M.A. /M.Sc. IN STATISTICS

SYLLABUS

(EFFECTVIE FROM 2020-21)

P.G. DEPARTMENT OF STATISTICS
Utkal University, Vani Vihar, Bhubaneswar – 751004.

P.G. DEPARTMENT OF STATISTICS

UTKAL UNIVERSITY

M.A / M.Sc. IN STATISTICS EXAMINATION

(UNDER CHOICE BASED CREDIT SYSTEM)

(Effective from 2020-21 Academic Session)

OBJECTIVES OF M.A./M.SC. STATISTICS

- To equip learners with the core statistical knowledge from the standpoint of both theory and applications of statistics;
- To help learners in exploring the applications of statistics in Social Sciences, Applied Sciences and Industries;
- To provide opportunities for continuing education and developing human resources in emerging disciplines;
- To provide the knowledge and hands-on training in different areas of statistics;

M.A./M.SC. IN STATISTICS EXAMINATION, 2021 ONWARDS
(CBCS SYSTEM)
COURSE OUTLINE

	Paper Code	Paper Title	Credits
SEMESTER- I			
CORE COURSES	ST-C-101	Mathematical Analysis and Linear Algebra	6
	ST-C-102	Statistical Methods	6
	ST-C-103	Probability Theory and Distributions-I	6
	ST-C-104	Statistical Inference-I	6
	ST-C-105	Statistical Computing-I: Computer Applications and Data Processing using Advanced Excel & SPSS	6
SEMESTER- II			
CORE COURSES	ST-C-201	Probability Theory and Distributions –II	6
	ST-C-202	Statistical Inference-II	6
	ST-C-203	Survey Sampling Methods	6
ALLIED ELECTIVE	ST-AE-204	Any one paper out of the following papers: 1. Operations Research 2. Biostatistics	6
CORE COURSES	ST-C-205	Statistical Computing-II: R Programming Language	6
	SEMESTER- III		
CORE COURSES	ST-C-301	Multivariate Analysis	6
	ST-C-302	Design and Analysis of Experiments	6
CORE ELECTIVE	ST-CE-303	Any one paper out of the following papers: 1. Decision Theory & Bayesian Inference 2. Applied Stochastic Processes	6
ALLIED ELECTIVE	ST-AE-304	Any one paper out of the following papers: 1. Demography 2. Official Statistics	6
CORE COURSES	ST-C-305	Statistical Computing-III: Data Analysis using PYTHON	6
	SEMESTER- IV		
ALLIED	ST-AE-401	Any one paper out of the following papers:	6

ELECTIVE		1. Linear Model and Regression Analysis 2. Econometrics	
CORE ELECTIVE	ST-CE-402	Any one paper out of the following papers: 1. Advanced Survey Sampling Methods 2. Advanced Design and Analysis of Experiments 3. Advanced Operations Research	6
	ST-CE-403	Any one paper out of the following papers: 1. Time Series Analysis and Statistical Quality Control 2. Reliability Theory	6
FREE ELECTIVE	ST-FE-404	Any one paper out of the following papers: 1. Actuarial Statistics 2. Categorical Data Analysis 3. Survival Analysis & Clinical Trials 4. Big Data Analytic Techniques	6
CORE COURSES	ST-C-405	Industry Exposure and Project Work	6

ST-C-101: MATHEMATICAL ANALYSIS AND LINEAR ALGEBRA (100 MARKS)

Course Objectives: The main objective of this course is to introduce students the knowledge of real field and its properties. It will provide grounds for Probability Theory and help them in theoretical and applied researches in Statistics.

Course Learning outcomes:
After successful completion of this course, a student will be able to:

- understand the basic concepts of real analysis including completeness of set, suprimum, infimum, sequence and series.
- understand convergence of sequence and series of real valued function
- understand existence of integral and their evaluation.
- understand change of multiple integral and Lebesgue integral.
- find maxima-minima of functions of several variables.
- understand algebraic methods involving matrices, determinants, Eigen values and Eigen vectors and quadratic forms.

UNIT-I

Sequence and series, convergence, Bolzano-Weirstrass theorem, Heine-Borel theorem. Real valued function, continuous functions, Uniform continuity, sequences and series of functions, Uniform convergence. Differentiation, maxima-minima of functions.

UNIT-II

Functions of several variables, partial and total differentials, maxima-minima of functions, multiple integrals, change of variables in multiple integration, Improper Integrals, Convergence of improper integrals of first and second kinds.

UNIT-III

The Lebesgue integral – length of open sets and closed sets, inner and outer measures. Definition and existence of Lebesgue integral for bounded functions, properties of Lebesgue integral for bounded measurable functions, Lebesgue integral for unbounded functions, Dominated Convergence Theorem and its applications.

UNIT-IV

Matrix: Characteristic roots and vectors, Cayley-Hamilton theorem, minimal polynomial, similar matrices, spectral decomposition of a real symmetric matrix, Hermitian matrix. Real quadratic forms, reduction and classification of quadratic forms.

Books Recommended

1. Ruddin, Walter: Principles of Mathematical Analysis, McGraw-Hill.
2. Goldberg, R.R.: Methods of Real Analysis, Oxford & IBH Publication
3. Apostal, T.M.: Mathematical Analysis, Narosa Publishing House
4. Graybill, F.E.: Matrices with Applications in Statistics, 2nd ed., Wadsworth
5. Searle, S.R.: Matrix Algebra Useful for Statistics, John Wiley & Sons

ST-C-102: STATISTICAL METHODS (100 MARKS)

Course Objectives: This course has been designed to make students familiar with some of the basic methods of analysis of both univariate and bivariate data. Also, this course is to provide a thorough theoretical base in different types of sampling distributions, non-central distributions and categorical data analysis.

Course Learning outcomes:

After successful completion of this course, a student will be able to:

- understand Bivariate data. Significance of various coefficients of correlation(simple, Multiple & Partial).
- understand Fitting of linear and nonlinear curve.
- understand Bivariate probability distribution.
- understand Exact sampling distributions, its properties and applications.
- understand the relationship between the variables/attributes in a given dataset.
- understand categorical data analysis and related inferences.
- apply statistical tools for drawing meaningful inferences.

UNIT-I

Review of Descriptive Statistics, Bivariate and multivariate data, Curve fittings and orthogonal polynomials, regression and correlation analysis, rank correlation, correlation ratio, intra-class correlation.

UNIT-II

Concept of multivariate distribution, multiple regression analysis, partial and multiple correlations, properties of residuals and residual variance. Random sampling, sampling distribution and standard error, standard errors of moments and functions of moments.

UNIT-III

Exact sampling distributions – t, F and χ^2-square distributions (Central and Non-central distributions), sampling from bivariate normal distribution, distribution of sample correlation coefficient (null case) and regression coefficient, tests based on t, F and χ^2-square distributions.

UNIT-IV

Categorical response data, likelihood functions and maximum likelihood estimation, Wald–Likelihood Ratio–Score test triad, statistical inference for binomial and multinomial parameters, theory of attributes.

