M. Sc. Part II

M.Sc. (Statistics) Semester – III

Course Code	Title of the course	Instruction Hrs./week	Marks- End Semester Exam	Marks- Internal Assessment	Credits
MST 301	Asymptotic Inference	4	80	20	4
MST 302	Survival Analysis	4	80	20	4
MST 303	Regression Analysis	4	80	20	4
MST 304	Data Mining	4	80	20	4
MST 305	Clinical Trials	4	80	20	4
MSP 316	Practical III	12	80	20	4

M.Sc. (Statistics) Semester – IV

Course Code	Title of the Course	Instruction Hrs./week	Marks End Semester Exam (ESE)	Marks Internal Assessment (ISE)	Credits
MST 401	Optimization Techniques –II	4	80	20	4
MST 402	Elementary Stochastic Processes	4	80	20	4
MST 403	Time Series Analysis	4	80	20	4
MST 404	Planning and Analysis of Industrial Experiments	4	80	20	4
MST 405	Actuarial Statistics	4	80	20	4
MSP 416	Practical-IV	12	80	20	4

Titles of papers of M.Sc. course:

M.Sc.-II Semester-III

Course Code	Title of the course	
MST 301	Asymptotic Inference	Theory: 60 hours and 4 credits for each paper
MST 302	Survival Analysis	
MST 303	Regression Analysis	
MST 304	Data Mining	
MST 305	Clinical Trials	
MSP 316	Practical-III	120 hours and 4 credits

M.Sc.-II Semester-IV

Course Code	Title of the course	
MST 401	Optimization Techniques –II	Theory: 60 hours and 4 credits for each paper
MST 402	Elementary Stochastic Processes	
MST 403	Time Series Analysis	
MST 404	Planning and Analysis of Industrial Experiments	
MST 405	Actuarial Statistics	
MSP 416	Practical-IV	120 hours and 4 credits

MST 301: ASYMPTOTIC INFERENCE

Course Objective:

The main objective of the course is to understand the basic idea of consistency of an estimator and their applications in large sample theory.

Unit 1: Review of Consistency of an estimator, weak and strong consistency, joint and marginal consistency, invariance property under continuous transformations, methods of constructing consistent estimators, asymptotic relative efficiency. Consistent and Asymptotic Normal (CAN) Estimators: Definition of CAN estimator for real and vector valued parameters, invariance of CAN property under non-vanishing differentiable transformation. Methods of constructing CAN estimators: Method of Moments, method of percentiles, comparison of CAN estimators. (15)

Unit 2: BAN estimators, CAN and BAN estimators in one parameter and multi-parameter exponential family of distributions, super efficient estimators, Crammer regularity conditions, Cramer – Huzurbazar results. Sheffe's theorem, Polya's theorem and Slutsky's theorem. (15)

Unit 3: Variance stabilizing transformations; their existence; their applications in obtaining large sample tests and estimators. Asymptotic Confidence Intervals based on CAN estimators and based on VST, Asymptotic disribution of function of sample moments. Asymptotic Confidence regions in multi-parameter families. Gauss-Legendre-Boscovich Revisited, unbiased confidence intervals. (15)

Unit 4: Likelihood ratio test and its asymptotic distribution, Wald test, Rao's Score test, Pearson Chi-square test for goodness of fit, Bartlett's test for homogeneity of variances. Consistent test, comparison of tests: asymptotic relative efficiency of tests (Pitman and Bahadur efficiency). (15)

Course Outcomes: Students are able to

1. Distinguish between weak and strong consistency , joint and marginal consistency
2. Uunderstand the concept of CAN and BAN estimators, their related results, super-efficient estimator, variance stabilizing transformation and their application in large sample test.
3. Obtain the asymptotic confidence interval based on CAN and VST.

BOOKS RECOMMENDED:

1. **A first course on parametric inference**, Kale B.K., Narosa Pub.,1999
2. **Theory of statistical inference**, Zacks S.,Wiley & Sons inc.,1971
3. **Introduction to Probability Theory and Mathematical Statistics**, Rohatagi V.K. and Saleh A. K. Md. E., John Wiley and sons Inc.,2001
4. **A Course in Large Sample Theory**., Ferguson, T.S.,Chapman and Hall, 1996
5. **Elements of Large Sample Theory**, Lehmann E L,Springer,1999
6. **Asymptotic Theory of Statistics and Probability**, Das Gupta A.,Springer Texts in Statistics., 2008
7. **Statistical Inference**, Manoj Kumar Srivastava, PHI learning pvt. ltd.

