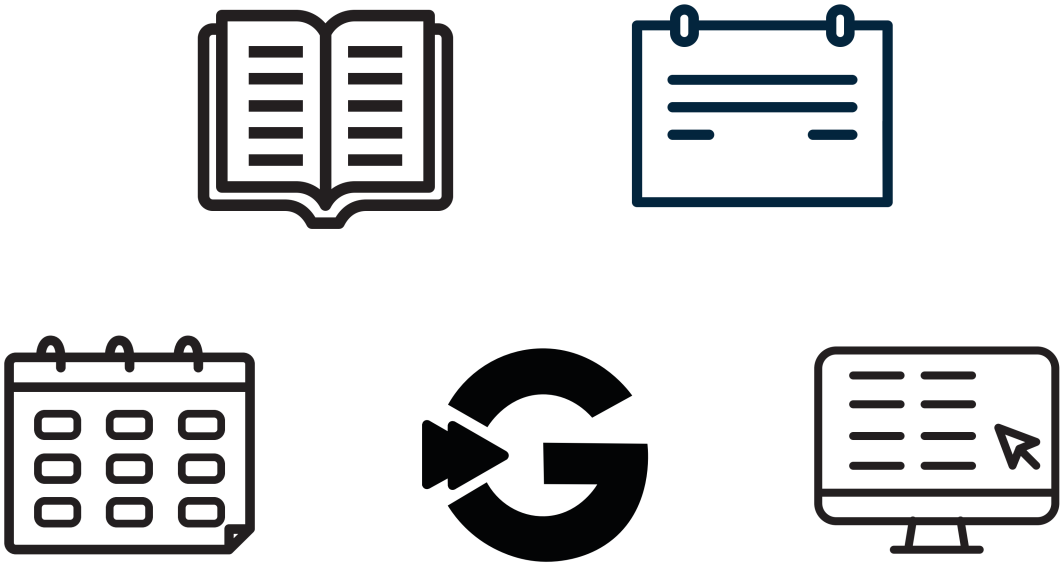
ACTEX Learning

Study Manual for Exam 5

3rd Edition

David H. Deacon, Jr, ACAS, MAAA
Peter J. Murdza, Jr, FCAS



A CAS Exam

ACTEX Learning

Study Manual for Exam 5

3rd Edition

David H. Deacon, Jr, ACAS, MAAA
Peter J. Murdza, Jr, FCAS

Actuarial & Financial Risk Resource Materials
Since 1972

Welcome to Actuarial University

Actuarial University is a reimagined platform built around a more simplified way to study. It combines all the products you use to study into one interactive learning center.

You can find integrated topics using this network icon.

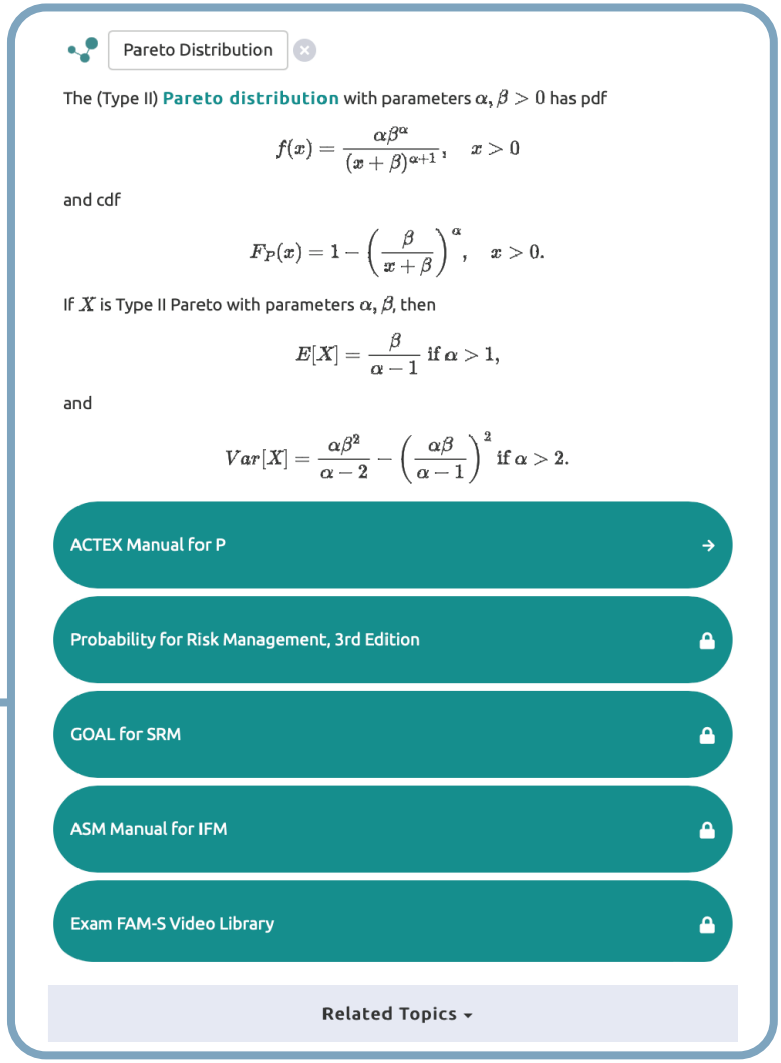
When this icon appears, it will be next to an important topic in the manual. Click the **link** in your digital manual, or search the underlined topic in your print manual.

1. Login to: www.actuarialuniversity.com

2. Locate the **Topic Search** on your exam dashboard and enter the word or phrase into the search field, selecting the best match.

3. A topic "**Hub**" will display a list of integrated products that offer more ways to study the material.

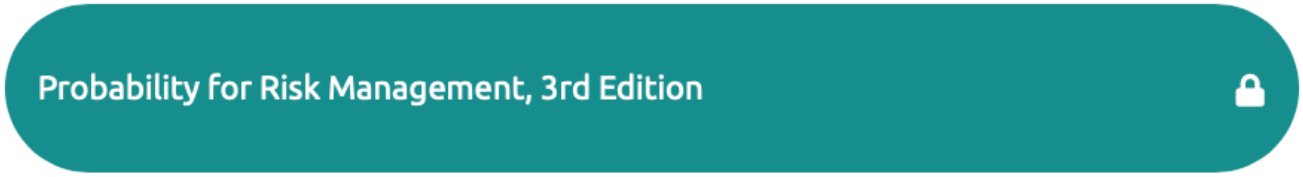
4. Here is an example of the topic **Pareto Distribution:**



Within the **Hub** there will be unlocked and locked products.

Unlocked Products are the products that you own.

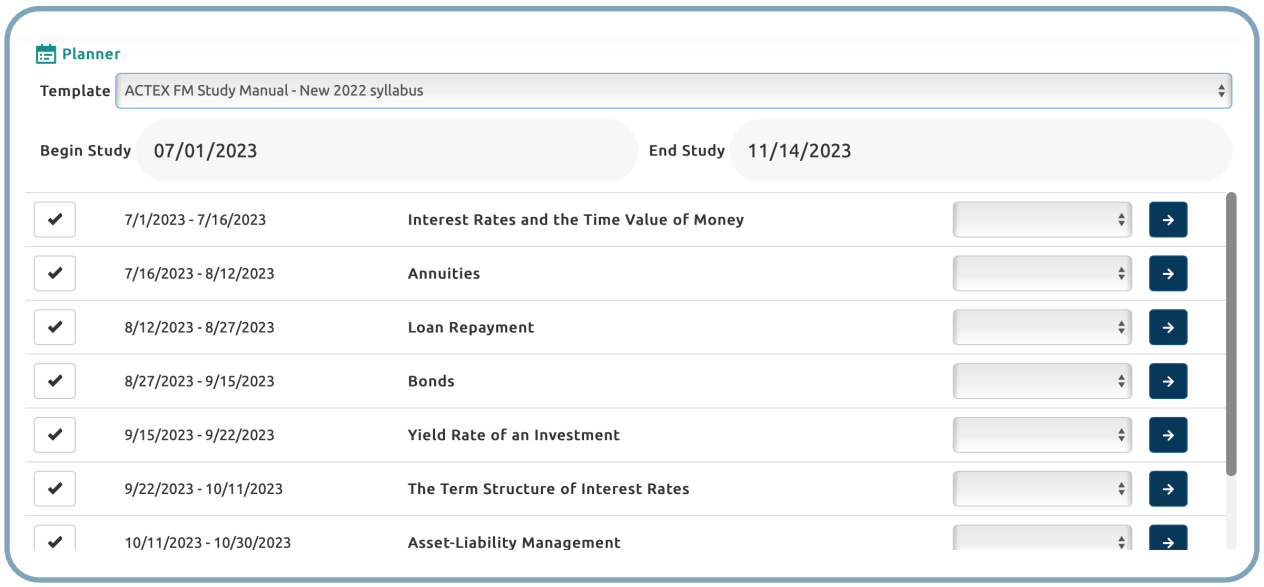
Locked Products are products that you do not own, and are available for purchase.



Many of Actuarial University's features are already unlocked with your study program, including:

Instructional Videos*	**Planner**
Topic Search	**Formula & Review Sheet**

Make your study session more efficient with our Planner!



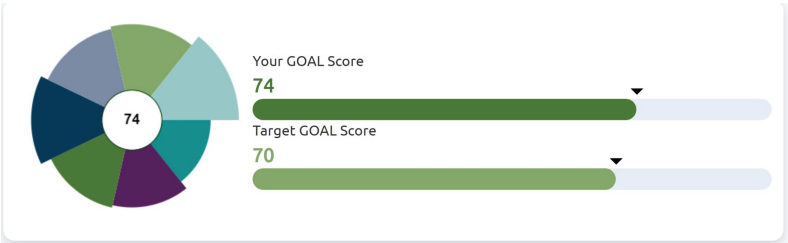
**Available standalone, or included with the Study Manual Program Video Bundle*

Track your exam readiness with GOAL Score!