Books Recommended

1. Mukhopadhyaya, P.: Mathematical Statistics, New Central Book Agency, Calcutta
2. Gun, A.M., Gupta, M.K. and Dasgupta, B.: An Outline of Statistical Theory, Vol.II (4th Edition), World Press.
3. Kale, B.K.: A First Course in Parametric Inference, Narosa Publishing House
4. Casella, G. and Berger, R.L.: Statistical Inference. Wodsworth & Brooks

Pacific Grove, California.
5. Rao, C.R: Linear Statistical Inference and Its Application. John Wiley.
6. Agresti, A. (2002): Categorical Data Analysis, second Edition, Wiley-Interscience.

ST-C-103: PROBABILITY THEORY AND DISTRIBUTIONS – I (100 MARKS)

Course Objectives: The aim of the course is to pay a special attention to applications of measure theory in the probability theory, understanding of random variables, functions of random variables and various distributions along with their applications.

Course Learning outcomes:
After successful completion of this course, a student will be able to:

- understand the basic principles of probability
- understand the concepts of random variables, sigma-fields generated by random variables, probability distributions and independence of random variables related to measurable functions.
- understand discrete and continuous distributions and their applications,
- learn various inequalities and its applications
- provide students with the foundations of probabilistic and statistical analysis mostly used in varied applications of real time data.
- quantify the chance of an outcomes in the midst of uncertainty.

UNIT-I

Sequence of sets, limsup, liminf and limit of sequence of sets, classes of sets, field, sigma field, minimal sigma field, Borel sigma field, set functions. Measure and its properties, measurable functions and inverse functions. Probability measure, conditional probability, Bayes' theorem, independence of events.

UNIT-II

Random variables and probability distributions, distribution function of a random variable. Discrete and continuous random variables, functions of a random variable. Moments, probability generating and moment generating functions and moment inequalities, Markov, Holder, Jenson, Liapnov and Chebyshev's inequalities.

UNIT-III

Random vectors – distribution function of a vector of random variables, joint, marginal and conditional distributions. Independence of a sequence of random variables. Functions of random vectors and their distributions. Extreme values and their asymptotic distributions. Conditional expectations.

UNIT-IV

Discrete probability distributions – degenerate, uniform, hypergeometric, binomial, Poisson, negative binomial, geometric distributions and their properties.
Continuous probability distributions – uniform, normal, Cauchy, gamma and beta, lognormal, Weibull distributions and their properties.

Books Recommended

1. Rohatgi, V.K. and Ehsanes Saleh, A.K.M.: An Introduction to Probability and Statistics, 2nd ed., Wiley-Interscience.
2. Bhat, B.R.: Modern Probability Theory, 3rd ed., New Age International.
3. Gun, A.M., Gupta, M.K. and Dasgupta, B.: An Outline of Statistical Theory, Vol.I (4th ed.), World Press.
4. Jonson, S. and Kotz, S. (1972): Distribution in Statistics Vol. I-II & III, Houghton and Mifflin.
5. Arnold, B.C, Balakrishnan, N, and Nagaraja, H.N: A First Course in Order Statistics. John Wiley

ST-C-103: STATISTICAL INFERENCE -I
(100 MARKS)

Course Objectives: This will help students to understand the basic concepts and methods of point and interval estimation.

Course Learning outcomes:

After successful completion of this course, a student will be able to:

- learn the basic concepts of statistical inference including point estimation and interval estimation
- understand methods of estimation of parameters, methods of obtaining minimum variance unbiased estimators
- understand consistency, CAN estimator, MLE.
- evaluate the properties of these estimators and tests for both finite sample sizes and asymptotically as the sample size tends to infinity.
- build a foundation on inferential statistics which is the basis of higher level mathematical statistics.

UNIT-I

Point estimation, properties of estimators: unbiasedness, consistency, efficiency, sufficiency. Neyman factorization criterion, minimal sufficient statistics, invariance properties of sufficiency, completeness.

UNIT-II

Mean square error, Unbiasedness and minimum variance, Minimum Variance Unbiased Estimators(MVUE), C-R inequality, Cramer-Rao lower bound, Bhattacharya bounds, Rao-Blackwell Theorem, Chapman-Robbins Inequality, Lehmann-Scheffe theorem, necessary and sufficient conditions for MVUE.

UNIT-III

Consistent estimators, sufficient conditions for consistency, efficient estimators. methods of estimation: method of maximum likelihood and its properties, minimum chi-square and modified minimum chi-square methods, method of moments, method of least squares, method of percentiles.

UNIT-IV

Consistent Asymptotic Normal (CAN) estimators and properties of CAN estimators.
Interval estimation, confidence interval and confidence coefficient, confidence belt, theory of confidence sets.

Books Recommended

1. Kale, B.K.: A First Course on Parametric Inference, Narosa Publishing House
2. Rohatgi, V.K. and Ehsanes Saleh, A.K.M.: An Introduction to Probability and Statistics, 2nd ed., Wiley-Interscience.
3. Gun, A.M., Gupta, M.K. and Dasgupta, B.: An Outline of Statistical Theory, Vol.II, (4thed.), World Press.
4. George Casella and Roger L. Berger: Statistical Inference. Wodsworth & Brooks Pacific Grove, California.
5. Lehmann E. L & Casella, G.(1999): Theory of Point Estimation. Springer.
6. Rao, C. R: Linear Statistical Inference and Its Applications. Wiley Eastern.

ST-C-105: STATISTICAL COMPUTING-I: COMPUTER APPLICATIONS AND DATA PROCESSING USING ADVANCED EXCEL & SPSS (100 MARKS)

Course Objectives: The paper aims at enriching the computing power of students using spreadsheets and packages like Microsoft Excel and SPSS.

Course Learning outcomes:

After successful completion of this course, a student will be able to:

- understand how to go around with the computing part of some of the theoretical aspects using statistical packages.
- develop computational expertise on topics of linear algebra, distribution theory and other basic topics of statistics.

Data analysis using Excel and SPSS

I. Frequency distribution, measures of central tendency, dispersion, moments, skewness and kurtosis

II. Correlation, regression, rank correlation

III. Test of hypothesis - *t* and *F* tests, chi-square test, *z* test

IV. Fitting of distributions.

Books Recommended

1. Rajaraman,V, “Fundamentals of Computers”, PHI
2. Norton , Peter (2001), “Introduction to Computers”, 4th Ed., TMH.
3. Berk, K.N. & Carey, P. (2000): Data Analysis with Microsoft Excel, Duxbury Press

Marks Distribution

Practical Work : - 80 marks

Viva-voce + Records - 20 marks

ST-C-201: PROBABILITY THEORY AND DISTRIBUTIONS – II (100 MARKS)

Course Objectives: The aim of the course is to pay a special attention to applications of measure theory in the probability theory, order statistics, convergence, understanding of Weak Law of Large Numbers, Strong Law of Large Numbers and the Central Limit Theorem with their applications.

Course Learning outcomes:

After successful completion of this course, a student will be able to:

- gain the ability to understand the concepts of measurable functions, sequence of random variables, convergence, modes of convergence.
- learn the concepts of weak and strong laws of large numbers and central limit theorem.
- learn how to model product failure, droughts, floods and other extreme occurrences.
- understand characteristic function and its applications
- have good concepts of each and every topic of distribution theory because distribution theory is the heart of statistics and almost every topic of statistics need the concepts of distribution theory.

UNIT-I

Bivariate normal and bivariate hypergeometric distributions. Exponential family of distributions. Order statistics and their distributions

UNIT-II

Convergence on a probability space – convergence in distribution (law), convergence in probability, convergence in r-th mean, convergence almost surely and their relationships.

