SOLAPUR UNIVERSITY, SOLAPUR.

SYLLABUS

FOR

M.Sc. (Part-II) STATISTICS
(Semester III and IV)
Credit System

WITH EFFECT FROM ACADEMIC YEAR 2012-13

(JUNE-2012).

SOLAPUR UNIVERSITY, SOLAPUR

SCHOOL OF COMPUTATIONAL SCIENCES

DEPARTMENT OF STATISTICS

Revised Syllabi of M.Sc. in Statistics (Credit System)

1) **Title of the course:** M.Sc. in Statistics.
2) **Duration of course**: Two years.
3) **Pattern:** Semester and Credit system.
4) **Eligibility:** For M. Sc. in Statistics following candidates are eligible.
   (i) B.Sc. with Statistics as principal level.
   (ii) B.Sc. with Mathematics as principal and Statistics at subsidiary level.
5) **Strength of the Students:** 20

M. Sc. program in Statistics consists of 100 credits. Credits of a course are specified against the title of the course.

A Four Semester M.Sc. Statistics Course

Semester	No. of Papers/ Practicals / Seminar	Marks	Credits
Semester I			
• Theory Papers	05	500	20
• Practical Paper	01	100	04
• Seminar/Tutorial/Home Assignment /Field Tour/ Industrial Visit	01	25	01
Semester II			
• Theory Papers	05	500	20
• Practical Paper	01	100	04
• Seminar/ Tutorial/Home Assignment /Field Tour/ Industrial Visit	01	25	01
Semester III			
• Theory papers	05	500	20
• Practical Paper	01	100	04
• Seminar/ Tutorial/Home Assignment /Field Tour/ Industrial Visit	01	25	01
Semester IV			
• Theory papers	05	500	20
• Practical Paper	01	100	04
• Seminar/ Tutorial/Home Assignment /Field Tour/ Industrial Visit	01	25	01
Total marks and credits for M.Sc. Course		**2500**	**100**

SOLAPUR UNIVERSITY, SOLAPUR

M.Sc. Part-II (STATISTICS)

Syllabus (Credit System)

(To be effective from 2012-13)

STRUCTURE

The following table gives the scheme of Examination at M.Sc. Part II (Statistics) according to the Revised Syllabus and Credit System Pattern of Examination.

Notations: A six-character code is given to each paper. In MST "M" stands for M.Sc. and "ST" stands for Statistics. The first digit following MST is Semester number. The second digit "0" stands for the compulsory theory paper, the digit "1" stands for practical paper and the digit "2" stands for an elective paper. The third digit indicated the serial number of paper in that semester.

M.Sc. (STATISTICS) Semester-III

Paper Code	Paper No.	Title of the Paper	Contact hours/ week	Distribution of Marks for Examination			Credits
				Internal	External	Total	
MST-301	XI	Asymptotic Inference	04	30	70	100	04
MST-302	XII	Multivariate Analysis	04	30	70	100	04
MST-303	XIII	Planning and Analysis of Industrial Experiments	04	30	70	100	04
---	XIV	Elective-I	04	30	70	100	04
---	XV	Elective-II	04	30	70	100	04
MST-316	---	Statistics Practical-III	12	30	70	100	04
Seminar			02	25	--	25	01
Total			**34**	**205**	**420**	**625**	**25**

Elective Papers from which <u>Any Two</u> are to be chosen

MST-321: Modeling and Simulation
MST-322: Regression Analysis
MST-323: Econometrics
MST-324: Actuarial Statistics
MST-325: Demography
MST-326: Statistical Genetics
MST-327: Official Statistics

M.Sc. (STATISTICS) Semester-IV

Paper Code	Paper No.	Title of the Paper	Contact hours/ week	Distribution of Marks for Examination			Credits
				Internal	External	Total	
MST-401	XVI	Discrete Data Analysis	04	30	70	100	04
MST-402	XVII	Industrial Statistics	04	30	70	100	04
MST-403	XVIII	Reliability and Survival Analysis	04	30	70	100	04
---	XIX	Elective-I	04	30	70	100	04
---	XX	Elective-II	04	30	70	100	04
MST-416	---	Statistics Practical-IV and Project	12	30	70	100	04
Seminar			02	25	--	25	01
Total			**34**	**205**	**420**	**625**	**25**

Elective Papers from which <u>Any Two</u> are to be chosen

MST-421: Operations Research
MST-422: Time Series Analysis
MST-423: Clinical Trials
MST-424: Data Mining
MST-425: Statistical Decision Theory
MST-426: Statistical Ecology
MST-427: Advanced Multivariate Analysis
MST-428: Statistical Methods for Total Quality Management

Note: Syllabus for some Elective courses has been given. Depending on need and demand, syllabus for other elective courses listed or of new elective courses will be submitted for approval.