MST 302: SURVIVAL ANALYSES

Course Objective:

To provide students the ability to sharpen the skills necessary to collect, handle and analyse the lifetime data.

Unit 1: a) Concept of ageing, Functions Characterizing life-time random variables: Survival function, distribution function, hazard function, cumulative hazard function. Characterizing of IFR, IFRA, NBU, NBUE class. Parametric analysis of Survival data.
b) Concept of censoring, various types of censoring, type-I, type-II, random censoring, progressive censoring. Writing likelihood function under all these censoring schemes, estimation and testing of parameters under above types of censoring. (15)

Unit 2: a) Estimation of survival function: Nelson-Aalen estimators, Actuarial Estimator, Kaplan–Meier (product limit) estimator, properties: self-consistency and MLE, redistribution to the right algorithm.
b) Concept of TTT Transform and its applications. Test for exponentially against alternatives IFRA, NBU and NBUE. (15)

Unit 3: a) Two-sample problem: Gehen test, Log rank test, Mantel Haenszel test.
b) Competing risk models, parametric and nonparametric inference for this model. (15)

Unit 4: a) Semi parametric regression for failure rate – Cox's proportional hazards model with one and several covariates, related estimation and test procedures.
b) Introduction to accelerated time models: Linear rank tests, Least squares, Miller, Buckley-James and Koul-Susarla Vanryzin estimators (15)

Course Outcomes: Students are able to

1. Collect the life time data using different methods of censoring.
2. Estimate survival time of patients or electrical components using different estimators.
3. Understand concept of competing risk analysis and how to apply in real life situations.
4. Use regression methods for life time data.

BOOKS RECOMMENDED:

1. **Mathematical Theory of Reliability**, Barlow R. E. & Proschann F., John Wiley & Sons, Inc.,1965
2. **Life Time Data: Statistical Models and Methods**, Deshpande J. V. and Purohit S.G. world scientific publishing.,2005
3. **Statistical Models and Methods of Failure Time Data**, Lawless J. F., John Wiley.,1982
4. **Survival Analysis**, Miller R. G., John Wiley and Sons., 1981
5. **Statistical Analysis of Reliability and Life Testing Models**, Bain L. O., Marcel Dekker,1978
6. **Applied Life Data Analysis**, Nelson W., Jhon Wiley and Sons Inc.,1982
7. **Stochastic Processes**, Medhi J., second edition,1994

MST 303: REGRESSION ANALYSIS

Course Objectives: Students should to develop

1. The deeper understanding of the linear and non-linear regression model and its limitations.
2. The regression model and apply for specific perspective data in appropriate manner.

Unit 1: Multiple regression model. Least square estimate and their Properties. Hypothesis testing, general linear hypothesis testing. Dummy variable. Residuals and their properties, Residual diagnostics. Transformation of variables: VST and Box-Cox Power transformation. Variable Selection Procedure: R – square, adjusted R-square, Mallows' Cp, forward, backward selection methods. AIC, BIC., Autocorrelation & Durbin – Watson test. (15)

Unit 2 : Multicollinearity and Ridge regression. Robust Regression: Influential observation, leverage, outlier. Methods of detection of outlier and Influential observation. Estimation in presence of outlier: M estimator. Breakdown point, efficiency. Nonlinear regression models: Parameter estimation in a linear system. Transformation to a linear model. Statistical inference in non linear regression. (15)

Unit 3 : Generalized linear models, Link function, ML and Quasi-likelihood estimation.

Large sample tests about parameters, goodness of fit. Deviance analysis. Residual analysis : raw, Pearson, deviance, Anscombe, quantile. AIC, BIC. Logistic regression: logit, probit and cloglog model for single and multiple variables..ML estimation, Large sample test about parameter. Hosmer-Lemeshow test. ROC curve. Logistic regression for Nominal response . Proportional odds model. (15)

Unit 4: Poisson Regression : ML estimation using power link function. Testing significance of coefficients. Goodness of fit. Over dispersion. NB-2 model. Generalized linear mixed model: Structure of the model. Random effects. Marginal versus conditional models. Estimation by generalized equation and conditional likelihood. Testing of hypothesis.

