Changes to Exams FM/2, M and C/4 for the May 2007 Administration

Listed below is a summary of the changes, transition rules, and the complete exam listings as they will appear in the Spring 2007 Basic Education Catalog which will be available in Fall 2006.

Summary of Changes

Exam FM/2:
- Add an introduction to financial derivatives, (forwards, options, futures, swaps) and their use in risk management.
- Add an introduction to the concept of no-arbitrage as a fundamental concept in financial mathematics.
- To accommodate the additional material, expand Exam FM/2 to a 2.5-hour multiple-choice examination.

Exam M:
- Add learning outcomes on option pricing: put-call parity, the binomial model, and Black-Scholes formula. A study note introducing actuarial applications of option pricing.
- Add learning outcomes on interpretation of option Greeks and delta-hedging
- Add learning outcomes on the features of exotic options.
- Add an introduction to Brownian motion and Itô's lemma.
- To accommodate the additional material, move loss models, including risk theory, to Exam C/4.
- Given the relative increase in the amount of material, expand Exam M to a 5-hour multiple-choice examination.

Exam C/4:
- Add lognormal models for asset prices and its relationship to the Black-Scholes formula.
- Include Monte-Carlo valuation of derivative securities with the current material on simulation
- Add characteristics and calculation of risk measures such as value at risk and conditional tail expectation.
- Add the loss models and risk theory material moved from Exam M.
- Remove interpolation and smoothing (splines).
- The exam will remain a 4-hour multiple choice examination

SOA Transition Rules

There will be no special transition rules in that candidates with credit for any of Exams FM/2, M or C/4 before May 2007 will retain credit for those exams on May 2007.

Full Spring 2007 Catalog Listings

Exam FM   Financial Mathematics

The examination for this material consists of two and one-half hours of multiple-choice questions and is identical to CAS Exam 2.

The goal of the Financial Mathematics course of reading is to provide an understanding 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 following learning outcomes are presented with the understanding that candidates are allowed to use specified calculators on the exam. The education and examination of candidates should reflect that fact. In particular, such calculators eliminate the need for candidates to learn and be examined on certain mathematical methods of approximation.

LEARNING OUTCOMES
1. Candidates will know <u>definitions</u> of key terms of financial mathematics: inflation; rates of interest [simple, compound (interest and discount), real, nominal, effective, dollar-weighted, time-weighted, spot, forward], term structure of interest rates; force of interest (constant and varying); equivalent measures of interest; yield rate; principal; equation of value; present value; future value; current value; net present value; accumulation function; discount function; annuity certain (immediate and due); perpetuity (immediate and due); stocks (common and preferred); bonds (including zero-coupon bonds); other financial instruments such as mutual funds, and guaranteed investment contracts.

    Specifically, candidates are expected to demonstrate the ability to:
    a.   Choose the term, given a definition
    b.   Define a given term
    c.   Determine an equation of value, given a valuation problem involving one or more sets of cash flows at specified times

2. Candidates will understand key <u>procedures</u> of the financial mathematics: determining equivalent measures of interest; discounting; accumulating; determining yield rates; estimating the rate of return on a fund; amortization

    Specifically, candidates are expected to demonstrate the ability to:
    a.   Calculate the equivalent <u>annual</u> effective rate of interest or discount, given a nominal annual rate and a frequency of interest conversion, discrete or continuous, other than annual.
    b.   Calculate the equivalent effective rate of interest or discount per payment period given a payment period different from the interest conversion period.
    c.   Estimate the interest return on a fund
    d.   Calculate the appropriate equivalent <u>single</u> value (present value, net present value, future (accumulated) value or combination), given a set of cash flows (level or varying), where the cash flows may occur as frequently or more frequently than interest or discount is accrued, an appropriate term structure of interest rates, the method of crediting interest (e.g., portfolio or investment year) as necessary, an appropriate set of inflation rates as necessary, and accounting for reinvestment interest rates as necessary; for example:

        i.   Calculate the loan amount or outstanding loan balance, given a set of loan payments (level or varying) and the desired yield rate (level or varying)