Evaluation Scheme:

Each theory and practical paper will have 100 marks out of which 70 marks will be for Term End examination and 30 marks for Internal Assessment. The candidate has to appear for internal evaluation of 30 marks and external evaluation (University Examination) of 70 marks for each paper/ practical.

Internal Evaluation:

- In case of theory papers internal examinations will be conducted by department / school.
- In case of practical paper 10 marks shall be for day-to-day journal and internal test will be for 20 marks will be conducted by the department / school.

External Evaluation (End of Term University Examination):

I) Nature of Theory question paper:

1) Each Theory paper is of 70 marks.
2) Each theory paper will be of 3 hours duration
3) There shall be 7 questions each carrying 14 marks.
4) Students have to attempt **five questions**.
5) Q.No.1 is **compulsory** and shall contain 14 objective type sub-questions each carrying 1 mark.
6) Q. No.2 is **compulsory** and shall contain 4 short answer type sub-questions each carrying 3 or 4 marks.
7) Students have to attempt **any three** questions from Q. N0. 3 to Q. No. 7.
8) Q. N0. 3 to Q. No. 7 shall contain 2 long answer type sub-questions.

II) Nature of Practical question paper: (End of Term Examination)

For Sem-III: Practical examination will be conducted for 60 marks and is of 3 hours duration. There shall be 6 questions each of 15 marks, of which student has to attempt any 4 questions. VIVA will be for 10 marks.

For Sem-IV: i) Practical examination will be conducted for 40 marks and is of two hours duration. There shall be 3 questions each of 20 marks, of which a student has to attempt any 2 questions.

ii) Project work carries 30 marks. Project work consists of collecting of data, analyzing the data and preparing a report. Out of 30 marks, 10 marks are reserved for VIVA.

Equivalence for Theory Papers:

Semester No.	Old Syllabus		Revised Syllabus	
	Paper code	**Title of the Paper**	**Paper code**	**Title of the Paper**
III	MST-301	Asymptotic Inference	MST-301	Asymptotic Inference
	MST-302	Multivariate Analysis	MST-302	Multivariate Analysis
	MST-303	Design and Analysis of Experiments	MST-303	Planning and Analysis of Industrial Experiments
	MST-321	Reliability Theory	MST-321	Modeling and Simulation
	MST-322	Regression Analysis	MST-322	Regression Analysis
IV	MST-401	Optimization Techniques	MST-421	Operations Research
	MST-402	Industrial Statistics	MST-402	Industrial Statistics
	MST-403	Discrete Data Analysis	MST-401	Discrete Data Analysis
	MST-404	Statistical Decision Theory	MST-422 MST-423	Time Series Analysis OR Clinical Trials
	MST-405	Survival Analysis	MST-403	Reliability and Survival Analysis

Paper No. XI

Paper Code: MST 301

ASYMPTOTIC INFERENCE

Unit-1. Consistency of estimators, Joint and marginal consistency, Weak and strong consistency, Invariance of consistent estimator under continuous transformation, Consistency of estimators by method of moments and method of percentiles, Mean squared error criterion, Asymptotic relative efficiency, Error probabilities and their rates of convergence, Minimum sample sizes required to attain given level of accuracy. **(10 L)**

Unit-2. Asymptotic Normality, Consistent Asymptotic Normal (CAN) estimators, Invariance of CAN estimator under non-vanishing differentiable transformation, Methods of obtaining CAN estimators, Large sample tests and confidence intervals based on CAN estimators, Super efficient estimators. **(10 L)**

Unit-3. Best Asymptotic Normal (BAN) estimator, Cramer regularity conditions and asymptotic properties of the MLE (Cramer-Huzurbazar results). **(8 L)**

Unit-4. CAN and BAN estimation for multiparameter exponential family. **(8 L)**

Unit-5. Variance stabilizing transformations, their existence, their applications in obtaining large sample tests and confidence intervals. **(6 L)**

Unit-6. Likelihood Ratio Test (LRT), Asymptotic distribution of LRT statistic, Wald test, Rao's score test, Pearson χ^2 test for goodness of fit, Barttletts test for homogeneity of variances. **(8 L)**

Reference Books:

1) Kale B. K. (1999): A first course on parametric inference, Narosa Pub.
2) Zacks S. (1971): Theory of statistical inference, Wiley & Sons Inc.
3) Rohatagi V. K. & Saleh A. K. Md. E. (2001): Introduction to Probability Theory and Mathematical Statistics, John Wiley and Sons Inc.
4) Dudewicz E. J. and Mishra S.N. (1988): Modern Mathematical Statistics, Wiley Eastern.