(15)

Course Outcomes: Students are able to

1. Understand and apply multiple regression models in real life situations.
2. Understand concept of multicolinearity and non-linear regression.
3. Do residual analysis and will able to understand and apply the logistic regression.
4. Understand and apply the Poisson regression.

BOOKS RECOMMENDED:

1. **Introduction to Linear Regression Analysis**, Montgomery, D. C., Peck, E. A. and Vining G.G.,Wiley,2003.
2. **Applied Logistic Regression**, Hosmer, D. W. and Lemeshow, S.,Wiley, 1989.
3. **Nonlinear Regression**, Seber, G. E. F. and Wild, C. J.,Wiley,1989.
4. **Generalized linear and mixed models**, McCulloch, C.E., & Searle, S.R.,Wiley series in probability and statistics, New York.,2003.
5. **Generalized Linear Models**, McCullagh, P. and Nelder, J. A.,Chapman & Hall.,1989.
6. **Negative binomial regression**, Hilbe J.,Cambridge University Press, 2nd Edition,2011.

MST 304: DATA MINING

Course Objectives:

The course aims to develop the skills necessary to handle and analyse the big and complex data to solve the problems.

Unit-1: Data understanding and data cleaning, concept of supervised and unsupervised learning. Problem of classification, classification techniques: k-nearest neighbor, decision tree, Naïve Bayesian, classification based on logistic regression, Bayesian belief Network., CART(classification and regression trees) (15)

Unit-2: Model evaluation and selection: Metrics for Evaluating Classifier Performance, Holdout Method and Random Subsampling, Cross-Validation, Bootstrap, Model Selection Using Statistical Tests of Significance, Comparing Classifiers Based on Cost–Benefit and ROC Curves. Techniques to Improve Classification Accuracy: Introduction to Ensemble Methods, Bagging, Boosting and AdaBoost, Random Forests, Improving Classification Accuracy of Class-Imbalanced Data. (15)

Unit-3: ANN and SVM: Artificial Neutral Network (ANN): Introduction to ANN, types of activation function, McCulloch-Pitts AN model, single layer network, multilayer feed forward network model, training methods, ANN & regression models. Convexity and optimization: Convexity, unconstrained and constrained optimization, KKT conditions. Support vector machine: Introduction to support vector machine, loss functions, soft margin, optimization hyperplane, support vector classification, support vector regression, linear programming support vector machine for classification and regression. (15)

Unit-4: Unsupervised learning: Clustering: k-mediods, CLARA, DENCLUE, DBSCAN, Probabilistic model based clustering. Market Basket Analysis: Association rules and prediction, Apriori Algorithm, data attributes, applications to electronic commerce.

(15)

Course Outcomes: Students are able to

1. Understand and clean the big data sets. Also they will able to classify the data using different techniques.
2. Select and evaluate the models based on datasets using different modelling techniques.
3. Make different clusters of dataset and also they will able to do market basket analysis.

BOOKS RECOMMENDED:

1. **Data warehousing, Data Mining, and OLAP**, Berson and Smith S.J., McGraw-Hill.,1997
2. **Classification and Regression Trees**, Breiman J.H Friedman, R.A. Olshen and stone C.J. Wadsworth and Brooks / Cole.,1984
3. **Data Mining: Concepts and Techniques**, Han, J. and Kamber, M. and Pei, J. Morgan Gaufmann.,3rd Edition.,2012
4. **Machine Learning** , Mitchell T.M., McGraw-Hill.,1997
5. **Pattern Recognition and Neural Networks**, Ripley B. D.,Cambridge University Press.,1996
6. **The nature of Statistical learning theory**, Vapnik V.N., Springer.

MST 305: CLINICAL TRIALS

Course Objectives: Students should to

1. Understand fundamentals of clinical trials in order to deepen the understanding of clinical trials that are very important part of the any medicine.
2. Develop the skills to analyse the clinical trial data.

