TABLE OF CONTENTS

2015 SYLLABUS UPDATES

In Fall 2015, the CAS will be administering Exams LC, ST, S, 5, 6 Canada, 6 United States, and 8. The CAS Syllabus Committee has approved changes for the Fall 2015 syllabus as outlined in the Changes for the Fall 2015 CAS Syllabus of Basic Education memorandum from the Vice President-Admissions.

The following are the changes made to the *Syllabus of Basic Education* after its initial publication.

2015 Spring Examinations

Exam 7

Errata added for International Actuarial Association, "A Global Framework for Insurer Solvency Assessment," a research report of the Insurer Solvency Assessment Working Party, 2004, Chapters 1, 2, 5, 7, 8, and 9; Appendices B, D, E, H, and I.

Exam 6-U.S.

Errata added for Odomirok, K.C.; McFarlane, L.M.; Kennedy, G.L; and Brenden, J., *Financial Reporting Through the Lens of a Property/ Casualty Actuary*, Casualty Actuarial Society, 2014, Edition 4.

2015 Fall Examinations

Exam S

An initial syllabus for Exam S was published on the CAS website earlier this year. After careful review, the Syllabus Committee made some clarifying changes to the Exam S Syllabus. The final syllabus for the October 2015 administration of this exam can be found in the Exams & Admissions section of the CAS website.

Note: This Syllabus is subject to change in the future. The CAS is not responsible for any errors or omissions in the Syllabus.

ANOUNCEMENTS FOR FALL 2015

(Revised May 14, 2015)

Exam Registration

Candidates may find online exam registration and related information on the Exam Registration page of the CAS website. Prior to completing an online application for Exams LC, ST, S, and 5-9, candidates must submit an Electronic Signature Authorization Form—details are available on the same page.

There is only one registration deadline for each exam. **No late registrations will be accepted**. The exam dates and registration deadlines are available in the "2015 Examination Schedule" section. Please allow at least 10 working days for your mailed application to reach its destination. Whether payment is made by personal or company check, it is the candidate's responsibility to ensure that the application and fee are received by the stated deadline. **Exceptions will not be made**.

Transition Rules for new Exam S

Candidates should review carefully the Transition Rules for Exam S approved by the CAS Board of Directors. These rules can be located in the Examination Rules, C. Grades and Accreditation, Transition Programs section of the *Syllabus.*

Syllabus Update for Exam S

An initial syllabus for Exam S was published on the CAS website earlier this year. After careful review, the Syllabus Committee made some clarifying changes to the Exam S Syllabus. **The final syllabus for the October 2015 administration of this exam can be found in the Exams & Admissions section of the CAS website**.

The Examination Committee expects that Exam S will consist of approximately 40 to 50 multiple-choice questions.

Note: This Syllabus is subject to change in the future. The CAS is not responsible for any errors or omissions in the Syllabus.

INTRODUCTION

Principles of the Casualty Actuarial Society for Basic Education

The primary purpose of the Casualty Actuarial Society (CAS) basic education process is to ascertain whether candidates for the CAS designations have satisfied CAS learning objectives. The CAS Board of Directors adopted the following principles on May 6, 2001.

1. Basic education will remain a cornerstone of the CAS.

2. The CAS will assure that its members have the knowledge of those areas needed to practice effectively in the broad and expanding range of property, casualty, and similar business and financial risks (general insurance).

3. The CAS is committed to a depth of knowledge of techniques associated with the broad range of property, casualty, and similar business and financial risks.

4. The CAS will provide the basic education necessary to meet qualification standards to sign statements of actuarial opinion for general insurance and related specialties in at least the U.S. and Canada.

5. The education process will provide a balance among theoretical concepts, practical applications, and business acumen, to prepare our members to deliver high-quality service to meet current and projected future needs of employers and clients.

6. The CAS will approve the syllabus and examination standards used in determining eligibility for CAS membership.

7. Demonstration of mastery of the skill sets required of members is critical to basic education.

8. The CAS is committed to maintaining self-study as one route for attainment of designations.

9. The CAS will pursue strong working relationships with academia and professionals in related fields.

10. The CAS will attract a pool of strong candidates from a variety of backgrounds to the actuarial profession.

11. The CAS supports the goal of developing a global shared foundation of actuarial education, including joint sponsorship of examinations where consistent with other principles.

12. The CAS, as an educator of general insurance and related specialties, will remain a significant contributor to the worldwide actuarial profession.

Syllabus Goals and Objectives

One of the primary objectives of the Casualty Actuarial Society (CAS) is the development of qualified professionals in the field of casualty actuarial science. The CAS conducts an educational and examination program for prospective members in order to achieve this objective.

The syllabus goals and objectives are as follows:

1. To develop a general understanding of the social, political, regulatory, legal, economic, and financial environment of the business of property and casualty insurance and similar risk assessment as well as the historical development of that environment.

2. To develop a thorough understanding of the fundamental mathematical concepts applicable to solving insurance and similar risk assessment problems, and to develop a high degree of skill in their applications.

3. To develop a comprehensive understanding of the business of property and casualty insurance, including underwriting, claims, marketing, and finance, as well as how these functions are performed and interrelated.

4. To develop a working knowledge of property and casualty insurance policies and contracts.

5. To develop an expert knowledge of a broad range of techniques to solve problems and to develop the ability to discern the appropriateness of techniques for particular applications based on knowledge of the underlying assumptions, strengths, and weaknesses.

6. To develop an expert knowledge of a broad range of relevant and standard actuarial practices in order to present a framework for the use of problem-solving techniques.

7. To encourage a sense of inquisitiveness and creativity toward problem solving in order to foster an appreciation of the art in actuarial science.

Note: The items in this Syllabus were chosen for their educational value. They are intended to expose the candidate to a wide range of information and to a variety of methods, opinions, and practices in the casualty actuarial field. Inclusion of material in the Syllabus does not imply that the CAS endorses the views, methodologies, or techniques therein.

Education and Examination System

The CAS vice president-admissions supervises the CAS education and examination system. The vice president-admissions is supported by the following four admissions committees:

CAS Education Policy Committee

The Education Policy Committee recommends to the CAS Board of Directors the goals and objectives of the CAS education and examination system to ensure that the needs of the Society, its members, and its potential members are met. The committee reviews and recommends any changes to the CAS Executive Council on the CAS Basic Education Waiver Policy and similar issues. The committee also monitors the operations of the other educational and examination committees to ensure continued effectiveness.

CAS Syllabus Committee

The Syllabus Committee determines the scope and content of the CAS Syllabus and course of readings for CAS Examinations.

A chairperson supervises the committee that is composed of Fellows who represent a broad spectrum of CAS

members including insurers, consultants, regulators, and academicians. At least one representative of the Canadian Institute of Actuaries (CIA) also serves on the committee; usually at least one of the representatives is a member of the CIA Education and Examination Committee. One or more members specialize in the material for each examination part. These specialists recommend changes to the Syllabus; however, the entire committee must approve recommendations.

Members of the Syllabus Committee review the individual exam syllabi regularly. Both short- and long-term goals for improvement are developed. Textbooks and articles may be designated for inclusion. If the committee determines that new study material needs to be developed or that existing material needs to be revised, the committee may commission the creation of Study Notes for inclusion. Every effort is made to develop material that is appropriate, relevant, up-to-date, concise, and well written. Suggestions for improvement are always welcome and should be directed to the Syllabus Committee at the CAS Office address.

CAS Examination Committee

The Examination Committee organizes, manages, administers, and grades the CAS Examinations. The committee also establishes the standards to be achieved by successful candidates.

The chairperson supervises the committee and is responsible for the overall administration of the CAS Examinations. Several senior committee officers with the title of general officer assist the chairperson. The committee is subdivided into Examination Part Committees, each headed by an examination part chairperson.

The following provides details about the CAS-specific examinations:

- The responsibility for each CAS Examination is assigned to a part committee that writes, grades, and maintains the standards for that examination. One or more examination consultants who are CAS members and are experts on the material covered by that examination assist each part committee. A proofreader who concentrates on uniformity and grammar also assists the part committees. In addition, academic consultants who are independent experts from the academic community assist some part committees.

- Each examination is drafted by the responsible Examination Part Committee to test candidates' knowledge of the items listed in the syllabus for the specific exam. The individual part committee, examination consultants, one of the Examination Committee general officers, the Examination Committee chairperson, and, in some cases, academic consultants review each examination to assure its quality.

- Every effort is made to ensure that the questions fall within the scope of the individual exam syllabus. Complete coverage of all material is not practical for every examination every year. The goal is to produce examinations that contain representative, high-quality questions that test candidates' knowledge of the material. Trick questions are deliberately avoided, and the wording of each question is considered carefully to eliminate possible ambiguities. Preliminary versions of each examination are thoroughly reviewed in relation to all of these factors before the final examination is approved.

CAS Candidate Liaison Committee

The Candidate Liaison Committee strives to focus on issues of importance to candidates who are taking CAS

Examinations. The committee serves as a direct point of contact for candidates to voice individual or group concerns regarding the education and examination process. It also provides a means for an exchange of information between candidates and the admissions committees via *Future Fellows*, a quarterly newsletter. Candidate representatives who are actively involved in the examination process serve as advisors to the committee.

2015 EXAMINATION SCHEDULE

Exams for Online Courses 1 and 2 by Computer-Based Testing

	EXAM DATES	DURATION	START TIME	EXAM REFUND DEADLINE
January-March Test Window	Jan. 15 – March 15, 2015	2 Hours	Various	Three business days prior to scheduled exam—fees apply.
April-June Test Window	April 15 – June 15, 2015	2 Hours	Various	Three business days prior to scheduled exam—fees apply.
July-September Test Window	July 15 – Sept. 15, 2015	2 Hours	Various	Three business days prior to scheduled exam—fees apply.
October-December Test Window	Oct. 15 – Dec. 15, 2015	2 Hours	Various	Three business days prior to scheduled exam—fees apply.

April 2015 Exam Administration

Exam	EXAM DATES	DURATION	START TIME	REGISTRATION DEADLINE	REFUND DEADLINE
Exam LC	April 30, 2015	1.5 Hours	1:30 p.m.	March 5, 2015	April 17, 2015
Exam ST	April 30, 2015	2.5 Hours	8:30 a.m.	March 5, 2015	April 17, 2015
Exam 5	April 27, 2015	4 Hours	8:30 a.m.	March 5, 2015	April 17, 2015
Exam 6-Canada and 6 U.S.	April 28, 2015	4 Hours	8:30 a.m.	March 5, 2015	April 17, 2015
Exam 7	April 24, 2015	4 Hours	8:30 a.m.	March 5, 2015	April 17, 2015
Exam 9	April 29, 2015	4 Hours	8:30 a.m.	March 5, 2015	April 17, 2015

October 2015 Exam Administration

Exam	EXAM DATES	DURATION	START TIME	REGISTRATION DEADLINE	REFUND DEADLINE
Exam LC	October 29, 2015	1.5 Hours	1:30 p.m.	September 3, 2015	October 23, 2015
Exam ST	October 29, 2015	2.5 Hours	8:30 a.m.	September 3, 2015	October 23, 2015
Exam S	October 30, 2015	4 Hours	8:30 a.m.	September 3, 2015	October 23, 2015
Exam 5	October 26, 2015	4 Hours	8:30 a.m.	September 3, 2015	October 23, 2015
Exams 6-Canada and 6-U.S.	October 27, 2015	4 Hours	8:30 a.m.	September 3, 2015	October 23, 2015
Exam 8	October 28, 2015	4 Hours	8:30 a.m.	September 3, 2015	October 23, 2015

ST9 Exam Administration for CERA Designation

Exam	EXAM DATES	DURATION	START TIME	REGISTRATION DEADLINE	REFUND DEADLINE
April Administration	April 30, 2015	3 Hours	Check Entry Permit	February 12, 2015	February 11, 2015
October Administration	October 12, 2015	3 Hours	Check Entry Permit	July 23, 2015	July 22, 2015

Important Schedule Notes

- Starting times listed for examinations refer to the local time.

- Candidates should arrive at the examination center at least 30 minutes prior to the scheduled exam time for the check-in process.

- Examinations administered exclusively by the CAS will have a reading time prior to the commencement of the timed exams. For Exams LC and ST, there will be a 10-minute reading period; for Exams S, 5-9, there will be a 15-minute reading period.

- Currently, waivers for Exam 1, Exam 2, Exam 3F, and Exam 4 are accepted from the Actuarial Society of South Africa, the Actuaries Institute (Australia), the Canadian Institute of Actuaries (except for Exam 1), the Institute and Faculty of Actuaries, and the Society of Actuaries.

- Updated information for waivers for Exam 1, Exam 2, Exam 3F, and Exam 4 will be incorporated as necessary and will be noted in the syllabus section for the specific exam.

- To meet the CAS requirements for CERA, candidates should submit their registration to the CAS for Institute and Faculty of Actuaries (U.K.) Exam ST9.

ASSOCIATESHIP REQUIREMENTS

Validation by Educational Experience

VEE-Corporate Finance

VEE-Economics.

Online Courses

Online Course 1   Risk Management and Insurance Operations (same as The Institutes Course CA1)

Online Course 2   Insurance Accounting, Coverage Analysis, Insurance Law, and Insurance Regulation (same as The Institutes Course CA2)

Examinations

Exam 1   Probability (receive credit for SOA Exam P)

Exam 2   Financial Mathematics (receive credit for SOA Exam FM)

Exam 3F   Models for Financial Economics (receive credit for SOA Exam MFE)

Exam 4   Construction and Evaluation of Actuarial Models (receive credit for SOA Exam C)

Exam S   Statistics and Probabilistic Models*

Exam 5   Basic Techniques for Ratemaking and Estimating Claim Liabilities

Exam 6   Regulation and Financial Reporting (Nation-Specific)

New exam required beginning in Fall 2015 replacing Exam LC, Exam ST, and VEE-Applied Statistical Methods. However, transition rules allow candidates with credit for either Exam LC and/or Exam ST to take the remaining exam/educational requirements to obtain credit for the new Exam S by August 31, 2016.

Course on Professionalism

FELLOWSHIP REQUIREMENTS

Fellowship requires all Associateship requirements plus the following:

Exam 7   Estimation of Policy Liabilities, Insurance Company Valuation, and ERM

Exam 8   Advanced Ratemaking

Exam 9   Financial Risk and Rate of Return

EXAMINATION RULES

A. Registration

Administration of Examinations

The CAS basic education structure has Validation by Educational Experience (VEE) requirements, two online courses, several examinations (see Basic Education Summary), and the Course on Professionalism. Credit for Exams 1, 2, 3F, and 4 is granted based on exam options as defined in the individual exam syllabi. The two online courses are available through The Institutes. The CAS exclusively administers Exams LC, ST, S, and 5-9 and the Course on Professionalism.[1] The Canadian Institute of Actuaries (CIA) cosponsors all the examinations except Exam 6-United States and Exam 6-Actuarial Institute of Chinese Taipei.

Filing of Applications and Deadlines

Exams 1, 2, 3F, and 4

For Exams 1, 2, 3F, and 4, the candidate should follow the application process and deadlines of the sponsoring organizations.

Exams LC, ST, S, and 5-9

All candidates filing for an examination(s) must submit a signed application for each examination period. Both online registration and application forms are linked at each of the individual Examination pages under the "Exams and Admissions" section of the CAS website. Payment must accompany each application to be valid. **Applications must be received by the registration deadlines stated in the Examination Schedule of this Syllabus.** Please allow at least 10 working days for your mailed application to reach its destination. Whether payment is made by personal or company check, **it is the candidate's responsibility to ensure that the application and fee are received by the stated deadline. Exceptions will not be made**.

Send applications as follows: Candidates may submit examination registrations for Exams LC, ST, S, and 5-9 by mail or online. Applications must be received by the published deadlines. Candidates submitting a hard copy of their registration should mail them as follows:

Mail application with check or money order in U.S. funds or Canadian equivalent (payable to "Casualty Actuarial Society") to:	*Send application with credit card payment (Visa, MasterCard, or American Express) and all overnight deliveries to:*
Casualty Actuarial Society P.O. Box 425 Merrifield, VA 22116-0425	Casualty Actuarial Society 4350 N. Fairfax Drive, Suite 250 Arlington, Virginia 22203 Telephone: 703.276.3100

---

[1] Exam LC and Exam ST will be offered through Spring 2016. See Transition Rules.

Candidates submitting their registrations online for Exams LC, ST, S, and 5-9 must pay by credit card. All credit card payments will be processed in U.S. funds. Prior to completing an online application, candidates must submit an Electronic Signature Authorization Form (ESAF). By signing the ESAF, candidates agrees to be bound by the rules and regulations related to the examinations. It will also provide a signature of record for comparison to signatures on the individual examination envelopes. The ESAF is available in the Exam Registration page of the CAS website. Unless the candidate has a name change, the ESAF only needs to be submitted once. **Candidates who intend to register online should submit their ESAFs at least one week prior to the exam registration deadline to allow for processing time.**

Candidates will be sent an acknowledgment of receipt of their application within three weeks of the date that the application form was received at the CAS Office beginning in early February for April Examinations and early August for October Examinations. This acknowledgment is the candidate's receipt of exam fees paid. Please retain this acknowledgment for tax purposes if needed. **Candidates that have not received an acknowledgment prior to the registration deadline should contact the CAS Office or their accounting department to ensure that their applications reached the CAS Office.** The candidate can also verify their registration by logging into their CAS account and checking their profile.

Online Courses 1 and 2

CAS Online Courses 1/CA1 and 2/CA2 are available through The Institutes. When candidates register for the individual online course, the fee includes one attempt at the exam. Before registering for the exam, candidates must obtain their Master ID number from the CAS—it will be required to register for the exam. After progressing through the online course, candidates arrange for their exam by contacting:

> The Institutes, Customer Service
> 720 Providence Road, Suite 100
> Malvern, PA 19355-3433
> Telephone: (800) 644-2101 or (610) 644-2100 ext. 6000
> E-mail: CustomerService@TheInstitutes.org
> CAS Online Courses page at The Institutes website: www.aicpcu.org/cas.htm

Name

Candidates must use their legal name on all examination registration materials and when corresponding with the CAS. Any change in name must be accompanied by acceptable documentation.

Fees

Examination fees must be paid each time a candidate registers for an exam. Payment options are described in a previous section, Filing of Applications and Deadlines. A $20 surcharge will be assessed for all returned checks. The charts below show the examination fee schedules for 2015 at the time of publication. All fees are listed in U.S. dollars and are subject to change. Other fees that may apply include fees for change of center, refund, and/or a special exam center.

Exams 1, 2, 3F, and 4

Contact the sponsoring organization.

Exams LC, ST, S, and 5-9 and Online Courses 1 and 2

2015 Examination Fees		
	Candidates	**Full-Time**
Exams LC and ST	$200	$160
Exam S	$400	$320
Exams 5, 6, 7, 8, and 9	$625	$500
Online Courses 1 & 2 Retest[†]	$315	$315
Exam ST9	$625	$625

Other Fees	
Refund (Exams LC, ST, S, 5-9, and ST9)	$100
Change of Exam Center	$60
Special Exam Center	$60
Online Courses 1/CA1 and 2/CA2: Contact The Institutes for fees that apply.	

[†]The first exam attempt is included in the $575 Online Course fee.

Exams 1 and 2 Fee Reimbursement Program in the U.S.

The CAS/SOA Committee on Diversity Recruiting sponsors a program to reimburse qualified minority candidates for Exam 1 (SOA Exam P) and Exam 2 (SOA Exam FM) fees. Eligible candidates are members of specified groups that are underrepresented in the actuarial profession in the United States, including African-Americans, Hispanics, and Native North Americans who are sitting for actuarial exams. The reimbursement application is available in the Diversity Programs section of the actuarial career website at www.BeAnActuary.org.

Fee Discount Program in Qualified Countries

The CAS sponsors a program to provide financial relief to candidates of qualified countries. Eligible candidates must be current full-time residents of a qualified country and verify that they are personally paying for exam fees and study materials without assistance from employers or other entities. Candidates must write their exams in a qualified country. Information, including a list of qualified countries and the application, is available on the Exams page of the CAS website.

Computer-Based Testing - Online Courses 1 and 2

The exams for Online Courses 1/CA1 and 2/CA2 are offered by computer-based testing (CBT). Because there are distinctive processes and procedures for CBT, additional information is available on The Institutes website. The rules and procedures provided on The Institutes website related to Online Courses 1/CA1 and 2/CA2 are part of the CAS examination rules.

Examination Centers

CAS examination centers are listed on the Exam Registration page of the CAS website. Centers are determined by the number of candidates near a center and the availability of proctors. Special examination centers may be arranged at the discretion of the CAS if the request is received by the registration deadline. The additional fee for a special center is $60. Candidates will be sent the exact location of their examination center at least three weeks before the examination.

Examinations by computer-based testing are administered at established test centers. The Prometric website (http://www.prometric.com/SOA/default.htm) contains a list of the CBT centers.

The CAS will not host exams in any country that has trade sanctions held against it per the U.S. Department of the Treasury.

Change of Center

For Exams LC, ST, S, and 5-9, any registered candidate who requests a change in examination center must pay a change-of-center fee. No requests will be accepted after the registration deadline. If a request for a change of center occurs, every effort will be made to have the candidate's records and supplies on hand at the appropriate center in time for the examination. If this effort fails, however, the CAS is not responsible. If either a candidate's registration and fees, or request for change of center are received so late that it is not feasible to arrange for the candidate to write the examination, the fees will be refunded in full. The CAS is not responsible for difficulties caused by postal service delays or inadequate postage.

Details for changing a CBT center for the exams for Online Courses 1/CA1 and 2/CA2 are available on The Institutes website (http://www.aicpcu.org/cas.htm).

Languages other than English

Exams LC, ST, S, and 5-9 and Online Courses 1 and 2

Exam questions and instructions will be printed, and exams administered, exclusively in English. Candidates must submit written responses in English; non-English responses will not be graded with the following exception: Should a candidate for an exam jointly sponsored by the Canadian Institute of Actuaries wish to respond to any or all of the constructed response (essay) questions in French, advanced notice must be provided to the CAS Office when applying to write the exam. Provided such advanced notice was received and a suitable translator is available from the Canadian Institute of Actuaries, responses submitted in French will be translated into English by qualified translators and graded exclusively in translation. All translations will be literal translations from French to English. If advanced notice has not been provided, non-English responses will not be graded. If a suitable translator cannot be engaged before the date of the exam, the candidate will be notified. The CAS cannot guarantee the accuracy of any translation. Appeals based upon errors in translation of candidates' responses will not be considered. Grade reports for exams requiring translation may be delayed.

Special Arrangements for Candidates with a Disability

A candidate with a formally diagnosed disability who needs special testing arrangements must submit a written request for each examination that the candidate intends to write. For Exams 1, 2, 3F, and 4, contact the sponsoring organization. For Exams LC, ST, S, and 5-9, contact the CAS Office. For the two online courses, contact The Institutes. Documentation of the disability, e.g., physician's statement, diagnostic test results, as well as the need for special arrangements, is required of each candidate. Previous accommodations given to the candidate in an educational program or work setting may be considered. Requests for special arrangements and supporting documentation must be submitted at the applicant's expense at least two weeks prior to the registration deadline for Exams LC, ST, S, and 5-9; and prior to the first day of the testing window for exams for Online Courses 1/CA1 and 2/CA2.

Refunds

Exams 1, 2, 3F, and 4

Contact the sponsoring organization.

Online Courses 1 and 2

The fee for Online Courses 1/CA1 and 2/CA2 includes one attempt at the exam by CBT. No refund for a course is provided once the candidate has accessed the online course. If the candidate decides not to access the online course after payment has been made, the candidate may submit a request for a refund. The request must be submitted to Customer Service at The Institutes.

Any candidate who registered for a course exam and subsequently decides not to take the exam may receive a refund for the exam portion of the course fee ($190) only by doing both of the following:

- Cancel the appointment prior to the third day preceding the exam at the test center as described the in the Canceling or Changing an Appointment section under Exam Rules on the Be An Actuary website (http://www.beanactuary.org/exams/rules/?fa=canceling-or-changing-an-appointment).

- Submit a refund request to Customer Service at The Institutes (CustomerService@TheInstitutes.org) that must arrive prior to the third day preceding the exam.

Exams LC, ST, S, and 5-9

Any candidate who submits an application for Exams LC, ST, S, or 5-9 and subsequently does not write the examination should submit a written request for an examination fee refund. This request must reach the CAS Office by the refund deadline stated in the Examination Schedule of this Syllabus. Refund requests may be sent via e-mail to refund@casact.org or by fax to (703) 276-3108. Late requests will not be considered. A $100 administrative fee per examination will be assessed on all refunds. Change-of-center fees, special center fees, and other additional fees will not be refunded in any case. Refunds will be issued one month after the refund deadline. Refunds are issued in the manner that fees were paid (i.e., by credit to a bank card or by check to an individual or company). Fees cannot be transferred from one exam session to another.

B. The Examination

Introduction

The examinations for admission to the Casualty Actuarial Society are designed to establish the qualifications of candidates. The Examination Committee creates exams that follow guidelines developed by the Syllabus Committee. Complete coverage of all readings listed in the Syllabus is not practical for every exam every year. The goal is to produce exams that contain representative, high-quality questions that test candidates' knowledge of topics that are presented in the learning objectives. Thus, the candidate should expect that each exam will cover a large proportion of the learning objectives and associated knowledge statements and syllabus readings, and that all of these will be tested at least once over the course of a few years.

The exam questions will be based on the published learning objectives and supporting knowledge statements. It is intended that the readings, in conjunction with the material on the lower numbered examinations, will provide sufficient resources to allow the candidate to perform the learning objectives. The exams will test not only candidates' knowledge of the subject matter, but also candidates' ability to apply that knowledge.

The Institutes create exams for the online courses that follow the learning objectives contained in the individual courses.

Order of Examinations and VEE Topics

In the development of the syllabus readings and exam questions, it is generally assumed that candidates for Associateship-level Exams S, 5, and 6 are familiar with material covered on Exams 1, 2, 3F, and 4; Fellowship-level Exams 7, 8, and 9 generally assume familiarity with material on the Associateship-level exams. There are, however, circumstances when another order might be more appropriate. For example, a candidate may wish to study an exam that is closely related to his or her current work.

VEE topics are not prerequisites to taking actuarial exams and may be fulfilled independently of the exam process (i.e., prior to or concurrent with taking actuarial exams). The following insights on VEE topics, however, may be helpful. VEE-Applied Statistical Methods will help strengthen candidates' statistical skills and completing it prior to taking Exams ST and 4 will make these exams easier to understand.[2] VEE-Economics and VEE-Corporate Finance will help strengthen candidates' understanding of managerial decision-making and completing these topics prior to taking Exam 9 will make this exam easier to understand.

To help candidates decide which exam to take, the following chart indicates which exams assume knowledge of material found on prior exams. Most candidates will find it easiest to study for an exam after studying for all of the exams listed in the "prior knowledge" column.

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[2] Candidates should review carefully the Transition Rules for Exam S as it relates to VEE-Applied Statistical Methods.

Exam or VEE Topic	Assumes Prior Knowledge from the Following Exam(s)
VEE-Applied Statistical Methods	None
VEE-Corporate Finance	None
VEE-Economics	None
Online Course 1/CA1	None
Online Course 2/CA2	None
Exam 1	None
Exam 2	None
Exam 3F	Exams 1 and 2
Exams LC and ST	Exam 1
Exam 4	Exam 1
Exam S	Exam 1
Exam 5	Exams 1 and 2
Exam 6	Exams 1 and 5 and Online Course 2
Exam 7	Exams 1, 2, 4, and 5
Exam 8	Exams 1, 2, 3F, 4, S, and 5
Exam 9	Exams 1, 2, 3F, 4, and 5

Notes on Order of Examinations

- Candidates may find it helpful to take Online Course 1 and Online Course 2 immediately after they begin their first property-casualty employment.

- Candidates should generally take the exams in order noted in the table above, except that a candidate with a background in finance may wish to take Exam 2 before Exam 1.

- Many candidates find it easier to study for the more mathematical exams (i.e., Exams 1, 2, 3F, LC, ST, 4, and S) when they are not too far removed from college math.

- The statistical material on Exam S is closely related to the material on Exam 4, and so candidates may wish to take these exams close together, but it is reasonable to take Exam S at any point after Exam 3F and before Exam 7.

- Exams 3F, 4, S (or the prior Exams LC and ST), and 8 make extensive use of Exam 1 material. Exams 5 and 9 assume an understanding of Exam 1 material.

- Some candidates may find it helpful to take Exam 4 closer to Exam S (or the prior Exams LC and ST) as the statistical concepts in those exams are related. Similarly, candidates may find it helpful to take Exams 2 and 3F close together.

- Exam 5 is approachable without detailed knowledge of the material on Exam 2. A candidate who has studied this material, however, may gain a deeper understanding of the material on Exam 5 and its foundations.

- Exam 4 covers the theory of credibility. Credibility theory is applied in Exam 5. Candidates who have mastered credibility theory in Exam 4 may find its application more intuitive on Exam 5. On the other hand, candidates who have experience applying credibility on Exam 5 may find the theory on Exam 4 easier to understand.

- Candidates may find their understanding of Exam 7, which has the advanced reserving techniques in the Estimation of Policy Liabilities section, and Exam 8, the Advanced Ratemaking exam, enhanced by material learned on Exam 5, Basic Techniques for Ratemaking and Estimating Claims Liabilities

Requirements for Admission to Examination Center

To be admitted into an examination center, each candidate must present a positive identification with a signature and a photograph (e.g., driver's license, passport, etc.). If a photo ID is not available, the candidate must present two forms of identification with a signature, with at least one form containing a physical description (height, weight, hair color, eye color, etc.). Each candidate will be required to sign in at the examination center. A candidate who does not present positive identification or who refuses or is unable to provide a matching signature will not be permitted to write the examination.

For examinations offered by computer-based testing, each candidate must present a valid government-issued photo identification that includes the candidate's signature (details are available on The Institutes website for exams for the two online courses).

Candidates should arrive at the examination center at least 30 minutes before the scheduled exam time. Candidates may not leave until two hours after the start of the examination. For Exams LC, ST, S, and 5-9, candidates may not leave during the last 15 minutes of the examination.

Conduct of Examinations

The examinations are recorded exclusively in writing (except for exams that are administered by computer-based testing). Except as is noted in the following paragraphs, no books, papers, typewriters, slide rules, laptops, or electronic or mechanical aids for computation of any kind may be brought into the examination room by candidates, nor may any candidate communicate with, or obtain any assistance from, any other candidate during the examination. Candidates must respond to constructed response (essay) questions in English unless advance notice is given (see Languages Other than English under Examination Rules—Registration). Examination answer sheets are not returned to candidates.

For Exams LC, ST, S, and 5-9, a candidate wishing to obtain his or her own examination booklet and scrap paper subsequent to the examination must bring a self-addressed stamped envelope to the examination center. The recommended minimum postage is $2.87 for domestic mail in the U.S. For Exams LC, ST, S, and 5-9, approximately one week after all exams have been completed, the exam will be posted on the Exams page of the CAS website.

Calculators

Electronic calculators will be allowed in the examination room for all examinations. Only the calculators listed below may be brought into the examination room. Books, papers, computers, or other electronic devices may not be brought into the examination room. Candidates may use the battery- or solar-powered models of the following Texas Instruments calculators:

BA-35	TI-30Xa
BA II Plus	TI-30X II (IIS solar or IIB battery)
BA II Plus Professional	TI-30XS MultiView (or XB battery)

Candidates may use more than one of the approved calculators during the examination. **For those using the BA II Plus, BA II Plus Professional, TI-30X II (IIS solar or IIB battery) or TI-30XS MultiView (or XB battery) models, candidates will be required to show examination proctors that the memory has been cleared prior to the start of the examination. For the BA II Plus and BA II Plus Professional, clearing will reset the calculator to the factory default settings.**

Calculator instructions cannot be brought into the examination room. During the examination, the calculator must be removed from its carrying case so the proctor can confirm it is an approved model. **Any unauthorized calculator brought to the examination center will be confiscated for the duration of the examination. Candidates using a calculator other than the approved models will be subject to examination disqualification and other disciplinary action.**

Candidates may purchase calculators from stores or directly from Texas Instruments: telephone: (800) 842-2737; website: www.ti.com.

It is the candidate's responsibility to see that the calculator used during the examination is in good working order.

Earplugs

Simple foam earplugs are allowed and must be checked in with the supervisor upon entrance to the exam. The ability to hear all verbal instructions, including exam start and stop times is the responsibility of the candidates, regardless of the use of earplugs.

Examination Discipline

Candidates must not give or receive assistance of any kind during the examination. Any cheating, attempt to cheat, assisting others to cheat, participating therein, or engaging in such improper conduct as listed below is a serious violation and will result in the CAS disqualifying the candidate's paper and other disciplinary action as may be deemed appropriate. Candidates have agreed in their applications for examination to be bound by the rules and regulations governing the examinations.

Examples of improper conduct include but are not limited to:

1. Gaining access to examination questions before the examination or aiding someone else to do so.

2. Using an unauthorized calculator (as defined in the Syllabus) or other mechanical aid that is not permitted.

3. Looking in the examination book before the instruction to begin is given.

4. Marking or otherwise writing on the examination book or answer sheet before the instruction to begin is given.

5. Making any changes, additions, deletions, or otherwise marking, erasing, or writing on the examination book or answer sheet after the time for the examination has expired.

6. Having access to or consulting notes or books during the examination.

7. Looking at or copying from another candidate's paper.

8. Enabling another candidate to copy from one's paper.

9. Talking or otherwise communicating with another candidate during the examination.

10. Disturbing other candidates during the examination.

11. Consulting other persons outside the examination room during the examination.

12. Copying questions, answers, or answer choices to take from the examination room.

13. Taking an examination book from the examination room.

14. Taking an examination for another candidate.

15. Arranging to have another person take an examination for the candidate.

16. Threatening or physically or verbally abusing a supervisor or proctor responsible for curbing or reporting improper conduct.

17. Disclosing the contents of an examination to any other person prior to the examination's release. (For CAS Exams LC, ST, S, and 5-9, this would generally apply to the day when the examination is administered.)

18. Presenting false information on an examination application.

19. Failing to remain in the examination room for a minimum of two hours during the examination [for examinations with this requirement].

20. Failing to follow other examination instructions.

21. Accessing or using a communication device (PDA, cell phone, etc.) during the exam or while at the exam site.

The CAS Examination Committee, or its designee, will investigate any irregularity or suspected violation of the rules involving the examination process, and a determination will be made regarding the matter. Where there is a determination to invoke a penalty, the candidate is advised by letter. In the case of a candidate who is a member of the CAS, the candidate's conduct will be reported to the Actuarial Board for Counseling and Discipline (ABCD) or to the Canadian Institute of Actuaries (CIA) if the final penalty invoked is more than disqualification of the examination.

Candidates for the CAS Examinations are expected to follow the rules and procedures included in this Syllabus, the Instructions to Candidates printed on their examination booklets, and announcements made by the supervisors at the examination locations. All candidates, on their applications for examinations, are required to read and sign the following statement: "I have read the rules and regulations concerning the examination(s) for which I am applying and agree to be bound by them. I also agree that the results of any examination(s) which I take, and any action taken as a result of my conduct may, at the sole discretion of the Casualty Actuarial Society, be disclosed to any other bona fide actuarial organization that has a legitimate interest in such results and/or actions."

The CAS may, at its sole discretion, disclose to any other bona fide actuarial organization having a legitimate interest, information on the identity of candidates determined to have committed a serious examination violation (those for which the penalty is greater than the simple disqualification/nullification of the examination), and the specific penalties imposed on those candidates.

If an actuarial organization with which the CAS has a working relationship (such as the Society of Actuaries) invokes a penalty against a candidate for improper conduct during an examination for which the CAS is not a joint sponsor, the CAS will invoke the same penalty for all CAS-sponsored examinations. If the CAS takes any disciplinary action, it will notify the other actuarial organizations of that action.

These standards may seem stricter than those which candidates are accustomed to in other examination environments. The CAS maintains these strict standards because the examinations are such a significant part of a candidate's career. Therefore, the equitable administration of the examinations and enforcement of the highest standards of conduct cannot be emphasized too strongly.

Candidates may obtain a copy of the full CAS Policy on Examination Discipline by sending a written request to the CAS Office.

Discipline for Computer-Based Testing

The Policy on Examination Discipline is the same for those taking exams by computer-based testing or in the traditional paper-and-pencil format. The rules for the CBT administration for Online Courses 1/CA1 and 2/CA2 are available on The Institutes website (http://www.aicpcu.org/). If there is a discrepancy between specific rules for the traditional paper-and-pencil exam administration and computer-based testing, the computer-based testing rules will govern.

Multiple-Choice Questions

Exams LC, ST, and S consist entirely of multiple-choice questions; other CAS examinations may have a section of multiple-choice questions. Each multiple-choice problem includes five answer choices identified by the letters A, B, C, D, and E, only one of which is correct. For examinations administered by computer-based testing, candidates should click on the appropriate answer. For all other exams, a separate answer sheet provides a row of five ovals for each problem, identified with the letters A, B, C, D, and E, corresponding to the five answer choices. After deciding which answer is correct, candidates should blacken the oval that has the same letter as the appropriate answer. Since the answer sheets are scored by optical scanning equipment, a Number 2 pencil must be used to blacken the ovals. It is important that only one oval be blackened for each question.

Exams for the two online courses will consist entirely of multiple-choice questions. Each multiple-choice problem includes four answer choices identified by the letters A, B, C, and D, only one of which is correct. For exams administered by computer-based testing, candidates should click on the appropriate answer. For all other exams, a separate answer sheet provides a row of four ovals for each problem, identified with the letters A, B, C, and D, corresponding to the four answer choices. After deciding which answer is correct, candidates should blacken the oval that has the same letter as the appropriate answer. Since the answer sheets are scored by optical scanning equipment, a Number 2 pencil must be used to blacken the ovals. It is important that only one oval be blackened for each question.

Guessing Adjustment

For the exams for Online Courses 1/CA1 and 2/CA2, no guessing adjustment are made to candidates' scores. Therefore, candidates will maximize their scores on these examinations by answering every question. On Exams LC, ST, S, and 5-9, multiple-choice questions are scored in such a way that there is no advantage or disadvantage to be anticipated from

guessing answers in a purely random fashion as compared with omitting the answers entirely. No additional points will be given for multiple-choice questions left blank, but one-quarter of the point value for each question will be deducted for each incorrect answer.

Constructed Response Test Items

The admissions process is intended to identify candidates that have demonstrated sufficient mastery of the learning objectives to be admitted as members of the CAS. Examinations that provide a means for better-prepared candidates to demonstrate that mastery are critical to meeting that objective.

Educators often refer to a tool called Bloom's Taxonomy to classify questions into six cognitive levels. Bloom's levels range from Level 1, broadly characterized as knowledge, to Level 6, characterized as evaluation. Lower levels of the taxonomy stress recall of facts and an understanding of main ideas; higher levels within the taxonomy stress synthesis, comparison, and subtlety of understanding.

Bloom's levels are as follows:

Level 1: Knowledge—tests the ability of the candidate to recall or remember knowledge or facts

Level 2: Comprehension—requires the candidate to demonstrate comprehension of central concepts through explanation of those concepts

Level 3: Application—measures the candidate's ability to apply ideas and concepts to new situations

Level 4: Analysis—requires the candidate to analyze information by separating material into component parts, including identification of facts and development of inferences with respect to a situation

Level 5: Synthesis—tests the ability of a candidate to synthesize, or combine, concepts or ideas and develop and defend the position resulting from that combination

Level 6: Evaluation—requires the candidate to support conclusions by evaluating the validity of ideas and concepts

The test specifications for each upper-level examination include the long-term target range of points for each Bloom's cognitive level. A thorough review of the learning objectives in the Bloom's context described above will help the candidate to assess the level of mastery that the CAS expects successful candidates to demonstrate.

Generally, questions at higher Bloom's levels will have higher associated point values. As a result, examinations with higher synthesis and evaluation targets will contain fewer questions that may result in less syllabus coverage on a particular exam.

Lost Examinations

The CAS—or its designee—is not responsible for lost or destroyed examinations. In the case where an examination is lost or destroyed, the examination fee will be refunded. The CAS and its designees will assume no other obligation and candidates must take the examinations with this knowledge. For Online Courses 1/CA1 and 2/CA2 that are administered by The Institutes, the policy of The Institutes will apply.

C. Grades and Accreditation

Defective Questions

Occasionally, through error or because of varying interpretations, a question on an examination is found to be ambiguous or defective. If a candidate believes a question is ambiguous or defective, he or she should bring this to the attention of the Examination Committee in writing within two weeks after the examination date. The candidate must submit this correspondence to The Institutes for the two online courses; or to the CAS Office for Exams LC, ST, S, and 5-9. The correspondence should include detailed reasons why the question is believed to be ambiguous or defective. In addition, statistics are calculated on each test item to determine how well the candidates answered the question. The statistics can indicate that a question may be faulty and the question will be reviewed even without a candidate writing.

The CAS Examination Committee and/or The Institutes, as appropriate, will investigate all questions brought to their attention in this manner. Correspondence that does not reach these organizations within two weeks after the date of the examination will not be considered in the grading process.

Any multiple-choice question found to be defective is carefully examined to determine the most reasonable way to correct the situation. In some cases, the question is discarded, leaving scores and rankings as they would have been if the defective question had not been asked. In other cases, more than one answer for a multiple-choice question is given credit for being correct.

For Exams 1, 2, 3F, and 4, the candidate should follow the procedural rules of the sponsoring organizations.

CAS Examination Processing

Computer-based tests are administered and scored according to computer-based testing methodologies. Although the multiple-choice exams that are administered exclusively by paper-and-pencil have a process that is similar to the description below, this section and the next, Grading of Examinations: A Timeline, provide details about CAS-specific Exams 5-9.

Examination papers are sent to the CAS Office upon completion of the examination. The CAS Office prepares the examinations for the grading process. Approximately one week after all examinations have been completed, the examination and a preliminary list of multiple-choice answers will be posted on the Exams page of the CAS website. This is intended to assist candidates and the Examination Committee in determining whether they believe a question is ambiguous or defective.

Grading of Examinations: A Timeline

Week 1
After the examinations are administered, proctors return the exam packages to the CAS Office. Staff members log in each exam. Signatures are verified and the candidate numbers are checked against the proctor's report. As each envelope is opened, the candidate's number must be checked against the number on the short answer card (both the written number and the coded number) and on all the essay sheets. The short answer cards are prepared for scanning and the essay sheets for all the candidates must be sorted so that individual questions can be copied for the graders.

Week 2
Constructed response (essay) question responses are sent to a vendor to be reproduced. Short answer cards are scanned twice and output is compared to ensure accuracy. Random checks are made of each series of cards to ensure that the scanner is working properly. When the essay sheet copies are received, copies of candidate responses are sent

to the individual graders. Any comments on potentially ambiguous or defective questions are forwarded to the graders, exam part chair, and the general officer of the exam series for review.

Weeks 3 and 4

Committee members review candidate comments about possibly defective questions and decide how they will be handled in the grading process. Discussions on the best course of action are often a very time-consuming part of the grading process.

Copies of responses to each constructed response question on the exam are sent to two graders. Some graders are given more than one question to grade. There can be 500 to more than 1,000 answer sheets for each grader to evaluate for a single question. A suggested answer key exists for each question, but alternative solutions may be correct, and the graders must be open to different approaches to a problem. About two-dozen responses are graded and then the results are compared. The grading partners will establish a consistent grading scale and then evaluate the solution key. Consistency and accuracy are the most important factors in grading the responses. After looking at hundreds of papers, it is possible that a grader could slightly shift focus (either harder or easier). To minimize the chance of this happening the graders will begin grading at different points on the candidate list, then when the two grades are compared any significant differences will be checked. Each grader prepares a computer file with each candidate's number and the score for each question.

Week 5

The part chair holds the grading session with the graders. The first step is running the data through a standard grading program, verifying the data, and noting any significant discrepancies. For each candidate and each question the scores of each grading partner must be within a prescribed tolerance. If the scores do not fall within this tolerance, the partners must discuss the candidate's answer sheet and come to a decision on what the point value should be. When all the questions have been reconciled to the required tolerance, the scores are totaled and a tentative pass score is selected based on the pass mark panel's recommendation, various statistics, and guidelines.

This triggers the second round of reconciliation. Candidates who have scores within a certain number of points from the tentative pass score will have all of their answers reconciled completely. This gives an exact score for any candidate near the passing score. The scores for any candidates who are close to passing will be checked manually as well. The committee members will then look at the statistics one more time and make a final recommendation for the passing score.

Weeks 6 and 7

After the grading session, the part chair will create and submit a report to the general officer of the exam series, the Examination Committee chairperson, and the vice president–admissions. In the report, the part chair recommends a passing score, gives a detailed analysis of the exam, and notes any unusual questions or situations that required special handling. The chairperson and general officer hold a teleconference with the vice president–admissions and a representative from the Canadian Institute of Actuaries to discuss all of the exams from the series and to finalize the passing scores.

Week 8

After the vice president–admissions has approved the passing score the data is verified and released to the CAS Office to update each candidate's record. A link to the web page with passing candidate numbers, which will reside at a randomly generated web address, will be sent via e-mail to the candidates who sat for the exam for which results are available Lastly, grade reports will be sent to candidates.

Determination of the Pass Mark

The goal of the examination system of the CAS is to pass all candidates who have demonstrated adequate knowledge of the syllabus and to fail those candidates who have not. The objective of the examinations is to evaluate candidate performance using criteria for demonstrating adequate knowledge that remain constant throughout the lifetime of the exam series. Pre-set pass marks (e.g., a candidate will pass if he or she answers x percent of the questions correctly) are counter to this philosophy. The examinations are meant to measure the candidate's level of achievement of the required learning objectives and their required level of capability of accomplishing specified learning outcomes.

Multiple-Choice Test Items

As part of the input to the pass mark determination process for the multiple-choice exams that are not offered by computer-based testing, a modified Angoff passing score study is performed where a panel of experts in the subject material is convened to review the examination. This is a common testing and measurement technique. Each expert is asked to review each question in the examination, and assess the difficulty of that question. More specifically, they are asked to estimate the likelihood that a candidate with minimum adequate knowledge competency would answer the question correctly. The sum of these probabilities, averaged across the panel of experts, gives a preliminary estimate of the pass mark.

The estimated pass mark resulting from the modified Angoff passing score study is compared to and balanced with the actual performance statistics on the exam in finalizing the pass mark. The effects of any particularly difficult questions are also factored into the determination of the final pass mark.

Computer-based tests are administered and scored according to computer-based testing methodologies.

Constructed Response Test Items

For CAS examinations consisting in whole or in part of constructed response items (written-answer or essay test items), the assessment process is somewhat different. Before the exam is administered, a pass mark panel reviews the exam and assesses it based on how the panelists think a minimally qualified candidate will perform based on a predetermined definition of the minimally qualified candidate. This process follows the same basic technique used for multiple-choice exams as described above. Based on this assessment, an expected pass mark is set.

Following the administration of each exam, responses to each constructed response item are graded simultaneously by two graders who must reconcile their grading rubrics and grades. When all responses have been scored, the part committee chooses a preliminary pass mark based on the results of the pass mark panel augmented by actual performance of the current candidates versus historical performance of previous candidate cohorts. Candidate papers with scores close to the preliminary pass mark are re-graded to ensure correct and consistent scoring.

The part committee then determines the tentative pass mark by again balancing actual performance statistics against minimum adequate knowledge while taking into account other factors such as time pressure situations that may have occurred on some questions. Because the level of difficulty for each examination may vary from year to year, each part committee collects extensive data to ascertain the level of difficulty of its examination. The part committee compares the performance of the present year's candidates to the performance of candidates from prior years. Appropriate recognition is given to any peculiarities that may appear in connection with the answers to any question on an examination despite all the care taken in setting the examination questions.

With the use of content-based pass marks, fluctuation in the pass rate from session to session is expected. Although the percentage of candidates passing will vary from year to year, those candidates demonstrating the required level of

competence with the material will pass.

Final Pass Mark

A recommended pass mark is reached by consultation among the part chairperson, the general officer overseeing that examination, and the Examination Committee chairperson. Any significant deviations from the a priori pass mark set by the pass mark panel are explored at this time. The recommended pass mark and explanations for deviations from the a priori pass mark and any abnormal passing percentages are submitted to the vice president–admissions who approves the final pass mark. The final exam statistics are forwarded to the Executive Council and Board of Directors.

After the pass mark is finalized, each candidate is assigned a score. Scores of 0 to 5 are assigned to candidates who do not pass. On this scale, each interval is 10 percent of the pass mark. For example, a grade of 5 equates to a candidate's score of at least 90 percent, but less than 100 percent, of the pass mark. A grade of 0 means that the candidate's score is less than 50 percent of the pass mark. Candidates at or above the passing mark receive a grade of Pass.

The CAS releases the pass scores for Exams LC, ST, S, and 5-9 after the appeals deadline for the specific exam session. They are available from the Past Exams and Pass Marks page of the CAS website (http://www.casact.org/admissions/studytools/index.cfm?parentID=163&fa=PastExams). The purpose of releasing the pass scores is to help candidates prepare for future exam sittings. The 75th and 95th percentile scores are also released for each exam. These two key statistics indicate the performance level achieved by the better-prepared candidates on the exam. Raw scores are not provided to candidates.

Examination Results

Examination results are available approximately eight weeks after the examination date. After exam results are received at the CAS Office, a list of passing candidate ID numbers will be e-mailed to candidates. Individual statements of examination results generally are sent to candidates on the day that they become available.

For Exams LC, ST, S, and 5-9, passing candidates are informed that they passed the exam, but they are not given a numeric score. Candidates with scores of 0 to 5 are informed of the score. Within a few days, a list of the names of all passing candidates is posted on the CAS website. Requests for reprints of individual grade reports will be accepted starting two weeks after the date that results were released.

To preserve candidate confidentiality, in the event of a lost or misplaced candidate ID number, the candidate ID number will be mailed to the candidate upon request. Under no circumstance will a candidate number be given over the telephone or by e-mail. Candidates can also verify their candidate number by logging into their profile on the CAS webpage.

Online Courses 1 and 2

The exams for Online Courses 1 and 2 are offered by computer-based testing. An unofficial pass/fail result will be displayed on the computer screen at the conclusion of the exam. When the official grades have been processed, candidates will receive an e-mail from The Institutes stating that their grades are available. Candidates may then log into their account on The Institutes website (www.TheInstitutes.org) to access their grades. The grade report for each candidate will show the candidate's overall score on the exam in ten point increments (e.g., 60 to 69%, 70 to 79%, and so on). It will similarly show the candidate's performance by assignment using those same ten point increments. Numeric scores are not released. Once final grades have been released, The Institutes will send a copy of the grades directly to the CAS Office to be added to the candidates' admissions records. **The Institutes sends this information to the CAS several weeks following the closing of the testing window. The CAS will post the list of passing names**

approximately two weeks later.

Analyses for Exams LC, ST, S, and 5-9

Candidates for Exams LC, ST, S, and 5-9 who did not pass will automatically be sent an analysis of their examination with the grade notification. The analysis of an examination is computer-generated. Actual points received for multiple-choice questions will be displayed. For constructed response test items, ranges will be given for the actual score. This information is intended to provide the educational guidance that most candidates desire. Copies of the exam analyses will not be provided after the appeals deadline.

Appeals for Exams LC, ST, S, and 5-9

Multiple-Choice Questions

If a candidate believes that a multiple-choice question is ambiguous or defective, he or she should bring this to the attention of the Examination Committee in writing within two weeks after the examination date. In order to aid the candidate, preliminary answer keys for multiple-choice questions will be available the week following the examinations. The candidate may submit comments to the CAS Office by mail, fax, or e-mail. The correspondence should include detailed reasons why the question is believed to be ambiguous or defective. (In addition to candidate comments, statistics are calculated on each problem to see how well the candidates answered the question. The statistics can indicate that a question may be faulty and the question will be reviewed even without a candidate writing.) The CAS Examination Committee will investigate all questions brought to its attention in writing. To be considered in the grading process, correspondence must reach the CAS Office **within two weeks of the date that the exam was administered**. The decision of the Examination Committee chairperson is final.

No appeals based on ambiguous or defective questions will be considered after these deadlines. After grades are released, the only appeal permitted on multiple-choice questions will be to request an administrative check of the candidate's short answer card to verify that the card reader scanned the card correctly and that the output file reflected this data. This request must be made within three weeks after the release of grades.

Constructed Response Test Items

Once candidates have received the analyses of their exams, they may appeal their grade. Only candidates with valid appeals will be considered.

Appeals must reach the CAS Office not later than 30 days for Exams 7-9, and 2 weeks for Exams 5, 6-Canada, and 6-United States, from the publication of the Examiner's Report for the specific exam. The Examiner's Report is generally published 12 weeks after the exams are administered. (Should an Examiner's Report for a given exam be posted later than this, the appeal deadline for that specific exam will be extended to 30 days after the posting date of that report.)

If the candidate believes that the sample constructed response answer is incorrect or there is an alternative correct solution, the candidate must provide specific information on why his or her solution is correct. With specific information, the Examination Committee can research the answer properly and reply to the candidate. An example of an invalid appeal would be the following: "I am appealing my score of 5 on Exam 9, please recheck my examination." Another example of an invalid appeal would be: "On question number 2, I believe I should get full credit because I answered the following . . ."

When a valid appeal is received, the part chairperson reviews the appeal and makes a recommendation to the Examination Committee chairperson. The Examination Committee chairperson will respond based on the

recommendation of the part chairperson. The decision of the Examination Committee chairperson is final.

Confidentiality of Examination Records

The fact that a candidate has passed a particular examination is considered public knowledge. Any further information as to examinations taken by candidates and scores received by candidates is available only to the candidates themselves, to Examination Committee officials if required for committee purposes, and to the CAS Office, unless the candidate requests in writing that such information be provided to someone else. However, if any action is taken against a candidate as a result of his or her conduct (as described in the section on Examination Discipline), the Casualty Actuarial Society, at its sole discretion, may disclose such information to any other bona fide actuarial organization that has a legitimate interest in such results and/or actions. The candidate authorizes and consents to the Society using and disclosing (including, but not limited to, disclosing to the third-party contractors and service-providers of the Society) personally identifiable information about the candidate as necessary and appropriate for the purposes of registering the candidate for the exam, conducting the exam, determining the results of the exam, and communicating with the candidate regarding the results of the exam.

Transition Programs

The CAS generally reviews and makes revisions to the study material on an annual basis. Occasionally, a major topic will be added to or deleted from the syllabus. A major topic is defined as a series of learning objectives comprising a segment of an examination. When a major topic is added, the Syllabus Committee will determine if a transition program is appropriate. A transition program is generally appropriate when candidates are in a position to lose credit for a segment of an examination.

A transition program usually will provide candidates with at least two opportunities to complete the requirements for that examination. The completion of the requirements will result in the achievement of credit for that entire examination. The failure to fulfill the requirements for that complete examination could result in the expiration of credit for that deleted topic at the end of the transition period. The CAS Board of Directors must approve any transition program.

Current Education Structure

The CAS Board of Directors approved the following transition rules for the **Fall 2015 education structure.**

To receive credit for the new Exam S on Statistics and Probabilistic Models during the transition, the candidate must have credit for Exams ST and LC[†] and the VEE-Applied Statistical Methods educational requirement. At the time of transition, if a candidate has credit for either Exam ST or Exam LC, but not both, the candidate will be allowed to take just the exam for which he or she is missing credit in order to obtain partial credit for the new exam. This option will be available for a transition period of two sittings, i.e., Fall 2015 and Spring 2016.

Credit for the VEE-Applied Statistical Methods educational requirement will also be accepted for those candidates who complete it by August 31, 2016. If the candidate has not completed Exam ST, Exam LC, and the VEE-Applied Statistical Methods educational requirement by this date, the candidate will need to pass the full version of Exam S to receive credit.

Candidates with credit for neither Exam ST nor Exam LC on August 31, 2015 will not be permitted to sit for Exam ST or Exam LC during the transition period and will need to pass the full version of Exam S to receive credit.

The following table summarizes the above:

Candidate Credit on August 31, 2015			Action Required by August 31, 2016 to Earn Credit for new Exam S
Exam ST	Exam LC	VEE-Applied Statistical Methods	
✓	✓	✓	Credit granted. No candidate action required.
✓	✓		Complete VEE-Applied Statistical Methods.
✓		✓	Pass Exam LC.
✓			Pass Exam LC and complete VEE-Applied Statistical Methods.
	✓	✓	Pass Exam ST.
	✓		Pass Exam ST and complete VEE-Applied Statistical Methods.
		✓	Candidate must take full version of Exam S.
			Candidate must take full version of Exam S.

†The CAS has also granted waivers for Exam LC to candidates who have:

- Passed SOA Exam MLC;

- Passed the Institute and Faculty of Actuaries (U.K.), Actuaries Institute (Australia), or Institute of Actuaries of India Subject CT5; or

- Passed the Actuarial Society of South Africa Course A203; or

- Received a waiver granted by the Canadian Institute of Actuaries University Accreditation Program.

For those candidates who have credit for Exam ST by August 31, 2015, the CAS will continue to grant Exam LC waivers through August 31, 2016.

Older Transition Rules Applicable to the Current Education Structure

1. The CAS Board of Directors approved the following transition rules for the education structure that was implemented in January 2014:

Credit in 2013*	Credit in Education Structure Implemented in 2014
Exam 3L	Exams LC and ST
SOA Exam MLC	Exams LC and ST

    *Note: Credit for Exam 3L or SOA Exam MLC must have been achieved through an examination administered prior to January 2014.

    In addition, the CAS Board of Directors approved the following waiver that will continue beyond January 2014:

Credit	Credit in Current CAS Education Structure
SOA Exam MLC	Exam LC

2. The CAS Board of Directors approved the following transition rules for the education structure that was implemented in January 2011:

Credit in 2010	Credit in Education Structure Implemented in 2011
Exam 5	Half of Exam 5 (section on Basic Techniques for Ratemaking)* and Online Course 1
Exam 6	Half of Exam 5 (section on Estimating Claim Liabilities)* and Exam 7 on Estimation of Policy Liabilities, Insurance Company Valuation, and Enterprise Risk Management
Exam 7	Nation-specific Exam 6 on Regulation and Financial Reporting and Online Course 2
Exam 8	Exam 9 on Financial Risk and Rate of Return
Exam 9	Exam 8 on Advanced Ratemaking

    *Note: To receive credit for the new Exam 5 on Basic Techniques for Ratemaking and Estimating Claim Liabilities, the candidate must have credit for both old Exams 5 and 6. At the time of transition, if a candidate has credit for only one of the required exams (either old Exam 5 or Exam 6), the candidate will be allowed to take just the part of the exam for which he or she is missing credit (i.e., either the Basic Techniques for Ratemaking section or the Estimating Claim Liabilities section of the new exam) in order to obtain credit for the new exam. This option will be available for a transition period of two sittings after the official conversion to the new education structure (i.e., May 2011 and May 2012). If the candidate does not have credit for both halves of Exam 5 at the end of the transition period, the candidate would have to pass the full version of Exam 5 to receive credit.

3. The CAS Board of Directors approved the following transition rule for the revision to Exam 3 that was implemented in January 2008:

Credit in 2007	Credit in Education Structure Implemented in 2008
Exam 3	Exams 3F and 3L

4. The CAS Board of Directors approved the following transition rules for the revised education structure that was implemented in January 2005:

Credit in 2004	Credit in Education Structure Implemented in 2005
Exam 1	Exam 1
Exam 2	Exam 2, VEE-Economics, VEE-Corporate Finance
Exam 3	Exam 3 [Exams 3F and 3L]
Exam 4	Exam 4, VEE-Applied Statistical Methods

5. The following rules apply for candidates with unused credit from exams administered prior to 2000:

Pre-2000 Credit	Credit in Education Structure Implemented in 2014
Exam 2 (Probability & Statistics) and Exam 4B (Credibility Theory and Loss Distributions)	Exam ST

Pre-2000 Credit	Credit in Education Structure Implemented in 2011
Exam 3B	Online Course 1

Pre-2000 Credit	Credit in Education Structure Implemented in 2005
Exam 3A	VEE-Applied Statistical Methods
Exam 4A	Exam 2
Exam 4B	Exam 4
Exam 5A	VEE-Economics
Exam 5B	VEE-Corporate Finance

CAS Course on Professionalism

The CAS Course on Professionalism is designed to present candidates with real situations that contain ethical and professional issues for the actuary. Volunteer members of the CAS facilitate small group discussions of actual case studies. Although grades are not given for the course, candidates must actively participate in order to receive credit. Successful completion of this course is required before a candidate can become a member of the Casualty Actuarial Society.

Candidates are urged to register for this course as soon as they are eligible. To be eligible for the CAS Course on Professionalism, in the current education structure, a candidate must:

- Have credit for any five actuarial exams in the current education structure—regardless of online courses or VEE status.

  OR

- Have credit for any four actuarial exams and credit for any four of the following five requirements: Online Course 1/CA1, Online Course 2/CA2, VEE-Applied Statistical Methods, VEE-Corporate Finance, or VEE-Economics.

Note: For this eligibility prerequisite, the actuarial exams are: Exams 1, 2, 3F AND S (or prior Exams LC and ST together), 4, 5, and 6. While VEE-Applied Statistical Methods is no longer part of the current education requirements, it will still be considered for eligibility to take the CAS Course on Professionalism.

Dates for the course will be posted in the CAS Course on Professionalism page of the CAS website (http://www.casact.org/education/index.cfm?fa=prof). This page also has a link to the course readings that must be completed prior to attending the course. Each course is limited to 60 participants; early registration is recommended. Facility information and course times are provided when registration for specific courses is announced.

CAS Membership Requirements

Associateship

Candidates for Associateship in the Casualty Actuarial Society must fulfill the examination requirements by successful completion of, or credit for, Exams 1, 2, 3F, 4, S, 5, and 6; have credit for Online Courses 1/CA1 and 2/CA2; have credit by Validation by Educational Experience (VEE) for the required topics of corporate finance and economics; and successful completion of, or credit for, the CAS Course on Professionalism. Exam 6 is nation specific and passage of any one of the CAS-approved nation-specific exams fulfills the Associateship requirements.

After completing all the prescribed requirements, all prospective Associate members must submit a formal application to the Casualty Actuarial Society. The application form and list of application requirements are available on the CAS website in the Join/Renew section. Obtaining the two letters of reference is the prospective member's responsibility. If no member of the CAS is familiar with the prospective Associate and his or her work history, references from members of the American Academy of Actuaries, the Canadian Institute of Actuaries, the Society of Actuaries, other actuarial organizations that are part of the International Actuarial Association, or senior executives where the candidate is employed may be substituted. For further information on alternative acceptable references, please contact the CAS Office. An application for membership will not be processed without these references.

Candidates must have completed all educational requirements prior to submitting an application for CAS membership.

After all requirements are met and a completed application has been submitted to the CAS, each candidate is voted on by the CAS Executive Council. Upon approval of the CAS Executive Council, the candidate will be admitted as an Associate of the Casualty Actuarial Society (ACAS). Candidates approved by the Executive Council will be notified by

letter from the CAS president. Members may indicate their designation as an Associate of the Casualty Actuarial Society by using the initials "A.C.A.S." after their names only after they have received official notification of acceptance as an Associate from the CAS.

Fellowship

In addition to fulfilling all the requirements of Associateship, successful completion of, or credit for, all Fellowship examinations is required to fulfill the requirements for Fellowship and to be designated as a Fellow of the Casualty Actuarial Society (FCAS). Candidates who are admitted to the CAS as Fellows rather than Associates may indicate their designation as a Fellow of the Casualty Actuarial Society by using the initials "F.C.A.S." after their names only after they have received official notification of acceptance as a Fellow from the CAS. Associates who complete their Fellowship requirements may use the "F.C.A.S." designation immediately following official notification of successful completion of all the Fellowship requirements as prescribed by the Board of Directors.

CERA Requirements

Candidates for the CERA (Certified Enterprise Risk Analyst) designation must fulfill the educational requirements by successful completion of all CAS Associateship requirements, CAS Exams 7 and 9, the Enterprise Risk Management and Modeling Seminar (specifically designed for the CERA designation), and Exam ST9 of the Institute and Faculty of Actuaries (U.K.).

After completing all the prescribed requirements, all prospective CERA designees must submit a formal application to the Casualty Actuarial Society. The application form will be available in the CERA section of the CAS website (http://www.casact.org/cera/). Candidates must have completed all educational requirements prior to submitting an application for the CERA designation.

After all requirements are met and a completed application has been submitted to the CAS, each candidate is voted on by the CAS Executive Council and then submitted to the international Treaty Board for the CERA Global Credential for approval. Upon approval, the candidate will be granted the CERA designation. CERA designees may indicate their designation by using the initials "CERA" after their names only after they have received official notification from the CAS.

Waiver of Examinations

Actuarial Examinations

The CAS's **Basic Education Waiver Policy** addresses the extent to which the CAS will grant waivers of its basic education requirements including Exams 1, 2, 3F, LC, ST, and 4; Online Courses 1 and 2; Course on Professionalism; and Validation by Educational Experience requirements, or their equivalents as defined by the Executive Council.

The Board of Directors agrees that an exam waiver should be considered for verified educational accomplishments, e.g., exams or university courses, required by another actuarial organization that substantially meet the learning objectives of a particular CAS exam with reasonably equivalent rigor and level of mastery of the material. The Board agrees that the alternative should not be required to cover every learning objective that is covered in the CAS syllabus for the particular exam in order to consider a waiver and that other learning objectives covered by the alternative may be considered as substitutes.

In addition to actuarial exam requirements, the CAS may grant waivers for other basic education requirements provided that the educational experience is deemed equivalent in subject matter coverage and depth. For example, the CAS may accept a professionalism course offered by another actuarial organization provided that it is deemed equivalent to the CAS Course on Professionalism or the Executive Council provides a supplement to address any significant CAS requirement that may be lacking. Other examples where CAS requirements may be waived include Online Courses or Validation by Educational Experience requirements. In general, the CAS will not grant waivers for its upper-level exams.

The CAS will not grant waiver of all or any portion of its examination requirements for work experience or contribution to actuarial literature.

Under this Policy, the granting of waivers by the Executive Council will be based on the recommendation of the vice president-admissions. The vice president-admissions' recommendation will be guided by policy discussions and recommendations of the CAS Education Policy Committee.

Canadian Institute of Actuaries

The CAS recognizes the exam waivers granted by the Canadian Institute of Actuaries University Accreditation Program for Exams 2, 3F, LC, and 4. The CAS will only grant waivers for CIA UAP exam credits that were awarded based on work at universities in Canada

Institute and Faculty of Actuaries (U.K.), Actuaries Institute (Australia), Actuarial Society of South Africa (ASSA), and Institute of Actuaries of India Examinations

The CAS recognizes some of the examinations sponsored by the Institute and Faculty of Actuaries (United Kingdom), Actuaries Institute (Australia), Actuarial Society of South Africa (ASSA), and the Institute of Actuaries of India. Credit will be granted for examinations passed or waived in accordance with examination equivalencies between the CAS Syllabus and the syllabi of each of the aforementioned actuarial organizations.

The CAS will not grant credit for examinations waived on account of academic records achieved in U.S. universities, nor for credit granted to candidates not qualifying directly in obtaining membership through the normal qualification/examination process.

Credit will not be given to Fellows of these actuarial organizations who have attained their designation through mutual recognition rather than through the organization's standard credentialing process. Fellows by mutual recognition

should pursue examination waivers based on their original credentials.

The CAS has approved the following waiver policy:

Subject of the Institute and Faculty of Actuaries (U.K.), Actuaries Institute (Australia), and Institute of Actuaries of India	Actuarial Society of South Africa	Waiver Granted for CAS Exam/Educational Experience
CT1	A201	Exam 2
CT2	A103	VEE-Corporate Finance
CT3	A101	Exam 1
CT4 and CT6	A202 and A204	Exams ST & 4 and VEE-Applied Statistical Methods
CT5	A203	Exam LC
CT7	A102	VEE-Economics
CT8	A205	Exam 3F

Society of Actuaries

The CAS recognized the SOA exams listed in the chart below. Candidates who check the "Property and Casualty" field on their preliminary exam application will have the results of their exams automatically updated in the CAS candidate database. Candidates who did not check the Property and Casualty field can have their exam results verified and updated in the CAS candidate database by completing the online form.

