MANONMANIAM SUNDARANAR UNIVERSITY
TIRUNELVELI – 627 012

Syllabus for Ph.D., Course Work in Statistics

(With effect from the academic year 2018-2019 onwards)

Following is the list of 14 courses carrying 4 credits each available to the Ph.D., candidates of statistics for selection according to their requirements:

Sl. No.	Course
1	Research Methodology
2	Advanced Sampling Techniques
3	Advanced Design of Experiments
4	Advanced Statistical Quality Control
5	Bayesian Inference
6	Statistical Inference in Econometrics
7	Stochastic Modeling and Its Applications
8	Markov Chains and Their Applications
9	Time Series Analysis and Its Applications
10	Advanced Operations Research
11	Reliability Theory and Its Applications
12	Data Mining Methods and Their Applications
13	Categorical Data Analysis
14	Mini Project

SYLLABUS

PAPER I: RESEARCH METHODOLOGY

Preamble: This course aims to guide the scholars towards achieving competence and proficiency in the theory of statistics and practice to research. This fundamental objective can be realized through helping the scholars to develop the subject of their research, encourage the formation of trained intellectual ability in higher level, critical analysis, rigor, and independence of thought, foster individual judgement, and skill in the application of research theory and methods, and develop skills required in writing research proposals, reports, and dissertation.

(12L)

Unit -I

Concept of Research – Importance of Research - Ethics in Research - Selection of Research Topics and Problems – Research in Statistics - Literature Survey and its Importance

(12L)

Unit- II

Preparation of Assignments, Thesis and Reports – Significance of Publications in Research – Journals in Statistics.

(12L)

Unit III

Measurable function and its properties - Measure and Integration - Monotone convergence theorem and Dominated convergence theorem - Fatou's lemma. Absolute continuity – Radon-Nikodym theorem – Singularity – Lebesgue Decomposition theorem – Fubini's theorem – Convergence types for measureable functions: almost everywhere, in mean and in measure and their relationships.

(12L)

Unit IV

Basic Concepts of probability-Conditional Probability and Expectation-Inversion theorem for characteristic functions-Helly's theorem- Prokhorov's theorem-Levy's continuity theorem and its variations.

(12L)

Unit V

Introduction to R – Using the help facility. R data types and objects, reading and writing data- import and expert. Data structures: vectors, matrices, lists and data frames – Built –in data – Reading data from others sources – Merging data across data sources. Control structures: function, scoping rules, R dates and times- Grouping, loop and conditional execution – Ordered and unordered factors – Arrays and matrices – Classes and methods – graphical procedures – packages.

(Total: 60L)

BOOKS FOR STUDY

1. Kingman J.F.C and Taylor. J (1973): Introduction to Measure & Probability, Cambridge University Press.
2. Loeve M. (1963): Probability Theory, Van Nostrand, Princeton, Newyork.
3. Halmos P.R (1974): Measure theory, East-West Press, New Delhi.
4. Kothari, C.K. (2006): Research Methodology, Prentice-Hall of India (P) Limited, New Delhi.
5. MLA Handbook for writers of research papers, Modern Language Association, New York (2009).
6. Rowena Murry (2010): How to Write a Thesis, Tata McGraw, New Delhi.

PAPER II: ADVANCED SAMPLING TECHNIQUES

Preamble: Various methods of sampling widely used in practice are introduced in this course, which include PPS, SRS, Cluster, two-stage and two-phase sampling. The contents will enable the scholars to learn about the field survey, and the computational aspects of various estimators and their sampling errors.

Unit – I **(12L)**

Single stage cluster sampling: Clusters of equal sizes – Reasons for Cluster Sampling – A simple rule – Comparison of Precision Made from Survey Data – Variance in terms of Intracluster correlation – Variance and Cost Functions – Cluster Sampling for Proportions.

Cluster Units of unequal sizes – Selection with unequal probabilities with replacement – Optimum measure of size – The Horvitz-Thompson estimator – Brewer's Method – Murthy's Method – The Rao, Hartley, Cochran Method.

(12L)

Unit – II

Multi stage sampling-Two-Stage and three Stage Sampling – Finding means and variance in two-stage sampling – variance of the estimated mean in two-stage sampling. Sample estimation of the variance – estimation of proportions. Optimum Sampling and Subsampling Fractions.

(12L)

Unit – III

Double Sampling – Description – Double sampling for Startification – Optimum allocation – Estimation of variance in Double Sampling for Starttification. Regression and Ratio Estimators.