Unit 1: Introduction to clinical trials: the need and ethics of clinical trials, bias and random error in clinical studies, conduct of clinical trials, overview of Phase I-IV trials, multi-center trials. Data management: data definitions, case report forms, database design, data collection systems for good clinical practice, Concept of Randomization and blinding. (15)

Unit 2: Design of clinical trials: parallel vs. cross-over designs, cross-sectional vs. Longitudinal designs, review of factorial designs, objectives and endpoints of clinical trials, design of Phase I trials, design of single-stage and multi-stage Phase II trials, Active control trials and combination trials, design and monitoring of Phase III trials with sequential stopping. (15)

Unit 3: Design of bioequivalence trials, Classical methods of interval hypothesis, testing for bioequivalence Baysian methods, non-parametric methods, Assesment of inter and intra subject variability, drug interaction study, Dose proportionality steady state analysis, Clinical end points, alpha spending function. (15)

Unit 4: Analysis and Reporting of clinical trials: Concept of sample size and it's calculation, Analysis of categorical outcomes from Phase I - III trials, analysis of survival data from clinical trials. (15)

Course Outcomes: Students are able to

1. Understand need and ethics of any clinical trial and how to conduct clinical trial of any medicine in different phases.
2. Understand the designs of clinical trials.
3. Analyse and report the clinical trials.

BOOKS RECOMMENDED:

1. **Clinical Trials: A Methodologic Perspective**, S. Piantadosi, Wiley and Sons,1997
2. **Design and analysis of clinical trials: Concept and Methodologies**, SHEIN-CHUNG CHOW and JEIN-PEI LIU,Wiley series in probability and Statistics, second edition.
3. **Group Sequential Methods with Applications to Clinical Trials**, C. Jennison and B. W. Turnbull, CRC Press.,1999
4. **Fundamentals of Clinical Trials**, L. M. Friedman, C. Furburg, D.

L. Demets, SpringerVerlag.,1998

5. **The Design and Analysis of Clinical Experiments**, J. L. Fleiss,Wiley and Sons.,1989
6. **Introduction to Statistics in Pharmaceutical Clinical Trials**, Todd A Durham & J. Rick Turner.

MSP 316: PRACTICAL-III

Course Objective: Students should to understand and implement theory in real life problems.

1. Construction of Consistent/CAN Estimators.
2. Construction of BAN Estimators and confidence interval based on it.
3. Confidence interval based on CAN.
4. Confidence interval based on VST.
5. Parametric analysis of survival data.
6. Estimation of Survival Function.
7. Estimation of parameters in PH model.
8. Analysis of two sample non-parametric problem.
9. Classification.
10. Cluster Analysis.
11. Artificial Neural Network.
12. Support Vector Machine.
13. Multiple Linear Regression Model.
14. Multicollinearity and Nonlinear regression.
15. Logistic Regression.
16. Poisson Regression.
17. Pharmokinetics.
18. Confidence interval.
19. Analysis of categorical outcomes.
20. Non-parametric test based on Clinical Trials.

Course Outcomes: Students are able to understand

1. Construction of Estimators and obtaining confidence interval.
2. Estimation of Survival Function and parameters.
3. Construction of regression model.
4. Analysis and Non Non-parametric test based on Clinical Trials.

BOOKS RECOMMENDED:

1. **A first course on parametric inference**, Kale B.K.,Narosa Pub.,1999
2. **Survival Analysis**, Miller R. G ,John Wiley and Sons.,1981
3. **Introduction to Linear Regression Analysis**, Montgomery, D. C., Peck, E. A. and Vining, G. G. , Wiley, 2003
4. **Data warehousing, Data Mining, and OLAP,** Berson and Smith S.J., McGraw- Hill.,1997
5. **Clinical Trials : A Methodologic Perspective**, S. Piantadosi, Wiley and Sons,1997

MST 401: OPTIMIZATION TECHNIQUES –II

Course Objectives: Students should to understand

1. The basic components of optimization problem and formulation of design problem as mathematical programming problem.
2. Concept of goal programming problem, inventory model, EOQ, replacement problem and data envelopment analysis.