The CAS recognizes the following exams:

SOA Exam	Waiver Granted for CAS Exam
P	1
FM	2
MFE	3F
MLC	LC
C	4

CAS Exam Requirements of SOA Members

The CAS has seen an increase in the number of credentialed actuaries in the SOA asking what is needed to obtain their ACAS or FCAS designation from the CAS. The Education Policy Committee reviewed this issue and noted that until 2014 the CAS and the SOA administered jointly preliminary exams, and that prior to that, both societies gave conversion credit that was applicable to the current CAS exam requirements. Thus, any actuary who achieved Fellowship or

Associateship of the SOA by completing the qualification requirements of the SOA, not solely in recognition of membership of another actuarial association, has CAS examination credit for:

Exam 1
Exam 2
Exam 3F
Exam LC
Exam ST if credit for MLC was obtained prior to 2014
Exam 4
All 3 VEE Requirements

Therefore, the remaining exams/courses required of an ASA or FSA to achieve ACAS are:

Online Course 1
Online Course 2
Exam ST unless credit for MLC was obtained prior to 2014; only required for ASA
Exam 5
Exam 6
CAS Course on Professionalism

Important Note: The syllabus material covered on CAS Exam 7 is still required in addition to ACAS to sign a Statement of Actuarial Opinion, NAIC Property and Casualty Annual Statement, in the United States.

At this time, there is no waiver of any other CAS exams based on the SOA's General Insurance (GI) exam materials process.

Other Actuarial Organizations

For individuals that have obtained the highest possible actuarial qualification in an actuarial organization that is a member of the International Association of Actuaries, the CAS will grant waivers of some of its examinations/educational requirements as defined by the Executive Council (Exams 1, 2, 3F, LC, ST, and 4; and Validation by Educational Experience requirements) provided that the individual has been practicing as a professional actuary for at least two years subsequent to obtaining the qualification.

Online Courses and VEE

Online Courses: The CAS will grant a waiver of CAS Online Course 1, Risk Management and Insurance Operations, to those who have the Chartered Property Casualty Underwriter (CPCU) designation.

Validation by Educational Experience: Unlike other CAS admissions requirements, the Validation by Educational Experience (VEE) requirements are generally fulfilled outside an actuarial organization. Candidates requesting waiver of any VEE requirements based on actuarial exams should follow the procedure for requesting a waiver. Most candidates, however, will fulfill the VEE requirements through approved educational experiences and must submit the Application for Validation by Educational Experience Credit. Details are provided in the VEE section of this Syllabus.

Waiver Request Process

For a waiver of a CAS admissions requirement that has an approved waiver policy stated above, candidates should present their request to the vice president-admissions with appropriate evidence that demonstrates the passing of (or score on) the educational equivalent for which a waiver is requested.

Requests for waivers for CAS admissions requirements for which there currently is no approved waiver policy are considered on a case-by-case basis. Candidates must present their requests to the vice president-admissions and include with their applications documented evidence that demonstrates the asserted equivalence, as well as the appropriate educational policy material of their local actuarial organization or appropriate educational organization. If such material is not included, the vice president-admissions will request it from the candidates. The vice president-admissions will forward the request to the Education Policy Committee for a determination of whether sufficient equivalence exists to permit granting a waiver. The vice president-admissions will review all such requests and, when appropriate, recommend action to the CAS Board of Directors.

Please address all waiver requests to: Vice President-Admissions, Casualty Actuarial Society, 4350 N. Fairfax Drive, Suite 250, Arlington, VA 22203, U.S.A.

D. CAS Code of Professional Ethics for Candidates

The purpose of the Casualty Actuarial Society (CAS) Code of Professional Ethics for Candidates (Candidate Code) is to require actuarial candidates to adhere to the high standards of conduct, practice, and qualifications of the actuarial profession, thereby supporting the actuarial profession in fulfilling its responsibility to the public. An actuarial candidate shall comply with the Candidate Code. An actuarial candidate who commits a material violation of the provisions of the Candidate Code shall be subject to the counseling and discipline procedures of the CAS.

"Actuarial candidates" are those persons who have registered for a CAS specific exam but have yet to fulfill all of the requirements for admission into the CAS. In situations where actuarial candidates perform actuarial work, their "principal" is defined as their client or employer. "Actuarial services" are professional services provided to a principal by an individual acting in the capacity of an actuary. Such services include the rendering of advice, recommendations, findings, or opinions based upon actuarial considerations.

Rule 1: An actuarial candidate shall act honestly, with integrity and competence, to uphold the reputation of the actuarial profession.

Rule 2: An actuarial candidate shall not engage in any professional conduct involving dishonesty, fraud, deceit, or misrepresentation or commit any act that reflects adversely on the actuarial profession.

Rule 3: An actuarial candidate shall perform actuarial services with courtesy and professional respect and shall cooperate with others in the principal's interest.

Rule 4: An actuarial candidate shall adhere to the CAS Policy on Examination Discipline.

Rule 5: Actuarial candidates are not authorized to use membership designations of the CAS until they are admitted to membership by the CAS Executive Council.

Rule 6: An actuarial candidate shall not disclose to another party any confidential information unless authorized to do so by the principal or required to do so by law, statute, or regulation. Confidential information includes information of a proprietary nature and information that is legally restricted from circulation.

Rule 7: An actuarial candidate shall respond promptly, truthfully, and fully to any request for information by, and cooperate fully with, appropriate counseling and disciplinary body of the CAS in connection with any disciplinary, counseling or other proceeding of such body relating to the Candidate Code. The actuarial candidate's responsibility to respond shall be subject to applicable restrictions listed in Rule 6 and those imposed by law, statute, or regulation.

(The CAS Board of Directors approved the code above on November 12, 2006.)

A copy of the Casualty Actuarial Society Rules of Procedure for Disciplinary Actions Involving Candidates is available in the Exams & Admissions section of the CAS website under "Candidates' Code of Ethics."

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HINTS ON STUDY AND EXAM TECHNIQUES

Editor's Note: *These hints do not include any material on which candidates will be examined, but are provided by members of the CAS Syllabus and Examination Committees to encourage candidates to do their best when sitting for CAS Examinations. This section has been updated many times over the years, most recently in 2014. It is based on the experience and advice of many people. James L. Clare for the Society of Actuaries prepared an early version and then G.D. Morison adapted it for the Casualty Actuarial Society.*

Motivation

Motivation is the single most important ingredient in learning—and in passing exams. Motivation suffers when candidates worry about or are preoccupied with personal matters or other problems. This suggests that candidates should keep the studying for the exam at the very top of their lists of priorities, and should always have a constructive attitude about their studying. In particular, candidates should approach the exam as an opportunity to enhance their knowledge and understanding of actuarial science, rather than as an obstacle in their paths to membership in the CAS.

Motivation is increased by incentives, such as the following:

- Passing actuarial exams requires many hours of study—more for some people and less for others—but often more than many candidates realize. Putting in enough hours can actually save a candidate time. Suppose, for example, that mastering the syllabus for one exam will take a candidate 400 study hours, and that a candidate only puts in 300 hours and fails the exam the first time. He or she then puts in an additional 300 hours and passes the exam the second time. That candidate will have spent 600 hours, when by studying 400 hours the first time around, he or she would have saved 200 hours, not to mention passing sooner. It is recommended that candidates decide for themselves how many hours they really need to study, and then do that much studying—the first time around.

- Candidates can increase their motivation level by regarding the exams as a stepping stone to greater responsibility at their places of employment, to opportunities for getting more done on their own, and to greater results and rewards from their work.

- Candidates can also increase their motivation through sufficiently intensive and sustained study so that they come to appreciate more fully the fascination of the various subjects, and the interrelationships between them. A number of doctors, educators, executives, and human resources professionals agree that motivation can be greatly increased by having a goal in mind. Candidates must determine their goals and keep them in mind.

Techniques

It has been proven many times in various countries, both by individuals and by controlled groups, that improved study and exam techniques can strengthen a candidate's mastery of a subject and increase his or her exam scores significantly. Provided that the candidate is motivated and spends enough time studying, techniques such as those given here often make the difference between failing or passing an exam.

Each person has his or her own strengths and weaknesses, so candidates are advised to work out their own personal sets of techniques which will work best for them. What follows are merely suggestions to help candidates in getting started in building up their own techniques.

The Challenge

It is easy to underestimate the effort that is required because substantial changes may be needed to switch from college or university life to successful study of actuarial exams.

University courses often do much to smooth the path for students with lectures, personal contacts, organized places of study, and a focus on learning.

By contrast, actuarial candidates must work a great deal on their own to reach their goals. Much actuarial studying is normally fit in after a full day's work, or is done on a weekend when one's friends are free to do as they please. Making adequate time available for studying requires sustained self-discipline and is a purely individual and personal responsibility.

Schedule of Study

There is only one substitute for hours of study time omitted one week—at least as many additional hours of study in another week. An unavoidably "necessary condition" for success in studying (though not necessarily "sufficient condition") is simply spending enough total hours studying.

Candidates must decide how many hours in total they need to study. Then they need to set out their schedules in writing, specifically stating the weekday evening and weekend periods allocated to studying. They then should total the number of hours made available. If the total hours scheduled are less than the total hours necessary, candidates should expand their schedules until they at least have equaled the required total time plus an additional cushion for absorbing time that will inevitably be lost along the way on account of illness, work pressures, etc.

Then candidates should fit all the segments of the syllabus into their schedules so that they will thoroughly cover all the learning objectives, knowledge statements, and readings in good time before the exam, with time left over for a thorough final review. It is important for candidates to spread their time over the entire syllabus in some deliberate way, for example, in proportion to the pages of reading material on the syllabus or to the range of weight given to the material.

It is not appropriate to assume that certain parts of the syllabus will not appear on the exam either because of historical precedent or because of the range of weight given to the material.

Candidates may find it helpful to study several subjects within an exam, or all of them, in parallel. This gives them more variety each week, and may give them a combination of both study that is more appealing and study that requires greater effort and concentration. Particularly demanding study may be best left for weekends when candidates are less fatigued from regular work.

It is a good idea for candidates to keep a record of the hours they spend studying. Even if candidates are completely confident that they know the syllabus before putting in their required total hours, there is much to be said for carrying out the full schedule and completing the total time quotas.

Retention

As part of human nature, our memories forget facts and ideas most rapidly during the time immediately following our study of them. For a given number of study hours, therefore, candidates will remember more if they review promptly and frequently. It is recommended that candidates review what they have learned as part of ending their study for the day.

Before reading a paper or section of text, candidates should scan the section for titles, headings, subheadings, and topic sentences to get the general idea, paying attention to graphs, charts, and diagrams. They should read the summary at the end of the paper or chapter and look for leading questions and exercises at the beginning and at the end.

After the initial skim, candidates should read through the entire material one section at a time for the main ideas, and not worry if the reading is relatively slow. Technical reading is challenging and requires more careful processing. Although it is tempting, candidates may want to avoid taking detailed notes at this time, but rather focus on understanding the material. Taking notes at this point may not be an efficient technique— candidates may take down too much information or simply copy information without understanding. If a section is difficult to understand, candidates should mark it to review in a later pass.

As each section or paper is completed, candidates should paraphrase and write down just the main ideas in their own words without looking at the source material. Putting the information in one's own words forces one to become actively involved with the material. It helps improve retention, and forces attention to those items that are not really understood and require further study. While the extent of a candidate's notes will be a matter of his or her own personal tastes, taking thorough notes will be a good investment of time for most people. Upon reviewing their notes, if candidates find gaps in their knowledge or in their understanding, they should bear down on those areas and master them.

As they begin their next study session, candidates should review what they learned the last time and what they learned during other recent sessions. Then they can recall points they have learned during odd spare moments in between study sessions.

In their study for the mathematical sections of the exams, candidates are advised to work out as many examples as possible in order to acquire facility in the application of the mathematical principles and methods to specific problems.

Candidates should note the considerable emphasis in actuarial exams on knowledge. They should remember, however, that the best way to learn facts by heart is to understand the whole subject, and to tie together ideas that are related. They should look at any single subject from several different angles, relating what they learn to what they know already. Candidates should look for as many connections as they can between their actuarial work and their actuarial studies.

Another study technique candidates might want to try is to test themselves as they go along. They can review previous exams when they start to study to get an idea of the mastery of the syllabus expected. Candidates can also take these as "trial exams" to help them in testing their knowledge and understanding of the course of reading, and in improving their exam speed and confidence.

Some candidates deliberately test themselves; others prefer not to do so. Candidates should expect a gradual gathering of momentum as they begin their study for a particular exam. By keeping at it, according to their plans, candidates will find their rate of progress speeding up after the first few weeks.

When a candidate finds himself or herself getting very "stale," one possibility is to stop studying altogether for, perhaps, three days. Then the candidate should continue on with his or her study plan, no matter how he

or she feels, for at least the next month or six weeks. A candidate's study plan should have enough spare time available in it to allow for such occasional "down time." Following a mixed schedule, with a weekly combination of subjects that the candidate likes and subjects that he or she finds difficult, will help to minimize staleness.

Discussing the syllabus with friends taking the same exam, or with others who have passed the exam, will help candidates remember the material firmly and understand it. It also helps candidates to realize their own gaps and difficulties. If effective study circles, online forums, and review courses can be found, they will give candidates a different slant on the subject, give them a chance to review and to practice, keep them moving through the syllabus, and help to combat lethargy and self-satisfaction.

It is important for candidates to leave time for a thorough final review before the exam. In the last three or four weeks before the exam, candidates should use practice exams to simulate the exam experience as closely as possible, while keeping in mind that they need to be able to pass any set of exam questions which has been drawn from the syllabus.

When taking the practice exams, candidates should set up a clean, distraction-free space and allow plenty of uninterrupted time. Candidates should develop a plan for how to answer the questions. One strategy is to determine a time limit for each point and stick to it. If there are 80 points on the four-hour exam, allow about two and a half minutes for each point, leaving time for review at the end. When the time is up for one question, move on to the next question. Incomplete answers may be completed during the review time.

Candidates are responsible for mastery of the learning objectives and knowledge statements in the syllabus and the associated readings that pertain to these learning objectives and knowledge statements. Simply relying on seminar notes, past exams, or on material from review courses or online forums may leave a candidate missing salient and important knowledge necessary to obtain maximum points on the exam.

Formulating Answers

Multiple-Choice Questions

Candidates can definitely improve their speed and mastery by seriously practicing sample exam type questions before the exam. It helps to have a good understanding of the subject material. Candidates can also develop valuable shortcuts, such as eliminating impossible answers by checking out boundary conditions, by inspecting other aspects of certain suggested solutions, or by substituting numerical values and cutting out some answers. Since questions are varied, candidates will need a variety of techniques to cope with them.

In a multiple-choice exam, candidates increase their chances of passing if they are able to seriously attempt each question on the entire exam at least once. It may help them to determine the proportionate number of questions to answer in the first half-hour of the exam, to check how much ground they cover in that time, and then accordingly either speed up, or slow down and dig more deeply.

When pressed for time, it may pay for candidates to omit a few multiple-choice questions that they expect to take more time than average; so as to have time for a larger number of more quickly answered questions. For example, a cluster of questions may have a common introduction that a candidate does not readily grasp, in which case he or she might skip the entire cluster at a first attempt.

Candidates may find it helpful to keep a list of the number of the questions not answered so that they quickly can get an idea of how many they are omitting. This will allow the candidate to quickly return to these

questions.

Candidates should change their answers only if they are sure that their first solution was wrong.

Constructed Response Questions

The model response to the typical constructed response (e.g., essay style) question depends on the level of knowledge that the question is asking the candidate to demonstrate.

For non-calculation questions, there are typically six levels of information that may be tested corresponding with Bloom's taxonomy:

Level 1: Knowledge—tests the ability of the candidate to recall or remember knowledge or facts

Level 2: Comprehension—requires the candidate to demonstrate comprehension of central concepts through explanation of those concepts

Level 3: Application—measures the candidate's ability to apply ideas and concepts to new situations

Level 4: Analysis—requires the candidate to analyze information by separating material into component parts, including identification of facts and development of inferences with respect to a situation

Level 5: Synthesis—tests the ability of a candidate to synthesize, or combine, concepts or ideas and develop and defend the position resulting from that combination

Level 6: Evaluation—requires the candidate to support conclusions by evaluating the validity of ideas and concepts

The "action" verbs of each question (e.g., explain, identify, describe, determine, etc.) are chosen very deliberately by question writers to instruct the candidates how to answer the question in order to demonstrate the required mastery of the learning objective(s) that the question is testing.

Very often, the question writer will add an adverb before the action verb, most notably the adverb "briefly." This one simple word means a great deal to both the question writer and the grader. Just as importantly, the absence of this word means a great deal to the writer and the grader. The verbs and adverbs used, or not used, and the point values assigned to each question and subpart provide cues to how the candidates are expected to answer each item. A typical key for any exam follows this rubric:

- "Brief" descriptions, discussions, etc., are worth generally ¼ point, so candidates should respond concisely, but with clarity regarding what is being communicated.

- (Unmodified) discussions or descriptions are worth generally ½ point, so candidates should provide a more in-depth response with more detail compared to a question that asks for a brief response, but typically not more than one-half of a written page.

As upper level exam questions gravitate towards higher levels in the Bloom's taxonomy (in particular, levels 3-6), candidates should pay closer attention to the wording of the item. Prompts such as "recommend," "justify," "propose," "assess," "fully discuss," and "compare and contrast" will require the candidate to write a more substantive and coherent answer rather than simply list knowledge gained from syllabus readings. For such items, point totals can vary considerably. Nevertheless, candidates can continue to use point totals as a guide to gauge how much content is required to appropriately answer the item.

For questions that require candidates to work a numerical solution, candidates should take the time to set up the problem so that they document their understanding. They should set forth relevant equations or formulae, and then enter appropriate values. They should lay out complicated calculations in tables that demonstrate their understanding of the correct solution. If the candidate needs to set forth further assumptions to answer the question, these assumptions should be provided and explained. If a candidate is pressed for time, then setting up the response and walking through how it would be calculated will earn the candidate partial credit on the question despite not having punched the numbers on the calculator to get the final answer.

Candidates should keep each answer relevant to the precise question being asked. They should make sure they first understand exactly what is wanted before they begin to answer a question. When they have written part or all of their answer, they should take another look at the question and make sure they have answered— not their own question—but the question as set on the exam page.

If a candidate believes that a question is ambiguous, or that it does not provide all the information necessary to answer the question, the candidate should state how he or she interprets the question and/or what assumptions are made to answer it.

Candidates should take time to write legibly, since examiners can only give credit for what they can read. They should try to "organize" their answer. Then, their aim should be to get down sufficient relevant detail given the question's scope and available time.

There is no advantage to answering the questions in any particular order. Candidates may answer the questions in the order given if they wish. Candidates are given a 15-minute reading period prior to the exam at which point the candidate can quickly read over the whole paper and determine their ideal test taking approach. For example, candidates may wish to start on questions that come easily to them, then gradually work into the questions they find more challenging, and end on a question that they think can be answered readily even though, by that time, their energy and concentration may be falling off.

Note that since each question is graded separately, each answer must be self-contained. Candidates should not write, "Part of my answer to question 3 is found in my answer to question 1."

It is important that candidates remember that they have limited time. Candidates will find that it is worth checking their progress to assure that they have an opportunity to respond to every question. If they know that a question will take too much time, they can pass it and return to it later, if time permits.

Candidates should never give up in the examination room. They should use every minute and every second of the available time. They should not "grade their own papers," and decide not to hand in an answer to a question or two because they feel it is all-wrong. They should hand in all of their answers, and let the examiners do the grading. More than one candidate has not handed in some answer pages which he or she had condemned in his or her own mind, only to find out later that the work was correct, and to find out still later that he or she had narrowly failed to pass.

STUDY RESOURCES

Study Notes

Official Study Notes are published to help candidates prepare for the examinations. In some instances, Study Notes are the principal materials for study; in others, they are designed to coordinate the subject for the candidate or to complement other readings. Occasionally, the course of reading for an examination may be changed after publication of the *Syllabus*. Such a change will be announced on the specific exam syllabus Web page.

Study Notes may be downloaded at no charge from the specific exam syllabus Web page.

Study Kits for Exams 5-9

The Study Kit contains required readings not owned by the CAS but for which the CAS has been granted permission to include in the Study Kit. Study Kits will be available the first Monday in December, for April 2015 exams and on the first Monday in April 2015, for October 2015 exams. Study Kits may be purchased from the CAS Online Store; there are **NO RETURNS** and **NO REFUNDS**.

Online Publications for Exams LC, ST, S, and 5-9

All readings listed as "Online Publications" will be available on a web page titled Complete Text References at no charge.

Online Courses 1/CA1 and 2/CA2

All required educational content for Online Courses 1/CA1 and 2/CA2 is provided in the online courses themselves.

Sample Examination Questions

Preliminary Exams

Sample examination questions for Exams 1, 2, 3F, and 4 may be available from the sponsoring organizations.

Exams LC, ST, S, and 5-9

Copies of recent past exams including answer key for Exams LC and ST are available at no charge in the "Past Exams and Pass Marks" section of the CAS website.

Copies of recent past exams for Exams 5-9 with sample answers are available at no charge in the "Past Exams and Pass Marks" section of the CAS website. Sample essay answers are actual responses that received credit and are illustrative of successful answers, although they may not be considered perfect answers.

Sample questions/answers for new topics for Exam ST are available on the website, but candidates can look to previously administered Exam 3L for sample questions/answers for Learning Objectives that overlap with Exams LC and ST. For Exam S, the candidate can look to previously administered Exams 3L, LC, and ST for sample questions/answers for Learning Objectives that overlap with Exam S. Sample questions/answers for new topics for Exam S are available on the website.

Exams LC, ST, S, and 5-9 will be posted in the "Exams" section of the CAS website approximately one week after these examinations have been administered. They will include a preliminary list of multiple-choice answers. Sample essay answers and final multiple-choice answers will be posted at the end of July for April Examinations and at the end of January for October Examinations.

In referring to a published prior examination, candidates should keep in mind that the questions were based on the learning objectives in effect for that particular examination and may not reflect the current learning objectives. Candidates may also expect future examinations to vary somewhat as to the proportions of question styles and subjects. New forms of questions may appear from time to time, and the total number of questions may vary from one exam sitting to the next.

E-Mail Study Groups

The CAS has available e-mail study groups for those preparing for CAS examinations. Information about joining a study group is available in the "E-Mail Study Groups" section of the CAS website. Please direct any questions to the CAS Webmaster at webmaster@casact.org.

CAS Library

The CAS Library has available for loan a limited number of the books marked with a bold **B** in this *Syllabus*. Candidates registered for CAS Examinations and all members of the CAS have access to the library. The CAS Library is located at the CAS Office in Arlington, Virginia. For those who reside in East Asia, the Actuaries Office in Hong Kong has CAS Library books available for lending and candidates residing in that area should contact the office in Hong Kong.

Books and manuals may be withdrawn from the library for a period of one month without charge. In general, not more than two references may be in the hands of one borrower at a time. Requests must be in writing and must include the borrower's complete name, address, and telephone number as well as the complete title(s) and author(s) of the requested book(s). Address requests for library books to:

For Candidates Outside East Asia:	For candidates in East Asia:
Casualty Actuarial Society	Actuaries Office in Hong Kong
Attention: Library Service	Attention: Patricia Kum
4350 N. Fairfax Drive, Suite 250	2202 Tower Two, Lippo Centre
Arlington, Virginia 22203	89 Queensway
Fax: (703) 276-3108	Hong Kong
E-mail: library@casact.org	E-mail: hongkonglibrary@casact.org

Candidates are responsible for the cost of returning library books. Books must be returned to the office from which they were borrowed. The CAS ships the requested book(s) in the U.S. via United Parcel Service (UPS) and internationally via Air Mail. Due to delays in the mail system, the CAS requires all shipments of books returned to the CAS Office to be shipped via UPS, FedEx, or an equivalent carrier with tracking capabilities.

Please do not use the postal service. Overdue books will be charged at a cost of 25¢ per day.

Books that are not available through the CAS Library may be obtained by contacting the organizations listed in the "Publishers and Distributors" section at the end of each examination syllabus section.

2015 Exam 1 Syllabus
Probability

The syllabus for this exam is defined in the form of learning objectives that set forth, usually in broad terms, what the candidate should be able to do in actual practice.

Please check the "Syllabus Update" for this exam for any changes to this syllabus or options for obtaining credit for this exam.

The purpose of the syllabus for this examination is to develop knowledge of the fundamental probability tools for quantitatively assessing risk. The application of these tools to problems encountered in actuarial science is emphasized. A thorough command of the supporting calculus is assumed. Additionally, a very basic knowledge of insurance and risk management is assumed.

A. General Probability

LEARNING OBJECTIVES

1. Use and apply the following concepts in a risk management context:
    - Set functions including set notation and basic elements of probability
    - Mutually exclusive events
    - Addition and multiplication rules
    - Independence of events
    - Combinatorial probability
    - Conditional probability
    - Bayes Theorem / Law of total probability

B. Univariate Probability Distributions

This section includes binomial, negative binomial, geometric, hypergeometric, Poisson, uniform, exponential, gamma, and normal distributions.

LEARNING OBJECTIVES

1. Use and apply the following concepts in a risk management context:
    - Probability functions and probability density functions
    - Cumulative distribution functions
    - Mode, median, percentiles, and moments
    - Variance and measures of dispersion
    - Moment generating functions
    - Transformations

C. Multivariate Probability Distributions

This section includes the bivariate normal distribution.

LEARNING OBJECTIVES

1. Use and apply the following concepts in a risk management context:
   • Joint probability functions and joint probability density functions
   • Joint cumulative distribution functions
   • Central Limit Theorem
   • Conditional and marginal probability distributions
   • Moments for joint, conditional, and marginal probability distributions
   • Joint moment generating functions
   • Variance and measures of dispersion for conditional and marginal probability distributions
   • Covariance and correlation coefficients
   • Transformations and order statistics
   • Probabilities and moments for linear combinations of independent random variables

Options for Obtaining Exam 1 Credit

The CAS will grant credit for Exam 1 to those who have successfully completed one of the following examinations:

Organization	Exam
Actuarial Society of South Africa	A101, Probability and Mathematical Statistics
Actuaries Institute (Australia)	CT3, Probability and Mathematical Statistics
Institute of Actuaries of India	CT3, Probability and Mathematical Statistics
Institute and Faculty of Actuaries (U.K.)	CT3, Probability and Mathematical Statistics
Society of Actuaries	P, Probability

To obtain credit, the candidate should contact the Actuaries' Resource Center (arc@casact.org). Provide the name of the actuarial organization that administered the exam, the exam name and number, the date that you passed, as well as your full name, date of birth, and contact information.

Note: The Exam 1 credit chart includes a new waiver for the Actuarial Society of South Africa.

2015 Exam 2 Syllabus
Financial Mathematics Exam

The syllabus for this exam is defined in the form of learning objectives that set forth, usually in broad terms, what the candidate should be able to do in actual practice.

Please check the "Syllabus Update" for this exam for any changes to this syllabus or options for obtaining credit for this exam.

The purpose of the syllabus for this examination is to develop knowledge of the fundamental concepts of financial mathematics, and how those concepts are applied in calculating present and accumulated values for various streams of cash flows as a basis for future use in: reserving, valuation, pricing, asset/liability management, investment income, capital budgeting, and valuing contingent cash flows. The candidate will also be given an introduction to financial instruments, including derivatives, and the concept of no-arbitrage as it relates to financial mathematics.

The Financial Mathematics Exam assumes a basic knowledge of calculus and an introductory knowledge of probability.

A. Interest Theory

LEARNING OBJECTIVES

1. For time value of money, define and recognize the definitions of the following terms:
   a. Interest rate (rate of interest)
   b. Simple interest
   c. Compound interest
   d. Accumulation function
   e. Future value
   f. Present value/net present value
   g. Discount factor
   h. Discount rate (rate of discount)
   i. Convertible m-thly
   j. Nominal rate
   k. Effective rate
   l. Inflation and real rate of interest
   m. Force of interest
   n. Equation of value

2. For time value of money, the candidate will be able to do the following:
   a. Given any two of interest rate, present value, or future value, calculate the third based on simple or compound interest.
   b. Given any one of the effective interest rate, the nominal interest rate convertible m-thly, the effective discount rate, the nominal discount rate convertible m-thly, or the force of interest, calculate all of the other items.
   c. Write the equation of value given a set of cash flows and an interest rate.

3. For annuities with payments that are not contingent, define and recognize the definitions of the following terms:
   a. Annuity-immediate
   b. Annuity-due
   c. Perpetuity
   d. Payable m-thly, or Payable continuously
   e. Level payment annuity
   f. Arithmetic increasing/decreasing payment annuity
   g. Geometric increasing/decreasing payment annuity
   h. Term of annuity

4. For annuities with payments that are not contingent, the candidate will be able to do the following:
   a. Given an annuity with level payments, immediate (or due), payable m-thly, (or payable continuously), and any three of present value, future value, interest rate, payment, and term calculate the remaining two items.
   b. Given an annuity with non-level payments, immediate (or due), payable m-thly, (or payable continuously), the pattern of payment amounts, and any three of present value, future value, interest rate, payment amounts, and term of annuity calculate the remaining two items.

5. For loans, define and recognize the definitions of the following terms:
   a. Principal
   b. Interest
   c. Term of loan
   d. Outstanding balance
   e. Final payment (drop payment, balloon payment)
   f. Amortization
   g. Sinking fund

6. For loans, the candidate will be able to do the following:
   a. Given any four of term of loan, interest rate, payment amount, payment period, principal, calculate the remaining items.
   b. Calculate the outstanding balance at any point in time.
   c. Calculate the amount of interest and principal repayment in a given payment.
   d. Given the quantities, except one, in a sinking fund arrangement calculate the missing quantity.

7. For bonds, define and recognize the definitions of the following terms:
   a. Price
   b. Redemption value
   c. Par Value/Face value
   d. Coupon, Coupon rate
   e. Term of bond
   f. Yield rate g. Callable/non-callable
   g. Book value
   h. Accumulation of discount/Amortization of premium

8. For bonds, the candidate will be able to do the following:
   a. Given any four of price, redemption value, yield rate, coupon rate, and term of bond, calculate the remaining item.

9. For general cash flows and portfolios, define and recognize the definitions of the following terms:
   a. Yield rate/rate of return
   b. Dollar-weighted rate of return/Time-weighted rate of return
   c. Current value
   d. Duration (Macaulay, modified and effective)
   e. Convexity
   f. Portfolio and investment year allocation methods
   g. Spot rate
   h. Forward rate
   i. Yield curve
   j. Stock price, stock dividend

10. For general cash flows and portfolios, the candidate will be able to do the following:
    a. Calculate the current value of a set of cash flows.
    b. Calculate the portfolio yield rate.
    c. Calculate the dollar-weighted and time-weighted rate of return.
    d. Calculate the duration and convexity of a set of cash flows.
    e. Calculate either Macaulay or modified duration given the other.
    f. Use duration and convexity to approximate the change in present value due to a change in interest rate.
    g. Calculate the price of a stock using the dividend discount model.

11. For immunization, define and recognize the definitions of the following terms:
    a. Cash-flow matching;
    b. Immunization (including full immunization);
    c. Redington immunization.

12. For immunization, the candidate will be able to do the following:
    a. Construct an investment portfolio to fully immunize a set of liability cash flows.
    b. Construct an investment portfolio to match present value and duration of a set of liability cash flows.
    c. Construct an investment portfolio to exactly match a set of liability cash flows.

B. Financial Economics

LEARNING OBJECTIVES

1. For general derivatives, define and recognize the definitions of the following terms:
   a. Derivative, Underlying asset, Over-the-counter market
   b. Ask price, Bid price, Bid-ask spread
   c. Short selling, Short position, Long position
   d. Stock index
   e. Spot price
   f. Net profit/payoff
   g. Credit risk
   h. Marking-to-market
   i. Margin, Maintenance margin, Margin call

2. For general derivatives, evaluate an investor's margin position based on changes in asset values.

3. For options, define and recognize the definitions of the following terms:
   a. Call option, Put option
   b. Expiration, Expiration date
   c. Strike price/Exercise price
   d. European option, American option, Bermudan option
   e. In-the-money, At-the-money, Out-of-the-money
   f. Covered call, Naked writing
   g. Dividends
   h. Put-call parity

4. For options, evaluate the payoff and profit of basic derivative contracts.

5. For hedging and investment strategies, define and recognize the definitions of the following terms:
   a. Hedging, Arbitrage
   b. Diversifiable risk, Nondiversifiable risk
   c. Synthetic forwards
   d. Spreads (including bull, bear, box, and ratio spreads)
   e. Collars (including zero-cost collars), Paylater strategy
   f. Straddles (including strangles, written straddles and butterfly spreads)
   g. Convertible bond, Mandatorily convertible bond

6. For hedging and investment strategies, the candidate will be able to:
   a. Explain how derivative securities can be used as tools to manage financial risk.
   b. Explain the reasons to hedge and not to hedge.
   c. Evaluate the payoff and profit of hedging strategies.

7. For forwards and futures, define and recognize the definitions of the following terms:
   a. Forward contract, Prepaid forward contract
   b. Outright purchase, Fully leveraged purchase
   c. Implied repo rate
   d. Cost of carry
   e. Lease rate
   f. Futures contract

8. For forwards and futures, the candidate will be able to:
   a. Determine forward price from prepaid forward price.
   b. Explain the relationship between forward price and futures price.
   c. Explain the relationship between forward price and future stock price.
   d. Use the concept of no-arbitrage to determine the theoretical value of futures and forwards.
   e. Given any four of call premium, put premium, forward price, strike price and interest rate, calculate the remaining item using the put-call parity formula.

9. For swaps, define and recognize the definitions of the following terms:
   a. Swap, Prepaid swap
   b. Swap term, Swap spread, Notional Amount
   c. Simple commodity swap, Interest rate swap
   d. Deferred swap

10. Use the concept of no-arbitrage to determine the theoretical values of swaps.

Options for Obtaining Exam 2 Credit

The CAS will grant credit for Exam 2 to those who have successfully completed one of the following examinations:

Organization	Exam
Actuarial Society of South Africa	A201, Financial Mathematics
Actuaries Institute (Australia)	CT1, Financial Mathematics
Canadian Institute of Actuaries	University Accreditation Program credit for Financial Mathematics
Institute of Actuaries of India	CT1, Financial Mathematics
Institute and Faculty of Actuaries (U.K.)	CT1, Financial Mathematics
Society of Actuaries	Exam FM, Financial Mathematics

To obtain credit, the candidate should contact the Actuaries' Resource Center (arc@casact.org). Provide the name of the actuarial organization that administered the exam, the exam name and number, the date that you passed, as well as your full name, date of birth, and contact information.

Note: The Exam 2 credit chart includes a new waiver for the Actuarial Society of South Africa.

2015 Exam 3F Syllabus
Models for Financial Economics

The syllabus for this exam is defined in the form of learning objectives that set forth, usually in broad terms, what the candidate should be able to do in actual practice.

Please check the "Syllabus Update" for this exam for any changes to this syllabus or options for obtaining credit for this exam.

The purpose of the syllabus is to develop the candidate's knowledge of the theoretical basis of certain actuarial models and the application of those models to insurance and other financial risks. A thorough knowledge of calculus, probability, and interest theory is assumed.

A. Interest Rate Models

LEARNING OBJECTIVES
1. Evaluate features of the Vasicek and Cox-Ingersoll-Ross bond price models.
2. Explain why the time-zero yield curve in the Vasicek and Cox-Ingersoll-Ross bond price models cannot be exogenously prescribed.
3. Construct a Black-Derman-Toy binomial model matching a given time-zero yield curve and a set of volatilities.

B. Rational valuation of derivative securities

LEARNING OBJECTIVES
1. Use put-call parity to determine the relationship between prices of European put and call options and to identify arbitrage opportunities.
2. Calculate the value of European and American options using the binomial model.
3. Calculate the value of European options using the Black-Scholes option-pricing model.
4. Identify the situations where the values of European and American options are the same.
5. Interpret the option Greeks.
6. Explain the cash flow characteristics of the following exotic options: Asian, barrier, compound, gap, and exchange.
7. Explain the properties of a lognormal distribution and explain the Black-Scholes formula as an expected value for a lognormal distribution.
8. Explain what it means to say that stock prices follow a diffusion process.
9. Apply Itô's lemma in the one-dimensional case.

C. Simulation

LEARNING OBJECTIVES
1. Simulate lognormal stock prices.
2. Use variance reduction techniques to accelerate convergence.

D. Risk Management Techniques

LEARNING OBJECTIVES
1. Explain and demonstrate how to control risk using the method of delta-hedging.

Options for Obtaining Exam 3F Credit

The CAS will grant credit for Exam 3F to those who have successfully completed one of the following examinations:

Organization	Exam
Actuarial Society of South Africa	A205, Financial Economics
Actuaries Institute (Australia)	CT8, Financial Economics
Canadian Institute of Actuaries	University Accreditation Program credit for Models for Financial Economics
Institute of Actuaries of India	CT8, Financial Economics
Institute and Faculty of Actuaries (U.K.)	CT8, Financial Economics
Society of Actuaries	MFE, Models for Financial Economics

To obtain credit, the candidate should contact the Actuaries' Resource Center (arc@casact.org). Provide the name of the actuarial organization that administered the exam, the exam name and number, the date that you passed, as well as your full name, date of birth, and contact information.

Note: The Exam 3F credit chart includes a new waiver for the Actuarial Society of South Africa.

2015 Exam 4 Syllabus
Construction and Evaluation of Actuarial Models Exam

The syllabus for this exam is defined in the form of learning objectives that set forth, usually in broad terms, what the candidate should be able to do in actual practice.

Please check the "Syllabus Update" for this exam for any changes to this syllabus or options for obtaining credit for this exam.

The syllabus for this examination provides an introduction to modeling and covers important actuarial methods that are useful in modeling. A thorough knowledge of calculus, probability, and mathematical statistics is assumed.

The candidate will be introduced to useful frequency and severity models beyond those covered in Exams 3F and 3L. The candidate will be required to understand the steps involved in the modeling process and how to carry out these steps in solving business problems. The candidate should be able to: (1) analyze data from an application in a business context; (2) determine a suitable model including parameter values; and (3) provide measures of confidence for decisions based upon the model. The candidate will be introduced to a variety of tools for the calibration and evaluation of the models.

The candidate is expected to be familiar with survival, severity, frequency and aggregate models, and use statistical methods to estimate parameters of such models given sample data. The candidate is further expected to identify steps in the modeling process, understand the underlying assumptions implicit in each family of models, recognize which assumptions are applicable in a given business application, and appropriately adjust the models for impact of insurance coverage modifications.

Specifically, the candidate is expected to be able to perform the tasks listed below.

A. Severity Models

LEARNING OBJECTIVES

1. Calculate the basic distributional quantities:
   a. Moments
   b. Percentiles
   c. Generating functions
2. Describe how changes in parameters affect the distribution.
3. Recognize classes of distributions and their relationships.
4. Apply the following techniques for creating new families of distributions:
   a. Multiplication by a constant
   b. Raising to a power
   c. Exponentiation,
   d. Mixing
5. Identify the applications in which each distribution is used and reasons why.
6. Apply the distribution to an application, given the parameters.
7. Calculate various measures of tail weight and interpret the results to compare the tail weights.

B. Frequency Models

LEARNING OBJECTIVES
For the Poisson, Mixed Poisson, Binomial, Negative Binomial, Geometric distribution and mixtures thereof: 1. Describe how changes in parameters affect the distribution. 2. Calculate moments. 3. Identify the applications for which each distribution is used and reasons why. 4. Apply the distribution to an application given the parameters. 5. Apply the zero-truncated or zero-modified distribution to an application given the parameters.

C. Aggregate Models

LEARNING OBJECTIVES
1. Compute relevant parameters and statistics for collective risk models. 2. Evaluate compound models for aggregate claims. 3. Compute aggregate claims distributions.

D. For Severity, Frequency and Aggregate Models

LEARNING OBJECTIVES

1. Evaluate the impacts of coverage modifications:
    a. Deductibles
    b. Limits
    c. Coinsurance
2. Calculate Loss Elimination Ratios.
3. Evaluate effects of inflation on losses.

E. Risk Measures

LEARNING OBJECTIVES
1. Calculate VaR, and TVaR and explain their use and limitations.

F. Construction of Empirical Models

LEARNING OBJECTIVES

1. Estimate failure time and loss distributions using:
    a. Kaplan-Meier estimator, including approximations for large data sets
    b. Nelson-Åalen estimator
    c. Kernel density estimators
2. Estimate the variance of estimators and confidence intervals for failure time and loss distributions.
3. Apply the following concepts in estimating failure time and loss distribution:
    a. Unbiasedness
    b. Consistency
    c. Mean squared error

G. Construction and Selection of Parametric Models

LEARNING OBJECTIVES

1. Estimate the parameters of failure time and loss distributions using:
   a. Maximum likelihood
   b. Method of moments
   c. Percentile matching
   d. Bayesian procedures
2. Estimate the parameters of failure time and loss distributions with censored and/or truncated data using maximum likelihood.
3. Estimate the variance of estimators and the confidence intervals for the parameters and functions of parameters of failure time and loss distributions.
4. Apply the following concepts in estimating failure time and loss distributions:
   a. Unbiasedness
   b. Asymptotic unbiasedness
   c. Consistency
   d. Mean squared error
   e. Uniform minimum variance estimator
5. Determine the acceptability of a fitted model and/or compare models using:
   a. Graphical procedures
   b. Kolmogorov-Smirnov test
   c. Anderson-Darling test
   d. Chi-square goodness-of-fit test
   e. Likelihood ratio test
   f. Schwarz Bayesian Criterion

H. Credibility

LEARNING OBJECTIVES
1. Apply limited fluctuation (classical) credibility including criteria for both full and partial credibility. 2. Perform Bayesian analysis using both discrete and continuous models. 3. Apply Bühlmann and Bühlmann-Straub models and understand the relationship of these to the Bayesian model. 4. Apply conjugate priors in Bayesian analysis and in particular the Poisson-gamma model. 5. Apply empirical Bayesian methods in the nonparametric and semiparametric cases.

I. Simulation

LEARNING OBJECTIVES
1. Simulate both discrete and continuous random variables using the inversion method. 2. Estimate the number of simulations needed to obtain an estimate with a given error and a given degree of confidence. 3. Use simulation to determine the p-value for a hypothesis test. 4. Use the bootstrap method to estimate the mean squared error of an estimator. 5. Apply simulation methods within the context of actuarial models.

Options for Obtaining Exam 4 Credit

The CAS will grant credit for Exam 4 to those who have successfully completed one of the following examinations:

Organization	Exam
Actuarial Society of South Africa	A202, Models, and A204, Statistical Methods**
Actuaries Institute (Australia)	CT4, Models, and CT6, Statistical Methods*
Canadian Institute of Actuaries	University Accreditation Program credit for Construction and Evaluation of Actuarial Models
Institute of Actuaries of India	CT4, Models, and CT6, Statistical Methods*
Institute and Faculty of Actuaries (U.K.)	CT4, Models, and CT6, Statistical Methods*
Society of Actuaries	C, Construction and Evaluation of Actuarial Models Exam

*CT4 & CT6, together, will provide credit for CAS Exams ST and 4 & Validation by Education Experience for Applied Statistical Methods.

**A202 & A204, together, will provide credit for CAS Exams ST and 4 & Validation by Education Experience for Applied Statistical Methods.

To obtain credit, the candidate should contact the Actuaries' Resource Center (arc@casact.org). Provide the name of the actuarial organization that administered the exam, the exam name and number, the date that you passed, as well as your full name, date of birth, and contact information.

Note: The Exam 4 credit chart includes a new waiver for the Actuarial Society of South Africa.

Spring and Fall 2015 Exam LC Syllabus
Models for Life Contingencies

The syllabus for this one-and-a-half-hour exam is defined in the form of learning objectives, knowledge statements, and readings.

LEARNING OBJECTIVES set forth, usually in broad terms, what the candidate should be able to do in actual practice. Included in these learning objectives are certain methodologies that may not be possible to perform on an examination, such as complex simulations, but that the candidate would still be expected to explain conceptually in the context of an examination.

KNOWLEDGE STATEMENTS identify some of the key terms, concepts, and methods that are associated with each learning objective. These knowledge statements are not intended to represent an exhaustive list of topics that may be tested, but they are illustrative of the scope of each learning objective.

READINGS support the learning objectives. It is intended that the readings, in conjunction with the material on the lower numbered examinations, provide sufficient resources to allow the candidate to perform the learning objectives. Some readings are cited for more than one learning objective. The Syllabus and Examination Committees emphasize that candidates are expected to use the readings cited in this *Syllabus* as their primary study materials.

Thus, the learning objectives, knowledge statements, and readings complement each other. The learning objectives define the behaviors, the knowledge statements illustrate more fully the intended scope of the learning objectives, and the readings provide the source material to achieve the learning objectives. Learning objectives should not be seen as independent units, but as building blocks for the understanding and integration of important competencies that the candidate will be able to demonstrate.

Note that the range of weights shown should be viewed as a guideline only. There is no intent that they be strictly adhered to on any given examination—the actual weight may fall outside the published range on any particular examination.

The overall section weights should be viewed as having more significance than the weights for the individual learning objectives. Over a number of years of examinations, absent changes, it is likely that the average of the weights for each individual overall section will be in the vicinity of the guideline weight. For the weights of individual learning objectives, such convergence is less likely. On a given examination, in which it is very possible that not every individual learning objective will be tested, there will be more divergence of guideline weights and actual weights. Questions on a given learning objective may be drawn from any of the listed readings, or a combination of the readings. There may be no questions from one or more readings on a particular exam.

After each set of learning objectives, the readings are listed in abbreviated form. Complete text references are provided at the end of this exam syllabus.

Items marked with a bold **OP** (Online Publication) are available at no charge and may be downloaded from links in the Complete Text References section below. Books and other publications marked with a bold **B** may be purchased from the publisher or a bookstore (with limited copies available to be borrowed from the CAS Library). Items marked with a bold **BO** are optional books that may be purchased from the publisher or bookstore.

Please check the "Syllabus Update" for this exam for any changes to this syllabus.

The CAS will grant credit for CAS Exam LC to those who successfully complete SOA Exam MLC (Models for Life Contingencies) in the current education structure.

A thorough knowledge of calculus, probability, and interest theory is assumed. Knowledge of risk management at the level of Exam 1 is also assumed.

This examination develops the candidate's knowledge of the theoretical basis of contingent payment models and the application of those models to insurance risks.

The candidate will be required to develop an understanding of contingent payment models. The candidate will be expected to understand what important results can be obtained from these models for the purpose of making business decisions, and what approaches can be used to determine these results.

A variety of tables will be provided to the candidate with the exam. The tables include values for the standard normal distribution and illustrative life tables. Since they will be included with the examination, candidates will not be allowed to bring copies of the tables into the examination room.

The CAS will test the candidate's knowledge of topics that are presented in the learning objectives. Thus, the candidate should expect that each exam will cover a large proportion of the learning objectives and associated knowledge statements and syllabus readings, and that all of these will be tested at least once over the course of a few years—but each one may not be covered on each exam.

A guessing adjustment will be used in grading Exam LC. Details are provided under "Guessing Adjustment" in the "Rules-The Examination" section of the CAS Syllabus of Basic Education.

A. Survival Models

Range of weight for Section A: 65-70 percent

Candidates should be able to work with discrete and continuous univariate probability distributions for failure time random variables. They will be expected to set up and solve equations in terms of life table functions, cumulative distribution functions, survival functions, probability density functions, and hazard functions (e.g., force of mortality), as appropriate. They should have similar facility with models of the joint distribution of two failure times (multiple lives) and the joint distribution of competing risks (multiple decrement).

Candidates should be able to use Markov Chains in order to determine state probabilities and transition probabilities.

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
1. For discrete and continuous univariate probability distributions for failure time random variables, develop expressions in terms of the life table functions, l_x, q_x, p_x, $_nq_x$, $_np_x$, and $_{m|n}q_x$, for the cumulative distribution function, the survival function, the probability density function and the hazard function (force of mortality), and be able to: • Establish relations between the different functions • Develop expressions, including recursion relations, in terms of the functions for probabilities and moments associated with functions of failure time random variables, and calculate such quantities using simple failure time distributions The distributions may be left-truncated, right-censored, both, or neither. Range of weight: 10-20 percent	a. Failure time random variables b. Life table functions c. Cumulative distribution functions d. Survival functions e. Probability density functions f. Hazard functions g. Relationships between failure time random variables in the functions above
READINGS	
Cunningham et al., Chapters 5.1-5.3 and 6.1-6.4	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
2. Assuming a uniform distribution of deaths, define the continuous survival time random variable that arises from the discrete survival time random variable. Range of weight: 5-10 percent	a. Life table function forms under uniform distribution of deaths assumption
READINGS	
Cunningham et al., Chapter 6.6	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
3. Given the joint distribution of two failure times: • Calculate probabilities and moments associated with functions of these random variables' variances. • Characterize the distribution of the smaller failure time (the joint life status) and the larger failure time (the last survivor status) in terms of functions analogous to those in the Learning Objective 1 above, as appropriate. • Develop expressions, including recursion relations, for probabilities and moments of functions of the joint life status and the last survivor status, and express these in terms of the univariate functions in Learning Objective A1 above (assuming independence of the two failure times). Range of weight: 10-20 percent	a. Joint distribution of failure times b. Probabilities and moments
READINGS	
Cunningham et al., Chapters 12.1-12.2 and 12.6	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
4. Based on the joint distribution (pdf and cdf) of the time until failure and the cause of failure in the competing risk (multiple decrement) model and in terms of the functions $l_x^{(t)}$, $_tq_x^{(t)}$, $_tp_x^{(t)}$, $_td_x^{(t)}$: • Establish relations between the functions. • Calculate probabilities and moments associated with functions of these random variables, given the joint distribution of the time of failure and the cause of failure. Note: Candidates will not be tested on the absolute rate of death ($q_x^{'(1)}$) Range of weight: 10-20 percent	a. Time until failure b. Competing risk (multiple decrement) models
READINGS	
Cunningham et al., Chapters 13.1-13.3	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
5. For homogenous and non-homogenous discrete-time Markov chain models: • Define each model. • Calculate probabilities of being in a particular state at a particular time. • Calculate probabilities of transitioning between states. Range of weight: 10-20 percent	a. Markov chains b. Transition probability matrix c. Discrete-time Markov chains
READINGS	
Daniel Markov, Chapters 1 and 3	

B. Life Contingency Models

Range of weight for Section B: 30-35 percent

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
1. Apply a principle to a present value model to associate a cost or pattern of costs (possibly contingent) with a set of future contingent cash flows. Range of weight: 20-25 percent	a. Principles include: equivalence, exponential, standard deviation, variance, and percentile b. Models including those listed in Learning Objective A: Survival Models. c. Principle applications include: life insurance, annuities, health care, credit risk, environmental risk, consumer behavior (e.g., subscriptions), and warranties
READINGS	
Cunningham et al., Chapters 7.1-7.3, 8.1-8.3, 9.1.1-9.1.3, 9.2, and 9.4	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
2. Using present-value-of-benefit random variables extended to discrete time Markov chains, calculate: • Actuarial present values of cash flows at transitions between states • Actuarial present values of cash flows while in a state • Considerations (premiums) using the Equivalence Principle Range of weight: 5-15 percent	a. Cash flows at transition b. Triple product summation c. Transition probabilities
READINGS	
Daniel Markov, Chapters 2 and 3	

Complete Text References for Exam LC

Text references are alphabetized by the citation column.

Citation	Abbreviation	Learning Objectives	Source
Cunningham, R.; Herzog, T.; and London, R., *Models for Quantifying Risk* (Fifth Edition), 2012, ACTEX Publications, Chapters 5.1-5.3, 6.1-6.4, 6.6, 7.1-7.3, 8.1-8.3, 9.1.1-9.1.3, 9.2, 9.4, 12.1-12.2, 12.6, and 13.1-13.3. Candidates are not responsible for formulae 6.51 through 6.55 nor are they responsible for the "Hyperbolic (Balducci)" column of Table 6.3. Note: Note: Candidates may use the Fourth Edition in place of the Fifth Edition. Text references for the Fourth Edition are identical to those listed for the Fifth Edition.	Cunningham et al.	A1-A4, B1	**B**
Daniel, J.W., "Multi-state Transition Models with Actuarial Applications," Study Note, 2004 (second printing with minor corrections, October 2007).	Daniel Markov	A5, B2	**OP**

Source Key

B   Book—may be purchased from the publisher or bookstore or borrowed from the CAS Library.

OP   All text references marked as Online Publications will be available on a web page titled Complete Text References.

Publishers and Distributors for Exam LC

Contact information is furnished for those who wish to purchase the text references cited for Exam LC. Publishers and distributors are independent and listed for the convenience of candidates; inclusion does not constitute endorsement by the CAS.

ACTEX Publications, 107 Groppo Drive, Suite A, P.O. Box 974, Winsted, CT 06098; telephone: (800) 282-2839 or (860) 379-5470; fax: (860) 738-3152; e-mail: retail@actexmadriver.com; Website: www.actexmadriver.com.

Actuarial Bookstore, P.O. Box 69, Greenland, NH 03840; telephone: (800) 582-9672 (U.S. only) or (603) 430-1252; fax: (603) 430-1258; Website: www.actuarialbookstore.com.

Cunningham, R.; Herzog, T.; and London, R, *Models for Quantifying Risk* (Fifth Edition), 2012, ACTEX Publications, Inc., 140 Willow Street, Suite One, P.O. Box 974, Winsted, CT 06098; telephone: (800) 282-2839 or (860) 379-5470; fax: (860) 738-3152; Website: www.actexmadriver.com; e-mail: retail@actexmadriver.com.

Mad River Books (A division of ACTEX Publications), 140 Willow Street, Suite One, P.O. Box 974, Winsted, CT 06098; telephone: (800) 282-2839 or (860) 379-5470; fax: (860) 738-3152; e-mail: retail@actexmadriver.com.

SlideRule Books, P.O. Box 69, Greenland, NH 03840; telephone: (877) 407-5433 or (603) 373-6140; fax: (877) 417-5433 or (603) 430-1258; Website: www.sliderulebooks.com.

Tables for CAS Exam LC

Updated 2013

The following tables will be provided to the candidate with the exam. The tables are reprinted with the permission of the Society of Actuaries.

Tables of the Normal Distribution

Probability Content from -∞ to Z

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.0	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990

Values of z for selected values of Pr(Z<z)

z	0.842	1.036	1.282	1.645	1.960	2.326	2.576
Pr(Z<z)	0.800	0.850	0.900	0.950	0.975	0.990	0.995

Illustrative Life Table: Basic Functions and Single Benefit Premiums at $i = 0.06$

x	l_x	$1000q_x$	$\ddot{a}_x$	$1000A_x$	$1000(^2A_x)$	1000_5E_x	$1000_{10}E_x$	$1000_{20}E_x$	x
0	10,000,000	20.42	16.8010	49.00	25.92	728.54	541.95	299.89	0
5	9,749,503	0.98	17.0379	35.59	8.45	743.89	553.48	305.90	5
10	9,705,588	0.85	16.9119	42.72	9.37	744.04	553.34	305.24	10
15	9,663,731	0.91	16.7384	52.55	11.33	743.71	552.69	303.96	15
20	9,617,802	1.03	16.5133	65.28	14.30	743.16	551.64	301.93	20
21	9,607,896	1.06	16.4611	68.24	15.06	743.01	551.36	301.40	21
22	9,597,695	1.10	16.4061	71.35	15.87	742.86	551.06	300.82	22
23	9,587,169	1.13	16.3484	74.62	16.76	742.68	550.73	300.19	23
24	9,576,288	1.18	16.2878	78.05	17.71	742.49	550.36	299.49	24
25	9,565,017	1.22	16.2242	81.65	18.75	742.29	549.97	298.73	25
26	9,553,319	1.27	16.1574	85.43	19.87	742.06	549.53	297.90	26
27	9,541,153	1.33	16.0873	89.40	21.07	741.81	549.05	297.00	27
28	9,528,475	1.39	16.0139	93.56	22.38	741.54	548.53	296.01	28
29	9,515,235	1.46	15.9368	97.92	23.79	741.24	547.96	294.92	29
30	9,501,381	1.53	15.8561	102.48	25.31	740.91	547.33	293.74	30
31	9,486,854	1.61	15.7716	107.27	26.95	740.55	546.65	292.45	31
32	9,471,591	1.70	15.6831	112.28	28.72	740.16	545.90	291.04	32
33	9,455,522	1.79	15.5906	117.51	30.63	739.72	545.07	289.50	33
34	9,438,571	1.90	15.4938	122.99	32.68	739.25	544.17	287.82	34
35	9,420,657	2.01	15.3926	128.72	34.88	738.73	543.18	286.00	35
36	9,401,688	2.14	15.2870	134.70	37.26	738.16	542.11	284.00	36
37	9,381,566	2.28	15.1767	140.94	39.81	737.54	540.92	281.84	37
38	9,360,184	2.43	15.0616	147.46	42.55	736.86	539.63	279.48	38
39	9,337,427	2.60	14.9416	154.25	45.48	736.11	538.22	276.92	39
40	9,313,166	2.78	14.8166	161.32	48.63	735.29	536.67	274.14	40
41	9,287,264	2.98	14.6864	168.69	52.01	734.40	534.99	271.12	41
42	9,259,571	3.20	14.5510	176.36	55.62	733.42	533.14	267.85	42
43	9,229,925	3.44	14.4102	184.33	59.48	732.34	531.12	264.31	43
44	9,198,149	3.71	14.2639	192.61	63.61	731.17	528.92	260.48	44
45	9,164,051	4.00	14.1121	201.20	68.02	729.88	526.52	256.34	45
46	9,127,426	4.31	13.9546	210.12	72.72	728.47	523.89	251.88	46
47	9,088,049	4.66	13.7914	219.36	77.73	726.93	521.03	247.08	47
48	9,045,679	5.04	13.6224	228.92	83.06	725.24	517.91	241.93	48
49	9,000,057	5.46	13.4475	238.82	88.73	723.39	514.51	236.39	49
50	8,950,901	5.92	13.2668	249.05	94.76	721.37	510.81	230.47	50
51	8,897,913	6.42	13.0803	259.61	101.15	719.17	506.78	224.15	51
52	8,840,770	6.97	12.8879	270.50	107.92	716.76	502.40	217.42	52
53	8,779,128	7.58	12.6896	281.72	115.09	714.12	497.64	210.27	53
54	8,712,621	8.24	12.4856	293.27	122.67	711.24	492.47	202.70	54
55	8,640,861	8.96	12.2758	305.14	130.67	708.10	486.86	194.72	55
56	8,563,435	9.75	12.0604	317.33	139.11	704.67	480.79	186.32	56
57	8,479,908	10.62	11.8395	329.84	147.99	700.93	474.22	177.53	57
58	8,389,826	11.58	11.6133	342.65	157.33	696.85	467.12	168.37	58
59	8,292,713	12.62	11.3818	355.75	167.13	692.41	459.46	158.87	59
60	8,188,074	13.76	11.1454	369.13	177.41	687.56	451.20	149.06	60
61	8,075,403	15.01	10.9041	382.79	188.17	682.29	442.31	139.00	61
62	7,954,179	16.38	10.6584	396.70	199.41	676.56	432.77	128.75	62
63	7,823,879	17.88	10.4084	410.85	211.13	670.33	422.54	118.38	63
64	7,683,979	19.52	10.1544	425.22	223.34	663.56	411.61	107.97	64
65	7,533,964	21.32	9.8969	439.80	236.03	656.23	399.94	97.60	65

Illustrative Life Table: Basic Functions and Single Benefit Premiums at $i = 0.06$

x	l_x	$1000q_x$	$\ddot{a}_x$	$1000A_x$	$1000(^2A_x)$	1000_5E_x	$1000_{10}E_x$	$1000_{20}E_x$	x
66	7,373,338	23.29	9.6362	454.56	249.20	648.27	387.53	87.37	66
67	7,201,635	25.44	9.3726	469.47	262.83	639.66	374.36	77.38	67
68	7,018,432	27.79	9.1066	484.53	276.92	630.35	360.44	67.74	68
69	6,823,367	30.37	8.8387	499.70	291.46	620.30	345.77	58.54	69
70	6,616,155	33.18	8.5693	514.95	306.42	609.46	330.37	49.88	70
71	6,396,609	36.26	8.2988	530.26	321.78	597.79	314.27	41.86	71
72	6,164,663	39.62	8.0278	545.60	337.54	585.25	297.51	34.53	72
73	5,920,394	43.30	7.7568	560.93	353.64	571.81	280.17	27.96	73
74	5,664,051	47.31	7.4864	576.24	370.08	557.43	262.31	22.19	74
75	5,396,081	51.69	7.2170	591.49	386.81	542.07	244.03	17.22	75
76	5,117,152	56.47	6.9493	606.65	403.80	525.71	225.46	13.04	76
77	4,828,182	61.68	6.6836	621.68	421.02	508.35	206.71	9.61	77
78	4,530,360	67.37	6.4207	636.56	438.42	489.97	187.94	6.88	78
79	4,225,163	73.56	6.1610	651.26	455.95	470.57	169.31	4.77	79
80	3,914,365	80.30	5.9050	665.75	473.59	450.19	151.00	3.19	80
81	3,600,038	87.64	5.6533	680.00	491.27	428.86	133.19	2.05	81
82	3,284,542	95.61	5.4063	693.98	508.96	406.62	116.06	1.27	82
83	2,970,496	104.28	5.1645	707.67	526.60	383.57	99.81	0.75	83
84	2,660,734	113.69	4.9282	721.04	544.15	359.79	84.59	0.42	84
85	2,358,246	123.89	4.6980	734.07	561.57	335.40	70.56	0.22	85
86	2,066,090	134.94	4.4742	746.74	578.80	310.56	57.83	0.11	86
87	1,787,299	146.89	4.2571	759.03	595.79	285.44	46.50	0.05	87
88	1,524,758	159.81	4.0470	770.92	612.51	260.21	36.61	0.02	88
89	1,281,083	173.75	3.8442	782.41	628.92	235.11	28.17	0.01	89
90	1,058,491	188.77	3.6488	793.46	644.96	210.36	21.13	0.00	90
91	858,676	204.93	3.4611	804.09	660.61	186.21	15.41	0.00	91
92	682,707	222.27	3.2812	814.27	675.83	162.90	10.91	0.00	92
93	530,959	240.86	3.1091	824.01	690.59	140.69	7.47	0.00	93
94	403,072	260.73	2.9450	833.30	704.86	119.79	4.93	0.00	94
95	297,981	281.91	2.7888	842.14	718.61	100.43	3.13	0.00	95
96	213,977	304.45	2.6406	850.53	731.83	82.78	1.90	0.00	96
97	148,832	328.34	2.5002	858.48	744.50	66.97	1.10	0.00	97
98	99,965	353.60	2.3676	865.99	756.60	53.09	0.60	0.00	98
99	64,617	380.20	2.2426	873.06	768.13	41.14	0.31	0.00	99
100	40,049	408.12	2.1252	879.70	779.08	31.12	0.15	0.00	100
101	23,705	437.28	2.0152	885.93	789.44	22.91	0.07	0.00	101
102	13,339	467.61	1.9123	891.76	799.21	16.37	0.03	0.00	102
103	7,101	498.99	1.8164	897.19	808.41	11.33	0.01	0.00	103
104	3,558	531.28	1.7273	902.23	817.02	7.56	0.00	0.00	104
105	1,668	564.29	1.6447	906.90	825.06	4.86	0.00	0.00	105
106	727	597.83	1.5685	911.22	832.53	2.99	0.00	0.00	106
107	292	631.64	1.4984	915.19	839.46	1.76	0.00	0.00	107
108	108	665.45	1.4341	918.82	845.84	0.98	0.00	0.00	108
109	36	698.97	1.3755	922.14	851.69	0.52	0.00	0.00	109
110	11	731.87	1.3223	925.15	857.04	0.26	0.00	0.00	110

Interest Functions

Interest Functions at $i = 0.06$

m	$i^{(m)}$	$d^{(m)}$	$i/i^{(m)}$	$d/d^{(m)}$	$\alpha(m)$	$\beta(m)$
1	0.06000	0.05660	1.00000	1.00000	1.00000	0.00000
2	0.05913	0.05743	1.01478	0.98564	1.00021	0.25739
4	0.05870	0.05785	1.02223	0.97852	1.00027	0.38424
12	0.05841	0.05813	1.02721	0.97378	1.00028	0.46812
∞	0.05827	0.05827	1.02971	0.97142	1.00028	0.50985

Special Note: Unless specified, the force of interest is constant in each question .

Spring and Fall 2015 Exam ST Syllabus
Models for Stochastic Processes and Statistics

The syllabus for this two-and-a-half-hour exam is defined in the form of learning objectives, knowledge statements, and readings.

LEARNING OBJECTIVES set forth, usually in broad terms, what the candidate should be able to do in actual practice. Included in these learning objectives are certain methodologies that may not be possible to perform on an examination, such as calculating the likelihood ratio test when there is no closed from solution, but that the candidate would still be expected to explain conceptually in the context of an examination.

KNOWLEDGE STATEMENTS identify some of the key terms, concepts, and methods that are associated with each learning objective. These knowledge statements are not intended to represent an exhaustive list of topics that may be tested, but they are illustrative of the scope of each learning objective.

READINGS support the learning objectives. It is intended that the readings, in conjunction with the material on the lower numbered examinations, provide sufficient resources to allow the candidate to perform the learning objectives. Some readings are cited for more than one learning objective. The Syllabus and Examination Committees emphasize that candidates are expected to use the readings cited in this *Syllabus* as their primary study materials.

Thus, the learning objectives, knowledge statements, and readings complement each other. The learning objectives define the behaviors, the knowledge statements illustrate more fully the intended scope of the learning objectives, and the readings provide the source material to achieve the learning objectives. Learning objectives should not be seen as independent units, but as building blocks for the understanding and integration of important competencies that the candidate will be able to demonstrate.

Note that the range of weights shown should be viewed as a guideline only. There is no intent that they be strictly adhered to on any given examination—the actual weight may fall outside the published range on any particular examination.

The overall section weights should be viewed as having more significance than the weights for the individual learning objectives. Over a number of years of examinations, absent changes, it is likely that the average of the weights for each individual overall section will be in the vicinity of the guideline weight. For the weights of individual learning objectives, such convergence is less likely. On a given examination, in which it is very possible that not every individual learning objective will be tested, there will be more divergence of guideline weights and actual weights. Questions on a given learning objective may be drawn from any of the listed readings, or a combination of the readings. There may be no questions from one or more readings on a particular exam.

After each set of learning objectives, the readings are listed in abbreviated form. Complete text references are provided at the end of this exam syllabus.

A thorough knowledge of calculus and probability is assumed, as is familiarity with discounting cash flows. While some problems may have an insurance or risk management theme, no prior knowledge of insurance terminology is expected.

In general, the material covered under the Statistics section covers topics that would be commonly found in a second semester course of a two-semester Probability & Statistics sequence at the undergraduate level. Coverage of the topics listed under the Statistics section will vary by college and the candidate may need to supplement that course work with additional reading and problem solving work from the suggested textbooks listed at the end of section B.

A variety of tables will be provided to the candidate with the exam. The tables include values for the standard normal distribution, abridged inventories of discrete and continuous probability distributions, Chi-square Distribution, *t*-Distribution, *F*-Distribution as well as the tables required to perform the Signed-Rank test and Mann Whitney tests from the non-parametric section. Since they will be included with the examination, candidates will not be allowed to bring copies of the tables into the examination room.

The CAS will test the candidate's knowledge of topics that are presented in the learning objectives. Thus, the candidate should expect that each exam will cover a large proportion of the learning objectives and associated knowledge statements and syllabus readings, and that all of these will be tested at least once over the course of a few years—but each one may not be covered on each exam

A guessing adjustment will be used in grading Exam ST. Details are provided under "Guessing Adjustment" in the "Rules-The Examination" section.

A. Stochastic Processes

Range of weight for Section A: 5-15 percent

Candidates should be able to solve problems using stochastic processes. They should be able to determine the probabilities and distributions associated with these processes. Specifically, candidates should be able to use a Poisson process in these applications.

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
1. Describe the properties of Poisson processes: • For increments in the homogeneous case • For interval times in the homogeneous case • For increments in the non-homogeneous case • Resulting from special types of events in the Poisson process • Resulting from sums of independent Poisson processes Range of weight: 0-5 percent	a. Poisson process b. Non-homogeneous Poisson process

2. For any Poisson process and the inter - arrival and waiting distributions associated with the Poisson process, calculate: • Expected values • Variances • Probabilities Range of weight: 0-5 percent	a. Probability calculations for Poisson process
3. For a compound Poisson process, calculate moments associated with the value of the process at a given time. Range of weight: 0-5 percent	• Compound Poisson process
READINGS	
Daniel Poisson	

B. Statistics

Range of weight for Section B: 85-95 percent

Candidates should have a thorough understanding of the concepts typically covered in the 2nd semester of a two semester undergraduate sequence in Probability and Statistics. The specific topics to be tested are described below.