Paper No. XII

Paper Code: MST 302

MULTIVARIATE ANALYSIS

Unit-1.Multivariate normal distribution, singular and non-singular normal distributions, characteristic function, moments, marginal and conditional distributions. **(10 L)**

Unit-2.Maximum likelihood estimators of the parameters of the multivariate normal distribution and their sampling distributions. **(8 L)**

Unit-3.Wishart matrix and its distribution, properties of Wishart distribution, Distribution of generalized variance. **(8 L)**

Unit-4.Hotelling's T^2 statistics and its distribution, Applications of T^2 statistic and its relationship with Mahalanobis D^2 statistic, Confidence region for the mean vector. **(8 L)**

Unit-5. Discrimination and Classification, Fisher's discriminant function and likelihood ratio procedure, Minimum Expected Cost of Misclassification (ECM) rule, Rao's U statistic and its use in tests associated with discriminant function. **(6 L)**

Unit-6. Principal components, Dimension reductions, Canonical correlation and Canonical variables **(5 L)**

Unit-7. Introduction to Factor analysis and Cluster analysis. **(5 L)**

Reference Books:

1) Anderson T. W. (1984): An Introduction to Multivariate Analysis.
2) Kshirsagar A. M. (1972): Multivariate Analysis, Marcel Dekker
3) Johnson and Dean W. Wichern (2002): Applied Multivariate Analysis, John Wiley.
4) Rao C. R. (1973): Linear Statistical Inference and Its Applications, 2nd Ed. Wiley.
5) Sharma S. (1996): Applied multivariate techniques, Wiley.
6) Srivastava M. S. and Khatri C. G. (1979): An introduction to multivariate statistics, North Holland.

Paper No. XIII

Paper Code: MST 303

PLANNING AND ANALYSIS OF INDUSTRIAL EXPERIMENTS

Unit-1. A review of basic concepts of design of experiment. **(6 L)**

Unit-2. Factorial Experiments: Concepts of main effects, interaction, Analysis of full 2^n and 3^2 factorial designs, Analysis of single replicate of 2^n and 3^2 design. **(8 L)**

Unit-3. Confounding: Total and partial confounding, construction and analysis of 2^n and 3^n confounded design. **(8 L)**

Unit-4. Factorial replication for symmetric factorials, concept of aliasing, resolution and minimum aberration, construction of 2^{n-k} design, analysis of 2^{n-k} replicated and single replicate design **(8 L)**

Unit-5. Response surface experiments: Linear and quadratic model, stationary point, central composition design. **(8 L)**

Unit-6. Taguchi Methods: Concept of loss function, S/N ratio. Liner graphs, inner and outer arrays, ANOVA. **(7 L)**

Unit-7. Random effects model for one way classification. **(5 L)**

Reference Books:

1) Jeff Wu C. F., Hamada M. (2000): Experiments: Planning, Analysis and parameter design optimization, John Wiley & Sons.
2) Phadke, M.S. (1989): Quality Engineering using Robust Design, Prentice-Hall.
3) Montgomery D.C. (2001): Design and Analysis of Experiments, 5^{th} edition, Wiley New York.
4) Angela Dean and Daneil Voss (1999): Design and Analysis of Experiments, Wiley.

Elective Paper

Paper Code: MST 321

MODELING AND SIMULATION

Unit-1. Stochastic Models: Introduction, Discrete distributions (Bernoulli, Binomial, Poisson, Geometric, Hypergeometric, Uniform), Continuous distributions (Uniform, Exponential, Gamma, Normal), Poisson Process, Markov chains and applications. **(6 L)**

Unit-2. Inventory Models: Introduction, Types of Inventories, Reasons for carrying inventory, Objectives of scientific Inventory Control, Concept of EOQ (Deterministic Model). **(8 L)**

Unit-3. Queuing Models: Introduction, Queuing System, Elements of queuing system, birth and death process model, Queuing Models M/ M/1, M/M/C. **(8 L)**

Unit-4. Network Analysis: Applications of PERT and CPM techniques, Network diagram representation,Rules for constructing the network diagram,Determination of critical path.**(8 L)**

Unit-5. Simulation: Introduction, Uses of simulation, Steps in simulation study, Advantages and disadvantages of simulation, Simulation models- continuous and discrete simulations. **(4 L)**

Unit-6. Random Number Generation : Introduction, Types of random numbers, Pseudo random number generator, Tests for random numbers, Techniques for generating random numbers, Inverse transformation technique, Generating random variates from Uniform, Bernoulli, Binomial, Exponential and Normal distributions. **(8 L)**

Unit-7. Simulation Models: (Flow chart and/or algorithms): Monte-Carlo simulation, Simulation of inventory problem, Simulation of queuing system, Fixed time step versus event to event model, Simulation of PERT problems. **(8 L)**

Reference Books:

1) Allen Arnold o.(1978). Probability, Statistics and Queuing with Computer Science Applications, Academic Press.