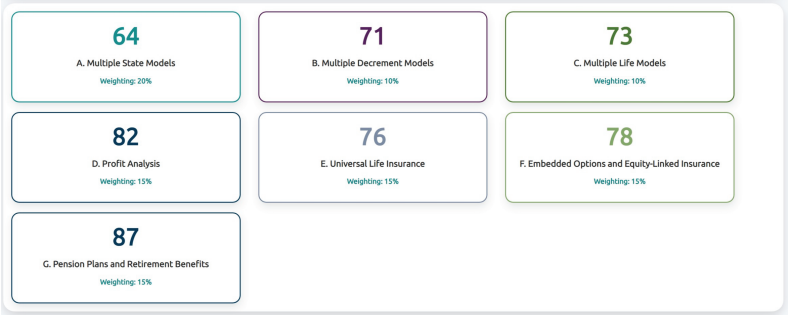
Available for P, FM, FAM, FAM-L, FAM-S, ALTAM, ASTAM, MAS-I, MAS-II, & CAS 5

GOAL Score tracks your performance through GOAL Practice Sessions, Quizzes, and Exams, resulting in an aggregate weighted score that gauges your exam preparedness.

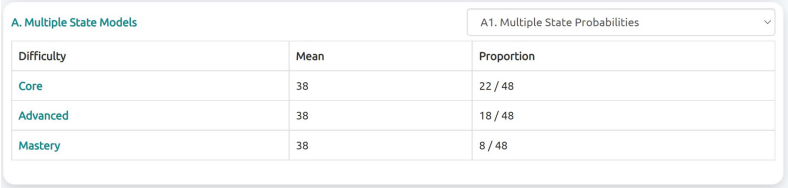
By measuring both your performance, and the consistency of your performance, **GOAL Score** produces a reliable number that will give you confidence in your preparation before you sit for your exam.



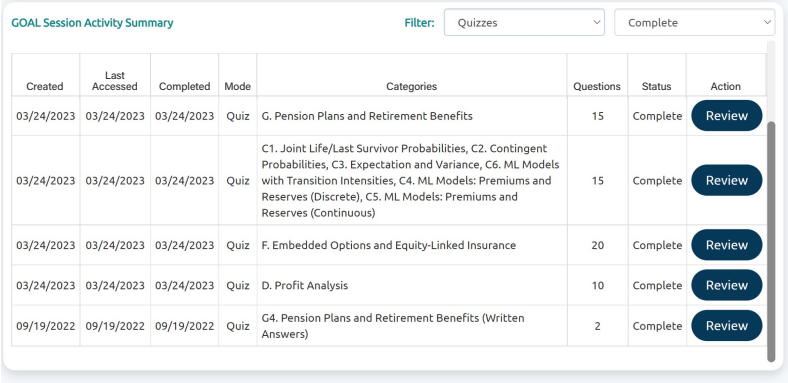
If your GOAL Score is a 70 or higher, you are well-prepared to sit for your exam!



See key areas where you can improve.



Detailed performance tracking.



Quickly return to previous sessions.

Contents

INTRODUCTORY COMMENTS

CAS Exam 5 is typically the first upper-level exam actuarial students will take on the property and casualty side of the actuarial track. This exam is unlike any of the other exams you have previously taken in that it introduces concepts much more specifically tailored to the property and casualty area. The syllabus of material is robust and diverse enough to make this into two smaller exams, one on Ratemaking and one on Reserving, but where would be the fun in that? You can expect each of those two topics to make up roughly half of the exam.

The first half of the exam relies mainly on a well-written and well-sequenced text by Geoff Werner and Claudine Modlin on ratemaking. It starts with the foundational information on insurance terms and data before getting into the high-level topic areas specific to ratemaking, premiums, losses, and expenses. The text walks through each area with several examples scattered throughout each topic. The writings also vary between lines of business keeping it engaging for students in any p&c line of business. After going through the areas of ratemaking in the first portion of the text, the second half brings it all together and walks through implementation and considerations in ratemaking. The remainder of the ratemaking source material is much smaller and supplements elements covered in the ratemaking text.

The second half of the exam is focused on reserving and heavily relies on a text authored by Jacqueline Friedland. This text is also the main text for the reserving portion of the exam with some additional readings included in the syllabus to supplement portions of the main reserving text. This reading introduces basic terminology and claims information before delving into the various claims-reserving techniques presented.

The authorship and contribution to the materials on this exam by Werner, Modlin, and Friedland can't be highlighted enough. More veteran p&c actuaries will recall when the material on these two texts was scattered throughout several source materials. These authors, bringing those topics together into one text for ratemaking and one on reserving, have made studying much easier for actuarial students.

I suggest that you work through the study guide by studying a section of notes and then attempting the exercises in the problem set that follows that section. The ordering of the study guide follows the sequencing of the readings in the syllabus. I have intended to make this study guide self-contained and comprehensive for the CAS 5 Exam topics, however, it is important to be familiar with original reference material on all topics. As mentioned before, the amount of material in the course readings for CAS Exam 5 is robust, but to be expected for a 4-hour upper-level exam. This study guide provides a summary of the topics presented but is absolutely not a substitute for thoroughly reading the source material as that is the best way to familiarize any student with these topics.

With this new edition, several questions have been converted to Microsoft Excel-based questions. While you can still work the questions by hand using paper and pencil, working them in Excel will give the student a better feel for how the questions will be presented in the actual CAS exam.

If you have any questions, comments, or concerns about this study guide, please contact ACTEX as we want this study guide to be as helpful to all current and future actuarial candidates as possible. A good deal of effort has gone into addressing any errors, but in the event you come across one, I humbly apologize in advance and would appreciate it if you would bring them to my attention. ACTEX will be maintaining a website for errata that can be accessed from www.actexlearning.com.

It is my sincere hope that you find this study guide helpful and useful in your preparation for the exam. I wish you the best of luck on the exam.

-DD

**** New October/November 2023 Content Outline ****

In early 2023, the CAS released a new exam content outline starting with the fall exams. This update left the syllabus of readings unchanged. The topics covered were rearranged slightly in terms of how the CAS presented them in the syllabus, but for all intents and purposes, no text/materials were changed. There was also a cognitive structure listed in the syllabus, which in my opinion, really just restates what has been underlying the exam all along and isn't a change to be concerned with at all.

The biggest (and only) change really introduced with the fall 2023 sitting is the format of the questions on the exam. Previously, all questions were free response. With this being the first upper-level exam, many candidates often fell into the partial-credit trap, pondering, "Did I put enough down to get credit?" Oftentimes, several paragraphs were written by a candidate only for them to see that a simple 2- or 3-sentence explanation of how their solution was derived would have sufficed. Make sure to key in on the way a question is phrased, picking up on terms like "briefly describe", "list", "explain", etc. Typically, the intended responses aren't long and wordy but should be enough to display your understanding of what is being asked in the question.

The new question format introduced by the CAS allows for multiple choice and fill-in the blank question types. These will be a minority of the question types compared to the typical constructed response questions. The approach by the student should be unchanged in that the answer to the question should be derived based on their knowledge and then provided as required by the way the question was posed (written response, fill-in the blank, multiple choice, etc.)

Part I

RATEMAKING

Geoff Werner and Claudine Modlin, Chapter 3: "Ratemaking Data,"

in *Basic Ratemaking*, 2016, pp. 36–48.

INTRODUCTION:

This chapter covers the various data types, data elements, and data sources typically used in ratemaking.

KEY CONCEPTS:

1) Overall

   a. **Data is vital to the ratemaking process and drives the quality of the final rates**.

      i. Ratemaking involves analyzing rate adequacy using internal or external/industry historical data.

      ii. Pricing new products requires data with some relationship to the products being priced.

      iii. The granularity of the data required is dictated by the level of analysis being performed.

      iv. Ratemaking uses historical data to project future profitability.

      v. The actuary is responsible for the appropriateness and reasonableness of the data being used in ratemaking.

2) Internal Data

   a. Types of internal data:

      i. Risk/Policy level information **(risk specific characteristics, exposures, premiums, losses, claim counts, etc.)**

      ii. **Financial/accounting information** generally only available at an aggregate level (underwriting expenses, ULAE, general expenses, etc.)

   b. Policy Database

      i. Defined & organized by **records** and **fields**

         A. Records are typically at the policy level or some further segmentation (e.g.: coverage level where there may be multiple coverages on a policy).

- Records defined and established based on typical company and industry practice.
- Changes in risk profile are also recorded as new records (e.g.: a deductible change or a coverage change).

ii. **Fields** contain descriptive information about the policy.

A. Fields use the information that is current on the policy as of that given time.

B. Typical fields in a record:

- **Policy identifier / number** – A unique number assigned to the policy
- **Risk identifier** **(e.g. vehicle # and operator #)** - Keeps the record at a singular/granular risk level
- **Relevant dates** (effective, termination)
- **Premium** associated with that record at the appropriate segment level
- **Exposure** associated with that record at the appropriate segment level
- **Risk Characteristics** – Descriptive of the policy and the risk (e.g.: selected coverage limits and deductibles)

iii. Data Storage

A. Data may be stored in multiple databases within a company.

B. It's best to store the data in a stable fashion with stable data elements (e.g.: use year of construction for home insurance rather than age of home which will change from one policy term to the next)

c. **Claims Database**

i. Typically separate from policy database and stored on a per claim transaction basis (e.g.: claim payment or reserve change).

ii. Data may also be stored on a per feature basis rather than per claim (e.g.: an auto claim may have multiple features such as a bodily injury record as well as a property damage record).

iii. Record & Field Definitions

A. **Policy identifier / number**

B. **Risk identifier at a singular risk level** (e.g.: vehicle # and operator # on a policy)

C. **Claim identifier / number**

D. **Claimant identifier** – Distinguishes on claims with multiple impacted parties

E. **Relevant loss dates** – Date of loss, reported date, loss transaction date, etc.

F. **Claim status** – Open/active or closed/settled

G. **Claim count** – Used if multiple claims are stored on a record (depending on how the data is stored)

H. **Paid loss** – Amount of money actually paid out by the insurer at a given point in time on the loss record

I. **Event identifier** – Catastrophe indicator or other extraordinary event noted in the claims database

J. **Case reserve** – The amount of the case reserve or the change in case reserve as of the date of the record. Case reserve is the amount of funds set aside by the insurer on the portion of the claim that the insured is aware of but has not yet paid out

K. **Allocated loss adjustment expense (ALAE)** – Portion of the claims handling expense that can be directly tied to a claim (i.e.: claims adjuster expense)

L. **Salvage**/ **Subrogation**– Any recoupment the company receives from salvage (e.g.: value of an automobile the company assumed ownership for after paying out on a total loss used to offset the loss payment) or subrogation (e.g.: any recovery from a third party who contributed to the loss)

M. **Claim characteristics** – Any additional descriptive information available to the company that they can capture in their database (e.g.: type of injury, description of loss event, etc.)

d. *Accounting Information* used in ratemaking

i. Typically tracked by calendar year and is not specific to any one policy or claim

ii. Underwriting Expense – expenses associates with the acquisition and servicing of a policy. Some can be specifically allocated to a policy (e.g.: commissions), but most cannot (e.g.: cost associates with the company's building)

1. Loss adjustment expenses (LAE) - Some can be allocated (ALAE) while others cannot (ULAE) -> (as discussed in chapter 1)

e. By keeping data at a detailed/segmented level, aggregation to the appropriate levels for ratemaking can be achieved.

f. Data should be aggregated to the appropriate level of the analysis being performed (i.e.: state level, territory level, risk classification level, etc.).

g. **General objectives when aggregating data for ratemaking purposes:**

i. Be able to accurately match premium and loss by policy/segment

ii. Use the most recent evaluation of data

iii. Keep the data costs minimized

h. Common data aggregation methods:

i. **Calendar Year**

A. All premium and loss transactions that occur during a twelve-month period with no regard to the dates of the events (policy issuance, claims date, etc.) which generated those transactions.