UNIT-III

Characteristic function – definition and properties, inversion theorem, uniqueness theorem, characteristic function and moments.

Convergence of distribution function and characteristic function. Helly-Bray theorem, Extended Helly-Bray theorem, continuity theorem, Borel-Cantelli lemma.

UNIT-IV

Laws of large numbers – Chebyshev's, Khinchin's, and Bernoulli's laws of large numbers. Hajek-Reni and Kolmogorov inequalities (statements only) and Kolmogorv's strong law of large numbers. Central limit theorem – Lindberg –Levy and Liapounov forms with proofs and applications. Lindberg-Feller form (without proof).

Books Recommended

1. Rohatgi, V.K. and Ehsanes Saleh, A.K.M.: An Introduction to Probability and Statistics, 2nd ed., Wiley-Inter Science
2. Bhat, B.R.: Modern Probability Theory, 3rd Edition, New Age International.
3. Gun, A.M., Gupta, M.K. and Das Gupta, B.: An Outline of Statistical Theory, Vol-I (4thed.), World Press
4. Ash, R.B. and Doleans-Dade, C.A.: Probability and Measure Theory. Elsevier.
5. Billingsley, P: Probability and Measure. John Wiley.
6. Sen, A. K: Measure and Probability. Narosa Publishing House.
7. Feller, W: An Introduction to Probability Theory and its Applications, Vol I. John Wiley.

ST-C-202: STATISTICAL INFERENCE-II
(100 MARKS)

Course Objectives: The aim of the course is to make students aware of concept of Testing of Hypotheses and non-parametric approaches.

Course Learning outcomes:

After successful completion of this course, a student will be able to:

- understand the concepts of likelihood ratio test, monotone likelihood ratio test and similar test.
- understand the use of sequential probability ratio test and various non-parametric methods.
- identify appropriate statistical inference techniques from a given research or applied problems and perform correct statistical analysis using different inferential techniques and tests.
- understand different non-parametric methods.
- gather advanced knowledge in inference extending which they can learn topics like Bayesian Data Analysis, sequential techniques

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UNIT-I

Tests of hypothesis, concepts of critical regions, test functions, two kinds of errors, size function, power function, level, MP and UMP test, Neyman-Pearson Lemma, MP test for simple null against simple alternative hypothesis. UMP tests for simple null hypothesis against composite alternative.

UNIT-II

Type A and type A1 tests, similar tests, tests having Neyman structure, likelihood ratio test, one-tailed and two-tailed likelihood ratio tests for mean and variance of normal populations, Asymptotic property of LRT and applications, monotone likelihood ratio test and applications.

UNIT-III

Wald's sequential probability ratio test and its properties, OC and ASN function, derivation of OC and ASN functions, Efficiency of SPRT, SPRT for a composite hypothesis.

UNIT-IV

Non-parametric tests: Kolmogorov-Smirnov test, sign test, Wilcoxon signed rank test, Wilcoxon paired sample signed rank test, Mann-Whitney U-test, Krushkal-Wallis test, Freedman's test.

Books Recommended

1. Mukhopadhyaya, P.: Mathematical Statistics, New Central Book Agency, Calcutta
2. Gun, A.M., Gupta, M.K. and Dasgupta, B.: An Outline of Statistical Theory, Vol. II (4th Edition), World Press.
3. Kale, B.K.: A First Course in Parametric Inference, Narosa Publishing House
4. Casella, G. and Berger, R.L.: Statistical Inference. Wodsworth & Brooks Pacific Grove, California.
5. Rao, C.R: Linear Statistical Inference and Its Application. John Wiley.
6. Agresti, A. (2002): Categorical Data Analysis, second Edition, Wiley-Interscience.

ST-C-203: SURVEY SAMPLING METHODS
(100 MARKS)

Course Objectives: The main objective of this course is to enable students to learn techniques in survey sampling with practical applications in daily life which would be beneficial for the students to their further research.

Course Learning outcomes:

After successful completion of this course, a student will be able to:

- learn basic concepts in Sampling Theory.
- explore various sampling techniques viz., SRS, Stratified and systematic sampling and understand their merits and drawbacks.
- understand cluster and two stage sampling procedure and its applications
- understand auxiliary information and its use in sampling estimation.

UNIT-I

Basic concepts of finite population and sampling techniques. sampling design and sampling strategy, simple random sampling with and without replacement, determination of sample size.

Stratified random sampling – estimation of population mean/total with standard error and its estimate, problems of allocations, comparison of variance for fixed sample size, comparison with unrestricted sampling.

UNIT-II

Systematic sampling – method of selection, estimation of population mean/total, sampling variance, comparison with simple random sampling and stratified sampling, efficiency for structural populations.

UNIT-III

Cluster sampling – equal size, estimation of population mean/total, standard error and its estimation, comparison with mean per unit estimator.

Two-stage sampling with equal first stage units, estimation of population mean/total, standard error and its estimation, comparison with single-stage sampling, three-stage sampling.

UNIT-IV

Use of auxiliary information in sample surveys, methods of estimation – ratio, product, difference and regression methods, sampling variance and efficiency of the estimators, multivariate ratio estimator (Olkin's estimator), double sampling.

Books Recommended

1. Cochran, W.G.: Sampling Techniques, 3rd ed., Wiley
2. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C.: Sampling Theory of Surveys With Applications, Indian Soc. of Agric. Stat., New Delhi
3. Swain, A.K.P.C.: Finite Population Sampling – Theory & Methods, South Asian Publishers
4. Sampath, S: Sampling Theory and Methods. Narosa Publising House.
5. Murthy, M. N: Sampling Theory and Methods. Statistical Publishing Society

ST-AE-204: OPERATIONS RESEARCH
(100 MARKS)

Course Objectives: This paper shall expose the students to different aspects of linear programming and operations research. Linear programming, inventory management, network analysis and transportation models are commonly used to set up strategy in different real life situations including business.

Course Learning outcomes:

After successful completion of this course, a student will be able to:

- learn how to convert a real-life problem into mathematical model, place the constraints in the form of equations and solve the problems under a given set of constraints.
- understand transportation & assignment problem, and also inventory control.
- understand the concepts of game theory and methods of solutions to two-person zero sum games
- understand the theoretical basis of the mathematical models governing queues, waiting time for getting a service, average number of customers in a queue and so on in both real and virtual queues.

UNIT-I

Definition and Scope of Operations Research: phases in operation research, models and their solutions, decision making under uncertainty and risk, use of different criteria, sensitivity analysis, duality theorem, economic interpretation of duality, Karmakar interior point algorithm.

UNIT-II

Transportation, assignment and transhipment problems, travelling salesman's problem, non-linear programming – constrained optimization and Kuhn-Tucker conditions, Wolfe's and Beale's algorithm.

UNIT-III

Analytical structure of inventory problems, Harris EOQ formula, its sensitivity analysis, extension allowing quantity discounts and shortages, probabilistic inventory problems, Models with random demand, the static risk model.
Network scheduling by PERT/CPM.