2) Kishore Trivedi. (1982). Probability and Statistics with Reliability, Queuing with computer science Applications, Prentice Hall.

3) Geofrey Gordon (1999). System Simulation, PHI, Second ed.

4) Narsingh Deo (1979). System Simulation with Digital Computer, PHI.

5) Fred Maryanski (1987). Digital Computer, Simulation, CBSPD.

6) Jerry Banks, John Carson, B. L. Nelson (1998). Discrete-Event Simulation. PHI, 2nd ed.

7) Taylor and Karlin, Stochastic Modeling, Academic Press.

8) Sharma J. K. (2003): Operations Research Theory and Applications, 2nd Ed. Macmillan

9) Sharma S.D. Operations Research,

10) J. Mehdi,(1982), Stochastic Process, Wiley

Elective Paper

Paper Code: MST 322

REGRESSION ANALYSIS

Unit-1. Simple regression with one independent variable, assumptions, estimation of parameters, standard error of estimator, testing of hypothesis about regression parameters, standard error of prediction. **(4 L)**

Unit-2. Multiple regression model, Least squares estimates (LSE), Properties of LSE, Hypothesis testing, Confidence and prediction intervals, General linear hypothesis testing. **(10 L)**

Unit-3. Multiple correlation and adjusted multiple correlation coefficient, Null distribution of sample correlation and multiple correlation coefficient, Partial correlation coefficient and its relation with multiple correlation coefficient. Test for significance of simple, multiple and partial correlation coefficients. **(8 L)**

Unit-4. Variable selection procedures, Mallows Cp, Forward, Backward selection methods. **(6 L)**

Unit- 5. Residuals and residual diagnostics, Transformation of variables: Box-Cox power transformation. **(6 L)**

Unit-6. Multicollinearity: Consequences, detection and remedies. Autocorrelation: Consequences. Durbin-Watson test, Estimation of parameters in presence of autocorrelation. **(10 L)**

Unit-7. Dummy variables and their use in regression analysis. **(2 L)**

Unit-8. Nonlinear Regression Models: linearization transforms, their use and limitations, examination of non-linearity, initial estimates. **(4 L)**

Reference Books:

1) Draper N. R. and Smith H. (1998): Applied Regression Analysis, 3rd Ed. Wiley.
2) Wiesberg S. (1985): Applied Linear Regression, Wiley.
3) Kutner, Neter, Nachtsheim and Wasserman (2003): Applied Linear Regression Models, 4th Ed. McGraw-Hill.
4) Montgomery, D. C., Peck E. A. and Vining, G. (2001): Introduction to Linear Regression Analysis, 3rd Ed. Wiley.
5) Cook, R. D. and Wiesberg, S. (1982): Residuals and Influence in Regression, Chapman and Hall.

Elective Paper

Paper Code: MST 323

ECONOMETRICS

Unit-1. Nature of Econometrics, The general linear model (GLM) and its extensions, Ordinary least square (OLS) estimation and prediction, Use of dummy variables and seasonal adjustment, Generalized least squares (GLS) estimation and prediction, Heteroscedastic disturbances, Pure and mixed estimation, Grouping of observations. **(10 L)**

Unit-2. Auto correlation, its consequences and tests, Theil's BLUE procedure, Estimation and prediction, Multicollinearity problem, its implications and tools for handling the problem, ridge regression. **(10 L)**

Unit-3. Linear regression with stochastic regressors, Instrumental variable estimation, Errors in variables. **(10 L)**

Unit-4. Simultaneous linear equations model, Examples, Identification problem, Restrictions on structural parameters- rank and order conditions. **(10 L)**

Unit-5. Estimation in simultaneous equations model, Recursive systems, 2 SLS estimators, Limited information estimators. **(10 L)**

Reference Book:

1) Johnston J. (1984): Econometric Methods, 3rd Ed. McGraw Hill.

2) Apte P. G. (1990): Text Book of Econometrics. Tata McGraw Hill.

