

UNIVERSITY OF PUNE

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Department Of Statistics
And
Centre For Advanced Studies
Ganeshkhind,
Pune - 411007 (India)

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

Course Code	Course Title	Number of Credits
AS1	Financial Mathematics	5
AS2	Distribution Theory	5
AS3	Economics	5
AS4	Finance & financial reporting	5
AS5	Demography	3
AS6	Practical I: Introduction to Statistical software	3

Semester II

Course Code	Course Title	Number of Credits
AS7	Regression theory	5
AS8	Stochastic processes I	3
AS9	Statistical Inference	5
AS10	Life Contingencies I	5
AS11	Practical II	6

Semester III

Course Code	Course Title	Number of Credits
AS12	Stochastic processes II	3
AS13	Time Series	5
AS14	Finance & Investment	5
AS15	Communication Skills	2
AS16	Life Contingencies II	5
ASE1	Elective I	5

Semester IV

Course Code	Course Title	Number of Credits
AS17	Stochastic Models in Finance	5
AS18	Survival Analysis	3
ASE2	Elective II	4
ASE3	Elective II	4
AS19	Projects (Preferably in Insurance companies)	9

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:

- 1) Donald D.W.A. (1984). Compound Interest & Annuities Certain. Published for the Institute of Actuaries and the Faculty of Actuaries, London.

- 2) Dixit S. P., Modi C.S. and Joshi R.V. (2000). Mathematical Basis of Life Assurance. Published by Insurance Institute of India, Bombay.
- 3) McCutcheon, J.J. and Scott, W.F. (1989). Financial Mathematics. Butterworth-Heinemann.

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)

Total lectures 60

Books Recommended:

- 1) Hogg, R. V. and Craig, T. T. (1978) Introduction to Mathematical Statistics (Fourth Edition) (Collier-McMillan)
- 2) Rohatgi, V. K. (1988) Introduction to Probability Theory and Mathematical Statistics (Wiley Eastern)
- 3) C. R. Rao (1995) Linear Statistical Inference and Its Applications (Wiley Eastern) Second Edition
- 4) H, Cramer (1946) Mathematical Methods of Statistics,(Princeton).
- 5) J. D. Gibbons & S. Chakraborti (1992) Nonparametric statistical Inference (Third Edition) Marcel Dekker, New York

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:

- 1) Begg, D., Fischer, S. and Dornbusch, R. (2005). Economics McGraw Hill.

AS4. Finance & Financial Reporting

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)
6. Capital structure, its effect of valuation of a company. Distribution of profits: dividend policies. (4)
7. Company's cost of capital, interaction with investment project, Evaluation of projects and risky investments. (10)
8. Annual reports and accounts, Construction of accounts, types of accounts. Construction of balance sheets. Various accounting ratios. (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:

- 1) Brealey, R.A., Meyers S.C. and Allen F. (2001). Principles of corporate Finance, 9th Edition, McGraw Hill Professional.

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)
3. Process of population projection and its main determinants, component method of population projection. (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)
4. Multiple regression model, Standard Gauss Markov Setup, Least square(LS) estimation. (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:

- 1) Draper, N. R. & Smith, H(1998) Applied Regression Analysis, 3rd Ed. (John Wiley).
- 2) McCullagh, P & Nelder, J. A. (1989) Generalized Linear Models (Chapman &

- Hall).
- 3) Ratkowsky, D.A. (1983) Nonlinear Regression Modelling (Marcel Dekker).
 - 4) Hosmer, D.W. & Lemeshow, S. (1989) Applied Logistic Regression (John Wiley).
 - 5) Seber, G.E.F. and Wild, C.J. (1989) Nonlinear Regression (Wiley)
 - 6) Neter, J., Wasserman, W., Kutner, M.H. (1985) Applied Linear Statistical Models. (Richard D. Irwin).
 - 7). Montgomery, Douglas C.; Peck, Elizabeth A.; Vining, G. Geoffrey: (2003) Introduction to Linear Regression Analysis. (Wiley)

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:

- 1) Taylor, H. M. and Karlin, S. (1984) An Introduction to Stochastic Modelling. (Academic Press)
- 2) Medhi, J. (1982) Stochastic Processes (Wiley Eastern Ltd.)
- 3) Ross, S. (2000) Introduction to Probability Models (7th Ed.) Academic Press
- 4) Bhat B.R. (2000) Stochastic Models: Analysis and Applications (New Age Internationals)
- 5) Feller, W. (1972) An Introduction to Probability Theory and its Applications, Vol.1 3rd rd. (Wiley Eastern Ltd.)
- 6) Karlin, S & Taylor, H. M. (1969) A First Course in Stochastic Processes (Second.Edition) (Academic Press)
- 7) Hoel, P. G. Port, S.C. & Stone, C. J. (1972) Introduction to Stochastic Processes (Houghton Mifflin)

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.

