Exam M **Actuarial Models**

The examination for this material consists of five hours of multiple-choice questions offered in two independent segments: a three-hour life contingencies segment (Exam MLC) and a two-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. Exam MFE is administered jointly by the CAS and the SOA and is identical to CAS Exam 3F. Check the Updates section of the SOA Web site for any changes to the exam or syllabus.

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. In addition, for Exam MFE, candidates are assumed to be familiar with the earlier chapters of the McDonald text, which are in the syllabus of Exam FM.
Tables will be provided for the candidate on the SOA Web site and at the examination. For Exam MLC these include values for the standard normal distribution and illustrative life tables. For Exam MFE a table of values from the standard normal distribution and the formula for the density function of a standard normal random variable are included in the "Exam MFE Tables" that are provided in the online study note package and will be provided at the examination. Since the tables for Exam MLC and Exam MFE will be included with their respective examination, candidates will not be allowed to bring copies of the tables into the examination room.

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

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 MLC 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. The # indicates new or updated material or changes in the sections selected.

Texts - Life Contingencies Segment*

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.actexmadriver.com.

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

Study Notes - Life Contingencies Segment

Code	**Title**
MLC-11-08#	Exam MLC Introductory Study Note Exam MLC Tables Candidates using the First Edition of *Models for Quantifying Risk* will need to supplement the text with the Errata Package available on the Actex web site www.actexmadriver.com Notational differences between *Actuarial Mathematics (AM)* and *Models for Quantifying Risk* (MQR) for candidates taking MLC
Past Exams	All released exam papers, since 2000 can be found here.
MLC-09-08	Exam MLC Sample Questions and Solutions
MLC-24-05	Multi-State Transition Models with Actuarial Applications (Second printing with minor corrections, October 2007)
MLC-25-05	Section 8.5 from the second printing of *Actuarial Mathematics,* Second Edition **(to be used with text option A only)** Second Printing
MLC-28-08	Poisson Processes (and mixture distributions)

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 MFE 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. The # indicates new or updated material or changes in the sections selected.

Texts – Financial Economics Segment *

- *Derivatives Markets* (Second Edition), 2006, by McDonald, R.L., Chapters 9-11, 12.1–12.5, 13, 14, 20.1–20.6 (through "Functions of an Itô Process"), 20.7 (up to but excluding the last subsection on "Valuing a Claim on S^aQ^b"), 24.1–24.5 (up to but excluding "Forward rate agreements"), (including Errata, see below). Chapter appendices are not included in the required readings from this text.

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

Study Notes - Financial Economics Segment

Code	Title
MFE-11-08#	Exam MFE Introductory Study Note
	Exam MFE/3F Tables
	Some Remarks on *Derivatives Markets*
	Derivatives Markets, Errata 2006 Second Edition, by R. McDonald, http://www.kellogg.northwestern.edu/faculty/mcdonald/htm/typos2e.html
Past Exams	All released exam papers, since 2000 can be found here.
MFE-09-08	Exam MFE Sample Questions and Solutions (Revised 5-20-08)
	Additional Sample Questions and Solutions (#21-31) (10.06.08)