(12L)

Unit – IV

Successive Sampling – Repetitive Surveys – Sampling on two occasions – Sampling on more than two occasions – Sampling for Time series.

(12L)

Unit – V

Sequential Sampling – definition – estimation of population size – comparative study – estimation of population mean – acceptable sequential estimators – Markov Sampling

(Total: 60L)

BOOKS FOR STUDY

1. Ardilly P and Yves T. (2006): Sampling Methods: Exercise and Solutions. Springer.
2. Cochran, W.G. (1977): Sampling Techniques, Third Edition, Wiley Eastern Ltd., New Delhi.
3. Daroga Singh and F.S. Choudry (1977): Theory and Analysis of Sample Survey Designs. Wiley Eastern Ltd., New Delhi.
4. Mukhopadyay, P. (1998): Theory and Methods of Survey Sampling. Narosa Publisher, New Delhi.
5. Murthy, M.N. (1977): Sampling Theory and Methods. Statistical Publishing Society, Kolkatta, India.
6. Raj, D. (1976): Sampling Theory, Tata McGraw Hill, New York.
7. Raj, D. and Chandhok, P. (1998). Sample Survey Theory. Narosa Publishing House, London.
8. Mukhopadyay, P. (2007). Survey Sampling. Narosa Publisher, New Delhi.
9. Mukhopadyay, P. (1998). Small area estimation in Survey Sampling. Narosa Publisher, New Delhi.

PAPER – III: ADVANCED DESIGN OF EXPERIMENTS

Preamble: This course introduces scholars to concepts and techniques of Classical and Bayesian design - experimental units, randomization, treatments, blocking and restrictions to randomization, and utility of designs. To be able to determine appropriate fixed, random , mixed models, general block designs, missing plot techniques, analysis of covariance, factorial experiments and split plot experimental designs and statistical analyses for the optimization of processes.

Unit – I **(12L)**

Construction of Orthogonal Latin Square of order s, s is a prime or prime power. Construction of Orthogonal arrays.

(12L)

Unit – II

Construction and analysis of confounded Symmetrical and Asymmetrical Factorial Experiments. Fractional Factorials and Main Effects plans – Method of construction of plans with factors at 2 levels, a series of orthogonal arrays of strength 3 (Resolution 4 Plans) with factors at 2 levels. Orthogonal main effects plans with factors at 3 and other levels. Construction and Analysis of Fractionally replicated Factorial Experiments Blocking in fractionally replicated designs.

(12L)

Unit – III

Construction and analysis of Quasi-Factorial Experiments Lattice designs – Simple Lattice – Kple Lattice, 'n' dimensional Lattice; Square Lattice – Rectangular Lattice. Construction and Analysis of Balanced Incomplete Block Designs.

BIBD,Partially balanced incomplete block designs, Revision and construction. Balanced / partially balanced 'n' array designs - Augmented designs.

(12L)

Unit – IV

Second and third order Rotatable designs – Central composite rotatable designs. Blocking in response surface designs.

Analysis of groups of Experiments – Sequential experiments analysis of long term experiments – Problems faced in the design and analysis of experiments for perennial crops. Construction and analysis of cross-over designs

(12L)

Unit – V

Diallel Crosses – Complete Diallel crosses, its analysis and efficiency factor, Optimal Diallel crosses plane. Robustness of Designs. Robustness of Diallel crosses plan.

(Total: 60L)

BOOKS FOR STUDY

1. Cochran, W.G and Cox, G.M. (1987): Experimental Designs, John Wiley, New York.
2. Das, M.N. and Giri, N.C. (1986): Design and analysis of experiments, Wiley Eastern Ltd. New Delhi.
3. Fisher, R.A. (1947): The Design of experiments, 4th edition, Oliver and Boyd, London.
4. Graybill, F.A. (1976): Theory and Application of the Linear Model, Wadsworth.
5. John, P.W.M.(1971): Statistical Design and analysis of experiments, Macmillon.
6. Joshi, D.D. (1987): Linear estimation and design of experiments. Wiley Eastern, New Delhi.
7. Rao, C.R.(1974): Linear Statistical inference and its applications, Wiley Eastern, 2nd edition.
8. Searle, S.R. (1971): Linear models, John Wiley, New York.

PAPER – IV: ADVANCED STATISTICAL QUALITY CONTROL

Preamble: This course facilitates an understanding of the principles of statistical quality control and reliability. Various types of control charts and techniques, acceptance sampling procedures, concepts of system reliability and maintenance policies are introduced, which will enable the scholars to understand the application of the concepts in industries.