Unit 1: Goal Programming: Meaning & Concept of GP, Difference between LP & GP Approach, Model Formulation, Graphical Method to Solve GP, Modified Simplex Method. (15)

Unit 2: Deterministic inventory models: The meaning of inventory control, factors involved in inventory problem, inventory model building, Concept of EOQ,

i) **Single item inventory control models without shortages:** Model I (a): EOQ model with constant rate of demand. Model I (b): EOQ model with different rates of demand in different cycles. Model I (c): Economic lot size with finite Rate of replenishment. (EOQ production model)

ii) **Single item inventory control models with shortages:** Model II(a): EOQ model with constant demand and variable order cycle time, Model II(b): EOQ model with constant demand and fixed reorder cycle time, Model II (c): The production lot size model with shortages. (15)

Unit 3: Replacement Problems, Types of failure: Gradual failure, Sudden failure

a) **Replacement policy for items whose efficiency deteriorates with time:** when value of money remains constant and when value of money changes

b) **Replacement of items that completely fail:** Mortality tables, mortality theorem, individual and group replacement policy (15)

Unit 4: Data Envelopment Analysis (DEA) : Concept of DEA, Meaning of productivity and efficiency. Types of efficiency, variable return to scale, mathematical formulation of DEA model, basic DEA models: CCR and BCC models and their duals. (15)

Course Outcomes: Students are able to

1. Understand meaning of goal programming, distinguish between LP and GP.
2. Understand problem of inventory control, factor affecting on it, their model building and concept of EOQ.
3. Analyse replacement problem and various replacement policies, their applications in real life.
4. Use data envelopment technique to find out the efficient resources.

BOOKS RECOMMENDED:

1. **Linear Programming**, Hadley G., Addison Wesley.,1969
2. **Operation Research An Introduction**, Taha H. A.,Macmillan,1971
3. **Operations Research**, Kanti Swaroop & Gupta M. M., Sultan Chand & P. Gupta,1985
4. **Operation Research**, D. S. Hira, Sultan Chand &Co.ltd.,2010
5. **Operation Research Theory and Applications**, J. K. Sharma, Macmillan.,2003
6. **Data envelopment analysis: theory and techniques for economics and operations research**, Subhash C. Ray,2004.

MST 402: STOCHASTIC PROCESSES

Course Objectives: Students should to

1. Learn and understand stochastic processes predictive approach.
2. Develop the ability to analyse and apply some basic stochastic processes for real life situations.

Unit 1: a) Stochastic process: Definition, Classification of Stochastic processes according to state space and time domain, Transition Probability Matrix, Markov chain, Examples of Markov Chain Formulation of Markov Chain models, initial distribution.

b) Chapman-Kolmogorov Equation, calculation of n-step transition probabilities, Classification of States and Limiting Distributions. (15)

Unit 2: a) First entrance theorem, first passage time distribution, random walk model, Gambler's ruin problem. b) Long-run distributions of Markov chain, relation with mean recurrence time, stationary distribution. (15)

Unit 3: Poisson process, Birth and death processes. Growth model with immigration, Queuing systems, Markovian and non-Markovian queuing systems, embedded Markov chain applications to M/G/1. (15)

Unit 4: a) Renewal and delayed renewal processes, related theorems, key renewal theorem, Galton-Watson Branching process. probability of ultimate extinction.
b) Simulation of Markov Chain, Poisson process and branching process. (15)

Course Outcomes: Students are able to understand

1. The stochastic processes, Markov chain and Transition probability matrix, various types of states and limiting distribution.
2. The random walk model, Gambler Ruin Problem and able to compute long run distribution of Markov chain.
3. Apply the Poisson process, Birth and Death process and various Queuing systems in real life.
4. The branching process and able to make simulation of Markov Chain, Poisson process and branching process.

BOOKS RECOMMENDED:

1. **Stochastic Process**, Medhi J. , Wiley Eastern.,1982
2. **A First Course in Stochastic Process**, Karlin & Taylor , , Academic Press., Vol. -1,
3. **Introduction to Stochastic Process**, Cinlar E. , Prentice Hall.
4. **Introduction to Probability Module**., Ross S, Eleventh Edition, Academic Press elsevier.com.
5. **An Introduction to Probability Theory and Its Applications,** William Feller, Vol. 1, 3rd Edition.
6. **Introduction to Stochastic Processes**., Hoel P, Port S., Stone C., Waveland Pr Inc. publisher.

MST 403: TIME SERIES ANALYSIS

Course Objective:

Students should to develop the necessary skills to identify the nature of the phenomenon represented by the sequence of observations and forecasting future values.