4) Cramer J. S. (1971): Empirical Econometrics, North Holland.

5) Gujarathi D. (1979): Basic Econometrics, McGraw Hill.

6) Klein L. R. (1962): An introduction to Econometrics, Prentice Hall of India.

Elective Paper

Paper Code: **MST 324**

ACTUARIAL STATISTICS

Unit-1. Basic Concepts and Life Tables: Utility theory, insurance and utility theory, models for individual claims and their sums, survival function, curate future lifetime, force of mortality. Life table and its relation with survival function, examples, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables. Multiple life functions, joint life and last survivor status, insurance and annuity benefits through multiple life functions evaluation for special mortality laws. **(12 L)**

Unit-2. Probability Models: Multiple decrement models, deterministic and survivorship groups associated single decrement tables, central rates of multiple decrement, net single premiums and their numerical evaluations. Distribution of aggregate claims, Compound Poisson distribution and its applications. **(12 L)**

Unit-3. Principles of compound interest: Nominal and effective rates of interest and discount force of interest and discount, compound interest, accumulation factor, continuous compounding. Life insurance: Insurance payable at the moment's of death and at the end of the year of death level benefit insurance, endowment insurance, differed insurance and varying benefit insurance, recursions, communication functions. Life annuities: Single payment, continuous life annuities, discrete life annuities, life annuities with monthly payments, commutation functions, varying annuities, recursions, complete annuities-immediate and apportion able annuities-due. **(10 L)**

Unit-4. Net premiums: Continuous and discrete premiums, true monthly payment premiums apportion able premiums, commutation functions and accumulation type benefits. Payment premiums, apportion able premiums, commutation functions accumulation type benefits**. (8 L)**

Unit-5. Net premium reserves: Continuous and discrete net premium reserve, reserves on a semi continuous basis, reserves based on true monthly premiums, reserves on an apportion able or discounted continuous basis, reserves at fractional durations, allocations of loss to policy years, recursive formulas and differential equations for reserves, commutation functions.Some practical considerations: premiums that include expenses-general expenses, types of expenses per policy expenses. Claim amount distributions, approximating the individual model, step-loss Insurance. **(8 L)**

Reference Books:

1) Actuarial Mathematics, Society of Actuaries, Itasca, IIIinois, U.S.A. 2nd Ed. (1997).
2) Spurgeon E. T. (1972); Life Contingencies, Cambridge University Press.
Neill, A. Life Contingencies, Heinemann.

Practical Paper III

Paper Code: MST 316

STATISTICS PRACTICAL-III

1. Consistent Estimators and Comparisons
2. Construction of CAN estimators.
3. Bartlett's test for Homogeneity of Variances.
4. Variance Stabilizing Transformation
5. Multivariate Analysis
6. Maximum Likelihood Estimation of μ and Σ.
7. Hotelling's T^2 Statistic
8. Discriminant Analysis
9. Dimension Reduction Techniques
10. Analysis of full replicated unconfounded 2^n and 3^n factorial experiments.
11. Analysis of single replicate 2^n factorial experiment.
12. Analysis of confounded 2^n factorial experiments: total and partial confounding.
13. Analysis of confounding 3^n factorial experiments.
14. Analysis of one way classification random effects data.

15-20. Three practicals on each of the elective courses.

Paper No. XVI

Paper Code: MST 401

DISCRETE DATA ANALYSIS

Unit-1. Log linear model for two and three dimensional contingency tables: Interpretation of parameters, comparison with ANOVA and regression, ML estimation of parameters, likelihood ratio tests for various hypotheses including independence, marginal and conditional independence, partial association, models with quantitative levels. **(13 L)**

Unit-2. Generalized linear models: Concept of generalized linear model, Link function, ML estimation, large sample tests about parameters, goodness of fit, analysis of deviance, introduction to poisson regression. **(10 L)**

Unit-3. Logistic regression: logit model for dichotomous data with single and multiple explanatory variables, ML estimation, large sample tests about parameters, variable selection, extension to polynomial data. **(10 L)**

Unit-4. Nonparametric regression and interpolating and smoothing and smoothing splines for simple regression, use of cross-validation, applications to logistic and Poisson regression. **(12 L)**

Reference Books:

1) Yvonne M. Bishop, Stephen E. Fienberg, Paul W. Holland Discrete (1975): Multivariate Analysis: Theory and Practice.
2) Hosmer D. W. and Lemeshow S. (2000): Applied Logistic Regression, 2nd Ed. Wiley New York.
3) Agesti A. (1990): Categorical Data Analysis, Wiley New York.
4) R. Christensen (1997): Log-linear Models and Logistic Regression, 2nd ed. Springer, New York.