B. Advantages

- All values (earned, paid, etc.) are recorded during the calendar year which results in them being fixed at year-end.
- Aggregation of data is available as soon as the calendar year ends.
- This data also ties into financial statements.

C. Disadvantages

- Mismatch in timing of premium and losses since data is only recorded based on calendar occurrence and not necessarily tied to a policy.
- Only appropriate to use in ratemaking for lines of business that close relatively quickly (e.g.: homeowners).
- Least accurate method for ratemaking.

ii. **Accident Year**

A. Premium and exposure is the same as the calendar year basis (sometimes referred to as "calendar-accident year method) while losses only consider losses for accidents that occur during that time period.

B. Advantage

- Better match of exposure and premium earned with losses than calendar year data.
- More quickly available than policy year data.

C. Disadvantage

- Loss amounts (paid and reserved) on an accident year basis can change at the end of a calendar year.

- Future development of losses needs to be estimated.

iii. **Policy Year / Underwriting Year**

A. Uses all premium and losses on policies written during the year.

B. Losses are like accident year in that loss's values (paid and reserved) will potentially continue to change into the future.

C. Advantage

- Best match to policies of premium and losses.

D. Disadvantage

- Premiums and exposures aren't fixed until the expiration of all policies associated with that policy year.
- It takes longer for this data to develop.

iv. **Report Year**

A. Like claims-accident year except losses are grouped based on when they are reported not when the claim occurred.

B. Typically used for claims-made policies (e.g.: medical malpractice insurance).

3) External data

a. External data is sometimes used when historical data is unavailable (e.g.: a new line of business), not credible (e.g.: a line of business with few inforce policies) or as a benchmark.

b. The actuary is responsible to pick the reasonableness of the external data used given the situation.

c. *Types of external data:*

i. **Statistical plans**

A. Regulators require companies to submit statistical data to them while regulating the companies.

B. This data is collected (either by the government or by an industry service organization).

- Examples:
  - ▷ National Council for Compensation Insurance (NCCI)
  - ▷ Insurance Services Office, Inc. (ISO)

C. Companies can request this data to provide additional information in their ratemaking work.

D. Regulators may also make ad hoc data calls from which data can be made available for companies to use.

ii. **Other Aggregated Industry Data**

A. Voluntarily reported information to third parties which is then aggregated for use by regulators, public policy makers of the general public.

B. Examples:

- Fast Track Monitoring System
- Highway Loss Data Institute (HLDI)

iii. **Competitor Filings / Manuals**

A. Companies are typically required to submit changes to their rates or rating structure to regulators for review.

B. Many of these submissions contain information that can supplement the ratemaking process.

iv. **Other Third-Party Data**

A. Ratemaking can use data not specific to insurance (where appropriate).

B. Economic data

- Consumer Price Index (CPI) components

C. Geo-demographic data

- US Census data
- Weather indices
- Theft indices
- Average annual miles driven

KEY FORMULAS:

1) *Incurred Losses = Paid Losses + Case Reserves*
2) *Case Reserves = Ending Loss Reserve – Beginning Loss Reserve*
3) *(These formulas will be explored in more depth in later chapters.)*

SUMMARY:

Ratemaking requires enough data to estimate the future cost of providing insurance protection. The data used in ratemaking must be aggregated to an appropriate level for the analysis being performed. Data used in ratemaking can come from various sources all with the goal of making a better-informed decision on rates.

PAST CAS EXAMINATION QUESTIONS (MODIFIED)

1. Discuss the advantages and disadvantages (with respect to ratemaking) of the calendar year and accident year measures of loss experience relative to each other.
2. A loss ratio, on which basis, most accurately match the losses with the premiums intended to fund those losses?
3. What are the advantages and disadvantages associated with the use of calendar year and policy year data for ratemaking?
4. Modify the wording below to make each statement true.
   a. Policy year premium statistics can be distorted by significant audit premiums.
   b. Compared to policy year ones, calendar year statistics for the same year take longer to develop.
   c. Calendar year data and calendar-accident year data differ primarily in calculating premium.
5. Which method of gathering statistics provides an exact matching of losses and premiums to a specific group of insured entities?
6. Give three properties of ratemaking using the calendar year method.
7. Of the three methods for gathering ratemaking statistics described by Werner and Modlin, which method is the only method that provides an exact match between premium and losses for a specific group of insured entities?
8. What is the formula for incurred losses?
9. Can calendar year statistics can have parts of a single claim being included in several years?
10. Which method provides the best match of losses to premiums?
11. Which method is the least accurate method?
12. What is a disadvantage of the policy year method of compiling ratemaking statistics versus the accident year method is that the policy year method?
13. The only method for gathering ratemaking statistics that provides an exact matching of losses and premiums to a specific group of insureds is which method?
14. Under the policy year method, are incurred losses are affected by changes in reserves for events that occurred in earlier periods?
15. The accident year method uses what kind of earned premiums?
16. Werner and Modlin, in "Basic Ratemaking," describe three different types of experience periods by which insurance data is compiled.

a. Describe how premiums and losses are compiled under each of the three experience periods:

i. Policy year

ii. Calendar year

iii. Calendar-accident year

b. State one advantage and one disadvantage associated with each type of experience period.

17. For purposes of ratemaking, which method in a. is most responsive and which method is least responsive?

18. Discuss the appropriateness of applying each of the following data aggregation methods to the given line of business:

a. Calendar year aggregation for auto physical damage

b. Policy year aggregation for homeowners

c. Report year aggregation for medical professional liability.

19. Given the following information:

Claim	Policy Effective Date	Accident Date	Report Date	Transaction Date	Claim Status	**Loss Payment**	Case Reserve Change
1	10/1/2016	12/15/2016	1/5/2017	1/7/2017	Open	-	+5,000
				3/1/2017	Open	4,000	-4,000
				1/5/2018	Closed	500	-1,000
2	11/1/2016	2/1/2017	2/10/2017	3/1/2017	Open	-	+6,000
				3/15/2017	Closed	6,000	-6,000
3	1/1/2017	6/1/2017	6/5/2017	6/10/2017	Open	-	+10,000
				9/1/2017	Open	1,000	+10,000
				1/3/2018	Open	4,000	-5,000
				7/20/2018	Open	500	+5,000
4	6/1/2017	8/15/2017	7/15/2018	3/1/2019	Open	-	+5,000
				6/1/2019	Open	5,000	+7,000

- Calendar Year 2017 earned premium = 50,000
- Calendar Year 2018 earned premium = 60,000

a. Calculate the calendar year 2018 case incurred loss.

b. Calculate the policy year 2017 case incurred loss evaluated at 12/31/2017.

c. Calculate the accident year 2017 case incurred loss ratio evaluated at 12/31/2018.

20. Given the following automobile policies issued during calendar years 2016 through 2018:

Effective Date	Expiration Date	Number of Policies
4/1/2016	9/30/2017	100
10/1/2016	3/31/2017	110
4/1/2017	9/30/2017	105
10/1/2017	3/31/2018	100
4/1/2018	9/30/2018	110
10/1/2018	3/31/2019	105

All policies have a 6-month term.

a. Calculate the written policies for calendar year 2017.

b. Calculate the in-force policies as of 12/31/2017.

c. Calculate the earned policies for calendar year 2018.

21. Given the following information:

- 1,000 two-year policies with an effective date of 4/1/18
- 1,000 one-year policies with an effective date of 7/1/18

a. Calculate the calendar year 2018 written exposures.

b. Calculate the calendar year 2018 earned exposures.

c. Calculate the calendar year 2019 earned exposures.

22. Given the following information about two claims:

Claim #	Accident Date	Transaction Date	Incremental Payment	Ending Case Reserves
1	1/1/2018	1/1/2018	$0	$20,000
1	1/1/2018	1/1/2019	$25,000	$0
2	4/1/2018	7/1/2018	$0	$50,000
2	4/1/2018	10/1/2018	$25,000	$75,000
2	4/1/2018	4/1/2019	$100,000	$20,000

a. Calculate the incurred losses for accident year 2018 as of 5/1/2019.

b. Calculate the incurred losses for calendar year 2018 and calendar year 2019.

c. Briefly describe one advantage and one disadvantage of calendar year aggregation.

23. An insurance company writes both 6-month and 12-month automobile policies. Given the following information:

Policy	Original Effective Date	Original Expiration Date	Transaction Effective Date	Full-Term Written Premium	Notes
A	1/1/2018	12/31/18	1/1/18	1,000	Start of New Policy
A	1/1/2018	12/31/18	7/1/18	n.a.	Policy Cancelled
B	7/1/2018	6/30/19	7/1/18	500	Start of New Policy
B	7/1/2018	6/30/19	9/30/18	400	Changed Policy
C	10/1/2018	3/31/19	10/1/18	1,000	Start of New Policy

Full-term written premium represents the policy premium if policy characteristics shown were in place from the original effective date to the original expiration date.

a. Calculate the 2018 calendar year written premium as of 12/31/18.

b. Calculate the 2018 calendar year earned premium as of 12/31/18.

c. Calculate the 2018 policy year written premium as of 12/31/2018.

