DEPARTMENT OF ACTUARIAL SCIENCE
SCHOOL OF MATHEMATICAL SCIENCES
KAVAYITRI BAHINABAI CHAUDHARI
NORTH MAHARASHTRA UNIVERSITY
JALGAON - 425001, INDIA

SYLLABUS FOR

Third Year of B.Sc.(Actuarial Science)
(w.e.f. 2020-21)

In the three-year course

B.Sc.(Actuarial Science)

UNDER
FACULTY OF SCIENCE & TECHNOLOGY

Department of Actuarial Science
School of Mathematical Sciences
KavayitriBahinabai Chaudhari
North Maharashtra University, Jalgaon, India

Syllabus Structure for Third Year B.Sc.(Actuarial Science)

Under

Three-year course
B.Sc.(Actuarial Science)

Semester-V

Course Code	Title of the Course	Contact Clock Hours/week			Distribution of Marks for Examination						Credits
					Internal		External		Total		
		Th(L)	Pr	Total	Th	Pr	Th	Pr	Th	Pr	
AS-501	Survival Models	04	--	04	40	--	60	--	100	--	04
AS-502	Applied Statistics	04	--	04	40	--	60	--	100	--	04
AS-503	Finance and Financial Reporting	04	--	04	40	--	60	--	100	--	04
AS-504	Life Contingencies-II	04	--	04	40	--	60	--	100	--	04
AS-505	Practicals-V	--	06	06	--	40	--	60	--	100	03

Semester-VI

Course Code	Title of the Course	Contact Clock Hours / week			Distribution of Marks for Examination						Credits
					Internal		External		Total		
		Th(L)	Pr	Total	Th	Pr	Th	Pr	Th	Pr	
AS-601	Stochastic Modeling	04	--	04	40	--	60	--	100	--	04
AS-602	Total Quality Management and Statistical Process Control	04	--	04	40	--	60	--	100	--	04
AS-603	Credibility Theory & Loss Distributions	04	--	04	40	--	60	--	100	--	04
AS-604	Financial Economics	04	--	04	40	--	60	--	100	--	04
AS-605	Practicals-VI	--	06	06	--	40	--	60	--	100	03

Note: Syllabus structure of complete Three-year course B.Sc.(Actuarial Science) is given separately.

Examination and Declaration of result: Internal and External Examinations will be conducted by the Department of Actuarial Science under Academic flexibility and results will be declared by University's Examination section based on CGPA system.

Detailed Syllabi for T.Y.B.Sc.(Actuarial Science)

AS-501-Survival Models

- Survival Models (10L)
  The distribution and density functions of the random future lifetime, the survival function, the force of mortality or hazard rate and derive relationships between them, Laws of mortality like Gompertz and Makeham, the distribution and density functions of the curtate future lifetime random variable.
- Estimating the lifetime distribution and Proportional hazards models (15L)
  Truncation, Right censoring, Left or interval censoring, Likelihood construction for censored and truncated data, Kaplan-Meier model, Nelson Aalen model, Cox proportional hazard model, Breslow's approximations to the partial likelihood estimator.
- Exposed to risk (3L)
  Central and Initial Exposed to risk, concepts of rate intervals and their impact on estimators
- Graduation (12L)
  Purpose and methods of graduation, testing goodness of fit and testing smoothness of a set of graduated estimates, statistical test for comparing a set of crude estimates and a standard table or a set of crude estimates and a set of graduated estimates, effect of duplicate policies on estimates.
- Mortality projection (20L)
  Forecasting of future mortality rates based on extrapolation, explanation and expectation, and their advantages and disadvantages. Lee-Carter, age-period-cohort, and *p*-spline regression models for forecasting mortality.

References

1. Institute of Actuaries core reading for subject CS2.
2. Klein J.P. and Moeschberger, M.L.(2003) Survival Analysis: Techniques for Censoredand Truncated Data 2nd Edition, Springer Verlag, New York,.
3. Klugman, S.A.(June 2003), "Estimation, Evaluation, and Selection of Actuarial Models".
4. Dick London (1997), Survival Models and their Estimation, second edition, ACTEX publications.
5. Cox, D.R. and Oakes, D.(1984) Analysis of Survival Data, Chapman and Hall, New York.