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
1. Perform point estimation of statistical parameters using Maximum likelihood estimation ("MLE"). Apply criteria to the estimates such as: • Consistency • Unbiasedness • Sufficiency • Efficiency • Minimum variance • Mean square error Range of weight: 15-25 percent	a. Equations for MLE of mean, variance from a sample b. Estimation of mean and variance based on sample c. General equations for MLE of parameters d. Recognition of consistency property of estimators and alternative measures of consistency e. Application of criteria for measurement when estimating parameters through minimization of variance, mean square error f. Definition of statistical bias and recognition of estimators that are unbiased or biased g. Application of Rao-Cramer Lower Bound and Efficiency h. Relationship between Sufficiency and Minimum Variance i. Develop and estimate a sufficient statistic for a distribution j. Factorization Criterion for sufficiency k. Application of Rao-Cramer Lower Bound and Fisher Information l. Application of MVUE for the exponential class of distributions

2. Test statistical hypotheses including Type I and Type II errors using: • Neyman-Pearson lemma • Likelihood ratio tests • First principles Apply Neyman-Pearson lemma to construct likelihood ratio equation. Use critical values from a sampling distribution to test means and variances Range of weight: 15-25 percent	a. Presentation of fundamental inequalities based on general assumptions and normal assumptions b. Definition of Type I and Type II errors c. Significance levels d. One-sided versus two-sided tests e. Estimation of sample sizes under normality to control for Type I and Type II errors f. Determination of critical regions g. Definition and measurement of likelihood ratio tests h. Determining parameters and testing using tabular values i. Recognizing when to apply likelihood ratio tests versus chi-square or other goodness of fit tests j. Apply paired t-test to two samples k. Test for difference in variance under Normal distribution between two samples through application of F-test l. Test of significance of means from two samples under Normal distribution assumption in both large and small sample cases m. Test for significance of difference in proportions between two samples under Binomial distribution assumption in both large and small sample case n. Application of contingency tables to test independence between effects o. Asymptotic relationship between likelihood ratio tests and the Chi-Square distribution p. Application of Neyman-Pearson lemma to Uniformly Most Powerful hypothesis tests q. Equivalence between critical regions and confidence intervals
3. Calculate order statistics of a sample for a given distribution and use non parametric statistics to describe a data set. Range of weight 5-15 percent	a. General form for distribution of nth largest element of a set b. Application to a given distributional form c. Calculate Spearman's Rho and Kendall's Tau and understand how those correlation measures differ from the Pearson correlation coefficient d. Apply rank order statistics using Sign-Rank Wilcoxon e. Apply rank order statistics using Sign Test f. Apply rank order statistics using Mann-Whitney-Wilcoxon Procedure
4. Test parameters from Normal Models Range of weight 5-15 percent	a. Calculate student's t test for regression parameter results b. Calculate F test to compare two models (either Regression or ANOVA) c. Calculate student's t test to compare means in ANOVA

5.	Bayesian Statistics parameter estimation for conjugate prior and posterior distributions :	a. Calculate Bayesian Point Estimates for the three conjugate prior distributions listed on the Learning Objective
	Beta-Binomial Normal-Normal Gamma-Poisson Range of weight 10-20 percent	b. Calculate Bayesian Interval estimates for the three conjugate prior distributions listed on the Learning Objective

READINGS
There is no single required text for Section B The texts listed below may be considered as representative of the many texts available to cover the material on which the candidate may be examined based on the learning objectives and knowledge statements. One should note that the Schaum's Outline Series referenced below are not textbooks, but they do provide a fair number of practice problems and examples with worked solutions which may be useful to candidates as a review of past course work. *In the Hints on Study and Exam Techniques for Exam ST we have included a table showing which sections of the texts listed below are good starting points to learn more about topics described in the Knowledge Statements, but any single section in one of the texts cited should not be viewed as the definitive source for problems on Exam ST.* Asimow and Maxwell Hogg and Tanis Hogg et al. Larsen and Marx Wackerly, Mendenhall, and Scheaffer. Hsu Salvatore and Reagle Spiegel and Stevens Schiller, Srinivasan, Spiegel

Complete Text References for Exam ST

Text references are alphabetized by the citation column.

Citation	Abbreviation	Learning Objectives	Source
Asimow, L.A.; and Maxwell, M.A., *Probability and Statistics with Applications: A Problem Solving Text*, 2010, ACTEX Publications, Inc.	Asimow and Maxwell	B1-B5	**BO**
Daniel, J.W., "Poisson processes (and mixture distributions)," Study Note, June 2008.	Daniel Poisson	A1-A3	**OP**
Hogg, R.V.; McKean, J.W.; and Craig, A.T., *Introduction to Mathematical Statistics* (Seventh Edition), 2013, Prentice Hall.	Hogg et al.	B1-B5	**BO**
Hogg, R.V.; and Tanis, E., *Probability and Statistical Inference* (Eighth Edition), 2010, Prentice Hall.	Hogg and Tanis	B1-B5	**BO**
Larsen, R.J.; and Marx, M.L., *An Introduction to Mathematical Statistics and Its Applications* (Fifth Edition), 2012, Pearson Education, Inc.	Larsen and Marx	B1-B5	**BO**

Wackerly, D.; Mendenhall, W.; and Scheaffer, R., *Mathematical Statistics with Applications* (7th edition), 2008, Cengage Learning	Wackerly, Mendenhall, and Scheaffer	B1-B5	**BO**
Hsu, Hewi P*., Schaum's Outline of Probability, Random Variables, and Random Processes*, Second Edition (Schaum's Outline Series), 2010, McGraw Hill	Hsu	B1	**BO**
Salvatore, Dominick, and Reagele, Derrick, *Schaum's Outline of Statistics and Econometrics*, (Second Edition Schaum's Outline Series), 2010, McGraw Hill	Salvatore and Reagle	B2-B4	**BO**
Spiegel, Murray and Stephens, Larry, *Schaum's Outline of Statistics*, (Fourth Edition Schaum's Outline Series), 2011, McGraw Hill	Spiegel and Stevens	B1-B4	**BO**
Schiller, John, Srinivasan, R.,Spiegel, Murray, *Schaum's Outline of Probability and Statistics*, (Fourth Edition Schaum's Outline Series), 2013, McGraw Hill	Schiller, Srinivasan, Spiegel	B1-B5	**BO**

Source Key

B   Book—may be purchased from the publisher or bookstore or borrowed from the CAS Library.

BO   Book (Optional)—may be purchased from the publisher or bookstore.

OP   All text references marked as Online Publications will be available on a web page titled Complete Text References.

Publishers and Distributors for Exam ST

Contact information is furnished for those who wish to purchase the text references cited for Exam ST. Publishers and distributors are independent and listed for the convenience of candidates; inclusion does not constitute endorsement by the CAS.

ACTEX Publications, 107 Groppo Drive, Suite A, P.O. Box 974, Winsted, CT 06098; telephone: (800) 282-2839 or (860) 379-5470; fax: (860) 738-3152; e-mail: retail@actexmadriver.com; Website: www.actexmadriver.com.

Actuarial Bookstore, P.O. Box 69, Greenland, NH 03840; telephone: (800) 582-9672 (U.S. only) or (603) 430-1252; fax: (603) 430-1258; Website: www.actuarialbookstore.com.

Asimow, L.A.; and Maxwell, M.A., *Probability and Statistics with Applications: A Problem Solving Text*, 2010, ACTEX Publications, Inc., 140 Willow Street, Suite One, P.O. Box 974, Winsted, CT 06098; telephone: (800) 282-2839 or (860) 379-5470; fax: (860) 738-3152; website: www.actexmadriver.com; e-mail: retail@actexmadriver.com.

Hogg, R.V.; Craig, A.T.; and McKean, J.W., *Introduction to Mathematical Statistics* (Seventh Edition), 2013, Prentice Hall, Inc., 200 Old Tappan Road, Old Tappan, NJ 07675; telephone: (800) 282-0693; Website: www.pearsonhighered.com.

Hogg, R.V.; and Tanis, E., *Probability and Statistical Inference* (Eighth Edition), 2010, Prentice Hall, Inc., 200 Old Tappan Road, Old Tappan, NJ 07675; telephone: (800) 282-0693; Website: www.pearsonhighered.com.

Larsen, R.J.; and Marx, M.L., *An Introduction to Mathematical Statistics and Its Applications* (Fifth Edition), 2012, Pearson Education, Inc., 200 Old Tappan Road, Old Tappan, NJ 07675; telephone: (800) 282-0693; Website: www.pearsonhighered.com.

Mad River Books (A division of ACTEX Publications), 140 Willow Street, Suite One, P.O. Box 974, Winsted, CT 06098; telephone: (800) 282-2839 or (860) 379-5470; fax: (860) 738-3152; e-mail: retail@actexmadriver.com.

Schaum's Outline Series (A division of McGraw Hill Education), 860 Taylor Station Road. Blacklick, Ohio 43004, telephone: (877) 833-5324,
Website: http://www.mhprofessional.com, Email: pbg.ecommerce_custserv@mcgraw-hill.com.

Section	Knowledge Statement	Hogg, McKean & Craig (7th) Section	Schiller, Srinivasan & Spiegel Chapter	Spiegel & Stevens Chapter	Salvatore & Reagle Chapter	Hsu Chapter	Hogg & Tannis (8th) Section	Asimov & Maxwell Section	Larsen & Marx 5th Edition Section	Wackerly Mendenhall & Scheafer Section
A.1	a. Equations for MLE of mean, variance from a sample	6.1	#N/A	#N/A	#N/A	#N/A	6.1	11.2.2	5.1-5.2	9.7
A.1	b. Estimation of mean and variance based on sample	2.8	5	3,4, 8	#N/A	#N/A	2.3	Various	5.1-5.2	8.6-8.9
A.1	c. General equations for MLE of parameters	4.1, 6.1	#N/A	#N/A	#N/A	7	6.1	11.2.2 (skip 11.1.1 - method of mo	5.1-5.2	9.7
A.1	d. Recognition of consistency property of estimators and alternative measures of consistency	5.1	#N/A	#N/A	6	7	#N/A	11.3	5.7	9.3
A.1	e. Application of criteria for measurement when estimating parameters through minimization of variance, mean square error	7.1	#N/A	#N/A	6		#N/A	11.3	5.5	8.2
A.1	f. Definition of statistical bias and recognition of estimators that are unbiased or biased	4.1	6	9	6	7	6.1	11.1	5.4	8.2
A.1	g. Application of Rao-Cramer Lower Bound and Efficiency	6.2	6	9	#N/A	#N/A	10.7	11.3	5.5	9.5
A.1	h. Relationship between Sufficiency and Minimum Variance	7.3, 7.4	#N/A	#N/A	#N/A	#N/A	10.1	#N/A	5.6	9.5
A.1	i. Develop and estimate a sufficient statistic for a distribution	7.2	#N/A	#N/A	#N/A	#N/A	10.1	#N/A	5.6	9.4
A.1	j. Factorization Criterion for sufficiency	7.2	#N/A	#N/A	#N/A	#N/A	10.1	#N/A	5.6	9.4
A.1	k. Application of Rao-Cramer Lower Bound and Fisher Information	6.2, 6.4	#N/A	#N/A	#N/A	#N/A	#N/A	11.3	5.5	9.5
A.1	l. Application of MVUE for the exponential class of distributions		#N/A	#N/A	#N/A	#N/A	6.1	11.3	5.2	9.8
A.2	a. Presentation of fundamental inequalities based on general assumptions and normal assumptions	4.5	7	10	5		7.1	10.1	6.2	10.2
A.2	b. Definition of Type I and Type II errors	4.5, 8.1	7	10	5		7.1	10.1	6.4	10.2
A.2	c. Significance levels	4.5, 8.1	7	10	5		7.1	10.1	6.2	10.2
A.2	d. One-sided versus two-sided tests	4.6, 6.2	7	10	5		7.1	10.1	6.2	10.2
A.2	e. Estimation of sample sizes under normality to control for Type I and Type II errors	4.5	7	10			7.2	11.4	6.4	10.2
A.2	f. Determination of critical regions	4.5	7	10, 11	5		7.1	11.4, 11.5	6.2	10.2
A.2	g. Definition and measurement of likelihood ratio tests	6.3, 8.1, 8.2 , 8.3					6.5			10.11
A.2	h. Determining parameters and testing using tabular values	4.5, 4.6	7	10	5		7.1-7.4, 10.3-10.4	10 - various	Normal 6.2, t 7.4, F 7.3, Ap	0
A.2	i. Recognizing when to apply likelihood ratio tests versus chi-square or other goodness of fit tests	4.7	7	12	5		7.1-7.4, 10.3-10.4	10.6	10.1, 10.3-10.4	0
A.2	j. Apply paired t-test to two samples	?	?	?	?	?	7.2	10.3	8.2, 13.3	12.3
A.2	k. Test for difference in variance under Normal distribution between two samples through application of F-test	8.3	5, 6, 7	9,11			7.4	10.5.3 (skip the rest of 10.5 becau	7.1-7.4	10.9
A.2	l. Test of significance of means from two samples under Normal distribution assumption in both large and small sample cases	4.5, 4.6, 5.3	5, 6, 7	9, 10, 11	5		7.3	10.2	7.2	10.8
A.2	m. Test for significance of difference in proportions between two samples under Binomial distribution assumption in both large and small sample case	4.5, 4.6, 5.3	5, 6 , 7	9, 10, 11	5		7.1	10.4	8.1-8.2, 9.4	10.8
A.2	n. Application of contingency tables to test independence between effects	4.7	7	12	5		8.2	10.6	10.5	14.4
A.2	o. Asymptotic relationship between likelihood ratio tests and the Chi-Square distribution	6.3, 6.5	#N/A	#N/A	#N/A	#N/A	10.4	11.4, 11.5	7.3	#N/A
A.2	p. Application of Neyman-Pearson lemma to Uniformly Most Powerful hypothesis tests	6.4, 8.1	#N/A	#N/A	#N/A	#N/A	10.3	11.4	N/A	10.1
A.2	q. Equivalence between critical regions and confidence intervals	4.6	#N/A	#N/A	#N/A	#N/A	6.2-6.5, 7.1	9.1, 9.2, 9.3, 9.4, 9.5, 9.6, 9.7	9.5	10.5
A.3	a. General form for distribution of nth largest element of a set	4.4	#N/A	#N/A	#N/A	#N/A	8.3	8.1.5	3.10	6.7
A.3	b. Application to a given distributional form	4.4	#N/A	#N/A	#N/A	#N/A	8.3	8.1.5	3.10	6.7
A.3	c. Calculate Spearman's Rho and Kendall's Tau and understand how those correlation measures differ from the Pearson correlation coefficent	10.8	8, 10	17	#N/A	#N/A	NA	#N/A	N/A	15.10-
A.3	d. Apply rank order statistics using Sign-Rank Wilcoxon	10.3	10	#N/A	5	#N/A	8.5	#N/A	14.3	15.3
A.3	e. Apply rank order statistics using Sign Test	10.2	#N/A	17	#N/A	#N/A	8.5	#N/A	14.2	15.4
A.3	f. Apply rank order statistics using Mann-Whitney-Wilcoxon Procedure	10.4	10	#N/A	#N/A	#N/A	8.5	#N/A	N/A	15.3
A.4	a. Calculate student's t test for regression parameter results	#N/A	#N/A	#N/A	#N/A	#N/A	7.7	11.7, 11.8	12.2	11.5
A.4	b. Calculate F test to compare two models (either Regression or ANOVA)	9.6	9	16	5	#N/A	7.5	11.7, 11.8	12.2	13.3
A.4	c. Calculate student's t test to compare means in ANOVA	#N/A	9	16	5	#N/A	7.3		12.2	13.3
A.5	Calculate Bayesian Point Estimates for the three conjugate prior distributions listed on the Learning Objective	11.1, 11.2, 11.3	11	#N/A	#N/A	#N/A	9.2	#N/A	5.8	16.2
A.5	b. Calculate Bayesian Interval estimates for the three conjugate prior distributions listed on the Learning Objective	11.1, 11.2, 11.3	11	#N/A	#N/A	#N/A	9.2	#N/A	5.8	16.3

Tables for
CAS Exam ST

Updated 2014

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We are furnishing a set of tables for statistical tests as well as a set of distribution functions for Exam ST. We do not have a single authoritative textbook for Statistics. The format of the tables may vary from one textbook to the next. The nomenclature used to describe distribution functions may vary from one textbook to the next. To avoid confusion on the part of the candidates we will use the tables and distribution functions definitions that follow when writing exam questions for Exam ST.

Tables of the Normal Distribution

Probability Content from -∞ to Z

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.0	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990

Values of z for selected values of Pr(Z<z)

z	0.842	1.036	1.282	1.645	1.960	2.326	2.576
Pr(Z<z)	0.800	0.850	0.900	0.950	0.975	0.990	0.995

Excerpts from the Appendices to *Loss Models: From Data to Decisions, 2nd edition*

April 21, 2005

Appendix A

An Inventory of Continuous Distributions

A.1   Introduction

The incomplete gamma function is given by

$$\Gamma(\alpha; x) = \frac{1}{\Gamma(\alpha)} \int_0^x t^{\alpha-1} e^{-t} \, dt, \quad \alpha > 0, \ x > 0$$

$$\text{with } \Gamma(\alpha) = \int_0^\infty t^{\alpha-1} e^{-t} \, dt, \quad \alpha > 0.$$

Also, define

$$G(\alpha; x) = \int_x^\infty t^{\alpha-1} e^{-t} \, dt, \quad x > 0.$$

Integration by parts produces the relationship

$$G(\alpha; x) = -\frac{x^\alpha e^{-x}}{\alpha} + \frac{1}{\alpha} G(\alpha + 1; x)$$

For negative α, this can repeated until the first argument is postive, say at $\alpha + k$. Then the incomplete gamma function can be evaluated from

$$G(\alpha + k; x) = \Gamma(\alpha + k)[1 - \Gamma(\alpha + k; x)].$$

The incomplete beta function is given by

$$\beta(a, b; x) = \frac{\Gamma(a+b)}{\Gamma(a)\Gamma(b)} \int_0^x t^{a-1} (1-t)^{b-1} \, dt, \quad a > 0, \ b > 0, \ 0 < x < 1.$$

A.2 Transformed beta family

A.2.3 Three-parameter distributions

A.2.3.1 Generalized Pareto (beta of the second kind)—α, θ, τ

$$f(x) = \frac{\Gamma(\alpha + \tau)}{\Gamma(\alpha)\Gamma(\tau)} \frac{\theta^\alpha x^{\tau-1}}{(x+\theta)^{\alpha+\tau}} \qquad F(x) = \beta(\tau, \alpha; u), \quad u = \frac{x}{x+\theta}$$

$$\mathrm{E}[X^k] = \frac{\theta^k \Gamma(\tau+k)\Gamma(\alpha-k)}{\Gamma(\alpha)\Gamma(\tau)}, \quad -\tau < k < \alpha$$

$$\mathrm{E}[X^k] = \frac{\theta^k \tau(\tau+1)\cdots(\tau+k-1)}{(\alpha-1)\cdots(\alpha-k)}, \quad \text{if } k \text{ is an integer}$$

$$\mathrm{E}[(X \wedge x)^k] = \frac{\theta^k \Gamma(\tau+k)\Gamma(\alpha-k)}{\Gamma(\alpha)\Gamma(\tau)}\beta(\tau+k, \alpha-k; u) + x^k[1-F(x)], \quad k > -\tau$$

$$\text{mode} = \theta\frac{\tau-1}{\alpha+1}, \quad \tau > 1, \text{ else } 0$$

A.2.3.2 Burr (Burr Type XII, Singh-Maddala)—α, θ, γ

$$f(x) = \frac{\alpha\gamma(x/\theta)^\gamma}{x[1+(x/\theta)^\gamma]^{\alpha+1}} \qquad F(x) = 1 - u^\alpha, \quad u = \frac{1}{1+(x/\theta)^\gamma}$$

$$\mathrm{E}[X^k] = \frac{\theta^k \Gamma(1+k/\gamma)\Gamma(\alpha-k/\gamma)}{\Gamma(\alpha)}, \quad -\gamma < k < \alpha\gamma$$

$$\mathrm{E}[(X \wedge x)^k] = \frac{\theta^k \Gamma(1+k/\gamma)\Gamma(\alpha-k/\gamma)}{\Gamma(\alpha)}\beta(1+k/\gamma, \alpha-k/\gamma; 1-u) + x^k u^\alpha, \quad k > -\gamma$$

$$\text{mode} = \theta\left(\frac{\gamma-1}{\alpha\gamma+1}\right)^{1/\gamma}, \quad \gamma > 1, \text{ else } 0$$

A.2.3.3 Inverse Burr (Dagum)—τ, θ, γ

$$f(x) = \frac{\tau\gamma(x/\theta)^{\gamma\tau}}{x[1+(x/\theta)^\gamma]^{\tau+1}} \qquad F(x) = u^\tau, \quad u = \frac{(x/\theta)^\gamma}{1+(x/\theta)^\gamma}$$

$$\mathrm{E}[X^k] = \frac{\theta^k \Gamma(\tau+k/\gamma)\Gamma(1-k/\gamma)}{\Gamma(\tau)}, \quad -\tau\gamma < k < \gamma$$

$$\mathrm{E}[(X \wedge x)^k] = \frac{\theta^k \Gamma(\tau+k/\gamma)\Gamma(1-k/\gamma)}{\Gamma(\tau)}\beta(\tau+k/\gamma, 1-k/\gamma; u) + x^k[1-u^\tau], \quad k > -\tau\gamma$$

$$\text{mode} = \theta\left(\frac{\tau\gamma-1}{\gamma+1}\right)^{1/\gamma}, \quad \tau\gamma > 1, \text{ else } 0$$

A.2.4 Two-parameter distributions

A.2.4.1 Pareto—α, θ

$$f(x) = \frac{\alpha\theta^\alpha}{(x+\theta)^{\alpha+1}} \qquad F(x) = 1 - \left(\frac{\theta}{x+\theta}\right)^\alpha$$

$$\mathrm{E}[X^k] = \frac{\theta^k \Gamma(k+1)\Gamma(\alpha-k)}{\Gamma(\alpha)}, \quad -1 < k < \alpha$$

$$\mathrm{E}[X^k] = \frac{\theta^k k!}{(\alpha-1)\cdots(\alpha-k)}, \quad \text{if } k \text{ is an integer}$$

$$\mathrm{E}[X \wedge x] = \frac{\theta}{\alpha-1}\left[1 - \left(\frac{\theta}{x+\theta}\right)^{\alpha-1}\right], \quad \alpha \neq 1$$

$$\mathrm{E}[X \wedge x] = -\theta \ln\left(\frac{\theta}{x+\theta}\right), \quad \alpha = 1$$

$$\mathrm{E}[(X \wedge x)^k] = \frac{\theta^k \Gamma(k+1)\Gamma(\alpha-k)}{\Gamma(\alpha)}\beta[k+1, \alpha-k; x/(x+\theta)] + x^k\left(\frac{\theta}{x+\theta}\right)^\alpha, \quad \text{all } k$$

$$\text{mode} = 0$$

A.2.4.2 Inverse Pareto—τ, θ

$$f(x) = \frac{\tau\theta x^{\tau-1}}{(x+\theta)^{\tau+1}} \qquad F(x) = \left(\frac{x}{x+\theta}\right)^\tau$$

$$\mathrm{E}[X^k] = \frac{\theta^k \Gamma(\tau+k)\Gamma(1-k)}{\Gamma(\tau)}, \quad -\tau < k < 1$$

$$\mathrm{E}[X^k] = \frac{\theta^k(-k)!}{(\tau-1)\cdots(\tau+k)}, \quad \text{if } k \text{ is a negative integer}$$

$$\mathrm{E}[(X \wedge x)^k] = \theta^k \tau \int_0^{x/(x+\theta)} y^{\tau+k-1}(1-y)^{-k}dy + x^k\left[1 - \left(\frac{x}{x+\theta}\right)^\tau\right], \quad k > -\tau$$

$$\text{mode} = \theta\frac{\tau-1}{2}, \quad \tau > 1, \text{ else } 0$$

A.2.4.3 Loglogistic (Fisk)—γ, θ

$$f(x) = \frac{\gamma(x/\theta)^\gamma}{x[1+(x/\theta)^\gamma]^2} \qquad F(x) = u, \quad u = \frac{(x/\theta)^\gamma}{1+(x/\theta)^\gamma}$$

$$\mathrm{E}[X^k] = \theta^k \Gamma(1+k/\gamma)\Gamma(1-k/\gamma), \quad -\gamma < k < \gamma$$

$$\mathrm{E}[(X \wedge x)^k] = \theta^k \Gamma(1+k/\gamma)\Gamma(1-k/\gamma)\beta(1+k/\gamma, 1-k/\gamma; u) + x^k(1-u), \quad k > -\gamma$$

$$\text{mode} = \theta\left(\frac{\gamma-1}{\gamma+1}\right)^{1/\gamma}, \quad \gamma > 1, \text{ else } 0$$

A.2.4.4   Paralogistic—α, θ

<center>This is a Burr distribution with $\gamma = \alpha$.</center>

$$
\begin{aligned}
f(x) &= \frac{\alpha^2(x/\theta)^\alpha}{x[1+(x/\theta)^\alpha]^{\alpha+1}} \qquad F(x) = 1 - u^\alpha, \quad u = \frac{1}{1+(x/\theta)^\alpha} \\
E[X^k] &= \frac{\theta^k\Gamma(1+k/\alpha)\Gamma(\alpha-k/\alpha)}{\Gamma(\alpha)}, \quad -\alpha < k < \alpha^2 \\
E[(X\wedge x)^k] &= \frac{\theta^k\Gamma(1+k/\alpha)\Gamma(\alpha-k/\alpha)}{\Gamma(\alpha)}\beta(1+k/\alpha, \alpha-k/\alpha; 1-u) + x^k u^\alpha, \quad k > -\alpha \\
\text{mode} &= \theta\left(\frac{\alpha-1}{\alpha^2+1}\right)^{1/\alpha}, \quad \alpha > 1, \text{ else } 0
\end{aligned}
$$

A.2.4.5   Inverse paralogistic—τ, θ

<center>This is an inverse Burr distribution with $\gamma = \tau$.</center>

$$
\begin{aligned}
f(x) &= \frac{\tau^2(x/\theta)^{\tau^2}}{x[1+(x/\theta)^\tau]^{\tau+1}} \qquad F(x) = u^\tau, \quad u = \frac{(x/\theta)^\tau}{1+(x/\theta)^\tau} \\
E[X^k] &= \frac{\theta^k\Gamma(\tau+k/\tau)\Gamma(1-k/\tau)}{\Gamma(\tau)}, \quad -\tau^2 < k < \tau \\
E[(X\wedge x)^k] &= \frac{\theta^k\Gamma(\tau+k/\tau)\Gamma(1-k/\tau)}{\Gamma(\tau)}\beta(\tau+k/\tau, 1-k/\tau; u) + x^k[1-u^\tau], \quad k > -\tau^2 \\
\text{mode} &= \theta\,(\tau-1)^{1/\tau}, \quad \tau > 1, \text{ else } 0
\end{aligned}
$$

A.3   Transformed gamma family

A.3.2   Two-parameter distributions

A.3.2.1   Gamma—α, θ

$$
\begin{aligned}
f(x) &= \frac{(x/\theta)^\alpha e^{-x/\theta}}{x\Gamma(\alpha)} \qquad F(x) = \Gamma(\alpha; x/\theta) \\
M(t) &= (1-\theta t)^{-\alpha}, \quad t < 1/\theta \qquad E[X^k] = \frac{\theta^k\Gamma(\alpha+k)}{\Gamma(\alpha)}, \quad k > -\alpha \\
E[X^k] &= \theta^k(\alpha+k-1)\cdots\alpha, \quad \text{if } k \text{ is an integer}
\end{aligned}
$$

$$
\begin{aligned}
E[(X\wedge x)^k] &= \frac{\theta^k\Gamma(\alpha+k)}{\Gamma(\alpha)}\Gamma(\alpha+k; x/\theta) + x^k[1-\Gamma(\alpha; x/\theta)], \quad k > -\alpha \\
&= \alpha(\alpha+1)\cdots(\alpha+k-1)\theta^k\Gamma(\alpha+k; x/\theta) + x^k[1-\Gamma(\alpha; x/\theta)], \quad k \text{ an integer} \\
\text{mode} &= \theta(\alpha-1), \quad \alpha > 1, \text{ else } 0
\end{aligned}
$$

A.3.2.2 Inverse gamma (Vinci)—α, θ

$$f(x) = \frac{(\theta/x)^\alpha e^{-\theta/x}}{x\Gamma(\alpha)} \qquad F(x) = 1 - \Gamma(\alpha; \theta/x)$$

$$\mathrm{E}[X^k] = \frac{\theta^k \Gamma(\alpha - k)}{\Gamma(\alpha)}, \quad k < \alpha \qquad \mathrm{E}[X^k] = \frac{\theta^k}{(\alpha - 1)\cdots(\alpha - k)}, \quad \text{if } k \text{ is an integer}$$

$$\mathrm{E}[(X \wedge x)^k] = \frac{\theta^k \Gamma(\alpha - k)}{\Gamma(\alpha)}[1 - \Gamma(\alpha - k; \theta/x)] + x^k \Gamma(\alpha; \theta/x)$$

$$= \frac{\theta^k \Gamma(\alpha - k)}{\Gamma(\alpha)}G(\alpha - k; \theta/x) + x^k \Gamma(\alpha; \theta/x), \text{ all } k$$

$$\text{mode} = \theta/(\alpha + 1)$$

A.3.2.3 Weibull—θ, τ

$$f(x) = \frac{\tau(x/\theta)^\tau e^{-(x/\theta)^\tau}}{x} \qquad F(x) = 1 - e^{-(x/\theta)^\tau}$$

$$\mathrm{E}[X^k] = \theta^k \Gamma(1 + k/\tau), \quad k > -\tau$$

$$\mathrm{E}[(X \wedge x)^k] = \theta^k \Gamma(1 + k/\tau)\Gamma[1 + k/\tau; (x/\theta)^\tau] + x^k e^{-(x/\theta)^\tau}, \quad k > -\tau$$

$$\text{mode} = \theta\left(\frac{\tau - 1}{\tau}\right)^{1/\tau}, \quad \tau > 1, \text{ else } 0$$

A.3.2.4 Inverse Weibull (log Gompertz)—θ, τ

$$f(x) = \frac{\tau(\theta/x)^\tau e^{-(\theta/x)^\tau}}{x} \qquad F(x) = e^{-(\theta/x)^\tau}$$

$$\mathrm{E}[X^k] = \theta^k \Gamma(1 - k/\tau), \quad k < \tau$$

$$\mathrm{E}[(X \wedge x)^k] = \theta^k \Gamma(1 - k/\tau)\{1 - \Gamma[1 - k/\tau; (\theta/x)^\tau]\} + x^k \left[1 - e^{-(\theta/x)^\tau}\right], \quad \text{all } k$$

$$= \theta^k \Gamma(1 - k/\tau)G[1 - k/\tau; (\theta/x)^\tau] + x^k \left[1 - e^{-(\theta/x)^\tau}\right]$$

$$\text{mode} = \theta\left(\frac{\tau}{\tau + 1}\right)^{1/\tau}$$

A.3.3 One-parameter distributions

A.3.3.1 Exponential—θ

$$f(x) = \frac{e^{-x/\theta}}{\theta} \qquad F(x) = 1 - e^{-x/\theta}$$

$$M(t) = (1 - \theta t)^{-1} \qquad \mathrm{E}[X^k] = \theta^k \Gamma(k + 1), \quad k > -1$$

$$\mathrm{E}[X^k] = \theta^k k!, \quad \text{if } k \text{ is an integer}$$

$$\mathrm{E}[X \wedge x] = \theta(1 - e^{-x/\theta})$$

$$\mathrm{E}[(X \wedge x)^k] = \theta^k \Gamma(k + 1)\Gamma(k + 1; x/\theta) + x^k e^{-x/\theta}, \quad k > -1$$

$$= \theta^k k!\Gamma(k + 1; x/\theta) + x^k e^{-x/\theta}, \quad k \text{ an integer}$$

$$\text{mode} = 0$$

A.3.3.2 Inverse exponential—θ

$$
\begin{aligned}
f(x) &= \frac{\theta e^{-\theta/x}}{x^2} \qquad F(x) = e^{-\theta/x} \\
\mathrm{E}[X^k] &= \theta^k \Gamma(1-k), \quad k < 1 \\
\mathrm{E}[(X \wedge x)^k] &= \theta^k G(1-k; \theta/x) + x^k(1 - e^{-\theta/x}), \quad \text{all } k \\
\text{mode} &= \theta/2
\end{aligned}
$$

A.4 Other distributions

A.4.1.1 Lognormal—μ,σ (μ can be negative)

$$
\begin{aligned}
f(x) &= \frac{1}{x\sigma\sqrt{2\pi}} \exp(-z^2/2) = \phi(z)/(\sigma x), \quad z = \frac{\ln x - \mu}{\sigma} \qquad F(x) = \Phi(z) \\
\mathrm{E}[X^k] &= \exp(k\mu + k^2\sigma^2/2) \\
\mathrm{E}[(X \wedge x)^k] &= \exp(k\mu + k^2\sigma^2/2)\Phi\left(\frac{\ln x - \mu - k\sigma^2}{\sigma}\right) + x^k[1 - F(x)] \\
\text{mode} &= \exp(\mu - \sigma^2)
\end{aligned}
$$

A.4.1.2 Inverse Gaussian—μ, θ

$$
\begin{aligned}
f(x) &= \left(\frac{\theta}{2\pi x^3}\right)^{1/2} \exp\left(-\frac{\theta z^2}{2x}\right), \quad z = \frac{x - \mu}{\mu} \\
F(x) &= \Phi\left[z\left(\frac{\theta}{x}\right)^{1/2}\right] + \exp\left(\frac{2\theta}{\mu}\right)\Phi\left[-y\left(\frac{\theta}{x}\right)^{1/2}\right], \quad y = \frac{x + \mu}{\mu} \\
M(t) &= \exp\left[\frac{\theta}{\mu}\left(1 - \sqrt{1 - \frac{2t\mu^2}{\theta}}\right)\right], \quad t < \frac{\theta}{2\mu^2}, \qquad \mathrm{E}[X] = \mu, \quad \mathrm{Var}[X] = \mu^3/\theta \\
\mathrm{E}[X \wedge x] &= x - \mu z\Phi\left[z\left(\frac{\theta}{x}\right)^{1/2}\right] - \mu y \exp\left(\frac{2\theta}{\mu}\right)\Phi\left[-y\left(\frac{\theta}{x}\right)^{1/2}\right]
\end{aligned}
$$

A.4.1.3 log-t—r, μ, σ (μ *can be negative*)

Let Y have a t distribution with r degrees of freedom. Then $X = \exp(\sigma Y + \mu)$ has the log-t distribution. Positive moments do not exist for this distribution. Just as the t distribution has a heavier tail than the normal distribution, this distribution has a heavier tail than the lognormal distribution.

$$
\begin{aligned}
f(x) &= \frac{\Gamma\left(\frac{r+1}{2}\right)}{x\sigma\sqrt{\pi r}\,\Gamma\left(\frac{r}{2}\right)\left[1 + \frac{1}{r}\left(\frac{\ln x - \mu}{\sigma}\right)^2\right]^{(r+1)/2}}, \\
F(x) &= F_r\left(\frac{\ln x - \mu}{\sigma}\right) \text{ with } F_r(t) \text{ the cdf of a } t \text{ distribution with } r \text{ d.f.,}
\end{aligned}
$$

$$F(x) = \begin{cases} \dfrac{1}{2}\beta\left[\dfrac{r}{2}, \dfrac{1}{2}; \dfrac{r}{r + \left(\dfrac{\ln x - \mu}{\sigma}\right)^2}\right], & 0 < x \le e^\mu, \\[4em] 1 - \dfrac{1}{2}\beta\left[\dfrac{r}{2}, \dfrac{1}{2}; \dfrac{r}{r + \left(\dfrac{\ln x - \mu}{\sigma}\right)^2}\right], & x \ge e^\mu. \end{cases}$$

A.4.1.4   Single-parameter Pareto—α, θ

$$f(x) = \frac{\alpha\theta^\alpha}{x^{\alpha+1}}, \quad x > \theta \qquad F(x) = 1 - (\theta/x)^\alpha, \quad x > \theta$$

$$E[X^k] = \frac{\alpha\theta^k}{\alpha - k}, \quad k < \alpha \qquad E[(X \wedge x)^k] = \frac{\alpha\theta^k}{\alpha - k} - \frac{k\theta^\alpha}{(\alpha - k)x^{\alpha-k}}$$

$$\text{mode} = \theta$$

Note: Although there appears to be two parameters, only α is a true parameter. The value of θ must be set in advance.

A.5   Distributions with finite support

For these two distributions, the scale parameter θ is assumed known.

A.5.1.1   Generalized beta—a, b, θ, τ

$$f(x) = \frac{\Gamma(a + b)}{\Gamma(a)\Gamma(b)}u^a(1 - u)^{b-1}\frac{\tau}{x}, \quad 0 < x < \theta, \quad u = (x/\theta)^\tau$$

$$F(x) = \beta(a, b; u)$$

$$E[X^k] = \frac{\theta^k\Gamma(a + b)\Gamma(a + k/\tau)}{\Gamma(a)\Gamma(a + b + k/\tau)}, \quad k > -a\tau$$

$$E[(X \wedge x)^k] = \frac{\theta^k\Gamma(a + b)\Gamma(a + k/\tau)}{\Gamma(a)\Gamma(a + b + k/\tau)}\beta(a + k/\tau, b; u) + x^k[1 - \beta(a, b; u)]$$

A.5.1.2   beta—a, b, θ

$$f(x) = \frac{\Gamma(a + b)}{\Gamma(a)\Gamma(b)}u^a(1 - u)^{b-1}\frac{1}{x}, \quad 0 < x < \theta, \quad u = x/\theta$$

$$F(x) = \beta(a, b; u)$$

$$E[X^k] = \frac{\theta^k\Gamma(a + b)\Gamma(a + k)}{\Gamma(a)\Gamma(a + b + k)}, \quad k > -a$$

$$E[X^k] = \frac{\theta^k a(a + 1)\cdots(a + k - 1)}{(a + b)(a + b + 1)\cdots(a + b + k - 1)}, \quad \text{if } k \text{ is an integer}$$

$$E[(X \wedge x)^k] = \frac{\theta^k a(a + 1)\cdots(a + k - 1)}{(a + b)(a + b + 1)\cdots(a + b + k - 1)}\beta(a + k, b; u) + x^k[1 - \beta(a, b; u)]$$

Appendix B

An Inventory of Discrete Distributions

B.2 The $(a, b, 0)$ class

B.2.1.1 Poisson—λ

$$
\begin{aligned}
p_0 &= e^{-\lambda}, \quad a = 0, \quad b = \lambda \qquad p_k = \frac{e^{-\lambda}\lambda^k}{k!} \\
\mathrm{E}[N] &= \lambda, \quad \mathrm{Var}[N] = \lambda \qquad P(z) = e^{\lambda(z-1)}
\end{aligned}
$$

B.2.1.2 Geometric—β

$$
\begin{aligned}
p_0 &= \frac{1}{1+\beta}, \quad a = \frac{\beta}{1+\beta}, \quad b = 0 \qquad p_k = \frac{\beta^k}{(1+\beta)^{k+1}} \\
\mathrm{E}[N] &= \beta, \quad \mathrm{Var}[N] = \beta(1+\beta) \qquad P(z) = [1 - \beta(z-1)]^{-1}.
\end{aligned}
$$

This is a special case of the negative binomial with $r = 1$.

B.2.1.3 Binomial—$q, m, (0 < q < 1, m$ an integer$)$

$$
\begin{aligned}
p_0 &= (1-q)^m, \quad a = -\frac{q}{1-q}, \quad b = \frac{(m+1)q}{1-q} \\
p_k &= \binom{m}{k} q^k (1-q)^{m-k}, \quad k = 0, 1, \ldots, m \\
\mathrm{E}[N] &= mq, \quad \mathrm{Var}[N] = mq(1-q) \qquad P(z) = [1 + q(z-1)]^m.
\end{aligned}
$$

B.2.1.4 Negative binomial—β, r

$$
\begin{aligned}
p_0 &= (1+\beta)^{-r}, \quad a = \frac{\beta}{1+\beta}, \quad b = \frac{(r-1)\beta}{1+\beta} \\
p_k &= \frac{r(r+1)\cdots(r+k-1)\beta^k}{k!(1+\beta)^{r+k}} \\
\mathrm{E}[N] &= r\beta, \quad \mathrm{Var}[N] = r\beta(1+\beta) \qquad P(z) = [1 - \beta(z-1)]^{-r}.
\end{aligned}
$$

8

Approximate critical values of T in the Wilcoxon Matched-Pairs, Signed-Rank Test

One-sided	Two-sided	n=5	n=6	n=7	n=8	n=9	n=10
P = .05	P = .10	0	2	3	5	8	10
P = .025	P = .05		0	2	3	5	8
P = .01	P = .02			0	1	3	5
P = .005	P = .01				0	1	3

One-sided	Two-sided	n=11	n=12	n=13	n=14	n=15	n=16
P = .05	P = .10	13	17	21	25	30	35
P = .025	P = .05	10	13	17	21	25	29
P = .01	P = .02	7	9	12	15	19	23
P = .005	P = .01	5	7	9	12	15	19

One-sided	Two-sided	n=17	n=18	n=19	n=20	n=21	n=22
P = .05	P = .10	41	47	53	60	67	75
P = .025	P = .05	34	40	46	52	58	65
P = .01	P = .02	27	32	37	43	49	55
P = .005	P = .01	23	27	32	37	42	48

One-sided	Two-sided	n=23	n=24	n=25	n=26	n=27	n=28
P = .05	P = .10	83	91	100	110	119	130
P = .025	P = .05	73	81	89	98	107	116
P = .01	P = .02	62	69	76	84	92	101
P = .005	P = .01	54	61	68	75	83	91

One-sided	Two-sided	n=29	n=30	n=31	n=32	n=33	n=34
P = .05	P = .10	140	151	163	175	187	200
P = .025	P = .05	126	137	147	159	170	182
P = .01	P = .02	110	120	130	140	151	162
P = .005	P = .01	100	109	118	128	138	148

One-sided	Two-sided	n=35	n=36	n=37	n=38	n=39	n=40
P = .05	P = .10	213	227	241	256	271	286
P = .025	P = .05	195	208	221	235	249	264
P = .01	P = .02	173	185	198	211	224	237
P = .005	P = .01	159	171	182	194	207	220

One-sided	Two-sided	n=41	n=42	n=43	n=44	n=45	n=46
P = .05	P = .10	302	319	336	353	371	389
P = .025	P = .05	279	294	310	327	343	361
P = .01	P = .02	252	266	281	296	312	328
P = .005	P = .01	233	247	261	276	291	306

One-sided	Two-sided	n=47	n=48	n=49	n=50
P = .05	P = .10	407	426	446	466
P = .025	P = .05	378	396	415	434
P = .01	P = .02	345	362	379	397
P = .005	P = .01	322	339	355	373

For use on the CAS actuarial examinations

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Tail areas (two-sided) for t-distributions

df	0.20	0.10	0.05	0.02	0.01
1	3.078	6.314	12.706	31.821	63.657
2	1.886	2.920	4.303	6.965	9.925
3	1.638	2.353	3.182	4.541	5.841
4	1.533	2.132	2.776	3.747	4.604
5	1.476	2.015	2.571	3.365	4.032
6	1.440	1.943	2.447	3.143	3.707
7	1.415	1.895	2.365	2.998	3.499
8	1.397	1.860	2.306	2.896	3.355
9	1.383	1.833	2.262	2.821	3.250
10	1.372	1.812	2.228	2.764	3.169
11	1.363	1.796	2.201	2.718	3.106
12	1.356	1.782	2.179	2.681	3.055
13	1.350	1.771	2.160	2.650	3.012
14	1.345	1.761	2.145	2.624	2.977
15	1.341	1.753	2.131	2.602	2.947
16	1.337	1.746	2.120	2.583	2.921
17	1.333	1.740	2.110	2.567	2.898
18	1.330	1.734	2.101	2.552	2.878
19	1.328	1.729	2.093	2.539	2.861
20	1.325	1.725	2.086	2.528	2.845
21	1.323	1.721	2.080	2.518	2.831
22	1.321	1.717	2.074	2.508	2.819
23	1.319	1.714	2.069	2.500	2.807
24	1.318	1.711	2.064	2.492	2.797
25	1.316	1.708	2.060	2.485	2.787
26	1.315	1.706	2.056	2.479	2.779
27	1.314	1.703	2.052	2.473	2.771
28	1.313	1.701	2.048	2.467	2.763
29	1.311	1.699	2.045	2.462	2.756
30	1.310	1.697	2.042	2.457	2.750
35	1.306	1.690	2.030	2.438	2.724
40	1.303	1.684	2.021	2.423	2.704
45	1.301	1.679	2.014	2.412	2.690
50	1.299	1.676	2.009	2.403	2.678
55	1.297	1.673	2.004	2.396	2.668
60	1.296	1.671	2.000	2.390	2.660
70	1.294	1.667	1.994	2.381	2.648
80	1.292	1.664	1.990	2.374	2.639
90	1.291	1.662	1.987	2.368	2.632
100	1.290	1.660	1.984	2.364	2.626
120	1.289	1.658	1.980	2.358	2.617
400	1.284	1.649	1.966	2.336	2.588
Inf	1.282	1.645	1.960	2.326	2.576

For use on the CAS exams

Selected Upper-tail areas for F-distributions

Denominator df	Upper-tail	1	2	3	4	5	6	7	8	9	10	11	12	14	16	20	24	30	40	50	75	100	200	500	Inf	Upper-tail	Denominator df
1	0.20	9.472	12	13.064	13.644	14.008	14.258	14.439	14.577	14.685	14.772	14.844	14.904	14.998	15.07	15.171	15.238	15.306	15.374	15.415	15.47	15.497	15.539	15.563	15.58	0.20	1
1	0.10	39.86	49.5	53.59	55.83	57.24	58.2	58.91	59.44	59.86	60.19	60.47	60.71	61.07	61.35	61.74	62	62.26	62.53	62.69	62.9	63.01	63.17	63.26	63.33	0.10	1
1	0.05	161.4	199.5	215.7	224.6	230.2	234	236.8	238.9	240.5	241.9	243	243.9	245.4	246.5	248	249.1	250.1	251.1	251.8	252.6	253	253.7	254.1	254.3	0.05	1
1	0.02	1013	1249	1351	1406	1441	1464	1482	1495	1505	1514	1521	1526	1535	1542	1552	1558	1565	1571	1575	1581	1583	1587	1590	1591	0.02	1
1	0.01	4052	4999	5403	5625	5764	5859	5928	5981	6022	6056	6083	6106	6143	6170	6209	6235	6261	6287	6303	6324	6334	6350	6360	6366	0.01	1
2	0.20	3.556	4	4.156	4.236	4.284	4.317	4.34	4.358	4.371	4.382	4.391	4.399	4.41	4.419	4.432	4.44	4.448	4.456	4.461	4.468	4.471	4.476	4.479	4.481	0.20	2
2	0.10	8.526	9	9.162	9.243	9.293	9.326	9.349	9.367	9.381	9.392	9.401	9.408	9.42	9.429	9.441	9.45	9.458	9.466	9.471	9.478	9.481	9.486	9.489	9.491	0.10	2
2	0.05	18.51	19	19.16	19.25	19.3	19.33	19.35	19.37	19.38	19.4	19.4	19.41	19.42	19.43	19.45	19.45	19.46	19.47	19.48	19.48	19.49	19.49	19.49	19.5	0.05	2
2	0.02	48.51	49	49.17	49.25	49.3	49.33	49.36	49.37	49.39	49.4	49.41	49.42	49.43	49.44	49.45	49.46	49.46	49.47	49.48	49.48	49.49	49.49	49.5	49.5	0.02	2
2	0.01	98.5	99	99.17	99.25	99.3	99.33	99.36	99.37	99.39	99.4	99.41	99.42	99.43	99.44	99.45	99.46	99.47	99.47	99.48	99.49	99.49	99.49	99.5	99.5	0.01	2
3	0.20	2.682	2.886	2.936	2.956	2.965	2.971	2.974	2.976	2.978	2.979	2.98	2.981	2.982	2.982	2.983	2.983	2.984	2.984	2.984	2.984	2.984	2.985	2.985	2.985	0.20	3
3	0.10	5.538	5.462	5.391	5.343	5.309	5.285	5.266	5.252	5.24	5.23	5.222	5.216	5.205	5.196	5.184	5.176	5.168	5.16	5.155	5.148	5.144	5.139	5.136	5.134	0.10	3
3	0.05	10.128	9.552	9.277	9.117	9.013	8.941	8.887	8.845	8.812	8.786	8.763	8.745	8.715	8.692	8.66	8.639	8.617	8.594	8.581	8.563	8.554	8.54	8.532	8.526	0.05	3
3	0.02	20.62	18.86	18.11	17.69	17.43	17.25	17.11	17.01	16.93	16.86	16.81	16.76	16.69	16.63	16.55	16.5	16.45	16.39	16.36	16.32	16.3	16.26	16.24	16.23	0.02	3
3	0.01	34.12	30.82	29.46	28.71	28.24	27.91	27.67	27.49	27.35	27.23	27.13	27.05	26.92	26.83	26.69	26.6	26.5	26.41	26.35	26.28	26.24	26.18	26.15	26.13	0.01	3
4	0.20	2.351	2.472	2.485	2.483	2.478	2.473	2.469	2.465	2.462	2.46	2.457	2.455	2.452	2.449	2.445	2.442	2.439	2.436	2.434	2.432	2.43	2.428	2.427	2.426	0.20	4
4	0.10	4.545	4.325	4.191	4.107	4.051	4.01	3.979	3.955	3.936	3.92	3.907	3.896	3.878	3.864	3.844	3.831	3.817	3.804	3.795	3.784	3.778	3.769	3.764	3.761	0.10	4
4	0.05	7.709	6.944	6.591	6.388	6.256	6.163	6.094	6.041	5.999	5.964	5.936	5.912	5.873	5.844	5.803	5.774	5.746	5.717	5.699	5.676	5.664	5.646	5.635	5.628	0.05	4
4	0.02	14.04	12.142	11.344	10.899	10.616	10.419	10.274	10.162	10.074	10.003	9.944	9.894	9.815	9.755	9.67	9.612	9.554	9.495	9.46	9.412	9.388	9.352	9.33	9.315	0.02	4
4	0.01	21.2	18	16.69	15.98	15.52	15.21	14.98	14.8	14.66	14.55	14.45	14.37	14.25	14.15	14.02	13.93	13.84	13.75	13.69	13.61	13.58	13.52	13.49	13.46	0.01	4
5	0.20	2.178	2.259	2.253	2.24	2.228	2.217	2.209	2.202	2.196	2.191	2.187	2.184	2.178	2.173	2.166	2.161	2.156	2.151	2.148	2.144	2.141	2.138	2.136	2.134	0.20	5
5	0.10	4.06	3.78	3.619	3.52	3.453	3.405	3.368	3.339	3.316	3.297	3.282	3.268	3.247	3.23	3.207	3.191	3.174	3.157	3.147	3.133	3.126	3.116	3.109	3.105	0.10	5
5	0.05	6.608	5.786	5.409	5.192	5.05	4.95	4.876	4.818	4.772	4.735	4.704	4.678	4.636	4.604	4.558	4.527	4.496	4.464	4.444	4.418	4.405	4.385	4.373	4.365	0.05	5
5	0.02	11.323	9.454	8.67	8.233	7.953	7.758	7.614	7.503	7.415	7.344	7.285	7.235	7.156	7.095	7.009	6.951	6.893	6.833	6.797	6.749	6.724	6.687	6.665	6.65	0.02	5
5	0.01	16.258	13.274	12.06	11.392	10.967	10.672	10.456	10.289	10.158	10.051	9.963	9.888	9.77	9.68	9.553	9.466	9.379	9.291	9.238	9.166	9.13	9.075	9.042	9.02	0.01	5
6	0.20	2.073	2.13	2.113	2.092	2.076	2.062	2.051	2.042	2.034	2.028	2.022	2.018	2.01	2.004	1.995	1.989	1.982	1.976	1.972	1.966	1.963	1.959	1.956	1.954	0.20	6
6	0.10	3.776	3.463	3.289	3.181	3.108	3.055	3.014	2.983	2.958	2.937	2.92	2.905	2.881	2.863	2.836	2.818	2.8	2.781	2.77	2.754	2.746	2.734	2.727	2.722	0.10	6
6	0.05	5.987	5.143	4.757	4.534	4.387	4.284	4.207	4.147	4.099	4.06	4.027	4	3.956	3.922	3.874	3.841	3.808	3.774	3.754	3.726	3.712	3.69	3.678	3.669	0.05	6
6	0.02	9.876	8.052	7.287	6.859	6.585	6.393	6.251	6.141	6.055	5.984	5.925	5.876	5.797	5.737	5.651	5.593	5.534	5.474	5.438	5.389	5.364	5.327	5.304	5.289	0.02	6
6	0.01	13.745	10.925	9.78	9.148	8.746	8.466	8.26	8.102	7.976	7.874	7.79	7.718	7.605	7.519	7.396	7.313	7.229	7.143	7.091	7.022	6.987	6.934	6.902	6.88	0.01	6
7	0.20	2.002	2.043	2.019	1.994	1.974	1.957	1.945	1.934	1.925	1.918	1.911	1.906	1.897	1.89	1.879	1.872	1.865	1.857	1.852	1.845	1.842	1.837	1.833	1.831	0.20	7
7	0.10	3.589	3.257	3.074	2.961	2.883	2.827	2.785	2.752	2.725	2.703	2.684	2.668	2.643	2.623	2.595	2.575	2.555	2.535	2.523	2.506	2.497	2.484	2.476	2.471	0.10	7
7	0.05	5.591	4.737	4.347	4.12	3.972	3.866	3.787	3.726	3.677	3.637	3.603	3.575	3.529	3.494	3.445	3.41	3.376	3.34	3.319	3.29	3.275	3.252	3.239	3.23	0.05	7
7	0.02	8.988	7.203	6.454	6.035	5.765	5.576	5.435	5.327	5.241	5.171	5.113	5.064	4.985	4.925	4.839	4.781	4.722	4.662	4.625	4.576	4.551	4.513	4.49	4.475	0.02	7
7	0.01	12.246	9.547	8.451	7.847	7.46	7.191	6.993	6.84	6.719	6.62	6.538	6.469	6.359	6.275	6.155	6.074	5.992	5.908	5.858	5.789	5.755	5.702	5.671	5.65	0.01	7
8	0.20	1.951	1.981	1.951	1.923	1.9	1.883	1.868	1.856	1.847	1.838	1.831	1.825	1.815	1.807	1.796	1.787	1.779	1.77	1.765	1.757	1.753	1.748	1.744	1.742	0.20	8
8	0.10	3.458	3.113	2.924	2.806	2.726	2.668	2.624	2.589	2.561	2.538	2.519	2.502	2.475	2.455	2.425	2.404	2.383	2.361	2.348	2.33	2.321	2.307	2.298	2.293	0.10	8
8	0.05	5.318	4.459	4.066	3.838	3.687	3.581	3.5	3.438	3.388	3.347	3.313	3.284	3.237	3.202	3.15	3.115	3.079	3.043	3.02	2.99	2.975	2.951	2.937	2.928	0.05	8
8	0.02	8.389	6.637	5.901	5.489	5.223	5.036	4.897	4.79	4.705	4.635	4.577	4.528	4.449	4.389	4.304	4.245	4.186	4.125	4.088	4.038	4.013	3.975	3.952	3.936	0.02	8
8	0.01	11.259	8.649	7.591	7.006	6.632	6.371	6.178	6.029	5.911	5.814	5.734	5.667	5.559	5.477	5.359	5.279	5.198	5.116	5.065	4.998	4.963	4.911	4.88	4.859	0.01	8
9	0.20	1.913	1.935	1.901	1.87	1.846	1.826	1.811	1.798	1.787	1.778	1.771	1.764	1.753	1.745	1.732	1.723	1.714	1.704	1.698	1.69	1.686	1.68	1.676	1.673	0.20	9
9	0.10	3.36	3.006	2.813	2.693	2.611	2.551	2.505	2.469	2.44	2.416	2.396	2.379	2.351	2.329	2.298	2.277	2.255	2.232	2.218	2.199	2.189	2.174	2.165	2.159	0.10	9
9	0.05	5.117	4.256	3.863	3.633	3.482	3.374	3.293	3.23	3.179	3.137	3.102	3.073	3.025	2.989	2.936	2.9	2.864	2.826	2.803	2.771	2.756	2.731	2.717	2.707	0.05	9
9	0.02	7.961	6.234	5.51	5.103	4.84	4.654	4.517	4.41	4.325	4.256	4.198	4.149	4.071	4.011	3.925	3.866	3.806	3.745	3.708	3.658	3.632	3.593	3.57	3.554	0.02	9
9	0.01	10.561	8.022	6.992	6.422	6.057	5.802	5.613	5.467	5.351	5.257	5.178	5.111	5.005	4.924	4.808	4.729	4.649	4.567	4.517	4.449	4.415	4.363	4.332	4.311	0.01	9

df	p																										p	df
10	0.20	1.883	1.899	1.861	1.829	1.803	1.782	1.766	1.752	1.741	1.732	1.723	1.716	1.705	1.696	1.682	1.673	1.663	1.653	1.646	1.637	1.633	1.626	1.621	1.618	0.20	10
10	0.10	3.285	2.924	2.728	2.605	2.522	2.461	2.414	2.377	2.347	2.323	2.302	2.284	2.255	2.233	2.201	2.178	2.155	2.132	2.117	2.097	2.087	2.071	2.062	2.055	0.10	10
10	0.05	4.965	4.103	3.708	3.478	3.326	3.217	3.135	3.072	3.02	2.978	2.943	2.913	2.865	2.828	2.774	2.737	2.7	2.661	2.637	2.605	2.588	2.563	2.548	2.538	0.05	10
10	0.02	7.638	5.934	5.218	4.816	4.555	4.371	4.235	4.129	4.044	3.975	3.917	3.868	3.79	3.73	3.644	3.585	3.525	3.463	3.425	3.374	3.348	3.309	3.285	3.269	0.02	10
10	0.01	10.044	7.559	6.552	5.994	5.636	5.386	5.2	5.057	4.942	4.849	4.772	4.706	4.601	4.52	4.405	4.327	4.247	4.165	4.115	4.048	4.014	3.962	3.93	3.909	0.01	10
11	0.20	1.859	1.87	1.83	1.796	1.768	1.747	1.73	1.716	1.704	1.694	1.685	1.678	1.666	1.656	1.642	1.632	1.622	1.611	1.604	1.594	1.589	1.582	1.577	1.574	0.20	11
11	0.10	3.225	2.86	2.66	2.536	2.451	2.389	2.342	2.304	2.274	2.248	2.227	2.209	2.179	2.156	2.123	2.1	2.076	2.052	2.036	2.016	2.005	1.989	1.979	1.972	0.10	11
11	0.05	4.844	3.982	3.587	3.357	3.204	3.095	3.012	2.948	2.896	2.854	2.818	2.788	2.739	2.701	2.646	2.609	2.57	2.531	2.507	2.473	2.457	2.431	2.415	2.404	0.05	11
11	0.02	7.388	5.701	4.993	4.594	4.336	4.153	4.017	3.912	3.828	3.758	3.701	3.652	3.573	3.513	3.427	3.367	3.307	3.245	3.207	3.155	3.129	3.089	3.065	3.048	0.02	11
11	0.01	9.646	7.206	6.217	5.668	5.316	5.069	4.886	4.744	4.632	4.539	4.462	4.397	4.293	4.213	4.099	4.021	3.941	3.86	3.81	3.742	3.708	3.656	3.624	3.602	0.01	11
12	0.20	1.839	1.846	1.804	1.768	1.74	1.718	1.7	1.686	1.673	1.663	1.654	1.646	1.634	1.624	1.609	1.598	1.587	1.576	1.568	1.558	1.553	1.545	1.54	1.537	0.20	12
12	0.10	3.177	2.807	2.606	2.48	2.394	2.331	2.283	2.245	2.214	2.188	2.166	2.147	2.117	2.094	2.06	2.036	2.011	1.986	1.97	1.949	1.938	1.921	1.911	1.904	0.10	12
12	0.05	4.747	3.885	3.49	3.259	3.106	2.996	2.913	2.849	2.796	2.753	2.717	2.687	2.637	2.599	2.544	2.505	2.466	2.426	2.401	2.367	2.35	2.323	2.307	2.296	0.05	12
12	0.02	7.188	5.516	4.814	4.419	4.162	3.98	3.845	3.74	3.656	3.587	3.529	3.48	3.402	3.341	3.254	3.195	3.134	3.071	3.033	2.981	2.954	2.913	2.889	2.872	0.02	12
12	0.01	9.33	6.927	5.953	5.412	5.064	4.821	4.64	4.499	4.388	4.296	4.22	4.155	4.052	3.972	3.858	3.78	3.701	3.619	3.569	3.501	3.467	3.414	3.382	3.361	0.01	12
13	0.20	1.823	1.826	1.783	1.746	1.717	1.694	1.676	1.661	1.648	1.637	1.628	1.62	1.607	1.596	1.581	1.57	1.558	1.546	1.539	1.528	1.523	1.514	1.509	1.506	0.20	13
13	0.10	3.136	2.763	2.56	2.434	2.347	2.283	2.234	2.195	2.164	2.138	2.116	2.097	2.066	2.042	2.007	1.983	1.958	1.931	1.915	1.893	1.882	1.864	1.853	1.846	0.10	13
13	0.05	4.667	3.806	3.411	3.179	3.025	2.915	2.832	2.767	2.714	2.671	2.635	2.604	2.554	2.515	2.459	2.42	2.38	2.339	2.314	2.279	2.261	2.234	2.218	2.206	0.05	13
13	0.02	7.024	5.366	4.669	4.276	4.02	3.84	3.705	3.6	3.516	3.447	3.39	3.341	3.262	3.201	3.114	3.054	2.993	2.93	2.891	2.838	2.811	2.77	2.745	2.728	0.02	13
13	0.01	9.074	6.701	5.739	5.205	4.862	4.62	4.441	4.302	4.191	4.1	4.025	3.96	3.857	3.778	3.665	3.587	3.507	3.425	3.375	3.307	3.272	3.219	3.187	3.165	0.01	13
14	0.20	1.809	1.809	1.765	1.727	1.697	1.674	1.655	1.639	1.626	1.615	1.606	1.598	1.584	1.573	1.557	1.546	1.534	1.521	1.513	1.502	1.497	1.488	1.482	1.479	0.20	14
14	0.10	3.102	2.726	2.522	2.395	2.307	2.243	2.193	2.154	2.122	2.095	2.073	2.054	2.022	1.998	1.962	1.938	1.912	1.885	1.869	1.846	1.834	1.816	1.805	1.797	0.10	14
14	0.05	4.6	3.739	3.344	3.112	2.958	2.848	2.764	2.699	2.646	2.602	2.565	2.534	2.484	2.445	2.388	2.349	2.308	2.266	2.241	2.205	2.187	2.159	2.142	2.131	0.05	14
14	0.02	6.888	5.241	4.549	4.158	3.904	3.724	3.589	3.485	3.401	3.332	3.274	3.225	3.146	3.086	2.998	2.938	2.876	2.812	2.773	2.72	2.692	2.651	2.625	2.608	0.02	14
14	0.01	8.862	6.515	5.564	5.035	4.695	4.456	4.278	4.14	4.03	3.939	3.864	3.8	3.698	3.619	3.505	3.427	3.348	3.266	3.215	3.147	3.112	3.059	3.026	3.004	0.01	14
15	0.20	1.797	1.795	1.749	1.71	1.68	1.656	1.637	1.621	1.608	1.596	1.587	1.578	1.564	1.553	1.537	1.525	1.513	1.5	1.491	1.48	1.474	1.465	1.459	1.455	0.20	15
15	0.10	3.073	2.695	2.49	2.361	2.273	2.208	2.158	2.119	2.086	2.059	2.037	2.017	1.985	1.961	1.924	1.899	1.873	1.845	1.828	1.805	1.793	1.774	1.763	1.755	0.10	15
15	0.05	4.543	3.682	3.287	3.056	2.901	2.79	2.707	2.641	2.588	2.544	2.507	2.475	2.424	2.385	2.328	2.288	2.247	2.204	2.178	2.142	2.123	2.095	2.078	2.066	0.05	15
15	0.02	6.773	5.135	4.447	4.058	3.805	3.626	3.492	3.387	3.303	3.235	3.177	3.128	3.049	2.988	2.9	2.84	2.777	2.713	2.674	2.62	2.592	2.55	2.524	2.506	0.02	15
15	0.01	8.683	6.359	5.417	4.893	4.556	4.318	4.142	4.004	3.895	3.805	3.73	3.666	3.564	3.485	3.372	3.294	3.214	3.132	3.081	3.012	2.977	2.923	2.891	2.868	0.01	15
16	0.20	1.787	1.783	1.736	1.696	1.665	1.641	1.621	1.605	1.591	1.58	1.57	1.561	1.547	1.536	1.519	1.507	1.494	1.481	1.472	1.46	1.454	1.445	1.439	1.435	0.20	16
16	0.10	3.048	2.668	2.462	2.333	2.244	2.178	2.128	2.088	2.055	2.028	2.005	1.985	1.953	1.928	1.891	1.866	1.839	1.811	1.793	1.769	1.757	1.738	1.726	1.718	0.10	16
16	0.05	4.494	3.634	3.239	3.007	2.852	2.741	2.657	2.591	2.538	2.494	2.456	2.425	2.373	2.333	2.276	2.235	2.194	2.151	2.124	2.087	2.068	2.039	2.022	2.01	0.05	16
16	0.02	6.674	5.046	4.361	3.974	3.721	3.543	3.409	3.304	3.221	3.152	3.094	3.045	2.966	2.905	2.817	2.756	2.693	2.628	2.589	2.534	2.506	2.463	2.437	2.419	0.02	16
16	0.01	8.531	6.226	5.292	4.773	4.437	4.202	4.026	3.89	3.78	3.691	3.616	3.553	3.451	3.372	3.259	3.181	3.101	3.018	2.967	2.898	2.863	2.808	2.775	2.753	0.01	16
17	0.20	1.778	1.772	1.724	1.684	1.652	1.628	1.608	1.591	1.577	1.566	1.555	1.547	1.532	1.52	1.503	1.491	1.478	1.464	1.455	1.443	1.437	1.427	1.421	1.416	0.20	17
17	0.10	3.026	2.645	2.437	2.308	2.218	2.152	2.102	2.061	2.028	2.001	1.978	1.958	1.925	1.9	1.862	1.836	1.809	1.781	1.763	1.738	1.726	1.706	1.694	1.686	0.10	17
17	0.05	4.451	3.592	3.197	2.965	2.81	2.699	2.614	2.548	2.494	2.45	2.413	2.381	2.329	2.289	2.23	2.19	2.148	2.104	2.077	2.04	2.02	1.991	1.973	1.96	0.05	17
17	0.02	6.589	4.968	4.286	3.901	3.649	3.471	3.337	3.233	3.149	3.08	3.023	2.973	2.894	2.833	2.745	2.683	2.62	2.555	2.515	2.46	2.431	2.388	2.361	2.343	0.02	17
17	0.01	8.4	6.112	5.185	4.669	4.336	4.102	3.927	3.791	3.682	3.593	3.519	3.455	3.353	3.275	3.162	3.084	3.003	2.92	2.869	2.8	2.764	2.709	2.676	2.653	0.01	17
18	0.20	1.77	1.762	1.713	1.673	1.641	1.616	1.596	1.579	1.565	1.553	1.543	1.534	1.519	1.507	1.489	1.477	1.463	1.449	1.44	1.428	1.421	1.411	1.404	1.4	0.20	18
18	0.10	3.007	2.624	2.416	2.286	2.196	2.13	2.079	2.038	2.005	1.977	1.954	1.933	1.9	1.875	1.837	1.81	1.783	1.754	1.736	1.711	1.698	1.678	1.665	1.657	0.10	18
18	0.05	4.414	3.555	3.16	2.928	2.773	2.661	2.577	2.51	2.456	2.412	2.374	2.342	2.29	2.25	2.191	2.15	2.107	2.063	2.035	1.998	1.978	1.948	1.929	1.917	0.05	18
18	0.02	6.515	4.9	4.221	3.837	3.586	3.408	3.275	3.171	3.087	3.018	2.96	2.911	2.832	2.77	2.682	2.62	2.557	2.491	2.45	2.395	2.366	2.322	2.295	2.277	0.02	18
18	0.01	8.285	6.013	5.092	4.579	4.248	4.015	3.841	3.705	3.597	3.508	3.434	3.371	3.269	3.19	3.077	2.999	2.919	2.835	2.784	2.714	2.678	2.623	2.589	2.566	0.01	18
19	0.20	1.763	1.754	1.704	1.663	1.631	1.605	1.585	1.568	1.554	1.542	1.531	1.522	1.507	1.495	1.477	1.464	1.45	1.436	1.427	1.414	1.407	1.396	1.39	1.385	0.20	19
19	0.10	2.99	2.606	2.397	2.266	2.176	2.109	2.058	2.017	1.984	1.956	1.932	1.912	1.878	1.852	1.814	1.787	1.759	1.73	1.711	1.686	1.673	1.652	1.639	1.631	0.10	19
19	0.05	4.381	3.522	3.127	2.895	2.74	2.628	2.544	2.477	2.423	2.378	2.34	2.308	2.256	2.215	2.155	2.114	2.071	2.026	1.999	1.96	1.94	1.91	1.891	1.878	0.05	19
19	0.02	6.449	4.84	4.164	3.781	3.531	3.353	3.22	3.116	3.032	2.963	2.906	2.856	2.777	2.715	2.626	2.564	2.501	2.434	2.394	2.337	2.308	2.264	2.236	2.218	0.02	19
19	0.01	8.185	5.926	5.01	4.5	4.171	3.939	3.765	3.631	3.523	3.434	3.36	3.297	3.195	3.116	3.003	2.925	2.844	2.761	2.709	2.639	2.602	2.547	2.512	2.489	0.01	19
20	0.20	1.757	1.746	1.696	1.654	1.622	1.596	1.575	1.558	1.544	1.531	1.521	1.512	1.496	1.484	1.466	1.452	1.439	1.424	1.414	1.401	1.394	1.383	1.377	1.372	0.20	20
20	0.10	2.975	2.589	2.38	2.249	2.158	2.091	2.04	1.999	1.965	1.937	1.913	1.892	1.859	1.833	1.794	1.767	1.738	1.708	1.69	1.664	1.65	1.629	1.616	1.607	0.10	20
20	0.05	4.351	3.493	3.098	2.866	2.711	2.599	2.514	2.447	2.393	2.348	2.31	2.278	2.225	2.184	2.124	2.082	2.039	1.994	1.966	1.927	1.907	1.875	1.856	1.843	0.05	20
20	0.02	6.391	4.788	4.113	3.731	3.482	3.304	3.171	3.067	2.984	2.915	2.857	2.808	2.728	2.666	2.577	2.515	2.451	2.384	2.343	2.286	2.257	2.212	2.184	2.165	0.02	20
20	0.01	8.096	5.849	4.938	4.431	4.103	3.871	3.699	3.564	3.457	3.368	3.294	3.231	3.13	3.051	2.938	2.859	2.778	2.695	2.643	2.572	2.535	2.479	2.445	2.421	0.01	20