24. Using the information provided, answer the questions below:

Policy Number	Policy Written	Incurred Loss as of 12/31/16	Incurred Loss as of 12/31/18	Incurred Loss as of 12/31/19
1001	1/1/2017	1,000	1,200	1,400
1002	7/1/2017	0	5,000	6,200

a. What is the calendar year 2017 incurred loss as of 12/31/2017?

b. What is the calendar year 2017 incurred loss as of 12/31/2018?

c. What is the policy year 2017 incurred loss evaluated as of 12/31/2017?

d. What is the policy year 2017 incurred loss evaluated as of 12/31/2018?

e. Why are the answers to part b and c different?

SOLUTIONS

1. a. Calendar year data does not require development factors, whereas accident year data requires such factors to reflect changes in loss valuation called loss development.

   b. Calendar year losses and premiums do not have a close relationship as losses are affected by reserve changes, whereas accident year losses and calendar year premiums are more closely related.

2. A fully developed policy year loss ratio.

3. Calendar year data is available promptly but lacks accuracy in its estimation of incurred losses because of distortions caused by reserving inaccuracies. Policy year data provides a more accurate matching of losses and premiums but is not available promptly since the data stretch over two calendar years and is costlier since a separate system must be maintained.

4. a. It should be "calendar year" not "policy year".

   b. It should be "calendar year" not "policy year".

   c. The difference is in the calculation of losses.

5. Policy Year

6. a. The method can result in a single claim affecting several years of loss experience.

   b. The method is generally less accurate than the accident year method.

   c. The method estimates earned premium in the same manner as the accident year method.

7. Policy Year

8. Incurred Losses = Loss reserves at end of year plus losses paid during the year less loss reserves at beginning of year.

9. Yes, they can have parts of a single claim being included in several years.

10. Policy Year.

11. Calendar Year.

12. It involves more delays in gathering statistics.

13. Policy Year.

14. No. Incurred losses are only affected by changes in the reserves for the policy year.

15. Calendar year premiums are used.

16. a. Policy year experience uses earned premiums and incurred losses arising from policies issued in a twelve-year period. Calendar year experience uses financial data for a calendar year. Calendar year earned premium equals premiums written during that year plus the beginning unearned premium reserve less the ending unearned premium reserve.

Calendar year incurred losses equals paid calendar year losses plus the ending loss reserve less the beginning loss reserve. Calendar-accident year experience uses calendar year earned premium and losses arising from accidents that occur during the calendar year.

b. Policy year experience provides an exact match of premiums and losses as it arises from a defined set of policies. It is less mature than the other experience. Calendar year is fully mature at the end of the year but provides the least exact match of premiums and losses. Accident year experience is a compromise between policy year and calendar year experience. It provides a more exact match of premiums and losses than calendar year experience but a less exact match than policy year experience. On the other hand, it is more mature than policy year experience but less mature than calendar year experience.

17. Responsiveness reflects maturity. Thus, calendar year data is most responsive and policy year data the least responsive.

18. a. It is appropriate because auto physical damage losses are reported and settled relatively quickly.

b. Like automobile physical damage coverage, homeowners losses are reported and settled relatively quickly and thus calendar year aggregation is appropriate.

c. Report year is appropriate if claims-made policies are used. If occurrence policies are used, calendar-accident year aggregation is more appropriate.

19. a. $500 - 1{,}000 + 4{,}000 - 5{,}000 + 500 + 5{,}000 = 4{,}000$

(use only loss information with a 2018 transaction date)

b. $10{,}000 + 1{,}000 + 10{,}000 = 21{,}000$

(use loss information with a 2017 policy effective date with a transaction date prior to 12/31/2017)

c. $$\begin{aligned} \textit{Incurred Losses} &= 6{,}000 + 6{,}000 - 6{,}000 + 10{,}000 + 1{,}000 + 10{,}000 \\ &\quad + 4{,}000 - 5{,}000 + 5{,}500 \\ &= 31{,}500 \end{aligned}$$

(use only loss information with a 2017 accident date with a transaction date prior to 12/31/2018)

$\textit{Earned Premium} = 50{,}000$

(use calendar year 2017 earned premium)

$\textit{Loss Ratio} = \textit{Incurred Losses} \;/\; \textit{Earned Premium} = 63\%$

20. a. Written car-years for CY 2017 $= (105 + 100) \times \frac{1}{2} = 102.5$ (remember, these are 6-month policies)

b. Inforce car-years as of 12/31/2017 $= 100 \times \frac{1}{2} = 50$

The policy written on 10/1/2017 is the only one inforce as of 12/31/2017

c. Earned car-years for CY 2018 = $(100 \times \frac{1}{2} + 110 + 105 \times \frac{1}{2}) = 106.25$

21. a. *Written exposures* = $1{,}000 \times 2 + 1{,}000 = 3{,}000$

b. *Earned exposures* = $1{,}000 \times 0.75 + 1{,}000 \times 0.5 = 1{,}250$

c. *Earned exposures* = $1{,}000 \times 1.0 + 1{,}000 \times 0.5 = 1{,}500$

22. a. *Paid* = $25{,}000 + 25{,}000 + 100{,}000 = 150{,}000$

Ending Case Reserve= $0 + 20{,}000 = 20{,}000$

Incurred = Paid + Ending Case Reserve= $150{,}000 + 20{,}000 = 170{,}000$

b. CY 2018: $[0 + (20{,}000 - 0)] + [0 + (50{,}000 - 0)] + [25{,}000 + (75{,}000 - 50{,}000)] = 120{,}000$

CY 2019: $[25{,}000 + (0 - 20{,}000)] + [100{,}000 + (20{,}000 - 75{,}000)] = 50{,}000$

c. Advantage: There is no development after the calendar year is over.

Disadvantage: Does not match premium to losses

23. a. Written Premium on Policy A = $(\frac{1}{2})$ x 1,000 = 500 (since it was cancelled mid-year)

Written Premium on Policy B = 500 x $(\frac{1}{4})$ + 400 x $(\frac{3}{4})$ = 425 (since the premium changes after $\frac{1}{4}$ year)

Written Premium on Policy C = 1,000

Total CY 2018 WP = 1,925

b. Earned Premium on Policy A = 500 (only inforce for half of the year)

Earned Premium on Policy B = 500 x $(\frac{1}{4})$ + 400 x $(\frac{1}{4})$ = 225 (only interested in CY 2018)

Earned Premium on Policy C = 1,000 x $\frac{1}{2}$ = 500 (only interested in CY 2018)

Total CY 2018 EP = 1,225

c. Policy Year 2018 WP = Calendar Year 2018 WP since all policies written in 2018 = 1,925

24. a. The CY 2017 incurred loss as of 12/31/2017 is 1,000.

b. Since calendar year data is frozen at the end of the calendar year, no matter what future evaluation point is used, after 12/31/2017, the calendar year incurred losses remain unchanged at 1,000.

c. The PY 2017 incurred loss as of 12/31/2017 is 1,000.

d. The PY 2017 incurred loss as of 12/31/2018 is 6,200.

e. Since all losses are tied back to when the policy was written, the loss amounts on a policy year basis can continue to develop into the future until all losses on policies written in that policy term are closed.

Part II

RESERVING

Friedland, Introduction to Part 2: "Information Gathering"
Chapter 3: "Understanding the Types of Data Used in the Estimation of Unpaid Claims"

in *Estimating Unpaid Claims Using Basic Techniques*, 2010, pp. 27–43

INTRODUCTION:

This chapter explores the data to be used in the analysis that follows in the subsequent chapters. It includes data types and data organization methods as well.

KEY CONCEPTS:

1) Introduction
    a. **Wiser's 4-Phase Approach to Reserve Estimation**
        i. Explore the data to identify key characteristics and any anomalies
        ii. Apply the appropriate techniques
        iii. Evaluate the different results of the various methods
        iv. Monitor the projections
2) Sources of Data
    a. Large insurers can usually rely on internal data.
    b. Data for small insurers may be limited.
    c. External data may be relied on when entering a new **line of business** or geography.
    d. U.S. External Data Sources
        i. ISO
        ii. NCCI
        iii. RAA
        iv. SFAA
        v. A.M. Best
        vi. NAIC Annual Statements
    e. Canadian External Data Sources

i. A.M. Best

ii. GISA

iii. RRC

iv. MSA

f. *External data can be useful when selecting:*

i. Tail development

ii. Trend factors

iii. Expected loss ratios

g. External data may be misleading due to differences in:

i. Insurance products

ii. Reserves and settlement practices

iii. Operations

iv. Coding

v. Geography

vi. Business and product mix

3) Homogeneity and Credibility of Data

a. Claim behavior is different by line of business

b. Claims by subcoverge within a line can be different

c. **Key characteristics to group data by for analysis:**

i. Coverage consistency

ii. Claims counts

iii. Reporting pattern

iv. Ability to develop reserve estimate from early reporting period through the claim's life

v. Settlement pattern

vi. Reopening propensity

vii. Severity

d. Goal is to subdivide data into homogeneous groups while not compromising credibility.

e. **Credibility** – Predictive value given to a group of data.

i. Increasing homogeneity and data volume tends to increase credibility

ii. Too many homogeneous groups and volume of data may become insufficient

f. Other considerations in analysis:

i. Efficiency

ii. Resources required for separate versus combined analysis

g. When rates of change differ, grouping different lines may be inappropriate

4) Types of Data Used by Actuaries

a. Claims and Claim Count Data

i. Incremental paid claims

ii. Cumulative paid claims

iii. Paid claims on closed claims

iv. Paid claims on open claims

v. Case outstanding

vi. Reported claims

vii. Incremental reported claims

viii. Reported claim counts

ix. Claim counts on closed with payment

x. Claim counts on closed with no payment

xi. Open claim counts

xii. Reopened claim counts

b. Claim-Related Expenses

i. Losses are often combined with ALAE.

ii. ULAE is typically analyzed separately.

iii. Expenses may be divided by DCC & AAO instead of ALAE and ULAE

iv. Internal approached to expense categorization may be used as well.

c. Multiple Currencies

i. Currencies may need to be adjusted due to volume of business

ii. Solution is to separate by currency, adjust for exchange rate, then combine

d. Large Claims

i. Unusually large claims can distort projection methods

ii. May exclude from analysis and add in a smoothed estimate of large losses

iii. Large loss threshold considerations:

A. # of claims annually over threshold

B. Size of claim relative to policy limits

C. Size of claim relative to reinsurance limits

D. Credibility of internal large loss data

E. External data availability

iv. Claims department is a good source of of large loss information

e. Recoveries

i. Deductibles

A. First party (e.g.: auto insurance) – Deductibles comes out before payment

B. Third-party (e.g.: general liability) – Deductibles recovered from insured

C. Reserving gross or net of deductibles can differ by insurer

ii. Salvage and Subrogation

A. **Salvage** – Amount the insurer can recover from the sale of damaged property

B. **Subrogation** – Recovery of the claim amount from a responsible third-party

C. In estimation, need to consider:

- How are salvage and subro tracked relative to claim payments?
- Are salvage and subro recorded in claim payment data?
- Is salvage and subro data available?