AS-502-Applied Statistics

- Data analysis (6L)
  Exploratory data analysis; Describe the purpose of exploratory data analysis, use appropriate tools to calculate suitable summary statistics and undertake exploratory data visualizations, define and calculate Pearson's, Spearman's and Kendall's measures of correlation for bivariate data, use Principal Components Analysis to reduce the dimensionality of a complex data set.
- Linear regression (14L)
  Simple linear regression model, least-squares estimation of parameters, fitting of simple linear regression model, statistical inference on parameters, measures of goodness of fit, estimation of mean response, checking the model.
  Multiple linear regression model, fitting of multiple linear regression model, hypothesis testing in multiple linear regression model, checking the model, process of selecting explanatory variables.
- Generalised linear model (GLM) (10L)
  Generalised linear models, exponential family of distributions, Link function, Canonical link function, Linear Predictors, Model fitting and comparison, Deviance of model fitting, scaled deviance, Residuals analysis and assessment of model fit.
- Time Series Analysis (20L)
  Concepts underlying Time series models; concept and general properties of stationary, univariate time series, concept of stationary random series, concept and basic properties of autoregressive (AR), moving average (MA), autoregressive moving average (ARMA) and autoregressive integrated moving average (ARIMA) time series, applications of time series models.
  Compensating for trend and seasonality, identification of $MA(q)$ and $AR(p)$ models, fitting of time series model using Box-Jenkins methodology, forecasting, Multivariate time series models.
- Machine learning (10L)
  Explain and apply elementary principles of machine learning, supervised and unsupervised machine learning techniques, explaining the difference between regression and classification and between generative and discriminative models, explain in detail and use appropriate software to apply machine learning techniques (*eg.* penalised regression and decision trees) to simple problems.

References

1. Institute of Actuaries core reading for subject CS1.
2. Montegomery D.C,Peck, E.A and Vining G.G(2003). Introduction to Linear Regression Analysis, (3rd Ed. Wiley)
3. Montgemory, D.C. Johnson L.A (1977) Forecasting and Time Series Analysis, McGrawHill.
4. Brockwell, P.J. and Davis R.A. Time Series: Theory and Methods (Second Edition)Springer-Verlag.
5. Gupta S.C. & Kapoor V.K.: Fundamentals of Applied Statistics, S. Chand Sons, New Delhi

AS-503-Finance and Financial Reporting

- Principal terms in investment and asset management. (6L)
- Key principles of finance. (6L)
- Structure of Joint Stock Company and the different methods of financing by which it may be financed. (6L)
- Basic principle of personal and corporate taxation. (6L)
- The characteristics of principal forms of financial instrument used by companies. (6L)
- Factors to be considered by a company when deciding on its capital structure and dividend policy. (6L)
- Definition of company's cost of capital & the nature of the investment projects. (6L)
- The basic construction of accounts of different types and principal features of the accounts of a company. (6L)
- Interpretation of the accounts of a company or a group of companies and limitations of such interpretation. (6L)
- Financial techniques used in the assessment of capital investment projects. (6L)

Note: Teacher may relate above topics with the syllabus of CB1 and CB3 of IAI.

References

1. Brigham, Eugene F and Houston, Joel F., Fundamentals of financial management. 9th ed. Harcourt Brace, 2000 ISBN 0030314615.
2. Holmes, Geoffrey and Sugden, Alan, Interpreting company reports and accounts. 7th ed. Prentice hall, 1999 ISBN 027364615X.
3. Samuels, J.M; Wikes, F.M; Bray Shaw, R.E, Management of company finance. 6th ed. International Thomson, 1995 ISBN 1861522290.
4. Brealey, Richard A and Myers, Stewart C., Principles of corporate finance. 6th ed. McGraw-Hill, 1999 ISBN 0077095650.
5. Brett, How to read the financial pages. M. 2nd ed. Random House Business Books, 2003. ISBN:0712662596