UNIT-IV

Game Theory: Two-person zero-sum game, maximin-minimax principle, games without saddle points.
Queuing systems and their characteristics, transient and steady state solutions in Poisson queues (M/M/1 and M/M/c models), non-poison queuing systems

Books Recommended

1. Taha, H.A. (1992): Operational Research: An Introduction, Mc. Millan.
2. Kantiswarup, Gupta, P.K. and Man Mohan (2007): Operations Research, Sultan Chand & Sons.
3. Ravindran, A., Phillips, D.T. and Solberg, J.J. (2009): Operations Research: Principles and Practice, Wiley-India.
4. Rajasekharan, S. and Pai, G.A.V. (2006): Neural Networks, Fuzzy Logic and Genetic Algorithms, PHI.

ST-AE-204: BIOSTATISTICS
(100 MARKS)

Course Objectives: Biostatistics is one area of Applied Statistics that concerns itself with the application of statistical methods to medical, biological, epidemiological and health related problems.

Course Learning outcomes:

After successful completion of this course, a student will be able to:

- understand the concepts of Genetics and Hardy Weinberg law
- stochastic and epidemiology models, reproduction number
- concepts of Bio-logical assay, also understands dose-response relationships.
- different types of epidemiological study design
- understand sensitivity, specificity and accuracy
- understand concepts of odd ratio and relative risks

UNIT-I

Basic biological concepts in genetics, Mendels law, Hardy- Weinberg equilibirium, random mating, distribution of allele frequency (dominant/co-dominant cases), Approach to equilibirium for X-linked genes, natural selection, mutation, genetic drift, equilibirium when both natural selection and mutation are operative, detection and estimation of linkage in heredity.

UNIT-II

Stochastic models in Biology and Epidemiology: Discrete and continuous time stochastic models, Deterministic and stochastic models for epidemics and endemics, interference models, vaccination models, geographical spread, parasitic diseases, parameter estimation related to latent, infection and incubation periods. Reproduction number, stochastic models for population growth and extinction.

UNIT-III

Types of biological assays, direct assays, ratio estimators, asymptotic distributions, regression approaches for estimating dose response relationships. Quantal responses, methods of estimation of parameters, dose allocation schemes, median dose, estimation of points on the quantal response function, Estimation of safe doses.

UNIT-IV

Analysis of Epidemiologic and Clinical Data: Studying association between a disease and a characteristic: (a) Types of studies in Epidemiology and Clinical Research, (b) Dichotomous Response and Dichotomous Risk Factor: 2X2 Tables (c) Expressing relationship between a risk factor and a disease (d) Inference for relative risk and odds ratio for 2X2 table, Sensitivity, specificity and predictivities

Books Recommended

1. Jain and Prabhakaran: Genetics of Population, South Asian Publications.
2. Narain, P. (1990): Statistical Genetics, John Wiley and Sons
3. Ewens, W. J. (1979). Mathematics of Population Genetics, Springer Verlag.
4. Indrayan, A. (2008). Medical Biostatistics, Second Edition, Chapman & Hall/CRC.
5. S. Selvin (1996). Statistical Analysis of Epidemiologic Data, Oxford University Press.

ST-C-205: STATISTICAL COMPUTING-II: R PROGRAMMING LANGUAGE (100 MARKS)

Course Objectives: This paper aims at enriching the computing power of students by using R programming.

Course Learning outcomes:

After successful completion of this course, a student will be able to:

- understand how to read data, data frame and data types.
- understand matrix operations and simultaneous equation solving
- draw high-end graphs using various graphical parameters
- compute descriptive statistics and fit simple models

Data types in R: numeric, character, logical; real, integer, complex, strings and the paste command, matrices, dataframes, lists, setwd, read.table, read.csv, write.matrix, write.csv, creation of new variables, categorisation, cut, factor; round, apply, creation of patterned variables, saving output to a file; source; print, saving workspace/history.

Graphics in R: the plot command, histogram, barplot, boxplot, points, lines, segments, arrows, paste, inserting mathematical symbols in a plot, pie diagram, customisation of plot- setting graphical parameters, text and mtext, the pairs command, colours and palettes, saving to a file; graphical parameters such as mar/mai/mfrow, xlab/ylab/las/xaxp/yaxp/xlim/ylim /cex/axis/tck/srt main/title/legend/locator, identify.

Vector matrix operations: matrix operations, addition, subtraction, multiplication, linear equations and eigenvalues, matrix decomposition and inverse, the linear model and qr decomposition, determinant, g inverse, finding a basis, orthonormalisation, finding rank.

Books Recommended

1. Randall L. Eubank and Ana Kupresanin: Statistical Computing in C++ and R. Chapman &Hall/CRC The R Series.
2. Verzani, John. Using R for Introductory Statistics. Taylor & Francis.

Marks Distribution

Practical Work : - 80 marks

Viva-voce + Records - 20 marks

ST-C- 301: MULTIVARIATE ANALYSIS
(100 MARKS)

Course Objectives: The main objectives of this course are to deal with the data analysis involving several variables simultaneously with special reference to multivariate normal distribution. Necessary theoretical deductions of different multivariate techniques and deduction of multivariate probability distributions.

Course Learning outcomes:

After successful completion of this course, a student will be able to:

- understand the analysis of real-life data using multivariate tools like- factor analysis, discriminant analysis, cluster analysis, principal component analysis are also taught using appropriate statistical package.
- understand hotelling T2 and Mahalanobis – D^2 statistic and its applications
- perform multivariate data analysis on real life data using statistical packages, interpret the results and in addition shall develop necessary theoretical and mathematical understanding of the multivariate processes.

UNIT-I

Multivariate normal distribution – distribution of linear combination of normally distributed variables, marginal and conditional distributions, distribution of quadratic forms. Random sampling from normal distribution, maximum likelihood estimators of parameters, distributions of sample mean vector and matrix of corrected sum of squares and cross products.

UNIT-II

Estimation of partial and multiple correlation coefficients and their sampling distributions (null case only). Hotelling's T^2 statistic – properties, distribution and uses, tests on mean vector for one and more multivariate normal populations and also on equality of the components of a mean vector in a multivariate normal population. Mahalanobis – D^2 statistic and its use.

UNIT-III

Cluster Analysis, Wishart matrix – distribution and properties, characteristic function, reproductive property, marginal and conditional distributions. Distribution of sample generalized variance.

UNIT-IV

Factor Analysis, Principal components – definition, MLE of principal components and their variances. Canonical variables and canonical correlations – definition, use, estimation and computation.

Books Recommended

1. Anderson, T.W.: An Introduction to Multivariate Statistical Analysis, 2nd ed., Wiley
2. Morrison, D.F.: Multivariate Statistical Methods, 2nd ed., McGraw-Hill
3. Giri, N.C: Multivariate Statistical Inference. Academic Press, NY
4. Rao, C.R: Linear Statistical Inference and Its Application. John Wiley.
5. Sharma, S: Applied Multivariate Techniques, John Wiley.

ST-C-302: DESIGN & ANALYSIS OF EXPERIMENTS
(100 MARKS)

Course Objectives: This course provides the students with the ability to understand the design and conduct experiments, as well as to analyse and interpret data.

Course Learning outcomes:

After successful completion of this course, a student will be able to:

- understand the meaning of randomization, replication, local control and contrast
- make use of analysis of variance-one way, two-way with equal and unequal number of observations per cell along with analysis of covariance.

- identify the common and important types of experimental designs with respective advantages and disadvantages in terms of power, cost and time.
- understand and use factorial experiments, fractional factorial experiment and confounding in experiments.
- choose an appropriate design in a given research setting and interpret the model and report the findings scientifically.
- suggest appropriate experimental designs for agricultural and livestock experiments so as to minimize the experimental error.

