SOLAPUR UNIVERSITY, SOLAPUR.

M.Sc. (Part-II) STATISTICS
(Semester III and IV)
Choice Based Credit System (CBCS)
Syllabus

WITH EFFECT FROM ACADEMIC YEAR 2016-17

(JUNE-2016)

SOLAPUR UNIVERSITY, SOLAPUR

SCHOOL OF COMPUTATIONAL SCIENCES

DEPARTMENT OF STATISTICS

Syllabus of M.Sc. in Statistics

(Choice Based Credit System)

1) **Title of the course:** M.Sc. in Statistics.
2) **Duration of course**: Two years.
3) **Pattern:** Semester and Choice Based Credit System (CBCS).
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 (Choice Based Credit System)

(To be effective from 2016-17)

STRUCTURE

The following table gives the scheme of Examination at M.Sc. Part II (Statistics) according to the Choice Based Credit System (CBCS) 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: Time Series Analysis
MST-324: Actuarial Statistics
MST-325: Official Statistics
MST-326: Statistical Genetics
MST-327: Demography

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-III	04	30	70	100	04
---	XX	Elective-IV	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: Clinical Trials
MST-423: Data Mining
MST-424: Statistical Decision Theory
MST-425: Econometrics
MST-426: Statistical Ecology
MST-427: Advanced Multivariate Analysis

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 2.5 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.

M.Sc. (STATISTICS) Semester-III

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, Asymptotic relative efficiency, Asymptotic Normality, Consistent Asymptotic Normal (CAN) estimators, Invariance of CAN estimator under differentiable transformation, Methods of obtaining consistent and CAN estimators. **(15 L)**

Unit-2. Super efficient estimator, Best Asymptotic Normal (BAN) estimator, Cramer regularity conditions and asymptotic properties of the MLE (Cramer-Huzurbazar results), CAN and BAN estimation for multi-parameter exponential family. **(15 L)**

Unit-3. Variance stabilizing transformations (VST), their existence; their applications in obtaining large sample tests and estimators. Asymptotic distribution of likelihood ratio test statistic, Wald test, Rao's score test, Pearson Chi-square test for goodness of fit, Bartlett's test for homogeneity of variances. **(15 L)**

Unit-4. Asymptotic confidence intervals based on CAN estimators, Asymptotic confidence intervals based on VST, Performance evaluation (based on simulation) of asymptotic tests and confidence intervals, asymptotic confidence regions in multi-parameter families. **(15 L)**

Reference Books:

1) Kale, B. K. (1999): A first course on parametric inference, Narosa Pub.
2) Rao, C. R. (1995): Linear Statistical Inference and its Applications, Wiley New York.
3) Rohatagi, V. K. & Saleh A. K. Md. E. (2001): An Introduction to Probability and Statistics, John Wiley and Sons Inc.
4) Ferguson, T. S. (1996): A Course in Large Sample Theory, Chapman and Hall.
5) Lehman, E. L. (1999): Elements of Large Sample Theory, Springer.
6) Gupta Anirban Das. (2008), Asymptotic Theory of Statistics and Probability, Springer Texts in Statistics.

Paper No. XII
Paper Code: MST 302
MULTIVARIATE ANALYSIS

Unit-1.Exploratory Multivariate Data Analysis: Sample mean vector, sample dispersion matrix, correlation matrix, graphical representation of means, variances, covariances, correlation of linear transformations. Introduction to principal component analysis as dimension reduction technique, canonical correlation, canonical variables. **(15 L)**

Unit-2 Multivariate Normal Distribution: Two definitions and their equivalence, singular and non-singular normal distribution, characteristic function, moments, marginal and conditional distributions. Maximum likelihood estimator of the parameters of the multivariate normal distribution and their sampling distributions. Null distribution of sample correlation coefficient, partial and multiple correlation coefficients. **(15 L)**

Unit-3. Hotelling's T^2 statistics and its null distribution. Applications of T^2 statistic and its relationship with Mahalanobis D^2 statistic, Confidence region for the mean vector, Wishart matrix and its distribution, properties of Wishart distribution, Distribution of generalized variance. **(15 L)**

Unit-4. (a)Discrimination and Classification, Fisher's discriminant function and likelihood ratio procedure, Minimum Expected Cost of Misclassification (ECM) rule, Rao's U statistics and its use in tests associated with discriminant function, classification with three populations.

