0.96$. For each year, we multiply the reported losses for bodily injury by the applicable bodily injury loss development factor; then we add this sum to the product of the reported losses for property damage and the applicable property damage loss development factor. We multiple this sum by the trend factor taken to the power of the number of years to January 1, 2102.

For 2100, the total trended ultimate losses and ALAE are thus

$$(315125*1.23 + 125160*1.03)*0.96^2 = 476023.4957.$$  

For 2101, the total trended ultimate losses and ALAE are thus

$$(123929*1.45 + 231250*1.15)*0.96 = 427809.168.$$  

Total trended ultimate losses and ALAE for the two years are thus $476023.4957 + 427809.168 = 903832.6637 = \$903,832.66$.

**Problem S5-118-2.** For the historical experience period, what are the total trended ultimate exposures for Marcus's Macroscopic Microscopes?

**Solution S5-118-2.** To get the total trended ultimate exposures, we first need to trend the exposures from each year by multiplying them by the trend factor (here, $1 + 0.06 = 1.06$), taken
to the power of the number of years to January 1, 2102. Each $1000 of trended ultimate receipts from operations constitutes one exposure unit.

2100 trended ultimate exposures are thus \((31124160/1000) \times 1.06^2 = 34971.10618\).

2101 trended ultimate exposures are thus \((25612000/1000) \times 1.06 = 27148.72\).

Total trended ultimate exposures are thus \(34971.10618 + 27148.72 = 62119.82618\).

**Problem S5-118-3.** What is the adjusted premium for the historical period based on the data from the entire historical experience period?

**Solution S5-118-3.** The adjusted premium is equal to

\[
\text{(Trended Ultimate Loss & ALAE)/(Expected Loss & ALAE Ratio). Here, Trended Ultimate Loss & ALAE = 903832.6637 (from Solution S5-118-1), and Expected Loss & ALAE Ratio is given as 0.65. Thus, the adjusted premium is } 903832.6637/0.65 = \$1,390,511.79.
\]

**Problem S5-118-4.** What is the rate per exposure unit, based on the data from the historical experience period?

**Solution S5-118-4.** The rate per exposure unit is equal to \((\text{Adjusted Premium}/(\text{Trended Ultimate Exposures})\). Here, Adjusted Premium = 1390511.79 (from Solution S5-118-3), and Ultimate Exposures = 62119.82618 (from Solution S5-118-2). Thus, the rate per exposure unit is

\[
1390511.79/62119.82618 = 22.38434773.
\]

**Problem S5-118-5.** It is estimated that total receipts of Marcus's Macroscopic Microscopes for the year 2102 will be $31,130,103. What will be the deposit premium that Marcus's Macroscopic Microscopes will pay under this plan for 2102?

**Solution S5-118-5.** The deposit premium is equal to \((\text{Estimated Exposure Units})*(\text{Rate Per Exposure Unit})\). Here, since the exposure unit is $1000 of receipts, there are 31130.103 estimated exposure units. From Solution S5-118-4, Rate Per Exposure Unit = 22.38434773. Thus, the deposit premium will be 31130.103*22.38434773 = 696827.0505. = \$696,827.05.
Section 119

A Fictional Commercial Insurance Large Deductible Plan

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**Source:**

**Original Problems and Solutions from The Actuary's Free Study Guide**

All of the questions in this section apply to the following hypothetical example:

Insurance Company Θ writes commercial general liability insurance under a large deductible plan. The insured is Interactive Interfaces International, which has a deductible of $250,000 per occurrence.

Insurance Company Θ will pay for all loss adjustment expenses and will handle all claims, including claims that are entirely below the deductible. Allocated loss adjustment expenses (ALAE) are estimated at 23% of all losses. The cost to process losses that are below the deductible is estimated to be 5% of such losses.

The fixed expenses of this plan for the insurer are $100,000. Also, the insurer has variable expenses equal to 19% of premium and a profit provision of 4% of premium for a policy with no deductible. There is also a risk margin of 20% of excess losses for policies with a $250,000 deductible. The credit risk associated with the deductible payments from the insured is 3% of the expected deductible payments.

The loss elimination ratio associated with a loss limit of $250,000 is 76%.
During the policy period, it is estimated that the total ground-up losses of Interactive Interfaces International will be $711,240, without consideration of any deductibles.

**Problem S5-119-1.** What are the estimated losses of Interactive Interfaces International above the deductible?

**Solution S5-119-1.** We are given that the loss elimination ratio (LER) associated with a loss limit of $250,000 is 76%. We can calculate the excess ratio, which is equal to 1 - LER = 1 - 0.76 = 0.24. The excess ratio is the proportion of total estimated losses that are estimated to be above the deductible. Thus, the total magnitude of such losses is (Estimated total ground-up losses)*(Excess ratio) = 711240*0.24 = **$170,697.60**.

**Problem S5-119-2.** What are the estimated allocated loss adjustment expenses for the insurer?

**Solution S5-119-2.** ALAE in this case are a flat percentage (23%) of all losses, which are estimated to be $711,240. ALAE are thus estimated at 711240*0.23 = **$163,585.20**.

**Problem S5-119-3.** What are the estimated expenses to the insurer due to deductible processing?

**Solution S5-119-3.** It is given that the cost to process losses that are below the deductible is estimated to be 5% of such losses. Based on the given LER, the losses below the deductible of $250,000 are 0.76 of total losses. Thus, the estimated cost to process such losses is 0.05*0.76*711240 = **$27,027.12**.

**Problem S5-119-4.** Separately calculate the estimated dollar amount of credit risk posed by this policy to the insurer and the dollar amount corresponding to the insurer's risk margin.

**Solution S5-119-4.** The credit risk associated with the deductible payments from the insured is 3% of the expected deductible payments. Based on the given LER, the losses below the deductible of $250,000 are 0.76 of total losses (these are the expected deductible payments that the insured would need to refund to the insurer). Thus, the estimated dollar amount of credit risk is 0.03*0.76*711240 = 16216.272 = **$16,216.27**.

The risk margin is 20% of just the estimated excess losses. In Solution S5-119-1, we found the estimated excess losses to be $170,697.60. Thus, the dollar risk margin is 170697.60*0.2 = **$34,139.52**.

**Problem S5-119-5.** Based on the information given, what should be the premium charged for this policy?

**Solution S5-119-5.** We use the formula given by Werner and Modlin, p. 298:

\[
\text{Premium} = \frac{(\text{Losses above Deductible} + \text{ALAE} + \text{Fixed Expense} + \text{Credit Risk} + \text{Risk Margin})}{(1 - \text{Variable Expense Provision} - \text{Profit Provision})}
\]
Here, Losses above Deductible = $170,697.60 (from Solution S5-119-1);
ALAE = $163,585.20 (from Solution S5-119-2);
Fixed Expense has two components: the $100,000 given fixed expense and the $27,027.12 estimated cost of processing losses below the deductible (from Solution S5-119-3);
Credit Risk = $16,216.27 (from Solution S5-119-4);
Risk Margin = $34,139.52 (from Solution S5-119-4);
Variable Expense Provision = 0.19 (given);
Profit Provision = 0.04 (given).

Thus, Premium =
\[
(170697.60 + 163585.20 + 100000 + 27027.12 + 16216.272 + 34139.52)/(1 - 0.19 - 0.04) = 664500.9247 = \$664,500.92.
\]
Section 120

A Fictional Workers' Compensation Insurance Retrospective Rating Plan

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Source:

Original Problems and Solutions from The Actuary's Free Study Guide

All of the questions in this section apply to the following hypothetical example:

Insurance Company Ψ writes workers' compensation insurance under a retrospective rating plan. The insured is Interactive Interfaces International.

Under the plan, the retrospective premium is determined by the following formula:

Retrospective Premium = (Basic Premium + Converted Losses)*(Tax Multiplier), subject to a maximum and minimum agreed upon between the insurer and the insured.

Basic Premium is determined by the following formula:


Converted Losses are determined by the following formula:

Converted Losses = (Reported Losses)*LCF.
LCF is the Loss Conversion Factor, which is intended to account for loss adjustment expenses in the premium calculation.

Expense Provided Through LCF is determined by the following formula:

\[\text{Expense Provided Through LCF} = (\text{Expected Loss Ratio}) \times (\text{LCF} - 1).\]

The Net Insurance Charge is determined by the following formula:

\[\text{Net Insurance Charge} = (\text{Insurance Charge} - \text{Insurance Savings}) \times (\text{Expected Loss Ratio}) \times \text{LCF}.\]

The Standard Premium for the policy, before any retrospective adjustments are made, is $530,350. The insurer and the insured negotiate a minimum retrospective premium ratio (ratio of retrospective premium to standard premium) of 50% and a maximum retrospective premium ratio of 130%. They also negotiate an LCF of 1.20 and a per accident loss limitation of $200,000.

The insurer sets its expense allowance (not considering taxes) to 25% and its expected loss ratio to 60%. It also uses a tax multiplier of 1.06.

The insurance savings to the insurer because of the minimum premium are accounted for by a factor of 0.04. The insurance charge that the insurer requires in order to accommodate the maximum premium is accounted for by a factor of 0.28.

After a passage of a mutually agreed-upon amount of time, losses during the policy period are observed and valued at $400,000. This is the official figure used for reported losses.

**Problem S5-120-1.** What is the Net Insurance Charge factor?

**Solution S5-120-1.** We use the formula

\[\text{Net Insurance Charge} = (\text{Insurance Charge} - \text{Insurance Savings}) \times (\text{Expected Loss Ratio}) \times \text{LCF}.\]

Here, Insurance Charge = 0.28, Insurance Savings = 0.04, Expected Loss Ratio = 0.60, and LCF = 1.20. Thus, \((0.28 - 0.04) \times 0.60 \times 1.20 = \text{Net Insurance Charge} = 0.2592.\)

**Problem S5-120-2.** What is the factor representing Expense Provided Through LCF?

**Solution S5-120-2.** We use the formula

\[\text{Expense Provided Through LCF} = (\text{Expected Loss Ratio}) \times (\text{LCF} - 1) = 0.60 \times (1.20 - 1) = \text{Expense Provided Through LCF} = 0.12.\]

**Problem S5-120-3.** What are the Converted Losses?

**Solution S5-120-3.** We use the formula Converted Losses = (Reported Losses) \times \text{LCF}, where Reported Losses = $400,000, and LCF = 1.2. Thus, \(400000 \times 1.2 = \text{Converted Losses} = 480,000.\)
Problem S5-120-4. What is the Basic Premium?

Solution S5-120-4. We use the formula Basic Premium = (Expense Allowance - Expense Provided Through LCF + Net Insurance Charge)*(Standard Premium).

Here, Expense Allowance = 0.25 (given);
Expense Provided Through LCF = 0.12 (from Solution S5-120-2);
Net Insurance Charge = 0.2592 (from Solution S5-120-1);
Standard Premium = $530,350.

Thus, (0.25 - 0.12 + 0.2592)*530350 = Basic Premium = $206,412.22.

Problem S5-120-5. What is the Retrospective Premium? (This will be the premium that Interactive Interfaces International will actually end up paying.)

Solution S5-120-5. We use the formula

Retrospective Premium = (Basic Premium + Converted Losses)*(Tax Multiplier).

Here, Basic Premium = $206,412.22 (from Solution S5-120-4);
Converted Losses = $480,000 (from Solution S5-120-3);
Tax Multiplier = 1.06 (given).

Retrospective Premium = (206412.22 + 480000)*1.06 = 727596.9532.

However, we still need to check whether this amount exceeds the maximum premium of 130% of Standard Premium, which is 530350*1.30 = 689455. Since the maximum agreed-upon premium is less than the calculated retrospective premium, the actual retrospective premium is capped at $689,455.
Section 121

Occurrence-Based versus Claims-Made Insurance Policies

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Source:

Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-121-1. Werner and Modlin, p. 308, discuss five principles of claims-made insurance policies. Fill in the blanks in the following statements pertaining to each of these principles:

(a) If claim costs are increasing, a claims-made policy should cost ______ (more, less, the same, sometimes more and sometimes less) than an occurrence policy.

(b) Suppose that underlying trends in claim costs have suddenly and unexpectedly changed. Then the claims-made policy based on the prior trend will be _____ (more, less, just as, sometimes more and sometimes less) reflective of the correct price than an occurrence policy based on the prior trend.

(c) Suppose that the reporting pattern for claims has shifted suddenly and unexpectedly. The cost of a mature claims-made policy will be (more, less, just as, sometimes more and sometimes less) ______ affected than an occurrence policy.

(d) Claims-made policies have _____ (higher, lower, the same, sometimes higher and sometimes lower) risk of reserve inadequacy, compared to occurrence policies.

(e) These is _____ (more, less, the same, sometimes more and sometimes less) investment income earned by the insurer under claims-made policies, as compared to occurrence policies.
**Solution S5-121-1.** The following answers are in accord with the principles stated by Werner and Modlin, p. 308:

(a) If claim costs are increasing, a claims-made policy should cost **less** than an occurrence policy.

(b) Suppose that underlying trends in claim costs have suddenly and unexpectedly changed. Then the claims-made policy based on the prior trend will be **more** reflective of the correct price than an occurrence policy based on the prior trend.

(c) Suppose that the reporting pattern for claims has shifted suddenly and unexpectedly. The cost of a mature claims-made policy will be **less** affected than an occurrence policy.

(d) Claims-made policies have **lower** risk of reserve inadequacy, compared to occurrence policies.

(e) These is **less** investment income earned by the insurer under claims-made policies, as compared to occurrence policies.

**Problem S5-121-2.** Dr. □ had an occurrence-based medical malpractice insurance policy from January 1, 2013 to December 31, 2018. Immediately thereafter, Dr. □ purchased a claims-made policy.

The following medical malpractice claims were made against Dr. □:

- Claim A was reported on January 4, 2015, because of an incident that occurred on May 6, 2013.
- Claim B was reported on October 7, 2016, because of an incident that occurred on December 14, 2015.
- Claim C was reported on August 15, 2019, because of an incident that occurred on January 7, 2016.
- Claim D was reported on September 20, 2020, because of an incident that occurred on April 29, 2018.
- Claim E was reported on July 11, 2021, because of an incident that occurred on May 30, 2020.
- Claim F was reported on July 1, 2022, because of an incident that occurred on February 3, 2013.