f. **Reinsurance**

i. Appointed Actuaries are required to understand the reinsurance program

ii. Actuary should examine reserves on a gross and net of reinsurance basis

iii. Possible treatments of ALAE in excess-of-loss (XOL) reinsurance:

A. Included with the claim amount

B. Not included in coverage

C. Included on a pro-rata basis

g. Exposure Data

i. Typical exposure types used; earned premium, written premium, policies inforce, policy limits, # of vehicles, and payroll.

ii. Need to adjust premiums to current levels

A. Rerate historical data at current rates

B. Adjust aggregate premiums based on summary of rate level changes

iii. Exposure Examples

A. Workers Comp – Payroll

B. Auto Liability - # of vehicle or miles driven

C. GL for public entities – Population or operating expense

D. GL for corporations – Sales or square footage

E. Hospital Professional Liability – Average occupied beds and outpatient visits

F. Property – Property values

G. Crime - # of employees

iv. Exposures are also important for evaluating and reconciling results

5) Insurer Reporting and Understanding the Data

a. Its critical to understand the data and what it contains

b. Incurred loss definitions

i. Finance Department – Transactional losses during a fiscal period; includes sum of payments, change in unpaid claims, and IBNR.

ii. Actuarial Department – Cumulative payments through a valuation date plus case outstanding

c. Unpaid claims and reserves definitions

i. Finance Department – Unpaid claims include case outstanding and IBNR

ii. Claims Department – Unpaid claims include case outstanding only

iii. TPA Reports – Reserves include cumulative payments plus case outstanding

d. Additional considerations

i. Is the estimate net or gross of recoveries?

ii. Does case outstanding include expenses?

iii. Are paid claims cumulative or incremental?

e. Claim Counts

i. Single accident can involve multiple parties

ii. Reopened claim treatment can differ by insurer

f. Verification of the Data

i. Incorrect or incomplete data can produce bogus inaccurate results

ii. No formal audit required, but ASOPs require data verification procedures

iii. Data review may include:

- Consistency with financial statements
- Consistency with prior data
- Data reasonableness – Review questionable values
- Data definitions – Need to understand how data is defined

6) Organization of the Data

a. Key Dates

i. **Policy Effective Date** – Beginning and ending dates of the policy term

A. **Policy Term** – Coverage effective period

B. **Policy Year** – Effective year of the policy

ii. **Accident Date** – Date that the accident occurred

iii. **Report Date** – Date the claims was reported to the insurer and recorded

A. May be split into report date and recorded date (and possibly notification date)

B. Notification Date – Date insurer is put on notice that claim may exist

iv. **Accounting Date** – Date grouping claims where liability may exist

A. May be selected based on statistical or financial reporting

B. Experience in frozen at that point

v. **Valuation Date** – Date through which data is included in analysis

A. May be before, the same, or after the accounting date

b. *Calendar Year Aggregation*

i. Transactional data

ii. Primary use is diagnostic testing of accident year data

iii. CY WP = All WP during the CY

iv. CY EP = WP + Beginning Unearned Premium Reserve – Ending UPR

v. Advantages

A. No future development – values are fixed

B. Data is readily available

vi. Disadvantage

A. Lack of development makes unpaid claim analysis impractical

c. *Accident Year Aggregation*

i. **Most common grouping used by actuaries**

ii. **Accident Year Data** – Grouping claims according to occurrence date

iii. Timing of AY may not coincide to calendar years

iv. Accident data may be on a monthly or quarterly basis also

v. Various financial reports in US and Canada require AY reporting

vi. Advantages

A. Grouping is easy to achieve

B. Easy to understand

C. Short timeframe than underwriting year

D. Robust industry data available by AY

E. Valuable when there are economic changes or major events

vii. Disadvantages

A. Mismatch between claims and exposures

B. Claims come from varies policies writings/pricings

C. Masks retention and insurer changes on high-deductible insureds

d. *Policy Year Aggregation (Underwriting Year Aggregation)*

i. **Policy Year Data** – Data grouped by when the policy was written directly matching premium and losses on policies

ii. **Underwriting Year Data** – Grouping of data, commonly by reinsurers, based on when the reinsurance policy became effective

iii. Claims can extend over a 24-month period

iv. Advantages

A. True match of claims and premiums

B. Important to see underwriting or pricing changes

C. Useful for self-insureds with only one policy

v. Disadvantages

A. Extended time frame

B. Difficult to isolate a single large event

e. *Report Year Aggregation*

i. **Report Year Data** – Data grouped based on when the claim is reported to the insurer.

ii. Grouping is used to estimate the ultimate value of known claims

iii. Can also test case outstanding adequacy over time

iv. Advantages

A. # of claims fixed at the end of the year

B. More stable data

C. Development pattern easier to determine than AY approach

D. Uses known metric (claim counts) for an estimate

v. Disadvantage

A. Measures development on known claims and not IBNR

KEY FORMULAS:

$$CY\ EP = WP + Beginning\ Unearned\ Premium\ Reserve - Ending\ Unearned\ Premium\ Reserve$$

SUMMARY:

Understanding the data available for use in analysis is critical to all areas of an insurer with reserve estimation being no exception. What's included in the data and how it's organized are keys in the data's use. From a testing perspective, understanding the different date aggregations and advantages/disadvantages of each is an area that's been drawn from regularly in past test questions.

PAST CAS EXAMINATION QUESTIONS (MODIFIED)

1. Your company has recently written a large general liability policy on a chain of 50 major hotels across the country. The insured will handle all claims below the $1,000 deductible. All claims over $1,000 will be referred to a special claim office you have established at the insured's headquarters, from which they will be referred to your field claim office for adjustment. To provide the insured with timely information, all accounting and statistical information will be originated in the special office. What adjustments may be necessary in your procedures for establishing reserves at year-end? What additional information would you require to determine whether the adjustments should be made?

2. The distribution of unpaid claim dollars between reported claims and IBNR in the Annual Statement often varies significantly among companies writing similar lines of business. List reasons for these differences.

3. A common measure used in valuing claims reserves is the ratio of claim and claim adjustment expense liabilities at year-end to the premium earned for that year. With all other things being equal and assuming accurate reserving, would you expect this ratio to increase, decrease, or remain unchanged if a claims handling change resulting in quicker entry of reported claims into the company's computer.

4. You are charged with establishing adequate IBNR estimates for the XYZ Company and you have just been informed that one of the six changes listed below occurred three months ago. For each possible change, indicate whether you would increase, decrease, or leave unchanged the IBNR estimate, and why you would make such a decision.

   a. Major reductions were made in the amount of statistical detail required before a claim is recorded.

   b. The report date for reopened claims is changed from the date of the original claim to the date that the claim is reopened.

   c. A PD claim must be closed independently of associated claims, whereas previously both claims would be closed at the same time.

   d. The statute of limitations was reduced from seven to three years.

   e. The proportion of general liability premiums attributed to products liability has decreased dramatically with the expiration of several major accounts.

5. Your company has accepted a 2% share of business produced by a syndicate that underwrites primary miscellaneous general liability coverage. The syndicate reports each calendar year's data to you on the following May 31 and has done so for the last six years. These data include written and earned premiums, paid claims, and case outstanding. The syndicate has provided no additional information. Briefly discuss how you would estimate the provision for total claim reserves for inclusion in your next Annual Statement.

6. An insurance company has recently experienced the following changes. For each situation, indicate whether you would increase, decrease, or leave unchanged IBNR. Explain your answer:

   a. Exposure growth and personnel shortage has increased the average caseload for claims adjusters.

   b. There has been a shift from paying legal fees when a claim is settled to paying such expenses as they arise over the life of a claim.

   c. A change in the claims processing system now requires an average of three days for a claim to be entered in the system versus a previous average of five days.

   d. A change in the definition of claim count new requires one count for each claimant in an accident instead of only one count for the entire accident.

7. You are given the following information:

Report Year Ending	**Cumulative Reported Claims ($000s) at:**				**Estimated Ultimate Claims ($000s)**	**Estimated Unpaid Claims ($000s)**
	12 mos.	**24 mos.**	**36 mos.**	**48 mos.**		
12/31/93	60	66	69	69	69	0
12/31/94	50	55	58		58	3
12/31/95	70	77			81	11
12/31/96	80				92	0
Total						14

	12 mos.	**24 mos.**	**36 mos.**	**48 mos.**
Selected CDF	1.10	1.05	1.00	1.00
Cumulative CDF	1.16	1.05	1.00	1.00

The unpaid claim estimate, which is calculated by subtracting reported claims as of December 31, 1995 from estimated ultimate claims, equals $14,000.

   a. What is the accounting date of the evaluation of the unpaid claim estimate?

   b. What is the valuation date of the evaluation of the unpaid claim estimate?

   c. Which of the following components of a total unpaid claim estimate are considered in the unpaid claim estimate?

      i) Case outstanding

      ii) Future development on case outstanding

      iii) Incurred but not reported claims.

8. You have recently been hired as the chief actuary of a small multiline property and casualty company. The company has the following written premium by line during the past three years:

Line of Business	1994	1995	1996
Commercial auto bodily injury liability	$100,000	$150,000	$225,000
Personal auto bodily injury liability	200,000	220,000	242,000
Commercial auto property damage liability	20,000	30,000	45,000
Personal auto property damage liability	40,000	44,000	48,400
Commercial multiperil	250,000	275,000	300,000
Workers compensation	5,000	5,000	5,000

   a. Your first task as chief actuary is to determine how the data will be segregated by line for estimating unpaid claims. List three considerations you would use in making this decision.

   b. Based on your answers from a., list the different lines of business that you would combine for reserving purposes, explaining your rationale for each grouping.

9. An insurance company has 40 open claim counts as of December 31, 2000. Each has the same formula reserve of $6,250. The following is a breakdown of activity on these claim counts during the 2001 calendar year:

   - Five claim counts closed with payment for a total of $80,000 in payments.
   - Five claim counts closed without payment.
   - Five claim counts with a partial payment of $2,500 each, with a corresponding decrease in case outstanding on each claim of $2,500.
   - Five claim counts with a partial payment of $5,000 each, with each of these five claim counts having an increase in case outstanding to $10,000.
   - Twenty claim counts remain open with no payment or case outstanding activity.
   - Received unanticipated salvage and subrogation recoveries amounting to $5,000 in total.

