



Institute of Actuaries of India

Statutory body established under an Act of Parliament

Unit No. F-206, 2nd Floor, F Wing, Tower II, Seawoods Grand Central,
Plot no R-1, Sector 40, Nerul Road, Navi Mumbai - 400706
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Subject

B2 - Actuarial Mathematics



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COURSE STRUCTURE

SECTION	TOPIC	WEIGHTING
I	Fundamentals of actuarial modelling	10-20%
II	Actuarial mathematics and models in Life Insurance	40-45%
III	Actuarial mathematics and models in Non-life insurance and Risk Management	40-45%

TENTATIVE CHAPTER NAMES UNDER EACH SECTION WITH EXPECTED LEARNING OUTCOMES:

Section I: Fundamentals of actuarial modelling

- 1) **Actuarial models - principles, practical uses, process and limitations**
 - a. Explain the purpose and process of actuarial modelling, and discuss the limitations
 - b. Describe how preliminary considerations, model properties and analysis of model results help determine the suitability of a model to a given situation
 - c. Define and compare:
 - i. Stochastic and deterministic models
 - ii. Scenario based and proxy models

Section II: Actuarial mathematics and models in Life Insurance

- 2) **Life tables and population characteristics**
 - a. Define actuarial notation of survival and mortality probabilities used in life tables
 - b. Define life table functions at a given age and select age
 - c. Define premiums and benefits with respect to life assurance and annuity policies
 - d. Using life functions derive the survival and mortality probabilities
- 3) **Evaluation of life assurance contracts**
 - a. Define the following standard types of life assurance policies:
 - i. Whole life
 - ii. Term
 - iii. Pure Endowment
 - iv. Endowment
 - v. Deferred whole life
 - b. Using present value functions derive the expected present value and variance for each of the types of life insurance policies given above and their variants
 - c. Understand and demonstrate relationships between assurance functions
- 4) **Evaluation of life annuity contracts**
 - a. Define the following standard types of annuity policies:
 - i. Whole life level annuity
 - ii. Temporary level annuity
 - iii. Guaranteed level annuity

- b. Using present value functions derive the expected present value and variance for each of the types of annuity policies given above and their variants
- c. Understand and demonstrate relationships between annuity functions, and between annuity and assurance functions

5) Estimation of Gross and Net premiums

- a. Evaluate Gross premiums using the principle of economic equivalence
- b. Define the concept of net premium and how it is different from Gross premium

6) Estimation of Gross and Net reserves

- a. Explain Prospective and retrospective premium reserves and derive formulae to calculate the same
- b. Derive the recursive relationship between reserves at successive valuations
- c. Derive formula to evaluate profit between successive valuations
- d. Define the concept of net premium reserve and how it is different from Gross premium reserve, and derive formulae to estimate net premium reserve

7) Participating policies and discretionary benefits

- a. Derive formulae where assurance benefits increase at a constant rate
- b. Derive formulae where assurance benefits increase by a constant amount
- c. Derive formulae where annuity benefits increase at a constant rate
- d. Derive formulae where annuity benefits increase by a constant amount
- e. Outline on what basis surplus is evaluated and shared with policyholders and types of bonus

8) Joint life assurance and annuity contracts

- a. Derive formulae for assurance and annuity functions involving two lives
- b. Define the actuarial notation
- c. Derive formulae for assurance and annuity functions for contingent and reversionary benefits involving two lives

9) Single decrement & Multiple decrement models

- a. Describe the construction of multiple decrement tables, including the relationships with associated single decrement tables
- b. Define health insurance and its policy structure in terms of premiums and benefits
- c. Using Markov models of single state and multiple state in terms of transition rates and probabilities, evaluate cashflows of a simple health insurance policy
- d. Use multiple decrement tables to evaluate expected cashflows dependent upon more than one decrement, including:
 - pension benefits
 - other salary related benefits



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10) Mortality surplus

- a. Define mortality surplus and derive formulae for calculating mortality profit for single life and joint life contracts

11) Unit linked insurance contracts

- a. Define unit linked contract and concept of unit fund in a unit linked contract to express the quantum of insurance benefit
- b. Define the various charges of a unit fund
- c. Explain profit accumulation / bonus practices in a unit linked contract through guaranteed or discretionary unit price increase or by guaranteed minimum benefit

12) Profit test models and reserving aspects

- a. Describe how profit is projected in conventional and unit linked products (participating and non-participating)
- b. Describe the key methods of profit measurement
- c. Explain use of net present value approach to profit testing
- d. Explain process of calculating reserves and cashflow projections
- e. Explain the different bases used in assumptions and distinguish between experience and valuation bases

Section III: Actuarial mathematics and models in Non-life insurance and Risk Management

13) Loss distributions

- a. Demonstrate understanding of fitting a suitable loss distribution for individual claim amounts using an appropriate continuous probability distribution
- b. Estimate parameters using estimation techniques and apply goodness of fit test

14) Extreme Value Theory

- a. Define extreme events with examples
- b. Understand application of following two approaches for modelling extreme tail values:
 - i. Generalised extreme value family of distributions (Weibull, Gumbel, Frechet)
 - ii. Generalised Pareto family of distributions
- c. Define tail weight and outline the measures to quantify tail weight

15) Copulas

- a. Definition and characteristics of copula, and its uses
- b. Define the terms dependence, concordance, upper and lower tail dependence
- c. Explain the use of Gaussian copula and Archimedean family of copulas

16) Reinsurance

- a. Define excess/deductible, retention limits and layers
- b. Explain the operation of proportional and excess of loss reinsurance



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- c. Understand the difference in claims distribution for an insurer and reinsurer due to the excess/deductible and upper limit
- d. Estimate parameters of fitted reinsurance loss distribution using MLE and Method of moments

17) Risk models

- a. Understand use of compound distributions in claims modelling
- b. Describe the characteristics and derive the mean, variance and skewness of Compound Poisson, Compound Binomial and Compound Negative Binomial distributions for both the insurer and reinsurer

18) Credit Risk

- a. Define credit risk, credit events and recovery rates
- b. Discuss the following models for assessing credit risk:
 - i. Merton model
 - ii. The two-state model
 - iii. Jarrow-Lando-Turnbull model

19) Theory of financial ruin

- a. Define the theory of ruin and illustrate mathematically ruin probability
- b. Describe and apply the following concepts for estimating probability of ruin
 - i. Aggregate claims distribution model - Compound Poisson process
 - ii. Surplus process
 - iii. Lundberg's inequality
 - iv. Adjustment coefficient (with and without reinsurance)
- c. Assess the sensitivity of probability of ruin to changes in parameter estimates of the fitted aggregate loss model

Claims run-off triangles

- d. Describe the process of tabulating claims data by various cohorts
- e. Describe the uses and application of following claim triangulation methods:
 - i. Basic Chain Ladder method
 - ii. Inflation adjusted Chain Ladder method
 - iii. Average cost per claim method
 - iv. Bornhuetter-Fergusson method