(a) For which of these claims is there coverage overlap between the occurrence policy and the claims-made policy?

(b) The insurer writing the claims-made policy can set a retroactive date that would eliminate coverage overlaps. What should be the retroactive date for this policy?

**Solution S5-121-2.** This problem is based on the discussion in Werner and Modlin, pp. 311-312.

(a) Coverage overlaps exist for all claims that were reported after December 31, 2018, but for which the incidents occurred before December 31, 2018. This means that **Claims C, D, and F are subject to coverage overlap.**
(b) The retroactive date is the date on or after which an incident must have occurred in order to be eligible for coverage under a claims-made policy. To eliminate coverage overlaps, the insurer should set the retroactive date to the first day on which the occurrence policy was no longer in effect: \textbf{January 1, 2019.}

\textbf{Problem S5-121-3.} An insurer writing claims-made policies employs step factors pertaining to insureds who have recently obtained the policies.

For the first claims-made year, the factor is 0.2.
For the second claims-made year, the factor is 0.5.
For the third claims-made year, the factor is 0.6.
For the fourth claims-made year, the factor is 0.8.
For the fifth claims-made year, the factor is 0.98.
For the sixth claims-made year and every year thereafter, the factor is 1.00.

(a) Based on the step factors above, what is the fraction of the cost of a mature claims-made policy that the insurer estimates to be based on costs of claims pertaining to the year three years before the year for which the policy was issued?

(b) Based on the step factors above, what is the fraction of the cost of a mature claims-made policy that the insurer estimates to be based on costs of claims pertaining to the time period starting four years before the year for which the policy was issued and ending two years before the year for which the policy was issued?

\textbf{Solution S5-121-3.} This problem is based on the discussion in Werner and Modlin, p. 313.

(a) The step factor for the first claims-made year is also the factor pertaining to the insurer's estimates of costs for the current year of the policy. The step factor for the \( n \)th claims-made year is also the factor pertaining the insurer's estimates of costs for the time period from \( (n-1) \text{st year prior to the current year of the policy} \) to the current year of the policy. Thus, the following are true:

Factor for current year cost: 0.2
Factor for current and prior year cost: 0.5
Factor for prior year cost: 0.5 - 0.2 = 0.3
Factor for current and prior and 2\textsuperscript{nd}-prior year cost: 0.6
Factor for 2\textsuperscript{nd}-prior year cost: 0.6 - 0.5 = 0.1
Factor for current and prior and 2\textsuperscript{nd}-prior and 3\textsuperscript{rd}-prior year cost: 0.8
Factor for 3\textsuperscript{rd}-prior year cost: 0.8 - 0.6 = 0.2

(b) By the reasoning in part (a), the factor for the cost of the current year through the 4\textsuperscript{th}-prior year is 0.98. The factor for the current and prior year cost is 0.5. The difference between the two is the desired factor representing cost of a mature claims-made policy that the insurer estimates to be based on costs of claims pertaining to the time period starting four years before the year for
which the policy was issued and ending two years before the year for which the policy was issued: 0.98 - 0.5 = 0.48.

Problem S5-121-4. Dr. ◊ is an otherwise identical version of Dr. □, except that, instead of switching from an occurrence-based policy to a claims-made policy, Dr. ◊ switched from a claims-made policy to an occurrence-based policy. He had a claims-made medical malpractice insurance policy from January 1, 2013 to December 31, 2018. Immediately thereafter, Dr. ◊ purchased an occurrence-based policy.

The following medical malpractice claims were made against Dr. ◊:

Claim A was reported on January 4, 2015, because of an incident that occurred on May 6, 2013.
Claim B was reported on October 7, 2016, because of an incident that occurred on December 14, 2015.
Claim C was reported on August 15, 2019, because of an incident that occurred on January 7, 2016.
Claim D was reported on September 20, 2020, because of an incident that occurred on April 29, 2018.
Claim E was reported on July 11, 2021, because of an incident that occurred on May 30, 2020.
Claim F was reported on July 1, 2022, because of an incident that occurred on February 3, 2013.

(a) For which of these claims would there be a coverage gap due to the switch in policies?

(b) What could Dr. ◊’s new insurer do to eliminate the coverage gap?

Solution S5-121-4. This question is based on the discussion in Werner and Modlin, pp. 313-314.

(a) The coverage gap exists for claims that were reported after the expiration of the claims-made policy but pertain to incidents occurring prior to the effective date of the occurrence policy. Thus, the claims-made policy no longer provides coverage for these claims, and they are also not encompassed within the occurrence period of the occurrence policy. All claims for incidents that occurred before January 1, 2019, but were reported after January 1, 2019, fall into this category. Thus, there are coverage gaps for Claims C, D, and F.

(b) To eliminate the coverage gaps, the new insurer can provide Dr. ◊ with an extended reporting period endorsement that offers "tail coverage" for claims that are reported during the time period of the occurrence policy but pertain to incidents that occurred before the occurrence policy took effect.

Problem S5-121-5. Suppose an insurer decides to switch from writing occurrence-based policies to writing claims-made policies. Briefly explain how the following would be affected:

(a) Determination of the IBNR (incurred but not reported) reserve.
(b) Determination of the IBNER (incurred but not enough reported) reserve.

Solution S5-121-5. This question is based on the discussion in Werner and Modlin, p. 311.
(a) Claims-made policies do not have an IBNR aspect, because the insurer is only responsible for claims that are reported in the year of the policy. Claims that are not reported do not apply to the year in question.

(b) It is still necessary to calculate an IBNER reserve for claims that were reported during the year of the policy, but for which the costs end up being greater than originally expected. For instance, the costs of a claim reported in year X could, as a result of a protracted lawsuit, increase far beyond the original projections - but the higher costs might not be fully apparent until year X + k, where k ≥ 1.
Section 122

Common Types of Commercial Insurance

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Source:

Original Problems and Solutions from The Actuary’s Free Study Guide

Problem S5-122-1. The following types of organizations eligible for commercial insurance are discussed in *Commercial Insurance*, pp. 1.5-1.6:
1. Corporations;
2. Partnerships;
3. Joint Ventures;
4. Limited Liability Companies;
5. Unincorporated Associations.

Each of the following features apply to one of the types of organizations above. For each feature, identify the type of organization to which it applies.

(a) Organizations that have a small number of active investors use this form of organization to achieve limited liability while the owners remain taxed at their individual income tax rates.
(b) This type of organization can be formed quickly so that multiple entities can work together in a single undertaking and share profits and losses. Once the undertaking is completed, the organization is dissolved.
(c) This entity can sue, be sued, enter into contracts in its own name, own property, and hire employees. Its owners also have limited liability.
(d) The individual owners of this kind of organization are legally responsible for that organization's torts and contracts. The also share in the organization's profits and losses, although not necessarily on equal terms.

(e) This form of organization is not a legal entity, and its members can be held individually liable for the organization's activities. However, this form of organization is also exempt from most commonly levied taxes on business entities.

Solution S5-122-1.

Feature (a) applies to 4. Limited Liability Companies.

Feature (b) applies to 3. Joint Ventures.

Feature (c) applies to 1. Corporations.

Feature (d) applies to 2. Partnerships.

Feature (e) applies to 5. Unincorporated Associations.

Problem S5-122-2. The term "commercial property insurance" can be used in both a broad sense and in a narrow sense.

(a) When used in a narrow sense, what kinds of loss exposures is "commercial property insurance" intended to cover?

(b) When used in a narrow sense, what kinds of coverage does "commercial property insurance" typically exclude?

Solution S5-122-2. This problem is based on the discussion in Commercial Insurance, p. 1.8.

(a) When used in a narrow sense, "commercial property insurance" is intended to cover commercial buildings and their contents against losses due to fire, windstorm, and numerous other perils.

(b) When used in a narrow sense, "commercial property insurance" typically excludes coverage for property in transit or away from the insured location. It also excludes coverage for perils related to crime, steam boiler explosions, and mechanical or electrical breakdowns.

Problem S5-122-3.

(a) What is the traditional name for equipment breakdown insurance?

(b) Name three perils typically covered by equipment breakdown insurance. What two kinds of losses due to those perils are typically covered?
Solution S5-122-3. This problem is based on the discussion in *Commercial Insurance*, pp. 1.8-1.9.

(a) Equipment breakdown insurance was traditionally known as **boiler and machinery insurance**.

(b) Equipment breakdown insurance typically covers the following perils:

1. Mechanical breakdown;
2. Electrical injury, except injury due to lightning;
3. Steam boiler explosion.

Both **property losses** and **business income losses** due to these perils are typically covered.

**Problem S5-122-4.** "Inland marine insurance" is a rather counterintuitive name. List four kinds of risks that "inland marine insurance" would typically cover today.

**Solution S5-122-4.** This problem is based on the discussion in *Commercial Insurance*, p. 1.9.

The following are some risks that "inland marine insurance" would typically cover:

1. Property in domestic transit;
2. Mobile equipment;
3. Buildings in the course of construction;
4. Property essential to transportation or communication;
5. Other types of property that involve some manner of transportation.

Any four of the above suffice as an answer. Other valid answers may also be possible.

**Problem S5-122-5.**

(a) Fill in the blanks: Commercial general liability (CGL) insurance protects an organization against liability for _______ and _______ (two types of losses), arising out of its ______, _______, and _______ (three sources of losses).

(b) Aside from the items in part (a), what other kind of coverage does CGL insurance typically provide? Give two examples of this category of loss exposure.
(c) What kinds of loss exposures are excluded under both "commercial property insurance", narrowly defined, and CGL insurance? What common type of commercial insurance covers such loss exposures?

(d) Mr. ♫ owns a business that consists of a music store and services by traveling musicians who transport themselves using the business's vehicles. Mr. ♫ does not wish to spend much time contemplating the provisions of insurance that would protect his business and making complex insurance arrangements. He would prefer to have all the coverage he would require, as a typical businessowner, under no more than three insurance policies. What three kinds of insurance policies would probably suffice to fulfill his business's coverage needs?

**Solution S5-122-5.** This problem is based on the discussion in *Commercial Insurance*, pp. 1.9-1.10.

(a) Commercial general liability (CGL) insurance protects an organization against liability for bodily injury and operations, arising out of its premises, operations, and completed work.

(b) CGL insurance also typically covers liability due to "personal and advertising injury". Examples (any two will suffice) include the following: (1) slander, (2) libel, (3) invasion of privacy, and (4) false arrest.

(c) Physical damage and liability to automobiles are excluded under both "commercial property" and CGL insurance policies. However, commercial auto insurance covers such loss exposures.

(d) If Mr. ♫ gets the following three insurance policies, his business's coverage needs will probably be fulfilled:

1. A businessowner's policy (This policy combines most of the common commercial property and liability coverages);

2. A workers' compensation policy (for the musicians and any store employees working for Mr. ♫);

3. A commercial auto policy (for loss exposures arising out of the vehicles owned by the business).
Section 123

Common Elements and Additional Common Types of Commercial Insurance Policies

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**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-123-1.** Discuss the manner in which farm insurance combines what would typically be personal insurance coverages and commercial insurance coverages.

**Solution S5-123-1.** This question is based on the discussion in *Commercial Insurance*, p. 1.10.

The personal component of a farm insurance policy provides coverage similar to that in a typical homeowner's policy. The farmer's house and personal property in that house are covered. Liability arising from personal activities is covered.

The commercial component of a farm insurance policy provides coverage similar to that in typical commercial property and inland marine policies. Property and buildings used in farming operations are covered. Liability arising out of farming activities is also covered.

**Problem S5-123-2.**
(a) How does an *umbrella liability policy* differ from other excess liability policies?
(b) What is a *surety bond*? What are the parties to a surety bond called?

**Solution S5-123-2.**
(a) An umbrella liability policy does more than just provide coverage above the limits of the insured's primary insurer. In addition to providing limits in excess of what the primary insurer
would provide, the umbrella policy also covers some claims below the primary insurer's limit, if those claims are not covered by the primary insurer.

(b) A surety bond is "an agreement by one party (the surety) to answer for the failure of another (the principal) to perform as the principal has promised" (Commercial Insurance, p. 1.11).

Problem S5-123-3.

(a) Name four elements that are likely to be found in the declarations of a commercial package policy.

(b) Name and briefly describe four policy conditions that are likely to be found in a commercial package policy.

(c) Name four coverage parts that are likely to be found in a commercial package policy.

Solution S5-123-3. This question is based on the discussion in Commercial Insurance, pp. 1.14-1.17.

(a) The following elements are likely to be found in the declarations of a commercial package policy (Commercial Insurance, p. 1.14):

1. Policy number;

2. Names of the insurer and producer;

3. Name, address, and business description of the named insured;

4. Effective date and expiration date of the policy;

5. Premium for each coverage part included in the policy;

6. Total premium.

Any four of the above suffice as an answer. Other valid answers may also be possible.

(b) The following policy conditions are likely to be found in a commercial package policy:

1. Cancellation: Terms under which the insured and insurer may cancel the policy, and provisions pertaining to notices of cancellation;

2. Changes: Statement that the policy can only be changed by a written endorsement from the insurer;

3. Examination of Books and Records: The insurer's right to audit and examine the insured's books and records related to the policy;
4. **Inspections and Surveys**: The insurer's right to inspect the insured's premises and operations;

5. **Premiums**: The insured's responsibility for paying premiums and the insurer's responsibility of refunding any return premium owed to the insured;

6. **Transfer of Rights and Duties Under the Policy**: Non-transferability of the policy by the insured, except with the insurer's written consent - or an analogous provision.

Any four of the above suffice as an answer. Other valid answers may also be possible.

(c) The following coverage parts are likely to be found in a commercial package policy (*Commercial Insurance*, p. 1.17):

1. Commercial property;
2. Commercial crime;
3. Equipment breakdown;
4. Commercial inland marine;
5. Commercial general liability;

Any four of the above suffice as an answer. Other valid answers may also be possible.

**Problem S5-123-4.**

(a) In a commercial property insurance policy or coverage part, what is the purpose of the *cause of loss form*?