   What are the reported claims for these 40 claim counts for calendar year 2001?

10. Briefly describe each phase of the overall approach to estimation of unpaid claims described by Wiser.

11. Given the following data, valued as of December 31, 2006 (amount in $000s):

Accident Year	Cumulative Paid Claims Months of Development				
	12	**24**	**36**	**48**	**90**
2002	100	150	175	200	210
2003	110	130	150	155	
2004	90	120	130		
2005	105	130			
2006	100				

Calculate the value of 2006 calendar year paid claims.

12. A large insurer is considering combining data from a long-tailed, low-frequency line of business with data from a short-tailed, high-frequency line of business to estimate unpaid claims. Identify and briefly discuss four characteristics of the data that should be considered before combining these lines of business.

13. Describe a situation in which it is preferable to use accident year data for estimating unpaid claims rather than report year data.

14. Assess whether an accident year approach or a report year approach is more appropriate for reserving auto liability insurance.

15. An insurance company has the following information available for the four different geographic regions within the same line of business:

Region	Earned Exposures by Accident Year			Ultimate Claim Counts by Accident Year		
	2011	**2012**	**2013**	**2011**	**2012**	**2013**
1	21,900	22,560	22,125	2,075	2,143	2,010
2	2,575	2,460	2,520	126	124	125
3	18,000	17,460	17,800	880	895	877
4	4,450	10,720	27,500	227	580	1,330

Region	Observed Average Age-to-Age Paid Claim Development Factors (Age in Months)				
	12 – 24	**24 – 36**	**36 – 48**	**48 – 60**	**60 – ult.**
1	7.67	3.07	1.75	1.30	1.10
2	3.20	1.70	1.28	1.10	1.06
3	3.19	1.73	1.31	1.12	1.04
4	4.10	2.28	1.52	1.05	1.03

Justify an appropriate grouping of the regional data for estimating the insurer's unpaid claims for the total book of business.

16. Given the following data for an insurer that writes auto coverage in two states:

Underwriting Year	State A Earned Premium ($000s)	State B Earned Premium ($000s)
2012	2,000	154,000
2013	9,000	152,000
2014	20,000	147,000

	Reported CDFs as of (Months)			
State	**12**	**24**	**36**	**48**
A	2.43	1.58	1.14	1.00
B	2.47	1.55	1.17	1.00

- The State A policy limit is $50,000.
- The State B policy limit is $25,000.

a. Discuss an argument for and an argument against combining state A and state B when performing an unpaid claims analysis.

b. Discuss the expected change in severity from 2012 to 2014 when combining the experience from state A and state B.

17. List three considerations when establishing a large claim threshold for estimating unpaid claims.

18. Briefly discuss one advantage and one disadvantage of using each of the following data aggregation methods when performing an unpaid claim analysis.

a. Report year

b. Accident year.

19. Given the following information:

Accident Year	Personal Auto: Cumulative Reported Claims ($000) as of (Months)		
	12	24	36
2013	10,000	12,500	13,750
2014	10,500	13,120	
2015	11,000		

Accident Year	Commercial Auto: Cumulative Reported Claims ($000) as of (Months)		
	12	24	36
2013	2,000	4,000	5,000
2014	4,500	8,000	
2015	5,000		

a. The insurer began operating January 1, 2013.

b. Calculate personal auto reported claims for each of the calendar years 2013, 2014, and 2015.

c. Briefly discuss the appropriateness of using calendar year aggregation in estimating unpaid claims.

d. Evaluate the appropriateness of combining the two lines of business above when estimating unpaid claims for this insurer.

20. Actuary A and actuary B are each performing a reserve analysis for a small insurance company. To enhance credibility:

i. Actuary A relies only on internal data, aggregated across all lines of business.

ii. Actuary B supplements internal data with industry data separately by line of business.

Describe the benefits and deficiencies of each of these two strategies.

21. Given the following information as of December 31, 2016:

Accident Year	Cumulative Reported Claims ($000) as of (Months)		
	12	**24**	**36**
2013	120	200	276
2014	120	200	
2015	60		

Accident Year	Incremental Reported Claim Counts as of (Months)		
	12	**24**	**36**
2013	60	10	3
2014	60	10	
2015	60		

Accident Year	Cumulative Reported Claims ($000) as of (Months)		
	12	**24**	**36**
2013	120	180	240
2014	140	210	
2015	86		

- No claims are reported beyond 36 months.
- Accident year 36-to-ultimate development factor = 1.06
- No claims occurred prior to January 1, 2014.

Calculate the claims incurred but not yet reported (IBNYR) in total for all years as of December 31, 2016.

22. The following information is available for a private passenger automobile insurer:

    - The insurer started writing business 5 years ago.
    - External data from other auto insurers is used to supplement the insurer's data in estimating unpaid claims.
    - Unpaid claims have combined bodily injury and property damage claims in estimating historical unpaid claims.
    - Internal data shows that bodily injury claims take longer to reach ultimate than property damage claims.

    Internal management has asked the reserving actuary to begin estimating reserves separately for bodilty injury and property damage claims using internal data only.

    a. Fully discuss an argument supporting this change

    b. Fully discuss an argument against this change

23. A company starts writing insurance in 2021. In it's first year, it writes $1,000,000 of premium and ends the year with an unearned premium reserve of $180,000. How much premium was earned in 2021?

SOLUTIONS

1. Assume that previously there was no deductible and the insurer handled all claims. Since a deductible now applies, claim development factors will have to be adjusted since the insurer needs to reserve for net (after deductible) rather than gross claims. Such factors should take into account claims that are not initially reported to the insurer since they are expected to settle for less than the deductible but later exceed it. The establishment of a special claims office will also affect the time lag between accident date and report date, i.e., the reporting pattern. Since the office will be located at company headquarters, the delay will likely be less than if claims were first reported to a field office and then to the home office. To produce correct adjustments, additional information should be collected on gross and net claims (counts and severities for both) and any change in the reporting pattern.

2. The following information would be relevant:

   (1) The average lag from accident date to report date

   (2) The average lag from report date to recording date, which depends on such items as the amount of preliminary screening needed to verify coverage and detail, the extent of electronic processing, the extent of agent involvement, and the extent of decentralization.

   (3) The cutoff date for establishing estimated case outstanding.

   (4) Whether reopenings are classified as new claims

   (5) Whether different report dates apply to multiple claimants or multiple coverages from one accident.

   (6) An additional consideration would be whether IBNR is limited to pure IBNR or also includes development on case outstanding.

3. The claims handling change shifts claims from IBNR to case outstanding but should not affect total unpaid claims unless they are calculated without taking into account the change.

4. a. IBNR will decrease as claims are recorded more quickly.

   b. Additional payments on claims that will be reopened are now treated as IBNR rather than as development on case outstanding and thus IBNR increases.

   c. This change only affects the settlement pattern, not reporting or recording patterns, and thus the IBNR is unchanged.

   d. After three years from date of occurrence, IBNR is no longer possible and thus decreases.

   e. Because products liability has a large percentage of IBNR, IBNR will decrease,

5. A number of problems are involved, including the absence of accident year detail, the absence of an IBNR in a long-tail line, and the possibility of upward development on case outstanding. IBNR could be calculated using an industrywide factor applied to either a premium or claims base. Case outstanding adequacy should also be examined. Industrywide and syndicate ratios of paid claims to case outstanding (adjusted for exposure growth) could be compared to evaluate the adequacy level. If necessary, a provision for development on case outstanding should be added to IBNR.

6. a. This will increase IBNR because it will take longer for claims to be recorded.

   b. This will not affect IBNR, which is affected only by changes in reporting or recording patterns, not by changes in settlement or payment patterns.

   c. This will reduce IBNR because claims are now being recorded more quickly, thus reducing the number still to be recorded.

   d. This will increase IBNR because it will now include claim counts for claims other than the first one reported.

7. a. It is the date separating paid and unpaid claims, i.e., 12/31/95

   b. It is the date as of which the valuation of reserve liability is prepared. In this case, it is the latest date for which we have reported claims, i.e., 12/31/96

   c. i) This is not included since the unpaid claim estimate is the difference between the estimated ultimate claims and reported claims, which includes case outstanding.

      ii) Since this equals the difference between estimated ultimate claims and reported claims, it equals the unpaid claim estimate.

      iii) Since the analysis is on a report year basis, IBNR made up of claims reported after 12/31/96 are not included.

8. a. (1) Similarity of claim development patterns

      (2) Similarity of growth rates

      (3) Volume of data in each line

   b. (1) Do not combine the two auto liability lines as they have different growth rates and claim development patterns and each has sufficient volume.

      (2) Combine the two automobile property damage lines because of their low volume and the fact that their different growth rates will not have a major impact on short-tail lines.

      (3) Estimate unpaid claims separately for commercial multiperil because of its large volume.

      (4) Estimate unpaid claims for WC but use CDFs based on industry data because of the small volume.

9. $\textit{Paid Claims} = 80{,}000 + (5)(2{,}500) + (5)(5{,}000) - 5{,}000 = 112{,}500$

   $\textit{Change in Case Outstanding} = (-6{,}250)(10) + (-2{,}500)(5) + (3{,}750)(5) = -56{,}250$

   $$\begin{aligned}\textit{Incurred Claims} &= \textit{Paid Claims} + \textit{Change in Case Outstanding} \\ &= 112{,}500 - 56{,}250 \\ &= 56{,}250\end{aligned}$$

10. (1) "Exploring the data to identify its key characteristics and possible anomalies. Balancing the data to other verified sources should be undertaken at this point."

    (2) "Applying appropriate techniques for estimating unpaid claims."

    (3) "Evaluating the conflicting results of the various methods used, with an attempt to reconcile or explain the different outcomes. At this point the proposed reserving ultimate amounts are evaluated in contexts outside their original frame of analysis."

    (4) "Monitoring projections of claim development over subsequent calendar periods. Deviations of actual development from projected development of counts or amounts are one of the most useful diagnostic tools in evaluating accuracy of reserve estimates."

