Two year M.A. M.Sc. program in Actuarial Statistics

Two year M.A./M.Sc. program in Actuarial Statistics, will begin from the academic year 2009-2010 in the Department of Statistics, University of Pune. Structure of the course is given below.

1) **Duration of the course:**
   M.Sc. in Actuarial Statistics program will be of two years, each year consisting of two semesters.

2) **Eligibility:**
   The student who has passed B.A./B.Sc. in Statistics, B.A./B.Sc. in Mathematics with statistics at the subsidiary level, B.A. in Economics with Mathematics and statistics at the general level, of University of Pune or any other recognized university, will be eligible to take admission to this course.

3) **The Scheme of papers:** We follow semester pattern and the credit system. The M.Sc. program is of 100 credits. Following is the outline of the program.

### Semester I

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Number of Credits</th>
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<tbody>
<tr>
<td>AS1</td>
<td>Financial Mathematics</td>
<td>5</td>
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<tr>
<td>AS2</td>
<td>Distribution Theory</td>
<td>5</td>
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<td>AS3</td>
<td>Economics</td>
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<td>AS4</td>
<td>Finance &amp; financial reporting</td>
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<tr>
<td>AS5</td>
<td>Demography</td>
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<td>AS6</td>
<td>Practical I: Introduction to Statistical software</td>
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### Semester II

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<th>Number of Credits</th>
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<td>AS7</td>
<td>Regression theory</td>
<td>5</td>
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<tr>
<td>AS8</td>
<td>Stochastic processes I</td>
<td>3</td>
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<tr>
<td>AS9</td>
<td>Statistical Inference</td>
<td>5</td>
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<td>AS10</td>
<td>Life Contingencies I</td>
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<td>AS11</td>
<td>Practical II</td>
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Semester III

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<td>AS12</td>
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<td>3</td>
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<tr>
<td>AS13</td>
<td>Time Series</td>
<td>5</td>
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<tr>
<td>AS14</td>
<td>Finance &amp; Investment</td>
<td>5</td>
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<tr>
<td>AS15</td>
<td>Communication Skills</td>
<td>2</td>
</tr>
<tr>
<td>AS16</td>
<td>Life Contingencies II</td>
<td>5</td>
</tr>
<tr>
<td>ASE1</td>
<td>Elective I</td>
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</tbody>
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Semester IV

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<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Number of Credits</th>
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</thead>
<tbody>
<tr>
<td>AS17</td>
<td>Stochastic Models in Finance</td>
<td>5</td>
</tr>
<tr>
<td>AS18</td>
<td>Survival Analysis</td>
<td>3</td>
</tr>
<tr>
<td>ASE2</td>
<td>Elective II</td>
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<tr>
<td>ASE3</td>
<td>Elective II</td>
<td>4</td>
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<tr>
<td>AS19</td>
<td>Projects (Preferably in Insurance companies)</td>
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Elective Courses: (i) General Insurance  
   (ii) Pension & other Employee Benefits  
   (iii) Health & Care Insurance  
   (iv) Financial Econometrics.

4) Syllabus

Note: Numbers in the bracket indicate the number of lecture hours (55 minutes) allotted to the topic

Semester I

AS1. Financial Mathematics

1. Review of basic concepts in linear algebra and calculus. (10)
2. Concepts of compound interest theory, discounting and present value of future payments, interest rates and discount rates at different periods of time, force of interest, accumulated value of a stream of equal or unequal payments. (8)
3. Annuities certain, discrete (due and immediate) and continuous, with and without deferment, with m-thly payments. (16)
4. Concept of equation of a value, repayment of loan, investment project appraisal. (8)
5. Investment and risk characteristics of various types of assets. (6)
6. Concept of arbitrage and hedging. (6)
7. Understanding of the term structure of interest rates. (6)

Total lectures 60

Books Recommended:


AS2. Distribution Theory

1. Review of exploratory data analysis. (10)
2. Random Experiment and its sample space, probability as a set function on a collection of events, stating basic axioms, random variables, c.d.f., p.d.f., p.m.f., absolutely continuous and discrete distributions, Some common distributions. Transformations, moments, m.g.f., p.g.f., quantiles and symmetry. Random vectors, joint distributions, joint m.g.f. mixed moments, variance covariance matrix. (20)
3. Independence, sums of independent random variables, conditional expectation and variances, compound distributions. (6)
4. Sampling distributions of statistics from univariate normal random samples, chi-square, t and F distributions. (8)
5. Order statistics and their distributions. ((6)
6. Statement and application of central limit theorem for a sequence of independent and identically distributed random variables. (4)
7. Concept of Monte Carlo simulation using a series of pseudo random numbers. (6)

Books Recommended:


AS3. Economics

1. Interaction between supply and demand, elasticity and its calculation. (7)
2. Utility theory, utility function, risk aversion, dominance and its various types, its applications to insurance problems. (8)
3. Cost and revenue, profit maximization. (6)
4. Different sorts of markets. (3)
5. Microeconomic principles to understand markets, competitive firm, long run costs game theory, surplus economics. (8)
6. Public Sector finances direct and indirect taxes, progressive and regressive systems of taxation, revenue and expenditure of the governments Debt Repayment and National Debt. (4)
7. National income: GDP, GNP, NNP, Effects of propensity to save or to consume by public or private sector on national income. (6)
8. Fiscal and monetary policies, government interventions, banking systems. (6)
9. Exchange rates, international trade and BoP. (4)
10. Factors affecting inflation, interest rates, exchange rates, unemployment and growth. (8)  