21	0.20	1.751	1.739	1.688	1.646	1.614	1.588	1.567	1.549	1.535	1.522	1.511	1.502	1.487	1.474	1.455	1.442	1.428	1.413	1.403	1.39	1.383	1.371	1.364	1.36	0.20	21
21	0.10	2.961	2.575	2.365	2.233	2.142	2.075	2.023	1.982	1.948	1.92	1.896	1.875	1.841	1.815	1.776	1.748	1.719	1.689	1.67	1.644	1.63	1.608	1.595	1.586	0.10	21
21	0.05	4.325	3.467	3.072	2.84	2.685	2.573	2.488	2.42	2.366	2.321	2.283	2.25	2.197	2.156	2.096	2.054	2.01	1.965	1.936	1.897	1.876	1.845	1.825	1.812	0.05	21
21	0.02	6.339	4.74	4.068	3.687	3.438	3.261	3.128	3.024	2.94	2.872	2.814	2.764	2.685	2.623	2.533	2.471	2.406	2.339	2.298	2.24	2.211	2.165	2.137	2.118	0.02	21
21	0.01	8.017	5.78	4.874	4.369	4.042	3.812	3.64	3.506	3.398	3.31	3.236	3.173	3.072	2.993	2.88	2.801	2.72	2.636	2.584	2.512	2.475	2.419	2.384	2.36	0.01	21
22	0.20	1.746	1.733	1.682	1.639	1.606	1.58	1.559	1.541	1.526	1.514	1.503	1.494	1.478	1.465	1.446	1.433	1.418	1.403	1.393	1.379	1.372	1.361	1.353	1.349	0.20	22
22	0.10	2.949	2.561	2.351	2.219	2.128	2.06	2.008	1.967	1.933	1.904	1.88	1.859	1.825	1.798	1.759	1.731	1.702	1.671	1.652	1.625	1.611	1.59	1.576	1.567	0.10	22
22	0.05	4.301	3.443	3.049	2.817	2.661	2.549	2.464	2.397	2.342	2.297	2.259	2.226	2.173	2.131	2.071	2.028	1.984	1.938	1.909	1.869	1.849	1.817	1.797	1.783	0.05	22
22	0.02	6.292	4.698	4.028	3.647	3.399	3.222	3.089	2.985	2.902	2.833	2.775	2.725	2.646	2.584	2.494	2.431	2.366	2.299	2.257	2.199	2.169	2.123	2.095	2.075	0.02	22
22	0.01	7.945	5.719	4.817	4.313	3.988	3.758	3.587	3.453	3.346	3.258	3.184	3.121	3.019	2.941	2.827	2.749	2.667	2.583	2.531	2.459	2.422	2.365	2.329	2.305	0.01	22
23	0.20	1.741	1.728	1.676	1.633	1.599	1.573	1.552	1.534	1.519	1.506	1.495	1.486	1.47	1.457	1.438	1.424	1.41	1.394	1.384	1.37	1.362	1.351	1.343	1.338	0.20	23
23	0.10	2.937	2.549	2.339	2.207	2.115	2.047	1.995	1.953	1.919	1.89	1.866	1.845	1.811	1.784	1.744	1.716	1.686	1.655	1.636	1.609	1.594	1.572	1.558	1.549	0.10	23
23	0.05	4.279	3.422	3.028	2.796	2.64	2.528	2.442	2.375	2.32	2.275	2.236	2.204	2.15	2.109	2.048	2.005	1.961	1.914	1.885	1.844	1.823	1.791	1.771	1.757	0.05	23
23	0.02	6.249	4.66	3.991	3.611	3.363	3.187	3.054	2.95	2.867	2.798	2.74	2.69	2.61	2.548	2.458	2.395	2.33	2.262	2.22	2.162	2.132	2.085	2.056	2.037	0.02	23
23	0.01	7.881	5.664	4.765	4.264	3.939	3.71	3.539	3.406	3.299	3.211	3.137	3.074	2.973	2.894	2.781	2.702	2.62	2.535	2.483	2.411	2.373	2.316	2.28	2.256	0.01	23
24	0.20	1.737	1.722	1.67	1.627	1.593	1.567	1.545	1.527	1.512	1.499	1.488	1.479	1.463	1.45	1.43	1.416	1.401	1.385	1.375	1.361	1.353	1.341	1.334	1.329	0.20	24
24	0.10	2.927	2.538	2.327	2.195	2.103	2.035	1.983	1.941	1.906	1.877	1.853	1.832	1.797	1.77	1.73	1.702	1.672	1.641	1.621	1.593	1.579	1.556	1.542	1.533	0.10	24
24	0.05	4.26	3.403	3.009	2.776	2.621	2.508	2.423	2.355	2.3	2.255	2.216	2.183	2.13	2.088	2.027	1.984	1.939	1.892	1.863	1.822	1.8	1.768	1.747	1.733	0.05	24
24	0.02	6.211	4.625	3.958	3.579	3.331	3.155	3.022	2.919	2.835	2.766	2.708	2.658	2.578	2.516	2.426	2.363	2.297	2.229	2.187	2.128	2.097	2.05	2.021	2.001	0.02	24
24	0.01	7.823	5.614	4.718	4.218	3.895	3.667	3.496	3.363	3.256	3.168	3.094	3.032	2.93	2.852	2.738	2.659	2.577	2.492	2.44	2.367	2.329	2.271	2.235	2.211	0.01	24
25	0.20	1.733	1.718	1.665	1.622	1.588	1.561	1.539	1.521	1.506	1.493	1.482	1.472	1.456	1.443	1.423	1.409	1.394	1.378	1.367	1.353	1.345	1.333	1.325	1.32	0.20	25
25	0.10	2.918	2.528	2.317	2.184	2.092	2.024	1.971	1.929	1.895	1.866	1.841	1.82	1.785	1.758	1.718	1.689	1.659	1.627	1.607	1.579	1.565	1.542	1.527	1.518	0.10	25
25	0.05	4.242	3.385	2.991	2.759	2.603	2.49	2.405	2.337	2.282	2.236	2.198	2.165	2.111	2.069	2.007	1.964	1.919	1.872	1.842	1.801	1.779	1.746	1.725	1.711	0.05	25
25	0.02	6.176	4.593	3.928	3.549	3.302	3.126	2.993	2.89	2.806	2.737	2.679	2.629	2.549	2.487	2.396	2.333	2.267	2.199	2.156	2.097	2.066	2.018	1.989	1.969	0.02	25
25	0.01	7.77	5.568	4.675	4.177	3.855	3.627	3.457	3.324	3.217	3.129	3.056	2.993	2.892	2.813	2.699	2.62	2.538	2.453	2.4	2.327	2.289	2.23	2.194	2.169	0.01	25
26	0.20	1.729	1.713	1.66	1.617	1.583	1.556	1.534	1.516	1.5	1.487	1.476	1.466	1.45	1.437	1.417	1.402	1.387	1.371	1.36	1.345	1.337	1.325	1.317	1.312	0.20	26
26	0.10	2.909	2.519	2.307	2.174	2.082	2.014	1.961	1.919	1.884	1.855	1.83	1.809	1.774	1.747	1.706	1.677	1.647	1.615	1.594	1.566	1.551	1.528	1.514	1.504	0.10	26
26	0.05	4.225	3.369	2.975	2.743	2.587	2.474	2.388	2.321	2.265	2.22	2.181	2.148	2.094	2.052	1.99	1.946	1.901	1.853	1.823	1.782	1.76	1.726	1.705	1.691	0.05	26
26	0.02	6.144	4.564	3.9	3.522	3.275	3.099	2.967	2.863	2.78	2.711	2.652	2.603	2.523	2.46	2.369	2.306	2.24	2.171	2.128	2.068	2.037	1.989	1.959	1.939	0.02	26
26	0.01	7.721	5.526	4.637	4.14	3.818	3.591	3.421	3.288	3.182	3.094	3.021	2.958	2.857	2.778	2.664	2.585	2.503	2.417	2.364	2.29	2.252	2.193	2.156	2.131	0.01	26

Lower-tail areas for Chi-square distributions

df	0.005	0.010	0.025	0.050	0.950	0.975	0.990	0.995
1	0.00	0.00	0.00	0.00	3.84	5.02	6.63	7.88
2	0.01	0.02	0.05	0.10	5.99	7.38	9.21	10.60
3	0.07	0.11	0.22	0.35	7.81	9.35	11.34	12.84
4	0.21	0.30	0.48	0.71	9.49	11.14	13.28	14.86
5	0.41	0.55	0.83	1.15	11.07	12.83	15.09	16.75
6	0.68	0.87	1.24	1.64	12.59	14.45	16.81	18.55
7	0.99	1.24	1.69	2.17	14.07	16.01	18.48	20.28
8	1.34	1.65	2.18	2.73	15.51	17.53	20.09	21.95
9	1.73	2.09	2.70	3.33	16.92	19.02	21.67	23.59
10	2.16	2.56	3.25	3.94	18.31	20.48	23.21	25.19
11	2.60	3.05	3.82	4.57	19.68	21.92	24.72	26.76
12	3.07	3.57	4.40	5.23	21.03	23.34	26.22	28.30
13	3.57	4.11	5.01	5.89	22.36	24.74	27.69	29.82
14	4.07	4.66	5.63	6.57	23.68	26.12	29.14	31.32
15	4.60	5.23	6.26	7.26	25.00	27.49	30.58	32.80
16	5.14	5.81	6.91	7.96	26.30	28.85	32.00	34.27
17	5.70	6.41	7.56	8.67	27.59	30.19	33.41	35.72
18	6.26	7.01	8.23	9.39	28.87	31.53	34.81	37.16
19	6.84	7.63	8.91	10.12	30.14	32.85	36.19	38.58
20	7.43	8.26	9.59	10.85	31.41	34.17	37.57	40.00
21	8.03	8.90	10.28	11.59	32.67	35.48	38.93	41.40
22	8.64	9.54	10.98	12.34	33.92	36.78	40.29	42.80
23	9.26	10.20	11.69	13.09	35.17	38.08	41.64	44.18
24	9.89	10.86	12.40	13.85	36.42	39.36	42.98	45.56
25	10.52	11.52	13.12	14.61	37.65	40.65	44.31	46.93
26	11.16	12.20	13.84	15.38	38.89	41.92	45.64	48.29
27	11.81	12.88	14.57	16.15	40.11	43.19	46.96	49.64
28	12.46	13.56	15.31	16.93	41.34	44.46	48.28	50.99
29	13.12	14.26	16.05	17.71	42.56	45.72	49.59	52.34
30	13.79	14.95	16.79	18.49	43.77	46.98	50.89	53.67
31	14.46	15.66	17.54	19.28	44.99	48.23	52.19	55.00
32	15.13	16.36	18.29	20.07	46.19	49.48	53.49	56.33
33	15.82	17.07	19.05	20.87	47.40	50.73	54.78	57.65
34	16.50	17.79	19.81	21.66	48.60	51.97	56.06	58.96
35	17.19	18.51	20.57	22.47	49.80	53.20	57.34	60.27
36	17.89	19.23	21.34	23.27	51.00	54.44	58.62	61.58
37	18.59	19.96	22.11	24.07	52.19	55.67	59.89	62.88
38	19.29	20.69	22.88	24.88	53.38	56.90	61.16	64.18
39	20.00	21.43	23.65	25.70	54.57	58.12	62.43	65.48
40	20.71	22.16	24.43	26.51	55.76	59.34	63.69	66.77
41	21.42	22.91	25.21	27.33	56.94	60.56	64.95	68.05
42	22.14	23.65	26.00	28.14	58.12	61.78	66.21	69.34
43	22.86	24.40	26.79	28.96	59.30	62.99	67.46	70.62
44	23.58	25.15	27.57	29.79	60.48	64.20	68.71	71.89
45	24.31	25.90	28.37	30.61	61.66	65.41	69.96	73.17
46	25.04	26.66	29.16	31.44	62.83	66.62	71.20	74.44
47	25.77	27.42	29.96	32.27	64.00	67.82	72.44	75.70
48	26.51	28.18	30.75	33.10	65.17	69.02	73.68	76.97
49	27.25	28.94	31.55	33.93	66.34	70.22	74.92	78.23
50	27.99	29.71	32.36	34.76	67.50	71.42	76.15	79.49

For use on the CAS exams

n2 = 3

U0	n1 = 1	n1 = 2	n1 = 3
0	0.250	0.100	0.050
1	0.500	0.200	0.100
2		0.400	0.200
3		0.600	0.350
4			0.500

n2 = 4

U0	n1 = 1	n1 = 2	n1 = 3	n1 = 4
0	0.200	0.067	0.029	0.014
1	0.400	0.134	0.057	0.029
2	0.600	0.267	0.114	0.057
3		0.400	0.200	0.100
4		0.600	0.314	0.172
5			0.428	0.243
6			0.572	0.343
7				0.443
8				0.557

n2 = 5

U0	n1 = 1	n1 = 2	n1 = 3	n1 = 4	n1 = 5
0	0.167	0.048	0.018	0.008	0.004
1	0.334	0.095	0.036	0.016	0.008
2	0.500	0.191	0.071	0.032	0.016
3		0.286	0.125	0.056	0.028
4		0.429	0.197	0.095	0.048
5		0.571	0.286	0.143	0.075
6			0.393	0.206	0.111
7			0.500	0.278	0.155
8				0.365	0.210
9				0.452	0.274
10				0.548	0.345
11					0.421
12					0.500

n2 = 6

U0	n1 = 1	n1 = 2	n1 = 3	n1 = 4	n1 = 5	n1 = 6
0	0.143	0.036	0.012	0.005	0.002	0.001
1	0.286	0.071	0.024	0.009	0.004	0.002
2	0.429	0.143	0.048	0.019	0.009	0.004
3	0.571	0.214	0.083	0.033	0.015	0.008
4		0.321	0.131	0.057	0.026	0.013
5		0.428	0.191	0.086	0.041	0.021
6		0.572	0.274	0.129	0.063	0.033
7			0.357	0.176	0.089	0.047
8			0.452	0.238	0.123	0.066
9			0.548	0.305	0.164	0.090
10				0.381	0.214	0.120
11				0.457	0.268	0.155
12				0.543	0.331	0.197
13					0.396	0.242
14					0.465	0.294
15					0.535	0.349
16						0.409
17						0.469
18						0.531

n2 = 7

U0	n1 = 1	n1 = 2	n1 = 3	n1 = 4	n1 = 5	n1 = 6	n1 = 7
0	0.125	0.028	0.008	0.003	0.001	0.001	0.000
1	0.250	0.056	0.017	0.006	0.003	0.001	0.001
2	0.375	0.111	0.033	0.012	0.005	0.002	0.001
3	0.500	0.167	0.058	0.021	0.009	0.004	0.002
4		0.250	0.092	0.036	0.015	0.007	0.004
5		0.333	0.133	0.054	0.024	0.011	0.005
6		0.444	0.192	0.082	0.037	0.018	0.009
7		0.556	0.258	0.115	0.053	0.026	0.013
8			0.333	0.158	0.074	0.037	0.019
9			0.417	0.206	0.101	0.051	0.027
10			0.500	0.264	0.134	0.069	0.036
11				0.324	0.172	0.090	0.049
12				0.394	0.216	0.117	0.064
13				0.464	0.265	0.148	0.083
14				0.536	0.319	0.183	0.104
15					0.378	0.223	0.130
16					0.438	0.267	0.159
17					0.500	0.314	0.191
18						0.365	0.228
19						0.418	0.268
20						0.472	0.310
21						0.528	0.355
22							0.403
23							0.451
24							0.500

n2 = 8

U0	n1 = 1	n1 = 2	n1 = 3	n1 = 4	n1 = 5	n1 = 6	n1 = 7	n1 = 8
0	0.111	0.022	0.006	0.002	0.001	0.000	0.000	0.000
1	0.223	0.044	0.012	0.004	0.002	0.001	0.000	0.000
2	0.334	0.089	0.024	0.008	0.003	0.001	0.001	0.000
3	0.445	0.133	0.042	0.014	0.005	0.002	0.001	0.001
4	0.555	0.200	0.067	0.024	0.009	0.004	0.002	0.001
5		0.267	0.097	0.036	0.015	0.006	0.003	0.002
6		0.355	0.139	0.054	0.023	0.010	0.005	0.002
7		0.444	0.188	0.077	0.033	0.015	0.007	0.004
8		0.556	0.249	0.107	0.047	0.021	0.010	0.005
9			0.315	0.141	0.064	0.030	0.014	0.007
10			0.388	0.184	0.086	0.041	0.020	0.011
11			0.461	0.230	0.111	0.054	0.027	0.014
12			0.539	0.285	0.142	0.071	0.036	0.019
13				0.341	0.177	0.090	0.047	0.025
14				0.404	0.218	0.114	0.060	0.033
15				0.467	0.262	0.141	0.076	0.042
16				0.533	0.311	0.173	0.095	0.052
17					0.362	0.207	0.116	0.065
18					0.416	0.245	0.140	0.080
19					0.472	0.286	0.168	0.097
20					0.528	0.331	0.198	0.117
21						0.377	0.232	0.139
22						0.426	0.268	0.164
23						0.475	0.306	0.191
24						0.525	0.347	0.221
25							0.389	0.253
26							0.433	0.287
27							0.477	0.323
28							0.523	0.361
29								0.400
30								0.440
31								0.480
32								0.520

n2 = 9

U0	n1 = 1	n1 = 2	n1 = 3	n1 = 4	n1 = 5	n1 = 6	n1 = 7	n1 = 8	n1 = 9
0	0.100	0.018	0.004	0.001	0.001	0.000	0.000	0.000	0.000
1	0.200	0.036	0.009	0.003	0.001	0.000	0.000	0.000	0.000
2	0.300	0.073	0.018	0.006	0.002	0.001	0.000	0.000	0.000
3	0.400	0.109	0.032	0.010	0.004	0.001	0.001	0.000	0.000
4	0.500	0.164	0.050	0.017	0.006	0.002	0.001	0.001	0.000
5		0.218	0.073	0.025	0.009	0.004	0.002	0.001	0.000
6		0.291	0.105	0.038	0.014	0.006	0.003	0.001	0.001
7		0.364	0.141	0.053	0.021	0.009	0.004	0.002	0.001
8		0.455	0.186	0.074	0.030	0.013	0.006	0.003	0.001
9		0.545	0.241	0.099	0.041	0.018	0.008	0.004	0.002
10			0.300	0.130	0.056	0.025	0.011	0.005	0.003
11			0.364	0.165	0.073	0.033	0.016	0.008	0.004
12			0.432	0.207	0.095	0.044	0.021	0.010	0.005
13			0.500	0.252	0.120	0.057	0.027	0.014	0.007
14				0.302	0.149	0.072	0.036	0.018	0.009
15				0.356	0.182	0.090	0.045	0.023	0.012
16				0.413	0.219	0.112	0.057	0.029	0.016
17				0.470	0.259	0.136	0.071	0.037	0.020
18				0.530	0.303	0.164	0.087	0.046	0.025
19					0.350	0.194	0.105	0.057	0.031
20					0.399	0.228	0.126	0.069	0.039
21					0.449	0.264	0.150	0.084	0.047
22					0.500	0.303	0.176	0.100	0.057
23						0.344	0.204	0.118	0.068
24						0.388	0.235	0.138	0.081
25						0.432	0.268	0.160	0.095
26						0.477	0.303	0.185	0.111
27						0.523	0.340	0.211	0.129
28							0.379	0.240	0.149
29							0.419	0.270	0.170
30							0.459	0.303	0.193
31							0.500	0.336	0.218
32								0.371	0.245
33								0.407	0.273
34								0.444	0.302
35								0.481	0.333
36								0.519	0.365
37									0.398
38									0.431
39									0.466
40									0.500

U0	n1 = 1	n1 = 2	n1 = 3	n1 = 4	n1 = 5	n1 = 6	n1 = 7	n1 = 8	n1 = 9	n1 = 10
0	0.091	0.015	0.004	0.001	0.000	0.000	0.000	0.000	0.000	0.000
1	0.182	0.030	0.007	0.002	0.001	0.000	0.000	0.000	0.000	0.000
2	0.273	0.061	0.014	0.004	0.001	0.001	0.000	0.000	0.000	0.000
3	0.364	0.091	0.024	0.007	0.002	0.001	0.000	0.000	0.000	0.000
4	0.455	0.137	0.038	0.012	0.004	0.002	0.001	0.000	0.000	0.000
5	0.545	0.182	0.056	0.018	0.006	0.002	0.001	0.000	0.000	0.000
6		0.243	0.081	0.027	0.010	0.004	0.002	0.001	0.000	0.000
7		0.303	0.108	0.038	0.014	0.005	0.002	0.001	0.001	0.000
8		0.379	0.143	0.053	0.020	0.008	0.003	0.002	0.001	0.000
9		0.455	0.185	0.071	0.027	0.011	0.005	0.002	0.001	0.001
10		0.545	0.234	0.094	0.037	0.016	0.007	0.003	0.002	0.001
11			0.287	0.120	0.049	0.021	0.009	0.004	0.002	0.001
12			0.346	0.152	0.065	0.028	0.012	0.006	0.003	0.001
13			0.405	0.187	0.082	0.036	0.017	0.008	0.004	0.002
14			0.469	0.227	0.103	0.047	0.021	0.010	0.005	0.003
15			0.531	0.270	0.127	0.059	0.028	0.013	0.007	0.003
16				0.318	0.155	0.074	0.035	0.017	0.009	0.004
17				0.367	0.185	0.090	0.044	0.022	0.011	0.006
18				0.420	0.220	0.110	0.054	0.027	0.014	0.007
19				0.472	0.256	0.132	0.066	0.034	0.018	0.009
20				0.527	0.297	0.157	0.081	0.042	0.022	0.012
21					0.339	0.184	0.096	0.051	0.027	0.014
22					0.384	0.214	0.115	0.061	0.033	0.018
23					0.429	0.246	0.135	0.073	0.039	0.021
24					0.476	0.281	0.157	0.086	0.047	0.026
25					0.524	0.318	0.182	0.102	0.056	0.031
26						0.356	0.208	0.119	0.067	0.038
27						0.396	0.237	0.137	0.078	0.044
28						0.438	0.268	0.158	0.091	0.052
29						0.479	0.300	0.180	0.105	0.061
30						0.521	0.334	0.204	0.121	0.071
31							0.369	0.230	0.139	0.083
32							0.406	0.257	0.158	0.095
33							0.443	0.286	0.178	0.109
34							0.481	0.317	0.200	0.123
35							0.519	0.348	0.223	0.140
36								0.381	0.248	0.157
37								0.414	0.274	0.176
38								0.448	0.302	0.196
39								0.483	0.330	0.218
40								0.517	0.360	0.241
41									0.390	0.264
42									0.421	0.289
43									0.452	0.315
44									0.484	0.342
45									0.516	0.370
46										0.398
47										0.427
48										0.456
49										0.485
50										0.515

Tables for CAS Exam LC

Updated 2013

The following tables will be provided to the candidate with the exam. The tables are reprinted with the permission of the Society of Actuaries.

Tables of the Normal Distribution

Probability Content
from -∞ to Z

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.0	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990

Values of z for selected values of Pr(Z<z)

z	0.842	1.036	1.282	1.645	1.960	2.326	2.576
Pr(Z<z)	0.800	0.850	0.900	0.950	0.975	0.990	0.995

Illustrative Life Table: Basic Functions and Single Benefit Premiums at $i = 0.06$

x	l_x	$1000q_x$	$\ddot{a}_x$	$1000A_x$	$1000(^2A_x)$	1000_5E_x	$1000_{10}E_x$	$1000_{20}E_x$	x
0	10,000,000	20.42	16.8010	49.00	25.92	728.54	541.95	299.89	0
5	9,749,503	0.98	17.0379	35.59	8.45	743.89	553.48	305.90	5
10	9,705,588	0.85	16.9119	42.72	9.37	744.04	553.34	305.24	10
15	9,663,731	0.91	16.7384	52.55	11.33	743.71	552.69	303.96	15
20	9,617,802	1.03	16.5133	65.28	14.30	743.16	551.64	301.93	20
21	9,607,896	1.06	16.4611	68.24	15.06	743.01	551.36	301.40	21
22	9,597,695	1.10	16.4061	71.35	15.87	742.86	551.06	300.82	22
23	9,587,169	1.13	16.3484	74.62	16.76	742.68	550.73	300.19	23
24	9,576,288	1.18	16.2878	78.05	17.71	742.49	550.36	299.49	24
25	9,565,017	1.22	16.2242	81.65	18.75	742.29	549.97	298.73	25
26	9,553,319	1.27	16.1574	85.43	19.87	742.06	549.53	297.90	26
27	9,541,153	1.33	16.0873	89.40	21.07	741.81	549.05	297.00	27
28	9,528,475	1.39	16.0139	93.56	22.38	741.54	548.53	296.01	28
29	9,515,235	1.46	15.9368	97.92	23.79	741.24	547.96	294.92	29
30	9,501,381	1.53	15.8561	102.48	25.31	740.91	547.33	293.74	30
31	9,486,854	1.61	15.7716	107.27	26.95	740.55	546.65	292.45	31
32	9,471,591	1.70	15.6831	112.28	28.72	740.16	545.90	291.04	32
33	9,455,522	1.79	15.5906	117.51	30.63	739.72	545.07	289.50	33
34	9,438,571	1.90	15.4938	122.99	32.68	739.25	544.17	287.82	34
35	9,420,657	2.01	15.3926	128.72	34.88	738.73	543.18	286.00	35
36	9,401,688	2.14	15.2870	134.70	37.26	738.16	542.11	284.00	36
37	9,381,566	2.28	15.1767	140.94	39.81	737.54	540.92	281.84	37
38	9,360,184	2.43	15.0616	147.46	42.55	736.86	539.63	279.48	38
39	9,337,427	2.60	14.9416	154.25	45.48	736.11	538.22	276.92	39
40	9,313,166	2.78	14.8166	161.32	48.63	735.29	536.67	274.14	40
41	9,287,264	2.98	14.6864	168.69	52.01	734.40	534.99	271.12	41
42	9,259,571	3.20	14.5510	176.36	55.62	733.42	533.14	267.85	42
43	9,229,925	3.44	14.4102	184.33	59.48	732.34	531.12	264.31	43
44	9,198,149	3.71	14.2639	192.61	63.61	731.17	528.92	260.48	44
45	9,164,051	4.00	14.1121	201.20	68.02	729.88	526.52	256.34	45
46	9,127,426	4.31	13.9546	210.12	72.72	728.47	523.89	251.88	46
47	9,088,049	4.66	13.7914	219.36	77.73	726.93	521.03	247.08	47
48	9,045,679	5.04	13.6224	228.92	83.06	725.24	517.91	241.93	48
49	9,000,057	5.46	13.4475	238.82	88.73	723.39	514.51	236.39	49
50	8,950,901	5.92	13.2668	249.05	94.76	721.37	510.81	230.47	50
51	8,897,913	6.42	13.0803	259.61	101.15	719.17	506.78	224.15	51
52	8,840,770	6.97	12.8879	270.50	107.92	716.76	502.40	217.42	52
53	8,779,128	7.58	12.6896	281.72	115.09	714.12	497.64	210.27	53
54	8,712,621	8.24	12.4856	293.27	122.67	711.24	492.47	202.70	54
55	8,640,861	8.96	12.2758	305.14	130.67	708.10	486.86	194.72	55
56	8,563,435	9.75	12.0604	317.33	139.11	704.67	480.79	186.32	56
57	8,479,908	10.62	11.8395	329.84	147.99	700.93	474.22	177.53	57
58	8,389,826	11.58	11.6133	342.65	157.33	696.85	467.12	168.37	58
59	8,292,713	12.62	11.3818	355.75	167.13	692.41	459.46	158.87	59
60	8,188,074	13.76	11.1454	369.13	177.41	687.56	451.20	149.06	60
61	8,075,403	15.01	10.9041	382.79	188.17	682.29	442.31	139.00	61
62	7,954,179	16.38	10.6584	396.70	199.41	676.56	432.77	128.75	62
63	7,823,879	17.88	10.4084	410.85	211.13	670.33	422.54	118.38	63
64	7,683,979	19.52	10.1544	425.22	223.34	663.56	411.61	107.97	64
65	7,533,964	21.32	9.8969	439.80	236.03	656.23	399.94	97.60	65

Illustrative Life Table: Basic Functions and Single Benefit Premiums at $i = 0.06$

x	l_x	$1000q_x$	$\ddot{a}_x$	$1000A_x$	$1000(^2A_x)$	$1000{}_5E_x$	$1000{}_{10}E_x$	$1000{}_{20}E_x$	x
66	7,373,338	23.29	9.6362	454.56	249.20	648.27	387.53	87.37	66
67	7,201,635	25.44	9.3726	469.47	262.83	639.66	374.36	77.38	67
68	7,018,432	27.79	9.1066	484.53	276.92	630.35	360.44	67.74	68
69	6,823,367	30.37	8.8387	499.70	291.46	620.30	345.77	58.54	69
70	6,616,155	33.18	8.5693	514.95	306.42	609.46	330.37	49.88	70
71	6,396,609	36.26	8.2988	530.26	321.78	597.79	314.27	41.86	71
72	6,164,663	39.62	8.0278	545.60	337.54	585.25	297.51	34.53	72
73	5,920,394	43.30	7.7568	560.93	353.64	571.81	280.17	27.96	73
74	5,664,051	47.31	7.4864	576.24	370.08	557.43	262.31	22.19	74
75	5,396,081	51.69	7.2170	591.49	386.81	542.07	244.03	17.22	75
76	5,117,152	56.47	6.9493	606.65	403.80	525.71	225.46	13.04	76
77	4,828,182	61.68	6.6836	621.68	421.02	508.35	206.71	9.61	77
78	4,530,360	67.37	6.4207	636.56	438.42	489.97	187.94	6.88	78
79	4,225,163	73.56	6.1610	651.26	455.95	470.57	169.31	4.77	79
80	3,914,365	80.30	5.9050	665.75	473.59	450.19	151.00	3.19	80
81	3,600,038	87.64	5.6533	680.00	491.27	428.86	133.19	2.05	81
82	3,284,542	95.61	5.4063	693.98	508.96	406.62	116.06	1.27	82
83	2,970,496	104.28	5.1645	707.67	526.60	383.57	99.81	0.75	83
84	2,660,734	113.69	4.9282	721.04	544.15	359.79	84.59	0.42	84
85	2,358,246	123.89	4.6980	734.07	561.57	335.40	70.56	0.22	85
86	2,066,090	134.94	4.4742	746.74	578.80	310.56	57.83	0.11	86
87	1,787,299	146.89	4.2571	759.03	595.79	285.44	46.50	0.05	87
88	1,524,758	159.81	4.0470	770.92	612.51	260.21	36.61	0.02	88
89	1,281,083	173.75	3.8442	782.41	628.92	235.11	28.17	0.01	89
90	1,058,491	188.77	3.6488	793.46	644.96	210.36	21.13	0.00	90
91	858,676	204.93	3.4611	804.09	660.61	186.21	15.41	0.00	91
92	682,707	222.27	3.2812	814.27	675.83	162.90	10.91	0.00	92
93	530,959	240.86	3.1091	824.01	690.59	140.69	7.47	0.00	93
94	403,072	260.73	2.9450	833.30	704.86	119.79	4.93	0.00	94
95	297,981	281.91	2.7888	842.14	718.61	100.43	3.13	0.00	95
96	213,977	304.45	2.6406	850.53	731.83	82.78	1.90	0.00	96
97	148,832	328.34	2.5002	858.48	744.50	66.97	1.10	0.00	97
98	99,965	353.60	2.3676	865.99	756.60	53.09	0.60	0.00	98
99	64,617	380.20	2.2426	873.06	768.13	41.14	0.31	0.00	99
100	40,049	408.12	2.1252	879.70	779.08	31.12	0.15	0.00	100
101	23,705	437.28	2.0152	885.93	789.44	22.91	0.07	0.00	101
102	13,339	467.61	1.9123	891.76	799.21	16.37	0.03	0.00	102
103	7,101	498.99	1.8164	897.19	808.41	11.33	0.01	0.00	103
104	3,558	531.28	1.7273	902.23	817.02	7.56	0.00	0.00	104
105	1,668	564.29	1.6447	906.90	825.06	4.86	0.00	0.00	105
106	727	597.83	1.5685	911.22	832.53	2.99	0.00	0.00	106
107	292	631.64	1.4984	915.19	839.46	1.76	0.00	0.00	107
108	108	665.45	1.4341	918.82	845.84	0.98	0.00	0.00	108
109	36	698.97	1.3755	922.14	851.69	0.52	0.00	0.00	109
110	11	731.87	1.3223	925.15	857.04	0.26	0.00	0.00	110

Interest Functions

Interest Functions at $i = 0.06$

m	$i^{(m)}$	$d^{(m)}$	$i/i^{(m)}$	$d/d^{(m)}$	$\alpha(m)$	$\beta(m)$
1	0.06000	0.05660	1.00000	1.00000	1.00000	0.00000
2	0.05913	0.05743	1.01478	0.98564	1.00021	0.25739
4	0.05870	0.05785	1.02223	0.97852	1.00027	0.38424
12	0.05841	0.05813	1.02721	0.97378	1.00028	0.46812
∞	0.05827	0.05827	1.02971	0.97142	1.00028	0.50985

Special Note: Unless specified, the force of interest is constant in each question .

Exam ST

Models for Stochastic Processes and Statistics

2.5 HOURS

INSTRUCTIONS TO CANDIDATES

1. This 50 point examination consists of 25 multiple choice questions worth 2 points each.

2. To answer the multiple choice questions, use the short-answer card provided and a number 2 or HB pencil only.

    - Fill in that it is fall 2015 and that the exam name is ST.

    - Darken the spaces corresponding to your Candidate ID number. Five rows are available. If your Candidate ID number is fewer than 5 digits, include leading zeros. For example, if your Candidate ID number is 987, consider that your Candidate ID number is 00987, enter a zero on the first row, a zero on the second row, 9 on the third row, 8 on the fourth row, and 7 on the fifth [last] row. Write in your Candidate ID number next to the place where you darken the spaces for your Candidate ID number. Your name, or any other identifying mark, must not appear on the short-answer card.

    - Mark your short-answer card during the examination period. No additional time will be allowed for this after the exam has ended. Make your marks dark and fill in the spaces completely.

    - For each of the multiple choice questions, select the one best answer and fill in the corresponding letter. One quarter of the point value of the question will be subtracted for each incorrect answer. No points will be added or subtracted for responses left blank.

3. Do all problems until you reach the last page of the examination where "END OF EXAMINATION" is marked.

CONTINUE TO NEXT PAGE OF INSTRUCTIONS
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4.   Prior to the start of the exam you will have a **ten-minute reading period** in which you can silently read the questions and check the exam booklet for missing or defective pages. Writing will NOT be permitted during this time and you will not be permitted to hold pens or pencils. You will also not be allowed to use calculators. The supervisor has additional exams for those candidates who have defective exam booklets.

  - Verify that you have a copy of "Tables for CAS Exam ST" included in your exam packet.

  - Candidates should not interpolate in the tables unless explicitly instructed to do so in the problem, rather, a candidate should round the result that would be used to enter a given table to the same level of precision as shown in the table and use the result in the table that is nearest to that indicated by rounded result. For example, if a candidate is using the Tables of the Normal Distribution to find a significance level and has a Z value of 1.903, the candidate should round to 1.90 to find cumulative probability in the Normal table.

  - Candidates should employ a non-parametric test unless otherwise specified in the problem, or when there is a standard distribution that is logically or commonly associated with the random variable in question. Examples of problems with a logical or commonly associated distribution would include exponential wait times for Poisson processes and applications of the Central Limit Theorem.

5.   Your Examination Envelope is pre-labeled with your Candidate ID number, name, exam number, and test center. Do not remove this label. Keep a record of your Candidate ID number for future inquiries regarding this exam.

6.   Candidates must remain in the examination center until the examination has concluded. The examination starts after the reading period is complete. You may leave the examination room to use the restroom with permission from the supervisor.

7.   At the end of the examination, place the short-answer card in the Examination Envelope. Nothing written in the examination booklet will be graded. Only the short-answer card will be graded. Also place any included reference materials in the Examination Envelope. BEFORE YOU TURN THE EXAMINATION ENVELOPE IN TO THE SUPERVISOR, BE SURE TO SIGN IT IN THE SPACE PROVIDED ABOVE THE CUT-OUT WINDOW.

8.   If you have brought a self-addressed, stamped envelope, you may put the examination booklet and scrap paper inside and submit it separately to the supervisor. It will be mailed to you. Do not put the self-addressed stamped envelope inside the Examination Envelope. Interoffice mail is not acceptable.

If you do not have a self-addressed, stamped envelope, please place the examination booklet in the Examination Envelope and seal the envelope. You may not take it with you. Do not put scrap paper in the Examination Envelope. The supervisor will collect your scrap paper.

Candidates may obtain a copy of the examination from the CAS Web Site.

All extra answer sheets, scrap paper, etc. must be returned to the supervisor for disposal.

9.   Candidates must not give or receive assistance of any kind during the examination. Any cheating, any attempt to cheat, assisting others to cheat, or participating therein, or other improper conduct will result in the Casualty Actuarial Society and the Canadian Institute of Actuaries disqualifying the candidate's paper, and such other disciplinary action as may be deemed appropriate within the guidelines of the CAS Policy on Examination Discipline.

10.   The exam survey is available on the CAS Web Site in the "Admissions/Exams" section. Please submit your survey by November 14, 2015.

END OF INSTRUCTIONS

2015 Exam S Syllabus
Statistics and Probabilistic Models

The syllabus for this four-hour multiple-choice exam is defined in the form of learning objectives, knowledge statements, and readings.

LEARNING OBJECTIVES set forth, usually in broad terms, what the candidate should be able to do in actual practice. Included in these learning objectives are certain methodologies that may not be possible to perform on an examination, such as calculating the likelihood ratio test when there is no closed-form solution, but that the candidate would still be expected to explain conceptually in the context of an examination.

KNOWLEDGE STATEMENTS identify some of the key terms, concepts, and methods that are associated with each learning objective. These knowledge statements are not intended to represent an exhaustive list of topics that may be tested, but they are illustrative of the scope of each learning objective.

READINGS support the learning objectives. It is intended that the readings, in conjunction with the material on the preliminary examinations, provide sufficient resources to allow the candidate to demonstrate proficiency with respect to the learning objectives. Some readings are cited for more than one learning objective. The Syllabus and Examination Committees emphasize that candidates are expected to use the readings cited in this *Syllabus* as their primary study materials.

Thus, the learning objectives, knowledge statements, and readings complement each other. The learning objectives define the behaviors, the knowledge statements illustrate more fully the intended scope of the learning objectives, and the readings provide the source material to achieve the learning objectives. Learning objectives should not be seen as independent units, but as building blocks for the understanding and integration of important competencies that the candidate will be able to demonstrate.

Note that the range of weights shown should be viewed as a guideline only. There is no intent that they be strictly adhered to on any given examination—the actual weight may fall outside the published range on any particular examination.

The overall section weights should be viewed as having more significance than the weights for the individual learning objectives. Over a number of years of examinations, absent changes, it is likely that the average of the weights for each individual overall section will be in the vicinity of the guideline weight. For the weights of individual learning objectives, such convergence is less likely. On a given examination, in which it is very possible that not every individual learning objective will be tested, there will be more divergence of guideline weights and actual weights. Questions on a given learning objective may be drawn from any of the listed readings, or a combination of the readings. There may be no questions from one or more readings on a particular exam.

After each set of learning objectives, the readings are listed in abbreviated form. Complete text references are provided at the end of this exam syllabus.

A thorough knowledge of calculus and probability is assumed, as is familiarity with discounting cash flows. While some problems may have an insurance or risk management theme, no prior knowledge of insurance terminology is expected.

The Probability Models section (Section A) covers Stochastic Processes, Markov Chains and Survival Models along with a simplified version of Life Contingencies. Survival models are covered in depth as part of probability modeling in generic terms. Markov Chains provide the means to model how an entity can move through different states. Life Contingencies problems can be viewed as discounted cash flow problems that include the effect of probability of payment, and are covered through a Study Note linking the generic survival model concepts to a subset of life actuarial concepts to illustrate how to calculate annuities or single premium insurance amounts.

In general, the material covered under the Statistics section (Section B) covers topics that would be commonly found in a second semester course of a two semester Probability & Statistics sequence at the undergraduate level. Coverage of the topics listed under the Statistics section will vary by college and the candidate may need to supplement that course work with additional reading and problem solving work from the suggested textbooks listed at the end of Section B.

The Extended Linear Model section (Section C) covers Generalized Linear Models, a predictive modeling technique commonly used to construct classification plans. Ordinary least squares is covered as one member of the exponential family under the Generalized Linear Models section. Many textbooks covering this topic, including the textbook on the syllabus, use statistical software to illustrate the concepts covered in examples, since using a calculator to solve a realistic problem is impractical. While it is not required that the candidates learn a statistical language for the purposes of this examination, learning the basic concepts of a statistical language will be useful in applying the techniques on this exam in practice.

The Time Series section (Section D) covers an introduction to modeling activity over time like financial results or stock prices using the Auto Regressive Integrated Moving Average (ARIMA) where activity in a given time period may be linked to activity in subsequent time periods. That connection between adjacent time periods violates one of the assumptions behind the Extended Linear Model techniques, but the ARIMA approach incorporates that linkage as an aid in predicting future results.

The CAS will test the candidate's knowledge of topics that are presented in the learning objectives. Thus, the candidate should expect that each exam will cover a large proportion of the learning objectives and associated knowledge statements and syllabus readings, and that all of these will be tested at least once over the course of a few years—but each one may not be covered on each exam.

A variety of tables will be provided to the candidate with the exam. The tables include values for the illustrative life tables, standard normal distribution, abridged inventories of discrete and continuous probability distributions, Chi-square Distribution, *t*-Distribution, *F*-Distribution, Normal Distribution as well as the tables required to perform the Signed-Rank test and Mann Whitney tests from the non-parametric section. Since they will be included with the examination, candidates will not be allowed to bring copies of the tables into the examination room.

A guessing adjustment will be used in grading this exam. Details are provided under "Guessing Adjustment" in the "Examination Rules-The Examination" section of the *Syllabus of Basic Education*.

Items marked with a bold OP (Online Publication) are available at no charge and may be downloaded from the CAS website.

Changes made since this syllabus was first published are highlighted in red below. Please check the "Syllabus Update" for this exam for any further changes to this syllabus.

A. Probability Models (Stochastic Processes and Survival Models)

Range of weight for Section A: 20-40 percent

Candidates should be able to solve problems using stochastic processes. They should be able to determine the probabilities and distributions associated with these processes. Specifically, candidates should be able to use a Poisson process in these applications. Survival models are simply an extension of the stochastic process probability models where one is estimating the future lifetime of an entity given assumptions on the distribution function used to describe the likelihood of survival. Markov Chains are a useful tool to model movement between states in a given process and underlie modern Bayesian MCMC models. The Study Note will re-cast the generic survival model learning objectives to link those concepts to life actuarial symbols to help ensure P&C actuaries can communicate with life actuaries on basic concepts, but we should recognize that many disciplines like engineering or computer science incorporate survival models in their work. Life Contingencies problems can be viewed as discounted cash flow problems that can be set up and solved using Markov Chain concepts or simply viewed as three matrices in a spreadsheet indicating payment amount, likelihood of payment and discount effect by time period as illustrated by Learning Objective 7.

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
1. Understand and apply the properties of Poisson processes: • For increments in the homogeneous case • For interval times in the homogeneous case • For increments in the non-homogeneous case • Resulting from special types of events in the Poisson process • Resulting from sums of independent Poisson processes Range of weight: 0-5 percent	a. Poisson process b. Non-homogeneous Poisson process c. Memoryless property of Exponential and Poisson d. Relationship between Exponential and Gamma e. Relationship between Exponential and Poisson
2. For any Poisson process and the inter-arrival and waiting distributions associated with the Poisson process, calculate: • Expected values • Variances • Probabilities Range of weight: 0-5 percent	a. Probability calculations for Poisson process b. Conditional distribution of arrival times c. Greedy algorithms
3. For a compound Poisson process, calculate moments associated with the value of the process at a given time. Range of weight: 0-5 percent	a. Compound Poisson process mean and variance b. Normal approximation and hypothesis testing
READINGS	
Ross 5.3-5.4 Daniel	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
4. Apply the Poisson Process concepts to calculate the hazard function and related survival model concepts • Relationship between hazard rate, probability density function and cumulative distribution function • Effect of memoryless nature of Poisson distribution on survival time estimation Range of weight: 2-8 percent	a. Failure time random variables b. Cumulative distribution functions c. Survival functions d. Probability density functions e. Hazard functions and relationship to Exponential distribution f. Relationships between failure time random variables in the functions above

READINGS
Ross 5.2

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
5. Given the joint distribution of more than one source of failure in a system (or life) and using Poisson Process assumptions: • Calculate probabilities and moments associated with functions of these random variables' variances. • Understand difference between a series system (joint life) and parallel system (last survivor) when calculating expected time to failure or probability of failure by a certain time • Understand the effect of multiple sources of failure (multiple decrement) on expected system time to failure (expected lifetime) Range of weight: 2-8 percent	a. Joint distribution of failure times b. Probabilities and moments c. Time until failure of the system (life) d. Time until failure of the system (life) from a specific cause e. Time until failure of the system (life) for parallel or series systems with multiple components f. Paths that lead to parallel or series system failure for systems with multiple components g. Relationship between failure time and minimal path and minimal cut sets h. Bridge system and defining path to failure i. Random graphs and defining path to failure j. Effect of multiple sources of failure (multiple decrements) on failure time calculations (competing risk) k. Non-uniform probability of component failure (multiple decrement) l. Method of inclusion and exclusion as applied to failure time estimates m. Expected system lifetime as function of component lifetime and properties of expected lifetime estimates

READINGS
Ross 9.1-9.6

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
6. For discrete and continuous Markov Chains under both homogeneous and non-homogenous states • Definition of a Markov Chain • Chapman-Kolmogorov Equations for n-step transition calculations • Accessible states • Ergodic Markov Chains and limiting probabilities • Markov Chain Monte Carlo Methods Range of weight: 2-10 percent	a. Random Walk b. Classification of states and classes of states (absorbing, accessible, transition, irreducible, and recurrent) c. Transition step probabilities d. Stationary probabilities e. Recurrent vs. transient states f. Gamblers ruin problem g. Branching Processes h. Metropolis-Hastings algorithm i. Gibbs sampler j. Birth–Death process k. Homogeneous transition probabilities l. Memoryless property of Markov Chains m. Limiting probabilities
READINGS	
Ross 4.1-4.9 and 6.1-6.5	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
7. Solve Life Contingency problems using a life table in a spreadsheet as the combined result of discount, probability of payment and amount of payment vectors. Understand the linkage between the life table and the corresponding probability models. • Calculate annuities for discrete time • Calculate life insurance single net premiums (or property/casualty pure premiums) for discrete time • Solve for net level premiums (not including fractional lives) Range of weight: 2-8 percent	a. Discounted cash flow b. Relationship between annuity values and insurance premiums c. Life table linkage to probability models d. Equivalence property
READINGS	
Struppeck	

B. Statistics

Range of weight for Section B: 20-40 percent

Candidates should have a thorough understanding of the concepts typically covered in the 2nd semester of a two semester undergraduate sequence in Probability and Statistics. The specific topics to be tested are described below. Mastering the concepts listed under section B is necessary to understand the concepts behind the Generalized Linear Models presented under Section C.

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
1. Perform point estimation of statistical parameters using Maximum likelihood estimation ("MLE"). Apply criteria to the estimates such as: • Consistency • Unbiasedness • Sufficiency • Efficiency • Minimum variance • Mean square error Range of weight: 5-10 percent	a. Equations for MLE of mean, variance from a sample b. Estimation of mean and variance based on sample c. General equations for MLE of parameters d. Recognition of consistency property of estimators and alternative measures of consistency e. Application of criteria for measurement when estimating parameters through minimization of variance, mean square error f. Definition of statistical bias and recognition of estimators that are unbiased or biased g. Application of Rao-Cramer Lower Bound and Efficiency h. Relationship between Sufficiency and Minimum Variance i. Develop and estimate a sufficient statistic for a distribution j. Factorization Criterion for sufficiency k. Application of Rao-Cramer Lower Bound and Fisher Information l. Application of MVUE for the exponential class of distributions

2. Test statistical hypotheses including Type I and Type II errors using: • Neyman-Pearson lemma • Likelihood ratio tests • First principles Apply Neyman-Pearson lemma to construct likelihood ratio equation. Use critical values from a sampling distribution to test means and variances Range of weight: 5-10 percent	a. Presentation of fundamental inequalities based on general assumptions and normal assumptions b. Definition of Type I and Type II errors c. Significance levels d. One-sided versus two-sided tests e. Estimation of sample sizes under normality to control for Type I and Type II errors f. Determination of critical regions g. Definition and measurement of likelihood ratio tests h. Determining parameters and testing using tabular values i. Recognizing when to apply likelihood ratio tests versus chi-square or other goodness of fit tests j. Apply paired t-test to two samples k. Test for difference in variance under Normal distribution between two samples through application of F-test l. Test of significance of means from two samples under Normal distribution assumption in both large and small sample cases m. Test for significance of difference in proportions between two samples under Binomial distribution assumption in both large and small sample case n. Application of contingency tables to test independence between effects o. Asymptotic relationship between likelihood ratio tests and the Chi-Square distribution p. Application of Neyman-Pearson lemma to Uniformly Most Powerful hypothesis tests q. Equivalence between critical regions and confidence intervals
3. Calculate order statistics of a sample for a given distribution and use non-parametric statistics to describe a data set. Range of weight: 5-10 percent	a. General form for distribution of nth largest element of a set b. Application to a given distributional form c. Calculate Spearman's Rho and Kendall's Tau and understand how those correlation measures differ from the Pearson correlation coefficient d. Apply rank order statistics using Sign-Rank Wilcoxon for matched pair tests e. Apply rank order statistics using Sign Test for matched pairs and comparison of distributions with or without Normal approximation f. Apply rank order statistics using Mann-Whitney-Wilcoxon Procedure g. Application of QQ Plots to evaluate goodness of fit h. Relationship between Man-Whitney U test and Wilcoxon's rank sum

4. Bayesian Statistics parameter estimation for conjugate prior and posterior distributions:	a. Calculate Bayesian Point Estimates for the three conjugate prior distributions listed on the Learning Objective
• Beta-Binomial • Normal-Normal • Gamma-Poisson Range of weight: 5-10 percent	b. Calculate Bayesian Interval estimates for the Normal-Normal distribution and special cases of the other conjugate prior distributions listed on the Learning Objective c. Difference between confidence interval and Bayesian credible interval d. Posterior mean as weighted average of posterior distribution and observations e. Bayes Theorem f. Effect of changing variance of observations or prior distribution on posterior distribution parameters

READINGS

There is no single required text for Section B. No single text provides complete coverage of all learning objectives and knowledge statements. Each of the following textbooks has very good coverage of the syllabus material, but there may be other introductory statistics textbooks that cover much of the material as well:

Hogg, McKean, and Craig
Wackerly, Mendenhall, and Scheaffer

For a mapping of the sections of these texts to the learning objectives, candidates should refer to the "Knowledge Statement Mapping for Exam S" document posted on the CAS website under the Syllabus Material section for this exam.

C. Extended Linear Models

Range of weight for Section C: 25-40 percent

This section covers the Generalized Linear Model and treats Ordinary Least Squares as one type of a Generalized Linear Model that may be used when the dependent variable follows the Normal distribution. The models presented in this section all assume that the underlying data consists of independent and identically distributed observations from a member of the exponential distribution family. Also, we assume there is a formula describing the behavior of the dependent variable can be described as a linear process of the dependent variables after applying a link function. The specific topics to be tested are described below.

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
1. Understand the assumptions behind different forms of the Generalized Linear Model under the exponential family assuming independent and identically distributed observations and be able to select the appropriate model from list below: • Ordinary Least Squares • Generalized Linear Model • ANOVA Range of weight: 5-10 percent	a. Understand the relationship between mean and variance by model family member b. Understand how to select the appropriate distribution function for the dependent variable and the implication for the appropriate model form c. Link Functions (Identity, Log, Logit, Power, Inverse) d. (Natural) Exponential Family (Binomial, Normal, Exponential, Gamma, Poisson, Inverse Gaussian, Negative Binomial, Tweedie) e. Canonical Forms of link function and effect of non-canonical link function on bias f. Tweedie relationship to Gamma-Poisson

2. Evaluate models developed using Generalized Linear Model approach
 	
Range of weight: 5-10 percent
	a. Raw and studentized Residuals
	b. R^2 statistic
	c. Cook's Distance and outliers
	d. Influential points
	e. Leverage
	f. Akaike's Information /Criterion (AIC) and BIC(penalized log likelihood measures)
	g. Standardized/Studentized Residuals
	h. Deviance Residuals and relationship to likelihood
	i. PP Plots
	j. Type III Sequential Chi-Square test
	k. T-test and Wald test for significance of regression coefficients
	l. Prediction intervals for response variable
	m. Mean square error and standard error
	n. Calculation and validity of F test to compare two models (under OLS)
	o. Evaluate appropriateness of underlying assumptions including:
	    • Homoscedasticity
	    • Autocorrelation of residuals

3. Understand the algorithms behind the numerical solutions for the different forms of the GLM family to enable interpretation of output from the statistical software employed in modeling and to make appropriate modeling choices when selecting modeling options. Range of weight: 5-10 percent	a. Maximum Likelihood b. Fisher Scoring (iterative weighted least squares) c. Quasi-Likelihood and relationship to maximum likelihood d. Collinearity (Aliasing) and model stability
4. Understand and be able to select the appropriate model structure for GLM given the behavior of the data set to be modeled Range of weight: 5-10 percent	a. Predictor variables b. Response variables c. Regression through the origin d. Transformation of variables e. Categorical vs. continuous explanatory variables f. Interaction terms g. Significance and model comparison statistics h. Residuals and model parameter selection

READINGS

de Jong Chapters 1-8
Rosenberg Sections 2.1-2.2

Candidates may find it helpful to refer to the textbook they use for Section B for more background and examples on the Student's t-test, F test, Wald test, and chi-square test.

Exam questions from this section may contain parameter tables and diagnostic tables or plots of the type shown in the text. Candidates should understand how to interpret these tables. Candidates who become familiar with a statistical language capable of generating this type of output, such as R or SAS, will have an easier time understanding and applying the concepts covered in the syllabus material. However, for exam questions from this section, candidates will not be asked to write or interpret R or SAS code.

Candidates are encouraged to seek out examples of GLM problems to enhance their understanding of GLM concepts. Sources for such examples will be posted on the CAS website under the Syllabus Material section for this exam. Candidates will not be tested on concepts that are outside of the scope of the required reading that may appear in those examples. The examples are furnished so that candidates might reinforce concepts covered in the de Jong textbook.

D. Time Series with Constant Variance

Range of weight for Section D: 5-10 percent

This section will cover basic applications of the Auto Regressive Integrated Moving Average time series model. The specific topics to be tested are described below.

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS

1. Use time series to model trends
   a. Estimation, data analysis and forecasting
   b. Forecast errors and confidence intervals
	a. Mean-reverting time series
	b. Elimination of trends using differencing
	c. Relationship between seasonality and autocorrelation

2. Model relationships of current and past values of a statistic / metric.
   a. Estimation, data analysis and forecasting
   b. Forecast errors and confidence intervals
	a. Calculation and use of lag k autocorrelation statistic and cross correlation statistics in determining model structure
	b. Stationary series
	c. Autoregressive models of order 1, AR(1)
	d. Autoregressive integrated moving average models (ARIMA)
	   • AR(p) models
	   • Moving average models (MA)
	   • Autoregressive moving average models (ARMA)
	   • ARIMA models
	e. Invertible time series and relationship between AR and MA models
	f. Converting between AR and MA models
	g. Interpretation of auto-correlation function as aid to model selection (AR vs. MA and number of lags to include in model)
	h. Relationship between time series input and item modeled for AR vs. MA

3. Understand forecasts produced by ARIMA	a. Forecast using ARIMA models b. One step ahead prediction vs. many step ahead projection c. Change in variance in prediction by AR vs. MA model

READINGS
Cowpertwait Chapters 1-4, 6, 7 (sections 7.1, 7.2 and 7.3) Exam questions from this section may contain snippets of simple R code and illustrative output of the type shown in the text. Candidates should understand the general functionality of the R commands listed in the "Summary of commands used in examples" sections at the end of chapters 1-4 and 6. Candidates will not be asked to write R code, nor will they be required to interpret complex applications or complete R programs.

Complete Text References for Exam S

Text references are alphabetized by the citation column.

Citation	Abbreviation	Learning Objectives	Source
Cowpertwait, Paul S. P., and Metcalfe, Andrew N., *Introductory Time Series with R*, 2009, Springer	Cowpertwait	D1-D3	**B** **NEW**
Daniel, J.W., "Poisson processes (and mixture distributions)," Study Note, June 2008.	Daniel	A1-A3	**OP**
de Jong, P., and Heller, G., *Generalized Linear Models for Insurance Data*, 2008, Cambridge	de Jong	C1-C4	**B** **NEW**
Hogg, R.V.; McKean, J.W.; and Craig, A.T., *Introduction to Mathematical Statistics* (Seventh Edition), 2013, Prentice Hall.	Hogg, McKean, and Craig	B1-B4	**BO**
Rosenberg, M. and Guszcza, J., *Overview of Linear Models*, excerpted from the text *Predictive Modeling Applications in Actuarial Science*, 2014, Cambridge.	Rosenberg	C2	**OP** **NEW**
Ross, Sheldon M., *Introduction to Probability Models* (Eleventh Edition), 2014, Academic Press	Ross	A1-A6	**B** **NEW**
Struppeck, T., *Life Contingencies*, Study Note, October 2014.	Struppeck	A7	**OP** **NEW**
Wackerly, D.; Mendenhall, W.; and Scheaffer, R., *Mathematical Statistics with Applications,*(7th edition)*,* 2008, Cengage Learning	Wackerly, Mendenhall, and Scheaffer	B1-B4	**BO**

Source Key

B   Book—may be purchased from the publisher or bookstore or borrowed from the CAS Library.

BO   Book (Optional)—may be purchased from the publisher or bookstore.

NEW   Indicates new or updated material.

OP   All text references marked as Online Publications will be available on a web page titled Complete Text References.

Publishers and Distributors

Contact information is furnished for those who wish to purchase the text references cited for in the syllabus. Publishers and distributors are independent and listed for the convenience of candidates; inclusion does not constitute endorsement by the CAS.

Academic Press, 200 Wheeler Road, Burlington, MA, 01803, website: http:/www.academicpressbooks.com

Actex Publications (Mad River Books), 107 Groppo Drive, Suite A, P.O. Box 974, Winsted, CT 06098; telephone: (800) 282-2839 or (860) 379-5470; fax: (860) 738-3152; e-mail: retail@actexmadriver.com; Website: www.actexmadriver.com.

Actuarial Bookstore, P.O. Box 69, Greenland, NH 03840; telephone: (800) 582-9672 (U.S. only) or (603) 430-1252; fax: (603) 430-1258; Website: www.actuarialbookstore.com.

Tables for
CAS Exam S

The following tables will be provided to the candidate with the exam. The tables on pages 2 through 15 are reprinted with the permission of the Society of Actuaries; the tables on pages 16 through 25 are copyright material of the Casualty Actuarial Society.

We are furnishing a set of tables for statistical tests as well as a set of distribution functions for Exam S. We do not have a single authoritative textbook for Statistics. The format of the tables may vary from one textbook to the next. The nomenclature used to describe distribution functions may vary from one textbook to the next. To avoid confusion on the part of the candidates we will use the tables and distribution functions definitions that follow when writing exam questions for Exam S.

Tables of the Normal Distribution

Probability Content from -∞ to Z

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.0	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990

Values of z for selected values of Pr(Z<z)

z	0.842	1.036	1.282	1.645	1.960	2.326	2.576
Pr(Z<z)	0.800	0.850	0.900	0.950	0.975	0.990	0.995

Illustrative Life Table: Basic Functions and Single Benefit Premiums at $i = 0.06$

x	l_x	$1000q_x$	$\ddot{a}_x$	$1000A_x$	$1000(^2A_x)$	$1000\,_5E_x$	$1000\,_{10}E_x$	$1000\,_{20}E_x$	x
0	10,000,000	20.42	16.8010	49.00	25.92	728.54	541.95	299.89	0
5	9,749,503	0.98	17.0379	35.59	8.45	743.89	553.48	305.90	5
10	9,705,588	0.85	16.9119	42.72	9.37	744.04	553.34	305.24	10
15	9,663,731	0.91	16.7384	52.55	11.33	743.71	552.69	303.96	15
20	9,617,802	1.03	16.5133	65.28	14.30	743.16	551.64	301.93	20
21	9,607,896	1.06	16.4611	68.24	15.06	743.01	551.36	301.40	21
22	9,597,695	1.10	16.4061	71.35	15.87	742.86	551.06	300.82	22
23	9,587,169	1.13	16.3484	74.62	16.76	742.68	550.73	300.19	23
24	9,576,288	1.18	16.2878	78.05	17.71	742.49	550.36	299.49	24
25	9,565,017	1.22	16.2242	81.65	18.75	742.29	549.97	298.73	25
26	9,553,319	1.27	16.1574	85.43	19.87	742.06	549.53	297.90	26
27	9,541,153	1.33	16.0873	89.40	21.07	741.81	549.05	297.00	27
28	9,528,475	1.39	16.0139	93.56	22.38	741.54	548.53	296.01	28
29	9,515,235	1.46	15.9368	97.92	23.79	741.24	547.96	294.92	29
30	9,501,381	1.53	15.8561	102.48	25.31	740.91	547.33	293.74	30
31	9,486,854	1.61	15.7716	107.27	26.95	740.55	546.65	292.45	31
32	9,471,591	1.70	15.6831	112.28	28.72	740.16	545.90	291.04	32
33	9,455,522	1.79	15.5906	117.51	30.63	739.72	545.07	289.50	33
34	9,438,571	1.90	15.4938	122.99	32.68	739.25	544.17	287.82	34
35	9,420,657	2.01	15.3926	128.72	34.88	738.73	543.18	286.00	35
36	9,401,688	2.14	15.2870	134.70	37.26	738.16	542.11	284.00	36
37	9,381,566	2.28	15.1767	140.94	39.81	737.54	540.92	281.84	37
38	9,360,184	2.43	15.0616	147.46	42.55	736.86	539.63	279.48	38
39	9,337,427	2.60	14.9416	154.25	45.48	736.11	538.22	276.92	39
40	9,313,166	2.78	14.8166	161.32	48.63	735.29	536.67	274.14	40
41	9,287,264	2.98	14.6864	168.69	52.01	734.40	534.99	271.12	41
42	9,259,571	3.20	14.5510	176.36	55.62	733.42	533.14	267.85	42
43	9,229,925	3.44	14.4102	184.33	59.48	732.34	531.12	264.31	43
44	9,198,149	3.71	14.2639	192.61	63.61	731.17	528.92	260.48	44
45	9,164,051	4.00	14.1121	201.20	68.02	729.88	526.52	256.34	45
46	9,127,426	4.31	13.9546	210.12	72.72	728.47	523.89	251.88	46
47	9,088,049	4.66	13.7914	219.36	77.73	726.93	521.03	247.08	47
48	9,045,679	5.04	13.6224	228.92	83.06	725.24	517.91	241.93	48
49	9,000,057	5.46	13.4475	238.82	88.73	723.39	514.51	236.39	49
50	8,950,901	5.92	13.2668	249.05	94.76	721.37	510.81	230.47	50
51	8,897,913	6.42	13.0803	259.61	101.15	719.17	506.78	224.15	51
52	8,840,770	6.97	12.8879	270.50	107.92	716.76	502.40	217.42	52
53	8,779,128	7.58	12.6896	281.72	115.09	714.12	497.64	210.27	53
54	8,712,621	8.24	12.4856	293.27	122.67	711.24	492.47	202.70	54
55	8,640,861	8.96	12.2758	305.14	130.67	708.10	486.86	194.72	55
56	8,563,435	9.75	12.0604	317.33	139.11	704.67	480.79	186.32	56
57	8,479,908	10.62	11.8395	329.84	147.99	700.93	474.22	177.53	57
58	8,389,826	11.58	11.6133	342.65	157.33	696.85	467.12	168.37	58
59	8,292,713	12.62	11.3818	355.75	167.13	692.41	459.46	158.87	59
60	8,188,074	13.76	11.1454	369.13	177.41	687.56	451.20	149.06	60
61	8,075,403	15.01	10.9041	382.79	188.17	682.29	442.31	139.00	61
62	7,954,179	16.38	10.6584	396.70	199.41	676.56	432.77	128.75	62
63	7,823,879	17.88	10.4084	410.85	211.13	670.33	422.54	118.38	63
64	7,683,979	19.52	10.1544	425.22	223.34	663.56	411.61	107.97	64
65	7,533,964	21.32	9.8969	439.80	236.03	656.23	399.94	97.60	65

Illustrative Life Table: Basic Functions and Single Benefit Premiums at $i = 0.06$

x	l_x	$1000q_x$	$\ddot{a}_x$	$1000A_x$	$1000(^2A_x)$	1000_5E_x	$1000_{10}E_x$	$1000_{20}E_x$	x
66	7,373,338	23.29	9.6362	454.56	249.20	648.27	387.53	87.37	66
67	7,201,635	25.44	9.3726	469.47	262.83	639.66	374.36	77.38	67
68	7,018,432	27.79	9.1066	484.53	276.92	630.35	360.44	67.74	68
69	6,823,367	30.37	8.8387	499.70	291.46	620.30	345.77	58.54	69
70	6,616,155	33.18	8.5693	514.95	306.42	609.46	330.37	49.88	70
71	6,396,609	36.26	8.2988	530.26	321.78	597.79	314.27	41.86	71
72	6,164,663	39.62	8.0278	545.60	337.54	585.25	297.51	34.53	72
73	5,920,394	43.30	7.7568	560.93	353.64	571.81	280.17	27.96	73
74	5,664,051	47.31	7.4864	576.24	370.08	557.43	262.31	22.19	74
75	5,396,081	51.69	7.2170	591.49	386.81	542.07	244.03	17.22	75
76	5,117,152	56.47	6.9493	606.65	403.80	525.71	225.46	13.04	76
77	4,828,182	61.68	6.6836	621.68	421.02	508.35	206.71	9.61	77
78	4,530,360	67.37	6.4207	636.56	438.42	489.97	187.94	6.88	78
79	4,225,163	73.56	6.1610	651.26	455.95	470.57	169.31	4.77	79
80	3,914,365	80.30	5.9050	665.75	473.59	450.19	151.00	3.19	80
81	3,600,038	87.64	5.6533	680.00	491.27	428.86	133.19	2.05	81
82	3,284,542	95.61	5.4063	693.98	508.96	406.62	116.06	1.27	82
83	2,970,496	104.28	5.1645	707.67	526.60	383.57	99.81	0.75	83
84	2,660,734	113.69	4.9282	721.04	544.15	359.79	84.59	0.42	84
85	2,358,246	123.89	4.6980	734.07	561.57	335.40	70.56	0.22	85
86	2,066,090	134.94	4.4742	746.74	578.80	310.56	57.83	0.11	86
87	1,787,299	146.89	4.2571	759.03	595.79	285.44	46.50	0.05	87
88	1,524,758	159.81	4.0470	770.92	612.51	260.21	36.61	0.02	88
89	1,281,083	173.75	3.8442	782.41	628.92	235.11	28.17	0.01	89
90	1,058,491	188.77	3.6488	793.46	644.96	210.36	21.13	0.00	90
91	858,676	204.93	3.4611	804.09	660.61	186.21	15.41	0.00	91
92	682,707	222.27	3.2812	814.27	675.83	162.90	10.91	0.00	92
93	530,959	240.86	3.1091	824.01	690.59	140.69	7.47	0.00	93
94	403,072	260.73	2.9450	833.30	704.86	119.79	4.93	0.00	94
95	297,981	281.91	2.7888	842.14	718.61	100.43	3.13	0.00	95
96	213,977	304.45	2.6406	850.53	731.83	82.78	1.90	0.00	96
97	148,832	328.34	2.5002	858.48	744.50	66.97	1.10	0.00	97
98	99,965	353.60	2.3676	865.99	756.60	53.09	0.60	0.00	98
99	64,617	380.20	2.2426	873.06	768.13	41.14	0.31	0.00	99
100	40,049	408.12	2.1252	879.70	779.08	31.12	0.15	0.00	100
101	23,705	437.28	2.0152	885.93	789.44	22.91	0.07	0.00	101
102	13,339	467.61	1.9123	891.76	799.21	16.37	0.03	0.00	102
103	7,101	498.99	1.8164	897.19	808.41	11.33	0.01	0.00	103
104	3,558	531.28	1.7273	902.23	817.02	7.56	0.00	0.00	104
105	1,668	564.29	1.6447	906.90	825.06	4.86	0.00	0.00	105
106	727	597.83	1.5685	911.22	832.53	2.99	0.00	0.00	106
107	292	631.64	1.4984	915.19	839.46	1.76	0.00	0.00	107
108	108	665.45	1.4341	918.82	845.84	0.98	0.00	0.00	108
109	36	698.97	1.3755	922.14	851.69	0.52	0.00	0.00	109
110	11	731.87	1.3223	925.15	857.04	0.26	0.00	0.00	110

Interest Functions

Interest Functions at $i = 0.06$

m	$i^{(m)}$	$d^{(m)}$	$i/i^{(m)}$	$d/d^{(m)}$	$\alpha(m)$	$\beta(m)$
1	0.06000	0.05660	1.00000	1.00000	1.00000	0.00000
2	0.05913	0.05743	1.01478	0.98564	1.00021	0.25739
4	0.05870	0.05785	1.02223	0.97852	1.00027	0.38424
12	0.05841	0.05813	1.02721	0.97378	1.00028	0.46812
∞	0.05827	0.05827	1.02971	0.97142	1.00028	0.50985

Special Note: Unless specified, the force of interest is constant in each question .