11. Subtract the claims in the prior diagonal from the claims in the current diagonal:

    $$(100 + 130 + 130 + 155 + 210) - (105 + 120 + 150 + 200) = 150$$

12. Consistency of coverage – whether claims "will generally be subject to the same or similar laws, policy terms, claims handling"

    (1) Volume of claims counts – whether each line has sufficient volume such that reserves developed separately are credible

    (2) Reporting patterns – whether the patterns for each line are similar and thus incurred development factors are similar

    (3) Case reserve adequacy – whether the reserve adequacy levels are similar for each line and thus incurred development factors are similar

    (4) Payment patterns – whether the patterns for each line are similar and thus paid development factors are similar

    (5) Likelihoods of reopening – whether the likelihoods for each line are similar and thus development factors are similar

    (6) Average severity – whether the average settlement values for each line are similar and whether any differences will distort unpaid claim estimates.

13. When the goal is to include IBNR in the unpaid claims estimate.

14. An accident year approach is more appropriate for the following reasons:

    (1) It is easy to compile and to understand.

    (2) "There are numerous industry benchmarks available to actuaries based on accident year experience."

    (3) It is useful "when there is a change due to economic or regulatory forces (such as inflation or law amendments) or major claim events (such as atypical weather or a major catastrophe) which can influence clams experience."

    (4) It does not require the separate calculation of pure IBNR.

15. (1) Region 1 should be separated from the other three regions as its paid claim development patterns is significantly different.

    (2) Region 4 should be separated from the other three regions as its earned exposures are increasing rapidly, whereas those in the other three regions remain roughly the same.

    (3) Region 2 should be combined with region 3 because of its small volume and its similarity with region 3, i.e., stable exposures and a similar paid development pattern.

16. a. Although currently the reported CDFs are very similar for each state, the different volumes of earned premium and different premium growth rates may produce different CDFs in the future. Because of these differences, the data from the two states should not be combined for an unpaid claims analysis.

    b. Because of its higher policy limit, state A has a higher average severity than state B. If the two states are combined, the combined average from 2012 to 2014 will increase because state A's share of the data increases.

17. (1) Number of claims over the threshold each year

    (2) Size of claim relative to policy limits

    (3) Size of claim relative to reinsurance limits

    (4) Credibility of internal data regarding large claims

    (5) Availability of relevant external data.

18. a. Advantages of report year aggregation are the following:

    (1) The number of claims is fixed other than claims reported but not recorded.

    (2) Data is more stable than accident year data and thus development patterns are more easily determinable.

    (3) It uses a known quantity (number of claim counts) rather than an estimate.

    The disadvantage of report year aggregation is that another method must be used to estimate pure IBNR.

b. Advantages of accident year aggregation are the following:

(1) It is easy to compile and to understand.

(2) Numerous industry benchmarks exist based on accident year experience.

(3) It is useful "when there is a change due to economic or regulatory forces (such as inflation or law amendments) or major claim events (such as atypical weather or a major catastrophe) which can influence clams experience."

(4) It does not require the separate calculation of pure IBNR.

(5) Using accident year data can also produce estimated ultimate claims sooner than with policy/underwriting year data.

Disadvantages of accident year aggregation are the following:

1) There is a potential mismatch between claims and exposures for insurers.

2) It includes a more varied group of policies involved than in policy or underwriting year data.

3) For self-insurers with high retentions, it can hide retention or insurer changes.

19. a. $RC_{13} = 10{,}000 RC_{14} = 10{,}500 + (12{,}500 - 10{,}000) = 13{,}000$

$RC_{15} = 11{,}000 + (13{,}120 - 10{,}500) + (13{,}750 - 12{,}500) = 14{,}870$

b. "The fixed nature of calendar year data . . . presents a disadvantage. The inability to address the critical issue of development is a disadvantage of calendar year statistics. Very few techniques for estimating unpaid claims are based on calendar year claims."

c. Do not combine the two auto liability lines as they have different growth rates and claim development patterns and each has sufficient volume.

20. i. This strategy will increase the volume of data and perhaps its credibility and avoids the need to adjust other data (e.g., countrywide) to reflect the company's operations. On the other hand, such lines are likely to differ in their loss distributions and development and payout patterns undermining the accuracy of resulting estimates, especially if the mix of business is changing.

ii. This strategy will increase the volume of data and perhaps its credibility by reducing volatility. The resulting data will likely remain homogeneous and may produce more accurate estimates if industry data does not differ significantly from company data. If company operations differ significantly from other companies, combining them may distort estimates.

21.

Report Year	12–24	24–36
2014	180/120 = 1.5	240/180 = 1.33
2015	210/140 = 1.5	
Selected	1.5	1.33
Age-to-Ultimate	2.0	1.33

Ultimate	
2014	240
2015	$280 = 210 \times 1.33$
2016	$172 = 86 \times 2$
Total	692

Accident Year	12–24	24–36	36–Ult
2014	200/120 = 1.667	276/200 = 1.38	
2015	200/120 = 1.667		
Selected	1.667	1.38	1.06
Age-to-Ultimate	2.44	1.46	1.06

Ultimate	
2014	$292.56 = 276 \times 1.06$
2015	$292 = 200 \times 1.46$
2016	$146 = 60 \times 2.44$
Total	731

IBNYR = IBNR − IBNER = 731 − 692 = 39

22. a.
- The internal data shows a difference between these coverages, so separating them will produce more accurate estimates.
- If the distributions of claim types are changing over time, combining them will produce inaccurate results.
- Internal data may be very different from external data for a variety of reasons.
- Claims accuracy will improve the product pricing and improve the competitive edge.
- You'd be able to more accurately diagnose changing patterns by claim type.

b.
- With only 5 years of data, true claims patterns may not have emerged, particulary for the longer-tailed bodily injury coverage.
- Internal data may not be credible on its own.
- Further break-out of the data by coverage may lessen the data's credibility.
- Benefits of breaking out by coverage may be offset by the difficulty in performing additional reserve analysis.
- Key financial metrics used by investors could be misleading if there are drastic swings in reserve estimates.

23. $EP = WP + (\textit{starting UEPR} - \textit{ending UEPR})$

2021 $EP = \$1{,}000{,}000 + (\$0 - \$180{,}000) = \$820{,}000$

Who We Are

A Benefit Corporation Experienced at Teaching Actuaries!

Experienced

More than 50 years experience helping students prepare and pass actuarial exams! We are an eLearning technology and education company leveraging experts in the field to constantly update our learning content in a format that works for you.

Trustworthy

ACTEX Learning is a leading US based provider of study materials for actuarial exams. Our authors and content contributors are renowned academics and Actuaries that are proud to have their names on the cover of our manuals and textbooks!

Mission Focused

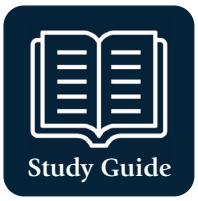
We are a Benefit Corporation focusing on the mission of accessible high quality actuarial education. We're dedicated to empowering actuarial students by offering test prep materials that are not just effective and efficient but also tailored to suit every type of student.

Become an ACTEX Champion

Join our Global ACTEX Champion Program and bring the benefits to your Actuarial Club. To learn more about the program, scan the QR code on the right. If you have any questions or would like to speak to a Champion Coordinator, please do not hesitate to reach out to us at champions@actexlearning.com.

ACTEX Learning

ACTEX Has the Solutions to Help You with Exam Prep



Our study guides offer the most recommended actuarial prep program. Search our interactive manuals for different topics and toggle easily between concepts and study materials.

Available for P, FM, FAM, ALTAM, ASTAM, PA. ATPA, MAS-I, MAS-II, CAS 5, CAS 6 US & CAN, CAS 7, CAS 8, CAS 9

Want to know you're prepared for your exam? Practice efficiently with our robust database of questions and solutions and predict your success through GOAL's innovative scoring system. GOAL also features dedicated instructor support so you can get help where you need it and pass the exam with confidence!

Available for P, FM, FAM, ALTAM, ASTAM, MAS-I, MAS-II, CAS 5, CAS 6 US & CAN

Master key topics and formulas with our flashcards, which allow you to filter by topic. To help you direct your focus, each card is rated to indicate its importance on the exam.

Available for P, FM, FAM, ALTAM, ASTAM, PA. ATPA, MAS-I, MAS-II, CAS 5, CAS 6 US & CAN, CAS 7, CAS 8, CAS 9

Studies have shown video learning can lead to better retention. We offer hours of video instruction to aid you in your studies. They're a great way to deepen your learning on challenging topics and gain a variety of perspectives from our expert instructors.

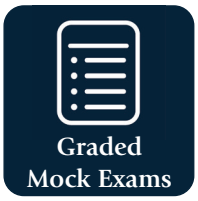
Available for P, FM, FAM, ALTAM, ASTAM, PA. ATPA, MAS-I, MAS-II, CAS 5, CAS 6 US & CAN, CAS 7, CAS 8, CAS 9

ACTEX offers convenient online courses approved for CAS VEE credits. All courses are available on-demand. Students complete the courses at their own pace and take the final exams on the date of their choosing.

Available for Accounting & Finance, Mathematical Statistics, and Economics

Study Materials are Available for the Following:

SOA: P, FM, FAM, ALTAM, ASTAM, SRM, PA, ATPA, CFE, GI, GH, ILA, RET
CAS: MAS-I, MAS-II, CAS 5, CAS 6C, CAS 6US, CAS 7, CAS 8, CAS 9



The ACTEX Graded Mock Exam is a great way to predict your exam outcome! Before you take the official exam - take the new ACTEX Graded Mock Exam and get feedback from an expert. The ACTEX Graded Mock Exam has all the typical elements your SOA exam will have. This can help you evaluate your progress. The questions and format are set up just like the SOA exam.

Available for ALTAM, ASTAM, PA

ACTEX Bootcamps provide a more individualized approach, allow you to ask questions in real time, and boost your last-minute learning. You'll review the harder topics on the exam, as well as common errors and exam strategy. All classes are recorded for future on-demand viewing.

Available for P, FM, FAM, SRM

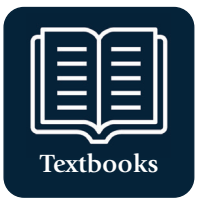
Alongside our P & FM study guide, this course is comparable to a one-semester college class. This course offers SOA Exam practice problems, video solutions, timed practice tests, sample questions, and more. You'll also have 1:1 email support from an instructor for 180 days after purchase.

The Advanced topics in Predictive Analytics video course is designed to help you more easily climb the steep ATPA learning curve. This module-focused video course for Topic 3 in the syllabus, includes videos, end of module assessments and lecture slides. This video course is a deep dive into the three modules. Access to an instructor during the duration of the course as well as participation in a discussion forum.