AS-504-Life Contingencies-II

- **Insurance Models Including Expenses** (8L)
  List the type of expenses incurred in writing a life insurance contract, Describe the influence of inflation on the expenses, Define the gross future loss random variable for the benefits and annuities using equivalence principle.
- **Multiple Life Functions** (8L)
  Joint distribution of Future Lifetimes, The Joint-Life Status, The Last-Survivor Status, More Probabilities and Expectations, Dependent Lifetime Models: Common Shock, Insurance and Annuity Benefits: Survival Status, Special Two-Life Annuities, Reversionary Annuities, Simple Contingent Functions.
- **Multiple Decrement Model** (12L)
  Two random variables, Random Survivorship Group, Deterministic Survivorship Group, Associated single Decrement tables: Basic Relationship, Uniform Distribution Assumption for multiple decrements, Construction of Multiple decrement table, Relationship between single and multiple decrement tables.
- **Application of multiple decrement theory** (12L)
  Actuarial present value and their numerical evaluation, benefit premium and reserves, competing risks, multiple state modelling, multiple state Markov model, Kolmogorov forward equations, multiple decrement tables.
- **Profit testing** (12L)
  Discounted emerging costs, unit-linked contract, Profit test annual premium contracts, the profit vector, the profit signature, the net present value and the profit margin, determining premiums using profit test, Profit criterion, determining reserves using profit testing, Zeroising negative cashflows, Equity-linked insurance, deterministic profit testing for equity linked insurance, Stochastic profit testing, Stochastic pricing, Stochastic reserving.
- **Pension funds** (8L)
  Multiple decrement service table for pensions calculations, updating a service table, the salary scale function, setting the DC contribution, the service table, funding plans, valuation of benefits: Final salary plans, Career average earnings plans.

References

1. Institute of Actuaries core reading for subjects CM1, CP1 and SP2.
2. Robin Cunningham, Thomas N. Herzog, Richard L. Models for Quantifying Risk, 4th Edition, ACTEX Publications, 2011.
3. Browers, Newton L et al., Actuarial Mathematics 2nd . Society of Actuaries, 1997.
4. Dickson, David C. M., Hardy, Mary R. and Waters, Howard R., Actuarial Mathematics for life contingent risks, International series on actuarial science, Cambridge 2009.
5. Deshmukh S. R., An Introduction to Actuarial Statistics, University Press, 2009

AS-505-Practicals-V

A. Practicals based on AS-501 (Survival Models) (30 Hrs)

1. Plotting of utility functions.
2. Life table using analytical laws of mortality.
3. Estimation of the empirical survival functions in the absence of censoring.
4. Kaplan-Meier (or product limit) estimate and Nelson-Aalen estimate of the survival function in the presence of censoring.
5. Find the actuarial estimates of Initial and Central Exposed to risk under Binomial and Poisson models of number of deaths observed.
6. Test crude estimates for consistency with a standard table or a set of graduated estimates.
7. Test for smoothness of a set of graduated estimates.
8. Practicals based on Mortality projections

B. Practicals based on AS-502 (Applied Statistics) (30 Hrs)

1. Exploratory data analysis
2. Simple linear regression
3. Multiple linear regression
4. Generalised linear model
5. Time Series Analysis
6. Machine learning

C. Practicals based on AS-504 (Life Contingencies-II) (30 Hrs)

1. Gross premium
2. Dependent Lifetime Models
3. Multiple Decrement Models.
4. Actuarial present value in Multiple Decrement Models.
5. Profit testing.
6. Pension funds.