(12L)

Unit – I:

Process Control: Control Charts by Variables and Attributes – Rational Subgroups - Basic Charts - Operating Characteristic and Average Run Length Functions – Designing Control Charts – Control Charts for Variable Sample Sizes and Varying Sampling Intervals – Control Charts for Short Production Runs. Cumulative Sum (CUSUM) Control Charts –V-mask Procedure – Tabular CUSUM Procedure. Moving Range, Moving Average, and Exponentially Weighted Moving Average Control Charts – Design and Robustness of Charts.

(12L)

Unit – II:

Tolerance Limits and Specification Limits – Setting Specification Limits – Estimation of Tolerance Limits. Acceptance Control Charts, Modified Control Charts. Capability Analysis: Process Capability Ratios - Process Capability Analysis using Histogram, Probability Plotting, Control Chart, Designed Experiments. Multivariate Control Chart: Hotelling's T^2 and Chi-square Control Charts, Multivariate Exponentially Weighted Moving Average Control Chart.

(12L)

Unit – III:

Product Control: Sampling Inspection by Attributes – Single, Double, Multiple, Repetitive Group, Sequential Sampling Plans – Operating Procedure, Plan Selection, Measures of Performance. Sampling Inspection by Variables – Assumption of Normality – Single, Double and Sampling Plans – Operating Procedures, Plan Selection Procedures, OC Functions.

(12L)

Unit – IV:

Attributes Sampling schemes – MIL-STD-105D - Normal, Reduced and Tightened Inspections - Plan selection. Variables Sampling Schemes – MIL-STD-414 – Procedures for Operation and Selection of Plans. Rectifying Sampling Schemes – Concept of ATI and AOQL - Dodge – Romig LTPD and AOQL Single and Double Sampling Plans Schemes – Selection of Parameters.

(12L)

Unit – V:

Sampling Plans for Continuous Production – Continuous Sampling Plans - CSP-1, CSP-2 and CSP-3 – Operation, Stopping Rules and Plan Selection – Measures of Performance. MIL-STD-1235 (ORD):

Special Purpose Plans: Skip-lot and Chain Sampling Plans - Operation and Selection - Measures of Performance. Switching Systems and TNT Sampling Schemes.

Reliability Sampling Plans – Type I and Type II Censoring – Reliability Criteria – Operation and Plan Selection – Measures of Performance.

(Total:60L)

BOOKS FOR STUDY

1. Bowker, A.N., and N.P.Goode (1952): Sampling Inspection by Variables. McGraw Hill, New York.

2. Costa, A.F.B.(1996): Joint $\bar{X}$ and R Charts with Variable Sample Size and Sampling Intervals. Report No.142, Centre for Quality and Productivity Improvement, University of Wisconsin, Wisconsin.
3. Costa, A.F.B.(1997): X-bar Chart with Variable Sample Size and Sampling Intervals. Journal of Quality Technology, 29(2), 197-204.
4. Duncan, A.J.(1986): Quality Control and Industrial Statistics (Fifth Edition): Irwin, Homewood, Illinois.
5. Juran, J.M., and J.A.De Feo (2010): Juran's Quality Handbook – The Complete Guide to Performance Excellence. Tata McGraw Hill, New Delhi.
6. Montgomery, D.C.(2002): Statistical Quality Control – An Introduction (Sixth Edition): Wiley India, New Delhi. (Reprint, 2008).
7. Schneider, H.(1989): Failure Censored Variables Sampling Plans for Lognormal and Weibull Distributions. Technometrics, 31(2), 199-206.
8. Squeglia, N.L. (2009): Zero Acceptance Number Sampling Plans (Fifth Edition): ASQ Quality Press, Wisconsin.
9. Stephens, K.S.(2001): The Handbook of Applied Acceptance Sampling – Plans, Principles and Procedures. ASQ Quality Press, Wisconsin.
10. Stephens, K.S.(1995): How to Perform Skip-Lot and Chain Sampling (Second Edition): ASQ Quality Press, Wisconsin.

PAPER V: BAYESIAN INFERENCE

Preamble: This course explains the theory of Bayesian methods and their applications. From the contents of this course, the scholars will understand the difference between classical (frequentist) methods and Bayesian methods. The course will emphasize Bayesian data analysis through modern computer simulation methods.

(12L)

Unit – I

Subjective probability – its interpretation and evaluation. Subjective determination of prior distributions. Improper prior, noninformative prior, invariant prior, Jeffreys noninformative prior and natural conjugate prior – family of distributions admitting natural conjugate prior. Models with hyperparameters and hierarchical priors.