Available for P, FM, and ATPA

This at-a-glance tool helps you memorize and recall key formulas and information. It covers important formulas needed to prepare your exam. Also, it's an easy-to-print format you can study with, no matter where you are.

Available for P, FM, FAM, ALTAM, ASTAM, PA. ATPA, MAS-I, MAS-II, CAS 5



Looking for Extra Preparation?

Explore our range of textbooks designed to support your studies. From recommended to required readings, ACTEX offers exceptional materials to help you succeed.

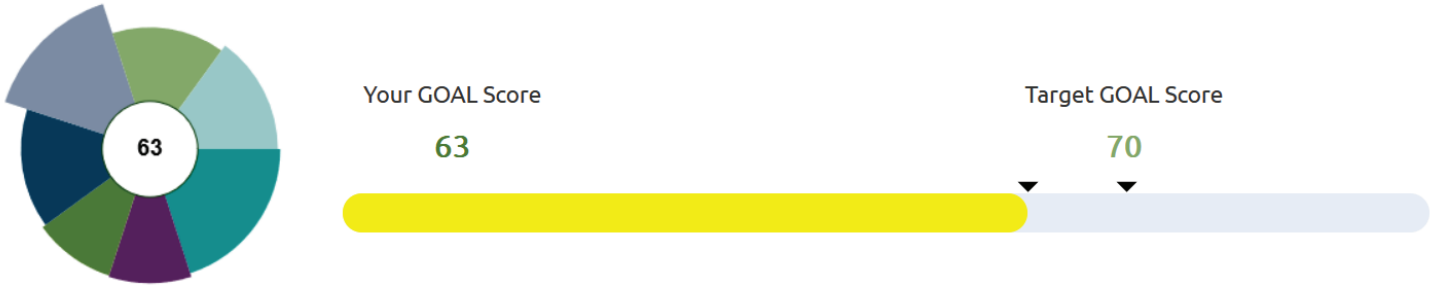
Use GOAL to Practice What You've Learned

- Over 22,000 exam-style problems with detailed solutions
- 3 learning modes (Practice, Quiz, Simulated Exams)
- 3 levels of difficulty (Core, Advanced and Mastery)
- You control your topics and sub-topics
- Dedicated instructor support

GOAL is currently available for the following SOA & CAS Exams:

Exam P 1,050+ Questions	Exam FM 1,500+ Questions	Exam FAM-L 1,300+ Questions	Exam FAM-S 900+ Questions	Exam FAM 2,300+ Questions
Exam ALTAM 1,400+ Questions	Exam ASTAM 1,300+ Questions	Exam SRM 1,150+ Questions	Exam MAS-I 1,050+ Questions	
Exam MAS-II 850+ Questions	Exam CAS 5C 500+ Questions	Exam CAS 6US 550+ Questions	Exam CAS 6CA 650+ Questions	

Use GOAL Score to Gauge Your Exam Readiness



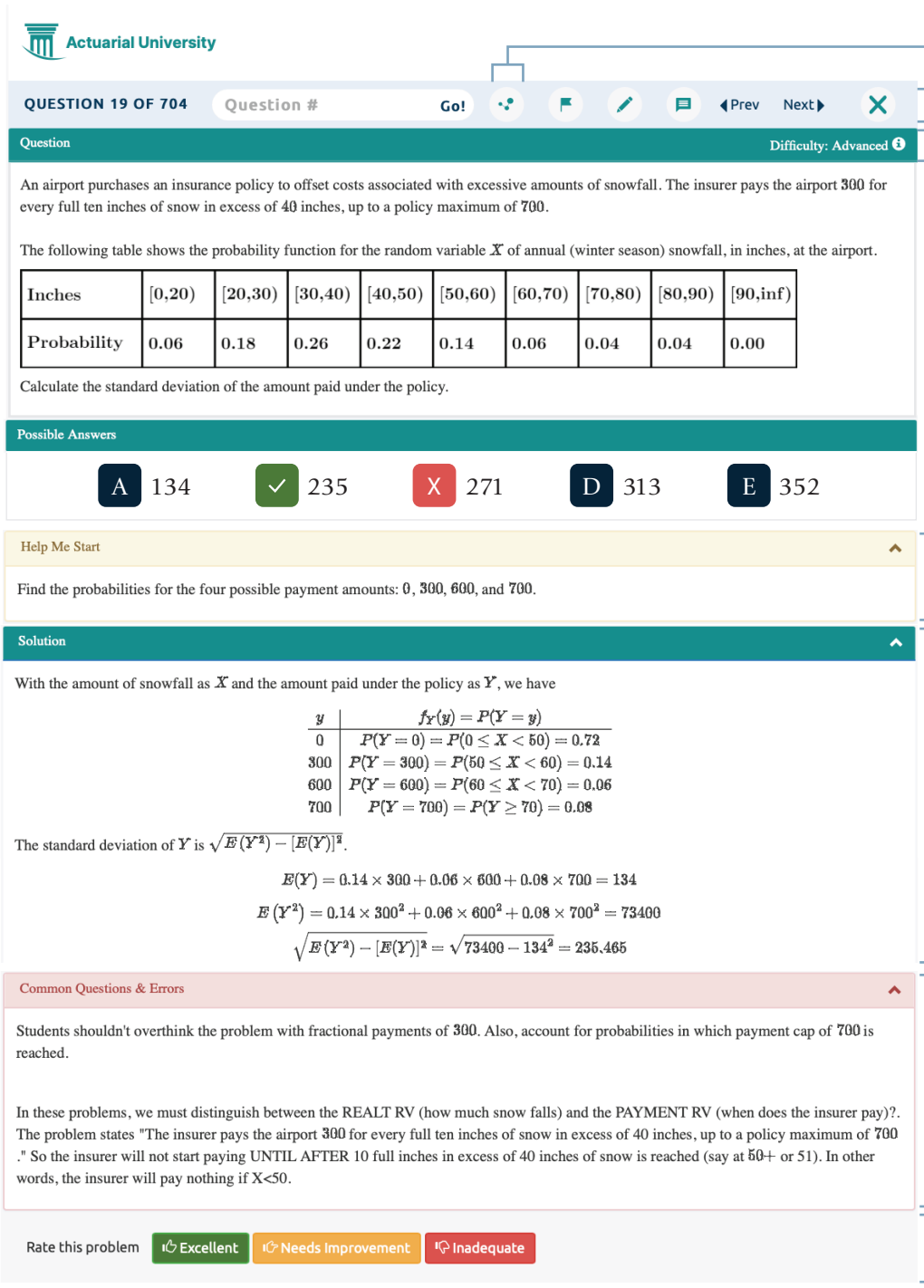
Measure how prepared you are to pass your exam with a tool that suits any study approach. A GOAL Score of 70 or above indicates readiness.

Your score is broken into categories, allowing you to study efficiently by concentrating on problem areas. GOAL Score quantifies your exam readiness by measuring both your performance and the consistency of your performance. Your GOAL Score also analyzes your strengths and weaknesses by category, topic, and level of difficulty.

Scan to Learn More

GOAL Improves Your Studies

How you can prepare for your exam confidently with GOAL custom Practice Sessions, Quizzes, & Simulated Exams:



Actuarial University

QUESTION 19 OF 704 | Question # | Go! | Prev | Next

Question — Difficulty: Advanced

An airport purchases an insurance policy to offset costs associated with excessive amounts of snowfall. The insurer pays the airport 300 for every full ten inches of snow in excess of 40 inches, up to a policy maximum of 700.

The following table shows the probability function for the random variable X of annual (winter season) snowfall, in inches, at the airport.

Inches	[0,20)	[20,30)	[30,40)	[40,50)	[50,60)	[60,70)	[70,80)	[80,90)	[90,inf)
Probability	0.06	0.18	0.26	0.22	0.14	0.06	0.04	0.04	0.00

Calculate the standard deviation of the amount paid under the policy.

Possible Answers

A 134 ✓ 235 X 271 D 313 E 352

Help Me Start

Find the probabilities for the four possible payment amounts: 0, 300, 600, and 700.

Solution

With the amount of snowfall as X and the amount paid under the policy as Y, we have

y	$f_Y(y) = P(Y = y)$
0	$P(Y = 0) = P(0 \le X < 50) = 0.72$
300	$P(Y = 300) = P(50 \le X < 60) = 0.14$
600	$P(Y = 600) = P(60 \le X < 70) = 0.06$
700	$P(Y = 700) = P(Y \ge 70) = 0.08$

The standard deviation of Y is $\sqrt{E(Y^2) - [E(Y)]^2}$.

$$E(Y) = 0.14 \times 300 + 0.06 \times 600 + 0.08 \times 700 = 134$$

$$E(Y^2) = 0.14 \times 300^2 + 0.06 \times 600^2 + 0.08 \times 700^2 = 73400$$

$$\sqrt{E(Y^2) - [E(Y)]^2} = \sqrt{73400 - 134^2} = 235.465$$

Common Questions & Errors

Students shouldn't overthink the problem with fractional payments of 300. Also, account for probabilities in which payment cap of 700 is reached.

In these problems, we must distinguish between the REALT RV (how much snow falls) and the PAYMENT RV (when does the insurer pay)?. The problem states "The insurer pays the airport 300 for every full ten inches of snow in excess of 40 inches, up to a policy maximum of 700 ." So the insurer will not start paying UNTIL AFTER 10 full inches in excess of 40 inches of snow is reached (say at 50+ or 51). In other words, the insurer will pay nothing if X<50.

Rate this problem | Excellent | Needs Improvement | Inadequate

Quickly access the Hub for additional learning.

Flag problems for review, record notes, and get instructor support.

View difficulty level.

Helpful strategies to get you started.

Full solutions with detailed explanations to deepen your understanding.

Commonly encountered errors.

Rate a problem or give feedback.

Thank You for Choosing ACTEX Learning!

We're committed to helping you succeed on your actuarial journey.

For the latest study guides, textbooks, free Formula Sheets, and more resources for SOA, CAS, IFoA, and IAI exams, visit:

ACTEX Learning https://actexlearning.com/

Your destination for comprehensive actuarial exam preparation and professional development.

Looking for additional study material or other actuarial books?

THE ACTUARIAL BOOKSTORE https://www.actuarialbookstore.com/

The #1 online source for actuarial books and study guides.

Scan to Learn More