        ii. Calculate the price of a bond (callable or non-callable), given the bond coupons, the redemption value, the term of the bond (constant or varying), the coupon interest rate, and the desired yield rate (level or varying)

        iii. Calculate the value of a stock, given the pattern of dividends and the desired yield rate (level or varying)

        iv. Calculate the net present value, given a set of investment contributions and investment returns

e.   Calculate a unique yield rate, when it exists, given a set of investment cash flows

f.   Calculate the amount(s) of investment contributions, given there is more than one contribution, and given a set of yield rates, the amount(s) and timing of investment return(s), and the desired timing of the investment contributions

g.   Calculate the amount(s) of investment returns, given there is more than one return, and given a set of yield rates, the amount(s) and timing of investment contribution(s) and the desired timing of the investment returns; for example:

        i.   Calculate loan payments, given the loan amount(s), the term of the loan, and the desired yield rate (level or varying)

        ii. Calculate the principal and interest portions of a loan payment, given the loan amount, the set of loan payments (level or varying), and a set of interest rates (level or varying)

        iii. Calculate bond coupons or redemption values, given the bond price, the term of the bond, and the desired yield rate (level or varying)

h.   Calculate the term of an investment, given a set of cash flows (level or varying), and a set of interest rates (level or varying); for example

        i.   Calculate the length of time required to accumulate a given amount, given the yield rate and an initial amount

        ii. Calculate the length of time to repay a given loan amount, given the loan payments and the loan interest rate(s)

        iii. Calculate the time to maturity of a bond, given the price of the bond, the coupon payments, redemption value, and yield rate

3. Candidates will know <u>definitions</u> of key terms of modern financial analysis at an introductory and intuitive level, and be able to complete basic calculations involving such terms: yield curves, spot rates, forward rates, duration, convexity, and immunization.

   Specifically, candidates are expected to demonstrate the ability to:
   a. Choose the term, given a definition
   b. Write the definition, given a term
   c. Perform calculations such as:
      i.   measuring interest rate risk using duration and convexity
      ii. basic immunization calculations
      iii. cash flow matching calculations (the terms dedication and asset-liability matching are used in the readings as equivalent to cash flow matching)

4. Candidates will know <u>definitions</u> of key terms of financial economics at an introductory level: derivatives, forwards, futures, short and long positions, call and put options, spreads, collars, hedging, arbitrage, and swaps.

   Specifically, candidates are expected to demonstrate the ability to:
   a. Explain why firms might care about risk management.

b. Evaluate the risk/return characteristics of the basic building blocks of financial derivatives: forward contracts; call and put options.
c. Identify associated hedging and investment strategies.
d. Explain the use of derivatives as risk management tools.
e. Explain the cash-flow characteristics of forwards, futures and swaps.
f. Use the concept of no-arbitrage to determine the theoretical value of forwards, futures and swaps.
g. Manage financial risk through use of forwards, futures and swaps.

Note that probability-based calculations for applications of financial mathematics are in Exam M.

Texts

Option A
- *Mathematics of Investment and Credit* (Third Edition), 2004, by Broverman, S.A., Chapter 1 (1.1-1.6); Chapter 2 (2.1-2.4 excluding 2.4.2 and 2.4.3); Chapter 3 (3.1-3.3 excluding pages 188–189), Chapter 4 (4.1- 4.3.1), Chapter 5 (5.1-5.3 excluding 5.1.4 and 5.3.2), Chapter 6 (6.1-6.3 excluding 6.2), Chapter 7 (7.1- 7.2), Chapter 8 (8.2.1, 8.2.4, 8.3.1–8.3.3).

- # *Derivatives Markets* (Second Edition), 2006 by McDonald, R. Chapter 1 (1.1-1.4); Chapter 2 (2.1-2.6); Chapter 3 (3.1-3.5), Chapter 4 (4.1-4.4), Chapter 5 (5.1-5.4), Chapter 8 (8.1-8.2), Appendices 2A and 5B.

Option B
- *Financial Mathematics – A Practical Guide for Actuaries and other Business Professionals* (Second Edition), 2005, by C. Ruckman and J. Francis, Chapters 1, 2, Chapter 3 (3.1-3.9), Chapter 4 (4.1-4.5), Chapter 5, Chapter 6 (6.1-6.3), Chapter 7 (7.1-7.9), Chapter 8 (8.1-8.3).