(12L)

Unit – II

Point estimation – Bayes estimators under various loss functions – generalization to convex loss functions. Evaluation of the estimate in terms of posterior risk – comparison with frequentist methods.

(12L)

Unit – III

Interval estimation – credible interval, highest posterior density region. Comparison of interpretation of the confidence co-efficient of an interval by Bayesian and frequentist methods – simple problems.

(12L)

Unit – IV

Bayesian testing of statistical hypotheses and model selection – specification of the appropriate form of the prior distribution for Bayesian hypothesis testing problem – prior odds, posterior odds, Bayes factor and their computations to various hypotheses testing problems – specification of Bayes tests.

(12L)

Unit – V

Bayesian computation – Monte Carlo sampling and integration – Markov Chain Monte Carlo methods – Metropolis-Hastings algorithm, Gibbs sampling – theory and applications of these methods to high dimensional problems. Large

sample methods – limit of posterior distribution, asymptotic expansion of posterior distribution, Laplace approximation.

(Total: 60L)

BOOKS FOR STUDY

1. Berger, J.O. (1985): Statistical Decision Theory and Bayesian Analysis (Second Edition): Springer Verlag, New York.
2. Bernardo, J.M., and A.F.M. Smith(2000): Bayesian Theory. John Wiley & Sons, New York.
3. Gelman, A., J.B. Carlin, H.B. Stern and D.B. Rubin (2004): Bayesian Data Analysis (Second Edition): Chapman & Hall, London.
4. Ghosh, J.K., Mohan Delampady and T. Samanta (2006): An Introduction to Bayesian Analysis – Theory and Methods. Springer Verlag, New York. (Reprint, 2011).
5. Lee, P.M. (2012): Bayesian Statistics – An Introduction (Fourth Edition): John Wiley & Sons, London.
6. Leonard, T., and J.S.J. Hsu (1999): Bayesian Methods: An Analysis for Statisticians and Interdisciplinary Researchers. Cambridge University Press, London.
7. Robert, C.P. (1994): The Bayesian Choice: A Decision-Theoretic Motivation (Second Edition): Springer Verlag, New York.
8. Robert, C.P., and G. Casella (2004): Monte Carlo Statistical Methods (Second Edition): Springer Verlag, New York.

PAPER-VI: STATISTICAL INFERENCE IN ECONOMETRICS

Preamble: The objective of this course is to provide the basic principles of econometric models. This course will enable the scholars to use the models in the fields like engineering sciences, biological sciences, medical sciences, geo-sciences, agriculture sciences etc. It focuses on general linear models, generalized least square method and estimation of the parameters of the models.

(12L)

Unit-I

Inference on OLS Model, Estimation Subject to linear Constraints test for Structural change, use of dummy variable, serial correlation, nature of multi-collinearity, Estimation in the presence of perfect Multi-collinearity, specification error, lagged variables, qualitative dependent variables.

(12L)

Unit-II

Estimation of parameters in single equation model and classical least square model, Generalized least estimator, Autocorrelation and its consequences, Hetrosedacity of disturbances and its testing, test for independence of disturbances, Stochastic regressors, use of instrumental variables.

(12L)

Unit-III

Concept of structure and model for simultaneous, Simultaneous Equation method of Estimation, Identification problem, limited information model, Indirect Least Square, Two Stage Least Square, LVRP method, Full Information method: Three Stage Least Square, and FIML Method.

(12L)

Unit-IV

Autoregressive model of first and second order, periodogram analysis, explosive models, Regression model for Time Series, concept relating to spectral density estimation.

(12L)

Unit-V

Multivariate Regression, classification analysis, Data Reduction Techniques: Discriminant function, principle components, Cluster analysis and canonical correlations.

(Total: 60L)

BOOKS FOR STUDY

1. Alvin C. Rencher (2002): Methods of Multivariate Analysis, John Wiley & Sons, New York.
2. Baltagi, B.H (2009): Econometrics, 5th Edition, Springer publisher, New York.
3. Goldberger (1964): Econometrics theory, Wiley Eastern, New Delhi.
4. Gujarati. D (2003): Basic Econometrics (4rd Ed.), McGraw Hill, New York.
5. Johnson, J (1984): Econometric methods (3rd Ed.), McGraw Hill, New York.
6. Anderson, T.W (1971): The Statistical Analysis of Series, John Wiley, New York.
7. Maddala, G.S and Kajal Lagari (2009): Introduction to Econometrics, John Wiley & Sons

PAPER - VII: STOCHASTIC MODELING AND ITS APPLICATIONS

Preamble: The contents of the course will explain various concepts of stochastic processes which have wider scope in many areas of scientific experiments and research. The course will focus on the theoretical concepts pertaining to classification of stochastic processes and their properties.

