

## 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.

### **LIFE CONTINGENCIES SEGMENT**

#### **LEARNING OUTCOMES – LIFE CONTINGENCIES SEGMENT**

- A. Survival 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. [This reference is also available as a reprint in Study Note MLC-27-07.]

**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*, Second Edition, 2006, by Cunningham, R., Herzog, T. and London, R.L., Chapters 3–10, excluding section 10.7. [Candidates may also use the First Edition, 2005, Chapters 5-6, 9–13, 15, sections 15.1–15.4, 15.6–15.7. Candidates using the First Edition will need to supplement the text with the Errata Package available on the Actex Web site at [www.actexamdriver.com](http://www.actexamdriver.com).

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

**\*Any textbook errata are included in the Introductory Study Note.**

### Study Notes - Life Contingencies Segment

Code	Title
MLC-11-07#	<a href="#">Exam MLC Introductory Study Note</a> <a href="#">Exam MLC Tables</a>  Candidates using the First Edition of <i>Models for Quantifying Risk</i> will need to supplement the text with the Errata Package available on the Actex web site <a href="http://www.actexamdriver.com">www.actexamdriver.com</a> .  <a href="#">Notational differences between <i>Actuarial Mathematics (AM)</i> and <i>Models for Quantifying Risk (MQR)</i></a> for candidates taking Exam MLC  <a href="#">Sample Problem Mapping for Exam MLC</a>
Past Exams	All released exam papers, since 2000, can be found at: <a href="http://www.soa.org/education/resources/edu-multiple-choice-essay-examinations.aspx">http://www.soa.org/education/resources/edu-multiple-choice-essay-examinations.aspx</a>
M-09-05	Exam M Sample <a href="#">Questions</a> and <a href="#">Solutions</a> Exam M Additional <a href="#">Questions and Solutions</a> Exam M Additional <a href="#">Sample Questions</a>
MLC-09-07	<a href="#">Exam MLC Sample Questions and Solutions</a>
MLC-24-05	<a href="#">Multi-State Transition Models with Actuarial Applications</a>
MLC-25-05	<a href="#">Section 8.5 from the second printing of <i>Actuarial Mathematics</i></a> , Second Edition <b>(to be used with text option A only)</b>
MLC-27-07	<a href="#">Reprint of Chapter 5 readings from <i>Introduction to Probability Models</i></a> , Eighth Edition, 2006 by Ross, S. M.

## **FINANCIAL ECONOMICS SEGMENT**

### **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. 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.

**\*Any textbook errata are included in the Introductory Study Note.**

### **Study Notes - Financial Economics Segment**

<b>Code</b>	<b>Title</b>
MFE-11-07#	<a href="#">Exam MFE Introductory Study Note</a> <a href="#">Exam MFE Tables</a> <a href="#">Some Remarks on <i>Derivatives Markets</i> - updated 06.27.07</a> <i>Derivatives Markets</i> , Errata 2006 Second Edition, first printing, by R. McDonald <a href="http://www.kellogg.northwestern.edu/faculty/mcdonald/htm/typos2e_01.html">http://www.kellogg.northwestern.edu/faculty/mcdonald/htm/typos2e_01.html</a>
Past Exams	All released exam papers, since 2000, can be found at: <a href="http://www.soa.org/education/resources/edu-multiple-choice-essay-examinations.aspx">http://www.soa.org/education/resources/edu-multiple-choice-essay-examinations.aspx</a>
MFE-09-07	<a href="#">Exam MFE Sample Questions and Solutions</a>