AS-601-Stochastic Modeling

- Stochastic processes (4L)
  Types of Stochastic processes, sample path, white noise, random walk, strictly stationary and weakly stationary processes, increments, Markov property of stochastic processes, Poisson process, Compound Poisson process.
- Markov chains (14L)
  Definitions, finite and countable state space Markov chains, Chapman-Kolmogorov equations, limiting and stationary distribution of Markov chains, classification of states, periodicity, transient and recurrent Markov chain and related results, first passage time, two state Markov model, Time homogenous and time inhomogeneous Markov processes, Long term behaviour of Markov chain, estimation of transition probabilities.
- Time homogenous Markov jump processes (14L)
  Poisson process, Sums of Poisson process, distribution of the number of events in given time interval, inter arrival times, holding times and waiting times distributions, occupancy probabilities, applications of these results, Kolmogorov forward and backward differential equations for a Markov process with time independent transition intensities, maximum likelihood estimator in general model.
- Time-inhomogeneous Markov jump processes (14L)
  Chapman Kolmogorov equations, transition rates, Kolmogorov forward and backward equations for a Markov process with time dependent transition intensities, integrated form of Kolmogorov forward and backward equations, simple survival models, sickness models and marriage models in terms of Markov processes and other simple applications.
- Brownian motion and Stochastic Models for security prices (14L)
  Basic properties of standard Brownian motion or Wiener process, stochastic differential equations, the Ito integral, diffusion and mean-reverting processes, stochastic differential equation for geometric Brownian motion and Ornstein-Uhlenbeck process. Stochastic differential equations, theIto integral, diffusion and mean-reverting processes, continuous-time lognormal model of security prices

References

1. Institute of Actuaries core reading for subject CS2.
2. Ross, S. (2005) Introduction to Probability Models (6th Ed. Academic Press).
3. Medhi, J. (1994). Stochastic Processes, (2nd Ed. New Age Publisher).
4. Brzezniak, Zdzislaw and Zastawniak, Tomasz, (1999) Basic stochastic processes: A course through exercises. (Springer)
5. Grimmett, Geoffrey and Stirzaker, David (2001) Probability and random processes.(3rd ed. Oxford University Press).
6. Grimmett, Geoffrey and Stirzaker, David(2001), One thousand exercises in Probability.(2nd ed. Oxford University Press).
7. Norris (1997), Markov Chains. (Cambridge Uni Press).

AS-602-Total Quality Management and Statistical Process Control

- Total Quality Management. (12L)
  - Concept of Quality, Quality improvement, Quality philosophy.
  - Introduction of TQM, evaluation of Total Quality.
  - Some important TQM concepts.
  - TQM Gurus' Ideas.
  - Japanese 5-S Practice.
  - Importance of team work
  - The Impact of National and International Quality Awards on TQM.
  - The European Quality Award.
  - The Deming Application Prize.
  - Six Sigma and other Extensions of TQM.
  - Quality systems.
  - The ISO 9000 and other Quality systems.

- Some Statistical methods useful in Quality Improvement. (5L)
  - Concept of variation, systematic variation, random variation, stable industrial processes.
  - Describing variation through graphical and numerical methods.
  - Some important Discrete and continuous probability distributions useful in quality control and improvement.
  - Some useful approximations of Distributions.

- Statistical Process Control (SPC).
  - Introduction of SPC. (5L)
    - Basic concept of process monitoring and control.
    - Seven tools of SPC.
    - General theory of Control charts.
    - Different types of limits, Specification limits, Natural tolerance limits, Control limits, Warning limits.
    - OC Curve and ARL of control charts.
  - Control Charts for Attributes. (8L)
    - Control chart for fraction nonconforming.
    - Control chart for fraction nonconformities (defects)
    - OC Curves for Attributes control charts.
  - Control Charts for Variables. (8L)
    - Statistical basis of the charts for variables.
    - $\overline{X}$, R, S, $\overline{X}$ *and* R, $\overline{X}$ *and* S, $\overline{X}$ *and* S^2 Control Charts.
    - Median chart and Midrange chart.
    - Control charts for Individual Measurements.
    - Special control charts: CUSUM, EWMA control charts.
  - Process Capability Analysis. (10L)
    - Capable process and Process capability.
    - Process Capability Analysis using Histogram or Probability plot.
    - Process Capability indices under normal distribution of quality characteristic.
      - Capability indices C_p, C_{pk}, C_{pm}.
      - Connection between proportion of nonconforming and C_p, C_{pk}.
      - Estimation, C.I. and tests of hypotheses relating to C_p.