(12L)

Unit-I

Introduction of stochastic processes - Specifications of a stochastic processes - Markov chains -Classification of states and chains - Higher transition probabilities and its limiting behavior -Chapman Kolmogorov's equations - Stationary distribution - Ergodic theorem - Continuous time Markov processes - Poisson processes.

(12L)

Unit-II

Birth and death processes - Kolmogorov Feller differential equations of birth and death processes - Renewal theory - Renewal equation - Stopping time - Wald's equation - Elementary renewal theorem and its applications - Renewal reward processes - Residual and Excess life times - Markov renewal and Semi Markov processes.

(12L)

Unit-III

Introduction to Queueing Theory - Basic characteristics of a Queueing system and Problems in Queueing system-Probability Distributions as Models - Basic Concepts in Stochastic Queueing models - Kendall's notation for Queueing models-Little's Formulas - Stochastic process representation of Queueing theory-Steady state solutions for the queueing models.

(12L)

Unit-IV

Birth and Death Queueing models-State dependent service pattern-transient behavior of queues-Inventory models as a queueing models - Detailed study of single and multiple server queueing models - Advanced Markovian Queueing Models - Erlangian Bulk Queues - Retrial Queues - Queue with Priority Disciplines - Preemptive priority and Non - Preemptive priority queue - Queueing Networks-Vacation Queueing Models- Bernoulli Vacation Queueing Models.

(12L)

Unit-V

Higher transition probabilities – higher order Markov chains - Multivariate Markov chain models - Applications to queues and storage problems - Decision Problems in Queueing Theory - Simulation techniques in Queueing Models - Case Studies and Applications in Queueing theory.

(Total: 60L)

BOOKS FOR STUDY

1. Ching, W.K and Michael, K (2006): Markov Chains: Models, Algorithms and Applications, Springer Science Business Media, Inc.
2. Cox, D.R. and A.D. Miller (1977): The Theory of Stochastic Processes, Chapman & Hall.
3. Feller, W. (1968): An Introduction to Probability Theory and its applications, Vol I and II. John Wiley.
4. Gross, D. and Harris, C. M. (2008): Fundamentals of Queueing Theory, Fourth Edition, John Wiley & Sons.
5. Hiller, F.S and Lieberman, G.J. (2004): Introduction to Operations Research, Chapters 10 and 11- Holden-Day.
6. Hiller, F.S and Taylor, H.M. (1980): Second Course in Stochastic Processes, Academic Press.
7. Karlin, S. and Taylor, H.M (1968): A First Course in Stochastic Processes – Vol. I. Academic Press, New York.
8. Medhi, J. (2009): Stochastic Processes, 3rd Edition, New Age International Publishing Limited, New Delhi.
9. Medhi, J. (2003): Stochastic Processes in Queueing Theory, second edition, Academic Press.
10. Narayan Bhat, U. (2008): An Introduction to Queueing Theory-Modeling and Analysis in Applications, Birkhauser.

PAPER- VIII: MARKOV CHAINS AND THEIR APPLICATIONS

Preamble: This course deals with Markov processes in various areas of applications. Markov chains in discrete and continuous time with respect to state diagram, recurrence and transience, classification of states, periodicity, irreducibility, etc., and be able to calculate transition probabilities and intensities for pursuing higher studies leading to post-graduate or doctorate degrees

(12L)

Unit-I

Introduction of stochastic processes-Classification of stochastic processes - Markov chains -Classification of states and chains - Higher transition probabilities and its limiting behavior - Chapman Kolmogorov's equations - Stationary distribution - Ergodic theorem - One dimensional random walk and Gambler's ruin problems.

(12L)

Unit-II

Continuous time Markov processes - Poisson processes and related distributions - Birth and death processes - Kolmogorov Feller differential equations of birth and death processes - Applications to queues and storage problems and Wiener process as a limit of random walks.

(12L)

Unit-III

Introduction to molecular biology – Bioinformatics and sequence analysis – Sequence alignment – BLAST – Multiple sequence alignment – Clustering algorithms.

(12L)

Unit-IV

Protein and DNA sequence analysis: Pattern discovery and sequence classification in proteins and nucleic acids - Proteins & proteomics prediction of molecular function and structures –DNA and RNA structure prediction.

