



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

A2 - Statistics for Risk Modelling



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COURSE STRUCTURE

SECTION	TOPIC	WEIGHTING
I	Stochastic processes	25-30%
II	Survival and hazard models	25-30%
III	Population forecasts, Graduation methods and exposed to risk	15-20%
IV	Time Series models	20-25%
V	Machine Learning	10-15%

TENTATIVE CHAPTER NAMES UNDER EACH SECTION WITH EXPECTED LEARNING OUTCOMES:

Section I: Stochastic processes

1. Define following concepts in the context of stochastic process:
 - a. Stochastic process with examples
 - b. Mixed process (discrete / continuous time) U (discrete / continuous space)
 - c. Stationarity
 - d. Independent increments
 - e. Filtrations
 - f. Markov property of stochastic processes
 - g. White noise
2. Describe following concepts and their application in the context of Markov Chains:
 - a. Features of a Markov Chain
 - b. Chapman Kolmogorov equations to represent Markov Chains
 - c. Time inhomogeneous Markov model
 - d. Simulation of Markov chains
3. Explain foundations of a two state Markov model and compare with survival models and waiting times
4. Estimate the transition intensities for a two state Markov model using MLE
5. Estimate the constant force of mortality of a Poisson model using MLE
6. Within the ambit of time homogeneous Markov chains:
 - a. Define properties of a Poisson process and sum of independent Poisson processes
 - b. Define properties of time homogeneous Markov jump process and its Chapman Kolmogorov equation
 - c. Describe a Generator matrix and show the Backward and Forward differential equations
 - d. Define and estimate Occupancy and transition probabilities
 - e. Estimate transition rates using MLE
7. Within the ambit of time inhomogeneous Markov chains:

- a. Define properties of time inhomogeneous Markov jump process and its Chapman Kolmogorov equation
- b. Describe a Generator matrix and show the Backward and Forward differential equations
- c. Define and estimate Occupancy and transition probabilities
- d. Estimate transition rates using MLE
- e. Show the Backward and Forward integral equations

Section II: Survival and hazard models

8. Within the ambit of life insurance models of survival and mortality:
 - a. Define a mortality model and a survival model
 - b. Derive formulae for death and survival probabilities and force of mortality
 - c. Estimate complete future life time and curtate future lifetime (dependant on survival up to a given age)
 - d. Use the following models of hazard rates
 - i. Exponential model
 - ii. Weibull model
 - iii. Gompertz law
 - iv. Makeham's law
9. Model the future lifetime distributions using:
 - a. Kaplan-Meier model
 - b. Nelson-Aalen model
10. Describe proportional hazard models
11. Describe the Cox model of proportional hazards

Section III: Population forecasts, Graduation methods and exposed to risk

12. Define and calculate central exposed to risk
13. Describe process of census approximation by age definition
14. Derive census formulae based on age classification (age last birthday, age next birthday, age nearest birthday)
15. Explain the process of consistency between exposure data and mortality data under different age definitions
16. Estimate transition probabilities and determine the specific age at which they would be applied
17. Define Graduation and explain its purpose
18. Describe the following tests for smoothness of fit of graduated estimates to crude estimates:
 - a. Chi squared test



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- b. Cumulative deviations test
 - c. Signs test
 - d. Grouping of signs test
 - e. Serial correlations test
19. Describe the three common methods of graduation and their advantages and disadvantages
20. Explain what is, and the need for, mortality projection and describe its main sources of error
21. Demonstrate mortality projection based on expectation method, extrapolation methods and explanation methods

Section IV: Time Series Models

22. Explain properties of integrated and stationary univariate time series
23. Describe the properties and uses of Auto regressive (AR), moving average (MA), Auto regressive moving average (ARMA) and Auto regressive integrated moving average (ARIMA) time series and their simple applications in forecasting economic variables
24. Explain the concept of drift with respect to random walks
25. Describe how a univariate time series model may be converted into a multivariate Markov model
26. Explain the following concepts in time series forecasting:
- a. Application of filters
 - b. Multivariate auto regressive model
 - c. Cointegrated time series
27. Describe steps in fitting a time series model using Box-Jenkins methodology:
- a. Removing seasonality, cycles and trends
 - b. Identification of an ARIMA (p,d,q) model
 - c. Estimation
 - d. Diagnostic tests on residuals
 - i. Turing test
 - ii. Normal approximation to sample autocorrelation term
 - iii. Ljung-Box 'portmanteau' test
 - e. Forecasting
28. Demonstrate basic understanding of other time series:
- a. Multivariate time series
 - b. Cointegrated series
 - c. Non-linear, non-stationary models (eg.ARCH models)



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Section V: Machine Learning

29. Describe concept of machine learning and its branches

30. Understand usage of technical terms in machine learning

- a. Loss function
- b. Model evaluation
- c. Confusion matrices
- d. Generalisation error
- e. Train validate test
- f. Parameters and hyperparameters
- g. Validation and overfitting

31. Explain the stages in machine learning analysis

Describe types of supervised and unsupervised learning techniques