(b) Name three types of cause of loss forms that are typically available for many commercial property insurance policies or coverage parts.

**Solution S5-123-4.** This problem is based on the discussion in *Commercial Insurance*, p. 2.5.

(a) A cause of loss form specifies the perils covered under the commercial property insurance policy or coverage part.

(b) The following are three common types of cause of loss forms: (1) the **basic form**, (2) the **broad form**, and (3) the **special form**.

**Problem S5-123-5.**

(a) What three broad categories of property are covered under the Building and Personal Property (BPP) form commonly used to provide commercial property coverage?

(b) Name four features, in addition to the building itself, that are encompassed in the definition of "building" under the Building and Personal Property (BPP) form?
**Solution S5-123-5.** This problem is based on the discussion in *Commercial Insurance*, pp. 2.7-2.8.

(a) The following three broad categories of property are covered under the Building and Personal Property (BPP) form:

1. The building itself;
2. The named insured's business personal property;
3. Personal property of others.

(b) The following features, in addition to the building itself, are encompassed in the definition of "building" under the Building and Personal Property (BPP) form (*Commercial Insurance*, p. 2.8):

1. "Completed additions to covered buildings";
2. Fixtures, indoor and outdoor;
3. "Permanently installed machinery and equipment";
4. "Personal property owned by the insured and used to maintain or service the building or its premises";
5. Additions, alterations, or repairs in progress, including materials, equipment, and supplies relating to such work, provided that they are in close proximity to the premises. These items are only covered if they are not otherwise insured.

Any four of the above suffice as an answer. Other valid answers may also be possible.
Section 124

Aspects of Typical Commercial Property Insurance Coverage Forms and Causes of Loss Forms

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**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-124-1.** Name four categories that are encompassed under the definition of the insured's "business personal property" in a typical building and personal property (BPP) coverage form. Define, where necessary, any terms whose meaning is different or more specific than their common meaning.

**Solution S5-124-1.** This question is based on the discussion in *Commercial Insurance*, p. 2.9. The following categories are encompassed under the definition of the insured's "business personal property" in a typical building and personal property (BPP) coverage form:

1. Furniture and fixtures owned by the insured and used in the insured's business;
2. Machinery and equipment owned by the insured and used in the insured's business;
3. Stock owned by the insured and used in the insured's business. "Stock" can encompass merchandise that is stored or held for sale, as well as raw, in-process, or finished goods and supplies that are used to pack and ship such goods;
4. "Labor, materials, or services furnished by the insured on personal property of others" (*Commercial Insurance*, p. 2.9);
5. Improvements and betterments: "Alterations or additions made to the building at the expense of an insured who does not own the building and who cannot legally remove them" (*Commercial Insurance*, p. 2.9);
6. Leased personal property, if the insured has a contractual responsibility to provide insurance coverage for that property.

Any four of the above suffice as an answer. Other valid answers may also be possible.

**Problem S5-124-2.**

(a) Under what two circumstances would a typical building and personal property (BPP) coverage form provide coverage for personal property of others, who are not insureds?

(b) In order for coverage to apply, must the insured be legally responsible for the damage to otherwise covered personal property of others?

**Solution S5-124-2.** This question is based on the discussion in *Commercial Insurance*, p. 2.9.

(a) A typical building and personal property (BPP) coverage form provides coverage for personal property of others, who are not insureds, under the following circumstances:

1. The property is in the care, custody, or control of the insured;
2. The property is in or in close proximity to a building described on the policy declarations as the "insured premises".

(b) In order for coverage to apply, the insured **need not be legally responsible** for the damage to otherwise covered personal property of others.

**Problem S5-124-3.**

(a) The property excluded under a typical building and personal property (BPP) coverage form can typically be insured via an endorsement. What kind of property is an exception to this rule and is totally uninsurable?

(b) How does a typical building and personal property (BPP) coverage form treat property that is insured under a different policy?

**Solution S5-124-3.** This question is based on the discussion in *Commercial Insurance*, p. 2.10.

(a) **Contraband**, or property that is being illegally transported and traded, is the only property that is totally uninsurable with regard to the BPP coverage form, and no endorsements are available to provide insurance for it.

(b) A typical BPP coverage form would provide coverage only **in excess** of other insurance that applies to property that would otherwise be covered. If the other insurance's limits are exhausted and some amount of the loss still remains, the BPP form would pay the difference between the loss amount that would be payable under the BPP form if no other insurance existed and the applicable limit of the other insurance policy.
**Problem S5-124-4.**
(a) Name the six *additional coverages* typically made available under a building and personal property (BPP) coverage form.
(b) Name the six *coverage extensions* typically made available under a building and personal property (BPP) coverage form.

**Solution S5-124-4.** This problem is based on the discussion in *Commercial Insurance*, pp. 2.11-2.16.

(a) The following additional coverages are typically made available under a building and personal property (BPP) coverage form:

1. Debris Removal;
2. Preservation of Property;
3. Fire Department Service Charge;
4. Pollutant Cleanup and Removal;
5. Increased Cost of Construction;

(b) The following coverage extensions are typically made available under a building and personal property (BPP) coverage form:

1. Newly Acquired or Constructed Property;
2. Personal Effects and Property of Others;
3. Valuable Papers and Records (Other Than Electronic Data);
4. Property Off-Premises;
5. Outdoor Property;

**Problem S5-124-5.**

(a) Three common causes of loss forms are the broad, basic, and special forms. Arrange these three forms in the order of the scope of the perils which they cover. Your answer should be in the format ______ > _______ > _______, where the first form listed covers the most perils.

(b) Of the forms mentioned in part (a), one form is not like the others with regard to the manner in which the determination of whether a peril is covered is made. Which form is different, and how?

**Solution S5-124-5.** This problem is based on the discussion in *Commercial Insurance*, pp. 3.3, 3.14.

(a) Special form > Broad form > Basic form.

(b) The **special form** is different, in that it shifts the burden of proving that a peril is excluded to the insurer. Under the basic and broad forms, unless a peril is explicitly named in the forms, it is excluded. Under the special form, unless the peril is specifically excluded in the form, it is covered.
Section 125

Covered Perils and Exclusions Under Typical Commercial Property Insurance Causes of Loss Forms

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Original Problems and Solutions from The Actuary’s Free Study Guide

Problem S5-125-1.
(a) List eight of the perils that are covered in the "basic" causes of loss form used in commercial property insurance.
(b) List three perils that are covered in the "broad" causes of loss form, but not the "basic" causes of loss form used in commercial property insurance.

Solution S5-125-1. This problem is based on the discussion in Commercial Insurance, p. 3.4.

(a) The following perils are covered in the "basic" causes of loss form:

1. Fire
2. Lightning
3. Explosion
4. Windstorm or hail
5. Smoke
6. Aircraft or vehicles
7. Riot or civil commotion
8. Vandalism
9. Sprinkler leakage
10. Sinkhole collapse
11. Volcanic action
12. Limited coverage for fungus, wet rot, dry rot, and bacteria

Any eight of the above suffice as an answer. Other valid answers may also be possible.

(b) The following perils are covered in the "broad" causes of loss form, but not the "basic" causes of loss form:

1. Falling objects
2. Weight of snow, ice, or sleet
3. Water damage
4. Collapse due to certain perils (an additional coverage)

Any three of the above suffice as an answer. Other valid answers may also be possible.

**Problem S5-125-2.**
(a) What is the distinction between a "friendly fire" and a "hostile fire", as traditionally used in insurance?
(b) What two categories of events are explicitly excluded from the definition of "explosion" in a typical causes of loss form that covers explosion as a peril?

**Solution S5-125-2.** This problem is based on the discussion in *Commercial Insurance*, p. 3.5.

(a) Traditionally (though this distinction is becoming somewhat less clear due to recent court decisions), a "friendly fire" is a fire within its intended location (e.g., a stove or fireplace), whereas a "hostile fire" is a fire that escapes from its intended location.

(b) The following two categories of events are explicitly excluded from the definition of "explosion" in a typical causes of loss form (*Commercial Insurance*, p. 3.5):

1. Situations where pressure relief devices rupture or burst;
2. Situations where a building ruptures or bursts because its contents swell or expand as a result of water absorption.

**Problem S5-125-3.**

(a) List six exclusions, found in a typical "basic" causes of loss form, which are subject to anti-concurrent-causation wording.

(b) List four exclusions, found in a typical "basic" causes of loss form, which are not subject to anti-concurrent-causation wording. (These may be known as "other exclusions".)

(c) Two of the exclusions which are valid answers for part (b) are not incorporated into a "broad" causes of loss form. Which two exclusions are these?
Solution S5-125-3. This question is based on the discussion in *Commercial Insurance*, pp. 3.7-3.11.

(a) The following exclusions, found in a typical "basic" causes of loss form, are subject to anti-concurrent-causation wording:

1. Ordinance or Law
2. Earth Movement
3. Governmental Action
4. Nuclear Hazard
5. Utility Services
6. War and Military Action
7. Water
8. "Fungus," Wet Rot, Dry Rot, and Bacteria

Any six of the above suffice as an answer. Other valid answers may also be possible.

(b) The following exclusions, found in a typical "basic" causes of loss form, are not subject to anti-concurrent-causation wording (*Commercial Insurance*, p. 3.10):

1. Electric currents that are artificially generated;
2. "Rupture or bursting of water pipes" that is not caused by a covered peril;
3. "Leakage of water or steam" that is not caused by a covered peril and is not from an automatic sprinkler system;
4. Explosion of steam pipes, turbines, engines, and boilers "owned by, leased to, or operated by the insured";
5. Mechanical breakdown;
6. Insured's neglect to save and preserve the property at or after loss using all reasonable means.

Any four of the above suffice as an answer. Other valid answers may also be possible.

(c) The following two exclusions are found in a typical "basic" causes of loss form, but not in a typical "broad" causes of loss form (*Commercial Insurance*, p. 3.11):

1. "Rupture or bursting of water pipes" that is not caused by a covered peril;
2. "Leakage of water or steam" that is not caused by a covered peril and is not from an automatic sprinkler system.

Problem S5-125-4.

(a) What kinds of situations is the "water damage" coverage in a typical "broad" causes of loss form intended to cover?

(b) List three kinds of losses that would typically be excluded from the definition of "water damage" under a typical "broad" causes of loss form - and would therefore not be covered under that peril.
Solution S5-125-4. This problem is based on the discussion in Commercial Insurance, p. 3.12.

(a) The "water damage" coverage in a typical "broad" causes of loss form is intended to cover losses due to water or steam leakage as a result of situations where appliances or systems that contain water or steam - including plumbing, heating, and air conditioning systems - crack or break apart.

(b) The following losses would typically be excluded from the definition of "water damage" (Commercial Insurance, p. 3.12):

1. Cost of repairing any defect that resulted in the water damage;
2. Damage that occurs gradually - typically over a period of two weeks or longer;
3. Leakage or discharge from an automatic sprinkler system (covered under the sprinkler leakage peril);
4. "Discharge or leakage from a sump, including overflow because of sump pump failure";
5. "Discharge or leakage from roof drains, gutters, downspouts, or similar fixtures or equipment".

Any three of the above suffice as an answer. Other valid answers may also be possible.

Problem S5-125-5.
(a) List four circumstances under which coverage for collapse would be provided under a typical "broad" causes of loss form.
(b) How is "collapse" typically defined under a "broad" causes of loss form?

Solution S5-125-5. This problem is based on the discussion in Commercial Insurance, pp. 3.12-3.13.

(a) Coverage for collapse would be provided under a typical "broad" causes of loss form under any of the following circumstances:

1. The collapse results from a cause of loss that is itself covered under the "broad" form;
2. The collapse results from hidden decay that is not known to the insured prior to the collapse;
3. The collapse results from hidden damage by insects or vermin that is not known to the insured prior to the collapse;
4. The collapse results from the weight of personal property or people;
5. The collapse results from the weight of rain that has collected on a roof;
6. The collapse occurs during the course of construction and is the result of poor construction methods or defective materials.

Any four of the above suffice as an answer. Other valid answers may also be possible.

(b) "Collapse" is typically defined under a "broad" causes of loss form as a falling down or caving in of a building or part of the building which (1) is abrupt and (2) results in the building or building part no longer being usable for its intended purpose (Commercial Insurance, p. 3.13).
Section 126

Elements of the "Special" Commercial Property Insurance Causes of Loss Form and Commercial General Liability Insurance

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**Source:**

Original Problems and Solutions from The Actuary's Free Study Guide

**Problem S5-126-1.**

(a) How does coverage of theft losses in the "special" causes of loss form used in commercial property insurance differ from coverage of theft losses in the "broad" and "basic" causes of loss forms?

(b) If rain, snow, ice, sleet, dust, or sand damage the interior of a building, and there was no damage to the roof or walls of the building by a covered peril, the "basic" and "broad" causes of loss forms would typically exclude coverage for such losses. How does treatment of such damage in the "special" cause of loss form differ from the above?

**Solution S5-126-1.** This problem is based on the discussion in *Commercial Insurance*, p. 3.14.

(a) The "broad" and "basic" forms only cover theft that occurs due to looting in the course of a riot or civil commotion.

By contrast, the "special" form covers theft of covered property under a broad array of circumstances - essentially in all cases not specifically limited or excluded in the form. Because
the "special" form covers all risks of direct physical loss not specifically excluded, it provides much broader coverage than the "basic" and "broad" forms, which only cover named perils.

(b) The "special" form treats damage to the interior of a building from rain, snow, ice, sleet, dust, or sand in the same manner as the "broad" and "basic" forms - except that if ice, snow, or sleet melt on the building, the resulting water damage loss is covered.

**Problem S5-126-2.**

(a) Describe five perils that are specifically excluded under a typical "special" causes of loss form but would not be excluded (or named, or covered) under "basic" or "broad" causes of loss forms.

(b) If a covered peril results from any of the excluded perils in part (a) above, how would the "special" cause of loss treat such a peril?