(12L)

Unit-V

Introduction of Hidden Markov model: Evaluation problem of HMM –Viterbi algorithm - Baum Welch algorithm - HMM applications in DNA &RNA – Advantages and limitations of HMM - Profile HMMs for Biological sequence Analysis.

BOOKS FOR STUDY

1. Cinlar, E (1974): Introduction to Stochastic Processes, Prentice Hall Publisher.
2. Cox, D.R. and A.D. Miller (1977): The Theory of Stochastic Processes, Chapman & Hall.
3. Gauham. N., (2009). Bioinformatics Databases and Algorithms, Narosa Publishing House, New Delhi.
4. Igacimuthu, S., (2009). Basic Bioinformatics Publishing House PVT. LTD, New Delhi.
5. Karlin, S. and Taylor, H.M (1968): A First Course in Stochastic Processes – Vol. I. Academic Press, New York.
6. Medhi, J. (2009): Stochastic Processes, 3rd Edition, New Age International Publishing Limited, New Delhi.
7. Ross, S.M (1996): Stochastic Processes, 2nd Edition, John Wiley & Sons, New Delhi.
8. Shui Qing Ye., (2008). Bio informatics A Practical Approach, Chapman & Hall/CRC, Taylor & Francis Group LLC.

PAPER-IX: TIME SERIES ANALYSIS AND ITS APPLICATIONS

Preamble: The objective of this course is to provide time series models which are applicable in various fields such as signal processing, pattern recognition, econometrics, mathematical finance, weather forecasting, intelligent transport and trajectory forecasting, earthquake prediction, control engineering, astronomy, communications engineering. The scholars will be able to apply the time series models focusing on MA, AR, ARMA, ARIMA models, estimation of ARIMA model parameters and forecasting.

(12L)

Unit- I

Stationary time Series, Auto correlation and Partial auto correlation function, Correlogram analysis, Spectral properties of stationary models, periodogram analysis, and spectral density function.

(12L)

Unit- II

Detail study of stationary process: moving average, autoregressive, autoregressive moving average and autoregressive integrated moving average process, Box – Jenkins models.

(12L)

Unit- III

Estimation of mean, auto covariance and auto correlation function under large sample theory, choice of AR and MA periods, Estimation of ARIMA model parameters, forecasting with Box – Jenkins model, Residual analysis and diagnostic checking.

(12L)

Unit- IV

Conditional Heteroscedasticity Model-Characteristic of Volatility- Auto regressive conditional Heteroscedasticity (ARCH)- Testing of ARCH effect-Generalized Auto regressive conditional Heteroscedasticity (GARCH) and GARCH-M model.

(12L)

Unit- V

Multivariate time series – cross correlation function and their properties-Vector Auto regressive model- Vector moving average model - VARIMA model – co integrated VAR model and Vector error control model (VECM).

(Total: 60L)

BOOKS FOR STUDY

1. Box, G.E.P., Jenkins, G.M. and Reinsel, G.C (2004). Time Series Analysis-Forecasting and Control, Pearson Education, Singapore.
2. Brockwel, P.J and Davis. R.A (1987). Time Series: Theory and Methods, Springer – Verlag, New York.
3. Granger, C.W.J. and Newbold (1984). Forecasting Econometric Time Series, Academic Press, New York.
4. Montgomery, D.C. and Johnson, L.A. (1977) Forecasting and Time Series Analysis, McGraw Hill, New York.
5. Shum way, R. H. and Stoffer, David S. (2006) Time Series Analysis and Its Applications: With R Examples. Springer-Verlag.
6. Tsay, R (2009). Analysis of Financial Time series, Willey Interscience Publisher.

PAPER-X: ADVANCED OPERATIONS RESEARCH

Preamble: Operations research is the professional discipline that deals with the application of scientific methods in decision making. The objective of this course is to provide adequate coverage of mathematical techniques and models and to equip the scholars to apply them in industries such as airline industry (routing and flight planes, crew scheduling), manufacturing industry (inventory control, production scheduling, capacity planning), transportation (traffic control, network flow, location planning) etc.

(12L)

Unit – I

Non-Linear integer programming-Beale's algorithm. Zero-one programming problem. Integer polynomial programming – Geometric programming and its applications. Stochastic programming.

(12L)

Unit – II

Continuous State Dynamic Programming. Bellman's principle of dynamic programming. Forward and backward process of solving a dynamic programming problem. Stage coach problem. Advanced multi-period stochastic models. Use of dynamic programming in inventory problems.

(12L)

Unit – III

Stochastic inventory models-multiperiod models - solution through dynamic programming (s, S) inventory policies. Replacement problems – replacement of item failing according to probability law-block and age replacement policies.