- # *Derivatives Markets* (Second Edition), 2006 by McDonald, R. Chapter 1 (1.1-1.4); Chapter 2 (2.1-2.6); Chapter 3 (3.1-3.5), Chapter 4 (4.1-4.4), Chapter 5 (5.1-5.4), Chapter 8 (8.1-8.2), Appendices 2A and 5B.

Knowledge and understanding of financial mathematics concepts are significantly enhanced through working out problems based on those concepts. Thus in preparing for the Financial Mathematics examination, whichever of the source of textbooks students choose to use, students are encouraged to work out the textbook exercises related to the listed readings.

Study Notes

SNs for the Preliminary Education examinations are available on the SOA Web site under Exams and Jobs/Candidate and Exam Information/Spring Exam Session/Spring 2007 Basic Education Catalog – Study Notes Information. Hard copies may be purchased by using the Study Note and Published Reference order form in the back of the printed catalog or by downloading the form from the Spring Exam Session Web page.

Code	Title
FM-05-07#	FM Introductory Study Note
FM-09-05	FM Sample Exam Questions and Solutions
FM-10-05	May 2005 FM Exam Questions and Solutions
FM-12-05	November 2005 FM Exam Questions and Solutions

Exam M   Actuarial Models

The examination for this material consists of five hours of multiple-choice questions offered in two independent segments: a 3-hour life contingencies segment (Exam MLC) and a 2-hour financial economics segment (Exam MFE). Each segment will be graded separately. In addition, a candidate will not be required to take both segments during the same exam administration period.

This material develops 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. Knowledge of risk management at the level of Exam P is also assumed.

A variety of tables will be provided to the candidate in the study note package and at the examination. These include values for the standard normal distribution and illustrative life tables. These tables are also available on the SOA Web site. Since they will be included with the examination, candidates will not be allowed to bring copies of the tables into the examination room.

LEARNING OUTCOMES – LIFE CONTINGENCIES SEGMENT
A. Survival and severity models.
　1. Define survival-time random variables
　　a) for one life, both in the single- and multiple-decrement models;
　　b) for two lives, where the lives are independent or dependent (including the common shock model).
　2. Calculate the expected values, variances, probabilities, and percentiles for survival-time random variables.
　3. Define the continuous survival-time random variable that arises from the discrete survival-time random variable using a:
　　a) uniform distribution;
　　b) constant force of mortality; or
　　c) hyperbolic assumption.
B. Markov Chain Models
　1. Define non-homogeneous and homogeneous discrete-time Markov Chain models and calculate the probabilities of
　　a) being in a particular state;
　　b) transitioning between particular states.
C. Life insurances and annuities
　1. Define present-value-of-benefit random variables defined on survival-time random variables:
　　a) for one life, both in the single- and multiple-decrement models;
　　b) for two lives, where the lives are independent or dependent (including the common shock model).
　2. Define and calculate the expected values, variances and probabilities for:
　　a) present-value-of-benefit random variables;
　　b) present-value-of-loss-at-issue random variables, as a function of the considerations (premiums);and
　　c) present-value-of-loss random variables, as a function of the considerations (premiums).
　3. Calculate considerations (premiums) for life insurances and annuities,
　　a) using the Equivalence Principle; and
　　b) using percentiles.
　4. Calculate liabilities, analyzing the present-value-of-future-loss random variables:
　　a) using the prospective method;
　　b) using the retrospective method;
　　c) using special formulas.

5. Calculate
    a) gross considerations (expense-loaded premiums);
    b) expense-loaded liabilities (reserves);
    c) asset shares.
6. Using recursion, calculate expected values (reserves) and variances of present-value-of-future-loss random variables for general fully-discrete life insurances written on a single life.
7. Extend the present-value-of-benefit, present-value-of-loss-at-issue, present-value-of-future-loss random variables and liabilities to discrete-time Markov Chain models, to calculate
    a) actuarial present values of cash flows at transitions between states;
    b) actuarial present values of cash flows while in a state;
    c) considerations (premiums) using the Equivalence Principle;
    d) liabilities (reserves) using the prospective method.
D. Poisson processes
    1. Define Poisson process and compound Poisson process.
    2. Define and calculate expected values, variances, and probabilities for Poisson processes,
        a) using increments in the homogeneous case;
        b) using interevent times in the homogeneous case;
        c) using increments in the non-homogeneous case.