**Solution S5-126-2.** This problem is based on the discussion in *Commercial Insurance*, pp. 3.15-3.16.

(a) Coverage for the following perils are specifically excluded only in the "special" causes of loss form:

1. Wear and tear;
2. "Rust, corrosion, decay, deterioration, or hidden or latent defect";
3. Smog;
4. "Settling, cracking, shrinking, or expansion";
5. "Infestations and waste products of insects, birds, rodents, or other animals";
6. Mechanical breakdown;
7. "Damage to personal property by dampness or dryness of atmosphere, changes or extremes in temperatures, or marring or scratching";
8. "Weather conditions that contribute to other excluded causes of loss";
9. Actions or decisions, or failures thereof, by any person, group of people, or organization;
10. "Faulty or inadequate planning, zoning, surveying, siting, design, specifications, workmanship, repair, construction, renovation, remodeling, grading, compaction, materials, or maintenance";
11. Any "release, discharge, or dispersal of pollutants".
Any five of the above suffice as an answer.

(b) If a covered peril results from an excluded peril, the "special" form will cover the resulting peril, but not the original excluded peril. For instance, if faulty workmanship resulted in the spread of a building fire, the special form would cover the damage due to the fire, but not any damage due to the faulty workmanship alone.

**Problem S5-126-3.**

(a) Under a typical "special" causes of loss form, what four kinds of property are covered only if specified causes of loss are responsible for damage to the property?

(b) Name two cases in which theft of covered property would be specifically excluded under a typical "special" causes of loss form.

(c) Name three types of property for which theft coverage under a "special" causes of loss form would be subject to limits.

(d) Name and briefly describe three coverage extensions that are found in a typical "special" causes of loss form.

**Solution S5-126-3.** This problem is based on the discussion in *Commercial Insurance*, pp. 3.16-3.18.

(a) Under a typical "special" causes of loss form, the following four kinds of property are covered only if specified causes of loss are responsible for damage to the property (*Commercial Insurance*, p. 3.16):

1. Valuable papers and records;

2. Animals, only when their death results;

3. Fragile items that are broken;

4. Builders' machinery or equipment that the insured owns and that is more than a certain distance away from the insured premises.

(b) Theft of covered property would be specifically excluded under a typical "special" causes of loss form in the following circumstances (*Commercial Insurance*, p. 3.16):

1. Theft by the insured or of the insured's employees, partners, directors, officers, managers, or members;

2. Voluntary relinquishment of property due to fraudulent schemes or tricks;
3. Transfer of property "outside the described premises on the basis of unauthorized instructions";

4. Theft of construction materials not attached to the building, unless these materials are being held by the named insured for sale;

5. Property that is missing without explanation.

(c) The following are types of property for which theft coverage under a "special" causes of loss form would be subject to limits (Commercial Insurance, p. 3.17):

1. Furs and fur-trimmed garments;

2. Jewelry, precious metals, and watches - unless these are valued at less than a specified amount;

3. Dies, molds, patterns, and forms;

4. Tickets, stamps, and letters of credit.

Any three of the above suffice as an answer.

(d) The following three coverage extensions are found in a typical "special" causes of loss form (Commercial Insurance, pp. 3.17-3.18):

1. Property in Transit - coverage for property transported in a motor vehicle owned, leased, or operated by the insured and within the coverage territory;

2. Water Damage, Other Liquids, Powder or Molten Material Damage - coverage for the "cost to tear out and replace any part of a building necessary to repair an appliance or a system from which water or another liquid... has escaped";

3. Glass - coverage for the cost of "installing temporary glass plates or boarding up openings when repair or replacement of damaged glass has been delayed".

Problem S5-126-4.

(a) Liability losses can bring about numerous costs to a commercial organization. What two kinds of costs of liability losses are generally not covered by insurance policies?

(b) Name and briefly describe the four principal types of loss exposures insured under commercial general liability (CGL) insurance policies.

Solution S5-126-4. This problem is based on the discussion in Commercial Insurance, pp. 8.3, 8.7-8.8.
(a) The following two kinds of costs of liability losses are generally not covered by insurance policies (*Commercial Insurance*, p. 8.3):

1. Costs to reduce the future probability of additional, similar, or related losses;
2. Indirect costs, such as adverse publicity from being sued and the time spent in defending against the liability claim.

(b) The following four principal types of loss exposures are insured under commercial general liability (CGL) insurance policies (*Commercial Insurance*, pp. 8.7-8.8):

1. **Premises liability exposures**: Exposures arising from the "ownership, occupancy, or use of premises";
2. **Operations liability exposures**: Exposures arising from "activities in addition to the ownership, occupancy, or use of premises";
3. **Products liability exposures**: Exposures arising from "products sold or distributed by the exposed party";
4. **Completed operations liability exposures**: Exposures arising from "work completed by the exposed party".

**Problem S5-126-5.** A typical commercial general liability (CGL) insurance policy offers three principal coverages: Coverages A, B, and C. Match the following coverage names to their respective letters from memory:

- Personal and Advertising Injury Liability
- Bodily Injury and Property Damage Liability
- Medical Payments

**Solution S5-126-5.** This problem is based on the discussion in *Commercial Insurance*, pp. 8.9.

**Coverage A** is *Bodily Injury and Property Damage Liability*.

**Coverage B** is *Personal and Advertising Injury Liability*.

**Coverage C** is *Medical Payments*. 
Section 127

Coverages and Exclusions of a Typical Commercial General Liability Insurance Policy

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Source:

Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-127-1.

(a) In the insuring agreement pertaining to typical commercial general liability (CGL) insurance policy coverages for bodily injury and property damage liability (Coverage A), as well as for personal and advertising injury liability (Coverage B), what are the two fundamental promises made by the insurer to the insured?

(b) What seven conditions must be met in order for an insurer to pay for damages under Coverage A of a typical occurrence-based CGL policy?

(c) If the CGL policy is claims-made, rather than occurrence-based, which of the conditions in your answer to part (b) would be different?

Solution S5-127-1. This problem is based on the discussion on pp. 8.9-8.10 of Commercial Insurance.
(a) In the insuring agreement for Coverages A and B of a CGL insurance policy, the insurer promises to (1) pay damages on the insured's behalf and (2) defend the insured against lawsuits or claims where damages that would be covered under the policy are sought.

(b) The following seven conditions must be met in order for an insurer to pay for damages under Coverage A of a typical occurrence-based CGL policy (Commercial Insurance, p. 8.10):

1. The insured must have legal liability for the damages;
2. "Bodily injury" or "property damage" - as defined in the policy - must have resulted in the damages;
3. The policy must cover the "bodily injury" or "property damage";
4. The "bodily injury" or "property damage" must have resulted from an "occurrence" as defined in the policy;
5. The "occurrence" must have occurred within the "coverage territory", as defined in the policy;
6. The "bodily injury" or "property damage" must have taken place during the policy period;
7. Prior to the policy period, the "bodily injury" or "property damage" must not be known to the insured or other persons described in the policy.

(c) If the CGL policy is claims-made, rather than occurrence-based, then the requirement that the "bodily injury" or "property damage" must have taken place during the policy period (requirement 6 in part (b) above) does not apply. Rather, the claim for the "bodily injury" or "property damage" must have been initiated during the policy period.

Problem S5-127-2. Name ten exclusions that are found in Coverage A of a typical commercial general liability (CGL) insurance policy.

Solution S5-127-2. This problem is based on the discussion on pp. 8.13-8.24 of Commercial Insurance.

The following ten exclusions that are found in Coverage A of a typical commercial general liability (CGL) insurance policy:

1. Expected or Intended Injury;
2. Contractual Liability (if the liability would not have existed in the absence of the contract);
3. Liquor Liability (for insureds in the business of manufacturing, distributing, or serving alcohol);
4. Workers' Compensation;
5. Employers' Liability;

6. Pollution;

7. Aircraft, Auto, or Watercraft;

8. Mobile Equipment (exclusion applies in narrow circumstances, when such equipment is being transported or used in racing, demolition, or stunt activities);

9. War;

10. Damage to Property (applies mostly to property owned, rented, or occupied by the insured and several other circumstances);

11. Damage to Your Product;

12. Damage to Your Work;

13. Damage to Impaired Property or Property Not Physically Injured;

14. Recall of Products, Work, or Impaired Property;

15. Personal and Advertising Injury (covered under Coverage B);


Any ten of the above suffice as an answer. Other valid answers may also be possible.

**Problem S5-127-3.**

(a) List four types of "personal and advertising injury", as defined under Coverage B of a typical commercial general liability (CGL) insurance policy.

(b) List eight exclusions that apply to Coverage B of a typical commercial general liability (CGL) insurance policy.

**Solution S5-127-3.** This question is based on the discussion in *Commercial Insurance*, pp. 8.25-8.29.

(a) The following actions are defined as "personal and advertising injury" under Coverage B of a typical commercial general liability (CGL) insurance policy (*Commercial Insurance*, p. 8.25):

1. False arrest, false detention, and false imprisonment;

2. Malicious prosecution;
3. Wrongful eviction, wrongful entry, and invasion of privacy;

4. Slanderous or libelous oral or written publication;

5. Oral or written publication that violates a person's right to privacy;

6. Use of another's advertising idea in an advertisement;

7. Infringement on a copyright, trade dress, or slogan in an advertisement.

Any four of the above suffice as an answer. Other valid answers may also be possible.

(b) The following exclusions apply to Coverage B of a typical commercial general liability (CGL) insurance policy:

1. Knowing Violation of the Rights of Another;

2. Material Published With Knowledge of Falsity;

3. Material Published Prior to Policy Period;

4. Criminal Acts;

5. Contractual Liability;

6. Breach of Contract;

7. Quality of Performance of Goods - Failure to Conform to Statements;

8. Wrong Description of Prices;

9. Infringement of Copyright, Patent, Trademark, or Trade Secret (does not apply to infringement in an advertisement of a copyright, trade dress, or slogan);

10. Insureds in Media and Internet-Type Businesses;

11. Electronic Chatrooms or Bulletin Boards;

12. Unauthorized Use of Another's Name or Product;

13. Pollution;

14. Pollution-Related (related to testing for, monitoring, or cleaning up pollutants);

15. War.
Any eight of the above suffice as an answer. Other valid answers may also be possible.

**Problem S5-127-4.** What kinds of supplementary payments will the insurer make, where necessary, in addition to policy limits, in relation to situations covered under Coverages A and B of a typical commercial general liability (CGL) insurance policy? Give five examples.

**Solution S5-127-4.** This question is based on the discussion in *Commercial Insurance,* pp. 8.29-8.30.

The following are supplementary payments that are payable in addition to policy limits in relation to situations covered under Coverages A and B of a typical commercial general liability (CGL) insurance policy:

1. Insurer's expenses - including costs of attorneys, witnesses, and police reports;
2. Cost of bail bonds, up to a certain amount, arising from accidents or traffic violations that involve a covered vehicle;
3. "Cost of bonds to release any property of the insured held by a plaintiff to ensure payment that may be rendered against the insured";
4. Reasonable expenses that the insured incurs at the insurer's request;
5. Court costs and other costs that are not damages and that the insured is required to pay as a result of a suit;
6. Prejudgment interest or post-judgment interest awarded against the insured.

Any five of the above suffice as an answer. Other valid answers may also be possible.

**Problem S5-127-5.**

(a) To what two kinds of accidents does Coverage C: Medical Payments of a typical commercial general liability (CGL) insurance policy apply?

(b) Name three kinds of persons who would be excluded from coverage under Coverage C: Medical Payments of a typical commercial general liability (CGL) insurance policy.

**Solution S5-127-5.** This question is based on the discussion in *Commercial Insurance,* p. 8.31.

(a) Coverage C: Medical Payments of a typical commercial general liability (CGL) insurance policy applies to accidents that either (1) occur on or adjacent to the named insured's premises and adjacent roads and other passages or (2) result from the named insured's operations.
(b) The following kinds of persons who would be excluded from coverage under Coverage C: Medical Payments of a typical commercial general liability (CGL) insurance policy (*Commercial Insurance*, p. 8.31):

1. An insured;

2. A tenant of an insured or a person hired to do work by an insured;

3. "A person injured on that part of the named insured's premises that the person normally occupies";

4. A person who is entitled to benefits from workers' compensation insurance as a result of the injury;

5. A person whose injury occurs while the person engages in athletic activity.

Any three of the above suffice as an answer. Other valid answers may also be possible.
Section 128

Insureds and Limits of Commercial General Liability Insurance Policies

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Problem S5-128-1.
(a) For a typical commercial general liability (CGL) insurance policy, if the named insured is an individual, then the named insured's spouse is considered an insured. However, there are two important types of situations in which coverage does not apply. What are these situations?
(b) Name two situations in which the named insured's employees and volunteer workers would not be considered insureds under a typical commercial general liability (CGL) insurance policy.

Solution S5-128-1. This problem is based on the discussion in Commercial Insurance, pp. 9.3-9.4.

(a) Coverage under a typical CGL policy does not apply (1) to the non-business activities of the named insured and spouse, and (2) to any business owned by an unnamed spouse, unless that business is specified as an insured within the policy (Commercial Insurance, p. 9.3).

(b) The following are situations in which the named insured's employees and volunteer workers would not be considered insureds under a typical commercial general liability (CGL) insurance policy (Commercial Insurance, p. 9.4):

1. The employees/volunteer workers commit bodily injury or personal and advertising injury to the named insured or the named insured's other employees, volunteer workers, partners or members;
2. There is bodily injury or personal and advertising injury as a result of the provision or failure by the employees/volunteer workers to provide professional health care services;
3. The employees/volunteer workers commit *property damage* to the named insured or the named insured's other employees, volunteer workers, partners or members.

Any two of the above suffice as an answer.

**Problem S5-128-2.** Name and describe three kinds of "other persons and organizations" that are considered insureds and afforded coverage under a typical commercial general liability (CGL) insurance policy.

**Solution S5-128-2.** This problem is based on the discussion in *Commercial Insurance*, pp. 9.5.

The following three kinds of "other persons and organizations" are considered insureds and afforded coverage under a typical commercial general liability (CGL) insurance policy:

1. **Real Estate Managers:** Persons or organizations who are not employees or volunteer workers of the named insured and who are acting as real estate managers for the named insured are considered insureds, only insofar as they act in this capacity.
2. **Legal Representatives:** Persons who are temporary custodians of the named insured's property, only with respect to their duties as legal representatives. The coverage afforded to such persons only exists for liability due to the use or maintenance of the property.
3. **Newly Acquired Organizations:** Organizations acquired or formed by the named insured, other than partnerships, limited liability companies (LLCs), and joint ventures. Coverage is only provided for the first X days (e.g., 90 days) after the organization's formation, or until the end of the policy period, whichever is earliest. Thereafter, the organization must be named in the policy in order to be an insured.