(12L)

Unit – IV

Queuing models: Transient and busy period analysis in M/M/1 system – M/G/1 and G1/M/1 Queues – imbedded Markov chain approach to queueing problems.

(12L)

Unit – V

Job sequencing problem – Principle assumptions of sequencing problem – Solution of sequencing problem – Processing n jobs through two machines problem and Processing n jobs through three machines problem.

Priority Queueing models-Preemptive and Non-preemptive priroty queueing models.

(Total: 60L)

BOOKS FOR STUDY

1. Gross.D and Harris.C.M. (1976): Fundamental of queueing throry, Jhon Wiley.
2. Hadley,G. (1974): Non-linear and Dynamic programming, Addition-Wesley.
3. Hadley,G and Whitin, (1963): Analysis of Inventory system, Prentice Hall.
4. Hiller.F.S and Lieberman,G.J. (1974): Operations Research, holden-Day.
5. Philips, D. T. Ravindran, A. and Solberg, J.T.(2007): Operations Research Principles and Practice.
6. Prabhu,N.U (2012): Queues and Inventories, John Wiley.
7. Rao,S.S. (1978): Operations Theory and application, Wiley Eastern.
8. Shamblin and Stevens,Jr. (1974): Operations Research, McGraw Hill.

PAPER - XI: RELIABILITY THEORY AND ITS APPLICATIONS

Preamble: Basic principles of reliability theory will be emphasized. Scholars will get the exposure on practical utility of reliability models.

(12L)

UNIT I

Reliability concepts and measures – components and systems – coherent systems and their reliability – cuts and paths – modular decomposition – bounds on system reliability – structural reliability importance of components.

(12L)

UNIT II

Life time distributions – reliability function – hazard rate - common life time distributions – exponential, gamma, normal, Weibull, Rayleigh etc. – estimation of parameters and testing of hypotheses in these distributions.

(12L)

UNIT III

Notions of ageing – IFR, IFRA, NBU, DMRL and NBUE classes and their duals – implications – closures of these classes under formation of coherent systems.

(12L)

UNIT IV

Reliability estimation based on failure times under various censored life tests and tests with replacement of failed items – stress-strength reliability and its estimation.

(12L)

UNIT V

Reliability growth models – probability plotting techniques – Hollander-Proschan and Deshpande tests for exponentiality – tests for HPP *vs* NHPP with repairable systems. Basic ideas of accelerated life testing.

(Total: 60L)

BOOKS FOR STUDY

1. Bain L.J., and Engelhardt (1991): Statistical Analysis of Reliability and Life Testing Models. Marcel Dekker, New York.
2. Barlow, R.E., and Proschan,F. (1981): Statistical Theory of Reliability and Life Testing (Second Edition). Holt, Rinehart and Winston, New York.
3. Blischke,W.R., and Murthy,D.N.P. (2000): Reliability – Modeling, Prediction and Optimization. John Wiley & Sons, New York.
4. Lawless,J.F. (2003): Statistical Models and Methods for Lifetime Data (Second Edition). Wiley Interscience, Singapore.
5. Mann,N.R., Schafer,R.E. and Singpurwalla,N.D. (1974): Methods of Statistical Analysis of Reliability and Life Data. John Wiley & Sons, New York.
6. Nelson,W.B. (2004): Applied Life Data Analysis. John Wiley & Sons, New York.
7. Singpurwalla,N.D. (2006): Reliability and Risk – A Bayesian Perspective. John Wiley & Sons, New York.
8. Zacks,S. (1991): Introduction to Reliability Analysis. Springer Verlag, New York.

PAPER-XII: DATA MINING METHODS AND THEIR APPLICATIONS

Preamble: This course aims at facilitating the scholars to understand the basic concepts of data warehousing and data mining. Techniques involved in mining the data from the databases will be emphasized.

(12L)

Unit-I

Data mining- History-Definitions-Data Mining Functionalities- Classification of Data mining System- Major Issues in Data mining-Data warehouse and OLAP Technology-Multidimensional Data Model-Data warehouse Architecture- Data Warehouse Implementation.

(12L)

Unit-II

Data Preprocessing-Data Cleaning- Data Integration and Transformation- Data Reduction-Discretization and concept of Hierarchy Generation- Concept Description-characterization and comparison. Association Rule Mining- Mining Single Dimensional – Multilevel Association Rules-mining to correlation analysis-classification and prediction

(12L)

Unit-III

Overview on outliers – nature of Outliers - Outliers in Univariate Data - Outliers in Multivariate Data - Cluster Analysis, Cluster Vs Classification - impact of Outliers on clustering - clustering problems - Clustering Approaches.