Unit 1: Time series as a discrete parameter stochastic process, Auto - Covariance, Autocorrelation functions and their properties. Partial auto covariance function. Stationary time series, Exploratory time series analysis, Exponential and moving average smoothing, Holt –Winter smoothing, forecasting based on smoothing. (15)

Unit 2: Wold representation of linear stationary processes, linear time series models: Autoregressive, Moving Average, Autoregressive Moving Average models. Concept of Causality, invertibility, computation of -weights and ψ- weights, computation of ACVF, ACF and PACF. Autoregressive Integrated Moving Average models. (15)

Unit 3: Estimation of ARMA models: Yule-Walker estimation for AR Processes, Maximum likelihood and least squares estimation for ARMA Processes, Discussion (without proof) of estimation of mean, Auto-covariance and auto-correlation function under large samples theory, Residual analysis and diagnostic checking. Minimum mean squared error Forecasting for ARIMA models. Introduction to SARIMA models.

(15)

Unit 4: Introduction to spectral analysis, Spectral Representation of the ACVF, Spectral density of an ARMA process, its computation for simple models. Introduction to ARCH and GARCH models. Properties and estimation under ARCH(1) and GARCH(1,1) model, Estimation and forecasting extension of ARCH and GARCH . (15)

Course Outcomes: Students are able to

1. Understand time series, auto-covariance, auto-correlation their properties, various smoothing techniques.
2. Obtain Causality and inevitability, π -weights and ψ- weights, ACVF, ACF, PACF.
3. Understand estimation of ARIMA model, residual analysis and diagnostic checking, their forecasting.

BOOKS RECOMMENDED:

1. **Time Series Analysis,Forecasting & Control**, Box, G.E.P and Jenkins G.M, Gregory C. Reinsel.,Holden-Day.,1970
2. **Time Series: Theory and Methods**, Brockwell, P.J and Davis R.A. Springer ,1987
3. **Analysis of Financial Time Series**, Tsay R. S., Wiley Series in Prob. and Statistics, 3rd Ed.
4. **Time Series**, Kendall, M.G., Charler Graffin,1978
5. **The Analysis of Time Series - An Introduction**, Chatfield, C., Chapman and Hall., Sixth edition, 2004
6. **Time Series Analysis**, James D. Hamilton.

MST 404: PLANNING AND ANALYSIS OF INDUSTRIAL EXPERIMENTS

Course Objective:

To develop the necessary skills of students to plan the experiments so that data obtained can be analyzed to yield valid and objective conclusions.

Unit 1: Review: Basic concepts of design of experiment. Methods to study Analyzing Design, Nested and Split Plot Design.
2^k factorial Experiments: Concepts of main effects, interaction, their graphical representation, Analysis of full 2k replicated and un-replicated factorial designs.
Concept of Confounding: Total and partial confounding, construction and analysis confounded design. (15)

Unit 2: 3^k factorial Experiments: Concepts of main effects, interaction, their graphical representation, linear and quadratic components, Analysis of full 3^k replicated and un- replicated factorial designs.
Confounding: construction and analysis confounded design, Factorials with mixed levels. (15)

Unit 3: Fractional Factorial: Fractional replication for symmetric factorials, concept of generator, defining contrasts, aliasing, resolution and minimum aberration, construction and analysis of 2^{k-p} and 3^{k-p}fractional designs, Central composite designs. (15)

Unit 4: Response surface experiments: linear and quadratic model, test for curvature, stationary point, central ridge systems, Rotatability, Multiple responses.
Taguchi methods: Concept of noise and control factors, inner and outer arrays, concept of loss function, S/N ratio, orthogonal arrays, linear graphs, interactiontables, ANOVA. (15)

Course Outcomes: Students are able to

1. Understand the basic concepts of design of experiments, concept of confounding.
2. Analyse different factorial and fractional experiments their interactions, graphical representation and confounding.
3. Understand concept of response surface, Taguchi methods and loss functions.

BOOKS RECOMMENDED:

1. **Design and Analysis of Experiments**, Montgomery D.C.,WileyIndia PvtLtd., 8th edition, 2013
2. **The design and analysis of industrial experiment**, Davies.O.L., Oliver and Boyd.,1954
3. **Design and Analysis of Experiments**, Voss, D., Dean, A., and Dean, A., Springer verlag Gmbh.,1999
4. **Experiments: Planning, Analysis and Parameter Design Optimization**, Wu, C. F., Hamada M. S, John Wiley & Sons.,2nd edition,2000
5. **Experimental Design.,** CochranW.G.andcox,G.M.,1959.