**Problems S5-128-3 through S5-128-5 apply to the following scenario:**

An occurrence-based commercial general liability (CGL) insurance policy issued by Insurance Company Ψ lists Snoitulos Solutions as the named insured. The following are the limits pertaining to the policy per policy term of one year:

- General aggregate limit: $2,000,000
- Products/completed operations aggregate limit: $4,000,000
- Personal and advertising injury limit: $500,000
- Each occurrence limit: $1,000,000
- "Damage to premises rented to you" limit: $300,000
- Medical expense per-person limit: $20,000

The following occurrences involved Snoitulos Solutions during the year 2055. All claims were submitted and settled shortly after the occurrences. The policy is so interpreted that each of the scenarios below is considered a *single* occurrence.
Occurrence 1. Snoitulos Solutions used another company's logo in its advertisements in an unauthorized fashion. It was found to be liable for $650,000. An irate representative of the other company also traveled to the headquarters of Snoitulos Solutions, went into a mad rage, and beat up two guests who just happened to be there, resulting in medical expenses of $25,000 for one guest and $12,000 for the other.

Occurrence 2. A salt solution manufactured by Snoitulos Solutions is found to actually contain trace amounts of poison. Customers who have consumed the solution are awarded damages of $3,000,000.

Occurrence 3. Employees of Snoitulos Solutions are found to have negligently mishandled an expensive piece of property that a client wanted repaired. As a result, the property had to be abandoned before being returned to the client and could not be restored to working condition. The client is entitled to recover damages of $4,500,000.

Problem S5-128-3. How much will Insurance Company Ψ pay for Occurrence 1?

Solution S5-128-3. The unauthorized use of the other company's logo was a personal and advertising injury, so the personal and advertising injury limit of $500,000 applies to the $650,000 damages for such unauthorized use. The medical expenses to the two guests, who were beaten up by the representative of the other company, are not the fault of Snoitulos Solutions but would be covered under Coverage C: Medical Payment, which provides coverage regardless of fault. Each person would be covered up to the per-person limit of $20,000. For the first injured guest, $20,000 of the $25,000 of medical costs would be paid. For the second injured guest, the entire $12,000 of medical costs would be paid. These combined medical costs are less than the per-occurrence limit of $1,000,000. Thus, the total that would be paid by the insurer is 500000 + 20000 + 12000 = $532,000.

This means that the general aggregate limit for the year is reduced to 2000000 - 532000 = $1,468,000.

Problem S5-128-4. How much will Insurance Company Ψ pay for Occurrence 2?

Solution S5-128-4. The $3,000,000 damages are encompassed within the policy's $4,000,000 products/completed operations aggregate limit, but are subject to the each occurrence limit of $1,000,000. Thus, the insurer will only pay $1,000,000.

This does not reduce the general aggregate limit, because the products/completed operations aggregate limit is separate from the general aggregate limit.

Problem S5-128-5. How much will Insurance Company Ψ pay for Occurrence 3?

Solution S5-128-5. The property damage of $4,500,000 is subject to the per-occurrence limit of $1,000,000 and also to the remaining general aggregate limit of $1,468,000. The insurer will pay the lesser of the two, i.e., $1,000,000.
Section 129

Conditions of a Typical Commercial General Liability Insurance Policy

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Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-129-1.

(a) In a typical commercial general liability (CGL) insurance policy, how would bankruptcy or insolvency of the insured affect the coverage available?

(b) If an insured under a typical commercial general liability (CGL) insurance policy believes that the insurer has not paid for losses covered by the policy and wishes to sue the insurer, what must happen first in order for the very existence of such a lawsuit to be legitimate?

Solution S5-129-1. This problem is based on the discussion in Commercial Insurance, pp. 9.10-9.11.

(a) In a typical commercial general liability (CGL) insurance policy, bankruptcy or insolvency of the insured would not affect the coverage available. A specific Bankruptcy condition will often state that, if the insured becomes bankrupt or insolvent, the insurer's obligations would not be diminished by this (Commercial Insurance, p. 9.10).

(b) If an insured under a typical commercial general liability (CGL) insurance policy believes that the insurer has not paid for losses covered by the policy and wishes to sue the insurer, the insured must first have fully complied with all of the conditions of the CGL policy. This
includes, for instance, cooperating with the insurer in the defense of the liability claim against the insured and forwarding to the insurer all documents relevant to the claim (Commercial Insurance, p. 9.11).

Problem S5-129-2.

(a) If the insured under a typical commercial general liability (CGL) insurance policy becomes aware of a situation that may lead to a claim, the insured is required under the policy to submit a notice to the insurer. What three elements must this notice contain?

(b) If a claim or lawsuit is brought against the insured under a typical commercial general liability (CGL) insurance policy, what are the duties of the named insured? Name four such duties.

Solution S5-129-2. This problem is based on the discussion in Commercial Insurance, pp. 9.10-9.11.

(a) If the insured under a typical commercial general liability (CGL) insurance policy becomes aware of a situation that may lead to a claim, the insured is required under the policy to submit a notice to the insurer containing the following three elements (Commercial Insurance, p. 9.10):

1. Description of the time and location of the occurrence, as well as how it occurred;
2. The names and addresses of (i) any persons injured and (ii) any witnesses;
3. Description of the injury or damage that resulted from the occurrence, as well as the location of the injury/damage.

(b) If a claim or lawsuit is brought against the insured under a typical commercial general liability (CGL) insurance policy, the following are duties of the named insured (Commercial Insurance, pp. 9.10-9.11):

1. Immediate recording of the date the claim/suit was received and the details of said claim/suit;
2. Written notification of the insurer as soon as is feasible;
3. If legal papers are received in connection with the claim/suit, immediate forwarding of such papers to the insurer;
4. Cooperation with the insurer in investigating, settling, and/or defending the claim/suit;
5. Authorization given to the insurer for obtaining any relevant legal records and other relevant documentation;
6. If requested, assistance given to the insurer for action against third parties that may be liable to the insured as a result of injuries/damage pertaining to the claim.

Any four of the above suffice as an answer. Other valid answers may also be possible.

Problem S5-129-3.

(a) Describe three circumstances under which a typical commercial general liability (CGL) insurance policy would be considered excess over other applicable insurance.
(b) If a typical commercial general liability (CGL) insurance policy is considered excess over other applicable insurance, how would the insurer's duty to defend the insured be affected?

**Solution S5-129-3.** This problem is based on the discussion in *Commercial Insurance*, pp. 9.11-9.12.

(a) A typical commercial general liability (CGL) insurance policy would be considered excess over other applicable insurance in the following circumstances:

1. If the other insurance offers coverage for fire, extended coverage, builders' risk coverage, installation risk coverage, "or similar coverage on the named insured's work";
2. If the other insurance is fire insurance on premises that the insured occupies, either through a rental or otherwise with the owner's permission;
3. If the other insurance is purchased by the named insured to cover the named insured's liability as a tenant with regard to premises that the named insured rents or otherwise occupies with the owner's permission;
4. If the other insurance offers auto, aircraft, or watercraft coverage;
5. If the other insurance is primary insurance to which the named insured has been added via endorsement and which covers liability for damages due to (i) premises, (ii) operations, (iii) products, and (iv) completed operations.

Any three of the above suffice as an answer. Other valid answers may also be possible.

(b) If a typical commercial general liability (CGL) insurance policy is considered excess over other applicable insurance, the CGL insurer **no longer has an obligation to defend a claim which any other insurer has the duty to defend.** However, the duty to defend will apply if no other insurer provides a defense to the insured (*Commercial Insurance*, p. 9.12).

**Problem S5-129-4.** Commercial general liability (CGL) insurers X, Y, and Z insure Policyholder A for the same peril, which occurs and causes a loss of $2,300,000.

The following are the limits of coverage offered by each insurer:

- Limit of Insurer X: $500,000
- Limit of Insurer Y: $1,200,000
- Limit of Insurer Z: $2,000,000

(a) Under the method of *contribution by equal shares*, how much would each insurer contribute to payment of the loss?

(b) Under the method of *contribution by limits*, how much would each insurer contribute to payment of the loss?

**Solution S5-129-4.** This problem is based on the discussion in *Commercial Insurance*, pp. 9.12-9.13.
(a) Under the method of contribution by equal shares, each insurer pays an equal amount of the loss until one insurer's limit is exhausted. Each of the three insurers will pay at least $500,000, whereafter Insurer X's limit will be exhausted. A total of $1,500,000 will have been paid at that point, after which Insurers Y and Z must share the remaining $800,000. If Insurers Y and Z each contribute half of this amount ($400,000), their respective limits will still not be exhausted. Thus, each insurer will contribute the following:

Insurer X will contribute $500,000;
Insurer Y will contribute $900,000;
Insurer Z will contribute $900,000.

(b) Under the method of contribution by limits, each insurer will pay that fraction of the loss which corresponds to its limit divided by the sum of all the limits. Thus, Insurer X will pay $1,200,000/(500,000 + 1,200,000 + 2,000,000) = 5/37 of the loss amount, i.e., (5/37)*2,300,000 = $310,810.81.

Insurer Y will pay $1,200,000/(500,000 + 1,200,000 + 2,000,000) = 12/37 of the loss amount, i.e., (12/37)*2,300,000 = $745,945.95.

Insurer Z will pay $2,000,000/(500,000 + 1,200,000 + 2,000,000) = 20/37 of the loss amount, i.e., (20/37)*2,300,000 = $1,243,243.24.

Problem S5-129-5.

(a) What other name might be considered synonymous with the "Transfer of Rights of Recovery Against Others to Us" condition in a typical commercial general liability (CGL) insurance policy?

(b) What is the purpose of the "Transfer of Rights of Recovery Against Others to Us" condition in a typical commercial general liability (CGL) insurance policy?

Solution S5-129-5. This problem is based on the discussion in Commercial Insurance, p. 9.14.

(a) The "Transfer of Rights of Recovery Against Others to Us" condition might also be referred to as the subrogation condition.

(b) The purpose of the "Transfer of Rights of Recovery Against Others to Us" condition is to prohibit the insured from impairing any rights the insurer might have to any part of a claim that it previously paid to the insured. For instance, if the insurer paid $X on behalf of the insured for a claim, and the insured subsequently obtains a payment of $K \leq X$ from a third party which was actually responsible for the claim, the insured must give the $K$ to the insurer. Also, at the insurer's request, the insured is required to assist the insurer, through reasonable means, in enforcing the insurer's subrogation rights.
Section 130

Elements of Typical Claims-Made Commercial General Liability Insurance Policies, Certificates of Insurance, and Other Liability Coverage Forms

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**Problem S5-130-1.** Explain the purpose of an *extended reporting period* in a claims-made commercial general liability insurance policy.

**Solution S5-130-1.** This question is based on the discussion in *Commercial Insurance*, pp. 9.16-9.17.

An extended reporting period is provided to an insured under a claims-made commercial general liability insurance policy in order to provide coverage for claims that (1) pertain to occurrences that took place after the policy's retroactive date and before the policy's expiration but (2) were made after the policy expiration and within the extended reporting period.

An extended reporting period is particularly useful for an insured who used to have a claims-made policy but has now purchased an occurrence-based policy or has no commercial general liability insurance at all. Claims that were made after the expiration of the claims-made policy, but which pertain to occurrences that took place prior to policy expiration, can be covered, where otherwise a coverage gap would exist.
Problem S5-130-2.

(a) What event(s) constitute(s) a claims-made trigger under a typical claims-made commercial general liability insurance coverage form?

(b) Illustrate the difference between notice of an occurrence and notice of a claim by developing a hypothetical scenario pertaining to commercial general liability insurance and providing examples of each kind of notice within the parameters of such a scenario.

Solution S5-130-2. This question is based on the discussion in Commercial Insurance, pp. 9.15-9.16.

(a) A claims-made trigger, i.e., an event that officially determines that a claim has been made, is the earliest of the following two events:
1. Receipt and recording of a notice of the claim by the insurer or by any insured;
2. Settlement of the claim by the insurer.

(b) Many examples are possible. The following is just one such possibility:

Company Γ is insured by Insurer Δ under a commercial general liability policy. A customer of Company Γ purchased a product sold by the company and then began suffering adverse health effects that are closely related to the product's functionality. Company Γ became aware of these effects and informed Insurer Δ that the customer suffered health problems after purchasing Company Γ’s product. This was a notice of an occurrence - a notice that an event happened that might give rise to a claim in the future.

Subsequently, the afflicted customer decided to sue Company Γ and submitted papers pertaining to the lawsuit to the company. Company Γ then forwards these papers to Insurer Δ. This was a notice of a claim. Notice of a claim can only occur after some injured party actually and formally asserts that the insured is liable.

Problem S5-130-3. Identify two differences between a typical claims-made commercial general liability insurance coverage form issued by the Insurance Services Office (ISO) and typical claims-made professional liability coverage forms independently developed by many insurers. (Note: It is assumed that the coverages provided would be different. This question focuses specifically on differences in the claims-made aspects of these forms).

Solution S5-130-3. This question is based on the discussion in Commercial Insurance, p. 9.18. The following differences exist (as of the 2007 publication date of Commercial Insurance):

1. The ISO claims-made form provides a basic extended reporting period of five years that is included in the price of the basic coverage form. The independent claims-made forms typically provide a much shorter included extended reporting period - circa 30 to 60 days.
2. The ISO claims-made form allows the insured to purchase a supplemental extended reporting period that lasts indefinitely. The independent claims-made forms typically only allow the purchase of a supplemental extended reporting period lasting three to seven years.

Other valid answers may be possible, depending on the independent forms being considered.

**Problem S5-130-4.** What is a *certificate of insurance*, and to whom is it provided? Does a certificate of insurance provide or modify insurance coverage under a commercial liability insurance policy?