Excerpts from the Appendices to *Loss Models: From Data to Decisions, 2nd edition*

April 21, 2005

Appendix A

An Inventory of Continuous Distributions

A.1 Introduction

The incomplete gamma function is given by

$$\Gamma(\alpha; x) = \frac{1}{\Gamma(\alpha)} \int_0^x t^{\alpha-1} e^{-t} \, dt, \quad \alpha > 0, \ x > 0$$

$$\text{with } \Gamma(\alpha) = \int_0^\infty t^{\alpha-1} e^{-t} \, dt, \quad \alpha > 0.$$

Also, define

$$G(\alpha; x) = \int_x^\infty t^{\alpha-1} e^{-t} \, dt, \quad x > 0.$$

Integration by parts produces the relationship

$$G(\alpha; x) = -\frac{x^\alpha e^{-x}}{\alpha} + \frac{1}{\alpha} G(\alpha + 1; x)$$

For negative α, this can repeated until the first argument is postive, say at $\alpha + k$. Then the incomplete gamma function can be evaluated from

$$G(\alpha + k; x) = \Gamma(\alpha + k)[1 - \Gamma(\alpha + k; x)].$$

The incomplete beta function is given by

$$\beta(a, b; x) = \frac{\Gamma(a + b)}{\Gamma(a)\Gamma(b)} \int_0^x t^{a-1} (1 - t)^{b-1} \, dt, \quad a > 0, \ b > 0, \ 0 < x < 1.$$

A.2   Transformed beta family

A.2.3   Three-parameter distributions

A.2.3.1   Generalized Pareto (beta of the second kind)—α, θ, τ

$$f(x) = \frac{\Gamma(\alpha+\tau)}{\Gamma(\alpha)\Gamma(\tau)} \frac{\theta^\alpha x^{\tau-1}}{(x+\theta)^{\alpha+\tau}} \qquad F(x) = \beta(\tau, \alpha; u), \quad u = \frac{x}{x+\theta}$$

$$\mathrm{E}[X^k] = \frac{\theta^k \Gamma(\tau+k)\Gamma(\alpha-k)}{\Gamma(\alpha)\Gamma(\tau)}, \quad -\tau < k < \alpha$$

$$\mathrm{E}[X^k] = \frac{\theta^k \tau(\tau+1)\cdots(\tau+k-1)}{(\alpha-1)\cdots(\alpha-k)}, \quad \text{if } k \text{ is an integer}$$

$$\mathrm{E}[(X \wedge x)^k] = \frac{\theta^k \Gamma(\tau+k)\Gamma(\alpha-k)}{\Gamma(\alpha)\Gamma(\tau)}\beta(\tau+k, \alpha-k; u) + x^k[1-F(x)], \quad k > -\tau$$

$$\text{mode} = \theta\frac{\tau-1}{\alpha+1}, \quad \tau > 1, \text{ else } 0$$

A.2.3.2   Burr (Burr Type XII, Singh-Maddala)—α, θ, γ

$$f(x) = \frac{\alpha\gamma(x/\theta)^\gamma}{x[1+(x/\theta)^\gamma]^{\alpha+1}} \qquad F(x) = 1 - u^\alpha, \quad u = \frac{1}{1+(x/\theta)^\gamma}$$

$$\mathrm{E}[X^k] = \frac{\theta^k \Gamma(1+k/\gamma)\Gamma(\alpha-k/\gamma)}{\Gamma(\alpha)}, \quad -\gamma < k < \alpha\gamma$$

$$\mathrm{E}[(X \wedge x)^k] = \frac{\theta^k \Gamma(1+k/\gamma)\Gamma(\alpha-k/\gamma)}{\Gamma(\alpha)}\beta(1+k/\gamma, \alpha-k/\gamma; 1-u) + x^k u^\alpha, \quad k > -\gamma$$

$$\text{mode} = \theta\left(\frac{\gamma-1}{\alpha\gamma+1}\right)^{1/\gamma}, \quad \gamma > 1, \text{ else } 0$$

A.2.3.3   Inverse Burr (Dagum)—τ, θ, γ

$$f(x) = \frac{\tau\gamma(x/\theta)^{\gamma\tau}}{x[1+(x/\theta)^\gamma]^{\tau+1}} \qquad F(x) = u^\tau, \quad u = \frac{(x/\theta)^\gamma}{1+(x/\theta)^\gamma}$$

$$\mathrm{E}[X^k] = \frac{\theta^k \Gamma(\tau+k/\gamma)\Gamma(1-k/\gamma)}{\Gamma(\tau)}, \quad -\tau\gamma < k < \gamma$$

$$\mathrm{E}[(X \wedge x)^k] = \frac{\theta^k \Gamma(\tau+k/\gamma)\Gamma(1-k/\gamma)}{\Gamma(\tau)}\beta(\tau+k/\gamma, 1-k/\gamma; u) + x^k[1-u^\tau], \quad k > -\tau\gamma$$

$$\text{mode} = \theta\left(\frac{\tau\gamma-1}{\gamma+1}\right)^{1/\gamma}, \quad \tau\gamma > 1, \text{ else } 0$$

A.2.4   Two-parameter distributions

A.2.4.1   Pareto—α, θ

$$f(x) = \frac{\alpha\theta^\alpha}{(x+\theta)^{\alpha+1}} \qquad F(x) = 1 - \left(\frac{\theta}{x+\theta}\right)^\alpha$$

$$\mathrm{E}[X^k] = \frac{\theta^k\Gamma(k+1)\Gamma(\alpha-k)}{\Gamma(\alpha)}, \quad -1 < k < \alpha$$

$$\mathrm{E}[X^k] = \frac{\theta^k k!}{(\alpha-1)\cdots(\alpha-k)}, \quad \text{if } k \text{ is an integer}$$

$$\mathrm{E}[X \wedge x] = \frac{\theta}{\alpha-1}\left[1 - \left(\frac{\theta}{x+\theta}\right)^{\alpha-1}\right], \quad \alpha \neq 1$$

$$\mathrm{E}[X \wedge x] = -\theta\ln\left(\frac{\theta}{x+\theta}\right), \quad \alpha = 1$$

$$\mathrm{E}[(X \wedge x)^k] = \frac{\theta^k\Gamma(k+1)\Gamma(\alpha-k)}{\Gamma(\alpha)}\beta[k+1,\alpha-k;x/(x+\theta)] + x^k\left(\frac{\theta}{x+\theta}\right)^\alpha, \quad \text{all } k$$

$$\text{mode} = 0$$

A.2.4.2   Inverse Pareto—τ, θ

$$f(x) = \frac{\tau\theta x^{\tau-1}}{(x+\theta)^{\tau+1}} \qquad F(x) = \left(\frac{x}{x+\theta}\right)^\tau$$

$$\mathrm{E}[X^k] = \frac{\theta^k\Gamma(\tau+k)\Gamma(1-k)}{\Gamma(\tau)}, \quad -\tau < k < 1$$

$$\mathrm{E}[X^k] = \frac{\theta^k(-k)!}{(\tau-1)\cdots(\tau+k)}, \quad \text{if } k \text{ is a negative integer}$$

$$\mathrm{E}[(X \wedge x)^k] = \theta^k\tau\int_0^{x/(x+\theta)} y^{\tau+k-1}(1-y)^{-k}dy + x^k\left[1 - \left(\frac{x}{x+\theta}\right)^\tau\right], \quad k > -\tau$$

$$\text{mode} = \theta\frac{\tau-1}{2}, \quad \tau > 1, \text{ else } 0$$

A.2.4.3   Loglogistic (Fisk)—γ, θ

$$f(x) = \frac{\gamma(x/\theta)^\gamma}{x[1+(x/\theta)^\gamma]^2} \qquad F(x) = u, \quad u = \frac{(x/\theta)^\gamma}{1+(x/\theta)^\gamma}$$

$$\mathrm{E}[X^k] = \theta^k\Gamma(1+k/\gamma)\Gamma(1-k/\gamma), \quad -\gamma < k < \gamma$$

$$\mathrm{E}[(X \wedge x)^k] = \theta^k\Gamma(1+k/\gamma)\Gamma(1-k/\gamma)\beta(1+k/\gamma,1-k/\gamma;u) + x^k(1-u), \quad k > -\gamma$$

$$\text{mode} = \theta\left(\frac{\gamma-1}{\gamma+1}\right)^{1/\gamma}, \quad \gamma > 1, \text{ else } 0$$

A.2.4.4 Paralogistic—α, θ

This is a Burr distribution with $\gamma = \alpha$.

$$
\begin{aligned}
f(x) &= \frac{\alpha^2 (x/\theta)^\alpha}{x[1 + (x/\theta)^\alpha]^{\alpha+1}} \qquad F(x) = 1 - u^\alpha, \quad u = \frac{1}{1 + (x/\theta)^\alpha} \\
E[X^k] &= \frac{\theta^k \Gamma(1 + k/\alpha)\Gamma(\alpha - k/\alpha)}{\Gamma(\alpha)}, \quad -\alpha < k < \alpha^2 \\
E[(X \wedge x)^k] &= \frac{\theta^k \Gamma(1 + k/\alpha)\Gamma(\alpha - k/\alpha)}{\Gamma(\alpha)} \beta(1 + k/\alpha, \alpha - k/\alpha; 1 - u) + x^k u^\alpha, \quad k > -\alpha \\
\text{mode} &= \theta \left(\frac{\alpha - 1}{\alpha^2 + 1} \right)^{1/\alpha}, \quad \alpha > 1, \text{ else } 0
\end{aligned}
$$

A.2.4.5 Inverse paralogistic—τ, θ

This is an inverse Burr distribution with $\gamma = \tau$.

$$
\begin{aligned}
f(x) &= \frac{\tau^2 (x/\theta)^{\tau^2}}{x[1 + (x/\theta)^\tau]^{\tau+1}} \qquad F(x) = u^\tau, \quad u = \frac{(x/\theta)^\tau}{1 + (x/\theta)^\tau} \\
E[X^k] &= \frac{\theta^k \Gamma(\tau + k/\tau)\Gamma(1 - k/\tau)}{\Gamma(\tau)}, \quad -\tau^2 < k < \tau \\
E[(X \wedge x)^k] &= \frac{\theta^k \Gamma(\tau + k/\tau)\Gamma(1 - k/\tau)}{\Gamma(\tau)} \beta(\tau + k/\tau, 1 - k/\tau; u) + x^k [1 - u^\tau], \quad k > -\tau^2 \\
\text{mode} &= \theta (\tau - 1)^{1/\tau}, \quad \tau > 1, \text{ else } 0
\end{aligned}
$$

A.3 Transformed gamma family

A.3.2 Two-parameter distributions

A.3.2.1 Gamma—α, θ

$$
\begin{aligned}
f(x) &= \frac{(x/\theta)^\alpha e^{-x/\theta}}{x\Gamma(\alpha)} \qquad F(x) = \Gamma(\alpha; x/\theta) \\
M(t) &= (1 - \theta t)^{-\alpha}, \quad t < 1/\theta \qquad E[X^k] = \frac{\theta^k \Gamma(\alpha + k)}{\Gamma(\alpha)}, \quad k > -\alpha \\
E[X^k] &= \theta^k (\alpha + k - 1) \cdots \alpha, \quad \text{if } k \text{ is an integer}
\end{aligned}
$$

$$
\begin{aligned}
E[(X \wedge x)^k] &= \frac{\theta^k \Gamma(\alpha + k)}{\Gamma(\alpha)} \Gamma(\alpha + k; x/\theta) + x^k [1 - \Gamma(\alpha; x/\theta)], \quad k > -\alpha \\
&= \alpha(\alpha + 1) \cdots (\alpha + k - 1)\theta^k \Gamma(\alpha + k; x/\theta) + x^k [1 - \Gamma(\alpha; x/\theta)], \quad k \text{ an integer} \\
\text{mode} &= \theta(\alpha - 1), \quad \alpha > 1, \text{ else } 0
\end{aligned}
$$

A.3.2.2 Inverse gamma (Vinci)—α, θ

$$f(x) = \frac{(\theta/x)^\alpha e^{-\theta/x}}{x\Gamma(\alpha)} \qquad F(x) = 1 - \Gamma(\alpha; \theta/x)$$

$$\mathrm{E}[X^k] = \frac{\theta^k \Gamma(\alpha-k)}{\Gamma(\alpha)}, \quad k < \alpha \qquad \mathrm{E}[X^k] = \frac{\theta^k}{(\alpha-1)\cdots(\alpha-k)}, \quad \text{if } k \text{ is an integer}$$

$$\mathrm{E}[(X \wedge x)^k] = \frac{\theta^k \Gamma(\alpha-k)}{\Gamma(\alpha)}[1 - \Gamma(\alpha-k; \theta/x)] + x^k \Gamma(\alpha; \theta/x)$$

$$= \frac{\theta^k \Gamma(\alpha-k)}{\Gamma(\alpha)} G(\alpha-k; \theta/x) + x^k \Gamma(\alpha; \theta/x), \text{ all } k$$

$$\text{mode} = \theta/(\alpha+1)$$

A.3.2.3 Weibull—θ, τ

$$f(x) = \frac{\tau(x/\theta)^\tau e^{-(x/\theta)^\tau}}{x} \qquad F(x) = 1 - e^{-(x/\theta)^\tau}$$

$$\mathrm{E}[X^k] = \theta^k \Gamma(1 + k/\tau), \quad k > -\tau$$

$$\mathrm{E}[(X \wedge x)^k] = \theta^k \Gamma(1 + k/\tau)\Gamma[1 + k/\tau; (x/\theta)^\tau] + x^k e^{-(x/\theta)^\tau}, \quad k > -\tau$$

$$\text{mode} = \theta\left(\frac{\tau-1}{\tau}\right)^{1/\tau}, \quad \tau > 1, \text{ else } 0$$

A.3.2.4 Inverse Weibull (log Gompertz)—θ, τ

$$f(x) = \frac{\tau(\theta/x)^\tau e^{-(\theta/x)^\tau}}{x} \qquad F(x) = e^{-(\theta/x)^\tau}$$

$$\mathrm{E}[X^k] = \theta^k \Gamma(1 - k/\tau), \quad k < \tau$$

$$\mathrm{E}[(X \wedge x)^k] = \theta^k \Gamma(1 - k/\tau)\{1 - \Gamma[1 - k/\tau; (\theta/x)^\tau]\} + x^k \left[1 - e^{-(\theta/x)^\tau}\right], \quad \text{all } k$$

$$= \theta^k \Gamma(1 - k/\tau)G[1 - k/\tau; (\theta/x)^\tau] + x^k \left[1 - e^{-(\theta/x)^\tau}\right]$$

$$\text{mode} = \theta\left(\frac{\tau}{\tau+1}\right)^{1/\tau}$$

A.3.3 One-parameter distributions

A.3.3.1 Exponential—θ

$$f(x) = \frac{e^{-x/\theta}}{\theta} \qquad F(x) = 1 - e^{-x/\theta}$$

$$M(t) = (1 - \theta t)^{-1} \qquad \mathrm{E}[X^k] = \theta^k \Gamma(k+1), \quad k > -1$$

$$\mathrm{E}[X^k] = \theta^k k!, \quad \text{if } k \text{ is an integer}$$

$$\mathrm{E}[X \wedge x] = \theta(1 - e^{-x/\theta})$$

$$\mathrm{E}[(X \wedge x)^k] = \theta^k \Gamma(k+1)\Gamma(k+1; x/\theta) + x^k e^{-x/\theta}, \quad k > -1$$

$$= \theta^k k!\Gamma(k+1; x/\theta) + x^k e^{-x/\theta}, \quad k \text{ an integer}$$

$$\text{mode} = 0$$

A.3.3.2   Inverse exponential—θ

$$
\begin{aligned}
f(x) &= \frac{\theta e^{-\theta/x}}{x^2} \qquad F(x) = e^{-\theta/x} \\
\mathrm{E}[X^k] &= \theta^k \Gamma(1-k), \quad k < 1 \\
\mathrm{E}[(X \wedge x)^k] &= \theta^k G(1-k; \theta/x) + x^k(1 - e^{-\theta/x}), \quad \text{all } k \\
\text{mode} &= \theta/2
\end{aligned}
$$

A.4   Other distributions

A.4.1.1   Lognormal—μ,σ (μ can be negative)

$$
\begin{aligned}
f(x) &= \frac{1}{x\sigma\sqrt{2\pi}} \exp(-z^2/2) = \phi(z)/(\sigma x), \quad z = \frac{\ln x - \mu}{\sigma} \qquad F(x) = \Phi(z) \\
\mathrm{E}[X^k] &= \exp(k\mu + k^2\sigma^2/2) \\
\mathrm{E}[(X \wedge x)^k] &= \exp(k\mu + k^2\sigma^2/2)\Phi\left(\frac{\ln x - \mu - k\sigma^2}{\sigma}\right) + x^k[1 - F(x)] \\
\text{mode} &= \exp(\mu - \sigma^2)
\end{aligned}
$$

A.4.1.2   Inverse Gaussian—μ, θ

$$
\begin{aligned}
f(x) &= \left(\frac{\theta}{2\pi x^3}\right)^{1/2} \exp\left(-\frac{\theta z^2}{2x}\right), \quad z = \frac{x - \mu}{\mu} \\
F(x) &= \Phi\left[z\left(\frac{\theta}{x}\right)^{1/2}\right] + \exp\left(\frac{2\theta}{\mu}\right)\Phi\left[-y\left(\frac{\theta}{x}\right)^{1/2}\right], \quad y = \frac{x + \mu}{\mu} \\
M(t) &= \exp\left[\frac{\theta}{\mu}\left(1 - \sqrt{1 - \frac{2t\mu^2}{\theta}}\right)\right], \quad t < \frac{\theta}{2\mu^2}, \qquad \mathrm{E}[X] = \mu, \quad \mathrm{Var}[X] = \mu^3/\theta \\
\mathrm{E}[X \wedge x] &= x - \mu z\Phi\left[z\left(\frac{\theta}{x}\right)^{1/2}\right] - \mu y \exp\left(\frac{2\theta}{\mu}\right)\Phi\left[-y\left(\frac{\theta}{x}\right)^{1/2}\right]
\end{aligned}
$$

A.4.1.3   log-t—r, μ, σ (μ can be negative)

Let Y have a t distribution with r degrees of freedom. Then $X = \exp(\sigma Y + \mu)$ has the log-t distribution. Positive moments do not exist for this distribution. Just as the t distribution has a heavier tail than the normal distribution, this distribution has a heavier tail than the lognormal distribution.

$$
\begin{aligned}
f(x) &= \frac{\Gamma\left(\dfrac{r+1}{2}\right)}{x\sigma\sqrt{\pi r}\,\Gamma\left(\dfrac{r}{2}\right)\left[1 + \dfrac{1}{r}\left(\dfrac{\ln x - \mu}{\sigma}\right)^2\right]^{(r+1)/2}}, \\
F(x) &= F_r\left(\frac{\ln x - \mu}{\sigma}\right) \text{ with } F_r(t) \text{ the cdf of a } t \text{ distribution with } r \text{ d.f.,}
\end{aligned}
$$

$$
F(x) = \begin{cases} \dfrac{1}{2}\beta\left[\dfrac{r}{2},\dfrac{1}{2};\dfrac{r}{r+\left(\dfrac{\ln x-\mu}{\sigma}\right)^2}\right], & 0 < x \le e^\mu, \\[4ex] 1-\dfrac{1}{2}\beta\left[\dfrac{r}{2},\dfrac{1}{2};\dfrac{r}{r+\left(\dfrac{\ln x-\mu}{\sigma}\right)^2}\right], & x \ge e^\mu. \end{cases}
$$

A.4.1.4 Single-parameter Pareto—α, θ

$$
\begin{aligned}
f(x) &= \frac{\alpha\theta^\alpha}{x^{\alpha+1}}, \quad x > \theta & F(x) &= 1-(\theta/x)^\alpha, \quad x > \theta \\[2ex]
E[X^k] &= \frac{\alpha\theta^k}{\alpha-k}, \quad k < \alpha & E[(X \wedge x)^k] &= \frac{\alpha\theta^k}{\alpha-k} - \frac{k\theta^\alpha}{(\alpha-k)x^{\alpha-k}} \\[2ex]
\text{mode} &= \theta &&
\end{aligned}
$$

Note: Although there appears to be two parameters, only α is a true parameter. The value of θ must be set in advance.

A.5   Distributions with finite support

For these two distributions, the scale parameter θ is assumed known.

A.5.1.1   Generalized beta—a, b, θ, τ

$$
\begin{aligned}
f(x) &= \frac{\Gamma(a+b)}{\Gamma(a)\Gamma(b)}u^a(1-u)^{b-1}\frac{\tau}{x}, \quad 0 < x < \theta, \quad u = (x/\theta)^\tau \\[2ex]
F(x) &= \beta(a,b;u) \\[2ex]
E[X^k] &= \frac{\theta^k\Gamma(a+b)\Gamma(a+k/\tau)}{\Gamma(a)\Gamma(a+b+k/\tau)}, \quad k > -a\tau \\[2ex]
E[(X \wedge x)^k] &= \frac{\theta^k\Gamma(a+b)\Gamma(a+k/\tau)}{\Gamma(a)\Gamma(a+b+k/\tau)}\beta(a+k/\tau,b;u) + x^k[1-\beta(a,b;u)]
\end{aligned}
$$

A.5.1.2   beta—a, b, θ

$$
\begin{aligned}
f(x) &= \frac{\Gamma(a+b)}{\Gamma(a)\Gamma(b)}u^a(1-u)^{b-1}\frac{1}{x}, \quad 0 < x < \theta, \quad u = x/\theta \\[2ex]
F(x) &= \beta(a,b;u) \\[2ex]
E[X^k] &= \frac{\theta^k\Gamma(a+b)\Gamma(a+k)}{\Gamma(a)\Gamma(a+b+k)}, \quad k > -a \\[2ex]
E[X^k] &= \frac{\theta^k a(a+1)\cdots(a+k-1)}{(a+b)(a+b+1)\cdots(a+b+k-1)}, \quad \text{if } k \text{ is an integer} \\[2ex]
E[(X \wedge x)^k] &= \frac{\theta^k a(a+1)\cdots(a+k-1)}{(a+b)(a+b+1)\cdots(a+b+k-1)}\beta(a+k,b;u) \\
&\quad + x^k[1-\beta(a,b;u)]
\end{aligned}
$$

Appendix B

An Inventory of Discrete Distributions

B.2 The $(a, b, 0)$ class

B.2.1.1 Poisson—λ

$$p_0 = e^{-\lambda}, \quad a = 0, \quad b = \lambda \qquad p_k = \frac{e^{-\lambda}\lambda^k}{k!}$$

$$\mathrm{E}[N] = \lambda, \quad \mathrm{Var}[N] = \lambda \qquad P(z) = e^{\lambda(z-1)}$$

B.2.1.2 Geometric—β

$$p_0 = \frac{1}{1+\beta}, \quad a = \frac{\beta}{1+\beta}, \quad b = 0 \qquad p_k = \frac{\beta^k}{(1+\beta)^{k+1}}$$

$$\mathrm{E}[N] = \beta, \quad \mathrm{Var}[N] = \beta(1+\beta) \qquad P(z) = [1 - \beta(z-1)]^{-1}.$$

This is a special case of the negative binomial with $r = 1$.

B.2.1.3 Binomial—$q, m, (0 < q < 1, m$ **an integer**$)$

$$p_0 = (1-q)^m, \quad a = -\frac{q}{1-q}, \quad b = \frac{(m+1)q}{1-q}$$

$$p_k = \binom{m}{k}q^k(1-q)^{m-k}, \quad k = 0, 1, \ldots, m$$

$$\mathrm{E}[N] = mq, \quad \mathrm{Var}[N] = mq(1-q) \qquad P(z) = [1 + q(z-1)]^m.$$

B.2.1.4 Negative binomial—β, r

$$p_0 = (1+\beta)^{-r}, \quad a = \frac{\beta}{1+\beta}, \quad b = \frac{(r-1)\beta}{1+\beta}$$

$$p_k = \frac{r(r+1)\cdots(r+k-1)\beta^k}{k!(1+\beta)^{r+k}}$$

$$\mathrm{E}[N] = r\beta, \quad \mathrm{Var}[N] = r\beta(1+\beta) \qquad P(z) = [1 - \beta(z-1)]^{-r}.$$

Approximate critical values of T in the Wilcoxon Matched-Pairs, Signed-Rank Test

One-sided	Two-sided	n=5	n=6	n=7	n=8	n=9	n=10
P = .05	P = .10	0	2	3	5	8	10
P = .025	P = .05		0	2	3	5	8
P = .01	P = .02			0	1	3	5
P = .005	P = .01				0	1	3

One-sided	Two-sided	n=11	n=12	n=13	n=14	n=15	n=16
P = .05	P = .10	13	17	21	25	30	35
P = .025	P = .05	10	13	17	21	25	29
P = .01	P = .02	7	9	12	15	19	23
P = .005	P = .01	5	7	9	12	15	19

One-sided	Two-sided	n=17	n=18	n=19	n=20	n=21	n=22
P = .05	P = .10	41	47	53	60	67	75
P = .025	P = .05	34	40	46	52	58	65
P = .01	P = .02	27	32	37	43	49	55
P = .005	P = .01	23	27	32	37	42	48

One-sided	Two-sided	n=23	n=24	n=25	n=26	n=27	n=28
P = .05	P = .10	83	91	100	110	119	130
P = .025	P = .05	73	81	89	98	107	116
P = .01	P = .02	62	69	76	84	92	101
P = .005	P = .01	54	61	68	75	83	91

One-sided	Two-sided	n=29	n=30	n=31	n=32	n=33	n=34
P = .05	P = .10	140	151	163	175	187	200
P = .025	P = .05	126	137	147	159	170	182
P = .01	P = .02	110	120	130	140	151	162
P = .005	P = .01	100	109	118	128	138	148

One-sided	Two-sided	n=35	n=36	n=37	n=38	n=39	n=40
P = .05	P = .10	213	227	241	256	271	286
P = .025	P = .05	195	208	221	235	249	264
P = .01	P = .02	173	185	198	211	224	237
P = .005	P = .01	159	171	182	194	207	220

One-sided	Two-sided	n=41	n=42	n=43	n=44	n=45	n=46
P = .05	P = .10	302	319	336	353	371	389
P = .025	P = .05	279	294	310	327	343	361
P = .01	P = .02	252	266	281	296	312	328
P = .005	P = .01	233	247	261	276	291	306

One-sided	Two-sided	n=47	n=48	n=49	n=50
P = .05	P = .10	407	426	446	466
P = .025	P = .05	378	396	415	434
P = .01	P = .02	345	362	379	397
P = .005	P = .01	322	339	355	373

For use on the CAS actuarial examinations

Tail areas (two-sided) for t-distributions

df	0.20	0.10	0.05	0.02	0.01
1	3.078	6.314	12.706	31.821	63.657
2	1.886	2.920	4.303	6.965	9.925
3	1.638	2.353	3.182	4.541	5.841
4	1.533	2.132	2.776	3.747	4.604
5	1.476	2.015	2.571	3.365	4.032
6	1.440	1.943	2.447	3.143	3.707
7	1.415	1.895	2.365	2.998	3.499
8	1.397	1.860	2.306	2.896	3.355
9	1.383	1.833	2.262	2.821	3.250
10	1.372	1.812	2.228	2.764	3.169
11	1.363	1.796	2.201	2.718	3.106
12	1.356	1.782	2.179	2.681	3.055
13	1.350	1.771	2.160	2.650	3.012
14	1.345	1.761	2.145	2.624	2.977
15	1.341	1.753	2.131	2.602	2.947
16	1.337	1.746	2.120	2.583	2.921
17	1.333	1.740	2.110	2.567	2.898
18	1.330	1.734	2.101	2.552	2.878
19	1.328	1.729	2.093	2.539	2.861
20	1.325	1.725	2.086	2.528	2.845
21	1.323	1.721	2.080	2.518	2.831
22	1.321	1.717	2.074	2.508	2.819
23	1.319	1.714	2.069	2.500	2.807
24	1.318	1.711	2.064	2.492	2.797
25	1.316	1.708	2.060	2.485	2.787
26	1.315	1.706	2.056	2.479	2.779
27	1.314	1.703	2.052	2.473	2.771
28	1.313	1.701	2.048	2.467	2.763
29	1.311	1.699	2.045	2.462	2.756
30	1.310	1.697	2.042	2.457	2.750
35	1.306	1.690	2.030	2.438	2.724
40	1.303	1.684	2.021	2.423	2.704
45	1.301	1.679	2.014	2.412	2.690
50	1.299	1.676	2.009	2.403	2.678
55	1.297	1.673	2.004	2.396	2.668
60	1.296	1.671	2.000	2.390	2.660
70	1.294	1.667	1.994	2.381	2.648
80	1.292	1.664	1.990	2.374	2.639
90	1.291	1.662	1.987	2.368	2.632
100	1.290	1.660	1.984	2.364	2.626
120	1.289	1.658	1.980	2.358	2.617
400	1.284	1.649	1.966	2.336	2.588
Inf	1.282	1.645	1.960	2.326	2.576

For use on the CAS exams

Selected Upper-tail areas for F-distributions

Numerator df	1	2	3	4	5	6	7	8	9	10	11	12	14	16	20	24	30	40	50	75	100	200	500	Inf		
Denominator df Upper-tail																									Upper-tail	
1 0.20	9.472	12	13.064	13.644	14.008	14.258	14.439	14.577	14.685	14.772	14.844	14.904	14.998	15.07	15.171	15.238	15.306	15.374	15.415	15.47	15.497	15.539	15.563	15.58	0.20	1
1 0.10	39.86	49.5	53.59	55.83	57.24	58.2	58.91	59.44	59.86	60.19	60.47	60.71	61.07	61.35	61.74	62	62.26	62.53	62.69	62.9	63.01	63.17	63.26	63.33	0.10	1
1 0.05	161.4	199.5	215.7	224.6	230.2	234	236.8	238.9	240.5	241.9	243	243.9	245.4	246.5	248	249.1	250.1	251.1	251.8	252.6	253	253.7	254.1	254.3	0.05	1
1 0.02	1013	1249	1351	1406	1441	1464	1482	1495	1505	1514	1521	1526	1535	1542	1552	1558	1565	1571	1575	1581	1583	1587	1590	1591	0.02	1
1 0.01	4052	4999	5403	5625	5764	5859	5928	5981	6022	6056	6083	6106	6143	6170	6209	6235	6261	6287	6303	6324	6334	6350	6360	6366	0.01	1
2 0.20	3.556	4	4.156	4.236	4.284	4.317	4.34	4.358	4.371	4.382	4.391	4.399	4.41	4.419	4.432	4.44	4.448	4.456	4.461	4.468	4.471	4.476	4.479	4.481	0.20	2
2 0.10	8.526	9	9.162	9.243	9.293	9.326	9.349	9.367	9.381	9.392	9.401	9.408	9.42	9.429	9.441	9.45	9.458	9.466	9.471	9.478	9.481	9.486	9.489	9.491	0.10	2
2 0.05	18.51	19	19.16	19.25	19.3	19.33	19.35	19.37	19.38	19.4	19.4	19.41	19.42	19.43	19.45	19.45	19.46	19.47	19.48	19.48	19.49	19.49	19.49	19.5	0.05	2
2 0.02	48.51	49	49.17	49.25	49.3	49.33	49.36	49.37	49.39	49.4	49.41	49.42	49.43	49.44	49.45	49.46	49.46	49.47	49.48	49.48	49.49	49.49	49.5	49.5	0.02	2
2 0.01	98.5	99	99.17	99.25	99.3	99.33	99.36	99.37	99.39	99.4	99.41	99.42	99.43	99.44	99.45	99.46	99.47	99.47	99.48	99.49	99.49	99.49	99.5	99.5	0.01	2
3 0.20	2.682	2.886	2.936	2.956	2.965	2.971	2.974	2.976	2.978	2.979	2.98	2.981	2.982	2.982	2.983	2.983	2.984	2.984	2.984	2.984	2.984	2.985	2.985	2.985	0.20	3
3 0.10	5.538	5.462	5.391	5.343	5.309	5.285	5.266	5.252	5.24	5.23	5.222	5.216	5.205	5.196	5.184	5.176	5.168	5.16	5.155	5.148	5.144	5.139	5.136	5.134	0.10	3
3 0.05	10.128	9.552	9.277	9.117	9.013	8.941	8.887	8.845	8.812	8.786	8.763	8.745	8.715	8.692	8.66	8.639	8.617	8.594	8.581	8.563	8.554	8.54	8.532	8.526	0.05	3
3 0.02	20.62	18.86	18.11	17.69	17.43	17.25	17.11	17.01	16.93	16.86	16.81	16.76	16.69	16.63	16.55	16.5	16.45	16.39	16.36	16.32	16.3	16.26	16.24	16.23	0.02	3
3 0.01	34.12	30.82	29.46	28.71	28.24	27.91	27.67	27.49	27.35	27.23	27.13	27.05	26.92	26.83	26.69	26.6	26.5	26.41	26.35	26.28	26.24	26.18	26.15	26.13	0.01	3
4 0.20	2.351	2.472	2.485	2.483	2.478	2.473	2.469	2.465	2.462	2.46	2.457	2.455	2.452	2.449	2.445	2.442	2.439	2.436	2.434	2.432	2.43	2.428	2.427	2.426	0.20	4
4 0.10	4.545	4.325	4.191	4.107	4.051	4.01	3.979	3.955	3.936	3.92	3.907	3.896	3.878	3.864	3.844	3.831	3.817	3.804	3.795	3.784	3.778	3.769	3.764	3.761	0.10	4
4 0.05	7.709	6.944	6.591	6.388	6.256	6.163	6.094	6.041	5.999	5.964	5.936	5.912	5.873	5.844	5.803	5.774	5.746	5.717	5.699	5.676	5.664	5.646	5.635	5.628	0.05	4
4 0.02	14.04	12.142	11.344	10.899	10.616	10.419	10.274	10.162	10.074	10.003	9.944	9.894	9.815	9.755	9.67	9.612	9.554	9.495	9.46	9.412	9.388	9.352	9.33	9.315	0.02	4
4 0.01	21.2	18	16.69	15.98	15.52	15.21	14.98	14.8	14.66	14.55	14.45	14.37	14.25	14.15	14.02	13.93	13.84	13.75	13.69	13.61	13.58	13.52	13.49	13.46	0.01	4
5 0.20	2.178	2.259	2.253	2.24	2.228	2.217	2.209	2.202	2.196	2.191	2.187	2.184	2.178	2.173	2.166	2.161	2.156	2.151	2.148	2.144	2.141	2.138	2.136	2.134	0.20	5
5 0.10	4.06	3.78	3.619	3.52	3.453	3.405	3.368	3.339	3.316	3.297	3.282	3.268	3.247	3.23	3.207	3.191	3.174	3.157	3.147	3.133	3.126	3.116	3.109	3.105	0.10	5
5 0.05	6.608	5.786	5.409	5.192	5.05	4.95	4.876	4.818	4.772	4.735	4.704	4.678	4.636	4.604	4.558	4.527	4.496	4.464	4.444	4.418	4.405	4.385	4.373	4.365	0.05	5
5 0.02	11.323	9.454	8.67	8.233	7.953	7.758	7.614	7.503	7.415	7.344	7.285	7.235	7.156	7.095	7.009	6.951	6.893	6.833	6.797	6.749	6.724	6.687	6.665	6.65	0.02	5
5 0.01	16.258	13.274	12.06	11.392	10.967	10.672	10.456	10.289	10.158	10.051	9.963	9.888	9.77	9.68	9.553	9.466	9.379	9.291	9.238	9.166	9.13	9.075	9.042	9.02	0.01	5
6 0.20	2.073	2.13	2.113	2.092	2.076	2.062	2.051	2.042	2.034	2.028	2.022	2.018	2.01	2.004	1.995	1.989	1.982	1.976	1.972	1.966	1.963	1.959	1.956	1.954	0.20	6
6 0.10	3.776	3.463	3.289	3.181	3.108	3.055	3.014	2.983	2.958	2.937	2.92	2.905	2.881	2.863	2.836	2.818	2.8	2.781	2.77	2.754	2.746	2.734	2.727	2.722	0.10	6
6 0.05	5.987	5.143	4.757	4.534	4.387	4.284	4.207	4.147	4.099	4.06	4.027	4	3.956	3.922	3.874	3.841	3.808	3.774	3.754	3.726	3.712	3.69	3.678	3.669	0.05	6
6 0.02	9.876	8.052	7.287	6.859	6.585	6.393	6.251	6.141	6.055	5.984	5.925	5.876	5.797	5.737	5.651	5.593	5.534	5.474	5.438	5.389	5.364	5.327	5.304	5.289	0.02	6
6 0.01	13.745	10.925	9.78	9.148	8.746	8.466	8.26	8.102	7.976	7.874	7.79	7.718	7.605	7.519	7.396	7.313	7.229	7.143	7.091	7.022	6.987	6.934	6.902	6.88	0.01	6
7 0.20	2.002	2.043	2.019	1.994	1.974	1.957	1.945	1.934	1.925	1.918	1.911	1.906	1.897	1.89	1.879	1.872	1.865	1.857	1.852	1.845	1.842	1.837	1.833	1.831	0.20	7
7 0.10	3.589	3.257	3.074	2.961	2.883	2.827	2.785	2.752	2.725	2.703	2.684	2.668	2.643	2.623	2.595	2.575	2.555	2.535	2.523	2.506	2.497	2.484	2.476	2.471	0.10	7
7 0.05	5.591	4.737	4.347	4.12	3.972	3.866	3.787	3.726	3.677	3.637	3.603	3.575	3.529	3.494	3.445	3.41	3.376	3.34	3.319	3.29	3.275	3.252	3.239	3.23	0.05	7
7 0.02	8.988	7.203	6.454	6.035	5.765	5.576	5.435	5.327	5.241	5.171	5.113	5.064	4.985	4.925	4.839	4.781	4.722	4.662	4.625	4.576	4.551	4.513	4.49	4.475	0.02	7
7 0.01	12.246	9.547	8.451	7.847	7.46	7.191	6.993	6.84	6.719	6.62	6.538	6.469	6.359	6.275	6.155	6.074	5.992	5.908	5.858	5.789	5.755	5.702	5.671	5.65	0.01	7
8 0.20	1.951	1.981	1.951	1.923	1.9	1.883	1.868	1.856	1.847	1.838	1.831	1.825	1.815	1.807	1.796	1.787	1.779	1.77	1.765	1.757	1.753	1.748	1.744	1.742	0.20	8
8 0.10	3.458	3.113	2.924	2.806	2.726	2.668	2.624	2.589	2.561	2.538	2.519	2.502	2.475	2.455	2.425	2.404	2.383	2.361	2.348	2.33	2.321	2.307	2.298	2.293	0.10	8
8 0.05	5.318	4.459	4.066	3.838	3.687	3.581	3.5	3.438	3.388	3.347	3.313	3.284	3.237	3.202	3.15	3.115	3.079	3.043	3.02	2.99	2.975	2.951	2.937	2.928	0.05	8
8 0.02	8.389	6.637	5.901	5.489	5.223	5.036	4.897	4.79	4.705	4.635	4.577	4.528	4.449	4.389	4.304	4.245	4.186	4.125	4.088	4.038	4.013	3.975	3.952	3.936	0.02	8
8 0.01	11.259	8.649	7.591	7.006	6.632	6.371	6.178	6.029	5.911	5.814	5.734	5.667	5.559	5.477	5.359	5.279	5.198	5.116	5.065	4.998	4.963	4.911	4.88	4.859	0.01	8
9 0.20	1.913	1.935	1.901	1.87	1.846	1.826	1.811	1.798	1.787	1.778	1.771	1.764	1.753	1.745	1.732	1.723	1.714	1.704	1.698	1.69	1.686	1.68	1.676	1.673	0.20	9
9 0.10	3.36	3.006	2.813	2.693	2.611	2.551	2.505	2.469	2.44	2.416	2.396	2.379	2.351	2.329	2.298	2.277	2.255	2.232	2.218	2.199	2.189	2.174	2.165	2.159	0.10	9
9 0.05	5.117	4.256	3.863	3.633	3.482	3.374	3.293	3.23	3.179	3.137	3.102	3.073	3.025	2.989	2.936	2.9	2.864	2.826	2.803	2.771	2.756	2.731	2.717	2.707	0.05	9
9 0.02	7.961	6.234	5.51	5.103	4.84	4.654	4.517	4.41	4.325	4.256	4.198	4.149	4.071	4.011	3.925	3.866	3.806	3.745	3.708	3.658	3.632	3.593	3.57	3.554	0.02	9
9 0.01	10.561	8.022	6.992	6.422	6.057	5.802	5.613	5.467	5.351	5.257	5.178	5.111	5.005	4.924	4.808	4.729	4.649	4.567	4.517	4.449	4.415	4.363	4.332	4.311	0.01	9

F-distributions

Selected Upper-tail areas for F-distributions

Denominator df	Upper-tail	1	2	3	4	5	6	7	8	9	10	11	12	14	16	20	24	30	40	50	75	100	200	500	Inf	Upper-tail	Denominator df
1	0.20	9.472	12	13.064	13.644	14.008	14.258	14.439	14.577	14.685	14.772	14.844	14.904	14.998	15.07	15.171	15.238	15.306	15.374	15.415	15.47	15.497	15.539	15.563	15.58	0.20	1
1	0.10	39.86	49.5	53.59	55.83	57.24	58.2	58.91	59.44	59.86	60.19	60.47	60.71	61.07	61.35	61.74	62	62.26	62.53	62.69	62.9	63.01	63.17	63.26	63.33	0.10	1
1	0.05	161.4	199.5	215.7	224.6	230.2	234	236.8	238.9	240.5	241.9	243	243.9	245.4	246.5	248	249.1	250.1	251.1	251.8	252.6	253	253.7	254.1	254.3	0.05	1
1	0.02	1013	1249	1351	1406	1441	1464	1482	1495	1505	1514	1521	1526	1535	1542	1552	1558	1565	1571	1575	1581	1583	1587	1590	1591	0.02	1
1	0.01	4052	4999	5403	5625	5764	5859	5928	5981	6022	6056	6083	6106	6143	6170	6209	6235	6261	6287	6303	6324	6334	6350	6360	6366	0.01	1
2	0.20	3.556	4	4.156	4.236	4.284	4.317	4.34	4.358	4.371	4.382	4.391	4.399	4.41	4.419	4.432	4.44	4.448	4.456	4.461	4.468	4.471	4.476	4.479	4.481	0.20	2
2	0.10	8.526	9	9.162	9.243	9.293	9.326	9.349	9.367	9.381	9.392	9.401	9.408	9.42	9.429	9.441	9.45	9.458	9.466	9.471	9.478	9.481	9.486	9.489	9.491	0.10	2
2	0.05	18.51	19	19.16	19.25	19.3	19.33	19.35	19.37	19.38	19.4	19.4	19.41	19.42	19.43	19.45	19.45	19.46	19.47	19.48	19.48	19.49	19.49	19.49	19.5	0.05	2
2	0.02	48.51	49	49.17	49.25	49.3	49.33	49.36	49.37	49.39	49.4	49.41	49.42	49.43	49.44	49.45	49.46	49.46	49.47	49.48	49.48	49.49	49.49	49.5	49.5	0.02	2
2	0.01	98.5	99	99.17	99.25	99.3	99.33	99.36	99.37	99.39	99.4	99.41	99.42	99.43	99.44	99.45	99.46	99.47	99.47	99.48	99.49	99.49	99.49	99.5	99.5	0.01	2
3	0.20	2.682	2.886	2.936	2.956	2.965	2.971	2.974	2.976	2.978	2.979	2.98	2.981	2.982	2.982	2.983	2.983	2.984	2.984	2.984	2.984	2.984	2.985	2.985	2.985	0.20	3
3	0.10	5.538	5.462	5.391	5.343	5.309	5.285	5.266	5.252	5.24	5.23	5.222	5.216	5.205	5.196	5.184	5.176	5.168	5.16	5.155	5.148	5.144	5.139	5.136	5.134	0.10	3
3	0.05	10.128	9.552	9.277	9.117	9.013	8.941	8.887	8.845	8.812	8.786	8.763	8.745	8.715	8.692	8.66	8.639	8.617	8.594	8.581	8.563	8.554	8.54	8.532	8.526	0.05	3
3	0.02	20.62	18.86	18.11	17.69	17.43	17.25	17.11	17.01	16.93	16.86	16.81	16.76	16.69	16.63	16.55	16.5	16.45	16.39	16.36	16.32	16.3	16.26	16.24	16.23	0.02	3
3	0.01	34.12	30.82	29.46	28.71	28.24	27.91	27.67	27.49	27.35	27.23	27.13	27.05	26.92	26.83	26.69	26.6	26.5	26.41	26.35	26.28	26.24	26.18	26.15	26.13	0.01	3
4	0.20	2.351	2.472	2.485	2.483	2.478	2.473	2.469	2.465	2.462	2.46	2.457	2.455	2.452	2.449	2.445	2.442	2.439	2.436	2.434	2.432	2.43	2.428	2.427	2.426	0.20	4
4	0.10	4.545	4.325	4.191	4.107	4.051	4.01	3.979	3.955	3.936	3.92	3.907	3.896	3.878	3.864	3.844	3.831	3.817	3.804	3.795	3.784	3.778	3.769	3.764	3.761	0.10	4
4	0.05	7.709	6.944	6.591	6.388	6.256	6.163	6.094	6.041	5.999	5.964	5.936	5.912	5.873	5.844	5.803	5.774	5.746	5.717	5.699	5.676	5.664	5.646	5.635	5.628	0.05	4
4	0.02	14.04	12.142	11.344	10.899	10.616	10.419	10.274	10.162	10.074	10.003	9.944	9.894	9.815	9.755	9.67	9.612	9.554	9.495	9.46	9.412	9.388	9.352	9.33	9.315	0.02	4
4	0.01	21.2	18	16.69	15.98	15.52	15.21	14.98	14.8	14.66	14.55	14.45	14.37	14.25	14.15	14.02	13.93	13.84	13.75	13.69	13.61	13.58	13.52	13.49	13.46	0.01	4
5	0.20	2.178	2.259	2.253	2.24	2.228	2.217	2.209	2.202	2.196	2.191	2.187	2.184	2.178	2.173	2.166	2.161	2.156	2.151	2.148	2.144	2.141	2.138	2.136	2.134	0.20	5
5	0.10	4.06	3.78	3.619	3.52	3.453	3.405	3.368	3.339	3.316	3.297	3.282	3.268	3.247	3.23	3.207	3.191	3.174	3.157	3.147	3.133	3.126	3.116	3.109	3.105	0.10	5
5	0.05	6.608	5.786	5.409	5.192	5.05	4.95	4.876	4.818	4.772	4.735	4.704	4.678	4.636	4.604	4.558	4.527	4.496	4.464	4.444	4.418	4.405	4.385	4.373	4.365	0.05	5
5	0.02	11.323	9.454	8.67	8.233	7.953	7.758	7.614	7.503	7.415	7.344	7.285	7.235	7.156	7.095	7.009	6.951	6.893	6.833	6.797	6.749	6.724	6.687	6.665	6.65	0.02	5
5	0.01	16.258	13.274	12.06	11.392	10.967	10.672	10.456	10.289	10.158	10.051	9.963	9.888	9.77	9.68	9.553	9.466	9.379	9.291	9.238	9.166	9.13	9.075	9.042	9.02	0.01	5
6	0.20	2.073	2.13	2.113	2.092	2.076	2.062	2.051	2.042	2.034	2.028	2.022	2.018	2.01	2.004	1.995	1.989	1.982	1.976	1.972	1.966	1.963	1.959	1.956	1.954	0.20	6
6	0.10	3.776	3.463	3.289	3.181	3.108	3.055	3.014	2.983	2.958	2.937	2.92	2.905	2.881	2.863	2.836	2.818	2.8	2.781	2.77	2.754	2.746	2.734	2.727	2.722	0.10	6
6	0.05	5.987	5.143	4.757	4.534	4.387	4.284	4.207	4.147	4.099	4.06	4.027	4	3.956	3.922	3.874	3.841	3.808	3.774	3.754	3.726	3.712	3.69	3.678	3.669	0.05	6
6	0.02	9.876	8.052	7.287	6.859	6.585	6.393	6.251	6.141	6.055	5.984	5.925	5.876	5.797	5.737	5.651	5.593	5.534	5.474	5.438	5.389	5.364	5.327	5.304	5.289	0.02	6
6	0.01	13.745	10.925	9.78	9.148	8.746	8.466	8.26	8.102	7.976	7.874	7.79	7.718	7.605	7.519	7.396	7.313	7.229	7.143	7.091	7.022	6.987	6.934	6.902	6.88	0.01	6
7	0.20	2.002	2.043	2.019	1.994	1.974	1.957	1.945	1.934	1.925	1.918	1.911	1.906	1.897	1.89	1.879	1.872	1.865	1.857	1.852	1.845	1.842	1.837	1.833	1.831	0.20	7
7	0.10	3.589	3.257	3.074	2.961	2.883	2.827	2.785	2.752	2.725	2.703	2.684	2.668	2.643	2.623	2.595	2.575	2.555	2.535	2.523	2.506	2.497	2.484	2.476	2.471	0.10	7
7	0.05	5.591	4.737	4.347	4.12	3.972	3.866	3.787	3.726	3.677	3.637	3.603	3.575	3.529	3.494	3.445	3.41	3.376	3.34	3.319	3.29	3.275	3.252	3.239	3.23	0.05	7
7	0.02	8.988	7.203	6.454	6.035	5.765	5.576	5.435	5.327	5.241	5.171	5.113	5.064	4.985	4.925	4.839	4.781	4.722	4.662	4.625	4.576	4.551	4.513	4.49	4.475	0.02	7
7	0.01	12.246	9.547	8.451	7.847	7.46	7.191	6.993	6.84	6.719	6.62	6.538	6.469	6.359	6.275	6.155	6.074	5.992	5.908	5.858	5.789	5.755	5.702	5.671	5.65	0.01	7
8	0.20	1.951	1.981	1.951	1.923	1.9	1.883	1.868	1.856	1.847	1.838	1.831	1.825	1.815	1.807	1.796	1.787	1.779	1.77	1.765	1.757	1.753	1.748	1.744	1.742	0.20	8
8	0.10	3.458	3.113	2.924	2.806	2.726	2.668	2.624	2.589	2.561	2.538	2.519	2.502	2.475	2.455	2.425	2.404	2.383	2.361	2.348	2.33	2.321	2.307	2.298	2.293	0.10	8
8	0.05	5.318	4.459	4.066	3.838	3.687	3.581	3.5	3.438	3.388	3.347	3.313	3.284	3.237	3.202	3.15	3.115	3.079	3.043	3.02	2.99	2.975	2.951	2.937	2.928	0.05	8
8	0.02	8.389	6.637	5.901	5.489	5.223	5.036	4.897	4.79	4.705	4.635	4.577	4.528	4.449	4.389	4.304	4.245	4.186	4.125	4.088	4.038	4.013	3.975	3.952	3.936	0.02	8
8	0.01	11.259	8.649	7.591	7.006	6.632	6.371	6.178	6.029	5.911	5.814	5.734	5.667	5.559	5.477	5.359	5.279	5.198	5.116	5.065	4.998	4.963	4.911	4.88	4.859	0.01	8
9	0.20	1.913	1.935	1.901	1.87	1.846	1.826	1.811	1.798	1.787	1.778	1.771	1.764	1.753	1.745	1.732	1.723	1.714	1.704	1.698	1.69	1.686	1.68	1.676	1.673	0.20	9
9	0.10	3.36	3.006	2.813	2.693	2.611	2.551	2.505	2.469	2.44	2.416	2.396	2.379	2.351	2.329	2.298	2.277	2.255	2.232	2.218	2.199	2.189	2.174	2.165	2.159	0.10	9
9	0.05	5.117	4.256	3.863	3.633	3.482	3.374	3.293	3.23	3.179	3.137	3.102	3.073	3.025	2.989	2.936	2.9	2.864	2.826	2.803	2.771	2.756	2.731	2.717	2.707	0.05	9
9	0.02	7.961	6.234	5.51	5.103	4.84	4.654	4.517	4.41	4.325	4.256	4.198	4.149	4.071	4.011	3.925	3.866	3.806	3.745	3.708	3.658	3.632	3.593	3.57	3.554	0.02	9
9	0.01	10.561	8.022	6.992	6.422	6.057	5.802	5.613	5.467	5.351	5.257	5.178	5.111	5.005	4.924	4.808	4.729	4.649	4.567	4.517	4.449	4.415	4.363	4.332	4.311	0.01	9

F-distributions

Numerator df		1	2	3	4	5	6	7	8	9	10	11	12	14	16	20	24	30	40	50	75	100	200	500	Inf		
Denominator df	Upper-tail																										
10	0.20	1.883	1.899	1.861	1.829	1.803	1.782	1.766	1.752	1.741	1.732	1.723	1.716	1.705	1.696	1.682	1.673	1.663	1.653	1.646	1.637	1.633	1.626	1.621	1.618	0.20	10
10	0.10	3.285	2.924	2.728	2.605	2.522	2.461	2.414	2.377	2.347	2.323	2.302	2.284	2.255	2.233	2.201	2.178	2.155	2.132	2.117	2.097	2.087	2.071	2.062	2.055	0.10	10
10	0.05	4.965	4.103	3.708	3.478	3.326	3.217	3.135	3.072	3.02	2.978	2.943	2.913	2.865	2.828	2.774	2.737	2.7	2.661	2.637	2.605	2.588	2.563	2.548	2.538	0.05	10
10	0.02	7.638	5.934	5.218	4.816	4.555	4.371	4.235	4.129	4.044	3.975	3.917	3.868	3.79	3.73	3.644	3.585	3.525	3.463	3.425	3.374	3.348	3.309	3.285	3.269	0.02	10
10	0.01	10.044	7.559	6.552	5.994	5.636	5.386	5.2	5.057	4.942	4.849	4.772	4.706	4.601	4.52	4.405	4.327	4.247	4.165	4.115	4.048	4.014	3.962	3.93	3.909	0.01	10
11	0.20	1.859	1.87	1.83	1.796	1.768	1.747	1.73	1.716	1.704	1.694	1.685	1.678	1.666	1.656	1.642	1.632	1.622	1.611	1.604	1.594	1.589	1.582	1.577	1.574	0.20	11
11	0.10	3.225	2.86	2.66	2.536	2.451	2.389	2.342	2.304	2.274	2.248	2.227	2.209	2.179	2.156	2.123	2.1	2.076	2.052	2.036	2.016	2.005	1.989	1.979	1.972	0.10	11
11	0.05	4.844	3.982	3.587	3.357	3.204	3.095	3.012	2.948	2.896	2.854	2.818	2.788	2.739	2.701	2.646	2.609	2.57	2.531	2.507	2.473	2.457	2.431	2.415	2.404	0.05	11
11	0.02	7.388	5.701	4.993	4.594	4.336	4.153	4.017	3.912	3.828	3.758	3.701	3.652	3.573	3.513	3.427	3.367	3.307	3.245	3.207	3.155	3.129	3.089	3.065	3.048	0.02	11
11	0.01	9.646	7.206	6.217	5.668	5.316	5.069	4.886	4.744	4.632	4.539	4.462	4.397	4.293	4.213	4.099	4.021	3.941	3.86	3.81	3.742	3.708	3.656	3.624	3.602	0.01	11
12	0.20	1.839	1.846	1.804	1.768	1.74	1.718	1.7	1.686	1.673	1.663	1.654	1.646	1.634	1.624	1.609	1.598	1.587	1.576	1.568	1.558	1.553	1.545	1.54	1.537	0.20	12
12	0.10	3.177	2.807	2.606	2.48	2.394	2.331	2.283	2.245	2.214	2.188	2.166	2.147	2.117	2.094	2.06	2.036	2.011	1.97	1.949	1.938	1.921	1.911	1.904	1.904	0.10	12
12	0.05	4.747	3.885	3.49	3.259	3.106	2.996	2.913	2.849	2.796	2.753	2.717	2.687	2.637	2.599	2.544	2.505	2.466	2.426	2.401	2.367	2.35	2.323	2.307	2.296	0.05	12
12	0.02	7.188	5.516	4.814	4.419	4.162	3.98	3.845	3.74	3.656	3.587	3.529	3.48	3.402	3.341	3.254	3.195	3.134	3.071	3.033	2.981	2.954	2.913	2.889	2.872	0.02	12
12	0.01	9.33	6.927	5.953	5.412	5.064	4.821	4.64	4.499	4.388	4.296	4.22	4.155	4.052	3.972	3.858	3.78	3.701	3.619	3.569	3.501	3.467	3.414	3.382	3.361	0.01	12
13	0.20	1.823	1.826	1.783	1.746	1.717	1.694	1.676	1.661	1.648	1.637	1.628	1.62	1.607	1.596	1.581	1.57	1.558	1.546	1.539	1.528	1.523	1.514	1.509	1.506	0.20	13
13	0.10	3.136	2.763	2.56	2.434	2.347	2.283	2.234	2.195	2.164	2.138	2.116	2.097	2.066	2.042	2.007	1.983	1.958	1.931	1.915	1.893	1.882	1.864	1.853	1.846	0.10	13
13	0.05	4.667	3.806	3.411	3.179	3.025	2.915	2.832	2.767	2.714	2.671	2.635	2.604	2.554	2.515	2.459	2.42	2.38	2.339	2.314	2.279	2.261	2.234	2.218	2.206	0.05	13
13	0.02	7.024	5.366	4.669	4.276	4.02	3.84	3.705	3.6	3.516	3.447	3.39	3.341	3.262	3.201	3.114	3.054	2.993	2.93	2.891	2.838	2.811	2.77	2.745	2.728	0.02	13
13	0.01	9.074	6.701	5.739	5.205	4.862	4.62	4.441	4.302	4.191	4.1	4.025	3.96	3.857	3.778	3.665	3.587	3.507	3.425	3.375	3.307	3.272	3.219	3.187	3.165	0.01	13
14	0.20	1.809	1.809	1.765	1.727	1.697	1.674	1.655	1.639	1.626	1.615	1.606	1.598	1.584	1.573	1.557	1.546	1.534	1.521	1.513	1.502	1.497	1.488	1.482	1.479	0.20	14
14	0.10	3.102	2.726	2.522	2.395	2.307	2.243	2.193	2.154	2.122	2.095	2.073	2.054	2.022	1.998	1.962	1.938	1.912	1.885	1.869	1.846	1.834	1.816	1.805	1.797	0.10	14
14	0.05	4.6	3.739	3.344	3.112	2.958	2.848	2.764	2.699	2.646	2.602	2.565	2.534	2.484	2.445	2.388	2.349	2.308	2.266	2.241	2.205	2.187	2.159	2.142	2.131	0.05	14
14	0.02	6.888	5.241	4.549	4.158	3.904	3.724	3.589	3.485	3.401	3.332	3.274	3.225	3.146	3.086	2.998	2.938	2.876	2.812	2.773	2.72	2.692	2.651	2.625	2.608	0.02	14
14	0.01	8.862	6.515	5.564	5.035	4.695	4.456	4.278	4.14	4.03	3.939	3.864	3.8	3.698	3.619	3.505	3.427	3.348	3.266	3.215	3.147	3.112	3.059	3.026	3.004	0.01	14
15	0.20	1.797	1.795	1.749	1.71	1.68	1.656	1.637	1.621	1.608	1.596	1.587	1.578	1.564	1.553	1.537	1.525	1.513	1.5	1.491	1.48	1.474	1.465	1.459	1.455	0.20	15
15	0.10	3.073	2.695	2.49	2.361	2.273	2.208	2.158	2.119	2.086	2.059	2.037	2.017	1.985	1.961	1.924	1.899	1.873	1.845	1.828	1.805	1.793	1.774	1.763	1.755	0.10	15
15	0.05	4.543	3.682	3.287	3.056	2.901	2.79	2.707	2.641	2.588	2.544	2.507	2.475	2.424	2.385	2.328	2.288	2.247	2.204	2.178	2.142	2.123	2.095	2.078	2.066	0.05	15
15	0.02	6.773	5.135	4.447	4.058	3.805	3.626	3.492	3.387	3.303	3.235	3.177	3.128	3.049	2.988	2.9	2.84	2.777	2.713	2.674	2.62	2.592	2.55	2.524	2.506	0.02	15
15	0.01	8.683	6.359	5.417	4.893	4.556	4.318	4.142	4.004	3.895	3.805	3.73	3.666	3.564	3.485	3.372	3.294	3.214	3.132	3.081	3.012	2.977	2.923	2.891	2.868	0.01	15
16	0.20	1.787	1.783	1.736	1.696	1.665	1.641	1.621	1.605	1.591	1.58	1.57	1.561	1.547	1.536	1.519	1.507	1.494	1.481	1.472	1.46	1.454	1.445	1.439	1.435	0.20	16
16	0.10	3.048	2.668	2.462	2.333	2.244	2.178	2.128	2.088	2.055	2.028	2.005	1.985	1.953	1.928	1.891	1.866	1.839	1.811	1.793	1.769	1.757	1.738	1.726	1.718	0.10	16
16	0.05	4.494	3.634	3.239	3.007	2.852	2.741	2.657	2.591	2.538	2.494	2.456	2.425	2.373	2.333	2.276	2.235	2.194	2.151	2.124	2.087	2.068	2.039	2.022	2.01	0.05	16
16	0.02	6.674	5.046	4.361	3.974	3.721	3.543	3.409	3.304	3.221	3.152	3.094	3.045	2.966	2.905	2.817	2.756	2.693	2.628	2.589	2.534	2.506	2.463	2.437	2.419	0.02	16
16	0.01	8.531	6.226	5.292	4.773	4.437	4.202	4.026	3.89	3.78	3.691	3.616	3.553	3.451	3.372	3.259	3.181	3.101	3.018	2.967	2.898	2.863	2.808	2.775	2.753	0.01	16
17	0.20	1.778	1.772	1.724	1.684	1.652	1.628	1.608	1.591	1.577	1.566	1.555	1.547	1.532	1.52	1.503	1.491	1.478	1.464	1.455	1.443	1.437	1.427	1.421	1.416	0.20	17
17	0.10	3.026	2.645	2.437	2.308	2.218	2.152	2.102	2.061	2.028	2.001	1.978	1.958	1.925	1.9	1.862	1.836	1.809	1.781	1.763	1.738	1.726	1.706	1.694	1.686	0.10	17
17	0.05	4.451	3.592	3.197	2.965	2.81	2.699	2.614	2.548	2.494	2.45	2.413	2.381	2.329	2.289	2.23	2.19	2.148	2.104	2.077	2.04	2.02	1.991	1.973	1.96	0.05	17
17	0.02	6.589	4.968	4.286	3.901	3.649	3.471	3.337	3.233	3.149	3.08	3.023	2.973	2.894	2.833	2.745	2.683	2.62	2.555	2.515	2.46	2.431	2.388	2.361	2.343	0.02	17
17	0.01	8.4	6.112	5.185	4.669	4.336	4.102	3.927	3.791	3.682	3.593	3.519	3.455	3.353	3.275	3.162	3.084	3.003	2.92	2.869	2.8	2.764	2.709	2.676	2.653	0.01	17
18	0.20	1.77	1.762	1.713	1.673	1.641	1.616	1.596	1.579	1.565	1.553	1.543	1.534	1.519	1.507	1.489	1.477	1.463	1.449	1.44	1.428	1.421	1.411	1.404	1.4	0.20	18
18	0.10	3.007	2.624	2.416	2.286	2.196	2.13	2.079	2.038	2.005	1.977	1.954	1.933	1.9	1.875	1.837	1.81	1.783	1.754	1.736	1.711	1.698	1.678	1.665	1.657	0.10	18
18	0.05	4.414	3.555	3.16	2.928	2.773	2.661	2.577	2.51	2.456	2.412	2.374	2.342	2.29	2.25	2.191	2.15	2.107	2.063	2.035	1.998	1.978	1.948	1.929	1.917	0.05	18
18	0.02	6.515	4.9	4.221	3.837	3.586	3.408	3.275	3.171	3.087	3.018	2.96	2.911	2.832	2.77	2.682	2.62	2.557	2.491	2.45	2.395	2.366	2.322	2.295	2.277	0.02	18
18	0.01	8.285	6.013	5.092	4.579	4.248	4.015	3.841	3.705	3.597	3.508	3.434	3.371	3.269	3.19	3.077	2.999	2.919	2.835	2.784	2.714	2.678	2.623	2.589	2.566	0.01	18
19	0.20	1.763	1.754	1.704	1.663	1.631	1.605	1.585	1.568	1.554	1.542	1.531	1.522	1.507	1.495	1.477	1.464	1.45	1.436	1.427	1.414	1.407	1.396	1.39	1.385	0.20	19
19	0.10	2.99	2.606	2.397	2.266	2.176	2.109	2.058	2.017	1.984	1.956	1.932	1.912	1.878	1.852	1.814	1.787	1.759	1.73	1.711	1.686	1.673	1.652	1.639	1.631	0.10	19
19	0.05	4.381	3.522	3.127	2.895	2.74	2.628	2.544	2.477	2.423	2.378	2.34	2.308	2.256	2.215	2.155	2.114	2.071	2.026	1.999	1.96	1.94	1.91	1.891	1.878	0.05	19
19	0.02	6.449	4.84	4.164	3.781	3.531	3.353	3.22	3.116	3.032	2.963	2.906	2.856	2.777	2.715	2.626	2.564	2.501	2.434	2.394	2.337	2.308	2.264	2.236	2.218	0.02	19
19	0.01	8.185	5.926	5.01	4.5	4.171	3.939	3.765	3.631	3.523	3.434	3.36	3.297	3.195	3.116	3.003	2.925	2.844	2.761	2.709	2.639	2.602	2.547	2.512	2.489	0.01	19