Total lectures 60

**Books Recommended:**

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1. Investment and Asset management. (5)
2. Principles of finance, stakeholders in an organization, role and effects of capital markets, agency theory. (5)
3. Finances of joint stock, companies, types of companies, short, medium and long term financing of companies. (5)
4. Principles of personal and corporate taxation, principles of double taxation relief. (4)
5. Financial instrument: stocks, loan, debentures, bonds and shares. Types of shares and share issues. (6)
7. Company’s cost of capital, interaction with investment project, Evaluation of projects and risky investments. (10)
9. Subsidiary and associated companies. (2)
10. Interpretation of accounts of a company or a group of companies. (4)
11. Assessment of capital investment projects. (5) 

Total lectures 60

**Books Recommended:**

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**AS5. Demography**

1. Crude birth and death rates, age specific death rates, tests of crude estimates for consistency with the standard table. (12)
2. Process of graduation by the following methods – parametric formula (Makeham’s model and Gompertz’ model), standard table and graphical, tests for smoothness of a set of graduated estimates. (12)

Total lectures 36
Books Recommended:

1) Pollard A. H., Pollard G.N. and Yusuf F. Demographic Techniques.
2) Pollard J.H. Mathematical models for the growth of Human Populations
3) Cox P.R. Demography.
4) Spiegelman M. Introduction to Demography.

AS6. Practical I: Introduction to Statistical Software

Excel, SAS, SPSS, R, Minitab, Matlab. Computations related to the above theory courses using these packages.

Semester II

AS7. Regression Theory

1. Investigation of linear relationships between variables using correlation & regression analysis. (4)

2. Simple regression model with one independent variable(X), assumptions, estimation of parameters, standard error of estimator, testing of hypothesis about parameters, coefficient of determination & its use to measure the goodness of fit of a linear regression model, prediction of response with confidence limits. (8)

3. Diagnostic checks for suitability and validity of a linear regression model, graphical techniques, tests for normality, uncorrelatedness, homoscedasticity, lack of fit, modifications like polynomial regression, transformations on Y or X, WLS. (12)


5. ANOVA, one-way analysis of variance. (4)

6. Fundamental concepts of generalized Linear model (GLM), exponential family of distributions, link functions such as Poisson, binomial, inverse binomial, inverse Gaussian, gamma. (8)

7 Concepts of deviance, estimation of parameters of a GLM, suitability of a model by using analysis of deviance and by examining the significance of parameters. (6)

8. Pearson & deviance residuals, statistical tests for acceptability of a fitted model, Pearson’s chi-square test and the likelihood ratio test. (6)

Total lectures 60

Books Recommended:


AS8. Stochastic Processes I

1. Concept of stochastic process, their classification into different types. (2)
2. Markov chains with stationary transition probabilities, properties of transition probabilities, classification of states, Markov chain as a tool for modeling, simulation of Markov chain. (12)
3. Stationary distribution of a Markov chain, existence and uniqueness, convergence to the stationary distribution. (8)
4. Methods based on Markov chains for simulation of random vectors. MCMC algorithm. (6)
5. Estimation of transition probabilities. (2)
6. Introduction to Wiener Process and Brownian motion. (6)

Total lectures 36

Books Recommended:


AS9. Statistical Inference

1. Review of methods of estimation & main properties of estimators, such as unbiasedness, efficiency, consistency. Mean square error. Asymptotic distribution of maximum likelihood estimator (only the Statement). (16)

2. Testing of hypotheses – null & alternative hypotheses, simple & composite hypothesis, type I and type II errors, test statistic, critical region, level of significance, power of a test. (12)

3. Basic tests for the one sample and two sample situations involving normal, binomial and Poisson distributions, tests for paired data, chi-square tests for goodness of fit, contingency table and chi-square test for independence of two classification criteria.
4. Elements of decision theory, optimum strategies under the theory of games, decision function, risk function, decision criteria such as minimax criterion and Bayes criterion. Bayesian estimation, prior distributions, posterior distribution, loss function, principle of minimum expected posterior loss, quadratic and other common loss functions, conjugate prior distributions. Bayesian HPD confidence intervals. (16)

Books Recommended:

3) Roussas, G. G. (1973) First Course in Mathematical Statistics (Addison Wesley)
4) Silvey, S. D. (1975) Statistical Inference (Chapman and Hall)

AS10. Life Contingencies I

1. Insurance and utility theory. (4)
2. Future life time random variable, its distribution function and density function, concept of force of mortality, curtate future life time random variable its probability mass function, deferred probabilities, all these functions in terms of international actuarial notation, analytical laws of mortality such as Gompertz and Makeham, single decrement life table, select and ultimate life table. (18)