UNIT-I

Analysis of variance – components and models, analysis of variance of one-way and two-way fixed and random effect models, Analysis of unbalanced data. Principles of designs of experiment, experimental error and data interpretation.

UNIT-II

Complete block designs - completely randomized designs, randomized block designs, latin square designs, Graeco-Latin square designs, cross-over designs. Missing plot techniques.

UNIT-III

Analysis of covariance. General factorial experiments, study of 2^n, 3^2, 3^3 factorial experiments in randomized blocks.
Confounding in 2^n, 3^2 and 3^3 factorial experiments - complete and partial confounding

UNIT-IV

Incomplete block designs – balanced incomplete block design, parametric equality and inequality, intra-block analysis, analysis with recovery of inter-block information. Split plot and strip plot designs – models and analysis.

Books Recommended

1. Das, M.N. and Giri, N.C.: Designs of Experiments, New Age International.
2. Kempthorne, O.: Design and Analysis of Experiments, Wiley Eastern.
3. Gun, A.M., Gupta, M.K. and Dasgupta, B.: An Outline of Statistical Theory, Vol.II, (4^{th} ed.), World Press.
4. Dey, Aloke: Theory of Block Designs. New Age International.
5. Dean, Angela and Voss, Daniel: Design and Analysis of Experiments. New Age International.
6. Chakrabarty, M.C.: Mathematics of Design of Experiments. Asian pub. House.
7. Montgomery, C.D.: Design and Analysis of Experiments. John Wiley, New York.

ST-CE-303: DECISION THEORY AND BAYESIAN INFERENCE
(100 MARKS)

Course Objectives: The objective of this course is to provide the understanding of the fundamentals of Bayesian inference including concept of subjectivity and priors by examining some simple Bayesian models

Course Learning outcomes:

After successful completion of this course, a student will be able to:

- understand the concepts of decision theory under different rules
- understand minimax theorem and its applications
- learn Subjective probability and its use
- understand different priors and posterior distributions
- apply Bayesian estimation techniques in real life situations.

UNIT-I

Game theory and decision theory – composition, decision and risk functions, loss functions, expected loss, utility and subjective probability, randomization. Optimal decision rules – ordering of the decision rules, geometrical interpretation, form of Bayes' rules for estimation problem.

UNIT-II

Theorems of decision theory – admissibility and completeness, existence and admissibility of Bayes' rules, existence of a minimal complete class.

UNIT-III

The separating hyper plane theorem, essential completeness of the class of non-randomized decision rules, Jensen's inequality, the minimax theorem, the complete class theorems and their applications, solving of minimax rules.

UNIT-IV

Subjective probability, Prior distribution, different types of priors, conjugate prior families, construction of conjugate families using sufficient statistics of fixed dimension. Bayesian inference: Bayes sufficiency, summary through posterior, predictive inference.

Books Recommended

1. Ferguson, T.W.: Mathematical Statistics- A Decision Theoretic Approach, Academic Press.

2. De Groot, M.A.: Optimal Statistical Decision, McGraw-Hill
3. Berger, J.O.: Statistical Decision Theory and Bayesian Analysis, Springer-Verlag.
4. Bernando, J.M. and Smith, A.F.M. : Bayesian Theory, John Wiley and Sons.
5. Robert, C.P. : The Bayesian Choice: A Decision Theoretic Motivation, Springer.
6. Box, G.P. and Tiao, G.C.: Bayesian Inference in Statistical Analysis, Addison-Wesley.
7. Montgomery, C.D.: Design and Analysis of Experiments. John Wiley, New York.

ST-CE- 303: APPLIED STOCHASTIC PROCESSES
(100 MARKS)

Course Objectives: The main objective of this course is to develop awareness for the use of stochastic models for representing random phenomena evolving in time.
Course Learning outcomes:
After successful completion of this course, a student will be able to:

- understand the meaning of stochastic process, Markov chain, and transition probability matrix along with classification of stochastic process.
- identify the states and stationary distribution of Markov Chain along with distribution of Markov chain at a given time.
- understand the concepts and applications of random walk and Gambler's ruin problem, Brownian motion, Wiener Process, Branching process and renewal process.
- finally, students are expected to choose appropriate stochastic process model(s) for a given research in applied problem and apply the theory to model real phenomena and solve several problems concerning random behavior in different fields of applied science.

UNIT-I

Notations and specification of stochastic process, stationary process, martingales, random walk and ruin problems, expected duration of the game, generating function of the duration of the game and for the first passage times, random walk in the plane and space. Markov chains - classification of states and chains, and related problems.

UNIT-II

Determination of higher transition probabilities, stability of a Markov system, limiting behavior of finite irreducible chains, ergodic theorem, graph theoretic approach, reducible chains, ergodic theorem for reducible chains (without proof), finite reducible chains with a single closed class and with more than one closed class.

UNIT-III

Markov processes with discrete state space – Poisson process and its properties, poison process and related distributions, generalization of poisson process – pure birth process, Yule-Furry process, birth-immigration process, pure death process, birth and death processes.

UNIT-IV

Markov processes with discrete state space – Champman-Kolmogorov forward and backward equations, derivation of poison process, pure birth process, pure death process by using Chapman-Kolmogorov equations

Books Recommended

1. Medhi, J. (1982): Stochastic Processes, Wiley Eastern.
2. Feller, W. (1968): Introduction to Probability and its Applications, Vol.1, Wiley Eastern.
3. Hoel, P.G, Port S.C. and Stone, C.J. (1972): Introduction to Stochastic Processes, Houghton Miffin and Co.
4. Karlin, S. and Taylor,H.M. (1975): A First course in Stochastic Processes, Vol.1,Academic Press.

ST-AE-304: DEMOGRAPHY
(100 MARKS)

Course Objectives: The main objective of this course is to describe current population trends in terms of fertility, mortality and population growth and the concepts stable population.

Course Learning outcomes:

After successful completion of this course, a student will be able to:

- understand content and coverage errors, different indices
- understand Population growth models and projections
- understand concepts of fertility and fertility models

- understands construction of life tables and its applications
- learn birth intervals and related models
- understand concepts of migration and related models
- understand the basic concepts of stable population theory

UNIT-I

Sources of demographic data, Coverage and content errors in demographic data, Chandrasekharan Deming formula. Adjustment of age data, Whiples, Mayers and UN indices. Population projection methods: Component & Growth Models, Leslie Matrix, Population distribution: Lorenz curve and Gini concentration ratio, Population pyramid.

UNIT-II

Measures of fertility (period and cohort), Coales fertility index, Measures of reproduction, Calculation of PPR, Fertility models, Birth Intervals. Nuptiality rate, Net Nuptiality table, Proportion Single and Singulate. Mean age at marriage, Hajnal's method of estimating SMAM, Mean duration of fertile union.

UNIT-III

Measures of mortality, comparative mortality index, Lexis Diagram and IMR, life table functions, Construction of Reed Merell, Greville life table, UN and Coale-Demeny model life tables, multiple decrement life table, measures of morbidity.

UNIT-IV

Measures of internal migration & international migration methods of estimation, Migration models. Stationary and stable population models, Simplified example of stable population, Lotka's demonstration of conditions producing a stable population, the equations characterizing a stable Population, Identification of the intrinsic growth rate.