F-distributions

Numerator df		1	2	3	4	5	6	7	8	9	10	11	12	14	16	20	24	30	40	50	75	100	200	500	Inf		
Denominator df	Upper-tail																										
20	0.20	1.757	1.746	1.696	1.654	1.622	1.596	1.575	1.558	1.544	1.531	1.521	1.512	1.496	1.484	1.466	1.452	1.439	1.424	1.414	1.401	1.394	1.383	1.377	1.372	0.20	20
20	0.10	2.975	2.589	2.38	2.249	2.158	2.091	2.04	1.999	1.965	1.937	1.913	1.892	1.859	1.833	1.794	1.767	1.738	1.708	1.69	1.664	1.65	1.629	1.616	1.607	0.10	20
20	0.05	4.351	3.493	3.098	2.866	2.711	2.599	2.514	2.447	2.393	2.348	2.31	2.278	2.225	2.184	2.124	2.082	2.039	1.994	1.966	1.927	1.907	1.875	1.856	1.843	0.05	20
20	0.02	6.391	4.788	4.113	3.731	3.482	3.304	3.171	3.067	2.984	2.915	2.857	2.808	2.728	2.666	2.577	2.515	2.451	2.384	2.343	2.286	2.257	2.212	2.184	2.165	0.02	20
20	0.01	8.096	5.849	4.938	4.431	4.103	3.871	3.699	3.564	3.457	3.368	3.294	3.231	3.13	3.051	2.938	2.859	2.778	2.695	2.643	2.572	2.535	2.479	2.445	2.421	0.01	20
21	0.20	1.751	1.739	1.688	1.646	1.614	1.588	1.567	1.549	1.535	1.522	1.511	1.502	1.487	1.474	1.455	1.442	1.428	1.413	1.403	1.39	1.383	1.371	1.364	1.36	0.20	21
21	0.10	2.961	2.575	2.365	2.233	2.142	2.075	2.023	1.982	1.948	1.92	1.896	1.875	1.841	1.815	1.776	1.748	1.719	1.689	1.67	1.644	1.63	1.608	1.595	1.586	0.10	21
21	0.05	4.325	3.467	3.072	2.84	2.685	2.573	2.488	2.42	2.366	2.321	2.283	2.25	2.197	2.156	2.096	2.054	2.01	1.965	1.936	1.897	1.876	1.845	1.825	1.812	0.05	21
21	0.02	6.339	4.74	4.068	3.687	3.438	3.261	3.128	3.024	2.94	2.872	2.814	2.764	2.685	2.623	2.533	2.471	2.406	2.339	2.298	2.24	2.211	2.165	2.137	2.118	0.02	21
21	0.01	8.017	5.78	4.874	4.369	4.042	3.812	3.64	3.506	3.398	3.31	3.236	3.173	3.072	2.993	2.88	2.801	2.72	2.636	2.584	2.512	2.475	2.419	2.384	2.36	0.01	21
22	0.20	1.746	1.733	1.682	1.639	1.606	1.58	1.559	1.541	1.526	1.514	1.503	1.494	1.478	1.465	1.446	1.433	1.418	1.403	1.393	1.379	1.372	1.361	1.353	1.349	0.20	22
22	0.10	2.949	2.561	2.351	2.219	2.128	2.06	2.008	1.967	1.933	1.904	1.88	1.859	1.825	1.798	1.759	1.731	1.702	1.671	1.652	1.625	1.611	1.59	1.576	1.567	0.10	22
22	0.05	4.301	3.443	3.049	2.817	2.661	2.549	2.464	2.397	2.342	2.297	2.259	2.226	2.173	2.131	2.071	2.028	1.984	1.938	1.909	1.869	1.849	1.817	1.797	1.783	0.05	22
22	0.02	6.292	4.698	4.028	3.647	3.399	3.222	3.089	2.985	2.902	2.833	2.775	2.725	2.646	2.584	2.494	2.431	2.366	2.299	2.257	2.199	2.169	2.123	2.095	2.075	0.02	22
22	0.01	7.945	5.719	4.817	4.313	3.988	3.758	3.587	3.453	3.346	3.258	3.184	3.121	3.019	2.941	2.827	2.749	2.667	2.583	2.531	2.459	2.422	2.365	2.329	2.305	0.01	22
23	0.20	1.741	1.728	1.676	1.633	1.599	1.573	1.552	1.534	1.519	1.506	1.495	1.486	1.47	1.457	1.438	1.424	1.41	1.394	1.384	1.37	1.362	1.351	1.343	1.338	0.20	23
23	0.10	2.937	2.549	2.339	2.207	2.115	2.047	1.995	1.953	1.919	1.89	1.866	1.845	1.811	1.784	1.744	1.716	1.686	1.655	1.636	1.609	1.594	1.572	1.558	1.549	0.10	23
23	0.05	4.279	3.422	3.028	2.796	2.64	2.528	2.442	2.375	2.32	2.275	2.236	2.204	2.15	2.109	2.048	2.005	1.961	1.914	1.885	1.844	1.823	1.791	1.771	1.757	0.05	23
23	0.02	6.249	4.66	3.991	3.611	3.363	3.187	3.054	2.95	2.867	2.798	2.74	2.69	2.61	2.548	2.458	2.395	2.33	2.262	2.22	2.162	2.132	2.085	2.056	2.037	0.02	23
23	0.01	7.881	5.664	4.765	4.264	3.939	3.71	3.539	3.406	3.299	3.211	3.137	3.074	2.973	2.894	2.781	2.702	2.62	2.535	2.483	2.411	2.373	2.316	2.28	2.256	0.01	23
24	0.20	1.737	1.722	1.67	1.627	1.593	1.567	1.545	1.527	1.512	1.499	1.488	1.479	1.463	1.45	1.43	1.416	1.401	1.385	1.375	1.361	1.353	1.341	1.334	1.329	0.20	24
24	0.10	2.927	2.538	2.327	2.195	2.103	2.035	1.983	1.941	1.906	1.877	1.853	1.832	1.797	1.77	1.73	1.702	1.672	1.641	1.621	1.593	1.579	1.556	1.542	1.533	0.10	24
24	0.05	4.26	3.403	3.009	2.776	2.621	2.508	2.423	2.355	2.3	2.255	2.216	2.183	2.13	2.088	2.027	1.984	1.939	1.892	1.863	1.822	1.8	1.768	1.747	1.733	0.05	24
24	0.02	6.211	4.625	3.958	3.579	3.331	3.155	3.022	2.919	2.835	2.766	2.708	2.658	2.578	2.516	2.426	2.363	2.297	2.229	2.187	2.128	2.097	2.05	2.021	2.001	0.02	24
24	0.01	7.823	5.614	4.718	4.218	3.895	3.667	3.496	3.363	3.256	3.168	3.094	3.032	2.93	2.852	2.738	2.659	2.577	2.492	2.44	2.367	2.329	2.271	2.235	2.211	0.01	24
25	0.20	1.733	1.718	1.665	1.622	1.588	1.561	1.539	1.521	1.506	1.493	1.482	1.472	1.456	1.443	1.423	1.409	1.394	1.378	1.367	1.353	1.345	1.333	1.325	1.32	0.20	25
25	0.10	2.918	2.528	2.317	2.184	2.092	2.024	1.971	1.929	1.895	1.866	1.841	1.82	1.785	1.758	1.718	1.689	1.659	1.627	1.607	1.579	1.565	1.542	1.527	1.518	0.10	25
25	0.05	4.242	3.385	2.991	2.759	2.603	2.49	2.405	2.337	2.282	2.236	2.198	2.165	2.111	2.069	2.007	1.964	1.919	1.872	1.842	1.801	1.779	1.746	1.725	1.711	0.05	25
25	0.02	6.176	4.593	3.928	3.549	3.302	3.126	2.993	2.89	2.806	2.737	2.679	2.629	2.549	2.487	2.396	2.333	2.267	2.199	2.156	2.097	2.066	2.018	1.989	1.969	0.02	25
25	0.01	7.77	5.568	4.675	4.177	3.855	3.627	3.457	3.324	3.217	3.129	3.056	2.993	2.892	2.813	2.699	2.62	2.538	2.453	2.4	2.327	2.289	2.23	2.194	2.169	0.01	25
26	0.20	1.729	1.713	1.66	1.617	1.583	1.556	1.534	1.516	1.5	1.487	1.476	1.466	1.45	1.437	1.417	1.402	1.387	1.371	1.36	1.345	1.337	1.325	1.317	1.312	0.20	26
26	0.10	2.909	2.519	2.307	2.174	2.082	2.014	1.961	1.919	1.884	1.855	1.83	1.809	1.774	1.747	1.706	1.677	1.647	1.615	1.594	1.566	1.551	1.528	1.514	1.504	0.10	26
26	0.05	4.225	3.369	2.975	2.743	2.587	2.474	2.388	2.321	2.265	2.22	2.181	2.148	2.094	2.052	1.99	1.946	1.901	1.853	1.823	1.782	1.76	1.726	1.705	1.691	0.05	26
26	0.02	6.144	4.564	3.9	3.522	3.275	3.099	2.967	2.863	2.78	2.711	2.652	2.603	2.523	2.46	2.369	2.306	2.24	2.171	2.128	2.068	2.037	1.989	1.959	1.939	0.02	26
26	0.01	7.721	5.526	4.637	4.14	3.818	3.591	3.421	3.288	3.182	3.094	3.021	2.958	2.857	2.778	2.664	2.585	2.503	2.417	2.364	2.29	2.252	2.193	2.156	2.131	0.01	26

For use on the CAS exams

Lower-tail areas for Chi-square distributions

df	0.005	0.010	0.025	0.050	0.950	0.975	0.990	0.995
1	0.00	0.00	0.00	0.00	3.84	5.02	6.63	7.88
2	0.01	0.02	0.05	0.10	5.99	7.38	9.21	10.60
3	0.07	0.11	0.22	0.35	7.81	9.35	11.34	12.84
4	0.21	0.30	0.48	0.71	9.49	11.14	13.28	14.86
5	0.41	0.55	0.83	1.15	11.07	12.83	15.09	16.75
6	0.68	0.87	1.24	1.64	12.59	14.45	16.81	18.55
7	0.99	1.24	1.69	2.17	14.07	16.01	18.48	20.28
8	1.34	1.65	2.18	2.73	15.51	17.53	20.09	21.95
9	1.73	2.09	2.70	3.33	16.92	19.02	21.67	23.59
10	2.16	2.56	3.25	3.94	18.31	20.48	23.21	25.19
11	2.60	3.05	3.82	4.57	19.68	21.92	24.72	26.76
12	3.07	3.57	4.40	5.23	21.03	23.34	26.22	28.30
13	3.57	4.11	5.01	5.89	22.36	24.74	27.69	29.82
14	4.07	4.66	5.63	6.57	23.68	26.12	29.14	31.32
15	4.60	5.23	6.26	7.26	25.00	27.49	30.58	32.80
16	5.14	5.81	6.91	7.96	26.30	28.85	32.00	34.27
17	5.70	6.41	7.56	8.67	27.59	30.19	33.41	35.72
18	6.26	7.01	8.23	9.39	28.87	31.53	34.81	37.16
19	6.84	7.63	8.91	10.12	30.14	32.85	36.19	38.58
20	7.43	8.26	9.59	10.85	31.41	34.17	37.57	40.00
21	8.03	8.90	10.28	11.59	32.67	35.48	38.93	41.40
22	8.64	9.54	10.98	12.34	33.92	36.78	40.29	42.80
23	9.26	10.20	11.69	13.09	35.17	38.08	41.64	44.18
24	9.89	10.86	12.40	13.85	36.42	39.36	42.98	45.56
25	10.52	11.52	13.12	14.61	37.65	40.65	44.31	46.93
26	11.16	12.20	13.84	15.38	38.89	41.92	45.64	48.29
27	11.81	12.88	14.57	16.15	40.11	43.19	46.96	49.64
28	12.46	13.56	15.31	16.93	41.34	44.46	48.28	50.99
29	13.12	14.26	16.05	17.71	42.56	45.72	49.59	52.34
30	13.79	14.95	16.79	18.49	43.77	46.98	50.89	53.67
31	14.46	15.66	17.54	19.28	44.99	48.23	52.19	55.00
32	15.13	16.36	18.29	20.07	46.19	49.48	53.49	56.33
33	15.82	17.07	19.05	20.87	47.40	50.73	54.78	57.65
34	16.50	17.79	19.81	21.66	48.60	51.97	56.06	58.96
35	17.19	18.51	20.57	22.47	49.80	53.20	57.34	60.27
36	17.89	19.23	21.34	23.27	51.00	54.44	58.62	61.58
37	18.59	19.96	22.11	24.07	52.19	55.67	59.89	62.88
38	19.29	20.69	22.88	24.88	53.38	56.90	61.16	64.18
39	20.00	21.43	23.65	25.70	54.57	58.12	62.43	65.48
40	20.71	22.16	24.43	26.51	55.76	59.34	63.69	66.77
41	21.42	22.91	25.21	27.33	56.94	60.56	64.95	68.05
42	22.14	23.65	26.00	28.14	58.12	61.78	66.21	69.34
43	22.86	24.40	26.79	28.96	59.30	62.99	67.46	70.62
44	23.58	25.15	27.57	29.79	60.48	64.20	68.71	71.89
45	24.31	25.90	28.37	30.61	61.66	65.41	69.96	73.17
46	25.04	26.66	29.16	31.44	62.83	66.62	71.20	74.44
47	25.77	27.42	29.96	32.27	64.00	67.82	72.44	75.70
48	26.51	28.18	30.75	33.10	65.17	69.02	73.68	76.97
49	27.25	28.94	31.55	33.93	66.34	70.22	74.92	78.23
50	27.99	29.71	32.36	34.76	67.50	71.42	76.15	79.49

For use on the CAS exams

n2 = 3

U0	n1 = 1	n1 = 2	n1 = 3
0	0.250	0.100	0.050
1	0.500	0.200	0.100
2		0.400	0.200
3		0.600	0.350
4			0.500

n2 = 4

U0	n1 = 1	n1 = 2	n1 = 3	n1 = 4
0	0.200	0.067	0.029	0.014
1	0.400	0.134	0.057	0.029
2	0.600	0.267	0.114	0.057
3		0.400	0.200	0.100
4		0.600	0.314	0.172
5			0.428	0.243
6			0.572	0.343
7				0.443
8				0.557

n2 = 5

U0	n1 = 1	n1 = 2	n1 = 3	n1 = 4	n1 = 5
0	0.167	0.048	0.018	0.008	0.004
1	0.334	0.095	0.036	0.016	0.008
2	0.500	0.191	0.071	0.032	0.016
3		0.286	0.125	0.056	0.028
4		0.429	0.197	0.095	0.048
5		0.571	0.286	0.143	0.075
6			0.393	0.206	0.111
7			0.500	0.278	0.155
8				0.365	0.210
9				0.452	0.274
10				0.548	0.345
11					0.421
12					0.500

n2 = 6

U0	n1 = 1	n1 = 2	n1 = 3	n1 = 4	n1 = 5	n1 = 6
0	0.143	0.036	0.012	0.005	0.002	0.001
1	0.286	0.071	0.024	0.009	0.004	0.002
2	0.429	0.143	0.048	0.019	0.009	0.004
3	0.571	0.214	0.083	0.033	0.015	0.008
4		0.321	0.131	0.057	0.026	0.013
5		0.428	0.191	0.086	0.041	0.021
6		0.572	0.274	0.129	0.063	0.033
7			0.357	0.176	0.089	0.047
8			0.452	0.238	0.123	0.066
9			0.548	0.305	0.164	0.090
10				0.381	0.214	0.120
11				0.457	0.268	0.155
12				0.543	0.331	0.197
13					0.396	0.242
14					0.465	0.294
15					0.535	0.349
16						0.409
17						0.469
18						0.531

n2 = 7

U0	n1 = 1	n1 = 2	n1 = 3	n1 = 4	n1 = 5	n1 = 6	n1 = 7
0	0.125	0.028	0.008	0.003	0.001	0.001	0.000
1	0.250	0.056	0.017	0.006	0.003	0.001	0.001
2	0.375	0.111	0.033	0.012	0.005	0.002	0.001
3	0.500	0.167	0.058	0.021	0.009	0.004	0.002
4		0.250	0.092	0.036	0.015	0.007	0.004
5		0.333	0.133	0.054	0.024	0.011	0.005
6		0.444	0.192	0.082	0.037	0.018	0.009
7		0.556	0.258	0.115	0.053	0.026	0.013
8			0.333	0.158	0.074	0.037	0.019
9			0.417	0.206	0.101	0.051	0.027
10			0.500	0.264	0.134	0.069	0.036
11				0.324	0.172	0.090	0.049
12				0.394	0.216	0.117	0.064
13				0.464	0.265	0.148	0.083
14				0.536	0.319	0.183	0.104
15					0.378	0.223	0.130
16					0.438	0.267	0.159
17					0.500	0.314	0.191
18						0.365	0.228
19						0.418	0.268
20						0.472	0.310
21						0.528	0.355
22							0.403
23							0.451
24							0.500

n2 = 8

U0	n1 = 1	n1 = 2	n1 = 3	n1 = 4	n1 = 5	n1 = 6	n1 = 7	n1 = 8
0	0.111	0.022	0.006	0.002	0.001	0.000	0.000	0.000
1	0.223	0.044	0.012	0.004	0.002	0.001	0.000	0.000
2	0.334	0.089	0.024	0.008	0.003	0.001	0.001	0.000
3	0.445	0.133	0.042	0.014	0.005	0.002	0.001	0.001
4	0.555	0.200	0.067	0.024	0.009	0.004	0.002	0.001
5		0.267	0.097	0.036	0.015	0.006	0.003	0.002
6		0.355	0.139	0.054	0.023	0.010	0.005	0.002
7		0.444	0.188	0.077	0.033	0.015	0.007	0.004
8		0.556	0.249	0.107	0.047	0.021	0.010	0.005
9			0.315	0.141	0.064	0.030	0.014	0.007
10			0.388	0.184	0.086	0.041	0.020	0.011
11			0.461	0.230	0.111	0.054	0.027	0.014
12			0.539	0.285	0.142	0.071	0.036	0.019
13				0.341	0.177	0.090	0.047	0.025
14				0.404	0.218	0.114	0.060	0.033
15				0.467	0.262	0.141	0.076	0.042
16				0.533	0.311	0.173	0.095	0.052
17					0.362	0.207	0.116	0.065
18					0.416	0.245	0.140	0.080
19					0.472	0.286	0.168	0.097
20					0.528	0.331	0.198	0.117
21						0.377	0.232	0.139
22						0.426	0.268	0.164
23						0.475	0.306	0.191
24						0.525	0.347	0.221
25							0.389	0.253
26							0.433	0.287
27							0.477	0.323
28							0.523	0.361
29								0.400
30								0.440
31								0.480
32								0.520

n2 = 9

U0	n1 = 1	n1 = 2	n1 = 3	n1 = 4	n1 = 5	n1 = 6	n1 = 7	n1 = 8	n1 = 9
0	0.100	0.018	0.004	0.001	0.001	0.000	0.000	0.000	0.000
1	0.200	0.036	0.009	0.003	0.001	0.000	0.000	0.000	0.000
2	0.300	0.073	0.018	0.006	0.002	0.001	0.000	0.000	0.000
3	0.400	0.109	0.032	0.010	0.004	0.001	0.001	0.000	0.000
4	0.500	0.164	0.050	0.017	0.006	0.002	0.001	0.001	0.000
5		0.218	0.073	0.025	0.009	0.004	0.002	0.001	0.000
6		0.291	0.105	0.038	0.014	0.006	0.003	0.001	0.001
7		0.364	0.141	0.053	0.021	0.009	0.004	0.002	0.001
8		0.455	0.186	0.074	0.030	0.013	0.006	0.003	0.001
9		0.545	0.241	0.099	0.041	0.018	0.008	0.004	0.002
10			0.300	0.130	0.056	0.025	0.011	0.005	0.003
11			0.364	0.165	0.073	0.033	0.016	0.008	0.004
12			0.432	0.207	0.095	0.044	0.021	0.010	0.005
13			0.500	0.252	0.120	0.057	0.027	0.014	0.007
14				0.302	0.149	0.072	0.036	0.018	0.009
15				0.356	0.182	0.090	0.045	0.023	0.012
16				0.413	0.219	0.112	0.057	0.029	0.016
17				0.470	0.259	0.136	0.071	0.037	0.020
18				0.530	0.303	0.164	0.087	0.046	0.025
19					0.350	0.194	0.105	0.057	0.031
20					0.399	0.228	0.126	0.069	0.039
21					0.449	0.264	0.150	0.084	0.047
22					0.500	0.303	0.176	0.100	0.057
23						0.344	0.204	0.118	0.068
24						0.388	0.235	0.138	0.081
25						0.432	0.268	0.160	0.095
26						0.477	0.303	0.185	0.111
27						0.523	0.340	0.211	0.129
28							0.379	0.240	0.149
29							0.419	0.270	0.170
30							0.459	0.303	0.193
31							0.500	0.336	0.218
32								0.371	0.245
33								0.407	0.273
34								0.444	0.302
35								0.481	0.333
36								0.519	0.365
37									0.398
38									0.431
39									0.466
40									0.500

U0	n1 = 1	n1 = 2	n1 = 3	n1 = 4	n1 = 5	n1 = 6	n1 = 7	n1 = 8	n1 = 9	n1 = 10
0	0.091	0.015	0.004	0.001	0.000	0.000	0.000	0.000	0.000	0.000
1	0.182	0.030	0.007	0.002	0.001	0.000	0.000	0.000	0.000	0.000
2	0.273	0.061	0.014	0.004	0.001	0.001	0.000	0.000	0.000	0.000
3	0.364	0.091	0.024	0.007	0.002	0.001	0.000	0.000	0.000	0.000
4	0.455	0.137	0.038	0.012	0.004	0.002	0.001	0.000	0.000	0.000
5	0.545	0.182	0.056	0.018	0.006	0.002	0.001	0.000	0.000	0.000
6		0.243	0.081	0.027	0.010	0.004	0.002	0.001	0.000	0.000
7		0.303	0.108	0.038	0.014	0.005	0.002	0.001	0.001	0.000
8		0.379	0.143	0.053	0.020	0.008	0.003	0.002	0.001	0.000
9		0.455	0.185	0.071	0.027	0.011	0.005	0.002	0.001	0.001
10		0.545	0.234	0.094	0.037	0.016	0.007	0.003	0.002	0.001
11			0.287	0.120	0.049	0.021	0.009	0.004	0.002	0.001
12			0.346	0.152	0.065	0.028	0.012	0.006	0.003	0.001
13			0.405	0.187	0.082	0.036	0.017	0.008	0.004	0.002
14			0.469	0.227	0.103	0.047	0.021	0.010	0.005	0.003
15			0.531	0.270	0.127	0.059	0.028	0.013	0.007	0.003
16				0.318	0.155	0.074	0.035	0.017	0.009	0.004
17				0.367	0.185	0.090	0.044	0.022	0.011	0.006
18				0.420	0.220	0.110	0.054	0.027	0.014	0.007
19				0.472	0.256	0.132	0.066	0.034	0.018	0.009
20				0.527	0.297	0.157	0.081	0.042	0.022	0.012
21					0.339	0.184	0.096	0.051	0.027	0.014
22					0.384	0.214	0.115	0.061	0.033	0.018
23					0.429	0.246	0.135	0.073	0.039	0.021
24					0.476	0.281	0.157	0.086	0.047	0.026
25					0.524	0.318	0.182	0.102	0.056	0.031
26						0.356	0.208	0.119	0.067	0.038
27						0.396	0.237	0.137	0.078	0.044
28						0.438	0.268	0.158	0.091	0.052
29						0.479	0.300	0.180	0.105	0.061
30						0.521	0.334	0.204	0.121	0.071
31							0.369	0.230	0.139	0.083
32							0.406	0.257	0.158	0.095
33							0.443	0.286	0.178	0.109
34							0.481	0.317	0.200	0.123
35							0.519	0.348	0.223	0.140
36								0.381	0.248	0.157
37								0.414	0.274	0.176
38								0.448	0.302	0.196
39								0.483	0.330	0.218
40								0.517	0.360	0.241
41									0.390	0.264
42									0.421	0.289
43									0.452	0.315
44									0.484	0.342
45									0.516	0.370
46										0.398
47										0.427
48										0.456
49										0.485
50										0.515

Here is the rule for Exam S which will be printed for the Fall 2015 Syllabus:

*Note: To receive credit for the new Exam S on Statistics and Probabilistic Models during the transition, the candidate must have credit for Exams ST and LC[†]and the Applied Statistical Methods VEE. At the time of transition, if a candidate has credit for either Exam ST or Exam LC, but not both, the candidate will be allowed to take just the exam for which he or she is missing credit in order to obtain partial credit for the new exam. This option will be available for a transition period of two sittings after the official conversion to the new education structure (i.e., Fall 2015 and Spring 2016). Credit for the Applied Statistical Methods VEE will be accepted through August 2016. After August 2016, candidates must contact the CAS Office to verify and add the Applied Statistical Methods VEE, or course equivalent, credit to their transcript. If the candidate has not completed Exam ST, Exam LC, and the Applied Statistical Methods VEE by this date, the candidate will need to pass the full version of Exam S to receive credit. ***Candidates with credit for neither Exam ST nor Exam LC on August 31, 2015 will not be permitted to sit for Exams ST or LC during the transition period and will need to pass the full version of Exam S to receive credit.***

The following table summarizes the above:

Candidate Credit on August 31, 2015			Action Required by August 31, 2016
Exam ST	Exam LC	Stats VEE	to Earn Credit for new Exam S
✓	✓	✓	Credit granted. No candidate action required.
✓	✓		Complete the Applied Statistical Methods VEE.
✓		✓	Pass Exam LC.
✓			Pass Exam LC *and* complete the Applied Statistical Methods VEE.
	✓	✓	Pass Exam ST.
	✓		Pass Exam ST *and* complete the Applied Statistical Methods VEE.
		✓	Candidate must take full Exam S.
			Candidate must take full Exam S.

[†]The CAS has also granted waivers for Exam LC to candidates who have:

- passed SOA Exam MLC;
- passed the Institute and Faculty of Actuaries (U.K.), Actuaries Institute (Australia), or Institute of Actuaries of IndiaSubject CT5; or
- passed the Actuarial Society of South Africa Course A203; or
- received a waiver granted by the Canadian Institute of Actuaries University Accreditation Program.

For those students who have credit for Exam ST by August 31, 2015, the CAS will continue to grant Exam LC waivers through December 31, 2016 for exams passed before August 31, 2016.

CAS Online Course 1, Second Edition
Risk Management and Insurance Operations

Notice about the 1st and 2nd Editions

1st Edition: The original CAS Online Course 1 (CA1, 1st Edition) was revised effective September 1, 2014. Although the 1st Edition of CA1 is no longer available for sale after August 31, 2014, for those who purchased the 1st Edition, the original online course will be available and unchanged through June 15, 2015. The exam for the 1st Edition of CA1 will be offered through June 15, 2015.

2nd Edition: CA1, 2nd Edition, is the current version that was effective on September 1, 2014. Exams on this content will be offered for the first time on January 15, 2015.

Risk Management and Insurance Operations is called Online Course 1 by the CAS and CA1, 2nd Edition, by The Institutes. (Prometric lists this course as CAS1 on its Web site under The Institutes.)

Online Course 1/CA1 prepares CAS candidates for a two-hour, seventy-five-point multiple-choice examination. The online course and exam were developed collaboratively with The Institutes. The online course is available through the Casualty Actuarial Society Online Courses Web Page on The Institutes' Web Site. Similarly, the exam is administered by The Institutes at Prometric test centers during four, two-month testing windows annually.

The CAS will grant a waiver of CAS Online Course 1 to those who have the Chartered Property Casualty Underwriter (CPCU) designation.

The study material for CAS Course 1/CA1 is contained in the online course access. The fee for access to the online course includes one attempt at passing the exam. Candidates are required to purchase the online course to obtain access to the exam. Exam retakes may be purchased separately if needed.

Purchasing the course requires that candidates declare the testing window in which they are planning to take the exam. To register for the exam, a candidate must:

- Call The Institutes at (800) 644-2101 or (610) 644-2100, extension 6000, to register for the exam itself. This will place the candidate on an eligibility list for Prometric.

- Then make an appointment with Prometric for a specific date and time during the testing window. Early registration for the exam is strongly encouraged as seats fill quickly. There is a $105 fee for changing testing windows.

- Schedule your appointment when you know you will be ready to sit for the exam. Effective January 1, 2012, Prometric will charge a $50 fee to candidates who reschedule their appointments between 3 to 12 business days of a test date. Changes to the appointment date/time are not permitted within 3 business days of the appointment.

Questions or concerns regarding CAS Online Course 1/CA1 should be directed to The Institutes' Customer Service Department at (800) 644-2101 or (610) 644-2100, extension 6000, or CustomerService@TheInstitutes.org.

Assignment 1: Introduction to Risk Management

MODULE TITLE	LEARNING OBJECTIVE
Understanding and Quantifying Risk	Describe each of the following in the context of risk: • Uncertainty • Possibility • Possibility compared with probability
Classifications of Risk	Explain how the following classifications of risk apply and how they help in risk management: • Pure and speculative risk • Subjective and objective risk • Diversifiable and nondiversifiable risk • Quadrants of risk (hazard, operational, financial, and strategic)
Financial Consequences of Risk	Describe the three financial consequences of risk.
Basic Purpose and Scope of Risk Management	Describe the basic purpose and scope of risk management in terms of the following: • How risk management is practiced by individuals and organizations • The basic distinction between traditional risk management and enterprise-wide risk management
Loss Exposures	Describe the following elements of property, liability, personnel, and net income loss exposures: • Assets exposed to loss • Causes of loss, including associated hazards • Financial consequences of loss
Risk Management Benefits	Describe the benefits of risk management and how it reduces the financial consequences of risk for individuals, organizations, and society.
Risk Management Program Goals	Summarize pre-loss and post-loss risk management program goals and the conflicts that can arise as they are implemented.
The Risk Management Process	Describe each of the steps in the risk management process

Assignment 2: Risk Control

MODULE TITLE	LEARNING OBJECTIVE
Risk Control Techniques	Describe the six categories of risk control techniques in terms of the following: • Whether each reduces loss frequency, reduces loss severity, or makes losses more predictable • How each can be used to address a particular loss exposure • How they differ from one another

Risk Control Goals	Explain how an organization can use risk control techniques and measures to achieve the following risk control goals: • Implement effective and efficient risk control measures • Comply with legal requirements • Promote life safety • Ensure business continuity
Application of Risk Control Techniques	Explain how risk control techniques can be applied to property, liability, personnel, and net income loss exposures.
Business Continuity Management	Describe business continuity management in terms of its scope, the process used to implement it, and the contents of a typical business continuity plan.

Assignment 3: Risk Financing

MODULE TITLE	LEARNING OBJECTIVE
Risk Financing Goals	Explain how individuals or organizations can achieve their overall and risk management goals by fulfilling the following risk financing goals: • Pay for losses • Manage the cost of risk • Manage cash flow variability • Maintain an appropriate level of liquidity • Comply with legal requirements
Retention and Transfer	Describe the following aspects of retention and transfer: • Retention funding measures • Limitations on risk transfer measures • The advantages of both retention and transfer
Selecting Appropriate Risk Financing Measures	Explain how the following can affect the selection of the appropriate risk financing measure: • Ability of a risk financing measure to meet risk financing goals • Loss exposure characteristics • Characteristics specific to an individual or organization
Risk Financing Measures	Explain how an organization meets its risk financing goals by using the following risk financing measures: • Guaranteed cost insurance • Self-insurance • Large deductible plans • Captives • Finite risk plans • Pools • Retrospective rating plans • Hold-harmless agreements • Capital market solutions

Assignment 4: Enterprise-Wide Risk Management

MODULE TITLE	LEARNING OBJECTIVE
Traditional Risk Management Versus ERM	Contrast traditional risk management and ERM.
Improving Strategic Decision Making With ERM	Explain how an organization can improve its strategic decision making by incorporating enterprise-wide risk management (ERM).
ERM in Approaching Business Uncertainties	Explain why ERM is an effective approach to use to face business uncertainties.
Major Risk Management Frameworks and Standards	Summarize the main risk management frameworks and standards.

Assignment 5: Insurance as a Risk Management Technique

MODULE TITLE	LEARNING OBJECTIVE
How Insurance Reduces Risk	Explain how insurance reduces risk through pooling.
Benefits of Insurance	Explain how insurance benefits individuals, organizations, and society.
Characteristics of an Ideally Insurable Loss Exposure	Explain why each of the six characteristics of an ideally insurable loss exposure is important to the insurance mechanism.
Insurability of Commercial Loss Exposures	Explain how the six characteristics of an ideally insurable loss exposure apply to commercial loss exposures.
Insurability of Personal Loss Exposures	Explain how the six characteristics of an ideally insurable loss exposure apply to personal loss exposures.
Government Insurance Programs	Explain how state and federal governments are involved in the insurance market and the rationale for, and level of, their involvement.

Assignment 6: Overview of Insurance Operations

MODULE TITLE	LEARNING OBJECTIVE
Classifications of Insurers	Explain how insurers have organized to provide property-casualty insurance.
Insurer Goals	Describe the major goals of an insurer.
Constraints on Achieving Insurer Goals	Describe the internal and external constraints that impede insurers from achieving their major goals.
Measuring Insurer Performance	Describe the measurements used to evaluate how successful an insurer is at meeting its established goals.
Functional View of Insurance	Describe the core and supporting functions performed by insurers.

Assignment 7: Insurance Marketing and Distribution

MODULE TITLE	LEARNING OBJECTIVE
Property-Casualty Insurance Marketplace	Describe the following attributes of the competitive property-casualty insurance marketplace: distinguishing characteristics of insurance customers, insurer marketing differentiations, and unique factors in the insurance marketplace.
Insurer Marketing Activities	Explain how typical insurer marketing activities are performed and why they are performed.
Insurance Distributions Systems and Channels	Describe the main types of insurance distribution systems and channels, including the principal characteristics that distinguish one distribution system from another.
Functions of Insurance Producers	Describe the functions performed by insurance producers.
Distribution System and Channel Selection for Insurance Marketing	Describe the key factors an insurer should evaluate during the distribution-system and distribution-channel selection process.

Assignment 8: The Underwriting Function

MODULE TITLE	LEARNING OBJECTIVE
Purpose of Underwriting	Describe the purpose of underwriting.
Underwriting Activities	Describe the underwriting activities typically performed by line and staff underwriters.
Underwriting Authority	Describe the importance of compliance with underwriting authority in individual account selection.
Constraints in Establishing Underwriting Policy	Describe the constraining factors considered in the establishment of underwriting policy.
Implementing Underwriting Policy	Describe the purposes that underwriting guidelines and underwriting audits serve.
Steps in the Underwriting Process	Summarize the steps in the underwriting process and the purpose of each.
Measuring Underwriting Results	Explain how an insurer's underwriting results are measured and how financial measures can be distorted.

Assignment 9: Underwriting Property and Liability Insurance

MODULE TITLE	LEARNING OBJECTIVE
Underwriting Property Insurance Using the COPE Model	Describe in detail each of the COPE factors used to evaluate property loss exposures.
Property Policy Provision Underwriting Considerations	Explain how insurable interest, policy provisions for valuing losses, and insurance to value affect a loss payment amount under property insurance.

Measures of Potential Loss Severity	Explain how underwriters use policy amount, amount subject, normal loss expectancy (NLE), probable maximum loss (PML), and maximum foreseeable loss (MFL) to measure potential loss severity.
Underwriting Business Income and Extra Expense Coverage	Describe the underwriting considerations for business income and extra expense coverage.
Underwriting Commercial Crime Insurance	Describe the underwriting considerations and risk control techniques associated with employee dishonesty and crimes committed by others.
Underwriting Commercial General Liability Insurance	Describe the loss exposures and the underwriting considerations for commercial general liability insurance.
Underwriting Personal and Commercial Auto Insurance	Describe the underwriting considerations for personal and commercial auto insurance.
Underwriting Workers Compensation Insurance	Describe the underwriting considerations for workers compensation insurance.
Underwriting Umbrella and Excess Liability Insurance	Describe the underwriting considerations for umbrella and excess liability insurance.

Assignment 10: Risk Control and Premium Auditing

MODULE TITLE	LEARNING OBJECTIVE
Insurer Risk Control Goals	Describe the goals of insurer risk control activities.
Risk Control Services Provided by Insurers	Describe the risk control services provided by insurers.
Cooperation Between Risk Control and Other Insurer Functions	Explain how risk control cooperates with other insurer functions.
Reasons for Premium Auditing	Explain why premium audits are conducted.
Premium Auditing Process	Describe the premium auditing process.
Importance of Accurate Premium Audits	Explain why premium audits must be accurate.
Premium Auditing Contributions	Explain how premium auditing contributes to other insurer functions.

Assignment 11: The Claim Function

MODULE TITLE	LEARNING OBJECTIVE
Overview of the Claim Function	Identify the goals of the claim function; the users of claim information, and the parties with whom claim personnel interact.
Claim Department Structure, Personnel, and Performance	Describe the claim departments in terms of the following: • How they are structured • The types and functions of claim personnel • How their performance can be measured

MODULE TITLE	LEARNING OBJECTIVE
Measures Used to Ensure Regulatory Compliance	Explain how the following measures are used to ensure regulatory compliance: • Claim guidelines, policies, and procedures • Controls • Supervisor and manager reviews • Claim audits
Activities in the Claim Handling Process	• Summarize the activities performed in the claim handling process and the purpose of each.
The Framework for Coverage Analysis and the Claim Handling Process Case Study	Given a claim scenario, demonstrate how a claim reprentative can use the claim handling process and framework for coverage analysis to resolve a claim.

Assignment 12: Adjusting Property and Liability Claims

MODULE TITLE	LEARNING OBJECTIVE
Property Claim Handling Process	Explain how and why the activities in the framework for handling property claims are accomplished.
Handling Specific Types of Property Claims	Describe the challenges of handling the following types of property claims: • Residential dwelling claims • Residential personal property claims • Commercial structure claims • Business income claims • Merchandise claims • Transportation and bailment claims • Catastrophe claims
Liability Claim Handling Process	Explain how and why the activities in the framework for handling a liability claim are accomplished.
Handling Specific Types of Liability Claims	Describe the challenges of handling each of the following types of claims: • Auto bodily injury liability claims • Auto property damage claims • Premises liability claims • Operations liability claims • Products liability claims • Workers compensation claims • Professional liability claims

Assignment 13: Reinsurance Principles and Concepts

MODULE TITLE	LEARNING OBJECTIVE
Reinsurance and Its Functions	Describe reinsurance and its principal functions.
Reinsurance Sources	Describe the three sources of reinsurance.
Reinsurance Transactions	Describe treaty reinsurance and facultative reinsurance.
Types of Pro Rata and Excess of Loss Reinsurance	Summarize the types of pro rata reinsurance and excess of loss reinsurance and their uses.
Alternatives to Traditional Reinsurance	Describe finite risk reinsurance and other methods that rely on capital markets as alternatives to traditional and non-traditional reinsurance.
Reinsurance Program Design	Describe the factors that should be considered in the design of a reinsurance program.
Reinsurance Program Design Case Studies	Given a case, identify the reinsurance needs of an insurer and recommend an appropriate reinsurance program to meet those needs.

Assignment 14: Insurer Strategic Management

MODULE TITLE	LEARNING OBJECTIVE
Strategic Management Process	Describe the strategic management process.
The Five Forces and SWOT Methods of Analyzing the Environment	Explain how the Five Forces and SWOT methods can be used to analyze the environment in which an insurer operates.
Determining Strategy at Different Organizational Levels	Explain how strategies are developed at the corporate, business, functional, and operational levels.
Insurers Global Expansion	Describe the strategic reasons, considerations, and approaches for insurers to expand their operations globally.
Strategic Management Case Study	Given information about an insurer's business strategies, conduct a SWOT analysis to evaluate its strategy.

Assignment 15: The Underwriting Cycle

MODULE TITLE	LEARNING OBJECTIVE
The Insurance Underwriting Cycle	Describe the phases of the insurance underwriting cycle and the strategies normally used by insurers and producers during each phase.
Financial Factors Influencing the Underwriting Cycle	Explain how the following financial factors influence underwriting cycles • Investment income • Capacity • Return on equity • Cash flow
Effects of Supply and Demand on the Underwriting Cycle	Explain how the theory of demand and supply applies to insurance and the underwriting cycle.

Assignment 16: Actuarial Data Management

MODULE TITLE	LEARNING OBJECTIVE
Data Quality	Summarize • The concepts of data quality and information quality • The impact of data quality on the actuarial work product
Principles of Data Quality	Given a principle of data quality, provide an example that illustrates the principle.
Data Quality—ASOP No. 23	Given a concept from the Actuarial Standard of Practice No. 23, provide an example of its application or use.
Life Cycle for Insurance Data	For each step in the life cycle for insurance data, describe the purpose, the responsible parties, and errors typically encountered.
Metadata	Summarize metadata including: • How metadata are defined • The actuary's role in creating and sharing metadata • How metadata are shared across an organization • The data collected under different statistical plans
The Need for Aggregate Insurance Statistical Data	Explain the regulatory and business needs for statistical data.
Types of Statistical Plans	Summarize the relationship of Statistical Plans to insurance rating elements and the two basic types of Statistical Plans: • Summary-based Statistical Plans • Transaction-based Statistical Plans
Insurance Data Elements: Date Fields and Amount Fields in Statistical Plans	Describe the functions of the date field and amount field data elements in a statistical plan.

Insurance Data Elements: Classification or Rating Variable Fields and Exposure Data Elements	Describe the following statistical plan data elements by line of business: • Classification and Rating Elements • Exposure
Techniques and Applications to Improve Information Quality	Summarize the following data quality analysis concepts: • Exploratory data analysis • Data cubes • Identifying missing data • Descriptive statistics • Box and whisker plots
Auditing Data and the Actuary's Responsibility in Assessing Data Reasonability	Explain the following: • The purpose and steps of data auditing • An actuary's responsibility in assessing data reasonability

Study Materials for CAS Online Course 1

The online course itself contains learning objectives and all the educational material to meet these objectives and successfully complete the exam. The course fee includes one attempt at the exam.

The following printed materials are supplemental and may also be purchased from The Institutes, but are not required:
- **Textbook** contains material that is identical to the online course—only in a hardcopy format.
- **Review Notes** is a condensed version of the textbook.
- **Course Guide** contains sample questions and answers.
- **Flashcards** contain key words and phrases.

The materials described above may be purchased individually or in various package combinations.

Questions about potentially defective questions or material should be directed to The Institutes' Customer Service Department at (800) 644-2101 or (610) 644-2100, extension 6000, or CustomerService@TheInstitutes.org.

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CAS Online Course 1/CA1 is available through The Institutes.

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Exam Results

Candidates taking this computer-based test will receive unofficial pass/fail results at the conclusion of their exam. The unofficial pass/fail result will be displayed on the computer screen at the conclusion of the exam. In most test centers, a printed copy of the candidate's unofficial pass/fail result will be available upon completion of the computer-based test from the proctor in the administrative area outside the testing room. The candidate, however, should carefully read the result that is displayed on the computer screen at the conclusion of the exam.

When the official grades have been processed, candidates will receive an e-mail from The Institutes stating that their grades are available. Candidates may then log into their account on The Institutes Web Site (www.TheInstitutes.org) to access their grades. The grade report for each candidate will show the candidate's overall score on the exam in ten point increments (e.g., 60 to 69%, 70 to 79%, and so on). It will similarly show the candidate's performance by assignment using those same ten point increments.

Numeric scores are not released. Approximately three weeks after the close of the testing window, The Institutes will send a copy of the grades directly to the CAS Office to be added to the candidates' admissions records.

CAS Online Course 2, Third Edition
Insurance Accounting, Coverage Analysis, Insurance Law, and Insurance Regulation

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Notice about the 3rd Edition of CA2 Replacing the 2nd Edition of CA2

3rd Edition: The CA2, 3rd Edition, reflects changes in commercial coverage forms and the addition of a new assignment on life insurance, annuities and health insurance. The 3rd Edition will be available on September 1, 2015. The exams on this content will be offered for the first time on January 15, 2016

2nd Edition: The CA2, 2nd Edition will no longer be sold after August 31, 2015. Candidates who have purchased the 2nd edition will be able to access the course and take the exam on this content through June 15, 2016. (Please note: CAS Candidates have access to the online modules for one year from the date of purchase.)

Insurance Accounting, Coverage Analysis, Insurance Law, and Insurance Regulation is called Online Course 2 by the CAS and CA2, 3rd Edition, by The Institutes. Prometric lists this course as CAS2 on its website under The Institutes.

Online Course 2/CA2 prepares CAS candidates for a two-hour, seventy-five-point, multiple-choice examination. The online course and exam were developed collaboratively with The Institutes. The online course is available through the Casualty Actuarial Society Online Courses Web page on The Institutes' website. Similarly, the exam is administered by The Institutes at Prometric test centers during four, two-month testing windows annually.

The study material for CAS Course 2/CA2 is contained in the online course access. The fee for access to the online course includes one attempt at passing the exam. Candidates are required to purchase the online course to obtain access to the exam. Exam retakes may be purchased separately if needed.

Purchasing the course requires that candidates declare the testing window in which they are planning to take the exam. To register for the exam, a candidate must:

- Call The Institutes at (800) 644-2101 or (610) 644-2100, extension 6000, to register for the exam itself. This will place the candidate on an eligibility list for Prometric.

- Then make an appointment with Prometric for a specific date and time during the testing window. Early registration for the exam is strongly encouraged as seats fill quickly. There is a $110 fee for changing testing windows.

- Schedule your appointment when you know you will be ready to sit for the exam. Prometric will charge a $50 fee to candidates who reschedule their appointments between 3 to 12 business days of a test date. Changes to the appointment date/time are not permitted within 3 business days of the appointment.

Questions or concerns regarding CAS Online Course 2/CA2 should be directed to The Institutes' Customer Service Department at (800) 644-2101 or (610) 644-2100, extension 6000, or CustomerService@TheInstitutes.org.

Assignment 1: Introductory Insurance Accounting

MODULE TITLE	LEARNING OBJECTIVE
Qualitative Accounting Information Criteria	Explain the following qualitative accounting information criteria: • Understandability • Relevance • Reliability • Comparability and consistency • Lack of bias • Cost-benefit effectiveness
Types of Accounting Frameworks	Describe the frameworks and the intended users and focus of each of the following sets of accounting frameworks: • Generally Accepted Accounting Principles (GAAP) accounting • Regulatory/supervisory accounting • Tax accounting • Management accounting
Accounting Frameworks and Rule Hierarchies	Explain the concept of a rule hierarchy and the sources of the following accounting frameworks: • Generally Accepted Accounting Principles (GAAP) • Regulatory/supervisory accounting • Tax accounting
Selected Accounting Concepts	Summarize the following accounting concepts: • Fair value versus historical cost • Recognition versus measurement • Deferral-matching versus asset-liability • Impairment • Revenue recognition • Reporting segment • Liquidation versus going concern • Change in accounting principle versus change in accounting estimate • Principle-based versus rule-based
Fundamentals of Insurer Financial Statements	Describe the purpose and primary components of these key schedules of an insurer's financial statements: • Balance sheet • Income statement • Cash flow statement • Notes and disclosures
Premium Accounting—Revenue Recognition	Explain how and when insurers recognize premium revenue in their financial statements under deferral-matching and asset-liability approaches.

Premium Accounting—Types of Written Premium	Distinguish between the various types of written premium and policy transactions that may not be classified as premium.
Other Premium Accounting Issues	Summarize the implications of these premium accounting issues: • Financing—premiums versus service charges • Earning premium before it is written • Extended reporting endorsements (definite versus indefinite periods) • Reinsurance lags • Large deductible credits
Unearned Premium	Summarize the purpose of unearned premium and these issues associated with how premiums are earned over time: • Pro rata and non-pro rata approaches to earning premium • Multiyear policies • Liability adequacy test and the premium deficiency reserve
The Relationship Between Loss Reserves and the Unearned Premium Reserve	Explain the relationship between loss reserves and the unearned premium reserve.
Loss and Loss Adjustment Expense Accounting	Describe the following issues related to loss and loss adjustment expense (LAE) accounting: • Loss accounts • Loss cycle • Paid loss versus cash payment • Recoverable amounts • Accounting for discounted reserves • Self-insurer issues
Reinsurance Accounting Basics	Explain the accounting and financial reporting considerations, including how values in insurers' financial reports are influenced by lags in the reporting of reinsurance transactions and bordereau reporting, for these types of reinsurance: • Assumed reinsurance • Ceded reinsurance • Commutations • Prospective versus retroactive reinsurance
Deposit Accounting	Explain the conditions under which an accounting framework may require deposit accounting for an insurance contract, and the operation of three general forms of deposit accounting rules.

Assignment 2: Insurance Policy Analysis

MODULE TITLE	LEARNING OBJECTIVE
Distinguishing Characteristics of Insurance Policies	Describe the following characteristics of insurance policies, including common exceptions to these characteristics. • Indemnity • Utmost good faith • Fortuitous losses • Contract of adhesion • Exchange of unequal amounts • Conditional • Nontransferable
Structure of Insurance Policies	Describe these approaches to insurance policy structure and how they can affect policy analysis: • Self-contained and modular policies • Preprinted and manuscript policies • Standard and nonstandard forms • Endorsements and other related documents
Types of Policy Provisions	Describe the purpose(s) and characteristics of each of these types of policy provisions in a property-casualty insurance policy: • Declarations • Definitions • Insuring agreements • Exclusions • Conditions • Miscellaneous provisions
Insurance Policy Analysis	Describe the primary methods of insurance policy analysis.

Assignment 3: Common Policy Concepts

MODULE TITLE	LEARNING OBJECTIVE
Insurable Interest	Given a case, evaluate one or more entities' insurable interests.
Insurance to Value	Explain why insurance to value is important to property insurers, how insurers encourage insurance to value, and what insureds can do to address the problems associated with maintaining insurance to value.
Property Valuation Methods	Explain how property is valued under each of the following valuation methods in property insurance policies: • Actual cash value • Replacement cost • Agreed value • Functional valuation

Valuation of Liability Claims	Explain how the amount payable for a claim covered under a liability insurance policy is determined.
Reasons for Property Deductibles	Explain how deductibles in property insurance benefit the insured.
Liability Deductibles and Self-Insured Retentions	Explain when and why deductibles and self-insured retentions are appropriate for use in liability insurance.
Other Sources Of Recovery	Describe the multiple sources of recovery that may be available to an insurance policyholder for a covered loss.

Assignment 4: Personal Auto Policy: Liability, Medical Payments, and Uninsured Motorist Coverage

MODULE TITLE	LEARNING OBJECTIVE
Overview of the Personal Auto Policy	Summarize the sections of the Personal Auto Policy.
Declarations	Identify the types of information typically contained on the declarations page of a personal auto policy.
Definitions	Define the words and phrases included in the definitions section of the Personal Auto Policy.
Part A - Liability Coverage	Summarize each of the provisions in Part A—Liability Coverage of the Personal Auto Policy.
Part A - Liability Coverage Case	Given a case describing an auto liability claim, determine whether Part A—Liability Coverage of the Personal Auto Policy would cover the claim and, if so, the amount the insurer would pay for the claim.
Part B - Medical Payments Coverage	Summarize each of the provisions in Part B—Medical Payments Coverage of the Personal Auto Policy.
Part B - Medical Payments Coverage Case	Given a case describing an auto medical payments claim, determine whether Part B—Medical Payments Coverage of the Personal Auto Policy would cover the claim and, if so, the amount the insurer would pay for the claim.
Part C - Uninsured Motorists Coverage	Summarize each of the provisions in Part C—Uninsured Motorists Coverage of the Personal Auto Policy.
UM/UIM Endorsements and State Variations	Describe underinsured motorists coverage in terms of: • Its purpose • The ways in which it can vary by state
Part C - Uninsured Motorists Coverage Case	Given a case describing an uninsured motorists claim, determine whether Part C—Uninsured Motorists Coverage of the Personal Auto Policy would cover the claim and, if so, the amount the insurer would pay for the claim.

Assignment 5: Personal Auto Policy: Physical Damage, Duties After an Accident, Endorsements, General Provisions

MODULE TITLE	LEARNING OBJECTIVE
Part D - Damage to Your Auto Coverage	Summarize each of the provisions in Part D—Damage to Your Auto of the Personal Auto Policy.
Part D - Damage to Your Auto Coverage Case	Given a case describing an auto physical damage claim, determine whether Part D—Coverage for Damage to Your Auto of the Personal Auto Policy would cover the claim and, if so, the amount the insurer would pay for the claim.
Part E - Duties After an Accident or Loss	Identify the insured's duties following an auto accident or loss (Part E) covered by the Personal Auto Policy.
Part F - General Provisions	Summarize each of the general provisions in Part F of the Personal Auto Policy.
Common Endorsements to the Personal Auto Policy	Identify the Personal Auto Policy endorsements that are used to handle common auto loss exposures.
Personal Auto Coverage Case	Given a case describing an auto claim, determine whether the Personal Auto Policy would cover the claim and, if so, the amount the insurer would pay for the claim.

Assignment 6: Homeowners Property Coverage

MODULE TITLE	LEARNING OBJECTIVE
ISO Homeowners Program	Describe how individuals and families can use the ISO Homeowners insurance program to address their personal risk management needs.
Homeowners Program Structure	Summarize these aspects of the 2011 Homeowners Program: • Structure of the Homeowners Policy (HO-3) • Key changes in the ISO 2011 Program Revision • Factors important to rating homeowners insurance
HO-3 Section I - Property Coverages	Determine whether the 2011 HO-3 policy provisions in the following Section I - Property Coverages provide coverage for a given loss or loss exposure: • Coverage A - Dwelling • Coverage B - Other Structures • Coverage C - Personal Property • Coverage D - Loss of Use • Additional Coverages
HO-3 Section I - Perils Insured Against and Exclusions	Summarize each of the 2011 HO-3 policy provisions: • Perils Insured Against • Exclusions

HO-3 Section I - Conditions	Summarize each of the 2011 HO-3 policy provisions in Section I - Conditions.
2011 HO-3 Section I - Property Coverage Case	Given a scenario describing a homeowners property claim, determine whether the 2011 HO-3 Policy Section I - Property Coverages would cover the claim, and if so, the amount the insurer would pay for the claim.

Assignment 7: Homeowners Liability, Conditions, Coverage Forms, and Endorsements

MODULE TITLE	LEARNING OBJECTIVE
HO-3 Section II - Liability Coverages	Determine whether the 2011 HO-3 Policy provisions in the following Section II - Liability Coverages provide coverage for a given loss or loss exposure: • Coverage E - Personal Liability • Coverage F - Medical Payments to Others • Additional Coverages
HO-3 Section II - Exclusions	Determine whether one or more exclusions preclude the coverage provided by Section II of the 2011 HO-3 policy provisions in Section II - Exclusions.
HO-3 Section II - Conditions	Summarize each of these 2011 HO-3 policy provisions: • Conditions applicable to Section II • Conditions applicable to Sections I and II
Homeowners Coverage Forms and Causes of Loss Comparison Summary to the HO-3	Compare the coverage provided by each of the following 2011 Homeowners policies to the coverage provided by the 2011 HO-3 policy: • HO-2 Broad Form • HO-5 Comprehensive Form • HO-4 Contents Broad Form • HO-6 Unit-Owners Form • HO-8 Modified Coverage Form
Commonly Used Endorsements that Modify the 2011 ISO Homeowners Policies	Summarize the coverages provided by various 2011 ISO Homeowners policy endorsements.
HO-3 Coverage Case	Given a case describing a homeowners claim, determine whether a 2011 HO-3 Policy that may include one or more endorsements would cover the claim, and, if so, the amount the insurer would pay for the claim.

Assignment 8: Life Insurance, Annuities and Health Insurance

MODULE TITLE	LEARNING OBJECTIVE
Premature Death Loss Exposures	Describe the financial impact of the premature death personal loss exposure on the following types of family structures: • Singles without children • Single-parent families • Two-income families • Traditional families • Blended families • Sandwiched families
Types of Life Insurance	Summarize the various types of life insurance.
Sources of Life Insurance	Summarize the distinguishing characteristics of life insurance provided by each of the following sources: individual life insurance, group life insurance, and government-provided life insurance.
Common Life Insurance Contractual Provisions and Riders	Summarize the common life insurance contractual provisions and riders.
Individual Annuities	Summarize the various types of individual annuities.
Disability and Health-Related Personal Loss Exposures	Describe the financial impact of disability and other health-related personal loss exposures on individuals and families.
Disability Income Insurance	Summarize the distinguishing characteristics of each of the following types of disability income insurance: • Individual disability income insurance • Group disability income insurance • Social Security disability income program
Health Insurance Plans	Describe the characteristics of the following nongovernment programs for providing healthcare benefits: • Traditional health insurance plans • Managed-care plans • Consumer-directed health plans

Assignment 9: Commercial Property Insurance, Part I

MODULE TITLE	LEARNING OBJECTIVE
Overview of the Commercial Property Insurance	Describe commercial property insurance in terms of these elements: • The major categories of loss exposures that can be covered • The components of a commercial property coverage part

BPP Covered Property	Determine whether a described item of property qualifies as Covered Property under one or more of these categories in the Building and Personal Property Coverage Form: • Building • Your Business Personal Property • Personal Property of Others
BPP Additional Coverages and Coverage Extensions	Determine which of the additional coverages and coverage extensions of the Building and Personal Property Coverage Form apply to a described loss.
Causes of Loss—Basic Form and Broad Form	Determine whether the cause of a described loss is a covered cause of loss under either the Causes of Loss—Basic Form or the Causes of Loss—Broad Form.
Cause of Loss—Special Form	Determine whether the cause of a described loss is a Covered Cause of Loss under the Causes of Loss—Special Form.
BPP Limits of Insurance and Deductibles	Apply the Limits of Insurance and Deductible provisions of the Building and Personal Property Coverage Form to a described loss.

Assignment 10: Commercial Property Insurance, Part ll

MODULE TITLE	LEARNING OBJECTIVE
BPP Loss Conditions and Additional Conditions	Explain how each of the Loss Conditions and Additional Conditions affects coverage under the Building and Personal Property Coverage Form.
BPP: Optional Coverages	Explain how each of the following optional coverages described in the BPP modifies the basic coverage of the BPP: • Agreed Value • Inflation Guard • Replacement Cost • Extension of Replacement Cost to Personal Property of Others
Commercial Property Conditions	Summarize each of the Commercial Property Conditions.
Common Policy Conditions	Explain how each of the conditions contained in the Common Policy Conditions affects coverage under a commercial property coverage part.
Commercial Property Endorsements	Explain how each of these documents modifies the Building and Personal Property Coverage Form: • Ordinance or Law Coverage endorsement • Spoilage Coverage endorsement • Flood Coverage endorsement • Earthquake and Volcanic Eruption Coverage endorsement • Peak Season Limit of Insurance endorsement • Value Reporting Form

Factors Affecting Commercial Property Premiums	Identify the factors that affect commercial property insurance premiums
Determining Whether the BPP Covers a Loss	Given a case, determine whether, and for what amount, a described loss would be covered by a commercial property coverage part that includes the Building and Personal Property Coverage Form and any of the three causes of loss forms.

Assignment 11: Commercial General Liability Insurance, Part l

MODULE TITLE	LEARNING OBJECTIVE
Overview of Commercial General Liability Insurance	Describe commercial general liability insurance in terms of these elements: • The types of losses that can be covered by general liability insurance • The components of a commercial general liability coverage part
CGL Coverage A—Insuring Agreement	Determine whether a described claim meets the conditions imposed by the Coverage A insuring agreement of the Commercial General Liability Coverage Form (occurrence version).
CGL Coverage A—Exclusions	Determine whether any of the exclusions applicable to Coverage A of the Commercial General Liability Coverage Form eliminate coverage for a described claim.
CGL Coverage B—Personal and Advertising Injury Liability	Determine whether a described claim meets the conditions imposed by the Coverage B insuring agreement of the Commercial General Liability Coverage Form and whether any of the Coverage B exclusions eliminate coverage for the claim.
CGL Coverage C—Medical Payments	Determine whether a described claim meets the conditions imposed by the Coverage C insuring agreement of the Commercial General Liability Coverage Form, and whether any of the Coverage C exclusions eliminate coverage for the claim.
CGL Supplementary Payments	Summarize the supplementary payments of the Commercial General Liability Coverage Form.

Assignment 12: Commercial General Liability Insurance, Part ll

MODULE TITLE	LEARNING OBJECTIVE
CGL Who Is an Insured Provisions	Determine whether a described person organization is an insured under the Commercial General Liability Coverage Form.
CGL Limits of Insurance	Explain how the following limits of insurance in the CGL Coverage Form are applied: • Each occurrence limit • Personal and advertising injury limit • Damage to premises rented to you limit • Medical expense limit • General aggregate limit • Products-completed operations aggregate limit
CGL Conditions	Apply the Commercial General Liability Conditions to claims or other interactions between the insurer and the insured.
Rating CGL Coverage	Explain how the premium for CGL coverage is determined.
Determining Whether the CGL Covers a Claim Case	Given a case, determine whether, and for what amount, the Commercial General Liability Coverage Form (occurrence version) covers a described claim.

Assignment 13: Specialty Coverages

MODULE TITLE	LEARNING OBJECTIVE
Commercial Excess and Umbrella Liability Insurance	Describe commercial excess liability insurance and commercial umbrella liability insurance in terms of these characteristics: • The three basic types of commercial excess liability insurance • The provisions commonly found in commercial umbrella liability policies that distinguish them from other types of commercial liability policies
Professional Liability and Management Liability Insurance	Describe professional liability insurance and management liability insurance in terms of these aspects: • How they differ from each other • How they differ from commercial general liability policies • The common types of professional and management liability policies

MODULE TITLE	LEARNING OBJECTIVE
Environmental Insurance	Describe the purpose and characteristics of each of these types of environmental insurance policies: • Site-specific environmental impairment liability (EIL) policies • Underground storage tank compliance policies • Remediation stop-loss policies • Contractors pollution liability policies • Environmental professional errors and omissions liability policies
Aircraft Insurance	Describe aircraft insurance in terms of these characteristics: • The purposes-of-use categories that insurers used to classify aircraft • The coverages that can be included in an aircraft policy
Cyber Risk Insurance	Describe the types of losses that can be covered by each of the insuring agreements generally available in cyber risk insurance policies.
Insuring Foreign Operations	Explain how an organization domiciled in the United States can insure foreign loss exposures that would not be covered under standard property and liability insurance policies.
Terrorism Endorsements for Commercial Property and Liability Forms	Summarize the purpose and provisions of the terrorism endorsements developed by Insurance Services Office, Inc., and the National Council on Compensation Insurance, Inc.
Types of Surety Bonds	Summarize the guarantee provided by the particular types of surety bonds within the following bond classifications: • Contract bonds • License and permit bonds • Public official bonds • Court bonds • Miscellaneous bonds

Assignment 14: Insurance Law, Part I

MODULE TITLE	LEARNING OBJECTIVE
Tort Law	Explain these concepts: • Tort as distinguished from other offenses • Classifications of tort • Application of laws in tort cases
Negligence	Describe negligence claims in terms of: • The elements of negligence • The required proof of negligence
Defenses Against Negligence Claims	Describe these defenses against negligence claims: Comparative negligence, releases and exculpatory clauses, immunity, statutes of limitations and repose, tortfeasor's capacity.
Liability of Landowners or Occupiers of Land	Explain how negligence applies to landowners or occupiers of land.

Intentional Torts Part 1 of 2	Describe these intentional torts, the circumstances under which they can occur, and common defenses to them: • Battery • Assault • False imprisonment and false arrest • Intentional infliction of emotional distress • Defamation (libel and slander) • Invasion of the right of privacy
Intentional Torts Part 2 of 2	Describe these intentional torts, the circumstances under which they can occur, and common defenses to them: • Fraud • Bad faith, or outrage • Interference with relationships between others • Misuse of legal process • Trespass • Nuisance • Conversion
Liability in Extraordinary Circumstances	Explain how liability attaches as a result of the unique circumstances presented by the following: • Ultrahazardous activities • Ownership and/or possession of animals • Escape of toxic substances

Assignment 15: Insurance Law, Part ll

MODULE TITLE	LEARNING OBJECTIVE
Products Liability	Describe these causes of action for products liability and the possible defenses to them: • Misrepresentation • Breach of warranty • Strict liability and negligence
Professional Liability	Describe professional and directors and officers liability.
Damages in Tort Suits	Describe the types of damages a court can award a plaintiff for a tort claim.
Equitable Remedies	Explain these equitable remedies: • Specific performance • Injunction
Factors Affecting Amounts and Payment of Damages	Summarize these legal concepts related to negligence damages and remedies: • *Restitutio in integrum* • Mitigation of damages • Aggravated damages • Structured settlements and judgments

Liability Concepts Affecting Tort Claims	Explain how any of these concepts can affect a tort claim: • Joint tortfeasor's liability • Expanded liability concepts • Vicarious liability • Good Samaritan issues • Class actions
Trends in Tort Litigation	Summarize these trends in tort litigation: • Class action litigation • Litigation funding • Punitive damages • Tort reform

Assignment 16: Insurance Regulation

MODULE TITLE	LEARNING OBJECTIVE
Economic Impact of the Insurance Industry	Explain the economic impact of the insurance industry.
The Objectives of Insurance Regulation	Describe the objectives of insurance regulation.
The Sources of Insurance Regulation	Describe the three sources from which insurance regulatory powers originate: • Legislation • Judicial review • Administrative agencies
The Structure of Insurance Regulations	Describe the structure of insurance regulations.
Elements of Rate Regulation and Ratemaking	Describe the following elements of rate regulation and ratemaking: • Purpose and unique qualities of the insurance industry • Actuarial ratemaking principles and considerations in rate regulation • Insurance advisory organizations
Types of Rate Regulations	Compare the following types of rate regulation: • Prior approval • File and use • Use and file • Open competition • Flex rating • Government-mandated rates
Effects of Rate Regulation on Insurers	Summarize the effects of rate regulation on these aspects of insurance: • Resources required for complying with rate regulations • The underwriting cycle • Insurers' decision making regarding where to operate

Study Materials for CAS Online Course 2

The online course itself contains learning objectives and all the educational material to meet these objectives and successfully complete the exam. The course fee includes one attempt at the exam.