(16)

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)

Total lectures 60

Books Recommended:

- 1) Kale, B.K. (1999) A First Course on Parametric Inference (Narosa)
- 2) Dudewicz, E. J. and Mishra, S.N. (1988) Modern Mathematical Statistics (John Wiley)
- 3) Roussas, G. G. (1973) First Course in Mathematical Statistics (Addison Wesley)
- 4) Silvey, S. D. (1975) Statistical Inference (Chapman and Hall)
- 5) Wilks, S. S. (1962) Mathematical Statistics (John Wiley)
- 6) Lehmann, E. L. (1986) Testing of Statistical hypothesis (John Wiley)
- 7) Lehmann, E. L. (1988) Theory of Point Estimation (John Wiley)
- 8) Rohatgi, V. K. (1976) Introduction to theory of probability and Mathematical Statistics (John Wiley & Sons)

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)

Total lectures 60

Books Recommended:

- 1) Bowers, JR. N.L., Gerber, H.U., Hickman, J.C., Jones, D.A. and Nesbitt, C.J. (1997). Actuarial Mathematics, Second Edition, The Society of Actuaries. Sahaumburg, Illinois.
- 2) Palande, P. S., Shah, R. S. and Lunawat, M. L.(2003). Insurance in India - Changing Policies and Emerging Opportunities, Response Books, New Delhi.
- 3) Harriett, E.J. and Dani, L.L.(1999).Principles of Insurance: Life,Health, and Annuities, Second Edition, Life Office Management Association, Inc. Atlanta, Georgia.

4) Neill, Alistair (1977). Life Contingencies, The Institute of Actuaries, London.

AS11. Practical II

Practical based on theory papers in Semester II

Semester III

AS12. Stochastic Processes II

1. Markov pure jump processes, Poisson process, Birth and Death processes. Finite state continuous time Markov chains. Maximum likelihood estimation of transition intensities, simulation of Markov pure jump processes. (20)
2. Poisson process, compound Poisson process, renewal processes. (16)

Total lectures 36

Books Recommended:

- 1) Taylor, H. M. and Karlin, S. (1984) An Introduction to Stochastic Modelling. (Academic Press)
- 2) Medhi, J. (1982) Stochastic Processes (Wiley Eastern Ltd.)
- 3) Ross, S. (2000) Introduction to Probability Models (7th Ed.) Academic Press
- 4) Bhat B.R. (2000) Stochastic Models: Analysis and Applications (New Age Internationals)
- 5) Feller, W. (1972) An Introduction to Probability Theory and its Applications, Vol.1 3rd rd. (Wiley Eastern Ltd.)
- 6) Karlin, S & Taylor, H. M. (1969) A First Course in Stochastic Processes (Second.Edition) (Academic Press)
- 7) Hoel, P. G. Port, S.C. & Stone, C. J. (1972) Introduction to Stochastic Processes (Houghton Mifflin)

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-Wiinters smoothing. Forecasting based on smoothing, adaptive smoothing. (10)
3. Stationary processes: (i) moving average (MA), (ii) Auto regressive (AR), (iii) ARMA and (iv) AR integrated MA (ARIMA) models. Box-Jenkins models. Discussion (without proof) of estimation of mean, auto covariance and autocorrelation functions under large sample theory. Concept of filter applied to stationary time series. Choice of AR and MA periods. Estimation of ARIMA models parameters. Forecasting. Residual analysis and diagnostic checking. (24)
4. Multivariate auto regressive model, co-integrated time series. (10)
5. Non-stationary and non-linear models. (8)

Books Recommended:

- 1) Box, G. E. P. and Jenkins, G. M. (1976). Time Series Analysis – Forecasting and Control, Holden-day, San Francisco.
- 2) Anderson, T. W. (1971). The Statistical Analysis of Time Series, Wiley, N.Y.
- 3) Montgomery, D. C. and Johnson, L. A. (1977). Forecasting and Time Series Analysis, McGraw Hill.
- 4) Kendall, Sir Maurice and Ord, J. K. (1990). Time Series (Third Edition), Edward Arnold.
- 5) Brockwell, P.J. and Davis, R. A. Time Series: Theory and Methods (second Edition). Springer – Verlag.