3. Assurance and annuity contracts with level and varying benefits, formulae for the means and variances of the present value random variables of the payments under these contracts under the assumption of constant force of interest, in discrete and continuous set up. (16)

4. Net premiums for insurance products and annuity schemes defined in (3), gross premiums. (12)

5. Concept of reserve, prospective & retrospective approach. (10)

Books Recommended:


**AS11. Practical II**

Practical based on theory papers in Semester II

**Semester III**

**AS12. Stochastic Processes II**


2. Poisson process, compound Poisson process, renewal processes. (16)

Total lectures 36

**Books Recommended:**


**AS13. Time Series**

1. Time-series as a discrete parameter stochastic process. Stationary time series. Auto-covariance and auto-correlation functions and their properties. (8)

2. Exploratory time Series Analysis, tests for trend and seasonality. Exponential and moving-average smoothing. Hot-Winters smoothing. Forecasting based on smoothing, adaptive smoothing. (10)


4. Multivariate auto regressive model, co-integrated time series. (10)
5. Non-stationary and non-linear models. (8)
**Books Recommended:**


**AS14. Finance & Investments**

1. Measures of investment: risk: variance of return, downside semi-variance of return, shortfall probabilities, extreme values, quantile estimators and Value at risk (VaR)/Tail VaR. (15)

2. Investor’s utility function. (3)

3. Mean-variance portfolio theory and its principal results. (8)

4. Single and multifactor models of asset returns; Capital Asset Pricing model; Arbitrage Pricing theory model. (12)

5. Investment indices. (3)

6. Efficient Markets Hypothesis. (3)

7. Financial and non-financial risk: Interest rate risk; market risk, Credit risk, Foreign Exchange risk, Sovereign risk, Liquidity risk, Compliance risk; actuarial techniques to
identify and measure these. (8)

8. Models for credit risk: structural models, reduced form models, intensity-based models, Merton model, two-state model and the Jarrow-Lando-Turnbull models for credit ratings (models based on discrete and continuous time Markov chains). (8)

Books Recommended:


AS15. Communication Skills

1. Written communication in different forms (for example, a letter/report/memo/e-mail/slide or visual presentation/rewriting or correcting a poor draft) to present fundamental actuarial ideas and arguments to others outside the profession. (8)

2. Presentation of the material – planning, format of the answers, language, tone, level of complexity, clear explanation of technical terms, correct grammar, and punctuation. (8)

3. Meeting objectives of the communication – Understanding of the written communication, answers to all relevant issues, style of communicating the message. (8)

AS16. Life Contingencies II

1. Multiple life functions, contingent functions, net premiums when more than one life are involved in the contract. (8)

2. Multiple decrement models and their application in the calculation of monetary functions when cause of death/decrement is involved. Application of multiple decrement models in valuation of pension funds. (16)

3. Multistate Markov models for cash flows contingent on competing risks, maximum likelihood estimators for the transition intensities in models of transfers between states, Binominal & Poisson models of mortality, maximum likelihood estimators for the probability of death. (16)


5. Stochastic interest rate model and its application in the calculation of monetary functions. (8)

Total lectures 60
Books Recommended:


ASE1. Elective course I

Semester IV

AS17. Stochastic Models in Finance


2. Options markets, properties of stock option prices. American and European options. (3)


5. Black Scholes model: Distribution of returns, volatility, risk neutral pricing, equivalent martingale measure, Black-Scholes-Merton differential equation. (7)

6. Estimating volatility. (3)

7. Options on stock indices, currencies and futures. Some exotic equity and foreign exchange derivatives. (6)

8. Greek Letters and hedging. (8)

9. Interest rate derivatives, Black model. (6)

10. Models of the term structure of interest rates: one factor diffusion model, Vasicek, Cox-Ingersoll-Ross and Hull white models. (7)

Total lectures 60

Books Recommended:
**AS18. Survival Analysis**


2. Life tables, Failure rate, mean residual life and their elementary properties. (6)


4. Semi-parametric regression for failure rate - Cox's proportional hazards model with one and several covariates. (10)

**Total lectures 36**

**Books Recommended:**

5) Zacks, S. Reliability

**ASE2. Elective course II**

**ASE3. Elective course III**

5. Projects (Preferably in Insurance companies)

**Some of the proposed Elective Courses:**
(i) General Insurance
(ii) Pension & other Employee Benefits
(iii) Health & Care Insurance
(iv) Financial Econometrics.

**Other relevant elective courses may be introduced as per the UoP rules.**

**Financial econometrics (pre-requisite: Time series)**

Unit roots, Cointegration and VAR models.

1) Difference stationary and trend stationary processes.
2) Testing for unit roots: the DF, ADF, PP and KPSS test statistics.
3) VAR, ML estimation Granger causality.
4) Cointegrating VAR’s.
5) Applications to the PPP (purchasing power parity).
6) Applications to the net present value model of stock prices, market microstructure and the efficient market hypothesis.

Stochastic Volatility

1) Definition, estimation and testing of ARCH, GARCH and related effects in time series.
2) Applications to modeling financial market volatility and time dependent risk premiums.

Structural equation modeling, state space models, Kalman filter.

Non linear models and their applications.

Recommended Books