The following printed materials are supplemental and may also be purchased from The Institutes, but are not required:
- **Textbook** contains material that is identical to the online course—only in a hardcopy format.
- **Review Notes** is a condensed version of the textbook.
- **Course Guide** contains sample questions and answers.
- **Flashcards** contain key words and phrases.

The materials described above may be purchased individually or in various package combinations.

Questions about potentially defective questions or material should be directed to The Institutes' Customer Service Department at (800) 644-2101 or (610) 644-2100, extension 6000, or CustomerService@TheInstitutes.org.

Publisher and Distributor

CAS Online Course 2/CA2, 3rd Edition is available through The Institutes.

> The Institutes, 720 Providence Road, Suite 100, Malvern, PA 19355-3433; telephone: (800) 644-2101 or (610) 644-2100 extension 6000; e-mail: CustomerService@TheInstitutes.org; Web page for CAS Online Courses: www.aicpcu.org/cas.htm.

Exam Results

Candidates taking this computer-based test will receive unofficial pass/fail results at the conclusion of their exam. The unofficial pass/fail result will be displayed on the computer screen at the conclusion of the exam. In most test centers, a printed copy of the candidate's unofficial pass/fail result will be available upon completion of the computer-based test from the proctor in the administrative area outside the testing room. The candidate, however, should carefully read the result that is displayed on the computer screen at the conclusion of the exam.

When the official grades have been processed, candidates will receive an e-mail from The Institutes stating that their grades are available. Candidates may then log into their account on The Institutes website (www.TheInstitutes.org) to access their grades. The grade report for each candidate will show the candidate's overall score on the exam in ten point increments (e.g., 60 to 69%, 70 to 79%, and so on). It will similarly show the candidate's performance by assignment using those same ten point increments. Numeric scores are not released. Approximately three weeks after the close of the testing window, The Institutes will send a copy of the grades directly to the CAS Office to be added to the candidates' admissions records.

2015 Exam 5 Syllabus
Basic Techniques for Ratemaking and Estimating Claim Liabilities

The syllabus for this four-hour exam is defined in the form of learning objectives, knowledge statements, and readings.

LEARNING OBJECTIVES set forth, usually in broad terms, what the candidate should be able to do in actual practice. Included in these learning objectives are certain methodologies that may not be possible to perform on an examination, such as complex simulations, but that the candidate would still be expected to explain conceptually in the context of an examination.

KNOWLEDGE STATEMENTS identify some of the key terms, concepts, and methods that are associated with each learning objective. These knowledge statements are not intended to represent an exhaustive list of topics that may be tested, but they are illustrative of the scope of each learning objective.

READINGS support the learning objectives. It is intended that the readings, in conjunction with the material on the lower numbered examinations, provide sufficient resources to allow the candidate to perform the learning objectives. Some readings are cited for more than one learning objective. The Syllabus and Examination Committees emphasize that candidates are expected to use the readings cited in this *Syllabus* as their primary study materials.

Thus, the learning objectives, knowledge statements, and readings complement each other. The learning objectives define the behaviors, the knowledge statements illustrate more fully the intended scope of the learning objectives, and the readings provide the source material to achieve the learning objectives. Learning objectives should not be seen as independent units, but as building blocks for the understanding and integration of important competencies that the candidate will be able to demonstrate.

Note that the range of weights shown should be viewed as a guideline only. There is no intent that they be strictly adhered to on any given examination—the actual weight may fall outside the published range on any particular examination.

The overall section weights should be viewed as having more significance than the weights for the individual learning objectives. Over a number of years of examinations, absent changes, it is likely that the average of the weights for each individual overall section will be in the vicinity of the guideline weight. For the weights of individual learning objectives, such convergence is less likely. On a given examination, in which it is very possible that not every individual learning objective will be tested, there will be more divergence of guideline weights and actual weights. Questions on a given learning objective may be drawn from any of the listed readings, or a combination of the readings. There may be no questions from one or more readings on a particular exam.

After each set of learning objectives, the readings are listed in abbreviated form. Complete text references are provided at the end of this exam syllabus.

Items marked with a bold **SK** constitute the 2015 CAS Exam 5 Study Kit that may be purchased from the CAS Online Store. Items marked with a bold **OP** (Online Publication) are available at no charge and may be downloaded from the CAS website.

Please check the "*Syllabus* Updates" section of the CAS Website for any changes to the *Syllabus*.

A. Basic Techniques for Ratemaking

Range of weight for Section A: 50-60 percent

This section introduces the general principles of ratemaking as well as specific details regarding data requirements, calculations, key assumptions, and implementation-related issues. Candidates require a thorough understanding of basic ratemaking so that they will be able to analyze data, select appropriate techniques, and develop solutions to problems. This section addresses the advantages and disadvantages of the various ratemaking techniques as they are applied to specific situations and different lines of business. Classification of insureds for the purpose of risk stratification and other important ratemaking topics, such as coinsurance and catastrophe provisions, are also examined in this section.

Candidates are also expected to be knowledgeable in the calculation of policy premiums using manual rate pages. Excerpts from the ISO Personal Automobile Manual will be provided with the examination. Candidates are not required to memorize the details, but will be expected to be able to use them during the examination. Since they will be included with the examination, candidates will not be allowed to bring copies of the documents into the examination room.

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
1. Calculate a policy premium for a specified risk using the rate pages provided. Range of weight: 0-3 percent	a. How to read and use manual rate pages
READINGS	
ISO PAM Werner & Modlin, Chapter 2	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
2. Describe, analyze, or design the information requirements for ratemaking related to exposures and demonstrate the use of exposures in ratemaking. Range of weight: 2-6 percent	a. Definition of exposure base b. Characteristics of exposure bases c. Relationship of exposures to coverage provisions d. Organization of data: calendar year, policy year, accident year e. Written exposure versus earned exposure versus in-force exposure f. Role of exposures in the ratemaking process g. Influence of changes in exposures
READINGS	
Werner & Modlin, Chapters 1- 4	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
3. Describe, analyze, or design the information requirements for ratemaking related to premiums and demonstrate the use of premiums in ratemaking. Range of weight: 4-8 percent	a. Organization of data: calendar year, policy year, accident year b. Written premium versus earned premium versus in-force premium c. Relationship between earned premium and earned exposure d. Policy terms e. Effect of law changes f. Effect of rate changes g. Determinations of and application of premium trend h. Adjustment for coverage and benefit level changes i. Distributional shifts and changes in volume (i.e., trend over time) j. Parallelogram method k. Extension of exposures
READINGS	
ASOP 13 Werner & Modlin, Chapters 1-3, 5, and Appendices A-D	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS

4. Describe, analyze, or design the information requirements for ratemaking related to loss and loss adjustment expenses and demonstrate the use of loss and loss adjustment expenses in ratemaking.
 	
Range of weight: 8-12 percent
	a. Organization of the data: calendar year, policy year, accident year, report year
	b. Policy provisions
	c. Occurrence coverage
	d. Claims-made coverage:
	  • report lag
	  • coverage triggers
	  • principles of claims-made policies
	  • retroactive date
	  • tail coverage
	e. Reported losses versus paid losses
	f. Claim counts
	g. Loss adjustment expense (allocated and unallocated expenses)
	h. Loss development
	i. Frequency trend
	j. Severity trend
	k. Pure premium trend
	l. Approaches to determining trend (e.g., exponential and linear analyses)
	m. Relationship between trend and loss development
	n. Effect of law changes
	o. Effect of changes in mix of business
	p. Adjustment for coverage and benefit level changes
	q. Credibility criteria and formulae
	r. Large loss adjustment

	s. Reinsurance recoveries
	t. Reinsurance costs
	u. Catastrophe adjustment

READINGS
ASOP 13
Werner & Modlin, Chapters 1, 3, 6, 12, 16, and Appendices A-D

LEARNING OBJECTIVES	**KNOWLEDGE STATEMENTS**
5. Calculate the underwriting expense provisions underlying the overall rate level indication. Range of weight: 0-5 percent	a. Expense categories (e.g., commission, general, other acquisition, taxes, licenses, and fees) b. Sources of data and selection criteria c. Profit and contingency provisions d. Net cost of reinsurance e. Cost of capital f. Fixed expenses and variable expenses g. Differences in procedures for loss adjustment expenses versus underwriting expenses

READINGS
Werner & Modlin, Chapters 1, 7, and Appendices A-D

LEARNING OBJECTIVES	**KNOWLEDGE STATEMENTS**
6. Calculate the overall rate level indication using the pure premium and loss ratio methods and argue the merits of each. Range of weight: 3-6 percent	a. Statement of Principles, CAS b. Assumptions of each method c. Mechanics associated with each method (including organization of the data) d. When each method works and when it does not

READINGS
CAS Principles
Werner & Modlin, Chapters 1, 8, and Appendices A-D

LEARNING OBJECTIVES	**KNOWLEDGE STATEMENTS**
7. Describe, analyze, and validate the considerations beyond the calculated cost-based estimate of the rate when selecting a final rate change to implement. Range of weight: 0-5 percent	a. Calculated cost-based rate b. Regulatory constraints c. Operational constraints d. Marketing constraints: • Competitive comparisons • Close ratios • Retention ratios • Growth • Distributional analysis • Policyholder dislocation analysis e. Lifetime value analysis f. Optimized pricing g. Underwriting cycles

READINGS
Werner & Modlin, Chapter 13

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
8. Explain the purpose for segregating data into homogeneous groups and summarize the considerations for determining such groups. Range of weight: 0-5 percent	a. Risk Classification Statement of Principles, AAA b. Criteria for selection of classification grouping c. Credibility d. Adverse Selection e. Efficiency of class plan
READINGS	
AAA Werner & Modlin, Chapter 9	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
9. Develop rating differentials for classification and territory and relativities for deductibles and increased limits. Range of weight: 8-12 percent	a. Formulae and process for each rating differential or relativity b. Credibility and complements of credibility c. Off balance d. Capping of change e. Loss elimination f. Basic limits versus total limits g. Layers of loss h. Expense adjustments i. Fundamentals of univariate and multivariate relativity analyses
READINGS	
Werner & Modlin, Chapters 9-12, 15 and Appendices E-F	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
10. Assess the considerations for implementing rates to achieve an organization's goals. Range of weight: 0-3 percent	a. Rating algorithms b. Rating variables and differentials c. Fixed expenses, if applicable d. Expense fee calculation e. Calculation of final base rates f. Minimum premiums g. Non-pricing solutions
READINGS	
Werner & Modlin, Chapter 14	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
11. Calculate premium for policies with coinsurance provisions. Range of weight: 0-5 percent	a. Definition of coinsurance b. Insurance to value c. Common policy provisions d. Layers of loss e. Coverage issues f. Guaranteed replacement cost g. Formula
READINGS	
Werner & Modlin, Chapter 11	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
12. Perform basic individual risk rating calculations. Range of weight: 0-5 percent	a. Purpose of individual risk rating b. Schedule rating c. Manual rating d. Retrospective rating e. Experience modification f. Composite loss-rated risks g. Formulae h. Experience period i. Credibility j. Layers of loss
READINGS	
Werner & Modlin, Chapter 15	

B. Estimating Claim Liabilities

Range of weight for Section B: 40-50 percent

This section explores basic techniques that actuaries use to estimate unpaid claims for both insurance entities and also for non-insurance entities that retain risk. The CAS Principles and the American Academy of Actuaries' Standards of Practice related to the estimation of unpaid claims are also examined in this section.

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
1. Describe, analyze, and validate the information requirements for estimating unpaid claims. Range of weight: 2-6 percent	a. Types of data and their sources b. Role of homogeneity and credibility of data in the process of estimating unpaid claims c. Fundamentals of different types of insurance (e.g., long tail versus short tail lines of business, low frequency versus high frequency lines) d. Organization of data: calendar year, accident year, policy year, underwriting year, report year e. Insurer's environment f. Importance of accurate estimates of unpaid claims
READINGS	
Friedland, Chapters 1, 3, and 4, and Appendices A and B	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS

2. Build and analyze claim development triangles.
 	
Range of weight: 2-6 percent
	a. Purposes of the development triangle
	b. Development triangle as a diagnostic tool
	c. Examples and uses of diagnostic development triangles:
	  • Claim and claim count
	  • Ratio of premium to claims
	  • Average values
	  • Ratios of claims and counts

READINGS	
Friedland, Chapters 5 and 6	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
3. Construct and appraise unpaid claims estimates using each of the following estimation techniques: • Development technique, including case outstanding technique • Expected claim technique • Bornhuetter-Ferguson technique • Cape Cod technique • Frequency-Severity techniques Range of weight: 12-16 percent	a. Standards of Practice, ASOP 43 b. Statement of Principles, CAS c. The claim process d. Assumptions of each estimation technique e. Mechanics associated with each technique (including organization of the data) f. Reporting and payment patterns g. When each techniques works and when it does not h. Key terms: case outstanding, paid claims, reported claims, incurred but not reported, ultimate claims, claims related expenses, reported and closed claim counts, claim counts closed with no payment, insurance recoverables, exposures, experience period, maturity or age, and components of unpaid claim estimates

READINGS
Friedland, Chapters 1-12, 15, and Appendices A-B

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
4. Assess the influence of operating changes on the estimation of unpaid claims. Range of weight: 0-5 percent	a. How internal operating changes affect estimates of unpaid claims: • Claims processing • Underwriting and policy provisions • Marketing • Coding of claim counts and/or claim related expenses • Treatment of recoveries such as policyholder deductibles and salvage and subrogation • Reinsurance

READINGS
Friedland, Part 3 (Chapters 6-15)

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
5. Adjust data and/or estimation techniques for changes in the: • Internal environment (e.g., claims processes that result in shift in the adequacy of case outstanding or shift in settlement rates, change in mix of business, change in rate level) • External environment (e.g., inflationary or legal environment) Range of weight: 3-7 percent	a. Effect on estimation techniques due to change in: rate levels, claim ratio, mix of business b. Use of trend factors and tort reform factors in estimation techniques c. Identification of changes in case outstanding adequacy d. Adjustment for changes in case outstanding adequacy e. Identification of changes in rate of claims settlement f. Adjustment for changes in rate of claims settlement

READINGS
Friedland, Chapters 7 -14

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
6. Estimate recoveries. Range of weight: 0-5 percent	a. Salvage and subrogation b. Reinsurance c. Key assumptions of estimation techniques

READINGS
Friedland, Chapter 14

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
7. Estimate unpaid claim adjustment expenses. Range of weight: 2-7 percent	a. Organization of the data b. Estimation of unpaid ALAE c. Estimation of unpaid ULAE d. Key assumptions of estimation techniques e. Strengths and weaknesses of the estimation techniques for claim related expenses

READINGS
Friedland, Chapters 1, 3, 16, and 17

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
8. Appraise and validate the results of the estimation process for adequacy and reasonableness. Range of weight: 4-8 percent	a. Components of evaluation: • Multiple methods • Explanation of differences • Test statistics (e.g., claim ratios, severities, pure premiums, frequencies, indicated unpaid claims) b. Monitoring and interim valuations

READINGS
Friedland, Chapter 15

Complete Text References for Exam 5

Text references are alphabetized by the citation column.

Citation	Abbreviation	Learning Objective	Source
Actuarial Standards Board of the American Academy of Actuaries, "Actuarial Standard of Practice No. 13, Trending Procedures in Property/Casualty Insurance Ratemaking."	ASOP 13	A3, A4	**OP**
American Academy of Actuaries Committee on Risk Classification, "Risk Classification Statement of Principles," June 1980. (Available at no charge from the American Academy of Actuaries at (202) 223-8196 or on the Academy's Website at www.actuary.org.)	AAA	A8	**OP**
Casualty Actuarial Society Committee on Ratemaking Principles, *Statement of Principles Regarding Property and Casualty Insurance Ratemaking*, Casualty Actuarial Society, May 1988.	CAS Principles	A6	**OP**
Friedland, J.F., *Estimating Unpaid Claims Using Basic Techniques*, Casualty Actuarial Society, Third Version, July 2010. Appendices A and B are integral parts of this reading.	Friedland	B1-B8	**OP**
Insurance Services Office, Inc., Personal Automobile Manual (Effective 6-98), General Rules 1-6 only. The entire manual is included for completeness.	ISO PAM	A1	**SK**
Werner, G, and Modlin, C., *Basic Ratemaking*, Casualty Actuarial Society, Fourth Edition, October 2010. [The Appendices are an integral part of the textbook and will be used for creating questions.]	Werner & Modlin	A1-A12	**OP**

Source Key

OP All text references marked as Online Publications will be available on a web page titled Complete Text References.

SK Material in the 2015 CAS Study Kit.

Items printed in red indicate an update, clarification, or change.

Publishers and Distributors

Contact information is furnished for those who wish to purchase the text references cited for Exam 5. Publishers and distributors are independent and listed for the convenience of candidates; inclusion does not constitute endorsement by the CAS.

Actex Publications (Mad River Books), 107 Groppo Drive, Suite A, P.O. Box 974, Winsted, CT 06098; telephone: (800) 282-2839 or (860) 379-5470; fax: (860) 738-3152; e-mail: retail@actexmadriver.com; Website: www.actexmadriver.com.

Actuarial Bookstore, P.O. Box 69, Greenland, NH 03840; telephone: (800) 582-9672 (U.S. only) or (603) 430-1252; fax: (603) 430-1258; Website: www.actuarialbookstore.com.

Actuarial Standards Board, American Academy of Actuaries, 475 N. Martingale Road, Suite 600, Schaumburg, IL 60173; telephone: (847) 706-3513; fax: (847) 706-3599.

Casualty Actuarial Society, 4350 N. Fairfax Drive, Suite 250, Arlington, VA 22203; telephone: (703) 276-3100; fax: (703) 276-3108; e-mail: office@casact.org; Website: www.casact.org.

SlideRule Books, P.O. Box 69, Greenland, NH 03840; telephone: (877) 407-5433 or (603) 373-6140; fax: (877) 417-5433 or (603) 430-1258; Website: www.sliderulebooks.com.

Fall 2015 Exam 6-Canada Syllabus
Regulation and Financial Reporting (Nation Specific)

The syllabus for this four-hour exam is defined in the form of learning objectives, knowledge statements, and readings.

LEARNING OBJECTIVES set forth, usually in broad terms, what the candidate should be able to do in actual practice. Included in these learning objectives are certain ones that may not be possible to perform on an examination, such as complex simulations, but that the candidate would still be expected to explain in the context of an examination.

KNOWLEDGE STATEMENTS identify some of the key terms, concepts, and methods that are associated with each learning objective. These knowledge statements are not intended to represent an exhaustive list of topics that may be tested, but they are illustrative of the scope of each learning objective.

READINGS support the learning objectives. It is intended that the readings, in conjunction with the material on the lower numbered examinations, provide sufficient resources to allow the candidate to perform the learning objectives. Some readings are cited for more than one learning objective. The Syllabus and Examination Committees emphasize that candidates are expected to use the readings cited in this *Syllabus* as their primary study materials.

Thus, the learning objectives, knowledge statements, and readings complement each other. The learning objectives define the purpose, the knowledge statements illustrate more fully the intended scope of the learning objectives, and the readings provide the source material to achieve the learning objectives. Learning objectives should not be seen as independent units, but as building blocks for the understanding and integration of important competencies that the candidate will be able to demonstrate.

Note that the range of weights shown should be viewed as a guideline only. There is no intent that they be strictly adhered to on any given examination—the actual weight may fall outside the published range on any particular examination.

The overall section weights should be viewed as having more significance than the weights for the individual learning objective. Over a number of years of examinations, absent changes, it is likely that the average of the weights for each individual overall section will be in the vicinity of the guideline weight. For the weights of individual learning objective, such convergence is less likely. On a given examination, in which it is very possible that not every individual learning objective will be tested, there will be more divergence of guideline weights and actual weights. Questions on a given learning objective may be drawn from any of the listed readings, or a combination of the readings. There may be no questions from one or more readings on a particular exam.

After each set of learning objectives, the readings are listed in abbreviated form. Complete text references are provided at the end of this exam syllabus.

In addition, this exam assumes that the candidate has completed Online Course 2. Online Course 2 contains fundamental background material for both Section A (Regulation of Insurance and Canadian Insurance Law) and Section C (Financial Reporting and Solvency).

Items marked with a bold **SK** or **SKU** constitute the Fall 2015 Exam 6-Canada Study Kit that may be purchased from the CAS Online Store. The Fall 2015 Update to the Spring 2015 Study Kit includes only the new items marked with a bold **SKU**; the Update may be purchased from the CAS Online Store. Items marked with a bold **OP** (Online Publication) are available at no charge and may be downloaded from the CAS website.

Please check the "*Syllabus* Updates" section of the CAS Web Site for any changes to the *Syllabus*.

The inherent nature of the material addressed in this nation-specific exam makes it subject to continual development and change. It is expected that the candidates will respond to exam questions based on the current syllabus presented below. Recognizing the changing nature of law, regulation, and financial reporting requirements, however, the Examination Committee will strive to acknowledge candidates who also respond with the current state in their solutions to examination questions.

A. Regulation of Insurance and Canadian Insurance Law

Range of weight for Section A: 15-20 percent

Candidates should understand the role of the insurance business as a supplier of a vital service. Because of the essential and highly technical nature of insurance, a system of regulatory controls has been established requiring insurers to demonstrate that they are providing fair and reliable services in accordance with the statutes and regulations of each jurisdiction.

The material in this section encompasses Canadian and U.S. insurance legislation and regulations including their historical development. Judicial decisions affect insurance regulation and insurance benefits to the extent they interpret the law and thereby modify regulatory behavior. Candidates are presented with a number of Canadian cases that have contributed to the development of legal precedents in the area of insurance.

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
1. Describe the historical development of insurance legislation and regulations, including the division of responsibility between federal and provincial/state regulators. Range of weight: 2-6 percent	a. British North America Act b. Privy Council c. Federal and provincial regulation of insurance d. Office of the Superintendent of Financial Institutions e. Foreign and provincial insurance companies f. Nature of Canadian insurance regulations g. History of U.S. insurance regulation

READINGS
Baer and Rendall
KPMG PACICC
Mayhall
McDonald
Noonan

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
2. Discuss the current state of insurance regulation in Canada. Range of weight: 5-10 percent	a. Motor vehicle injury compensation systems b. Rate regulation in Canada and its effects c. Examples of Canadian automobile rate filing requirements d. Reforms in Ontario automobile insurance e. Use of credit scoring in ratemaking and underwriting practices f. Market conduct g. Solvency h. Corporate Governance

READINGS

AAA Credit Scores
Alberta
CIA CSOP (Ratemaking, Section 2600)
FSCO Private Auto
FSCO Reforms
FSCO Reg. 664
FSCO UBI
IBC Code of Conduct
KPMG et al.
KPMG PACICC
KPMG Regulatory Oversight
OSFI Corporate Governance
OSFI Supervisory Framework

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS

3. Discuss the issues, outcome, rationale and implications of landmark decisions for the insurance industry.
 	
Range of weight: 5-10 percent
	a. Specific landmark court decisions cited in the Readings section
	b. Canadian cap for non-pecuniary general damages
	   1. Trilogy of Supreme Court of Canada decisions
	   2. Limits on damages
	   3. Current state of cap
	   4. Exceptions to cap

READINGS

Baer and Rendall
BC Credit
Davidson
Landmark Legal
McDonald

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
4. Describe the litigation environment with respect to insurance. Range of weight: 2-6 percent	a. Trends in tort litigation, including tort reform and class action suits b. Mass torts (e.g., asbestos) c. Types of litigation costs d. Canadian litigation system vs. other systems

READINGS
AAA Mass Torts ATRA Harris KPMG et al. Rand Asbestos

B. Government and Industry Insurance Programs

Range of weight for Section B: 15-20 percent

This section focuses primarily on the identification of major Canadian insurance programs administered by government agencies and insurance industry organizations. The candidates are expected to have an understanding of the objectives, operations, and effectiveness of the following programs:

- Flood insurance
- Agricultural Insurance
- Employment insurance
- Health care insurance
- Residual personal insurance markets (e.g., auto, property)
- Workers compensation insurance
- Pension plans
- Guaranty funds including the Canadian Property and Casualty Insurance Compensation Corporation ("PACCIC")
- Terrorism Risk Insurance

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
1. Describe the origin and purpose of specific government and insurance industry programs. Range of weight: 5-7 percent	a. Reason for inception b. Major historical developments c. Philosophy of program
2. Describe the operations and risk transfer process for each government and insurance industry program listed in the introduction to Section B and their interactions with the voluntary private insurance sector. Range of weight: 5-7 percent	a. Funding mechanisms and sources of funding b. Allocation/assignment of exposures and associated costs c. Automobile residual market participation ratios d. Eligibility provisions e. Claim settlement and insurance coverage provisions f. Welfare (subsidization) versus insurance principles g. Private response to gap in government program h. Government response to gap in private program

3. Evaluate the effectiveness of a government and insurance industry program (actual, as listed in the introduction to Section B, or hypothetical).
Range of weight: 5-7 percent
	a. How to measure performance of programs:
	    • Solvency
	    • Efficiencies
	    • Stability
	    • Viability and long term prospects
	b. How well program meets its purpose
	c. Effect of external factors (e.g., economic conditions, weather, regulation, etc.)

READINGS

Agricultural Programs
CAS
Dibra and Leadbetter
Dutil
KPMG et al.
Morneau Shepell
PACICC
Swiss Re
Webel

C. Financial Reporting and Solvency

Range of weight for Section C: 55-60 percent

This section addresses financial reporting and solvency issues. The intent is to address Canadian and global issues related to the reporting of financial results for property and casualty insurers. The core of the syllabus focuses on Canadian issues with an overview of relevant differences in other countries.

Candidates should have detailed knowledge of the contents, purposes, and recent changes in the Canadian Annual Return, including recent guidelines issued by the Office of the Superintendent of Financial Institutions (OSFI) and the provincial regulatory authorities. Specifically, candidates are expected to be knowledgeable of the sections of the Canadian Annual Return related to financial statements (such as the balance sheet and income statement), capital statements, insurance, and reinsurance.

This section is complemented by readings on solvency monitoring systems such as the Minimum Capital Test (MCT), Dynamic Capital Adequacy Testing (DCAT), and ORSA.

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
1. Describe the elements and prepare the schedules of the Canadian Annual Return. Range of weight: 25-35 percent	a. OSFI Annual Return b. Valuation of policy liabilities in accordance with accepted actuarial practice in Canada c. Reinsurance accounting issues including risk transfer and effect of different types of reinsurance on financial statements. d. Commutation e. Calculation of excess (deficiency) ratio of net claim liabilities f. Calculation of Earthquake Reserves

READINGS
Blanchard and Klann
CCIR Instructions
CAS Financial Reporting
CIA Accounting Standards
CIA CSOP
CIA Disclosure
CIA Discounting
CIA Materiality
CIA MfAD
CIA Premium Liabilities
CIA Reinsurance Treatment
CIA Runoff
CIA Subsequent Events
CIA Taxes
CIA Valuation
Freihaut and Vendetti
IFRS 4
OSFI Annual Return I
OSFI Annual Return II
OSFI Earthquake
OSFI Memorandum

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
2. Evaluate the financial health of an insurance entity based on various solvency frameworks. Range of weight: 25-35 percent	a. MCT formulae b. Definition of the components of the MCT c. DCAT • Purpose • Satisfactory financial condition • Plausible scenarios and ripple effects • Management actions d. Stress testing e. Internal target capital ratios f. MSA ratios g. Key financial measures used by rating agencies h. Rules-based and principles-based solvency regulation (ORSA, MCT and Solvency II) i. A.M. Best rating system and BCAR

READINGS
AM Best Understanding BCAR
AM Best Catastrophe Analysis
CIA CSOP
CIA DCAT
CIA Valuation
Feldblum
KPMG Solvency II
MSA
OSFI Annual Return I
OSFI Annual Return II
OSFI Framework
OSFI MCT
OSFI Stress Testing
OSFI Target Capital
OSFI ORSA

D. Professional Responsibilities of the Actuary in Financial Reporting

Range of weight for Section D: 10-15 percent

This section focuses on the professional responsibilities of the appointed actuary related to the reporting of financial results by property and casualty insurers in Canada. The candidate will be required to understand the various statutory requirements of the appointed actuary under the Insurance Companies Act and the provincial insurance acts related to financial reporting and general corporate governance.

The material in this section encompasses sections of federal and provincial insurance laws and regulations, regulatory guidelines, and professional standards of practice and educational notes issued by the Canadian Institute of Actuaries that are related to the financial reporting of general insurers.

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
1. Explain the responsibilities of an actuary as defined by standards of practice, regulators, and insurance laws for financial reporting. Range of weight: 10-15 percent	a. Statutory Actuarial Opinion b. Contents of Statutory Reports of the Actuary c. Standards of Practice d. Educational Notes e. Insurance Companies Act f. Actuary and auditor relationship g. Regulatory requirements

READINGS
CIA Accounting Standards
CIA CSOP
CIA DCAT
CIA Disclosure
CIA Discounting
CIA Materiality
CIA MfAD
CIA Runoff
CIA Subsequent Events
CIA Taxes
CIA Valuation
ICA
KPMG PACICC
OSFI Earthquake
OSFI Memorandum
OSFI AA

Complete Text References for Exam 6–Canada

Text references are alphabetized by the citation column.

NOTE: The inherent nature of the material addressed in this nation-specific exam makes it subject to continual development and change. It is expected that the candidates will respond to exam questions based on the current syllabus presented below. Recognizing the changing nature of law, regulation, and financial reporting requirements, however, the Examination Committee will strive to acknowledge candidates who also respond with the current state in their solutions to examination questions.

Citation	Abbreviation	Learning Objective	Source
Chevalier, Sarah, "Agricultural Risk Management Programs in Canada," October 2014. Note that the table on page 6 is for reference only.	Agricultural Programs	B1-3	**SK NEW**
"Auto Insurance Grid Rate Calculator," Alberta Automobile Insurance Rate Board, Candidates are only responsible for the information displayed under the sections titles "Background" and "Grid Premium for Basic Coverage".	Alberta	A2	**OP NEW**
A.M. Best Company, Inc. *A.M. Best Methodology*, "Understanding BCAR For Canadian Property/Casualty Insurers," June 2015.	AM Best Understanding BCAR	C2	**OP**
A.M. Best Company, Inc. *A.M. Best Methodology*, "Catastrophe Analysis in A.M. Best Ratings," November 3, 2011.	AM Best Catastrophe	C2	**OP**
American Academy of Actuaries Mass Torts Subcommittee, "Overview of Asbestos Claims Issues and Trends," Mass Torts Subcommittee monograph, August 2007, pages 1-11. Candidates will not be responsible for material in the exhibits.	AAA Mass Torts	A4	**OP**
American Academy of Actuaries, "NAIC Public Hearing on Credit-Based Insurance Scores," April 30, 2009.	AAA Credit Scores	A2	**OP**
"ATRA Tort Reform Record," CAS Study Note, December 19, 2012.	ATRA	A4	**SK**

Citation	Abbreviation	Learning Objective	Source
Baer, M.G.; and Rendall, J.A., *Cases on the Canadian Law of Insurance* (Sixth Edition), Carswell, 2000, pp. 67-91, 93-100 302-304, 518-529, 821-827 and 829-831. Candidates are responsible for the following cases: *Glenn v. Scottish Union and National Insurance Company Ltd.* (Chapter 1); *Regal Films Corporation Ltd. v. Glens Falls Insurance Company* (Chapter 2); *Fletcher v. MPIC* (Chapter 8); *Broadhurst and Ball v. American Home*; and *Dillon v. Guardian Insurance* (Chapter 11).	Baer and Rendall	A1, A3	**SK**
Blanchard, R.S.; and Klann, J., "Basic Reinsurance Accounting—Selected Topics," CAS Study Note, October 2012.	Blanchard and Klann	C1	**OP**
Office of the Superintendent of Financial Institutions Canada, Annual Supplement, 2014, Approved by the Canadian Council of Insurance Regulators – P&C-1, pp. 10.40, 10.41, 10.42, 10.60, 60.10, 60.40, 60.41, 70.10, 70.21, 80.20. NOTE: Please use the **2014** edition that has been archived on the CAS Web Site for educational purposes.	CCIR Instructions	C1	**OP NEW**
Canadian Institute of Actuaries, Standards of Practice, 1620, 1630, 2200, 2400, 2500, and 2600.	CIA SOP	A2, C1, C2, D1	**OP**
Canadian Institute of Actuaries, "Educational Note: Subsequent Events," September 2012.	CIA Subsequent Events	C1, D1	**OP**
Canadian Institute of Actuaries, "Educational Note: Consideration of Future Income Taxes in the Valuation of Policy Liabilities," July 2005.	CIA Taxes	C1, D1	**OP**
Canadian Institute of Actuaries, "Educational Note: Discounting," November 2010.	CIA Discounting	C1, D1	**OP**
Canadian Institute of Actuaries, "Educational Note: Dynamic Capital Adequacy Testing," November 2013. Candidates are not responsible for details related to life insurance companies.	CIA DCAT	C2, D1	**OP**
Canadian Institute of Actuaries, "Educational Note: Evaluation of the Runoff of P&C Claim Liabilities when the Liabilities are Discounted in Accordance with Accepted Actuarial Practice," June 2011.	CIA Runoff	C1, D1	**OP**
Canadian Institute of Actuaries, "Educational Note: Implications of CICA Accounting Standards 3855 and 1530," January 2007.	CIA Accounting Standards	C1, D1	**OP**
Canadian Institute of Actuaries, "Educational Note: Guidance to the Appointed Actuary for Property and Casualty Insurers," October 2014.	CIA Valuation	C1, C2, D1	**OP**

Citation	Abbreviation	Learning Objective	Source
Canadian Institute of Actuaries, "Educational Note: Margins for Adverse Deviations for Property-Casualty Insurance," December 2009.	CIA MfAD	C1, D1	**OP**
Canadian Institute of Actuaries, "Report: Materiality," October 2007. Candidates are not responsible for material in the Appendix.	CIA Materiality	C1, D1	**OP**
Canadian Institute of Actuaries," Educational Note: Premium Liabilities," November 2014.	CIA Premium Liabilities	C1	**OP NEW**
Canadian Institute of Actuaries, "Research Paper: Disclosure Requirements IFRS 4–Insurance Contracts for P&C Insurers," October 2010.	CIA Disclosure	C1, D1	**OP**
Canadian Institute of Actuaries, "Report of the CIA Task Force on the Appropriate Treatment of Reinsurance," October 2007. Candidates will be responsible for the following sections: Key Principles of Risk Transfer (pp. 11-12), Qualitative Assessment (pp. 13), Limitations of Risk Transfer (pp. 15-18) and Other Issues (pp. 18-23).	CIA Reinsurance Treatment	C1	**OP**
Canadian Underwriter, "B.C. judge quashes order requiring insurer to review all credit score consent forms obtained since 2004," May 2013.	BC Credit	A3	**OP**
CAS Study Note, "Government Insurers Study Note," October 2013, pp. 1-5, excluding Crop Insurance.	CAS	B1-3	**OP**
Davidson, J., "The Cap on Non Pecuniary General Damages: Where is it Going and How Does it Affect Litigation?"	Davidson	A3	**OP**
Dibra, S.; and Leadbetter, D., "Why insurers fail: The dynamics of property and casualty insurance insolvency in Canada," Property and Casualty Insurance Compensation Corporation, 2007, excluding pp. 9-13, 33-40.	Dibra and Leadbetter	B1-3	**OP**
Dutil, R., "Facility Association," CAS Study Note, May 2008.	Dutil	B1-3	**OP**
Feldblum, S., "Rating Agencies," CAS Study Note, October 3, 2011, pp. 1-7 and 14-19. Candidates are not responsible for Section 4, Appendices B-D, and the end notes.	Feldblum	C2	**OP**

Citation	Abbreviation	Learning Objective	Source
Financial Services Commission of Ontario, "Private Passenger Automobile Filing Guidelines–Major," October 2014.	FSCO Private Auto	A2	**OP**
Financial Services Commission of Ontario, "Providing more Choice to Consumers: What you need to know about changes to auto insurance in Ontario".	FSCO Reforms	A2	**OP**
Financial Services Commission of Ontario, "Regulation 664 of the Revised Regulations of Ontario 1990 Automobile Insurance made under the Ontario Insurance Act," last amended version under Ontario Regulation 291/10.	FSCO Reg. 664	A2	**OP**
Financial Services Commission of Ontario, "Usage-Based Automobile Insurance Pricing in Ontario," Bulletin A-05/13, October 2013	FSCO UBI	A2	**OP NEW**
Freihaut, D.; and Vendetti, P., "Common Pitfalls and Practical Considerations in Risk Transfer Analysis," Casualty Actuarial Society *E-Forum*, Spring 2009. Appendices A and B are for information only and will not be directly tested.	Freihaut and Vendetti	C1	**OP**
Harris, C., "Tort Reform Tension," Canadian Underwriter.ca, August 2005.	Harris	A4	**OP**
International Financial Reporting Standards Foundation, IFRS 4, "Insurance Contracts," as of 1 January 2015. [It is necessary to register (for free) on the IFRS Foundation Web Site in order to access the document.]	IFRS 4	C1	**OP**
Insurance Bureau of Canada, "Code of Conduct for Insurers' use of Credit Information (CODE)."	IBC Code of Conduct	A2	**OP**
"Insurance Companies Act," Chapter 47, Sections 165(1), 165 (2), 203, 331(1), 331(2), 331(4), 346, 357-370, 464, 465, 476-478, 517, 581, 625-632, 641, 664, 665, 667(1), 667(2), and 674 (updated to July 1, 2013).	ICA	D1	**SK**
KPMG, "Research Report – Best Practices for Actuarial Involvement in the Regulatory Oversight of Property and Casualty Insurance Rates," December 2012, pp. 14-31.	KPMG Regulatory Oversight	A2	**SK**
KPMG, Eckler Partners Ltd. & Exactor Insurance Services, Inc., "Motor Vehicle Insurance in British Columbia—At the Crossroads, Volume II: Options and Choices," Section II excluding Section F.	KPMG et al.	A2, A4, B1-3	**SK**

Citation	Abbreviation	Learning Objective	Source
KPMG, "Property and Casualty Insurance Compensation Corporation (PACICC), The P&C Actuary's Role in Solvency Monitoring," excluding pp. 2-3 and excluding Part 7.	KPMG PACICC	A1, A2, D1	**OP**
KPMG, "Solvency II," pp. 3 to 8 only. Candidates will not be responsible for discussions related to Risk Based Capital.	KPMG Solvency II	C2	**OP**
"Landmark Legal Insurance Cases in Canada" which covers the following cases: Whiten v. Pilot Insurance Co.; Somersall v. Friedman; Somersall v. Scottish and York; Sansalone v. Wawanesa Mutual Insurance Co.; Nichols v. American Home Assurance Co.; Amos v. Insurance Corporation of British Columbia; KP Pacific Holdings Ltd. v. Guardian Insurance Co. of Canada; Alie v. Bertrand & Frere Construction Company Limited; British Columbia v. Imperial Tobacco Canada Ltd.; Resurface Corp. v. Hanke; and Morrow v. Zhang (Sections I, II, III, IV, VI (E), VII, VIII, and IX.); PIPEDA Report of Findings #2012-005; Kusnierz v. Economical Mutual Insurance Company; Aviva Canada Inc. v. Pastore.	Landmark Legal	A3	**SK**
Mayhall, III, Van R. "A Brief Chronicle of Insurance Regulation in the United States, Parts 1 and II."	Mayhall	A1	**OP**
McDonald, B.R., *Life Insurance Laws of Canada (Common Law Provinces)*, Life Underwriters Association of Canada, 1995, pp. A1-1, A2-1 to A2-9, B1-1 to B1-2, B2-1 to B2-3, and B4-1 to B4-3. Candidates are responsible for all cases cited in this text.	McDonald	A1, A3	**SK**
Morneau Shepell Handbook of Canadian Pension and Benefit Plans (Fifteenth Edition), 2011, CCH Canadian Limited, Chapters 3 (pages 57-67, 71-77 up to "Disability Benefits", 87-90 starting at "Funding and Future Contributions") and Chapters 15-18. Candidates will not be responsible for specific values and figures included in the text.	Morneau Shepell	B1-3	**SK**
MSA Research, Inc., "MSA Report on Property & Casualty, Canada, 2014," Section 3, pp. 1-10.	MSA	C2	**SK NEW**

Citation	Abbreviation	Learning Objective	Source
Noonan, B., "Protecting the Pledge," Foundations of Regulation, *Best's Review*, October 2005.	Noonan	A1	**OP**
Odomirok, K.C.; McFarlane, L.M.; Kennedy, G.L; and Brenden, J., *Financial Reporting Through the Lens of a Property/Casualty Actuary*, Casualty Actuarial Society, 2014, Edition 4 – Parts I, II, VII, and VIII	CAS Financial Reporting	C1	**OP**
Office of the Superintendent of Financial Institutions Canada, Guideline E-15, "Appointed Actuary: Legal Requirements, Qualifications, and Peer Review," September 2012.	OSFI AA	D1	**OP**
Office of the Superintendent of Financial Institutions Canada, "Corporate Governance," January 2013.	OSFI Corporate Governance	A2	**OP**
Office of the Superintendent of Financial Institutions Canada, "Earthquake Exposure Sound Practices Guideline" Guideline B-9, February 2013.	OSFI Earthquake	C1, D1	**OP**
Office of the Superintendent of Financial Institutions Canada, "Key Principles for the Future Direction of the Canadian Regulatory Capital Framework for Property and Casualty Insurance," January 2010.	OSFI Framework	C2	**OP**
Office of the Superintendent of Financial Institutions Canada Guideline, "Minimum Capital Test (MCT) for Federally Regulated Property and Casualty Insurance Companies, Effective January 1, 2015," September 2014. Candidates will not be required to memorize transition rules nor capital factors	OSFI MCT	C2	**OP**
Office of the Superintendent of Financial Institutions Canada, "Memorandum for the Appointed Actuary's Report on Property and Casualty Insurance Business," 2014.	OSFI Memorandum	C1, D1	**OP NEW**
Office of the Superintendent of Financial Institutions Canada, "Own Risk and Solvency Assessment," January 2014.	OSFI ORSA	C2	**OP**
Office of the Superintendent of Financial Institutions Canada Guideline, "Regulatory Capital and Internal Capital Targets," January 2014.	OSFI Target Capital	C2	**OP**
Office of the Superintendent of Financial Institutions Canada Guideline E-18, "Stress Testing," December 2009.	OSFI Stress Testing	C2	**OP**
Office of the Superintendent of Financial Institutions Canada, "Supervisory Framework," December 2010.	OSFI Supervisory Framework	A2	**OP NEW**

Citation	Abbreviation	Learning Objective	Source
Office of the Superintendent of Financial Institutions Canada, Sample Return, 2015 (Q1), Approved by the Canadian Council of Insurance Regulators – P&C-1, pp. 20.10, 20.20, 20.30, 20.42, 20.54, 30.61, 30.62, 30.64, 30.66, 30.71, 30.73, 30.75, 30.77, 30.79, 40.07, 60.20, 60.21, 60.30, 67.10, 67.20, 67.30, 70.60, 70.61, 80.10,. NOTE: Please use the **2015 edition** that has been archived on the CAS Web Site for educational purposes	OSFI Annual Return I	C1, C2	**OP NEW**
Office of the Superintendent of Financial Institutions Canada, Annual Supplement, 2014, Approved by the Canadian Council of Insurance Regulators – P&C-1, pp. 10.40, 10.41, 10.42, 10.60, 60.10, 60.40, 60.41, 70.10, 70.21. NOTE: Please use the 2014 edition that has been archived on the CAS Web Site for educational purposes.	OSFI Annual Return II	C1, C2	**OP NEW**
Property and Casualty Insurance Compensation Corporation, "Guide to Compensation Plan for Property and Casualty Insurers," May 2010.	PACICC	B1-3	**OP**
Rand Institute for Civil Justice, *Research Brief*, "Bankruptcy Trusts, Asbestos Compensation, and the Courts," 2011.	Rand Asbestos	A4	**OP**
Swiss Re, "Making Flood Insurable for Canadian Homeowners," November 2010, Sections 3, 5, 6, 7, and 8.	Swiss Re	B1-3	**OP**
Webel, Baird, "Terrorism Risk Insurance: Issue Analysis and Overview of Current Program," July 2014, Summary and pp. 1-13 (excluding the section "TRIA in the 113th Congress (pp. 2-4)).	Webel	B1-3	**OP NEW**

Source Key

B   Book—may be purchased from the publisher or bookstore or borrowed from the CAS Library.

NEW   Indicates new or updated material.

OP   All text references marked as Online Publications will be available on a web page titled Complete Text References.

SK   Material included in the Fall 2015 CAS Study Kit.

SKU   Material included in both the Fall 2015 CAS Study Kit and the Fall 2015 Update to the Spring 2015 Study Kit.

Items printed in red indicate an update, clarification, or change.

Publishers and Distributors

Contact information is furnished for those who wish to purchase the text references cited for Exam 6-Canada. Publishers and distributors are independent and listed for the convenience of candidates; inclusion does not constitute endorsement by the CAS.

ACTEX Publications, 107 Groppo Drive, Suite A, P.O. Box 974, Winsted, CT 06098; telephone: (800) 282-2839 or (860) 379-5470; fax: (860) 738-3152; e-mail: retail@actexmadriver.com; Web site: www.actexmadriver.com.

Actuarial Bookstore, P.O. Box 69, Greenland, NH 03840; telephone: (800) 582-9672 (U.S. only) or (603) 430-1252; fax: (603) 430-1258; Web site: www.actuarialbookstore.com.

A.M. Best Company, Inc. Ambest Road, Oldwick, New Jersey, 00858 U.S.A; Website: www.ambest.com

American Academy of Actuaries, 1100 Seventeenth Street NW, Seventh Floor, Washington, DC 20036; telephone: (202) 223-8196; Web site: www.actuary.org.

American Institute for Chartered Property Casualty Underwriters, Order Department, P.O. Box 3016, 720 Providence Road, Malvern, PA 19355-0716; telephone: (610) 644-2100; fax: (610) 640-9576.

Baer, M.G.; and Rendall, J.A., *Cases on the Canadian Law of Insurance* (Fifth Edition), 1995, Carswell, Attention: Customer and Order Services, One Corporate Plaza, 2075 Kennedy Road, Scarborough, Ontario M1T 3V4, Canada; telephone: (416) 609-3800 or (800) 387-5164; fax: (416) 298-5082; Web site: www.carswell.com.

Canadian Institute of Actuaries, Secretariat, Suite 820, 360 Albert Street, Ottawa, Ontario K1R 7X7, Canada; telephone: (613) 236-8196; fax: (613) 233-4552; Web site: www.actuaries.ca.

Casualty Actuarial Society *Forum*, *Foundations of Casualty Actuarial Science* (Fourth Edition), *PCAS*, and *Discussion Paper Program*, Casualty Actuarial Society, 4350 N. Fairfax Drive, Suite 250, Arlington, VA 22203; telephone: (703) 276-3100; fax: (703) 276-3108; e-mail: office@casact.org; Web site: www.casact.org.

Facility Association, 151 Yonge Street, 18th Floor, Toronto, Ontario M5C 2W7, Canada; telephone: (416) 863-1750 or (800) 268-9572; fax: (416) 868-0894.

Financial Institutions Act, "Insurance Companies Act," Chapter 47, The Federal Publication, 388 King Street West, Toronto, Ontario M5V 1K2, Canada; telephone: (416) 860-1611.

Financial Services Commission of Ontario, 5160 Yonge Street, P.O. Box 85, North York, Ontario M2N 6L9, Canada; telephone: (416) 250-7250; fax: (416) 590-7070; Web site: www.ontarioinsurance.com.

Insurance Bureau of Canada, 240 Duncan Mill Road, Suite 700, Toronto, Ontario M3B 1Z4, Canada; telephone: (416) 445-5912; fax: (416) 445-2183.

Morneau Shepell Handbook of Canadian Pension and Benefit Plans (Fifteenth Edition), 2011, CCH Canadian Limited, 90 Shepherd East, Suite 300, North York, Ontario M2N 6X1, Canada; telephone: (416) 224-2248; fax: (800) 461-4131.

Office of the Superintendent of Financial Institutions Canada, 255 Albert Street, Ottawa, Ontario K1A 0H2 Canada; telephone: (613) 990-7788; fax: (613) 952-8219; Web site: www.osfi-bsif.gc.ca.

Exam 6-Actuarial Institute of Chinese Taipei Regulation and Financial Reporting

The Actuarial Institute of Chinese Taipei (AICT) uses the Casualty Actuarial Society examinations for its property-casualty actuaries. The CAS Board of Directors approved specific AICT exams (i.e., current AICT Exam 6GA3 on Actuarial Standard of Practice and Accounting and Exam 6GB3 on Insurance Regulations and Discipline) as fulfilling the nation-specific requirement for CAS membership effective January 1, 2010.

In the 2011 transition to a revised basic education structure, learning objectives from the 2010 nation-specific exams were mapped to both the new Exam 6 on Regulation and Financial Reporting and new Online Course 2 on Insurance Accounting, Coverage Analysis, Insurance Law, and Insurance Regulation. Because the AICT continues to cover material from both new Exam 6 and new Online Course 2, candidates who have passed both AICT Exams 6GA3 and 6GB3 will be granted credit for both CAS Exam 6-Taiepi and Online Course 2.

For details on the administration of the AICT examinations, please contact:

> Actuarial Institute of Chinese Taipei
> 10F.-1, No.216, Sec. 2
> Nanchang Road, Zhongzheng District
> Taipei 100
> Taiwan (R.O.C.)
> Telephone: 886-2-2364-9168
> Fax: 886-2-3365-2283
> E-mail: airc.org@gmail.com
> Web Site in Chinese: http://www.airc.org.tw/2011/index.php
> Web Site in English: http://airc.org.tw/newsfiles/AICT_exam.pdf

Applying for CAS Exam Credit

If a candidate has passed both parts of the AICT nation-specific exam (current AICT Exams 6GA3 and 6GB3) after January 1, 2010, then the candidate may apply for exam credit with the CAS. To receive credit for CAS Exam 6-Taipei and Online Course 2, the candidate should submit a written request to the Actuaries' Resource Center (arc@casact.org). The request must include the candidate's full legal name, contact information (including mailing address and telephone number), date of birth, and the administration (month/year of exam) that each of the AICT nation-specific exam parts was passed. The Actuaries' Resource Center will verify the exam information with the AICT and then update the candidate's record to reflect the credit as appropriate.

Fall 2015 and Spring 2016 Exam 6–United States Syllabus Regulation and Financial Reporting (Nation Specific)

The syllabus for this four-hour exam is defined in the form of learning objectives, knowledge statements, and readings.

LEARNING OBJECTIVES set forth, usually in broad terms, what the candidate should be able to do in actual practice. Included in these learning objectives are certain ones that may not be possible to perform on an examination, such as complex simulations, but that the candidate would still be expected to explain in an examination setting.

KNOWLEDGE STATEMENTS identify some of the key terms, concepts, and methods that are associated with each learning objective. These knowledge statements are not intended to represent an exhaustive list of topics that may be tested, but they are illustrative of the scope of each learning objective.

READINGS support the learning objectives. It is intended that the readings, in conjunction with the material on the lower numbered examinations, provide sufficient resources to allow the candidate to perform the learning objectives. Some readings are cited for more than one learning objective. The Syllabus and Examination Committees emphasize that candidates are expected to use the readings cited in this *Syllabus* as their primary study materials.

Thus, the learning objectives, knowledge statements, and readings complement each other. The learning objectives define the behavior, the knowledge statements illustrate more fully the intended scope of the learning objectives, and the readings provide the source material to achieve the learning objectives. Learning objectives should not be seen as independent units, but as building blocks for the understanding and integration of important competencies that the candidate will be able to demonstrate.

Note that the range of weights shown should be viewed as a guideline only. There is no intent that they be strictly adhered to on any given examination—the actual weight may fall outside the published range on any particular examination. The overall section weights should be viewed as having more significance than the individual learning objective weights. Over a number of years of examinations, absent changes, it is likely that the average of the weights for each individual overall section will be in the vicinity of the guideline weight. For the individual learning objective weights, such convergence is less likely. On a given examination, in which it is very possible that not every individual learning objective will be tested, there will be more divergence of guideline weights and actual weights. Questions on a given learning objective may be drawn from any of the listed readings, or a combination of the readings. There may be no questions from one or more readings on a particular exam.

After each set of learning objectives, the readings are listed in abbreviated form. Complete text references are provided at the end of this exam syllabus.

In addition, this exam assumes that the candidate has completed Online Course 2. Online Course 2 contains fundamental background material for both Section A (Regulation of Insurance and United States Insurance Law) and Section C (Financial Reporting and Taxation).

Items marked with a bold **SK** or **SKU** constitute the Fall 2015-Spring 2016 Exam 6-United States Study Kit that may be purchased from the CAS Online Store. The 2015 Update to the Fall 2014-Spring 2015 Study Kit includes only the new items marked with a bold **SKU**; the Update may be purchased from the CAS Online Store. Items marked with a bold **OP** (Online Publication) are available at no charge and may be downloaded from the CAS website.

Please check the "*Syllabus* Updates" section of the CAS Web Site for any changes to the *Syllabus*.

Section A of this examination covers insurance regulation with regards to property-casualty coverages, ratemaking, pricing, and solvency, and U.S. tort law as it affects the property-casualty business. Section B covers markets, coverages, and private and governmental programs for the property-casualty business in the United States. Section C covers the aspects of statutory, Generally Accepted Accounting Principles (GAAP), and International Financial Reporting Standards (IFRS) insurance accounting and taxation as these affect reserving and statutory reporting in the United States. Section D covers the professional responsibilities of the appointed actuary according to the Property and Casualty Annual Statement Instructions issued by the National Association of Insurance Commissioners (NAIC). Section E presents the general concepts of reinsurance accounting to the candidate.

The inherent nature of the material addressed in this nation-specific exam makes it subject to continual development and change. It is expected that the candidates will respond to exam questions based on the current syllabus presented below. Recognizing the changing nature of law, regulation, and financial reporting requirements, however, the Examination Committee will strive to acknowledge candidates who also respond with the current state in their solutions to examination questions.

A. Regulation of Insurance and United States Insurance Law

Range of weight for Section A: 15-20%

Candidates should understand that insurers are regulated by various governmental agencies because insurance is a valuable public service. An understanding of the dual U.S. state and federal regulatory system is required, along with the various state systems of regulation. The major areas of regulation for rate, contract terms, and solvency should be understood, as should the role of antitrust law as it pertains to insurance regulation.

Regulation as it affects insurance ratemaking in the U.S. is covered. Regulatory and political aspects of risk classification are also covered. Some learning objectives extend the topic to regulation and governmental actions designed to enhance the availability of insurance.

This section also covers the regulation for solvency in the U.S., including financial ratios tested by the National Association of Insurance Commissioners, Insurance Regulatory Information System (IRIS) tests and guaranty fund mechanisms set up by the various states. Also covered are risk-based capital calculations from the statutory blank and how they are used to monitor solvency.

U.S. tort law, while not a strictly actuarial subject, affects many areas of an actuary's work. The judicial role in the development of tort law is also covered.

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
1. Describe the historic development and the current state of insurance regulation. Range of weight: 3-7 percent	a. Basis of insurance regulation b. Functions of NAIC c. Antitrust provisions d. Rate regulation
READINGS	
Kucera McCarty NAIC Solvency Regulatory Framework Porter 1	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
2. Discuss the historic development of solvency regulation; describe current programs used to monitor solvency. Range of weight: 3-7 percent	a. Solvency, including RBC, insolvency, insurance department examination, and NAIC regulatory tests such as IRIS b. Receivership

READINGS
Odomirok et al. NAIC IRIS NAIC Solvency Regulatory Framework Porter 1 Porter 2 Vaughan (Economic Crisis)

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
3. Describe current regulation addressing specialized insurance topics. Range of weight: 0-5 percent	a. Surplus Lines Companies b. Risk Retention Groups and Purchasing Groups c. Captives d. Admitted vs. Non-admitted Companies e. Rating Agencies

READINGS
Feldblum (Rating Agencies) GAO Report Mayer Brown NAIC Solvency Regulatory Framework Porter 1

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
4. Discuss the issues, outcome, rationale, and implications of landmark decisions and antitrust laws for the insurance industry including the division of responsibility between federal and state regulators. Range of weight: 3-7 percent	a. Federal and State Antitrust Laws (e.g. Sherman Antitrust) b. McCarran-Ferguson c. Southeastern Underwriters d. Dodd-Frank Act e. Gramm Leach Bliley Act f. Paul vs. Virginia g. Mass torts (e.g. asbestos)

READINGS
Asbestos Mayer Brown NAIC Solvency Regulatory Framework Porter 1 Vaughan (Economic Crisis)

B. Government and Industry Insurance Programs

Range of weight for Section B: 10-15 percent

This section focuses on the identification of major United States insurance programs administered by government agencies and insurance industry organizations. The candidates are expected to have an understanding of the objectives, operations, and effectiveness of the following insurance programs:

- Flood insurance
- Crop Insurance
- Residual markets (e.g., auto, workers compensation, property)
- Workers compensation
- Automobile Plans (e.g., MD Fund)
- Guaranty funds
- Government Backstops, e.g., TRIA and FL Cat Fund

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
1. Describe the origin and purpose of government and industry insurance programs. Range of weight: 3-7 percent	a. Reason for inception b. Major historical development c. Philosophy of program
READINGS	
Government Insurers Study Note Hamilton and Ferguson King Porter 2 Webel	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
2. Describe the operations and risk transfer process for government/industry programs and their interaction with voluntary private insurance sector. Range of weight: 3-7 percent	a. Funding mechanisms/sources b. Allocation/assignment of exposures and associated costs c. Claim settlement and insurance coverage provisions d. Welfare (subsidization) versus insurance principles
READINGS	
Government Insurers Study Note Hamilton and Ferguson King Porter 2 Webel	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
3. Evaluate the effectiveness of a government/industry program. Range of weight: 3-7 percent	a. Solvency b. Efficiencies c. Stability d. Viability/longer term prospects e. How well program meets its purpose

READINGS
Government Insurers Study Note Hamilton and Ferguson King Porter 2 Webel

C. Financial Reporting and Taxation

Range of weight for Section C: 35-55 percent

This section addresses financial reporting, solvency, and taxation issues. Candidates should have detailed knowledge of the contents, purposes, and recent changes in the NAIC Annual Statement and the Insurance Expense Exhibits. Knowledge of federal income tax treatment, including loss reserve discounting, is expected.

Candidates may find it valuable to review an actual insurer's Annual Statement to gain a more complete understanding of the key schedules, particularly the Notes to Financial Statements and General Interrogatories Sections. A candidate may review the Annual Statement of the company for which the candidate works or the Annual Statement of a publicly held company. There are links to publicly available Annual Statements of a few U.S. insurers in the citation for the NAIC Annual Statement Examples in the Complete Text References section below. Candidates are not responsible for the details of the companies' Annual Statement.

Candidates should understand the details of, and the reasons for, the differences between Generally Accepted Accounting Principles (GAAP), Statutory Accounting Principles (SAP), and International Financial Reporting Standards (IFRS).

This section is complemented by readings on solvency monitoring systems such as Risk Based Capital (RBC) and the IRIS ratios.

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
1. Describe the elements of the Annual Statement. Complete specific schedules and exhibits and use them to evaluate the financial health of an insurance entity. Range of weight: 20-25 percent	a. Balance sheet b. Income statement c. Change in surplus d. Schedule P e. Insurance Expense Exhibit f. Notes to financial statements g. Reinsurance accounting including Schedule F h. Underwriting and Investment Exhibit i. Exhibit of Premiums and Losses (Statutory Page 14)

READINGS
2014 IEE Feldblum (Surplus) NAIC Annual Statement NAIC Annual Statement Examples NAIC SSAP 5R, 9, 53, 55, 62R, and 65 Odomirok et al.

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
2. Using RBC formulas and IRIS ratios, evaluate an insurer's financial health. Range of weight: 10-15 percent	a. RBC formula b. Components of RBC c. IRIS ratios d. Interaction of RBC and IRIS Ratios

READINGS
NAIC IRIS Odomirok et al.

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
3. Differentiate between various accounting reporting principles and standards. Range of weight: 5-10 percent	a. U.S. Statutory Accounting Principles b. Generally Accepted Accounting Principles (SEC Filers) c. Adjustments to go from SAP to GAAP d. Fair Value of claims liabilities, including Risk Margins e. International Financial Reporting Standards f. Solvency II

READINGS
DeFrain Lindbergh and Seifert NAIC APPM, Preamble NAIC Solvency Regulatory Framework Odomirok et al.

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
4. Calculate specific elements of income tax and evaluate their implications for a property/casualty insurer. Range of weight: 0-5 percent	a. Discounting b. Elements of income tax calculation c. Statutory book income versus taxable income d. Alternative minimum tax e. Deferred Tax Asset and Deferred Tax Liability f. Temporary vs. permanent differences
READINGS	
Feldblum (Loss Reserve Discounting, Taxable Income, and Taxes and Investment Strategy) Odomirok et al.	

D. Professional Responsibilities of the Actuary in Financial Reporting

Range of weight for Section D: 15-20 percent

This section focuses on the professional responsibilities of the appointed actuary related to the reporting of financial results by property/casualty insurance companies in the United States of America. The identification of the appointed actuary is described in the Property and Casualty Annual Statement Instructions issued by the NAIC.

The candidate will be required to understand the various statutory requirements of the appointed actuary, and the appropriate professional standards and educational notes issued by the American Academy of Actuaries that are related to the financial reporting of property and casualty insurance companies.

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
1. Explain the responsibilities of an actuary as defined by standards of practice, regulators, and insurance laws for financial reporting. Range of weight: 15-20 percent	a. Statutory Prescribed Statement of Actuarial Opinion b. Standards of Practice c. Actuarial Report d. Actuary and auditor relationship e. Materiality f. Actuarial Opinion Summary
READINGS	
AAA Materiality ASOP 20, 36, 41, and 43 COPLFR P&C Practice Note Odomirok et al.	

E. Reinsurance Accounting Principles

Range of weight for Section E: 5-10 percent

This section presents the general concepts of reinsurance accounting to the candidate. The candidate should become familiar with reinsurance accounting terminology and practice.

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
1. Describe reinsurance accounting terminology and practice, and evaluate considerations such as risk transfer testing and commutations. Range of weight: 5-10 percent	a. Identification and evaluation of insurance and financing components of the contracts b. Determination whether the contract qualifies for insurance accounting treatment or deposit accounting treatment (i.e., passes risk transfer), and understand impact on financial statements c. Commutations—definition, motivations of parties, and accounting and tax treatment
READINGS	
ASC 944-020-15 Blanchard and Klann Freihaut & Vendetti Klann SSAP 62R	

Complete Text References for Exam 6–United States

Text references are alphabetized by the citation column.

Citation	Abbreviation	Learning Objective	Source
2014 Insurance Expense Exhibit.	2014 IEE	C1	**B** **NEW**
Actuarial Standards Board of the American Academy of Actuaries, "Actuarial Standard of Practice, No. 20, Discounting of Property/Casualty Unpaid Claim Estimates," September 2011.	ASOP 20	D1	**OP**
Actuarial Standards Board of the American Academy of Actuaries, "Actuarial Standard of Practice No. 36, Statements of Actuarial Opinion Regarding Property/Casualty Loss and Loss Adjustment Expense Reserves," Revised Ed. December 2010.	ASOP 36	D1	**OP**
Actuarial Standards Board of the American Academy of Actuaries, "Actuarial Standard of Practice No. 41, Actuarial Communications," December 2010.	ASOP 41	D1	**OP**
Actuarial Standards Board of the American Academy of Actuaries, "Actuarial Standard of Practice No. 43, Property/Casualty Unpaid Claim Estimates," May 2011.	ASOP 43	D1	**OP**
American Academy of Actuaries Mass Tort Subcommittee, "Overview of Asbestos Claims Issues and Trends," A Public Policy Monograph, August 2007, pp. 1–11.	Asbestos	A4	**OP**
American Academy of Actuaries, Task Force on Materiality, "Materiality, Concepts on Professionalism," Discussion Paper, Professionalism Series, 2006, No. 8.	AAA Materiality	D1	**OP**
Blanchard, R.S.; and Klann, J., "Basic Reinsurance Accounting– Selected Topics," CAS Study Note, October 2012.	Blanchard and Klann	E1	**OP**
Committee on Property and Liability Financial Reporting, American Academy of Actuaries, "Property and Casualty Practice Note, Statements of Actuarial Opinion on P&C Loss Reserves as of December 31, 2014."	COPLFR P&C Practice Note	D1	**OP** **NEW**
DeFrain, K., "The Impact of International Financial Reporting Standards on U.S. Actuarial Practice," CAS Study Note, November 5, 2010.	DeFrain	C3	**OP**
Feldblum, S., "Computing Taxable Income for Property-Casualty Insurance Companies," CAS Study Note, 2007, pp. 1–13, excluding appendices and end notes.	Feldblum (Taxable Income)	C4	**OP**
Feldblum, S., "Federal Income Taxes and Investment Strategy," CAS Study Note, 2007, pp. 1–12, excluding Appendix and endnotes.	Feldblum (Taxes and Investment Strategy)	C4	**OP**
Feldblum, S., "IRS Loss Reserve Discounting," CAS Study Note, 2007, pp. 1–13, including errata, excluding Appendix and endnotes.	Feldblum (Loss Reserve Discounting)	C4	**OP**

Citation	Short Name	Range	Type
Feldblum, S., "Rating Agencies," CAS Study Note, October 3, 2011, pp. 1–7 and 14–15(stop at Best's Capital Adequacy Ratio). Candidates are not responsible for Sections 4 & 5, Appendices BD, and the endnotes.	Feldblum (Rating Agencies)	A3	**OP**
Feldblum, S., "Statutory Surplus: Computation, Pricing and Valuation," CAS Study Note, June 2003. Candidates are not responsible for the endnotes.	Feldblum (Surplus)	C1	**OP**
Financial Accounting Standards Board, Accounting Standards Codification 944, "Financial Guarantee Insurance Contracts," 2011, Section 15, Scope and Scope Exceptions, paragraphs 15-1 to 15-2; 15-5 to 15-8; 15-34 to 15-35; 15-41 to 15-44; and 15-49 to 15-54. Candidates are not responsible for material relating to long-duration contracts and/or life insurance.	ASC 944-020-15	E1	**SK**
Freihaut, D.; and Vendetti, P., "Common Pitfalls and Practical Considerations in Risk Transfer Analysis," Casualty Actuarial Society *E-Forum*, Spring 2009. (Appendices A and B are for information only and will not be directly tested.)	Freihaut & Vendetti	E1	**OP**
"GAO Report to the Chairman, Committee on Financial Services, House of Representatives, Risk Retention Groups, Common Regulatory Standards and Greater Member Protections are Needed," United States Government Accountability Office, GAO-05-536," August, 2005, pp. 8–14.	GAO Report	A3	**OP**
"Government Insurers Study Note," CAS Study Note, Updated September 2013, pp. 1–18 (stop at unemployment insurance). Candidates are not responsible for numbers or statistics in charts.	Government Insurers Study Note	B1, B2, B3	**OP**
Hamilton, K.L.; and Ferguson, C.L., Personal Risk Management and Property-Liability Insurance (First Edition), American Institute for Chartered Property Casualty Underwriters, 2002, pp. 6.31–6.34 and 9.36–9.40.	Hamilton and Ferguson	B1, B2, B3	**SK**
King, R. "The National Flood Insurance Program: Status and Remaining Issues for Congress", February 6, 2013, pp. 1–32.	King	B1, B2, B3	**OP**
Klann, J., "Reinsurance Commutation," 2013.	Klann	E1	**OP**
Kucera, J., "NAIC Public Hearing on Credit-Based Insurance Scores," April 30, 2009, American Academy of Actuaries.	Kucera	A1	**OP**
Lindbergh, D.L.; and Seifert, D.L., "A New Paradigm of Reporting on the Horizon, International Financial Reporting Standards (IFRS) and Implications for the Insurance Industry," *Journal of Insurance Regulation*, National Association of Insurance Commissioners, Volume 29, 2010, pp. 229–242.	Lindbergh and Seifert	C3	**SK**
Mayer Brown, "Understanding the New Financial Reform Legislation: The Dodd-Frank Wall Street Reform and Consumer Protection Act," July 2010, pp. 55–63, excluding Section B and F4. The candidates are encouraged to read pages xv-xix to understand acronyms cited in the article.	Mayer Brown	A3, A4	**OP**

McCarty, K.M., "Testimony of Kevin M. McCarty, Florida Insurance Commissioner, Florida Office of Insurance Regulation and Representing the National Association of Insurance Commissioners, Regarding: 'The Impact of Credit-Based Insurance Scoring on the Availability and Affordability of Insurance,' May 21, 2008," Subcommittee on Oversight and Investigations of the House Committee on Financial Services, excluding Appendices 1 and 2.	McCarty	A1	**OP**
National Association of Insurance Commissioners, *Accounting Practices and Procedures Manual*, 2014, Preamble.	NAIC APPM, Preamble	C3	**SKU NEW**
National Association of Insurance Commissioners, *Accounting Practices and Procedures Manual*, 2014, Statement of Statutory Accounting Principles 5R, "Liabilities, Contingencies, and Impairment of Assets," paragraphs 1–12, 26–29, and 33–34.	NAIC SSAP 5R	C1	**SKU NEW**
National Association of Insurance Commissioners, *Accounting Practices and Procedures Manual*, 2014, Statement of Statutory Accounting Principles 9, "Subsequent Events," paragraphs 1–8.	NAIC SSAP 9	C1	**SKU NEW**
National Association of Insurance Commissioners, *Accounting Practices and Procedures Manual*, 2014, Statement of Statutory Accounting Principles 53, "Property Casualty Contracts— Premiums," paragraphs 1–18.	NAIC SSAP 53	C1	**SKU NEW**
National Association of Insurance Commissioners, *Accounting Practices and Procedures Manual*, 2014, Statement of Statutory Accounting Principles 55, "Unpaid Claims, Loss and Loss Adjustment Expenses," paragraphs 1–6 and 10–17.	NAIC SSAP 55	C1	**SKU NEW**
National Association of Insurance Commissioners, *Accounting Practices and Procedures Manual*, 2014, Statement of Statutory Accounting Principles 62R, "Property and Casualty Reinsurance," paragraphs 1–89.	NAIC SSAP 62R	C1, E1	**SKU NEW**
National Association of Insurance Commissioners, *Accounting Practices and Procedures Manual*, 2014, Statement of Statutory Accounting Principles 65, "Property and Casualty Contracts," paragraphs 1–45.	NAIC SSAP 65	C1	**SKU NEW**
National Association of Insurance Commissioners, "NAIC Insurance Regulatory Information System (IRIS) Ratios Manual," 2014, Section II, Property/Casualty Ratios, pp. 5–26.	NAIC IRIS	A2, C2	**SKU NEW**

National Association of Insurance Commissioners, *Official 2014 NAIC Annual Statement Blanks, Property and Casualty*, (both individual and consolidated basis), pp. 2–13, Notes to the Financial Statement p. 14 (refer to the Odomirok paper for the Notes to cover); Schedules D (pp. SI03 through SI09), F (pp. 20-29), H (pp. 30-33), and P (pp. 33-93). Candidates will be expected to have knowledge of other sections of the annual statement that are discussed in other Syllabus readings. Candidates are not responsible for page numbers. [The "Notes to the Financial Statement" are cited for reference only. Candidates are responsible for the Notes as described in the Odomirok reading where the Notes are referenced by title. If the 2015 Annual Statement and the study materials differ, candidates may base their answers on either.]	NAIC Annual Statement	C1	**B NEW**
National Association of Insurance Commissioners Official Annual Statement Examples: The following companies post their annual statements online. Candidates may use these (or their own company's statements) as illustrations to better understand the annual statement but are not responsible for any company-specific data: (1) Travelers and (2) the Liberty Mutual Group.	NAIC Annual Statement Examples	C1	**OP NEW**
NAIC White Paper, "The U.S. National State-Based System of Insurance Regulation and the Solvency Modernization Initiative," 2013, excluding appendices, Section 2 paragraphs 15-18, 26-28, 32-34, 41-42; Section 3 paragraphs 9, 13 15, 23-32 and 38-39; Section 4; and Section 5 paragraphs 9, 20-29, 30-45 and 61-86.	NAIC Solvency Regulatory Framework	A1, A2, A3, A4, C3	**OP**
Odomirok, K.C.; McFarlane, L.M.; Kennedy, G.L; and Brenden, J., *Financial Reporting Through the Lens of a Property/ Casualty Actuary*, Casualty Actuarial Society, 2014, Edition 4, excluding Part VII [Canadian Introduction and Canadian Chapters 27-29 (pp. 335-362)], and Appendix II. Including Errata.	Odomirok et al.	A2, C1, C2, C3, C4, D1	**OP**
Porter, K., *Insurance Regulation*, Insurance Institute of America, 2008, Chapters 2 (excluding 2.19–2.29), 3 (excluding 3.21–3.25), 4 (exclude 4.16–4.23), 5 (exclude 5.12–5.22), 6 (pp. 6.11–6.17), 8 (pp. 8.3–8.6 and 8.12–8.15), and 12 (excluding pp. 12.12–12.17).	Porter 1	A1, A2, A3, A4	**B**
Porter, K., *Insurance Regulation*, Insurance Institute of America, 2008, Chapter 12 (pp. 12.12–12.17).	Porter 2	A2, B1, B2, B3	**B**
Vaughan, T.M., "The Economic Crisis and Lessons from (and for) U.S. Insurance Regulation," *Journal of Insurance Regulation*, National Association of Insurance Commissioners, Fall/Winter, Volume 28, No. 1, 2009.	Vaughan (Economic Crisis)	A2, A4	**SK**
Webel, B., "Terrorism Risk Insurance: Issue Analysis and Overview of Current Program," Congressional Research Service, April 26, 2013.	Webel	B1, B2, B3	**OP**

Source Key

B   Book—may be purchased from the publisher or bookstore or borrowed from the CAS Library.

