

Advanced Long-Term Actuarial Mathematics Exam – Draft Syllabus – November 2021 Draft

The following is a draft syllabus for the new Exam ALTAM, to be first offered in Spring 2023. This three-hour exam consists of 60 points of written -answer questions and is administered as a computer-based test (CBT). For additional details on CBT, please refer to [Exam Rules](#). It is possible that there will be small changes to this syllabus when the final version is released, which will be at least six months in advance of the exam. In particular, there may be adjustments to the percentage weights and the assigned readings.

DRAFT

LEARNING OUTCOMES

1. Topic: Survival Models for Multiple State Contingent Cashflows (15-25%)
Learning Objectives
The Candidate will understand key concepts concerning multiple state mortality/morbidity and joint life mortality models for insurance and annuity contracts.
Learning Outcomes
The Candidate will be able to: <ul style="list-style-type: none">a) Apply Markov multiple state models to state-contingent life and long-term health insurance, and Continuing Care Retirement Communities (CCRCs)b) Understand and critique the assumptions underlying Markov multiple state models for long term insurance.c) Derive and apply Kolmogorov's forward equations for continuous time Markov multiple state models.d) Calculate state-dependent probabilities for continuous time Markov models .e) Apply the Chapman-Kolmogorov equations to calculate discrete time transition probabilities in the Markov model.f) Understand how joint-life mortality can be modelled using (1) a time-to-status-failure random variable, and (2) a multiple state model.g) Understand the implications of independence or dependence of future lifetimes in both versions of the joint life model from 1(g). Identify sources of dependence and understand how they are accommodated in the models.h) Identify and apply standard international actuarial notation for joint life functions.

2. Topic: Estimation in the Multiple State Model (0-10%)

Learning Objectives

The Candidate will understand key concepts concerning estimation and construction of multiple state and joint life models for insurance and annuity contracts.

Learning Outcomes

The Candidate will be able to:

- a) Calculate maximum likelihood estimates of transition intensities and probabilities for multiple state and multiple decrement models, assuming piecewise constant transition intensities.
- b) Calculate approximate confidence intervals for the estimators in Topic 1(e), using asymptotic properties of the maximum likelihood estimators.
- c) Construct and deconstruct multiple decrement tables using the associated single decrement models and appropriate fractional age assumptions.

3. Topic: Premium and Policy Valuation for Long-Term State-Dependent Coverages (15-24%)

Learning Objectives

The Candidate will be able to perform calculations on the present value random variables associated with benefits and expenses for any of the models in Topic 1.

Learning Outcomes

The Candidate will be able to:

- a) Define, and interpret multiple state dependent insurance and annuity present value random variables and identify and calculate their expected values.
- b) Derive and apply two-term and three-term Woolhouse approximations for calculating expected present values of state dependent cash flows.
- c) Calculate premiums for state-contingent life and long term health insurance, CCRCs, and insurance and annuities on joint lives, using the equivalence principle.
- d) Calculate policy values for multiple state contingent life and long term health insurance, CCRCs, and insurance and annuities on joint lives.
- e) Apply Thiele's equation to multi-state dependent cash flows.

4. Topic: Profit Analysis (15-22%)

Learning Objectives

The Candidate will be able to analyze emerging surplus, and to set premiums and reserves, using profit testing.

Learning Outcomes

The Candidate will be able to:

- a) Calculate and interpret common profit measures such as expected profit, actual profit, gain, gain by source and period, profit signature, profit vector, net present value, internal rate of return, profit margin, and discounted payback period for long term life and health insurance, and annuity contracts.
- b) Calculate premiums for long term for long term life and health insurance and annuity contracts using profit testing.
- c) Calculate reserves for long term life and health insurance and annuity contracts using profit testing.

5. Topic: Pension Plans and Retirement Benefits (15-22%)

Learning Objectives

The Candidate will understand how retirement benefits are accrued, valued, and funded.

Learning Outcomes

The Candidate will be able to:

- a) Calculate replacement ratios for Defined Contribution (DC), and Defined Benefit (DB) plans, including final average salary (FAS), career average earnings (CAE), and career average revalued earnings (CARE) plans.
- b) Given data and assumptions, calculate the required contribution rate to meet a target replacement ratio for a DC plan participant, using a deterministic approach.
- c) Identify, interpret, and apply the service table and salary scale functions for pension plan valuation.
- d) For a DB plan, given participant data, plan provisions, and valuation assumptions, calculate and interpret replacement ratios, accrued benefits, gain or loss, and their expected values including adjustments such as the early retirement reduction factor, and including benefits contingent on age retirement, withdrawal, or death in service.
- e) For a DB plan, given participant data, plan provisions, and valuation assumptions, calculate and interpret the actuarial accrued liability and the normal cost for retirement, withdrawal, death in service, and dependents' benefits under the projected unit credit valuation method for FAS and CARE plans, and under the traditional unit credit valuation method for FAS, CAE and CARE plans.
- f) Identify and interpret the assumptions and methods for retiree health care plans.
- g) Given participant data, plan provisions, and valuation assumptions, calculate and interpret the expected present value of future benefits, accumulated postretirement benefit obligation (APBO), and the normal cost or service cost for retiree health care plans.

6. Topic: Embedded Options in Life Insurance and Annuity Products (15-22%)

Learning Objectives

The Candidate will understand various types of equity-linked life insurance guarantees, options that are embedded in life insurance and annuity contracts and be able to price, reserve and hedge the risk inherent in these options.

Learning Outcomes

The Candidate will be able to:

- a) Define and calculate payoffs under each of the following options embedded in insurance and annuity contracts.
 - Guaranteed minimum death benefit
 - Guaranteed minimum maturity benefit
 - Guaranteed minimum income benefit
 - Guaranteed minimum withdrawal benefit
- b) Value the following options embedded in insurance and annuity contracts, using the Black-Scholes model.
 - Guaranteed minimum death benefit
 - Guaranteed minimum accumulation/maturity benefit
- c) Use delta-hedging to reduce the risk to the insurer of issuing the options in Topic 6(b).
- d) Use deterministic (scenario-based) profit testing to assess emerging surplus for equity-linked life insurance.

Readings:

Actuarial Mathematics for Life Contingent Risks:

Chapter 7 (Section 2.4)

Chapter 8

Chapter 9

Chapter 10

Chapter 11

Chapter 13 (except section 8)

Chapter 15

Chapter 17

Chapter 18 (Section 6)