Note: Concepts, principles and techniques needed for Exam M are covered in the references listed below. Candidates and professional educators may use other references, but candidates should be very familiar with the notation and terminology used in the listed references.

Texts - Life Contingencies Segment

- *Introduction to Probability Models* (Eighth Edition), 2003, by Ross, S.M., Chapter 5, Sections 5.3.1, 5.3.2 (through Definition 5.1), 5.3.3, 5.3.4 (through Example 5.14 but excluding Example 5.13), Proposition 5.3 and the preceding paragraph, Example 5.18, 5.4.1(up to example 5.23**),** 5.4.2 (excluding Example 5.25), 5.4.3, and Exercise 40.

  And one of the following alternative references:

OPTION A
- *Actuarial Mathematics* (Second Edition), 1997, by Bowers, N.L., Gerber, H.U., Hickman, J.C., Jones, D.A. and Nesbitt, C.J., Chapter 3, Chapter 4, Sections 4.1–-4.4, Chapter 5, Sections 5.1–5.4, Chapter 6, Sections 6.1(excluding utility-theory approach), 6.2–6.4, Chapter 7, Sections 7.1(excluding utility-theory approach), 7.2–7.6, Chapter 8, Sections 8.1–8.4, Chapter 9, Sections 9.1–9.5, 9.6.1, 9.7, 9.9, Chapter 10, Sections 10.1–10.4, 10.5–10.5.1, 10.5.4, 10.6, Chapter 11, Sections 11.1–11.3 and Chapter 15, Sections 15.1–15.2.1, 15.4, 15.6–15.6.1.

OPTION B
- *Models for Quantifying Risk,* 2005, by Cunningham, R., Herzog, T. and London, R.L., Chapters 5-6, 9-13, Chapter 15, Sections 15.1-15.4, 15.6-15.7

Note: It is anticipated that candidates will have done the relevant exercises in the texts.

Study Notes - Life Contingencies Segment

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Code	Title
MLC-05-07#	Exam MLC Introductory Study Note
MLC-09-06	Exam MLC Sample Questions and Solutions
MLC-24-05	Multi-State Transition Models with Actuarial Applications
MLC-25-05	Section 8.5 from the second printing of *Actuarial Mathematics,* Second Edition **(to be used with text option A only)**

LEARNING OUTCOMES – FINANCIAL ECONOMICS SEGMENT

A. Interest rate models
   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
   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 and American options using the Black-Scholes option-pricing model.
   4. Calculate and interpret the option Greeks.
   5. Explain the cash flow characteristics of the following exotic options: Asian, barrier, compound, gap, and exchange.
   6. Explain what it means to say that stock prices follow a diffusion process.
   7. Apply Itô's lemma in the one-dimensional case.
   8. Apply option pricing concepts to actuarial problems such as equity-linked insurance.
C. Risk management techniques
   1. Explain and demonstrate how to control risk using the method of delta-hedging.

Note: Concepts, principles and techniques needed for Exam M are covered in the reference listed below. Candidates and professional educators may use other references, but candidates should be very familiar with the notation and terminology used in the listed references.

Texts – Financial Economics Segment

- # *Derivatives Markets* (Second Edition), 2006, by McDonald, R.L., Chapter 9-14 (excluding appendices), Chapter 20 through "Functions of an Itô Process", Chapter 24.

Study Notes - Financial Economics Segment

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Code	Title
MFE-05-07#	Exam MFE Introductory Study Note
MFE-09-07#	Exam MFE Sample Questions and Solutions
MFE-26-07#	Actuarial Applications of Financial Economics

Exam C   Construction and Evaluation of Actuarial Models

The examination for this material consists of four hours of multiple-choice questions and is identical to CAS Exam 4.

This material 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 Exam M. 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.