(b) Cluster and Factor Analysis: Hierarchical and Non-hierarchical clustering, single, complete, average linkage method and k-means clustering. Introduction to factor analysis, orthogonal factor model, estimation of factor loading, MLE and principle component method, rotation of factors. **(15 L)**

Reference Books:

1) Anderson T. W. (1984): An Introduction to Multivariate Analysis, 2nd Ed., John Wiley.
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.
7) Bhuyan, K. C. (2005), Multivariate Analysis and its Applications, New central Book Agency (P) Ltd. Kolkata.
8) Giri, N. C. (1977), Multivariate Statistical Inference, Academic Press.

Paper No. XIII
Paper Code: MST 303

PLANNING AND ANALYSIS OF INDUSTRIAL EXPERIMENTS

Unit-1. 2^n Factorial Experiments: Concepts of main effects, interaction, their graphical representation, Analysis of full 2^n replicated and unreplicated factorial design. Concept of confounding: Total and partial confounding, construction and analysis of confounded design. **(15 L)**

Unit-2. 3^n Factorial Experiments: Concepts of main effects, interaction, their graphical representation, linear and quadratic components. Analysis of Full 3^n replicated and unreplicated factorial design. Confounding: Construction and analysis of 3^n confounded design. **(15 L)**

Unit-3. Fractional Replication for Symmetric Factorial: Concept of generator, defining contrast, aliasing, resolution and minimum aberration, construction and analysis of 2^{n-k} and 3^{n-k} fractional designs, central composite designs.

(15 L)

Unit-4. **a)** Response Surface Experiments: Linear and quadratic model, test for curvature, stationary point, central ridge systems, Rotatability, Multiple responses.

b) Taguchi Methods: Concept of noise and control factors, inner and outer arrays, concept of loss function, S/N ratio, orthogonal arrays, Liner graphs, interaction tables. **(15 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.
5) Das, M. N. and Giri, N. (1979), Design and Analysis of Experiments, Wiley Eastern.

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, Gamma, Exponential, Normal), Poisson Process, Markov chains and applications. Inventory Models: Introduction, Types of Inventories, Reasons for carrying inventory, Objectives of scientific Inventory Control, Concept of EOQ (Deterministic Model). **(15 L)**

Unit-2. Queuing Models: Introduction, Queuing System, Elements of queuing system, birth and death process model, Queuing Models M/ M/1, M/M/C. Network Analysis: Applications of PERT and CPM techniques, Network diagram representation, Rules for constructing the network diagram, Determination of critical path. **(15 L)**

Unit-3. Simulation: Introduction, Uses of simulation, Steps in simulation study, Advantages and disadvantages of simulation, Simulation models- continuous and discrete simulations.

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. **(15 L)**

Unit-4. 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. **(15 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) Narsingh Deo (1979): System Simulation with Digital Computer, PHI.
4) Jerry Banks, John Carson, B. L. Nelson (1998): Discrete-Event Simulation. PHI, 2nd ed.
5) Taylor and Karlin: Stochastic Modeling, Academic Press.
6) Sharma J. K. (2003): Operations Research Theory and Applications, 2nd Ed. Macmillan
7) Sharma S.D.: Operations Research,
8) J. Mehdi,(1982): Stochastic Process, Wiley

Elective Paper
Paper Code: MST 322
REGRESSION ANALYSIS

Unit-1. Multiple regression model, Least squares estimates (LSE), Properties of LSE, Hypothesis testing, Confidence and prediction intervals, General linear hypothesis testing. Residuals and their properties, Residual diagnostics. Transformation of variables: VST and Box-Cox power transformation. **(15 L)**

Unit-2. Variable Selection Procedures: R-square, adjusted R-square Mallow's Cp, forward, backward selection, stepwise selection methods. Multicollinearity: Consequences, detection and remedies, Ridge regression. Autocorrelation: causes, consequences, detection: Durbin-Watson test, Estimation of parameters in presence of autocorrelation: Cochrane-Orkut method. **(15 L)**