NEW   Indicates new or updated material.

OP   All text references marked as Online Publications will be available on a web page titled Complete Text References.

SK   Material included in the Fall 2015-Spring 2016 Study Kit.

SKU   Material included in both the Fall 2015-Spring 2016 CAS Study Kit and the 2015 Update to the Fall 2014-Spring 2015 Study Kit.

Items printed in red indicate an update, clarification, or change.

Publishers and Distributors

Contact information is furnished for those who wish to purchase the text references cited for Exam 6-United States. Publishers and distributors are independent and listed for the convenience of candidates; inclusion does not constitute endorsement by the CAS.

Actex Publications (Mad River Books), 107 Groppo Drive, Suite A, P.O. Box 974, Winsted, CT 06098; telephone: (800) 282-2839 or (860) 379-5470; fax: (860) 738-3152; e-mail: retail@actexmadriver.com; Website: www.actexmadriver.com.

Actuarial Bookstore, P.O. Box 69, Greenland, NH 03840; telephone: (800) 582-9672 (U.S. only) or (603) 430-1252; fax: (603) 430-1258; Web site: www.actuarialbookstore.com.

Actuarial Digest, P.O. Box 1127, Ponte Vedra, FL 32004.

American Institute for Chartered Property Casualty Underwriters, Order Department, P.O. Box 3016, 720 Providence Road, Malvern, PA 19355-0716; telephone: (610) 644-2100; fax: (610) 640-9576.

Association Form of the Annual Statement Blanks, Bowne Insurance Services, 1717 Arch Street, 31st Floor, Philadelphia, PA 19103; telephone: (215) 988-5690 or (800) 234-6859.

Casualty Actuarial Society *E-Forum, Forum*, *Foundations of Casualty Actuarial Science* (Fourth Edition), *PCAS*, and *Discussion Paper Program*, Casualty Actuarial Society, 4350 N. Fairfax Drive, Suite 250, Arlington, VA 22203; telephone: (703) 276-3100; fax: (703) 276-3108; e-mail: office@casact.org; Web site: www.casact.org.

Insurance Expense Exhibit, Bowne Insurance Services, 1717 Arch Street, 31st Floor, Philadelphia, PA 19103; telephone: (215) 988-5690 or (800) 223-3103.

Insurance Institute of America, 720 Providence Road, Malvern, PA 19355-0770; telephone: (610) 644-2100.

Journal of Insurance Regulation, National Association of Insurance Commissioners, 120 W. 12th Street, #1100, Kansas City, MO 64105; telephone: (816) 842-3600.

Journal of Risk and Insurance, The, American Risk and Insurance Association, 716 Providence Road, P.O. Box 3028, Malvern, PA 19355; telephone: (610) 640-1997; fax: (610) 725-1007; Web site: www.aria.org.

NAIC Annual Statement Blanks, Property and Casualty may be obtained from Bowne Insurance Services, 1717 Arch Street, 31st Floor, Philadelphia, PA 19103; telephone: (215) 988-5690 or (800) 223-3103.

National Association of Insurance Commissioners, 120 W. 12th Street, #1100, Kansas City, MO 64105; telephone: (816) 842-3600.

RR Donnelley, Two Logan Square, 18th Floor, Philadelphia, PA 19103; telephone: (215) 988-5622 or (800) 234-6859 [for the *NAIC Annual Statement Blanks, Property and Casualty* and the Insurance Expense Exhibit (P&C)].

Stanford University Press, 1450 Page Mill Road, Palo Alto, CA, 94304; telephone (800) 621-2736; Web site: www.sup.org.

2015 Exam 7
Estimation of Policy Liabilities, Insurance Company Valuation, and Enterprise Risk Management

The syllabus for this four-hour exam is defined in the form of learning objectives, knowledge statements, and readings.

LEARNING OBJECTIVES set forth, usually in broad terms, what the candidate should be able to do in actual practice. Included in these learning objectives are certain methodologies that may not be possible to perform on an examination, such as complex simulations, but that the candidate would still be expected to explain conceptually in the context of an examination.

KNOWLEDGE STATEMENTS identify some of the key terms, concepts, and methods that are associated with each learning objective. These knowledge statements are not intended to represent an exhaustive list of topics that may be tested, but they are illustrative of the scope of each learning objective.

READINGS support the learning objectives. It is intended that the readings, in conjunction with the material on the lower numbered examinations, provide sufficient resources to allow the candidate to perform the learning objectives. Some readings are cited for more than one learning objective. The Syllabus and Examination Committees emphasize that candidates are expected to use the readings cited in this Syllabus as their primary study materials.

Thus, the learning objectives, knowledge statements, and readings complement each other. The learning objectives define the behaviors, the knowledge statements illustrate more fully the intended scope of the learning objectives, and the readings provide the source material to achieve the learning objectives. Learning objectives should not be seen as independent units, but as building blocks for the understanding and integration of important competencies that the candidate will be able to demonstrate.

Note that the range of weights shown should be viewed as a guideline only. There is no intent that they be strictly adhered to on any given examination—the actual weight may fall outside the published range on any particular examination.

The overall section weights should be viewed as having more significance than the weights for the individual learning objectives. Over a number of years of examinations, absent changes, it is likely that the average of the weights for each individual overall section will be in the vicinity of the guideline weight. For the weights of individual learning objectives, such convergence is less likely. On a given examination, in which it is very possible that not every individual learning objective will be tested, there will be more divergence of guideline weights and actual weights. Questions on a given learning objective may be drawn from any of the listed readings, or a combination of the readings. There may be no questions from one or more readings on a particular exam.

After each set of learning objectives, the readings are listed in abbreviated form. Complete text references are provided at the end of this exam syllabus.

Items marked with a bold **SK** or **SKU** constitute the 2015 CAS Exam 7 Study Kit that may be purchased from the CAS Online Store. Items marked with a bold **OP** (Online Publication) are available at no charge and may be downloaded from the CAS website. The 2015 Update to the 2014 Study Kit includes only the new items marked with a bold **SKU** and may be purchased from the CAS Online Store.

Please check the "Syllabus Update" for this exam for any changes to this syllabus.

A. Estimation of Policy Liabilities

Range of weight for Section A: 45–55 percent

This section focuses on advanced techniques that the actuary may need to estimate reserves for unpaid claims. The candidate is expected to be well versed in the basic Principles and Standards of Practice for unpaid claim estimation. This section addresses how actuarial concepts are adapted to evaluate liabilities arising in complex risk transfer agreements common in excess insurance and reinsurance contracts. Emphasis is placed on developing ranges around a best estimate.

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
1. Calculate unpaid claim estimates using credibility models. Range of weight: 3–4 percent	a. Application of credibility b. Mechanics of the methods c. Strengths and weaknesses d. Testing results for reasonableness

READINGS
Brosius Hürlimann Mack (2000)

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS

2. Estimate parameters and unpaid claims using claims development models related to loss reserving methods such as:
   • Chain ladder
   • Cape Cod
   • Chain ladder plus calendar-year effects
   • Bornhuetter-Ferguson
 	
3. Calculate the moments and percentiles of unpaid claim distributions implied by the models.
 	
Range of weight: 16-18 percent
	a. Key assumptions of the models and testing of assumptions
	b. Original Mack chain ladder assumptions
	c. Relationship of variance assumptions to methods of calculating development factors
	d. Row-factor times column-factor models
	e. Calendar-year effects in development factor models and in row-column factor models
	f. Effect of trends and their interrelationship (e.g., calendar year, accident year, and development year trends)
	g. Testing for and eliminating insignificant parameters
	h. Testing whether the methods work and how well the models fit
	i. Moments of the chain ladder unpaid claim estimate when factors are calculated based on different variance assumptions
	j. Simulation of parameter percentiles and unpaid claims percentiles when models assume a distribution of residuals fit by MLE

READINGS
Clark Mack (1994) Venter Factors

EARNING OBJECTIVES	KNOWLEDGE STATEMENTS
4. Estimate unpaid claims for various layers of claims. Range of weight: 3-4 percent	a. Methods for estimating unpaid claims in a deductible layer b. Methods for estimating unlimited unpaid claims excess of a threshold c. Methods for estimating unpaid claims excess of a retention but bounded by a limit d. Relationships of development patterns among layers e. Interrelationships between parameters for forecasting deductible, unlimited excess, layer excess and total claims

READINGS
Sahasrabuddhe Siewert

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
5. Describe the various sources of risk and uncertainty that are associated with the determination of reserves. Calculate risk margins that consider these sources of risk and uncertainty. Range of weight for Learning Objectives A5-A10 collectively: 16-18 percent	a. Systemic risks and independent risks b. Limitations of quantitative risk assessment c. Risk correlations d. Testing and evaluation of risk models
6. Calculate the mean and prediction error of a reserve given an underlying statistical model. Range of weight for Learning Objectives A5-A10 collectively: 16-18percent	a. Distributions and distribution-free models b. Comparison of Chain Ladder stochastic models
7. Derive predictive distributions using bootstrapping and simulation techniques. Range of weight for Learning Objectives A5-A10 collectively: 16-18percent	a. Comparison of methods b. Simulation using bootstrapping c. Simulation from parameters d. Bayesian methods
8. Identify data issues and related model adjustments for reserving models. 9. Test assumptions underlying reserve models. 10. Develop a distribution of reserves using weights and multiple stochastic models. Range of weight for Learning Objectives A5-A10 collectively: 16-18 percent	a. Bayesian methods b. Adjustments to various reserving techniques c. Comparison of ODP Bootstrap and GLM Bootstrap models

READINGS
Marshall et al Shapland and Leong Verrall

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS

11. Compare and contrast reinsurance and primary reserving procedures.
 	
12. Adjust primary methods and data to be used for reinsurance reserving.
 	
13. Calculate ceded loss reserves using appropriate methods.
 	
Range of weight for Learning Objectives A11-A13 collectively: 5-7 percent
	a. Overview of reinsurance and primary reserving methods
	b. Effect on assumptions from differences in information available to reinsurers
	c. Stanard-Buhlmann method
	d. Cape Cod method
	e. Underlying business characteristics of reinsurance contracts e.g., concentration of exposures
	f. Data structures:
	  • Ground up versus excess loss
	  • Accident year versus treaty year
	g. Reinsurance reserving methods

READINGS	
Patrik	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
14. Forecast Premium Reserves. Range of weight: 2-4 percent	a. Reserves for retrospective premiums b. Reserves for unearned premiums for policies with non pro-rata earning patterns
READINGS	
Teng and Perkins	

B. Insurance Company Valuation

Range of weight for Section B: 8-12 percent

This section focuses on methods used to determine the theoretical value of equity securities and extending the methodology to value property and casualty insurance companies. The candidate is expected to be proficient with the basic tools and techniques commonly used in the financial analysis of corporations as described in the knowledge requirements set forth for VEE–Corporate Finance.

Learning Objectives	Knowledge Statements
1. Calculate the effect of loss and expense reserve requirements and regulatory or rating agency capital requirements on the free cash flow to equity for a P&C insurer. Range of weight for Learning Objectives B1-B3 collectively: 8-12 percent	a. Free cash flow to equity for a P&C insurer
2. Value the equity of a P&C insurer based on its expected future dividends, its free cash flow to equity, or its expected abnormal earnings Range of weight for Learning Objectives B1-B3 collectively: 8-12 percent	a. Dividend Discount Model (DDM) b. Free cash flow to equity for a P&C insurer c. Discounted Cash Flow (DCF) Valuation using free cash flow to equity (FCFE), including effect of alternative methods of estimating terminal values and reasons why this method is preferred over the free cash flow to the firm (FCFF) method for P&C insurers d. Abnormal earnings e. Abnormal Earnings Valuation (AE), including effect of alternative methods of estimating terminal values
3. Value the equity of a firm using comparative or relative valuation methods based on multiples of selected financial variables obtained from either peer companies or from underlying fundamentals. Range of weight for Learning Objectives B1-B3 collectively: -8-12 percent	a. Comparative valuation ratios including price-earnings, price-sales, price-book, price-cash flow b. Relationship between the dividend discount model and the price-earnings (P-E) ratio c. Relationship between the abnormal earnings valuation model and the price-book value (P-BV) ratio
READINGS	
Goldfarb	

C. Enterprise Risk Management

Range of weight for Section C: 35-45 percent

This section introduces the candidate to the concepts and basic techniques of Enterprise Risk Management (ERM). ERM seeks to integrate the entire landscape of risk that confronts a business. Topics include value of risk management and basic modeling concepts.

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
1. Demonstrate how insurance and financial risk can be analyzed quantitatively. Range of weight: 9-11 percent	a. Currency risk b. Credit risk c. Spread risk d. Interest rate risk e. Equity risk f. Hazard/insurance risk

READINGS
Brehm et al IAA

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
2. Describe the use of enterprise-wide risk modeling and aggregation techniques. 3. Evaluate and select appropriate models to handle diverse risks, including stochastic approaches. Range of weight: 9-11 percent	a. Incorporating the use of correlation b. Evaluation and selection of appropriate copulas as part of the process of modeling multi-variate risks c. Alternatives to copulas d. Scenario analysis e. Stress testing f. Tail dependence and tail correlations g. Low frequency/high severity events h. Model and parameter risk

READINGS
Brehm et al Feldblum IAA Venter Copulas

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
4. Demonstrate the properties of various risk measures and their limitations. 5. Describe how risk measures and risk modeling, including allocation, can affect strategic management. Range of weight: 4-5 percent	a. (Semi) standard deviation b. VaR and TVaR c. Expected policyholder deficit and default put option d. Risk-adjusted TVaR e. OpVaR (including variations) f. Distortion measures and probability transforms

READINGS
IAA Venter and Underwood Venter Non-tail Measures Venter Strategic Management

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
6. Describe the rationale for, methods for, and effect of managing insurance and financial risks. Range of weight: 8-10 percent	a. Selection of appropriate degree of risk b. Risk optimization and value impact c. Retention including estimated costs compared to benefits of risk transfer, value of specific risk, costs of financial distress, taxation, firm value, financing costs, and risk attitudes of debtholders, customers, employees, etc.
READINGS	
IAA Venter and Underwood	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
7. Describe operational risk and demonstrate possible mitigation and quantification methodology. Range of weight: 1-2 percent	a. Types of operational risk b. Examples c. Quantification d. Capital charges d. Mitigation
READINGS	
Brehm et al	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
8. Evaluate best practices in risk measurement, modeling, and management of various financial and non-financial risks faced by an entity. Range of weight: 4-6 percent	a. Economic capital b. Extreme events c. Risks d. Model structure
READINGS	
Brehm et al	

Complete Text References for Exam 7

Text references are alphabetized by the citation column.

Citation	Abbreviation	Learning Objective	Source
Brehm, P.; Gluck, S.; Kreps, R.; Major, J.; Mango, D.; Shaw, R.; Venter, G.; White, S.; and Witcraft, S., Guy Carpenter, "Enterprise Risk Analysis for Property & Liability Insurance Companies," Chapter 1, Sections 2.2, 2.3, 3.1, 3.2, 4.1,4.2, 5.2, 5.4, 6.2. (Note: Chapter 4.1 was included in the prior 2014 Syllabus as "Mango and Venter").	Brehm et al	C1, C2, C3, C7, C8	**NEW SKU**
Brosius, E., "Loss Development Using Credibility," CAS Study Note, March 1993.	Brosius	A1	**OP**
Clark, D.R., "LDF Curve Fitting and Stochastic Reserving: A Maximum Likelihood Approach," Casualty Actuarial Society *Forum*, Fall 2003.	Clark	A2, A3	**OP**
Feldblum, S., "Dependency Modeling," CAS Study Note, September 2010 (Updated March 25, 2013).	Feldblum	C2, C3	**OP**
Goldfarb, R. "P&C Insurance Company Valuation," CAS Study Note, October 2010.	Goldfarb	B1, B2, B3	**OP**
Hürlimann, W., "Credible Loss Ratio Claims Reserves: The Benktander, Neuhaus and Mack Methods Revisited," *Astin Bulletin* 39(1), pp. 81-99, 2009. Candidates are not responsible for mathematical proofs.	Hürlimann	A1	**OP**
International Actuarial Association, "A Global Framework for Insurer Solvency Assessment," a research report of the Insurer Solvency Assessment Working Party, 2004, Chapters 1, 2, 5, 7, 8, and 9; Appendices B, D, E, H, and I. Including Errata.	IAA	C1, C2, C3, C4, C5, C6	**OP**
Mack, T., "Measuring the Variability of Chain Ladder Reserve Estimates," Casualty Actuarial Society *Forum*, Spring 1994.	Mack (1994)	A2, A3	**OP**
Mack, T. "Credible Claims Reserve: The Benktander Method," *ASTIN Bulletin*, 2000, pp. 333-337.	Mack (2000)	A1	**OP**
Marshall, K.; Collings, S.; Hodson, M.; and O'Dowd, C., "A Framework for Assessing Risk Margins," Institute of Actuaries of Australia 16th General Insurance Seminar, 9-12 November 2008, Coolum, Australia.	Marshall et al.	A5-A10	**OP**
Patrik, G.S., "Reinsurance," *Foundations of Casualty Actuarial Science* (Fourth Edition), Casualty Actuarial Society, 2001, Chapter 7, pp. 434-464 (section on Reinsurance Loss Reserving).	Patrik	A11, A12, A13	**OP**
Sahasrabuddhe, R., "Claims Development by Layer: The Relationship between Claims Development Patterns, Trend and Claim Size Models" Casualty Actuarial Society *E-Forum*, Fall 2010, Volume 1 (revised January 2, 2013). Including errata.	Sahasrabuddhe	A4	**OP**

Shapland, M.; and Leong, J.W.K., "Bootstrap Modeling: Beyond the Basics," Casualty Actuarial Society *E-Forum*, Fall 2010. Including errata.	Shapland and Leong	A5-A10	**OP**
Siewert, J.J., "A Model for Reserving Workers Compensation High Deductibles," Casualty Actuarial Society *Forum*, Summer 1996, pp. 217-244.	Siewert	A4	**OP**
Teng, M.T.S.; and Perkins, M.E., "Estimating the Premium Asset on Retrospectively Rated Policies," *PCAS* LXXXIII, 1996, pp. 611-647, excluding Section 5. Including discussion of paper: Feldblum, S., *PCAS* LXXXV, 1998, pp. 274-315, Sections 1 and 2 only. Candidates will not be held responsible for specific Annual Statement notation but will be responsible for concepts presented.	Teng and Perkins	A14	**OP**
Venter, G.G., "ERM for Strategic Management—Status Report," Society of Actuaries, 2010.	Venter Strategic Management	C4, C5	**OP**
Venter, G.G., "Non-tail Measures and Allocation of Risk Measures," CAS Study Note, 1/11/2010.	Venter Non-tail Measures	C4, C5	**OP**
Venter, G.G., "Tails of Copulas," *PCAS* LXXXIX, 2002, pp. 68-113.	Venter Copulas	C2	**OP**
Venter, G.G., "Testing the Assumptions of Age-to-Age Factors," *PCAS* LXXXV, 1998, pp. 807-847.	Venter Factors	A2, A3	**OP**
Venter, G.G.; and Underwood, A., "Value of Risk Reduction," CAS Study Note, 2010.	Venter and Underwood	C4, C5, C6	**OP**
Verrall, R.J., "Obtaining Predictive Distributions for Reserves Which Incorporate Expert Opinion," Variance, Vol. 1, Issue 1, 2007, Casualty Actuarial Society. Including errata.	Verrall	A5-A10	**OP**

Source Key

OP All text references marked as Online Publications will be available on a web page titled Complete Text References.

NEW Indicates new or updated material.

SK Material included in the 2014 CAS Study Kit.

SKU Material included in the 2014 CAS Study Kit and the 2014 Update to the 2013 Study Kit.

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Institute and Faculty of Actuaries, Staple Inn Hall, High Holborn, London WC1V 7QJ, United Kingdom; telephone: +44 (0)20 7632 2111; Website: www.actuaries.org.uk.

Institute of Actuaries of Australia, Level 7 Challis House 4 Martin Place, Sydney NSW 2000, Australia; telephone: +61 (2) 9233 3466; Website: http://www.actuaries.asn.au.

International Actuarial Association, 150 Metcalfe Street, Suite 800, Ottawa, Ontario K2P 1P1, Canada; telephone: (613) 236-0886; fax: (613) 236-1386; Website: www.actuaries.org.

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Society of Actuaries, 475 N. Martingale Road, Suite 600, Schaumburg, IL 60173; telephone: 847.706.3500; Website: www.soa.org.

2015 Exam 8 Syllabus
Advanced Ratemaking

The syllabus for this four-hour exam is defined in the form of learning objectives, knowledge statements, and readings.

LEARNING OBJECTIVES set forth, usually in broad terms, what the candidate should be able to do in actual practice. Included in these learning objectives are certain methodologies that may not be possible to perform on an examination, such as complex simulations, but that the candidate would still be expected to explain conceptually in the context of an examination.

KNOWLEDGE STATEMENTS identify some of the key terms, concepts, and methods that are associated with each learning objective. These knowledge statements are not intended to represent an exhaustive list of topics that may be tested, but they are illustrative of the scope of each learning objective.

READINGS support the learning objectives. It is intended that the readings, in conjunction with the material on the lower numbered examinations, provide sufficient resources to allow the candidate to perform the learning objectives. Some readings are cited for more than one learning objective. The Syllabus and Examination Committees emphasize that candidates are expected to use the readings cited in this *Syllabus* as their primary study materials.

Thus, the learning objectives, knowledge statements, and readings complement each other. The learning objectives define the behaviors, the knowledge statements illustrate more fully the intended scope of the learning objectives, and the readings provide the source material to achieve the learning objectives. Learning objectives should not be seen as independent units, but as building blocks for the understanding and integration of important competencies that the candidate will be able to demonstrate.

Note that the range of weights shown should be viewed as a guideline only. There is no intent that they be strictly adhered to on any given examination—the actual weight may fall outside the published range on any particular examination.

The overall section weights should be viewed as having more significance than the weights for the individual learning objectives. Over a number of years of examinations, absent changes, it is likely that the average of the weights for each individual overall section will be in the vicinity of the guideline weight. For the weights of individual learning objectives, such convergence is less likely. On a given examination, in which it is very possible that not every individual learning objective will be tested, there will be more divergence of guideline weights and actual weights. Questions on a given learning objective may be drawn from any of the listed readings, or a combination of the readings. There may be no questions from one or more readings on a particular exam.

After each set of learning objectives, the readings are listed in abbreviated form. Complete text references are provided at the end of this exam syllabus.

Items marked with a bold **SK** constitute the 2015 CAS Exam 8 Study Kit that may be purchased from the CAS Online Store. Items marked with a bold **OP** (Online Publication) are available at no charge and may be downloaded from the CAS website.

Please check the "*Syllabus* Updates" section of the CAS Web Site for any changes to the *Syllabus*.

Candidates for Exam 8 are expected to have already acquired considerable technical knowledge and practical experience in insurance ratemaking. Therefore, this examination will assume a working knowledge of basic ratemaking and will deal with advanced topics. To some degree, the examination will deal with the types of practical problems that a fully qualified actuary, working in ratemaking, should b e able to solve. The ability to apply ratemaking knowledge and experience may be tested through questions dealing with problems for which there are no generally recognized solutions.

The readings for Exam 8 should be studied for illustration of basic principles and theories, as well as for insight into advanced ratemaking problems and their solutions.

A. Classification Ratemaking

Range of weight for Section A: 20-30 percent

In this exam, classification ratemaking and rate filings, which were introduced earlier in the syllabus, are treated in greater depth. The material in this section provides tools that enable the practitioner to go beyond mechanical construction to the comparison and evaluation of alternative classification schemes.

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
1. Identify and evaluate possible rate classes. Range of weight: 5-10 percent	a. Characteristics of appropriate classifications b. Sampling techniques c. Credibility considerations d. Statistical significance e. Cluster analysis
READINGS	
AAA Bailey & Simon Mahler 1 Robertson	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
2. Measure statistical significance of possible classes and estimate the loss costs of rating classes. Range of weight: 5-10 percent	a. Multidimensional relativities b. Credibility techniques c. Quintiles Test d. Holdout sample
READINGS	
Bailey & Simon Couret & Venter	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
3. Formularize and solve generalized linear models (GLMs) for classification ratemaking. Range of weight: 5-10 percent	a. GLM assumptions compared to: • One-way analysis • Minimum bias procedures • Classical linear analysis b. Components of a GLM formula c. Aliasing and near-aliasing
READINGS	
Anderson et al.	

B. Excess, Deductible, and Individual Risk Rating

Range of weight for Section B: 50-70 percent

One of the important functions performed by an actuary is rating individual risks. Prior to Exam 8, most of the readings addressed group or classification risk rating. This section is intended to prepare candidates to design and manage excess, deductible, and individual risk rating systems.

The readings range from those that discuss the theoretical foundation of excess, deductible, and individual risk rating, to those that discuss the application of specific rating plans. Candidates are expected to apply these concepts in a creative and problem-solving manner.

The first subsection covers pricing for layers of loss including excess and deductible business while the following subsections cover individual risk rating consisting of:

Experience rating, in which prior individual risk experience is used to adjust rates prospectively.

Retrospective and loss sensitive rating, in which the insured will pay an amount (in premium or retained loss) that depends on the experience after the policy has been written.

Candidates are also expected to be knowledgeable in the application of individual risk rating plans currently in use. Excerpts from the NCCI *Experience Rating Plan Manual for Workers Compensation and Employers Liability Insurance*, NCCI *Retrospective Rating Plan Manual for Workers Compensation and Employers Liability Insurance*, and ISO *Commercial General Liability Experience and Schedule Rating Plan* will be provided with the examination. Candidates are not required to memorize the details, but will be expected to be able to use the details of these plans during the examination. Since the necessary excerpts will be included with the examination, candidates will not be allowed to bring copies of the documents into the examination room.

Excess and Deductible Rating

Excess and deductible rating allows the insured to retain the risk of loss and loss expenses up to limits selected in advance.

This section builds on the material covered in the basic ratemaking section of Exam 5. Candidates should have a general knowledge and understanding of excess coverages and the problems inherent in pricing these coverages for different lines of business.

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
1. Apply frequency and severity distributions to determine expected losses by layer of insurance. Range of weight: 8-12 percent	a. Severity distributions and their uses, including increased limits factors (ILFs) and loss elimination ratios (LERs) b. Properties of ILFs and LERs c. Interaction among inflation, changes in layer, and losses d. Methods of estimating frequency and severity distributions from losses
READINGS	
Gillam & Snader 1 Lee 1 Mahler 2 Miccolis	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
2. Estimate aggregate loss distributions. Range of weight: 8-12 percent	a. Techniques to estimate aggregate loss distributions directly from aggregate data (e.g., Table M, Table L) b. Construction of an aggregate loss distribution from frequency and severity distributions
READINGS	
Brosius Gillam & Snader 2 Lee 2 Mahler 3 Skurnick	

Experience Rating

The primary goal of experience rating is the adjustment of an individual risk's rate to reflect the extent to which that risk's own experience identifies it as being different from other risks in the same class. The readings begin with principles and concepts, and then move to a discussion of plans in current use.

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
3. Adjust class rates based on individual risk experience and exposure. Range of weight: 8-12 percent	a. Actuarial principles and concepts underlying the development of experience rating plans b. Credibility concepts (e.g., maximum single loss) c. Current NCCI and ISO experience rating plans d. Schedule rating
READINGS	
Gillam Gillam & Snader 1 ISO NCCI 1 Venter	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
4. Assess effectiveness of experience rating plans. Range of weight: 5-10 percent	a. Off-balance factors b. Evaluation techniques (e.g., quintile test)
READINGS	
Gillam Venter	

Retrospective and Loss Sensitive Rating

Retrospective rating allows adjustment of individual risk premium after policy expiration in response to actual loss and expenses associated with the policy. The retrospective rating plans currently in use adjust the premium up or down within limits selected in advance.

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
5. Construct a retrospectively rated plan. Range of weight: 8-12 percent	a. Actuarial principles and concepts underlying the construction of a retrospective rating plan (e.g., balance principle, construction of table of insurance charges) b. NCCI retrospective rating plans

READINGS
Brosius Gillam & Snader 2 Lee 2 NCCI 2 Skurnick

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
6. Analyze the elements of a loss sensitive rating plan. Range of weight: 8-12 percent	a. Influence of the parameters and other elements of the plan on the final price and potential profitability of product b. Influence of the parameters and other elements of the plan on cost and cash flow to insured

READINGS
Fisher Gillam & Snader 2 Lee 2 Skurnick

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
7. Calculate the cost of the layer of risk given the loss cost. Range of weight: 4-6 percent	a. Variability of expenses by layer and policy provisions b. Large dollar deductible (LDD) and excess policy provisions c. Advantages of LDD and excess policies

READINGS
Fisher Gillam & Snader 3 Teng

C. Catastrophic and Reinsurance Pricing

Range of weight for Section C: 15-20 percent

Catastrophe Ratemaking

This subsection introduces candidates to the methods used to model losses due to catastrophic events for the purpose of generating a catastrophe risk load and to manage the total exposure from catastrophic events within an insurance portfolio.

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
1. Describe the components and structure of catastrophe models.	a. Hazard, exposure, vulnerability and loss modules b. Exceedance Probability Curve c. Simulation and modeling techniques
2. Explain the use of catastrophe models in insurance ratemaking and portfolio management. Range of weight for Learning Objectives C.1 and C.2 collectively: 4-6 percent	a. Insurability of catastrophe risks b. Sources and nature of uncertainty in catastrophe modeling c. Use of catastrophe models in insurance ratemaking d. Use of catastrophe models in portfolio management
READING	
Grossi & Kunreuther, plus Errata for Section 2.4	

Reinsurance Ratemaking

This subsection introduces candidates to current and historical methods used to price reinsurance. The candidates will be familiar with many of these methods from the materials on primary insurance ratemaking; the emphasis here is on the application of these methods in pricing reinsurance contracts.

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
3. Determine the price of various types of reinsurance contracts. Range of weight: 3-5 percent	a. Types of contracts, including excess of loss, quota share, surplus share, treaty, aggregate excess of loss, and facultative b. Common methods for pricing reinsurance, including burn cost, exposure rating and experience rating c. Reinsurance loss development and trend d. Use of increased limit factors in reinsurance pricing e. Evaluation of aggregate distribution models f. Prospective and retrospective pricing in reinsurance
4. Determine the effect of common contract provision on the price of reinsurance contracts. Range of weight: 3-5 percent	a. Pricing for reinstatements, loss corridors, clash, profit and sliding scale commissions, and other common provisions in reinsurance contracts
5. Specify, fit, and use loss distribution based exposure curves. Range of weight: 3-5 percent	a. Define an exposure curve b. Limited and unlimited distributions c. Expected value and total loss probability d. Use of MBBEFD class distributions as exposure curves
READING	
Clark Bernegger	

Complete Text References for Exam 8

Text references are alphabetized by the citation column.

Citation	Abbreviation	Learning Objective	Source
American Academy of Actuaries Committee on Risk Classification, "Risk Classification Statement of Principles," June 1980. [Available at no charge from the American Academy of Actuaries at (202) 223-8196 or on the Academy's Web Site at www.actuary.org.]	AAA	A1	**OP**
Anderson, D.; Feldblum, S; Modlin, C; Schirmacher, D.; Schirmacher, E.; and Thandi, N., "A Practitioner's Guide to Generalized Linear Models" (Third Edition), CAS Study Note, February 2007, pp. 4-39 only. [Note: the study note edition is a revised version of a paper from the *CAS Discussion Paper Program*. Candidates must use the study note edition.]	Anderson et al.	A3	**OP**
Bailey, R. A.; and Simon, L. J., "An Actuarial Note on the Credibility of Experience of a Single Private Passenger Car," *PCAS* XLVI, 1959, pp. 159-164. Including discussion of paper: Hazam, W. J., *PCAS* XLVII, 1960, pp. 150-152.	Bailey & Simon	A1-A2	**OP**
Bernegger, S., "Swiss Re Exposure Curves and the MBBEFD Distribution Class," *ASTIN Bulletin*, Vol. 27, No. 1, May 1997, pp. 99-111.	Bernegger	C3, C5	**OP**
Brosius, J. E., "Table M Construction," CAS Study Note, 2002.	Brosius	B2, B5	**OP**
Clark, D. R., "Basics of Reinsurance Pricing," CAS Study Note, Revised 2014. Candidates are not responsible for Section 6 of the paper.	Clark	C3, C4	**OP**
Couret, J.; and Venter, G., "Using Multi-Dimensional Credibility to Estimate Class Frequency Vectors in Workers Compensation," *ASTIN Bulletin*, Vol. 38, No. 1, May 2008, pp. 72-85.	Couret & Venter	A2	**OP**
Fisher, G.K., "Pricing Aggregates on Deductible Policies," CAS Study Note, May 2002.	Fisher	B6, B7	**OP**
Gillam, W. R., "Workers' Compensation Experience Rating: What Every Actuary Should Know," *PCAS* LXXIX, 1992, Sections 1-5, pp. 215-239.	Gillam	B3, B4	**OP**
Gillam, W. R.; and Snader, R. H., "Fundamentals of Individual Risk Rating," National Council on Compensation Insurance (Study Note), 1992, Part I.	Gillam & Snader 1	B1, B3	**OP**
Gillam, W. R.; and Snader, R. H., "Fundamentals of Individual Risk Rating," National Council on Compensation Insurance (Study Note), 1992, Part II.	Gillam & Snader 2	B2, B5, B6	**OP**
Gillam, W. R.; and Snader, R.H., "Fundamentals of Individual Risk Rating," National Council on Compensation Insurance (Study Note), 1992, Part III.	Gillam & Snader 3	B7	**OP**

Grossi, P.; and Kunreuther, H., Editors, *Catastrophe Modeling: A New Approach to Managing Risk*, 2005, Springer, Chapters 2-6 (excluding references at the end of each chapter). Errata 2.4.	Grossi & Kunreuther	C1, C2	**B**
Insurance Services Office, Inc., *Commercial General Liability Experience and Schedule Rating Plan*, 2006. Excerpts from the ISO Commercial General Liability Experience and Schedule Rating Plan will be provided with the exam. Candidates are not required to memorize the details, but will be expected to be able to use them on the exam. Since they will be included with the exam, candidates will not be allowed to bring copies of the documents into the examination room.	ISO	B3	**SK**
Lee, Y. S., "The Mathematics of Excess of Loss Coverages and Retrospective Rating—A Graphical Approach," Sections 1-3, *PCAS* LXXV, 1988, pp. 49-64.	Lee 1	B1	**OP**
Lee, Y. S., "The Mathematics of Excess of Loss Coverage and Retrospective Rating—A Graphical Approach," Section 4, *PCAS* LXXV, 1988, pp. 64-78. Candidates are not responsible for "Other Applications" on pp. 75-76.	Lee 2	B2, B5, B6	**OP**
Mahler, H. C., "An Example of Credibility and Shifting Risk Parameters," *PCAS* LXXVII, 1990, pp. 225-282. Candidates will not be tested on the Appendices.	Mahler 1	A1	**OP**
Mahler, H. C., Discussion of "Retrospective Rating: 1997 Excess Loss Factors," *PCAS* LXXXV, 1998, pp. 316-344. Appendices B-D are for reference only; candidates do not need to memorize formulas in Appendices B-D. Including Errata.	Mahler 2	B1	**OP**
Mahler, H. C., "Workers Compensation Excess Ratios: An Alternative Method of Estimation," PCAS LXXXV, 1998, pp. 132-156.	Mahler 3	B2	**OP**
Miccolis, R. S., "On the Theory of Increased Limits and Excess of Loss Pricing," *PCAS* LXIV, 1977, pp. 27-59 excluding "Risk Reduction by Layering" (pp. 45-49). Including discussion of paper: Rosenberg, S., *PCAS* LXIV, 1977, pp. 60-73.	Miccolis	B1	**OP**
National Council on Compensation Insurance, *Experience Rating Plan Manual for Workers Compensation and Employers Liability Insurance*. Candidates are responsible for only the excerpted material included in the Study Kit. Candidates are not required to memorize the details, but will be expected to be able to use them on the examination. Since the required excerpts will be included with the examination, candidates will not be allowed to bring copies of the documents into the examination room.	NCCI 1	B3	**SK**

National Council on Compensation Insurance, *Retrospective Rating Plan Manual for Workers Compensation and Employers Liability Insurance*. Candidates are responsible for only the excerpted material included in the Study Kit, excluding Part 2, Section III, on cancellation provisions. Candidates are not required to memorize the details, but will be expected to be able to use them on the examination. Since the required excerpts will be included with the examination, candidates will not be allowed to bring copies of the documents into the examination room.	NCCI 2	B5	**SK**
Robertson, J.P., "NCCI's 2007 Hazard Group Mapping," *Variance*, Vol. 3, Issue 2, 2009, Casualty Actuarial Society, pp. 194-213.	Robertson	A1	**OP**
Skurnick, D., "The California Table L," *PCAS* LXI, 1974, pp. 117-140. Including discussion of this paper: Gillam, W.R., *PCAS* LXXX, 1993, pp. 353-365.	Skurnick	B2, B5, B6	**OP**
Teng, M.T.S., "Pricing Workers' Compensation Large Deductible and Excess Insurance," Casualty Actuarial Society *Forum*, Winter 1994, pp. 413-437.	Teng	B7	**OP**
Venter, G.G., "Experience Rating—Equity and Predictive Accuracy," *NCCI Digest*, April 1987, Volume II, Issue I, pp. 27-35. (Pages are shown as 1-9 in the Study Kit version.)	Venter	B3, B4	**SK**

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SK   Material included in the 2015 CAS Study Kit.

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2015 Exam 9
Financial Risk and Rate of Return

The syllabus for this four-hour exam is defined in the form of learning objectives, knowledge statements, and readings.

LEARNING OBJECTIVES set forth, usually in broad terms, what the candidate should be able to do in actual practice. Included in these learning objectives are certain methodologies that may not be possible to perform on an examination, such as complex simulations, but that the candidate would still be expected to explain conceptually in the context of an examination.

KNOWLEDGE STATEMENTS identify some of the key terms, concepts, and methods that are associated with each learning objective. These knowledge statements are not intended to represent an exhaustive list of topics that may be tested, but they are illustrative of the scope of each learning objective.

READINGS support the learning objectives. It is intended that the readings, in conjunction with the material on the lower numbered examinations, provide sufficient resources to allow the candidate to perform the learning objectives. Some readings are cited for more than one learning objective. The Syllabus and Examination Committees emphasize that candidates are expected to use the readings cited in this *Syllabus* as their primary study materials.

Thus, the learning objectives, knowledge statements, and readings complement each other. The learning objectives define the behaviors, the knowledge statements illustrate more fully the intended scope of the learning objectives, and the readings provide the source material to achieve the learning objectives. Learning objectives should not be seen as independent units, but as building blocks for the understanding and integration of important competencies that the candidate will be able to demonstrate.

Note that the range of weights shown should be viewed as a guideline only. There is no intent that they be strictly adhered to on any given examination—the actual weight may fall outside the published range on any particular examination.

The overall section weights should be viewed as having more significance than the weights for the individual learning objectives. Over a number of years of examinations, absent changes, it is likely that the average of the weights for each individual overall section will be in the vicinity of the guideline weight. For the weights of individual learning objectives, such convergence is less likely. On a given examination, in which it is very possible that not every individual learning objective will be tested, there will be more divergence of guideline weights and actual weights. Questions on a given learning objective may be drawn from any of the listed readings, or a combination of the readings. There may be no questions from one or more readings on a particular exam.

After each set of learning objectives, the readings are listed in abbreviated form. Complete text references are provided at the end of this exam syllabus.

Items marked with a bold **SK** constitute the 2014 CAS Exam 9 Study Kit that may be purchased from the CAS Online Store. Items marked with a bold **OP** (Online Publication) are available at no charge and may be downloaded from the CAS website. Books and other publications marked with a bold **B** may be purchased from the publisher or a bookstore (with limited copies available to be borrowed from the CAS Library).

Please check the "Syllabus Update" for this exam for any changes to this syllabus.

Exam 9 focuses on a broad array of finance, investment, and financial risk management topics. This examination assumes a working knowledge of basic ratemaking, finance, probability and statistical modeling, liability and reserve risk, and insurance underwriting. The ability to apply this knowledge and experience may be tested through questions dealing with problems for which there are no generally recognized solutions.

TEXTS FOR THIS EXAM

There are two main texts: *Investments* (Tenth Edition) by Bodie, Kane, and Marcus and *Options, Futures and Other Derivatives* (Eighth Edition) by Hull. *Investments* contains references to various websites. Candidates are not responsible for the identity of the websites or the actual content of the websites except to the extent that the content is reproduced in the text. Candidates are also not responsible for any aspect of the Excel applications or the boxes entitled "E-Investments" that are usually placed at or towards the end of a chapter.

While, in general, it is suggested that the candidate cover the learning objectives in the order listed, some references to later chapters in texts may occur before references to earlier chapters. In these cases, the candidate may need to review the earlier chapters first and then return to the learning objectives that reference the later chapters.

For the Financial Risk and Rate of Return exam, the appendices are part of the material covered unless specifically excluded.

There are various numeric tables scattered throughout the readings, illustrating actual observations or hypothetical examples. Candidates are not responsible for the actual numeric values.

BACKGROUND

Candidates may find it helpful to review Chapters 1-5 of *Investments* for background in financial markets and instruments as well as the Venter paper for background on liquidity risk.

A. Portfolio Theory and Equilibrium in Capital Markets

Range of weight for Section A: 20-30 percent

The portfolio theory portion of this section discusses the relationship between the risk and return for different combinations of risky and risk-free investments and discusses the effect of diversification on this relationship. Candidates are introduced to the manner in which investors might select a particular portfolio, from those available, that best suits their individual preferences for risk and return. In the portion of this section on equilibrium in capital markets, various equilibrium models are presented, including the Capital Asset Pricing Model (CAPM) and Arbitrage Pricing Theory (APT). The concept of market efficiency is presented to help candidates understand the factors that move market prices towards and away from the theoretical prices presented in these models.

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
1. Explain key concepts of risk: • Appetite • Tolerance • Aversion • Measurement • Portfolio construction • Strategies for monitoring Range of weight: 0-5 percent	a. Utility functions, utility scores, and utility maximization b. Risk aversion c. Mean-variance criterion d. Capital allocation line e. Complete portfolio f. Reward to volatility ratio (Sharpe ratio) g. Passive versus active strategies: costs of active strategy and free-rider benefit
READINGS	
BKM, Chapter 6	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
2. Calculate the expected value, variance, and covariance of returns of asset portfolios in a multi-dimensional setting. Range of weight: 0-5 percent	a. Expected return and standard deviation for portfolios of risky and risk-free assets b. Optimal risky portfolio c. Optimal complete portfolio
3. Describe the Markowitz Portfolio Selection Model. Range of weight: 3-7 percent	a. Minimum variance frontier b. Efficient frontier of risky assets c. Optimal capital allocation line d. Separation property e. Asset allocation versus security selection
4. Explain and demonstrate effects of various diversification strategies. Range of weight: 0-5 percent	a. Systematic risk b. Risk pooling c. Risk sharing d. Insurance principle
READINGS	
BKM, Chapter 7	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
5. Explain and use the single factor models and compare/contrast the process of portfolio construction with the full covariance (Markowitz) model. Range of weight: 3-7 percent	a. Markowitz model b. Single factor model c. Single index model d. Systematic risk e. Alpha, Beta estimating and forecasting f. Covariance and correlation estimates for single index model g. Risk premiums due to market and non-market factors h. Parameter estimation risk i. Macroeconomic factors
READINGS	
BKM, Chapter 8	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS

6. Explain the assumptions and construction of CAPM and use CAPM to calculate expected returns for risky securities.
 	
Range of weight: 3-7 percent
	a. CAPM assumptions
	b. Market price of risk
	c. Capital market line
	d. Security market line
	e. Extensions of CAPM
	   • Zero Beta CAPM
	   • CAPM with non-traded assets and labor income
	     • ICAPM
	   • CAPM with liquidity adjustments

7. Compare/contrast CAPM and single index model and explain the assumptions that are modified under various extensions of CAPM. Range of weight: 0-5 percent	a. CAPM b. Single index model c. Expected versus actual returns d. Market portfolio versus market index
READINGS	
BKM, Chapter 9	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
8. Use APT to determine the expected return for a security and compare/contrast with CAPM and factor models. Range of weight: 0-5 percent	a. Arbitrage and the Law of One Price b. APT and its comparison to CAPM c. Factor betas d. Factor portfolios and factor risk premiums e. Alternative factors in multifactor models
READINGS	
BKM, Chapter 10	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
9. Explain market efficiency and its implications for portfolio management, and describe the various tests and studies of market efficiency. Range of weight: 0-5 percent	a. Efficient market hypothesis b. Random walk c. Technical analysis d. Fundamental analysis e. Passive investment strategy f. Portfolio management
READINGS	
BKM, Chapter 11	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
10. Explain the influence of behavioral finance in understanding certain aspects of market efficiency. Range of weight: 0-5 percent	a. Information processing errors b. Behavioral biases c. Limits to arbitrage d. Violations of Law of One Price e. Behavioral critique f. Technical analysis
READINGS	
BKM, Chapter 12	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
11. Describe the use of historical data to test the CAPM and APT, the statistical limitations of these tests and the key findings of various studies. Range of weight: 0-5 percent	a. Two-stage test of the expected return - beta relationship b. Roll's critique c. Important tests of CAPM and their results/conclusions d. Accounting for Human Capital, Cyclical Variations, and Nontraded Business e. Chen, Roll and Ross tests of APT f. Fama and French's 3-Factor Model, including alternative explanations of the empirical results
12. Describe the Equity Premium Puzzle and various explanations for the puzzle. Range of weight: 0-5 percent	a. Equity Premium Puzzle b. Expected vs. realized returns c. Survivorship bias d. Extensions of CAPM e. Behavioral explanations
READINGS	
BKM, Chapter 13	

B. Asset-Liability Management

Range of weight for Section B: 15-25 percent

This section exposes the candidate to factors that influence the price sensitivity of fixed income securities and presents various ways in which a portfolio manager might manage the interest rate and cash flow risk in a portfolio of these instruments. The same concepts are also applied to the interest rate risk associated with a firm's liabilities and the interest rate risk associated with a firm's total market value, inclusive of their franchise value.

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
1. Explain the different Term Structure Theories. Range of weight: 0-5 percent	a. Expectations hypothesis b. Liquidity preference theory c. Segmentation theory d. Forward rate versus expected spot rate
2. Determine U.S. Treasury zero rates at different maturities. Range of weight: 3-7 percent	a. Bootstrap method for determining zero rates from coupon bonds using both continuous and semi-annual compounding b. Determining forward rates from spot rates (zero rates) c. Spot rates d. Short rates e. LIBOR zero rates f. Forward Rate Agreements
READINGS	
BKM, Chapter 15 Hull, Chapter 4	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
3. Utilize various strategies to manage interest rate risk and cash flow risk in a bond portfolio. Range of weight: 3-7 percent	a. Duration (Macaulay, modified, and effective) b. Convexity c. The effect of interest changes on bond prices d. Immunization e. Cash flow matching and dedication f. Rebalancing g. Use of interest rate swaps, mortgage-backed securities, and other derivative securities to alter the interest rate risk for a bond portfolio h. Currency swaps
READINGS	
BKM, Chapter 16 Hull, Sections 4.8 and 4.9, and Chapter 7	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
4. Calculate the Macaulay duration of loss reserves and the Macaulay duration of the surplus of a property and casualty (P&C) insurance company. Range of weight: 0-5 percent	a. Macaulay duration b. Relationship between surplus, asset, and liability durations
5. Understand the importance of Asset/Liability Matching (ALM) for property and casualty (P&C) insurance companies. Range of weight: 0-5 percent	a. Differences between life insurance and P&C insurance and its effect on ALM techniques b. Matching Techniques: cash flow matching & duration matching c. Inflation sensitive cash flows d. Choice of investment for P&C insurance companies - in theory and in practice.
READINGS	
Feldblum Asset Noris (excluding Sections I, II, V, and VI)	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
6. Quantify franchise value, evaluate the impact of interest rate sensitivity, and demonstrate how interest rate sensitivity of the franchise value can be managed. Range of weight: 0-5 percent	a. Total economic value b. Franchise value—magnitude and exposure to interest rate risk (duration) c. Pricing strategy d. Advantages of managing the interest rate sensitivity of the firm's total economic value through pricing strategy
READINGS	
Panning	

C. Financial Risk Management

Range of weight for Section C: 20-30 percent

This section addresses financial risks as well as risks related to the insurance industry from the financial economics perspective. The concepts and techniques presented in this section are important components in the field of enterprise risk management.

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
1. Estimate the credit risk due to default and default correlation associated with fixed income securities. Range of weight: 0-5 percent	a. Default intensity or hazard rate b. Unconditional default probability c. Expected loss from default d. Yield spread e. Recovery rate f. Relationship between asset volatility and equity volatility. g. Merton's model h. Credit ratings transition matrix i. Use of Gaussian copula to simulate correlated ratings transitions for two bonds j. *CreditMetrics* approach to estimating credit value at risk
2. Describe the credit risk in derivatives transactions and various mechanisms to manage the risk. Range of weight: 0-5 percent	a. Counterparty default risk b. Netting c. Collateralization d. Downgrade triggers
READINGS	
Hull, Chapter 23	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
3. Describe the reasons for the development of credit derivatives market, the valuation of credit derivative contracts, and the complexity of trading credit risks. Range of weight: 0-5 percent	a. Credit default swaps (CDS) b. Mark-to-market c. Total Return Swaps d. Collateralized debt obligation (CDO) and synthetic CDO e. The role CDS played in the 2008 financial crisis
READINGS	
Coval, Jurek, and Stafford Hull, Chapter 24 (24.1-24.9)	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
4. Describe liquidity risk and various mechanisms to manage the risk. Range of weight: 0-5 percent	a. Liquidity risk b. Sources of liquidity risk c. Risk reduction techniques d. Lessons from the recent economic crises
READINGS	
Academy Venter	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
5. Discuss the development and the complexity of financial engineering products such as mortgage-backed securities and other forms of securitization. Range of weight: 0-5 percent	a. Effect of securitization on sources of funds for mortgage holders and on interest rate risk retained by the mortgage originators b. Mortgage pass-throughs and the effect of mortgage prepayment on cash flows to investors c. Collateralized mortgage obligations (CMOs) and the effect of prepayments on cash flows to investors in particular tranches d. Market liquidity and credit rating e. Lessons from the recent subprime crisis

6. Describe the market for securitizing catastrophe risk in the insurance industry and explain the reasons for its growth.
 	
Range of weight: 0-5 percent
	a. Products on the market:
	  • Risk-linked securities
	  • CAT bonds
	  • Sidecars
	  • Cat-E-puts
	  • Catastrophe risk swaps
	  • Industry loss warranties
	b. Factors influencing interest in insurance securitization in relation to traditional reinsurance
	c. Factors impeding the growth of the market:
	  • Regulatory
	  • Accounting
	  • Tax
	  • Rating issues

READINGS
BKM, Chapters 1 (pp. 18-19), 2 (pp. 39-41), and 16 (Section 16.2) Coval, Jurek, and Stafford Cummins CAT Bond

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
7. Describe various risk measures and the need for practicing sound financial risk management. Range of weight: 0-5 percent	a. Capital structure and risk taking incentives b. Regulation and rating agency c. Value at risk (VaR) d. Cash flow at risk e. Shortfall risk f. Risk-based capital g. Expected policyholder deficit (EPD) h. Capital associated with a constant EPD ratio i. Risk-adjusted return on capital (RAROC), including alternative measures of income and alternative measures of risk-adjusted capital j. Economic value added (EVA) k. Friction costs, including agency costs and double taxation l. Lessons from past failures due to poor financial risk management m. Manager incentives as motivations for hedging risk

READINGS
Butsic   Culp, Miller and Neves (excluding Appendix)   Cummins Capital   Goldfarb   Stulz

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS

8. Describe the concept of economic capital (or risk capital) in the insurance industry and various methods of allocating the risk capital to business units or lines of business.
 	
Range of weight: 0-5 percent
	a. Financial and insurance risks
	b. Economic capital or risk capital
	c. Risk aggregation
	d. Strengths and weaknesses of the various allocation methods using risk measures such as:
	  • Percentile (VaR)
	  • Conditional tail expectation (CTE)
	  • EPD Ratio
	  • Merton-Perold method
	  • Insolvency Put/EPD ratio risk measure
	  • Myers-Read method
	  • Co-Measures
	  • Co-CTE

9. Apply the RAROC framework to risk management in the insurance industry. Range of weight: 0-5 percent	a. Economic profit as income measure b. Cost of capital c. RAROC d. Additional risk margin in price e. Multi-period capital commitment
10. Assess the performance of business units and set prices for insurance policies on a risk-adjusted basis. Range of weight: 0-5 percent	a. Economic profit as income measure b. Cost of capital c. RAROC d. Additional risk margin in price e. Multi-period capital commitment
READINGS	
Cummins Capital Goldfarb	

D. Rate of Return, Risk Loads, and Contingency Provision

Range of weight for Section D: 25-35 percent

This section explores the relationship between insurance concepts (such as underwriting profits, premium-to-surplus ratios, and investment income) and financial concepts (such as interest rates, inflation rates, cost of capital, and risk premiums). The readings build on a background of finance as related to the insurance business, and deal with specific techniques used by actuaries to develop an appropriate profit loading in insurance prices.

Because insurance claims are fortuitous, the expected profit loaded in rates may not be realized. Some models discuss insured events that are predictable in time and amount while other models consider when insured events are uncertain, particularly where capacity is limited and/or sufficient diversification of exposure is impossible.

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
1. Evaluate the internal rate of return framework. Range of weight: 3-7 percent	a. Inter-relationship between the product market and financial market b. Capital structure of insurance company compared to other industries c. Decision rule of the IRR model d. Distinction between equity flows and all other cash flows
	e. Impact of surplus allocation and timing on equity flows f. Methods of allocating surplus and impact on IRR g. Potential pitfalls in IRR analysis
READINGS	
Feldblum Financial	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
2. Evaluate the components of total return to stockholders and how leverage can be used to maximize shareholder value. Range of weight: 0-5 percent	a. Relationship between profitability measures from investors' perspective, society's perspective, and regulators' perspective b. Insurance leverage and reserve capital c. Influence of leverage on stockholders' equity d. Optimal capital structure e. Dynamic relationship among formula variables
READINGS	
Ferrari	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
3. Assess insurance profitability. Range of weight: 0-5 percent	a. Policyholder versus investor perspectives b. Return on equity versus return on sales c. Methods to determine benchmark rate of return
READINGS	
McClenahan	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
4. Describe the underwriting profit provision. Range of weight: 0-5 percent	a. Evolution of the profit provision b. Policyholder versus stockholder return c. Types of underwriting profit
5. Calculate and compare the provision for underwriting profit in property and casualty insurance rates. Range of weight: 3-7 percent	a. Calendar Year Investment Offset procedure b. Present Value Offset procedure c. Calendar Year Return on Equity method d. Present Value of Income over Present Value of Equity method e. Present Value Return on Cash Flow method f. Risk-Adjusted Discounted Cash Flow method g. Internal Rate of Return on Equity Flows method
READINGS	
Robbin	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
6. Assess the risks of allocating surplus. Range of weight: 0-5 percent	a. Controversies regarding surplus allocation and leverage ratio b. Sources of risks contributing to surplus need
7. Analyze and calculate income and total rate of return Range of weight: 0-5 percent	a. Measurement of the required rate of return b. Capital structure and the required rate of return
READINGS	
Roth	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
8. Use investment-equivalent reinsurance pricing to determine risk loads. Range of weight: 3-7 percent	a. Kreps' paradigm b. Loss safety level c. Swap technique d. "Put" option technique e. High excess layer f. Effects of pooling
READINGS	
Kreps	

LEARNING OBJECTIVES	KNOWLEDGE STATEMENTS
9. Calculate and compare the risk loads for property catastrophe insurance. Range of weight: 3-7 percent	a. Order dependency b. Marginal Surplus method c. Marginal Variance method d. Sub-additive and super-additive properties e. Renewal additivity f. Shapley Value method g. Covariance Share method
READINGS	
Mango	

Complete Text References for Exam 9

Text references are alphabetized by the citation column.

Citations	Abbreviation	Learning Objective	Source
American Academy of Actuaries, "Report of the Life Liquidity Work Group of the American Academy of Actuaries to the NAIC's Life Liquidity Working Group," December 2, 2000, pp. 1-9 (up to but excluding "Possible Sources of Liquidity Risk: Embedded Liquidity Options"), 12 (last paragraph) – 16 (first paragraph).	Academy	C4	**OP**
Bodie, Z.; Kane, A.; and Marcus, A.J., *Investments* (Tenth Edition), McGraw-Hill/Irwin, 2014. Chapter or section citations are listed under the appropriate learning objective.	BKM	A1-A10, B1-B3, C5-C6	**B**
Butsic, R.P., "Solvency Measurement for Property-Liability Risk-Based Capital Applications," *The Journal of Risk and Insurance*, Volume 61, No. 4 (December 1994), pp. 656-690.	Butsic	C7-C7	**SK**
Coval, J.; Jurek, J.; and Stafford, E., "The Economics of Structured Finance," *Journal of Economic Perspectives*, American Economic Association, Volume 23, Number 1, Winter 2009.	Coval, Jurek, and Stafford	C3, C5, C6	**SK**
Culp, C.L.; Miller, M.H.; and Neves, A.M.P., "Value at Risk: Uses and Abuses," *The New Corporate Finance: Where Theory Meets Practice* (Third Edition), Chew, D.H., editor; McGraw-Hill/Irwin, 2001, Chapter 33, pp. 462-471.	Culp, Miller, and Neves	C7	**SK**
Cummins, J. D., "Allocation of Capital in the Insurance Industry," *Risk Management and Insurance Review*, American Risk and Insurance Association, Inc., Spring 2000, Vol. 3, No. 1, pp. 7-27.	Cummins Capital	C7-C10	**SK**
Cummins, J. D., "CAT Bond and Other Risk-Linked Securities: State of the Market and Recent Developments," *Risk Management and Insurance Review*, American Risk and Insurance Association, Inc., 2008, Vol. 11, No. 1, pp. 23-47.	Cummins CAT Bond	C5-C6	**SK**
Feldblum, S., "Asset Liability Matching For Property/Casualty Insurers," *Valuation Issues, CAS Special Interest Seminar*, 1989, pp. 117-154.	Feldblum Asset	B4-B5	**OP**
Feldblum, S., "Pricing Insurance Policies: The Internal Rate of Return Model," CAS Study Note, May 1992. Only Sections 1, 3, and 6 will be directly tested, but the other sections may provide useful background.	Feldblum Financial	D1	**OP**
Ferrari, J.R., "The Relationship of Underwriting, Investment, Leverage, and Exposure to Total Return on Owners' Equity," *PCAS* LV, 1968, pp. 295-302. Includes discussion: Balcarek, R.J., *PCAS* LVI, 1969, pp. 58-60.	Ferrari	D2	**OP**
Goldfarb, R. "Risk-Adjusted Performance Measurement for P&C Insurers," October 2010.	Goldfarb	C7-C10	**OP**
Hull, J.C., *Options, Futures, and Other Derivatives* (Eighth Edition), Prentice Hall, 2012. Chapter or section citations are listed under the appropriate learning objective.	Hull	B1-B3, C1-C3	**B**

Kreps, R.E., "Investment-Equivalent Reinsurance Pricing," *Actuarial Considerations Regarding Risk and Return In Property-Casualty Insurance Pricing*, Casualty Actuarial Society, 1999, Chapter 6, excluding Section IV; including Errata.	Kreps	D8	**OP**
Mango, D.F, "An Application of Game Theory: Property Catastrophe Risk Load," *PCAS* LXXXV, 1998, pp. 157-186.	Mango	D9	**OP**
McClenahan, C.L., "Insurance Profitability," *Actuarial Considerations Regarding Risk and Return in Property- Casualty Insurance Pricing*, Casualty Actuarial Society, 1999, Chapter 8.	McClenahan	D3	**OP**
Noris, P.D., "Asset/Liability Management Strategies for Property and Casualty Companies," Morgan Stanley, May 1985.	Noris	B4	**SK**
Panning, W.H., "Managing Interest Rate Risk: ALM, Franchise Value, and Strategy," Willis Re Working Paper, July 2006.	Panning	B6	**OP**
Robbin, Ira, "The Underwriting Profit Provision," CAS Study Note, as updated in 1992.	Robbin	D4-D5	**OP**
Roth, R., "Analysis of Surplus and Rate of Return Without Using Leverage Ratios," *Insurer Financial Solvency, Casualty Actuarial Society Discussion Paper Program*, 1992, Volume I, pp. 439-464.	Roth	D6-D7	**OP**
Stulz, R.M., "Rethinking Risk Management," *The New Corporate Finance: Where Theory Meets Practice* (Third Edition), Chew, D.H., editor; McGraw-Hill/Irwin, 2001, Chapter 29, pp. 411-427.	Stulz	C7	**SK**
Venter, G., "Modeling and Managing Liquidity Risk," Society of Actuaries.	Venter	C4	**OP**

Source Key

B   Book—may be purchased from the publisher or bookstore or borrowed from the CAS Library.

OP   All text references marked as Online Publications will be available on a web page titled Complete Text References above..

SK   Material included in the 2015 CAS Study Kit.

Items printed in red indicate an update, clarification, or change.

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Contact information is furnished for those who wish to purchase the text references cited for Exam 9.
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American Academy of Actuaries, 1850 M Street, NW, Suite 300, Washington,

DC 20036; telephone: (202) 223.8196; fax 202.872.1948; Website: www.actuary.org.

American Risk and Insurance Association, 716 Providence Road, Malvern, PA 19355; telephone: (610) 640-1997; Website: aria@cpcuiia.org.

Bodie, Z.; Kane, A.; and Marcus, A.J., Investments (Tenth Edition), 2014, McGraw-Hill/Irwin, 860 Taylor Station Road, Blacklick, OH 43004; telephone: (800) 262-4729.

Casualty Actuarial Society E-Forum, Forum, PCAS, and Discussion Paper Program, Casualty Actuarial Society, 4350 N. Fairfax Drive, Suite 250, Arlington, VA 22203; telephone: (703) 276-3100; fax: (703) 276-3108; e-mail: office@casact.org;
Website: www.casact.org.

Chew, D.H., editor, The New Corporate Finance: Where Theory Meets Practice (Third Edition), 2001, McGraw-Hill/Irwin, 860 Taylor Station Road, Blacklick, OH 43004; telephone: (800) 262-4729.

Hull, J.C., Options, Futures, and Other Derivatives (Eighth Edition), 2012, Prentice Hall; telephone: (800) 374-1200; Website: www.prenhall.com.

Journal of Economic Perspectives, The, American Economic Association, 2014 Broadway, Suite 305, Nashville, TN 37203, telephone: (615) 322-2595; fax: (615) 343-7590; Website: http://www.aeaweb.org/jep/index.php.

Journal of Risk and Insurance, The, American Risk and Insurance Association, 716 Providence Road, P.O. Box 3028, Malvern, PA 19355; telephone: (610) 640-1997; fax: (610) 725-1007; Website: www.aria.org.

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