Books Recommended

1. Pathak, K.B. and Ram, F.: Techniques of Demography Analysis, Himalayan Publishers
2. Srinivasan, K.: Basic Demographic Techniques and Applications, Sage Publishers
3. Ramkumar, R.: Technical Demography, Wiley Eastern.
4. S.H. Preston, P. Heuveline & M. Guillot, Blackwell, 2003_-Demography
5. Applied Mathematical Demography by Nathan Keyfitz, Springer Verl

ST-AE-304: OFFICIAL STATISTICS
(100 MARKS)

Course Objectives: The main objective of this course is to enable students to know the official statistical systems in India and functions of different agencies.

Course Learning outcomes:

After successful completion of this course, a student will be able to:

- understand Indian official statistical system
- learn functions of various statistical organizations viz., CSO, NSSO
- understand agricultural statistical system
- understand population growth and economic development

UNIT-I

Introduction to Indian and International statistical systems, Role, function and activities of Central and State statistical organizations.

UNIT-II

Organization of large-scale sample surveys. Role of National Sample Survey Office. General and special data dissemination systems.

Estimation of national income-product approach, income approach and expenditure approach.

UNIT-III

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.

UNIT-IV

System of collection of Agricultural Statistics. Crop forecasting and estimation, Productivity, fragmentation of holdings, support process, buffer stocks, impact of irrigation projects. Statistics related to industries.

Books Recommended

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

ST-C- 305: STATISTICAL COMPUTING – III: ADVANCED R AND C/C++ PROGRAMMING (100 MARKS)

Data Analysis using PYTHON

Course Objectives: The paper aims at introducing python programming.
Course Learning outcomes:
After successful completion of this course, a student will be able to:

- understand fundamentals of Python
- learn input and output of variables
- understand simple function writing
- analyse data using python programming

Fundamentals of Python: Introduction to Python, Running Python Programs, Writing Python Code

Working with Data: Data Types and Variables, Using Numeric Variables, Using String Variables

Input and Output: Printing with Parameters, Getting Input from a User, String Formatting

Making Decisions: Logical Expressions, The “if” Statement, Logical Operators, More Complex Expressions

Finding and Fixing Problems: Types of Errors, Troubleshooting Tools, Using the Python Debugger

Lists and Loops, Working with Functions, Working with Strings: Character Data, String Functions, Python Classes: Thinking about Objects, Class Variables and Methods, Managing Class Files.

Class Instances: Creating Objects with Instance Data, Instance Methods, Managing Objects

Books Recommended

1. Python Programming: Using Problem Solving Approach by Reema Thareja, Oxford
2. Python Programming: A modular approach, by Taneja Sheetal & Kumar Naveen, Pearson

Marks Distribution:

Computational Lab. Work - 80 marks
Viva-Voce + Record - 20 marks.

ST-AE- 401: LINEAR MODELS AND REGRESSION ANALYSIS
(100 MARKS)

Course Objectives: The main objective of this course is to introduce linear models and regression modellings, e g simple, multiple and logistic.

Course Learning outcomes:

After successful completion of this course, a student will be able to:

- understand the concepts of linear models and regression including simple linear regression, multiple regression, inverse regression, non-linear regression, polynomial regression, logistic regression, non-linear growth models.
- study the maximum likelihood estimation for estimating parameters of these models and testing of hypothesis of parameters or functions of parameters.
- finally, students are expected to choose an appropriate linear or non-linear model in a given research setting and interpret the model and report the findings scientifically.
- suggest appropriate regression models for given datasets to predict the behaviour of complex systems or analyse experimental, financial and biological data.

UNIT-I

Regression on the full rank model - methods of estimation and their consequences, distributional properties, general linear hypothesis, testing of common hypothesis and reduced models.

UNIT-II

Regression on dummy variables – regression on allocated codes, regression on dummy (0,1) variables, use of dummy variables on multiple regression.

UNIT-III

Regression models (not of full rank) – consequences and distributional properties. Estimable functions – properties, testing for estimability, general linear hypothesis.

UNIT-IV

Selecting the ‘best’ regression equation – all possible regressions, backward and forward elimination procedures, step-wise regression procedures.

Multiple regression applied to analysis of variance problems – one way and two way classifications using the models.

Books Recommended

1. Searle, S.R.: Linear Models, John Wiley & Sons
2. Draper, N.R. and Smith, H.: Applied Regression Analysis, John Wiley & Sons.
3. Rao, C.R: Linear Statistical Inference and its Applications, Wiley Eastern Ltd.
4. Kshirsagar, A M: A Course in Linear Models. Marcel Dekker, N. Y.
5. Joshi, D D: Linear Estimation and Design of Experiments. New Age International Publication.
6. Weisberg, S. Applied Linear Regression. Wiley.
7. Chatterjee, S. and Price, B: Regression Analysis by Example. John Wiley, New York.

ST-AE- 401: ECONOMETRICS
(100 MARKS)

Course Objectives: The main objective of this course is to introduce Generalize linear models and simultaneous equation modellings.

Course Learning outcomes:

After successful completion of this course, a student will be able to:

- understand concepts of generalized linear model
- understand different assumptions of OLS, viz., heteroscedastic, autocorrelation and multicollinearity
- learn stochastic regression and instrumental variables
- learn simultaneous equation modelling

UNIT-I

Nature of econometrics, ordinary least squares (OLS) estimation and prediction, the general linear model (GLM) and its extensions, generalized least squares (GLS) estimation (Aitken estimators) and prediction, heteroscedastic disturbances–nature, OLS estimators in the presence of heteroscedasticity, detection, consequences and remedial measures, pure and mixed estimation.

UNIT-II

Autocorrelation-Nature and reasons of autocorrelation, OLS estimation in the presence of autocorrelation, its consequences and tests. Theil BLUS procedure, estimation and prediction, Multicollinearity- detection, consequences and remedial measures, its implications and tools for handling the problem, ridge regression.

UNIT-III

Linear regression and stochastic regression, instrumental variable estimation, errors in variables, autoregressive linear regression, lagged variables, distributed lag models, estimation of lags by OLS method, Koyck's geometric lag model.

UNIT-IV

Simultaneous equation models – examples, the simultaneous-equation bias. Identification problem – concepts and definitions, under, just or exact and over identifications, rules for identification, test of simultaneity, restrictions on structural parameters, rank and order conditions.

Books Recommended

1. Johnston, J.: Econometric Methods, McGraw-Hill
2. Gujarati, D.: Basic Econometrics, McGraw-Hill.
3. Theil, H.: Introduction to the Theory and Practice of Econometrics, John Wiley.
4. Apte, P.G.: Text Book of Econometrics, Tata McGraw-Hill.
5. Cramer, J.S.: Empirical Econometrics, North Holland.
6. Maddala, G.S.: Econometrics, McGraw-Hill.

ST-CE-402: ADVANCED SURVEY SAMPLING METHODS (100 MARKS)

Course Objectives: The main objective of this course is to introduce equal and unequal probability proportional to size sampling.