Unit-3. Robust Regression: Influential observation, leverage, outliers, methods of detection of outliers and influential observations, estimation in presence of outliers: M-estimator, Huber loss function, breakdown point, influence function, efficiency, Asymptotic distribution of M-estimator (Statement only), Mallow's class estimators. **(15 L)**

Unit-4. a) Nonlinear Regression Models: Nonlinear least squares, transformation to a linear model, Parameter estimation in a nonlinear system, Statistical inference in nonlinear regression.

b) Polynomial models in one and two variables, orthogonal polynomials, smoothing splines: linear, quadratic, cubic, cubic-B. Nonparametric regression: Kernel regression, locally weighted regression. **(15 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.
6) Seber, G. A. , Wild, C. J. (2003), Nonlinear Regression, Wiley.
7) Takezawa, K. (2005), Introduction to Nonparametric Regression, Wiley-Inter science.

Elective Paper
Paper Code: MST 323
TIME SERIES ANALYSIS

Unit-1. Time series as discrete parameter stochastic process, Auto-covariance, Auto-correlation functions and their properties. Exploratory Time series Analysis, Tests for trend and seasonality, Exponential and moving average smoothing. Holt-Winter smoothing, forecasting based smoothing. **(15 L)**

Unit-2. Wold representation of linear stationary processes, Detailed study of the linear time series models: Autoregressive (AR), Moving average (MA), Autoregressive Moving Average (ARMA) models. Concept of causality, invertibility, Computation of π-weights and Ψ-weights, computation of ACVF and ACF. Partial auto covariance function, Autoregressive Integrated Moving Average (ARIMA) models. **(15 L)**

Unit-3. Estimation of ARMA models: Yule-Walker estimation for ARMA processes, Discussion (without proof) of estimation of mean, Auto-covariance and auto-correlation function under large sample theory, Residual analysis and diagnostic checking, Forecasting using ARIMA models. **(15 L)**

Unit-4. Analysis of seasonal models: Parsimonious models for seasonal time series, SARIMA models, forecasting, identification, estimation and diagnosis methods for seasonal time series. Introduction to ARCH and GARCH models. **(15 L)**

Reference Books:

1) Box, G. E. P. and Jenkins, G. M. (1976): Time Series Analysis-Forecasting and control, Hodlen-day, San Francisco.
2) Brockwell, P. J. and Davis R. A. (1987): Time Series: Theory and Methods, 2nd Ed., Springer-Veriag.
3) Chatfield, C. (2004): The Analysis of Time Series-An Introduction, 6th Ed., Chapman and Hall.
4) Kendall, M. G. (1978): Time Series, Charler Graffin
5) Montgomery, D. C. and Johnson, L. A. (1977): Forecasting and Time Series Analysis, McGraw Hill.
6) Fuller, W. A. (1996): Introduction to Statistical Time Series, John Wiley, New York.

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. **(15 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. **(15 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. **(15 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.

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. **(15 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.

Elective Paper
Paper Code: MST 325
OFFICIAL STATISTICS

Unit-1. Introduction to Indian and International statistical systems. Role, function and activities of Central and State statistical organizations. Organization of large scale sample surveys. Role of National Sample Survey Organization. General and special data dissemination systems. **(15 L)**

Unit-2. Population growth in developed and developing countries, evaluation of performance of family welfare programmes, projections of labour force and manpower. Scope and content of population census of India. **(15 L)**

Unit-3. System of collection of Agricultural statistics. Crop forecasting and estimation, productivity, fragmentation of holdings, support prices, buffer stocks, impact of irrigation projects. **(15 L)**

Unit-4. Statistics related to industries, foreign trade, balance of payment, cost of living inflation, educational and other social statistics. **(15 L)**

References:

1. Basic Statistics related to Indian Economy (CSO) 1990.
2. Guide to official Statistics (CSO) 1999.
3. Statistical System in India (CSO) 1995.
4. Principle and accommodation of National Population Censuses, UNESCO.
5. Panse V.G. Estimation of Crop Yields, (FAO).
6. Family welfare, Yearbook. Annual publication of D/o Family Welfare.
7. Monthly Statistics of Foreign Trade in India, DGCIS, Calcutta and other Govt. Publication.