Paper No. XVII

Paper Code: MST 402

INDUSTRIAL STATISTICS

Unit-1. Basic concept of quality control, process control and product control, seven SPC tools, flowchart, Histogram, Check sheet, Ishikawa diagram, Pareto chart, Defect concentration diagram, control chart, Deming's PDCA cycle for continuous improvements and its applications. **(10 L)**

Unit-2. General Theory of Control charts, Different types of limits, Control limits, specification limits, Natural tolerance limits, Warning limits, Phase-I and Phase-II limits, OC and ARL of control charts. Control charts for variables: $\overline{X}$, R, S, and S^2 control charts, Median chart and Midrange chart, CUSUM chart, tabular form and V-mask, Moving average and Exponentially weighted moving average charts. Control charts for attributes: Control chart for fraction nonconforming, Control charts for nonconformities. **(10 L)**

Unit-3. Process capability Analysis: Capability indices, C_p, C_{pk} and C_{pm}. Estimation, confidence intervals and tests of hypotheses relating to capability indices $C_{p,}$ C_{pk} for normally distributed characteristics. Determining process capability with $\overline{X}$ chart. **(8 L)**

Unit-4. Acceptance sampling plans for attribute inspection: Single, double and sequential sampling plans and their properties. Plans for inspection by variables for one sided and two sided specifications. Dodge-Roming sampling plans. **(10 L)**

Unit-5. Multivariate control charts for measurements data. Hotelling's T^2 control charts. **(4 L)**

Unit-6. Introduction to Six-Sigma methodology. DMAIC cycle and case studies. **(4 L)**

Unit-7. Simulation of $\overline{X}$ and R control charts, estimation of ARL and process capability indices. **(4 L)**

Reference Books:

1) Guenther W. C. (1981): Sampling Inspection in Statistical Quality Control, Charter Grifits.

2) Montgomery D. C. (1996): Introduction to Statistical Quality Control, John Wiley & Sons

3) Kotz S. (1993): Process capability indices, Chapman and Hall.

4) Abraham Boyas (1998): Quality Improvements through Statistical Methods, Birkhauser.

5) Mittag H. J. and Rinne H. (1993): Statistical methods Quality Assurance, Chapmam and Hall.

6) Wetherill G. B. (1977). Sampling Inspection and Quality Control, Hoisted Press, N. W.

Paper No. XVIII

Paper Code: MST 403

RELIABILITY AND SURVIVAL ANALYSIS

Unit-1. Reliability concepts and measures, components and systems, coherent systems, reliability of coherent systems. Structure function, dual of a structure, cuts and paths. Modular decomposition, bounds on system reliability. Associated random variables. **(8 L)**

Unit-2. Life time distributions, survival functions, hazard rate, cumulative hazard function, residual life time, survival function of residual life time, mean residual life time, one-one correspondence of these functions. Computation of these function for common life time distributions; exponential, Weibull, Gamma, Pareto, Lognormal etc. computation of survival and failure rate function proportional hazard models**.** **(10 L)**

Unit-3. Notion of ageing; IFR, IFRA, DMRL, NBU, NBUE classes and their duals, aging properties of common life time distributions, closures of these classes under formation of coherent structures, convolutions and mixtures. **(8 L)**

Unit-4. Estimation and testing for Exponential, Gamma, Weibull, Lognormal, Pareto and Life failure rate distribution for complete life data. **(5 L)**

Unit-5. Concept of censoring, various types of censoring, Estimation and Testing of parameters of exponential distribution under various types of censoring. **(5 L)**

Unit-6. Estimation of survival function: Actuarial estimator, Kaplan-Meier estimator, properties: self consistency and MLE, estimation under the assumption of IFR/DFR. **(8 L)**

Unit-7. Two-sample problem: Gehen test, Log rank test, Mantel Haenszel test. Semi parametric regression for failure rate- Cox's proportional hazards model, related estimation and test procedures. **(6 L)**

Reference Books:

1) Barlow R. E. and Proschan F. (1975): Statistical Theory of Reliability & Life Testing, Holt, Reinhart and Winston.
2) Lawless J. F. (1982): Statistical Models and Methods of Life Time Data, John Wiley.
3) Miller R. C. (1981): Survival Analysis, John Wiley.
4) Bain L.J. and Engelhardt (1991): Statistical Analysis of Reliability and Life testing Models, Marcel Dekker.
5) Martz H. F. and Waller R. A. (1982): Bayesian Reliability Analysis, John Wiley.
6) Lawless J. F. (1982): Statistical models and methods for failure time data, John Wiley.
7) Nelson W. (1982): Applied Life Data Analysis, John Wiley and Sons, Inc.