**Solution S5-130-4.** This question is based on the discussion in *Commercial Insurance*, p. 9.21.

A certificate of insurance is a "brief description of insurance coverage prepared by an insurer or its agent; commonly used by policyholders to provide evidence of insurance". The end user of the certificate is not the insured, but another entity that interacts with the insured and seeks to verify that the insured has coverage. For instance, Business X, prior to entering into a business arrangement with Business Y, may seek to verify that Business Y has commercial general liability insurance. The certificate itself does *not* provide or modify insurance coverage; it merely summarizes coverage that exists via the policy and any applicable endorsements.

**Problem S5-130-5.** What kinds of liability coverage forms might business purchase in addition to commercial general liability (CGL) coverage forms in order to cover loss exposures not covered under a typical CGL policy? Briefly describe three examples.

**Solution S5-130-5.** This question is based on the discussion in *Commercial Insurance*, pp. 9.25-9.26. The following additional liability coverage forms may be available:

1. Liability coverage forms that cover liquor liability of business that manufacture, distribute, or sell alcoholic beverages;

2. Liability coverage forms for hazardous products or completed operations that would be excluded from coverage by a CGL insurer;

3. Liability coverage forms that protect a property owner against bodily injury liability and property damage liability that results from the contractor's operations and the property owner's errors and omissions in supervising the contractor's operations;

4. Liability coverage forms that protect a railroad against claims that result from a contractor's work on or adjacent to railroad property;

5. Coverage endorsements and liability coverage forms that insure against pollution liability arising out of various circumstances.

Any three of the above suffice as an answer. Other valid answers may also be possible.
Section 131

Elements of Workers' Compensation Insurance

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**Problem S5-131-1.**

(a) What are the four types of benefits that can be provided to covered employees under a workers' compensation insurance policy in the event of an occupational injury or occupational disease?

(b) Name and define the four types of disability classifications used in workers' compensation insurance.

**Solution S5-131-1.** This problem is based on the discussion in *Commercial Insurance*, pp. 12.4-12.5.

(a) The following four types of benefits can be provided to covered employees under a workers' compensation insurance policy in the event of an occupational injury or occupational disease:

1. Medical benefits;
2. Disability income benefits;
3. Rehabilitation benefits;
4. Death benefits.
(b) The following are the four types of disability classifications used in workers' compensation insurance (Commercial Insurance, p. 12.5):

1. Temporary partial disability: "A disability caused by a work-related injury or disease that temporarily limits the extent to which an employee can perform job duties for a period of time."

2. Temporary total disability: "A disability caused by a work-related injury or disease that temporarily renders an injured employee unable to perform any job duties for a period of time."

3. Permanent partial disability: "A disability caused by a work-related injury or disease that impairs the injured employee's earning capacity for life, but the employee is able to work at reduced efficiency."

4. Permanent total disability: "A disability caused by a work-related injury or disease that renders an injured employee unable to ever return to gainful employment."

Problem S5-131-2.

(a) Do workers' compensation medical benefits ordinarily have a deductible applied to them? If so, is the deductible in the form of time or money?

(b) Do workers' compensation disability income benefits ordinarily have a deductible applied to them? If so, is the deductible in the form of time or money?

Solution S5-131-2. This problem is based on the discussion in Commercial Insurance, pp. 12.4-12.5.

(a) Workers' compensation do not ordinarily have a deductible applied to them.

(b) Workers' compensation ordinarily have a deductible in the form of time, otherwise known as a waiting period, applied to them. If a disability does not continue beyond the waiting period, typically several days, then no disability income benefits are paid. If the disability does continue beyond the waiting period, then the disability income benefits are typically paid retroactive to the time of the injury.

Problem S5-131-3.

(a) What is the main rehabilitation benefit offered under typical workers' compensation insurance policies?

(b) Aside from the benefit from part (a) above, name two other kinds of rehabilitation benefits offered under many typical workers' compensation insurance policies.

Solution S5-131-3. This problem is based on the discussion in Commercial Insurance, p. 12.6.
(a) The main rehabilitation benefit offered under typical workers' compensation insurance policies is payment of expenses for medical treatment and medical rehabilitation.

(b) Other rehabilitation benefits offered under many typical workers' compensation insurance policies include the following:

1. Vocational rehabilitation;
2. Maintenance allowance to injured workers during rehabilitation;
3. Payment of expenses to customize a vehicle to accommodate physical disabilities during rehabilitation.

Any two of the above suffice as an answer. Other valid answers may also be possible.

**Problem S5-131-4.**

(a) Briefly describe two approaches that have typically been used in the contemporary United States to discourage employers from discriminating against employees with existing disabilities.

(b) Briefly describe the steps whereby a worker's injury may result in a workers' compensation claim and the possible payment of benefits.

**Solution S5-131-4.** This question is based on the discussion in *Commercial Insurance*, p. 12.7.

(a) The following two approaches that have typically been used in the contemporary United States to discourage employers from discriminating against employees with existing disabilities:

1. **Second-injury funds** that pay a portion of the claim for a total disability injury to a worker who was previously impaired.

2. The **Americans With Disabilities Act (ADA) of 1990**, which obligates employers to reasonably accommodate disabled employees and forbids discrimination against such employees as long as they can perform their work.

(b) The following are possible steps whereby a worker's injury may result in a workers' compensation claim and the possible payment of benefits:

1. The injured worker gives notice to the employer that the injury has occurred.
2. The employer sends a report regarding the injury to the insurer.
3. The insurer sends the report regarding the injury to the agency that administers the workers' compensation law.
4. If the employer does not contest the claim, the claim is settled between the injured employee and the employer's insurer. The agreement may be reviewed by the workers' compensation agency. (In some states, a direct payment system exists, where agreement is not required prior to the payment of benefits.)
5. If the employer or insurer contests the claim, a hearing is conducted by the workers' compensation agency. The hearing officer makes a decision.
6. After a hearing in step 5, the decision of the hearing officer may be appealed to the workers' compensation agency and, subsequently, to a court.

Variations on the above may constitute a satisfactory answer.

**Problem S5-131-5.**

(a) Name four kinds of workers to whom an ordinary employer would, in many cases, not be obligated to provide workers' compensation coverage.

(b) Identify four questions that might be asked, if an employee primarily works in one state, but a work-related injury or disease occurs in another state, in order to determine which state's workers' compensation laws apply.

**Solution S5-131-5.** This problem is based on the discussion in *Commercial Insurance*, pp. 12.8-12.10.

(a) An ordinary employer would, in many cases, not be obligated to provide workers' compensation coverage following kinds of workers (*Commercial Insurance*, pp. 12.8-12.9):

1. Workers employed by an employer with fewer than a certain number of employees that is stipulated by law;
2. Farm laborers;
3. Domestic workers;
4. Casual employees that are hired only for short periods;
5. Employees covered under alternate plans - such as federal government workers, interstate railroad workers, and maritime workers;
6. Independent contractors without subcontractors;
7. Independent contractors that provide workers' compensation insurance for their subcontractors;
8. Leased employees;
9. Temporary employees.

Any four of the above suffice as an answer. Other valid answers may also be possible.

(b) The following four questions might be asked, if an employee primarily works in one state, but a work-related injury or disease occurs in another state, in order to determine which state's workers' compensation laws apply (*Commercial Insurance*, p. 12.10):

1. Where is the employee typically employed, and what is the nature of this employment?
2. Where was the employee hired?
3. Where does the employee live?
4. In what state is the employer domiciled?

Other valid questions may be asked.
Section 132
Elements of Workers' Compensation Insurance – Part 2

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**Problem S5-132-1.**
(a) Name two kinds of employees that are allowed to sue their employers under U. S. federal law.
(b) What is the difference between an employers' mutual insurance company and a monopolistic state workers' compensation fund?

**Solution S5-132-1.** This question is based on the discussion in *Commercial Insurance*, pp. 12.11-12.13.

(a) Two kinds of employees that are allowed to sue their employers under U. S. federal law are (1) officers and crew members of vessels (per the United States Merchant Marine Act of 1920, a.k.a. the Jones Act) and (2) interstate railroad workers (per the Federal Employers' Liability Act).

(b) An employers' mutual insurance company is not officially a state entity and competes with other providers of workers' compensation. A monopolistic state workers' compensation fund is a state entity, and no competition with it is allowed. Employers must insure with the monopolistic fund in states where such a fund exists. Both types of entities are creations of the state legislatures.
Problem S5-132-2. Company Q is self-insured with regard to workers' compensation but also purchases an excess insurance policy to protect against large losses. The company has suffered the following losses, eligible for workers' compensation, this past policy period:

Occurrence 1: Loss of $500,000
Occurrence 2: Loss of $310,000
Occurrence 3: Loss of $50,000

(a) How much would the insurer pay for these losses if the company had an aggregate excess insurance policy that requires a retention of $760,000?
(b) How much would the insurer pay for these losses if the company had a specific excess insurance policy that requires a retention of $200,000?

Solution S5-132-2. This question is based on the discussion in Commercial Insurance, pp. 12.14.

(a) The retention of the aggregate excess policy applies to the entire policy period, so Company Q self-insures until it has paid out a total of $760,000, and then the aggregate excess policy pays the rest. For this policy period, the total losses are $500000 + $310000 + $50000 = $860,000, so the excess insurer is left to pay the difference: $860000 - $760000 = $100,000.

(b) The retention of a specific excess policy applies to each occurrence. Company Q pays the first $200,000 of each loss, and the excess insurer pays the rest. Here, Company Q will pay for the first $200,000 of Occurrence 1, the first $200,000 of Occurrence 2, and the entirety of Occurrence 3, paying a total of $450,000, leaving the excess insurer to pay the difference: $860000 - $450000 = $410,000.

Problem S5-132-3. Insurance is regulated at the state level. For instance, the holder of a personal automobile insurance policy would, upon moving to a different state, need to obtain a new personal automobile insurance policy specific to that state. Workers' compensation insurance is also regulated at the state level. Suppose that a business is also fully shifting its operations from one state to another. Would that business need to obtain a new workers' compensation policy pertaining to the state to which it moves? Why or why not? (Assume that the insurer of this business operates in both states, is willing to keep insuring the business, and is subscribing to the workers' compensation forms issued by the National Council on Compensation Insurance.)

Solution S5-132-3. This question is based on the discussion in Commercial Insurance, pp. 12.15.

The business would not need to obtain a new workers' compensation policy pertaining to the state to which it moves, because typical workers' compensation policies contain coverage for the obligations imposed under the workers' compensation statutes of the relevant state. Thus, when the insured business moves to a different state, its workers' compensation policy automatically begins to provide the coverage required in that state.

Problem S5-132-4.
(a) In a typical workers' compensation insurance policy, what is the equivalent of the declarations page often called?
(b) Would a typical workers' compensation insurance policy include federal laws such as the Longshore and Harbor Workers' Compensation Act within its definition of workers' compensation laws?

(c) What exclusions does a typical workers' compensation insurance policy list?

Solution S5-132-4. This question is based on the discussion in *Commercial Insurance*, pp. 12.16-12.18.

(a) In a typical workers' compensation policy, the equivalent of the declarations page is often called the information page.

(b) A typical workers' compensation policy would not include federal laws such as the Longshore and Harbor Workers' Compensation Act within its definition of workers' compensation laws. This definition typically only encompasses the workers' compensation laws of the 50 states, the District of Columbia, and explicitly named U. S. territories.

(c) This is a trick question. A typical workers' compensation insurance policy does not list any exclusions. It is written to cover obligations under the relevant states' workers' compensation laws and to pay any benefits prescribed by those laws. The scope of those laws defines the scope of coverage afforded by the policy, so exclusions are not necessary.

Problem S5-132-5.

(a) What additional costs, besides workers' compensation benefits, would an insurer typically be obligated to pay under a workers' compensation policy?

(b) For what four kinds of costs would an insured employer be required to reimburse the insurer under a typical workers' compensation policy?

Solution S5-132-5. This question is based on the discussion in *Commercial Insurance*, pp. 12.18-12.19.

(a) The insurer under a workers' compensation policy would typically be obligated to pay the costs of claim investigation and claim litigation, in addition to workers' compensation benefits.

(b) The insured under a typical workers' compensation policy would be required to reimburse the insurer for penalties arising out of the following situations (*Commercial Insurance*, p. 12.19):

1. The willful misconduct of the insured employer;
2. The insured employer's knowing employment of someone illegally;
3. The insured employer's non-compliance with safety and health statutes and regulations;
4. The insured employer's discrimination against employees who claim benefits under workers' compensation laws.
Section 133

Elements of Employers' Liability Insurance

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Source:

Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-133-1.

(a) Is an employee permitted to pursue direct legal action against the workers' compensation insurer of his/her employer? Briefly explain the rationale behind the answer.

(b) How would the benefits paid to injured employees under a workers' compensation policy be affected if the employer fails to comply with policy requirements?

Solution S5-133-1. This problem is based on the discussion in Commercial Insurance, p. 12.19.

(a) An employee is permitted to pursue direct legal action against the workers' compensation insurer of his/her employer. The reason for this is that workers' compensation insurance policies are obtained primarily for the benefit of employees, and so it would make sense for an employee with a grievance against the workers' compensation insurer to be able to pursue direct legal action against that insurer.

(b) The benefits paid to injured employees under a workers' compensation policy would not be affected if the employer fails to comply with policy requirements. The workers' compensation policy is intended to provide certain statutorily prescribed benefits to employees who experience occupational injury or occupational disease. The employer's failure to fully adhere to the policy's conditions does not prejudice the benefits to which the employees are entitled by law.
Problem S5-133-2.

(a) Name and briefly describe two kinds of claims that might arise against an employer, that are related to occupational injury or occupational disease, but that would be likely to be handled via the common-law system and not via workers' compensation statutes.