Practical Paper III

Paper Code: MST 316

STATISTICS PRACTICAL-III

Use of Statistical Software Packages

- MINITAB
- SPSS
- MATLAB

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.

M.Sc. (STATISTICS) Semester-IV

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. Collapsibility theorem. **(15 L)**

Unit-2. Generalized Linear Models: Concept of generalized linear model, Link function, ML estimation, Quasi-likelihood estimation, Large sample tests about parameters, goodness of fit, analysis of deviance. Residual Analysis: Types of residuals: raw, Pearson, deviance, Anscombe, quantile; residual plots. Variable selection: AIC and BIC . **(15 L)**

Unit-3. Logistic Regression: logit, Probit and cloglog model for dichotomous data with single and multiple explanatory variables, ML estimation, large sample tests about parameters. Hosmer-Lemshow test, ROC curve. Multilevel logistic regression, Logistic regression for Nominal response: Baseline Category model and ordinal response: Proportional odds model. **(15 L)**

Unit-4. Poisson Regression: ML and Quasi-Likelihood estimation of parameters, testing significance of coefficients, goodness of fit, power family of link function, over dispersion: Types, causes and remedies. **(15 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. Concept of quality and quality control, Basic concept of process monitoring and control, Process control and product control, Seven SPC tools, Deming's PDCA cycle for continuous improvements and its applications, General theory of Control charts, Different types of limits: Natural tolerance limits, Specification limits, Control limits, Warning limits, Performance measures of a control chart: ARL, ATS, OC. Control charts for measurement and attributes: $\overline{X}$, R, S, S^2, X-MR charts, p, np, c, u, charts, Demerit chart, Conforming run length chart. **(15 L)**

Unit-2. Memory type control charts: CUSUM chart, tabular form and V-mask. Moving and exponentially weighted moving average charts, use of these charts for process control. Non-parametric charts for location based on sign and signed rank test statistics, Multivariate control charts for measurements data, Hotelling's T^2 control charts. **(15 L)**

Unit-3. Process Capability Analysis: Process capability indices (PCI) C_p, C_{pk} and C_{pm} under normal distribution of quality characteristics, connection between proportion of nonconforming and C_p, C_{pk}. Estimation, confidence interval and testing hypotheses about C_p. Process capability analysis for non-normal data. Introduction to Six-sigma methodology, DMAIC Cycle and case studies. **(15 L)**

Unit-4. Acceptance Sampling Plans: Consumers risk, Producers risk, LTPD, AOQ. Sampling plans by attributes, single, double and sequential plans, Sampling by variables for one-sided and two-sided specifications. Simulation of X-bar and R control charts. **(15 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.

Paper No. XVIII
Paper Code: MST 403
RELIABILITY AND SURVIVAL ANALYSIS

Unit-1. Structure function, dual of a structure, cuts and paths, components and systems, coherent systems, pivotal decomposition, coherent modules, modular decomposition, reliability concepts and measures, reliability of coherent systems bounds on system reliability, Burnham's measure of structural importance, Associated random variables and their properties. **(15 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. Computation of these function for common life time distributions; Exponential, Weibull, Gamma, Pareto, Rayleigh, Lognormal distributions. Computation of survival and failure rate functions.

Notion of Ageing; IFR, IFRA, DMRL, NBU, NBUE, NWUE classes, ageing properties of common life time distributions, closures of these classes under formation of coherent structures, convolutions and mixtures of these classes. **(15 L)**

Unit-3. Estimation and testing for Exponential, Gamma, Weibull, Lognormal, Pareto and Life failure rate distribution for complete life data. Concept of censoring, various types of censoring, Estimation and Testing of parameters of exponential distribution under various types of censoring. **(15 L)**

Unit-4. Estimation of survival function: Actuarial estimator, Kaplan-Meier estimator, properties: self consistency and MLE, estimation under the assumption of IFR / DFR. Concept of TTT transform and its applications, Test for exponentiality against alternatives IFRA, NBU and NBUE. Two-sample problem: Gehen test, Log rank test, Mantel-Haenszel test. **(15 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) Deshpande, J. V. and Purohit, S. G. (2005): Life Time Data: Statistical Models and Methods, Word Scientific.
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. Linear Programming Problem (LPP): Introduction to linear programming problems, Graphical solution to LPP, Standard LPP (SLPP), basic solution and basic feasible solution to SLPP. **(15L)**

Unit-2. Methods for solving LPP: Simplex Algorithm, Two-phase simplex method, Big M method.