(12L)

Unit-IV

Data-outliers in regression analysis and Time series - Regression and collinearity: Tools for handling multi- collinearity, methods based on singular value decomposition – Robust Regression- ridge regression. Properties of ridge estimator. Addtive outlier – Multiplicative outlier and innovational outlier.

(12L)

Unit-V

Stationary time Series, Auto correlation and Partial auto correlation function, Correlogram analysis, Estimation of ARIMA model parameters, forecasting with Box – Jenkins model, Residual analysis and diagnostic checking.

(Total: 60L)

BOOKS FOR STUDY

1. Box, G.E.P., Jenkins, G.M. and Reinsel, G.C (2004). Time Series Analysis-Forecasting and Control, Pearson Education, Singapore.
2. Daniel T. Larose, (2006): Data Mining: Methods and Models, Wiley-Interscience, New Jersey.
3. Draper, N.R, and H. Smith,(1998): Applied regression analysis,(2nd Ed) John Wiley and sons, New York.
4. Hawkins, D.M, (1980): Identification of Outliers, Chapman and Hall, London.
5. Jiawei Han, Micheline Kamber, (2006): Data Mining: Concepts and Techniques, Morgan Kaufmann Publishers, second edition, San Francisco.
6. Krzysztof J.Cios, Wiltold Pedrycz, Roman W.Swiniarski, Lukasz A.Kurgan, (2007): Data Mining: A Knowledge Discovery Approach, Springer Science +Business Media, New York.
7. Montgomery, D.C. and Johnson, L.A. (1977) Forecasting and Time Series Analysis, McGraw Hill, New York.
8. Paolo Giudici, (2005): Applied Data Mining: Statistical Methods for Business and Industry, John Wiley & Sons Ltd, England.
9. Peter J. Rousseeuw and Annick M. Lorey, (1987): Robust Regression and Outlier Detection, John Wiley & Sons, United States.
10. Vic Barnett and Toby Lewis, (1978): Outliers in Statistical Data, John Wiley & sons.

PAPER - XIII: CATEGORICAL DATA ANALYSIS

Preamble: The objective of this course is to acquaint students with the basic ideas, applicability and methods of data analysis. This course enables the students to apply the various statistical techniques easily in practice.

Unit- I **(12L)**

Models for Binary Response Variables, Log Linear Models, Fitting Log linear and Logic Models-Building and applying Log Linear Models, Log- Linear- Logit Models for Ordinal Variables.

(12L)

Unit-II

Multinomial Reponse Models - Models for Matched Pairs- Analyzing Repeated Categorical Response Data - Asymptotic Theory for Parametric Models - Estimation Theory for Parametric Models.

Unit-III **(12L)**

Classical treatments of 2 and 3-way contingency tables, measures of association and nonparametric methods - Generalized linear models - Logistic regression for binary – multinomial and ordinal data - Log-linear models - Poisson regression- Modelling repeated measurements - generalized estimating equations.

Unit-IV **(12L)**

Introduction to contingency tables: 2×2 and $r \times c$ tables - tests for independence and homogeneity of proportions - Fishers exact test - Odds ratio and Logit, other measures of association - Introduction to 3-way tables – full independence and conditional independence - collapsing and Simpsons paradox.

(12L)

Unit-V

Polytomous logit models for ordinal and nominal response - Log-linear models (and graphical models) for multi-way tables - Causality, repeated measures, generalized least squares - mixed models, latent-class models, missing data, and algebraic statistics approach.

(Total: 60L)

BOOKS FOR STUDY

1. Agresti, Alan (1996). An Introduction to Categorical Data Analysis, Wiley.
2. Bergsma, W., Croon, M.A. and Hagenaars, J.A. (2009). Marginal Models: For Dependent, Clustered, and Longitudinal Categorical Data. Springer.
3. Bishop, Y.M., Fienberg, S.E. and Holland, P.W. (1975). Discrete Multivariate Analysis: Theory and Practice, MIT Press.
4. Edwards, D. (2000). Introduction to Graphical Modeling (Second Edition). Springer.
5. Fienberg, S.E. (1980). The Analysis of Cross-Classified Categorical Data. MIT Press.
6. Wasserman, L. (2004). All of Statistics: A Concise Course in Statistical Inference. Springer.
7. Whittaker, J. (1990). Graphical Models in Applied Multivariate Statistics. Wiley.

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