- Process Capability Analysis for non-normal data.
- Process Capability Analysis for Designed Experiments.
- Gauge and Measurement system capability studies.
- Setting specification limits on discrete components, linear and nonlinear combinations.
- Estimating the Natural tolerance limits of a process.

- Acceptance Sampling. (12L)
  - Single, double and sequential sampling plans for attributes and their properties.
  - Curtailed double sampling plans, operating characteristics functions and other properties of the sampling plans.
  - Sampling plans with rectification. OC, ASN, ATI, AOQ curves, AOQL, Designing of sampling plan. Dodge-Romig acceptance sampling plans.
  - Plan for inspection by variables for one-sided and two-sided specifications; AQL based sampling plans.

References

1. Besterfield, D.H., Besterfield-Michana, c., Besterfield, G.H., Besterfield-Sacre, M. Total Quality Management; Pearson Education(Singapore) Pte. Ltd. India. 2nd Edition 2001.
2. Caulcutt, Roland. Achieving Quality Improvement (A practical guide); Chapman and Hall, UK. 1st Edition 1995.
3. Montgomery, D.C. (2009) Introduction to Statistical Quality Control; Wiley, 6th Edition.
4. Wadsworth H.M.; Stephens K.S. and Godfrey A.B. Modern Methods for Quality Control and Improvement ,2nd Ed. Wiley.
5. Ho, Samuel K. TQM An Integrated Approach; Crest Publishing House, New Delhi. 1st Indian Edition 2002.
6. Wetherill, G.B. and Brown, D.W. Statistical Process Control, Theory and Practice; Chapman and Hall.
7. Logothetis, N.(1992). Managing Total Quality; Prentice Hall of India.
8. Oakland J.S. (1989). Total Quality Management; Butterworth-Heinemann.

AS-603-Credibility Theory & Loss Distributions

- Loss distributions (15L)
  Review of Statistical distributions suitable for modelling individual and aggregate losses including the gamma, exponential, Pareto, generalised Pareto, normal, lognormal, Weibull and Burr distributions , concepts of excesses (deductibles), and retention limits, operation of simple forms of proportional and excess of loss reinsurance, Estimation of the parameters of a failure time or loss distribution when the data is complete, or when it is incomplete, using maximum likelihood and the method of moments.
- Extreme value distributions (10L)
  Extreme Value distributions suitable for modelling the distribution of severity of loss and their relationships, various measures of tail weight and interpret the results to compare the tail weights.
- Copulas (5L)
  Dependence or concordance, upper and lower tail dependence the form and characteristics of the Gaussian copula and the Archimedean family of copulas.
- Risk models (14L)
  Reinsurance, Short term insurance contracts, compound Poisson distribution, compound binomial, compound negative binomial random variables, simple forms of proportional and excess of loss reinsurance for insurer and reinsurer.
- Credibility theory and Empirical Bayes Credibility theory (16L)
  Credibility, Credibility premium formula, credibility factor, Poisson/gamma model, normal/normal model, Bayes' Theorem, prior distribution, a posterior distribution and a conjugate prior distribution, loss function, Empirical Bayes approach to credibility theory, Calculation of credibility premium.

References

1. Institute of Actuaries core reading for subject CS2.
2. Loss Models: From Data to Decisions, 3rd Edition Stuart A. Klugman (Drake Univ., IA),Harry H. Panjer (Univ. of Waterloo, Canada), Gordon E. Willmot (Univ. of Waterloo,Canada) ISBN: 978-0-470-18781-4