A variety of tables will be provided to the candidate in the study note package and at the examination. These include values for the standard normal distribution, chi-square distribution, and abridged inventories of discrete and continuous probability distributions. These tables are also available on the SOA and CAS Web sites. Since they will be included with the examination, candidates will not be allowed to bring copies of the tables into the examination room.

LEARNING OUTCOMES
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:

LEARNING OUTCOMES
A. Severity Models
    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.
    8. Explain the properties of the lognormal distribution.
    9. Explain the Black-Scholes formula as a limited expected value for a lognormal distribution.

B. Frequency Models
   a. For the Poisson, Mixed Poisson, Binomial, Negative Binomial, Geometric distribution and mixtures thereof (as well as compound distributions):
   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.

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

E. Risk Measures
   1. Calculate risk measures VaR, CTE and explain their use and limitations

F. Ruin Theory
   1. Calculate survival and ruin probabilities using discrete models.
   2. Describe the considerations included in a ruin model

G. Construction of Empirical Models
   1. Estimate failure time and loss distributions using
      a) Kaplan-Meier estimator, including approximations for large data sets
      b) Nelson-Aalen estimator
      c) Kernel density estimators
   2. Estimate the variance of estimators and confidence intervals for failure time and loss distributions.
   3. Estimate failure time and loss distributions with the Cox proportional hazards model and other basic models with covariates.
   4. Apply the following concepts in estimating failure time and loss distribution

      a) Unbiasedness
      b) Consistency
      c) Mean squared error

H. Construction and Selection of Parametric Models
   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
5. Determine the acceptability of a fitted model using
    a) Graphical procedures
    b) Kolmogorov-Smirnov test
    c) Anderson-Darling test
    d) Chi-square goodness-of-fit test
    e) Likelihood ratio test

I. Credibility
    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.

J. Simulation
    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.
    6. Simulate lognormal stock prices.
    7. Incorporate jumps in stock prices by mixing Poisson and lognormal random variables.
    8. Use variance reduction techniques to accelerate convergence.
    9. Use the Cholesky decomposition method for simulating correlated random variables.

Texts
- *Loss Models: From Data to Decisions,* (Second Edition), 2004, by Klugman, S.A., Panjer, H.H. and Willmot, G.E., Chapter 3, Chapter 4, Sections 4.1-4.6.6 only, Chapter 5, Chapter 6, Sections 6.1-6.7, 6.11.1 only, Chapter 7, Sections 7.1, 7.2.3, 7.3.1, 7.3.2 only, Chapters 9–11, Chapter 12 (excluding 12.5.4, 12.5.5 and 12.6), Chapter 13, and Chapter 17.

- # *Derivatives Markets* (Second Edition), 2006, by McDonald, R.L., Chapters 18-19, excluding appendices.

Reading Options for Credibility
The candidate may use any of the alternatives shown below.

Option A
- *Loss Models: From Data to Decisions,* (Second Edition)*,* 2004, by Klugman, S.A., Panjer, H.H., and Willmot, G.E., Chapter 16, Sections 16.3, 16.4 (excluding16.4.7), 16.5 (excluding 16.5.3,

16.1 (background only**),** 16.2 (background only)**.**

Option B
- *Foundations of Casualty Actuarial Science* (Fourth Edition), 2001, Casualty Actuarial Society, Chapter 8, "Credibility", by Mahler, H.C., and Dean C.G., Section 1 (background only) Sections 2–5 **(**Available as SN C-21-01**)**.
- *Topics in Credibility Theory* (Study Note C-24-05) by Dean, C.G.

Option C
- *Introduction to Credibility Theory* (Third Edition), 1999, Herzog, T.N., Chapter 1-3 (background only)**,** 4–8, and 9 (background only)**.**

Study Notes

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Code	**Title**
C-05-07#	Exam C Introductory Study Note
C-09-05	Exam C Sample Questions and Solutions
C-10-05	May 2005 Exam C Questions and Solutions
C-12-05	November 2005 Exam C Questions and Solutions
C-21-01	Credibility **(to be used with Option B only)**
C-24-05	Topics in Credibility Theory (**to be used with Option B only)**
C-25-07**#**	Risk Measures