(b) Employer X purchased workers' compensation policies A, B, and C in sequence. Each policy also provides employers' liability coverage. The following are the terms of the policies:

Policy A: in force from October 1, 2034 to September 30, 2036
Policy B: in force from October 1, 2036 to September 30, 2037
Policy C: in force from October 1, 2037 to September 30, 2041

An employee of Employer X was exposed to hazardous working conditions and began to develop an occupational disease on December 30, 2035. On July 13, 2037, Employer X discovered the hazardous conditions and eliminated them. However, the effects of previous exposure to these conditions resulted in continuing adverse effects on the employee's health. The employee was only finally cured of the condition on April 24, 2041. The occupational disease was a rare condition that was not encompassed by the workers' compensation statutes of the state in question, because of a loophole in the wording of said statutes. Thus, the employee sued Employer X in common-law court, and Employer X's employer's liability coverage would apply. Which policy would provide coverage for this claim?

Solution S5-133-2. This problem is based on the discussion in Commercial Insurance, p. 12.20.

(a) The following are two kinds of claims that might arise against an employer that are related to occupational injury or occupational disease but that would be likely to be handled via the common-law system and not via workers' compensation statutes:

1. Third-party-over claims: An employee injured at work might sue a third party (such as a product manufacturer) alleging that third party's responsibility for the injury. That third party, in turn, sues the employer in order to recover some of the damages the third party paid to the employee. The suit by the third party would probably be covered under employers' liability coverage, but not under workers' compensation coverage.

2. Claims for care and loss of services: A family member of the injured employee might sue for loss of services, loss of companionship, or other kinds of loss to the family member because of the injury.

(b) Occupational disease claims, both for workers' compensation and for employers' liability, are covered by the policy that was in effect on the last day of the employee's exposure to conditions that caused the disease. Since the employee was no longer subject the these hazardous conditions
after July 13, 2037, the policy that was in effect at that time would provide coverage. This policy is **Policy B.**

**Problem S5-133-3.** List ten exclusions that employers' liability policies typically contain.

**Solution S5-133-3.** This problem is based on the discussion in *Commercial Insurance*, pp. 12.20-12.21.

Employers' liability policies typically exclude coverage for the following:

1. Claims covered under workers' compensation laws;
2. Claims covered under occupational disease laws;
3. Claims covered under unemployment compensation laws;
4. Claims covered under disability benefits laws;
5. Claims covered under the Longshore and Harbor Workers' Compensation Act;
6. Claims covered under the Federal Employers' Liability Act;
7. Damages that must be paid pursuant to the Migrant and Seasonal Agricultural Worker Protection Act;
8. Bodily injury to a captain or crew member of any vessel;
9. Injury outside the United States or Canada;
10. Contractually assumed liability;
11. Punitive damages owed because of the death or injury of an illegally employed individual;
12. Bodily injury to persons who were illegally and knowingly employed;
13. Bodily injury that the insured employer intentionally caused;
14. Damages resulting from employment practices such as discrimination, demotion, and termination;
15. Penalties or fines arising from violations of state or federal laws.

Any ten of the above suffice as an answer. Other valid answers may also be possible.

**Problem S5-133-4.** An incident at Company Y resulted in the following occupational injury and disease costs:

Employee A incurred accidental injury costs of $35,000 and disease costs of $10,000.

Employee B incurred accidental injury costs of $40,000 and disease costs of $50,000.

Employee C incurred only disease costs of $20,000.

The incident was not covered under any workers' compensation law, but it did result in a lawsuit against Company Y that was covered under the company's employer's liability policy. The following are the limits applicable to that policy:

- Bodily injury by accident limit: $60,000
- Bodily injury by disease - policy limit: $76,000
Bodily injury by disease - each employee limit: $25,000

Company Y was found to be liable for all of the damages resulting from the incident, and the insurer incurred $30,000 in costs in defending the lawsuit. How much will the insurer pay as a result of this incident?

**Solution S5-133-4.** This question is based on the discussion in *Commercial Insurance*, pp. 12.21-12.22.

The bodily injury by accident limit applies only to the accidental injury costs arising out of a single incident. Because the total costs due to this incident are $40,000 + $35,000 = $75,000, the insurer will only pay its bodily injury by accident limit of $60,000 for these costs. The disease costs are subject to a per-employee limit of $25,000. The only employee whose costs are affected by the limit is Employee B, for whose disease the insurer will only pay $25,000 instead of the full $50,000. The total the insurer will pay for disease costs is thus $10,000 + $25,000 + $20,000 = $55,000, which is less than the policy limit for disease of $76,000. The insurer will also pay defense costs in addition to the policy limits, so the full $30,000 of defense costs will be paid by the insurer.

The total paid by the insurer is therefore $60,000 + $55,000 + $30,000 = **$145,000**.

**Problem S5-133-5.**
(a) What is stopgap coverage for employers' liability?
(b) Name four topics that would be addressed in the conditions of a typical workers' compensation insurance or employer's liability insurance policy.

**Solution S5-133-5.**

(a) Stopgap coverage for employers' liability is "coverage for employers' liability that private insurers provide to employers operating in a monopolistic fund state that does not include such insurance in its workers' compensation policies" (*Commercial Insurance*, p. 12.22).

(b) The following topics are likely to be addressed in the conditions of a typical workers' compensation insurance or employer's liability insurance policy (*Commercial Insurance*, pp. 12.24-12.25):

1. Inspections
2. Conditions for policies whose terms are longer than one year
3. Transfer of the duties and rights of the insured
4. Cancellation
5. Named insured's status as a representative of other insureds under the policy

Any four of the above suffice as an answer. Other valid answers may also be possible.
Section 134

Special Elements of Some Workers' Compensation Insurance Programs and Basics of Excess and Umbrella Liability Insurance

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**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-134-1.** Describe the functions of the two most significant workers' compensation endorsements in the United States.

**Solution S5-134-1.** This question is based on the discussion in *Commercial Insurance*, pp. 12.25-12.26. The functions of the two most prevalent workers' compensation endorsements in the United States are, respectively, as follows:

1. Covering employees that are not subject to the workers' compensation statutes of the state(s) in which the policy applies. Such an endorsement would provide benefits to such employees that would have been payable if the employees were subject to the workers' compensation statutes; such an endorsement also provides employers' liability coverage for common-law suits brought forth by these employees.

2. Covering employees that are entitled to benefits under the Longshore and Harbor Workers' Compensation Act. This endorsement amends the definition of a workers' compensation statute to include this act.
Problem S5-134-2.
(a) For the purposes of workers' compensation insurance, what is a governing classification?
(b) List four categories of employees to which standard exception classifications in workers' compensation insurance would typically apply.

Solution S5-134-2. This problem is based on the discussion in Commercial Insurance, pp. 12.27-12.28.

(a) A governing classification is a single classification that is assumed to best describe an insured employer's activities. This classification, in most cases, is assigned to all workers at a particular location, and employers are generally not permitted to allocate their payrolls among multiple different governing classifications (Commercial Insurance, p. 12.27).

(b) Special exception categories would typically apply to the following categories of employees (Commercial Insurance, pp. 12.27-12.28):
1. Clerical office and drafting employees who work in areas which are physically separated from other work;
2. Clerical office and drafting employees who telecommute;
3. Collectors, messengers, and salespeople;
4. Chauffeurs, drivers, and their helpers.

Problem S5-134-3.
(a) Some workers' compensation insurers offer premium discounts to insureds whose premium exceeds a certain minimum amount. What is the rationale for this practice?

(b) What is the difference between a flat-dividend plan and a sliding-scale dividend plan in workers' compensation insurance.

Solution S5-134-3. This problem is based on the discussion in Commercial Insurance, pp. 12.29-12.31.

(a) The rationale for premium discounts for large-premium policies is that the insurer's underwriting expenses and costs of collecting premium do not increase uniformly with premium volume; they tend to increase at a decreasing rate. The same often holds for commission expenses as well. Producers of workers' compensation insurance also often do not get paid as high a percentage in commission on the dollar amounts of written premium exceeding a certain threshold. This reduces the insurer's commission expenses per additional dollar of premium.

(b) A flat-dividend plan pays all insureds the same percentage of premium as a dividend, irrespective of the loss experience of each insured.

A sliding-scale dividend plan rewards with higher dividends those insureds that have more favorable (lower) loss experience. Also, insureds with loss ratios above a certain threshold may not receive dividends at all.
Problem S5-134-4. Identify and describe three characteristics of many commercial liability insurance policies that result in some business organizations needing to purchase excess liability insurance.

Solution S5-134-4. This question is based on the discussion in Commercial Insurance, pp. 13.3-13.4. The following are three characteristics of many commercial liability insurance policies that result in some business organizations needing to purchase excess liability insurance:

1. The highly uncertain and possibly extremely high maximum possible loss (MPL) associated with liability loss exposures: It is difficult to estimate how much a liability claim will settle for or how much will be awarded by a court in damages. Some liability verdicts have been exorbitant and have exceeded $100 million.

2. The layering of liability coverages: Liability insurance is typically arranged in layers, such that one insurer's obligation up to a certain limit must be exhausted before the insurer for the next layer is obligated to pay anything. In order to obtain liability coverage for higher loss amounts due to a particular occurrence, a commercial insured would typically not simply be able to purchase multiple primary policies, but rather would need to purchase a primary policy and one or more excess policies.

3. Aggregate limits for most liability insurance policies: An aggregate limit applies to all occurrences within a policy period, leaving open the possibility that even an insured who only experiences a succession of smaller liability claims might exhaust its limits of liability coverage under the primary policy.

Problem S5-134-5.
(a) What is a "following form" excess liability insurance policy?
(b) What are the two functions of drop-down coverage provided under umbrella liability insurance policies?

Solution S5-134-5.

(a) A "following form" excess liability insurance policy is a policy that incorporates into itself the terms of the underlying liability insurance policy. Whatever is covered or excluded under the primary policy is also covered or excluded, respectively, under the "following form" policy (Commercial Insurance, p. 13.5).

(b) The following are the two functions of drop-down coverage provided under umbrella liability insurance policies (Commercial Insurance, p. 13.6):
1. To cover claims that the underlying policy will not cover because of the depletion of the underlying policy's aggregate limits;
2. To cover claims that the underlying policy would not cover at all.
Section 135

Elements of Umbrella Liability Insurance

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**Original Problems and Solutions from The Actuary's Free Study Guide**

The following conditions apply to Problems S5-135-1 through S5-135-3:

Company ○ is insured for commercial general liability (CGL) under two policies.

Insurer □ provides a primary CGL policy with an each-occurrence limit of $500,000 and an aggregate limit of $750,000. This policy only covers occurrences in the United States and Canada.

Insurer ◊ provides an umbrella policy that covers the same occurrences as the primary CGL policy, except that the coverage territory includes the entire world. This policy has an each-occurrence limit of $2,000,000 and an aggregate limit of $10,000,000. The umbrella policy also has a self-insured retention of $30,000 for claims not covered by the primary policy.

During the policy period in question, Company ○ experienced three occurrences involving commercial general liability losses:

Occurrence 1: A loss of $1,310,000 in Canada
Occurrence 2: A loss of $680,000 in Madagascar
Occurrence 3: A loss of $4,000,000 in the United States

Assume that, aside from territorial issues, there is no dispute that coverage for these losses would apply.
Problem S5-135-1. For Occurrence 1, how much would be paid by (a) Insurer □, (b) Insurer ◊, and (c) Company ○?

Solution S5-135-1.

(a) The loss in Canada would be covered under the primary policy of Insurer □, but would be subject to the each-occurrence limit of $500,000. Since $500,000 < $1,310,000, Insurer □ would pay $500,000.

This reduces the aggregate limit of the primary policy to 750000 - 500000 = $250,000.

(b) After a payment of $500,000 by the primary insurer, there remains 1310000 - 500000 = $810,000 to be paid by the umbrella insurer. This is within Insurer ◊'s each-occurrence limit of $2,000,000, so Insurer ◊ would pay $810,000. No self-insured retention applies, since the loss is also covered under the primary policy.

This reduces the aggregate limit of the umbrella policy to 10000000 - 810000 = $9,190,000.

(c) Company ○ would pay nothing, since the primary and umbrella insurer will have paid the entire loss amount.

Problem S5-135-2. For Occurrence 2, how much would be paid by (a) Insurer □, (b) Insurer ◊, and (c) Company ○?

Solution S5-135-2.

(a) The loss in Madagascar did not occur within the territory covered under the primary policy, which only extends to the United States and Canada. Thus, because the primary policy affords no coverage for this loss, Insurer □ would pay nothing.

(b) The loss in Madagascar did not occur within the territory covered under the primary policy, but the loss is covered by the umbrella policy. Because the loss is not covered under the primary policy, the insured is subject to the self-insured retention of $30,000. Insurer ◊ will pay the remaining $650,000, which is less than the per-occurrence limit of $2,000,000 and the remaining aggregate limit of $9,190,000.

This reduces the aggregate limit of the umbrella policy to 9190000 - 650000 = $8,540,000.

(c) Company ○ will pay the self-insured retention of $30,000.

Problem S5-135-3. For Occurrence 3, how much would be paid by (a) Insurer □, (b) Insurer ◊, and (c) Company ○?
Solution S5-135-3.

(a) The loss would be covered by the primary insurer, but the remaining aggregate limit of the primary policy would apply. This remaining limit is $250,000. Thus, Insurer □ will pay $250,000.

(b) After the primary insurer pays $250,000, the amount remaining to be paid is $3,750,000. The umbrella policy's per-occurrence limit, however, is $2,000,000, which is less than its remaining aggregate limit of $8,540,000. Thus, Insurer ◊ will pay $2,000,000. No self-insured retention applies, since the loss is also covered under the primary policy.

(c) After both insurers have made their payments, the amount that remains to be paid is $4,000,000 - $250,000 - $2,000,000 = $1,750,000. Thus, Company ○ will pay $1,750,000.

Problem S5-135-4. Do most umbrella insurance policies have an occurrence-based or a claims-made coverage trigger? Why might this sometimes create difficulties? What remedies exist for such difficulties?

Solution S5-135-4. This question is based on the discussion in Commercial Insurance, p. 13.10.

Most umbrella insurance policies have an occurrence-based coverage trigger. If the underlying policy has a claims-made coverage trigger, then this can create gaps in coverage under the umbrella policy. For instance, if the underlying policy covers a claim that was made because of an occurrence that happened prior to the policy period of the umbrella policy, then the umbrella policy would not provide coverage. The remedy for such difficulties is for an umbrella policy to include both occurrence-based and claims-made coverage triggers. This can be done by specifying that the umbrella policy will be subject to the same trigger as the underlying policy.