Course Learning outcomes:

After successful completion of this course, a student will be able to:

- understand the basic concepts of probability proportional to size sampling
- understand the unequal probability proportional to size sampling
- understand Basic Concepts, Design-based and model-based Inference
- learn super population concepts
- understand sampling and non-sampling errors, modeling observational error, and randomized response technique to get information for sensitive issues.
- perform different types of sampling procedure in real life situation.
- analyze the data, interpret the results and draw valuable conclusions coming from various aspects.

UNIT-I

Unequal probability sampling with replacement –PPSWR sampling, methods of selection, estimation of mean/total, standard error of estimate and it's estimation, comparison with SRSWR, gain due to PPSWR sampling,
Small area estimation – direct, synthetic and composite estimators.

UNIT-II

Unequal probability sampling without replacement – Des Raj's ordered estimator, Murthy's unordered estimator, Horvitv-Thompson estimator and it's optimal properties. Midzuno Scheme of Sampling, Rao-Hartly-Cochran sampling procedures, systematic sampling with varying probabilities.

UNIT-III

Variance estimation – methods of random groups, the Jack knife, balanced half sample, and the bootstrap techniques.
Inference under a Super-population Model: Basic Concepts, Design-based and model-based Inference

UNIT-IV

Measurement Errors in surveys – mathematical models for measurement error. Problems of non-response – Hansen and Hurwitz technique, Politz-Simon technique. Randomized response techniques – Warner's model and unrelated question model.

Books Recommended

1. Cochran, W.G.: Sampling Techniques, 3rd ed., Wiley
2. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C.: Sampling Theory of Surveys With Applications, Indian Soc. of Agric. Stat., New Delhi
3. Swain, A.K.P.C.: Finite Population Sampling – Theory & Methods, South Asian Publishers
4. Murthy, M. N: Sampling Theory and Methods. Statistical Publishing Society
5. Arnab, Raghunath, Survey Sampling Theory and Applications, Academic Press

ST–CE-402: ADVANCED DESIGN & ANALYSIS OF EXPERIMENT (100 MARKS)

Course Objectives: The main objective of this course is to introduce advanced design and analysis of experiment.
Course Learning outcomes:

After successful completion of this course,a student will be able to:

- understand construction and analysis of fractional factorial design
- understand Alias structure
- learn Optimal design tools
- understand the concept of response surface and its applications

UNIT-I

Analysis of fixed effects model: Estimation of model parameters, Unbalanced data, Model adequacy checking, Practical interpretation of results, determination of sample size.

UNIT-II

Two-Level Fractional Factorial Designs: The one-half fraction of the 2^k Design, one-quarter fraction of the 2^k Design, the general 2^{k-p} Fractional Factorial Design, Alias structure.

UNIT-III

Factorial experiments with mixed levels: Factors at two and Three levels, factors at two and four levels, Constructing Fractional Factorial Designs using an Optimal design tool.

UNIT-IV

Response surface designs – linear response surface designs, second order response surface designs. Experimental designs for fitting response surfaces, Mixture experiments.

Books Recommended

1. Montgomery, D.C. (2014): Design and Analysis of Experiments, Eighth edition, Wiley, NY
2. Dey, A.: Theory of Incomplete Block Designs, Wiley Eastern.
3. Das, M.N. and Giri, N.: Design and Analysis of Experiments, New Age International.
4. Kempthorne, O. (1952): The Design and Analysis of Experiments, Wiley, NY.
5. Chakrabarty, M.C. : Mathematics of Design of Experiments. Asian pub. House.
6. Khuri, A. and Cornell, M. : Response Surface Methodology. Marcel Dekker.

ST–CE-402: ADVANCED OPERATIONS RESEARCH (100 MARKS)

Course Objectives: The main objective of this course is to introduce advanced Operational Research.

Course Learning outcomes:

After successful completion of this course, a student will be able to:

- understand concepts of dynamic programming and its solution
- learn Fuzzy logic and use of fuzzy concepts in optimization techniques
- apply simulation technique for random number generation and model development
- solve integer programming problem

UNIT-I

Dynamic programming: Basic concepts, development of dynamic programming, continuous state dynamic programming, multiple state variables, Goal programming: categorization, formulation, graphical goal attainment method, simplex method.

UNIT-II

Fuzzy logic: Fuzzy relations, fuzzy systems, defuzzification methods, Non-Linear programming: Unconstrained optimization, constrained optimization: Equality constraints and inequality constraints.

UNIT-III

Simulation Modeling: examples, pseudo-random numbers, techniques for generating for random deviates, simulation languages, advanced concepts in simulation analysis: Design of simulation experiments, variance reduction techniques, statistical analysis of simulation output, optimization of simulation parameters.

UNIT-IV

Integer programming: Pure and mixed integer programming problem, Gomory's all integer programming problem, Gomory's constraints, fractional cut method: all integer and mixed integer, Branch and Bound algorithm.

Books Recommended

1. Hardly, G.(1964): Non-linear and Dynamic Programming, Addison Wesley
2. Wagner, H.M.(1969): Principles of Operations Research with Applications to Managerial Decisions, Prentice Hall
3. Ravindran, A., Phillips, D.T. and Solberg, J.J. (2009): Operations Research: Principles and Practice, Wiley-India.
4. Zimermann, H.J. (2001): Fuzzy Set Theory and its Applications, 2nd ed., Allied Publishers.
5. Lee, K.H. (2006): Fuzzy logic and Its Applications, Springer.
6. Rajasekharan, S. and Pai, G.A.V. (2006): Neural Networks, Fuzzy Logic and Genetic Algorithms, PHI.

ST–CE-403: TIME SERIES AND STATISTICAL QUALITY CONTROL (100 MARKS)

Course Objectives: The main objective of this course is to introduce time series modellings and forecasting. It also discusses the methods of statistical quality control.

Course Learning outcomes:

After successful completion of this course, a student will be able to:

- understand Auto-covariance and autocorrelation function and their properties
- understand Exponential smoothing and Holt and winters smoothing techniques
- apply smoothing procedure for forecasting
- understand AR, MA, ARMA and ARIMA models
- understand concepts of quality control and the methods of process control by using the different kinds of quality control charts for variables as well as for attributes along with the methods for product control.
- learn sequential probability sampling scheme

UNIT-I

Time series as discrete parameter stochastic process. Auto-covariance and autocorrelation function and their properties. Exploratory Time Series Analysis, Tests for trend and Seasonality. Exponential and Moving Average Smoothing, Holt and Winters smoothing. Forecasting based on smoothing, Adaptive smoothing.

UNIT-II

Detailed study of the stationary processes: (1) moving average (MA), (2) Auto regressive (AR)., (3) ARMA and (4) AR integrated MA (ARIMA) models, Box Jenkins models, Discussion (without proof) of estimation of mean, auto covariance and autocorrelation functions under large sample theory, Choice of AR and MA periods. Estimation of ARIMA model parameters.

UNIT-III

Industrial statistics – statistical quality control, need for statistical quality control, control charts in general, random and assignable causes, purpose of control charts, process control, control charts for measurements, charts for averages, attributes, defectives and defects

UNIT-IV

Acceptance sampling plans – single and double sampling plans for attributes, producer's and consumer's risk, variable sampling plans, sequential sampling plans. Sequential probability ratio test- OC and ASN functions, sequential tests for testing means of normal and binomial populations.