- 6) Fuller, W. A. (1976). Introduction to Statistical Time Series, John Wiley, N. Y.
- 7) Granger, C. W. J. and Newbold (1984). Forecasting Econometric Time Series, Third Edition, Academic Press.
- 8) Priestley, M. B. (1981). Spectral Analysis & Time Series, Griffin, London.
- 9) Bloomfield, P. (1976). Fourier Analysis of Time Series – An Introduction, Wiley.
- 10) Granger, C. W. J. and Hatanka, M. (1964). Spectral Analysis of Economic Time Series, Princeton University Press, N. J.
- 11) Koopmans, L. H. (1974). The Spectral Analysis of Time Series, Academic Press.
- 12) Nelson, C. R. (1973). Applied Time Series for Managerial Forecasting, Holden-Day.
- 13) Findley, D. F. (Ed.) (1981). Applied Time Series Analysis II, Academic Press.

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)

Total lectures 60

Books Recommended:

1. Elton, E J; Gruber, M J; Brown, S J; Goetzmann, W. N., (2003). Modern portfolio theory & investment analysis, (Sixth Edition) John Wiley and Sons.
2. Bodie, Z; Kane, A; Marcus, A J., (2004). Essentials of investments, McGraw-Hill.
3. Sharpe, W F; Alexander, G J; Bailey, J. V., (1999). Investments, Prentice Hall.

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)

Total lectures 24

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, Binomial & Poisson models of mortality, maximum likelihood estimators for the probability of death. (16)
4. Models for risk in a short duration, models for individual claims and their sums. Distribution of aggregate claims, compound Poisson distribution and its applications. Concept of ruin for a risk model, adjustment coefficients and Lundberg's inequality (12)
5. Stochastic interest rate model and its application in the calculation of monetary functions. (8)

Total lectures 60

Books Recommended:

- 1) Bowers, JR. N.L., Gerber, H.U., Hickman, J.C., Jones, D.A. and Nesbitt, C.J. (1997). Actuarial Mathematics, Second Edition, The Society of Actuaries. Schaumburg, Illinois.
- 2) Harriett, E.J. and Dani, L.L.(1999).Principles of Insurance: Life,Health, and Annuities, Second Edition, Life Office Management Association, Inc. Atlanta, Georgia.
- 3) Neill, Alistair (1977). Life Contingencies, The Institute of Actuaries, London.

ASE1. Elective course I

Semester IV

AS17. Stochastic Models in Finance

1. Derivatives : forward and future contracts. Markets, prices, arbitrage and hedging. Complete market, market risk and credit risks in the use of derivatives. (5)
2. Options markets, properties of stock option prices. American and European options. (3)
3. Binomial model : One-step and two-step models, Binomial trees. Risk neutral valuation. (5)
4. Behaviour of stock prices : Conditional expectation, Martingale, Brownian Motion and Geometric Brownian motion, Markov property, Ito integral, Ito/diffusion and Mean-reverting processes Process, Ito Lemma. (10)
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:

- 1) John Hull, (2008). Options, futures and other derivatives, (International 7th Edn), Prentice Hall.
- 2) M.Baxter and A.enne, (1996). Financial Calculus, Cambridge University Press.
- 3) N.Bingham and R.Keisel , (1998). Risk-Neutral Valuation, Springer.

AS18. Survival Analysis

1. Concepts of Time, Order and Random Censoring. Life distributions - Exponential Gamma, Weibull, Lognormal, Pareto, Linear Failure rate. Parametric inference: Point estimation, Confidence Intervals, Scores, tests based on LR , MLE. (10)
2. Life tables, Failure rate, mean residual life and their elementary properties. (6)
3. Estimation of survival function - Actuarial Estimator, Kaplan - Meier Estimator, Nelson Aalen estimator. (10)
4. Semi-parametric regression for failure rate - Cox's proportional hazards model with one and several covariates. (10)

Total lectures 36

Books Recommended:

- 1) Cox, D.R. and Oakes, D. (1984) Analysis of Survival Data, Chapman and Hall, New York.
- 2) Gross A.J. and Clark, V. A. (1975) Survival Distributions: Reliability Applications in the Biomedical Sciences, John Wiley and Sons.
- 3) Elandt - Johnson, R.E. Johnson N.L. (1980) Survival models and Data Analysis, John Wiley and Sons
- 4) Miller, R.G.(1981) Survival Analysis (Wiley)
- 5) Zacks, S. Reliability
- 6). Deshpande, J.V. and Purohit S.G. (2006). Life-Time Data: Statistical Models and Methods , World Scientific Book Publishing .

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

1. Campbell J., Lo A. & McKinley C. (1997) The econometrics of financial markets. Princeton University press.
2. Hamilton (1994): Time series analysis. Princeton University press.