Elective Paper

Paper Code: MST 421

OPERATIONS RESEARCH

Unit-1. Convex Sets and Functions: Convex sets, supporting and separating hyperplanes, convex polyhedra and polytope, extreme points, convex functions. **(5 L)**

Unit-2. Linear Programming Problem (LPP): Introduction to linear programming problems, Graphical solution to LPP, Standard LPP (SLPP), basic solution and basic feasible solution to SLPP. Methods for solving LPP: Simplex Algorithm, Two-phase simplex method, Big M method . **(15 L)**

Unit-3. Duality in LPP: Concept of duality, Theorems related to duality, complementary slackness property and development of dual simplex algorithm. **(5 L)**

Unit-4. Integer Linear Programming Problem (ILPP): The concept of cutting plane, Gomory's method of cutting plane for all ILPP and mixed ILPP, Branch and Bound method (Algorithm only). **(9 L)**

Unit-5. Quadratic Programming Problem (QPP): Definition of QPP, Kuhn-Tucker conditions, Algorithms for solving QPP: Wolfe's and Beale's algorithm. **(8 L)**

Unit-6. Theory of Games: Two person zero sum games, Minimax and Maxmin principles, Saddle point, Mixed strategies; Rules of dominance, Solution of 2 x 2 game by Algebraic method, Graphical method, Reduction of game problem as LPP, Minimax and Maxmin theorem (without proof). **(8 L)**

Reference Books:

1) Hadley G. (1969): Linear Programming, Addision Wesley.
2) Taha H. A. (1971): Operations Research an Introduction, Macmillan N. Y.
3) Kanti Swaroop, Gupta and Manmohan (1985): Operations Research, Sultan Chand & Co.
4) Sharma J. K. (2003): Operations Research Theory and Applications, 2nd Ed. Macmillan India ltd.
5) Sharma J. K. (1986): Mathematical Models Operations Research, Macgraw Hill.

Elective Paper

Paper Code: MST 422

TIME SERIES ANALYSIS

Unit-1. Time series as discrete parameter stochastic process. Auto covariance and auto correlation functions and their properties. **(10 L)**

Unit-2. Exploratory Time series Analysis, Tests for trend and seasonally exponential and moving average smoothing. Hot Wiinters smoothing, Forecasting based smoothing, adaptive smoothing. **(10 L)**

Unit-3. Stationary processes: (a) Moving average, (b) Auto regressive (AR), (c) ARMA and (d) AR integrated MA (ARIMA) models, Box-Jenkins Models. Discussion (without proof) of estimation of mean, auto covariance and auto correlation functions under large sample theory. **(10 L)**

Unit-4. Choice of AR and MA periods, Estimation of ARIMA models parameters. Forecasting, Residual analysis and diagnostic checking. **(10 L)**

Unit-5. Spectral analysis of weakly stationary process, Periodogram and correlation analysis. Computations based on Fourier transform. Spectral decomposition of weakly AR process and representations as a one sided MA process- necessary and sufficient conditions **(10 L)**

Reference Books:

1) Anderson, T. W. (1971): The statistical Analysis of Time Series, Wiley, N. Y.
2) Brockwell, P. J. and Davis R. A. Time Series: Theory and Methods, 2nd Ed., Springer-Veriag.
3) Box, G. E. P. and Jenkins, G. M. (1976): Time Series Analysis-Forecasting and control, Hodlen-day, San Francisco.
4) Kendall, Sir Maurice and Ord, J. K. (1990): Time Series, 3rd Ed., Edward Arnold.
5) Montgomery, D. C. and Johnson, L. A. (1977): Forecasting and Time Series Analysis, McGraw Hill.