Duality in LPP: Concept of duality, Theorems related to duality, complementary slackness property and development of dual simplex algorithm. **(15 L)**

Unit-3. 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). Quadratic Programming Problem (QPP): Definition of QPP, Kuhn-Tucker conditions, Algorithms for solving QPP: Wolfe's and Beale's algorithm. **(15 L)**

Unit-4. 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). **(15L)**

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

CLINICAL TRIALS

Unit-1. a) Introduction to clinical trials, need of ethics of clinical trials, bias and random error in clinical studies, conduct of clinical trials, overview of phase I-IV clinical trials. Classification of clinical trials, Multicenter clinical trials, Active control trials, Combination trials equivalence trials.

b) Data Management: Data definition, case report forms database design, data collection system for good clinical practice, **(15 L)**

Unit-2. Design of Clinical Trials: Parallel Vs cross-over designs, cross-sectional Vs longitudinal designs, review of factorial design, objective and endpoints of clinical trials, design of Phase I trials, design of single-stage and multi-stage Phase II trials, design and monitoring of Phase III trials with sequential stopping, design and analysis of bioequivalence trials. **(15 L)**

Unit-3. Reporting and Analysis: Power and sample size calculation for Phase I-III trials, qualitative and quantitative data analysis, and time to event data analysis in clinical trials. **(15 L)**

Unit-4. Surrogate endpoints: Selection and design of trials with surrogate endpoints, analysis of surrogate endpoint data. Meta-analysis of clinical trials. **(15 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 423
DATA MINING

Unit-1. Data preparation for knowledge discovery: Data understanding and data cleaning tools, Data transformation, Data Discretization, Data Visualization, Imbalanced data, Data Mining Process: CRISP and SEEMA; Concept of training data, testing data and validation of model. **(15 L)**

Unit-2. Supervised Learning techniques: Problem of classification, classification techniques: k-nearest neighbor, decision tree, Naïve Bayesian, Classification based on logistic regression. **(15 L)**

Unit-3. Artificial Neural Network (ANN): Introduction to ANN, types of activation function, McCulloch-Pitts AN model, single layer network, multilayer feed forward network model, training methods, ANN and regression models.

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 L)**

Unit-4. Unsupervised learning: Density based methods and grid based methods for clustering. Market Basket Analysis, Association rules and prediction. Apriori Algorithm, data attributes, applications to electronic commerce. **(15 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 424
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. **(15 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. **(15 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. **(15 L)**

Unit-4. Complete and minimal complete classes; essentially complete classes, Admissible rules; related theorems; Bayes and Admissible rules, Admissibility of aX+b , Inadmissibility of sample mean vector for the mean vector of normal distribution. Invariance, Maximal invariance of a function, Invariant decision problem, Invariant rule, Invariant estimators and tests, UMPI tests. **(15 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.

Elective Paper
Paper Code: MST 425
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. **(15 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. **(15 L)**

Unit-3. Linear regression with stochastic regressors, Instrumental variable estimation, Errors in variables. **(15 L)**

Unit-4. Simultaneous linear equations model, Examples, Identification problem, Restrictions on structural parameters- rank and order conditions. Estimation in simultaneous equations model, Recursive systems, 2 SLS estimators, Limited information estimators. **(15 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.

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

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

5) Klein L. R. (1962): An Introduction to Econometrics, Prentice Hall.

Practical Paper-IV

Paper Code: MST 416

STATISTICS PRACTICAL-IV AND PROJECT

Use of Statistical Software Packages

- MINITAB
- SPSS
- MATLAB

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

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