AS-604-Financial Economics

- Efficient Markets Hypothesis(EMH) (5L)
  Three forms of the Efficient Markets Hypothesis and their consequences forinvestment management, evidence for or against each form of the Efficient MarketsHypothesis
- Utility theory (5L)
  Applications of utility theory to financial problems, expected utility theorem, riskaversion, risk neutrality and risk seeking, concept of utility maximization and hence explain the traditional theory of consumer choice, conditions for absolute dominance and for first and second-order dominance and their relationship with utility theory
- Mean-Variance Portfolio theory (15L)
  Measures of investment risk, Variance of return, downside semi-variance of return,shortfall probabilities, Value at Risk (VaR) / Tail VaR, Diversification and its benefits,Calculation of the expected return and risk of a portfolio of many risky assets, giventhe expected return, variance and covariance of returns of the individual assets, using mean-variance portfolio theory.
- Single and multifactor models (5L)
  Single and multifactor models, types of multifactor models of asset returns, singleindex model of asset returns, diversifiable and non-diversifiable risk
- Asset pricing models (5L)
  Sharpe-Lintner-Mossin Capital Asset Pricing Model (CAPM), Ross Arbitrage PricingTheory model (APT)
- Simple models for credit risk (5L)
  Credit event and recovery rate, Merton model, two-state model for credit ratings witha constant transition intensity, Jarrow-Lando-Turnbull model for credit ratings.
- Run-off triangles (10L)
  The origins of run-off triangles, Presentation of claims data, basic chain ladder method, average cost per claim method and Bornhuetter-Ferguson method for estimating outstanding claim amounts.
- Ruin Theory (10L)
  Introduction, aggregate claim process and the cash-flow process for a risk, surplus process, probability of ruin in infinite/finite and continuous/discrete time and relationship between them, distribution of arrival, interarrival and waiting time in Poisson process, Compound Poisson process, Lundberg's inequality, Analysis of the effect on the adjustment coefficient and hence on the probability of ruin of simple reinsurance arrangements

References

1. Institute of Actuaries core reading for subject CM2.
2. Anderson, Sweeney, Williams. Statistics for Business and Economics, Thomson Publication 8th Edition.
3. Hall John C. Options, Futures and Other derivatives 5th edition, Prentice hall, 2002
4. Oksendal B. Stochastic Differential Equation, An Introduction with applications Springer, 2003.
5. Teresa Bradley and Paul Patton. Essential Mathematics for Economics and Business (Second Edition) Wiley India Pvt. Ltd.

AS-605-Practicals-VI

A. Practicals based on AS-601 (Stochastic Modelling) (22 Hrs)

1. Calculation of n-step transition probabilities and limiting distribution in Markov chain.
2. Realization of Markov chain.
3. Simulation of Random Walk.
4. Simulation of Poisson process.
5. Simulation of Brownian Motion
6. Estimation of transition probability of Markov chain using realization.
7. Testing and Estimation of transition probability of Markov chain using realization
8. Stochastic models of the behavior of security prices.
9. Black-Scholes derivative-pricing model.

B. Practicals based on AS-602 (TQM and SPC) (23Hrs)

1. Graphical tools used in SPC with their interpretations: Stem-and-leaf plot, Box plot, Histogram, Probability Plots, cause and effect diagram, Pareto chart, Scatter plot, Check sheet, Control chart.
2. Accessing normality of data
3. Identification of probability distribution of quality characteristics.
4. Plotting and interpretation of Control chart for attribute.
5. Plotting and interpretation of Control chart for variable.
6. Process capability analysis for normal and non-normal data.
7. Gauge capability analysis.
8. Single and double sampling plans for attributes: plotting OC, ASN, ATI, AOQ curves, finding AOQL.
9. Single sampling plan for variables.

C. Practicals based on AS-603 (Credibility Theory & Loss Distributions) (23 Hrs)

1. Loss distributions and fitting of loss distributions.
2. Estimation of parametric functions of loss distributions.
3. Short term insurance contracts.
4. Estimation of proportional and excess of loss reinsurance for insurer and reinsurer.
5. Estimation of probability of ruin in infinite/finite and continuous/discrete time.
6. Computation of posterior probabilities based on simulation.
7. Calculation of credibility premium
8. Practicals based on Extreme value distributions
9. Practicals based on Copula

D. Practicals based on AS-604 (Financial Economics) (22 Hrs)

1. Estimate the investment risks using variance of return, downside semi-variance of return, shortfall probabilities, Value at Risk (VaR) / Tail VaR.
2. Estimating parameters for Single and Multifactor Models.
3. Estimating parameters for Asset Pricing Models, Capital Asset Pricing Models.
4. Practicals based Ruin theory
5. Practicals Run-off triangles