Problem S5-135-5.

(a) A primary liability insurance policy contains the following exclusion:

"No coverage shall be provided for bodily injury or property damage arising out of the use of metal balls with three or more spikes."

An umbrella liability insurance has language modeled after that of the primary policy. However, the insurer providing the umbrella policy wishes to provide drop-down coverage for bodily injury and property damage arising out of the use of metal balls with three or four spikes. How might this most easily be accomplished without adding a new clause or section to the umbrella policy?

(b) If an insured fails to maintain underlying liability insurance, how would coverage be affected under a typical umbrella liability insurance applying to the same loss exposures?

Solution S5-135-5. This question is based on the discussion in Commercial Insurance, p. 13.11.
(a) The easiest way to create drop-down coverage for bodily injury and property damage arising out of the use of metal balls with three or four spikes is to adjust the exclusion clause from the primary policy to read as follows within the umbrella policy:

"No coverage shall be provided for bodily injury or property damage arising out of the use of metal balls with five or more spikes."

The exclusion is thereby narrowed, which, by implication, broadens the coverage available.

(b) If an insured fails to maintain underlying liability insurance, the application of the umbrella policy will not change. The umbrella policy will only pay what it would have paid if the underlying policy had been in effect. It would not provide any drop-down coverage for losses that the primary policy would have covered if it continued to be in force.
Section 136

Elements of Professional Liability Insurance and Management Liability Insurance

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Original Problems and Solutions from The Actuary's Free Study Guide

Problem S5-136-1.
(a) What is the difference between "malpractice" liability and "errors and omissions" liability?
(b) Name four types of insurance that can be considered management liability insurance.


(a) "Malpractice" liability is liability arising out of occupations where contact with the human body is involved. "Errors and omissions" liability is liability arising out of occupations where contact with the human body is typically not a part of the job. These occupations include engineering, law, accounting, and production of insurance.

(b) The following types of insurance that can be considered management liability insurance (Commercial Insurance, p. 13.13):

1. Directors' and officers' liability insurance
2. Employment practices liability insurance
3. Employee benefits liability insurance
4. Fiduciary liability insurance

Other valid answers may be possible.
Problem S5-136-2.
(a) Do professional or management liability insurance policies typically use an occurrence-based or a claims-made coverage trigger? What is the rationale for the type of coverage trigger being used?
(b) Does a typical professional or management liability insurance policy allow an insurer to settle a claim without the consent of the insured? Why or why not?
(c) In what situations might a duty-to-defend clause in a professional or management liability insurance policy actually be undesirable to the insured?

Solution S5-136-2. This problem is based on the discussion in *Commercial Insurance*, pp. 13.14-13.16.

(a) Professional or management liability insurance policies typically use a **claims-made** coverage trigger. This is because many professional liability claims manifest themselves long after the occurrence that gave rise to them (such claims are known to have "long tails"). A claims-made coverage trigger enables the insurer to avoid liability for policies that expired a long time ago.

(b) A typical professional or management liability insurance policy **does not allow** an insurer to settle a claim without the consent of the insured. The rationale for this is that the reputation of an insured professional might be damaged by such a settlement, and so the consent of that insured professional would give the insured a degree of control over the consequences to his/her reputation.

(c) A duty-to-defend clause in a professional or management liability insurance policy might actually be undesirable to the insured if the insured professionals or managers work for a company that has in-house legal staff on which they would prefer to rely in defending against a claim - or if these companies have established relationships with certain legal firms and are more confident in those firms' ability to defend the professionals or managers in question appropriately. A duty-to-defend clause also gives the insurer control over the defense, including the selection of attorneys, without the insured's consent or even necessarily the insured's input.

Problem S5-136-3.
(a) Name three exclusions that are common to most professional liability insurance policies.
(b) Name two exclusions, in addition to those in part (a) above, that would apply to most physicians' professional liability ("medical malpractice") insurance policies.
(c) Name three types of errors for which a physician might be held liable.

Solution S5-136-3. This question is based on the discussion in *Commercial Insurance*, pp. 13.17-13.18.

(a) Most professional liability insurance policies exclude coverage for the following (*Commercial Insurance*, p. 13.17):
1. Contractual liability
2. Punitive damages
3. Dishonest, criminal, or malicious acts of the insured

Other valid answers may also be possible.

(b) The following additional exclusions would apply to most physicians' professional liability ("medical malpractice") insurance policies (Commercial Insurance, p. 13.18):

1. "Liability arising out of hospitals or other enterprises"
2. Obligations arising out of workers' compensation laws and similar laws.

Other valid answers may also be possible.

(c) A physician might be held liable for the following types of medical errors (Commercial Insurance, p. 13.17):

1. Failing to diagnose a disease;
2. Improperly performing a surgical procedure;
3. Failing to warn a patient about hazards a particular treatment might entail;
4. Leaving a foreign object inside a patient after surgery;
5. Administrative errors or omissions associated with medical practice.

Any three of the above suffice as an answer. Other valid answers may also be possible.

Problem S5-136-4.

(a) Name three types of errors and omissions for which an insurance agent or broker might be held liable.

(b) In what cases might there be coverage overlaps between a professional liability policy and a commercial general liability (CGL) policy? What is one possible remedy for such overlaps?

Solution S5-136-4. This problem is based on the discussion in Commercial Insurance, pp. 13.18-13.19.

(a) An insurance agent or broker might be held liable for the following types of errors and omissions (Commercial Insurance, p. 13.18):

1. Giving improper advice regarding a client's insurance needs;
2. Not obtaining insurance for a client in a reasonably prompt fashion after agreeing to do so;
3. Not renewing a policy at expiration and failing to give a notice of nonrenewal to the client;
4. Giving improper advice regarding the limits of coverage the client should obtain;
5. Binding coverage without the insurer's authorization;
6. Not canceling a policy when instructed to do so by the insurer.
Any three of the above suffice as an answer. Other valid answers may also be possible.

(b) There may be coverage overlaps between a professional liability policy and a commercial general liability (CGL) policy when it is not clear whether it is a professional's errors/omissions/malpractice that caused the occurrence, or whether it is defective equipment. The professional liability and CGL insurers may be required to share the damages if it is not sufficiently clear which of these aspects caused the occurrence. To remedy such overlaps, the insured may wish to obtain both CGL and professional liability insurance from the same company, so that coverage for such incidents would not be disputed between two insurers.

Problem S5-136-5.

(a) What are "Side-A Coverage" and "Side-B Coverage" in a typical directors' and officers' liability insurance policy?

(b) List five exclusions that would be found in a typical directors' and officers' liability insurance policy.

Solution S5-136-5. This problem is based on the discussion in Commercial Insurance, pp. 13.20-13.21.

(a) Side-A Coverage is coverage for directors and officers that covers their wrongful acts - including errors, neglect, omissions, misleading statements, and misstatements.

Side-B Coverage is coverage for the sums that the corporation which is being insured would be permitted or required by law to pay as indemnification to its directors and officers for suits that allege wrongful acts.

(b) The following are typically excluded from coverage in directors' and officers' liability insurance policies:

1. Bodily injury liability;
2. Tangible property damage liability;
3. Pollution liability;
4. Libel or slander;
5. Personal profit gained by directors and officers without their being entitled to gain it;
6. Failure to provide or maintain adequate insurance for the company;
7. Deliberate dishonesty;
8. Some violations of the Securities Exchange Act

Any five of the above suffice as an answer. Other valid answers may also be possible.
Section 137


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Some of the questions here ask for short written answers based on the reading. This is meant to give the student practice in answering questions of the format that will appear on Exam 5. Students are encouraged to type their own answers first and then to compare these answers with the solutions given here. Please note that the solutions provided here are not necessarily the only possible ones.

**Source:**

**Original Problems and Solutions from The Actuary's Free Study Guide**

**Problem S5-137-1.** A directors' and officers' liability insurance policy has a limit of $600,000, a deductible of $40,000, and a participation percentage of 10%. An occurrence gives rise to a covered claim of $200,000. How much of that amount will the insurer pay?

**Solution S5-137-1.** This question is based on the discussion in *Commercial Insurance*, p. 13.21.

The participation percentage of 10% is the percent that the insured would have to pay of the difference between the limit and the deductible. The insurer would have to pay 90% of that difference, or 0.9*(600000 - 40000) = $504,000.

**Problem S5-137-2.** This question is based on the discussion in *Commercial Insurance*, pp. 13.21-13.22.

(a) With regard to directors' and officers' liability insurance, what is entity coverage?
(b) What possible disadvantage might entity coverage present to the directors and officers of a corporation?

**Solution S5-137-2.**

**a)** Entity coverage is a "coverage extension of directors' and officers' liability policies for claims made directly against a corporation (the 'entity') for wrongful acts" (*Commercial Insurance*, p. 13.21).

**b)** Entity coverage might present disadvantages to directors and officers, such as requiring them to share with the corporation in its limits of liability. Moreover, increased defense costs may arise if, as a result of the coverage's provisions, the corporation is required to maintain separate legal counsel for the corporation. This is particularly adverse if the defense costs are included within the policy limits. In a corporate bankruptcy, the entire limit of insurance may be devoted toward the corporation, leaving the directors and officers with no coverage (*Commercial Insurance*, pp. 13.21-13.22).

**Problem S5-137-3.**

(a) List four kinds of wrongful employment practices for which the ensuing liability is covered under a typical employment practices liability insurance policy.

(b) Name and briefly describe three laws that affect employment practices liability loss exposures in the United States.

(c) Do employment practices liability insurance policies typically have an occurrence-based or a claims-made coverage trigger?

**Solution S5-137-3.** This problem is based on the discussion in *Commercial Insurance*, pp. 13.22-13.23.

**a)** The following are wrongful employment practices for which the ensuing liability is covered under a typical employment practices liability insurance policy (*Commercial Insurance*, p. 13.22):

1. Wrongful termination;
2. Wrongful failure to promote, hire, or grant tenure;
3. Wrongful demotion, reassignment, or discipline;
4. Sexual harassment;
5. Unlawful discrimination;
6. Invasion of privacy;
7. Defamation;

8. Intentional infliction of emotional distress.

Any four of the above suffice as an answer. Other valid answers may also be possible.

(b) The following are laws that affect employment practices liability loss exposures in the United States (Commercial Insurance, p. 13.23):

1. **Title VII of the Civil Rights Act of 1964**: Forbids discrimination in employment on the basis of race, color, religion, gender, national origin, pregnancy, childbirth, or medical conditions related to pregnancy or childbirth.

2. **The Civil Rights Act of 1991**: Authorizes a jury trial and damages up to $300,000 for lawsuits related to intentional racial or gender discrimination.


4. **The Americans with Disabilities Act**: Forbids discrimination against disabled individuals and requires employers to make reasonable accommodations for such individuals.

Any three of the above suffice as an answer. Other valid answers may also be possible.

(c) Employment practices liability insurance policies typically have a **claims-made** coverage trigger.

Problem S5-137-4.

(a) What two common-law duties does an employer administrator of an employee benefit plan have?

(b) Give two examples of administrative errors that would be covered by a typical employee benefits liability insurance policy.

Solution S5-137-4. This problem is based on the discussion in Commercial Insurance, p. 13.24.

(a) An employer administrator of an employee benefit plan has the common-law duties of (1) accurately responding to an employee's request for advice or information and (2) competently administering the employee benefit plan (Commercial Insurance, p. 13.24).

(b) The following are administrative errors that would be covered by a typical employee benefits liability insurance policy (Commercial Insurance, p. 13.24):

1. Negligently advising regarding the selection of employee benefit programs;
2. Causing an employee to be without health care coverage for a condition that would have been covered if the employee were enrolled in the employer's group health insurance;

3. Miscalculating the pension benefits of a retired employee to that employee's detriment.

Any two of the above suffice as an answer. Other valid answers may also be possible.

**Problem S5-137-5.**

(a) What is a *fiduciary*?

(b) With respect to employee benefit plans, who is considered a fiduciary under the Employee Retirement Income Security Act (ERISA) of 1974?

(c) Briefly describe the difference between what is covered by employee benefits liability insurance policies and what is covered by fiduciary liability insurance policies.

**Solution S5-137-5.** This problem is based on the discussion in *Commercial Insurance*, pp. 13.24-13.25.

(a) A fiduciary is "someone who is bound by an agreement to act primarily for someone else's benefit" (*Commercial Insurance*, p. 13.24).

(b) The ERISA treats as a fiduciary anyone who exercises "discretionary control or judgment in the design, administration, funding, or management of a benefit plan" (*Commercial Insurance*, p. 13.24). This usually includes the key employees and the principal of a company.

(c) Fiduciary liability insurance policies cover breaches of fiduciary duties that involve discretionary judgment with respect to the benefit plan itself, whereas employee benefits liability insurance policies cover administrative errors and omissions with regard to particular employees' use of the plan (*Commercial Insurance*, p. 13.25).
About Mr. Stolyarov

Gennady Stolyarov II (G. Stolyarov II) is an actuary, science-fiction novelist, independent philosophical essayist, poet, amateur mathematician, composer, and Editor-in-Chief of *The Rational Argumentator*, a magazine championing the principles of reason, rights, and progress.

In December 2013, Mr. Stolyarov published *Death is Wrong*, an ambitious children’s book on life extension illustrated by his wife Wendy. *Death is Wrong* can be found on Amazon in *paperback* and *Kindle* formats.

Mr. Stolyarov has contributed articles to the *Institute for Ethics and Emerging Technologies (IEET)*, *The Wave Chronicle*, *Le Quebecois Libre*, *Brighter Brains Institute*, *Immortal Life*, *Enter Stage Right*, *Rebirth of Reason*, *The Liberal Institute*, and the *Ludwig von Mises Institute*. Mr. Stolyarov also published his articles on Associated Content (subsequently the Yahoo! Contributor Network) from 2007 until its closure in 2014, in an effort to assist the spread of rational ideas. He held the highest Clout Level (10) possible on the Yahoo! Contributor Network and was one of its Page View Millionaires, with over 3.1 million views.

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