MST 405: ACTUARIAL STATISTICS

Course Objective:

The course aims to develop the necessary skills of students to understand the insurance business and to design insurance policies.

Unit 1: Introduction to Insurance Business, Concept of risk, types of risk, characteristics of insurable risk, Risk models for Insurance: Individual and aggregate Risk models for short term, Distribution of aggregate claims, compound Poisson distribution and its applications. Survival function and Life tables: Survival function, Distribution function, Density functions and Force of mortality. Time-until death random variable and Curtate-future lifetime random variable. (15)

Unit 2: Life tables, Select and ultimate life tables. Assumptions for fractional ages and some analytical laws of mortality. Life Insurance: Principles of compound interest: Nominal and effective rates of interest and force of interest and discount, compound interest, Insurance payable at the moment of death and at the end of the year of death ,Whole life insurance, endowment insurance, term insurance, deferred insurance and varying benefit insurance. (15)

Unit 3: Annuities: annuity certain, discrete annuity, monthly annuity, continuous annuity, deferred annuity, present values and accumulated values of these annuities, Continuous life annuity, discrete life annuity, such as whole life annuity, temporary life annuity, n-year certain and life annuity, life annuities with mthly payments, Present value random variables for these annuity payments, their means and variances, Actuarial present value of the annuity. (15)

Unit 4: Loss at issue random variable, various principles to decide net premiums for insurance products and annuity schemes defined in unit II and III, fully continuous premiums and fully discrete premiums, True monthly payment premiums. Extended equivalence principle to decide gross premiums, Concept of reserve, Fully continuous reserve, Fully discrete reserve. (15)

Course Outcomes: Students are able to

1. Understand the insurance business, concept of risk and claims.
2. Compute the life tables.
3. Compute various types of annuities.
4. Understand various principles to decide premiums

BOOKS RECOMMENDED:

1. **An Introduction to Actuarial Statistics**, Deshmukh S. R., University Press.,2009
2. **Models for Quantifying Risk**, Robin Cunningham, Thomas N. Herzog, Richard L., ,ACTEX Publications, 4th Edition ,2011.
3. **Actuarial Mathematics for life contingent risks**,Dickson, David C. M., Hardy, Mary R. and Waters, Howard R., International series on actuarial science, Cambridge 2009.
4. **Insurance Industry in India: Features, Reforms and Outlook**, Narang, Uma New Century Publications.

MSP 416: PRACTICAL-IV

Course Objective: Students should to understand and implement theory in real life problems.

1. Goal Programming.
2. Deterministic inventory models
3. Replacement Problems
4. Data Envelopment Analysis (DEA)
5. Realization of stochastic process.
6. Classification of t.p.m. and computation of n- step probability matrix.
7. Classification of states: Computations of absorption probabilities.
8. Stationary distribution and recurrence time.
9. Auto covariance and Autocorrelation.
10. Causal and Invertible
11. Smoothing the series
12. Forecasting.
13. Analysis of full replicated un confounded 2^n and 3^n factorial experiments.
14. Analysis of single replicated 2^n and 3^n factorial experiments.
15. Analysis of confounded 2^n and 3^n factorial experiments: total and partial confounding.
16. Analysis of response surface 1^{st} and 2^{nd} order experiments.
17. Construction of Life Tables.
18. Computations of benefit premiums for n-year term insurance, whole life insurance, endowment insurance.
19. Computation of Annuities.
20. Computation of Reserve.

Course Outcomes: Students are able to

1. Solve the problems of goal programming, inventory, replacement and DEA.
2. Do classification of t.p.m., state space and computation of probability matrix.
3. Recognize trend of data and use appropriate time series model.
4. Construction of life tables and computation of benefit premiums, annuities and reserve.

REFERENCE BOOKS:

1. **Operation Research Theory and Applications**, J. K. Sharma ,Macmillan., 2003.
2. **Stochastic Process**, Medhi J. , Wiley Eastern.,1982.
3. **Time Series**, Kendall, M.G., Charler Graffin,1978.
4. **Design and Analysis of Experiments**, Montgomery D.C., , Wiley India Pvt Ltd., 8^{th} edition,2013.
5. **An Introduction to Actuarial Statistics**, Deshmukh S. R., University Press, 2009.

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