Elective Paper

Paper Code: MST 423

CLINICAL TRIALS

Unit-1.Introduction to Clinical Trials: Overview of drug development process, Need of ethics of clinical trials, Introduction to clinical trail guidelines, Bias and random error in clinical trials, Concept of Randomization and Blinding , Overview of phase I-IV clinical trials. **(10 L)**

Unit-2. Data Management : Data definition, Case report form, Data base design and data collection system for good clinical practice, Classification of clinical trials, Multicenter clinical trials, Active control trials, Combination trials equivalence trials. **(10 L)**

Unit-3. Design of Clinical Trials: Parallel Vs crossover design, Factorial design, Objective and end point of clinical trials, Concept of bioequivalence trials. **(10 L)**

Unit-4.Analysis and Reporting of Clinical Trials: Concept of sample size and it calculation, Concept of Normality, Analysis of quantities outcome, Analysis of qualitative outcome, Analysis of time to event (survival analysis). **(10 L)**

Unit-5.Introduction to SAS (Statistical Analysis System) : Concept of SAS datasets, Concept of SAS datasets, Introduction to SAS/base, Introduction to SAS/stat. **(10 L)**

Reference Books:

1. S. Piantadosi (1997). Clinical Trials: A Methodological Perspective. Wiley and Sons.
2. D.Wang and A. Bakhai (2006).Clinical Trials: A Practical Guide to Design, Analysis and Reporting, Andrew
3. L. M. Friedman, C. Furburg, D. L. Demets (1998). Fundamentals of Clinical Trials, Springer Verlag.
4. J. L. Fleiss (1989). The Design and Analysis of Clinical Experiments. Wiley and Sons.
5. E. Marubeni and M. G. Valsecchi (1994). Analyzing Survival Data from Clinical Trials and Observational Studies, Wiley and Sons.

Elective Paper

Paper Code: MST 424

DATA MINING

Unit-1. Review of classification methods from multivariate analysis, classification and decision trees. **(8 L)**

Unit-2. Clustering methods from both statistical and data mining view points, vector quantization. **(8 L)**

Unit-3. Unsupervised learning from univariate and multivariate data; dimension reduction and feature selection. **(8 L)**

Unit- 4. Supervised learning from moderate to high dimensional input spaces, artificial neural networks and extensions of regression models, regression trees. **(10 L)**

Unit-5. Introduction to databases, including simple relational databases, data warehouses and introduction to online analytical data processing. **(8 L)**

Unit-6. Association rules and prediction, data attributes, applications to electronic commerce. **(8 L)**

Reference Books:

1. Berson and Smith S. J. (1997): Data warehousing, Data mining and OLAP, McGraw Hill.
2. Breiman J. H., Friedman R. A., Olshen and Stone, C. J. (1984): Classification and Regression Trees, Wadsworth and Books/Cole.
3. Han and Kamber (2000): Data Mining: Concepts and Techniques, Morgan Gaufmann.
4. Mitchell T. M. (1997): Machine Learning, McGraw-Hill.
5. Ripley B. D. (1996): Pattern Recognition and Neural Networks, Cambridge University Press.

Elective Paper

Paper Code: MST 425

STATISTICAL DECISION THEORY

Unit-1. Decision Theory- Description of the problem, Estimation, testing and interval estimation as decision problems; randomized, non-randomized and behavioral decision rules and their risk functions. **(10 L)**

Unit-2. The concept of prior distribution, various types of priors, non-informative, Jeffrey's least favorable prior, posterior distribution; posterior distribution conjugate family and standard examples of such families. Bayes and minimax rules; geometric interpretation for finite parameter space. **(10 L)**

Unit-3. Construction of minimax rules using Bayes rules, Bayes rules for estimation, testing and confidence region problems, Relation between minimax and Bayes rules, Extended and generalized Bayes rules. **(10 L)**

Unit-4. Complete and minimal complete classes; essentially complete classes, Admissible rules; related theorems; Bayes and Admissible rules, Admissibility of aX+b for Ex. Inadmissibility of sample mean vector for the mean vector of normal distribution**. (12 L)**

Unit-5. Invariance, Maximal invariance of a function, Invariant decision problem, Invariant rule, Invariant estimators and tests, UMPI tests. **(8 L)**

Reference Books:

1) Ferguson T. S. (1967): Mathematical Statistics: Decision theoretic approach, Academic Press.
2) Degroot H.: Optimal Statistical Decisions
3) Berger J. O. (1980): Statistical Decision Theory-Foundations, Concepts and Methods, Springer Verlag.
4) Zacks (1971): Theory of Statistical Inference, John Wiley and Sons, Inc.
5) Lehmann E. L. Theory of Point Estimation.

Practical Paper-IV
Paper Code: MST 416

STATISTICS PRACTICAL-IV AND PROJECT

1. Log linear Model
2. Logistic Regression
3. Control chart for Variables and Attributes
4. Sampling Inspection Plans
5. Process Capability Analysis
6. Multivariate Control Charts
7. Reliability
8. Survival Analysis

In addition to the above, at least two practicals from each elective course be conducted.

- Project report should be based on Problem definition, Data collection, Data analysis, Interpretation, Major findings and Report writing.

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