Books Recommended

1. Box, G.E.P., Jenkins, G. M. and Reinsel, G. C.: Time Series Analysis, Pearson Edition
2. Burr, I.W.: Engineering Statistics and Quality Control, McGraw-Hill
3. Grant, E.L. and Leavenworth, R.S.: Statistical Quality Control, McGraw-Hill.
4. Anderson, T.W. (1971).The Statistical Analysis of Time Series, Wiley, N.V.
5. Montgomerv, D.C. (1985) Introduction to Statistical Quality Control: Wiley
6. Wetherill, G.B. and Brown, D.W. Statistical Process Control. Theory and Practice: Chapman and Hall

ST–CE-403: RELIABILITY THEORY
(100 MARKS)

Course Objectives: The main objective of this course is to introduce reliability theory and its real life applications.

Course Learning outcomes:

After successful completion of this course, a student will be able to:

- understand the concepts of reliability function and hazard function
- learn different life time distributions and its hazard and reliability functions
- understand series and parallel system
- understand ageing process, convolution and mixtures process
- understand reliability estimation based on failure times from variously censored life-tests data

UNIT-I

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

UNIT-II

Life distributions; reliability function; hazard rate; common life distributions – exponential, Weibull, gamma, normal, bivariate exponential, etc.; Estimation of parameters and tests in these models.

UNIT-III

Notions of aging; IFR; IFRA; NBU; DMRL and NBUE classes and their duals; loss of memory property of the exponential distribution; closures of these classes under formation of coherent systems; partial ordering of life distributions, convolution and mixtures.

UNIT-IV

Reliability estimation based on failure times from variously censored life-tests data for parametric families, stress-strength reliability and its estimation. Kaplan – Meier estimation of reliability curve, Greenwood formula

Books Recommended

1. Barlow, R.E. and Proschan, F. (1985): Statistical Theory of Reliability and Life Testing; Holt, Rinehart and Winston.
2. Lawless, J.F. (1982): Statistical Models and Methods of Life Time Data; John Wiley.
3. Nelson, W. (1982): Applied life Data Analysis; John Wiley.
4. Zacks, S.: Reliability Theory; Springer
5. Bain, L. J. and Engelhardt (1991): Statistical Analysis of Reliability and Life Testing Models; Marcel Dekker.
6. Kalbfleisch, J.D. & Prentice R.L. :The Statistical Analysis of Failure time data, 2nd ed.

ST–FE-404: ACTUARIAL STATISTICS
(100 MARKS)

Course Objectives: The main objective of this course is to let students know different aspects of the basics of actuarial sciences.

Course Learning outcomes:

After successful completion of this course, a student will be able to:

- understand the concept of insurance and its different terminologies like loss function, premium etc. along with some advanced models of demography concerning insurance industry.
- understand policy values, fractional premiums and survivorships
- understand contingent probabilities, contingent assurances, reversionary annuities, multiple decrement table etc.
- have basic knowledge as to how the insurance industry works, how the policies

are designed and the way in which premiums are fixed.

UNIT-I

Mortality – mortality experience, mortality table, graph of Lx, force of mortality, laws of mortality, mortality table as a population model, expectation of life, stationary funds.

UNIT-II

Annuities – pure endowments, annuities, accumulations, assurances, varying annuities and assurances, continuous annuities, family income benefits.

UNIT-III

Policy values – nature of reserve, prospective and retrospective reserves, fractional premiums and fractional duration, modified reserves, continuous reserves, surrender values and paid up policies, industrial assurance, children's deferred assurances, joint life and last survivorship.

UNIT-IV

Contingencies - contingent probabilities, contingent assurances, reversionary annuities, multiple decrement table, forces of decrement, construction of multiple decrement table.

Books Recommended

1. Dickson, C. M. D. (2005): Insurance Risk And Ruin (International Series On Actuarial Science), Cambridge University Press.
2. Bowers, N. L., Gerber, H. U., Hickman, J. C., Jones, D. A. And Nesbitt, C. J. (1997): Actuarial Mathematics, Society of Actuaries, Itasca, Illinois, U.S.A

ST–FE-404: CATEGORICAL DATA ANALYSIS
(100 MARKS)

Course Objectives: The main objective of this course is to introduce categorical data analysis

Course Learning outcomes:

After successful completion of this course, a student will be able to:

- understand categorical data and its related inferences
- understand fitting of generalized linear models, viz., Poisson and Logistic
- learn structural models for discrete data in two or more dimensions
- understand Chi-square approximation for various goodness-of-fit statistics Models for nominal and ordinal response.
- learn Structural equation modelling

UNIT-I

Introduction to Categorical Data**,** Probability distributions for categorical data, Statistical inference for discrete data, Visualizing Categorical data. Measures of association. Structural models for discrete data in two or more dimensions.

UNIT-II

Probability structure for contingency tables, Comparing proportions with 2x2 table, Estimation in complete tables. Goodness of fit, choice of a model. Generalized Linear Model for discrete data, Poisson and Logistic regression models.

UNIT-III

Log-linear models. Odds-ratio Product multinomials to model sampling from multiple populations. Elements of inference for cross-classification tables. Chi-square approximation for various goodness-of-fit statistics Models for nominal and ordinal response.

UNIT-IV

Path models and Structural Equations Modelling

Books Recommended

1. Agresti, An Introduction to Categorical Data Analysis Wiley
2. Bilder and Loughlin, Analysis of Categorical data with R, Chapman and Hall/CRC
3. Kateri, Contingency Table Analysis, Springer
4. Dobson and Barnett: An Introduction to Generalized Linear Models, Chapman & Hall/CRC
5. Hosmer, Lemeshow and Sturdivant, Applied Logistic Regression, Wiley

ST–FE-404: SURVIVAL ANALYSIS AND CLINICAL TRIALS (100 MARKS)

Course Objectives: The main objective of this course is to introduce survival analysis and clinical trials.

Course Learning outcomes:

After successful completion of this course, a student will be able to:

- understand concepts of censoring, survival and hazard functions
- understand various survival distributions and its applications
- understand the parametric and non-parametric estimation of survival function
- develop regression model for survival data
- learn various types of clinical study design
- understand different phases of clinical trials

UNIT-I

Concept of time, order, Type I, Type II and progressive or random censoring with biological examples, Functions of survival time, hazard function, survival distributions and their applications viz. exponential, gamma, Weibull, Rayleigh, lognormal, Pareto death density function for a distribution having bath-tub shape hazard function.

UNIT-II

Life tables, mean residual life, Non-parametric methods for estimating survival function and variance of the estimator viz. Actuarial and Kaplan –Meier methods. Estimation under the assumption of IFR/DFR. Two sample problem–Gehan test, log rank test.

UNIT-III

Semi-parametric regression for failure rate– Cox's proportional hazards model with one and several covariates, rank test for the regression coefficient, Competing risk model.

UNIT-IV

Introduction to clinical trials: overview of Phase I– IV trials, Multicenter trials, Single and double blinding. Design of clinical trials: parallel vs. cross-over designs, cross-sectional vs. Longitudinal designs, review of factorial designs, objectives and endpoints of clinical trials, design of Phase I,II and III trials.

Books Recommended

1. Kalbfleisch J. D. and Prentice R. (1980): The Statistical Analysis of failure Time data, John Wiley.
2. Kleinbaum, D.G. (1996): Survival Analysis, Springer
3. Lee, Elisa, T. (1992). Statistical Methods for Survival Data Analysis, John Wiley & Sons.
4. Miller, R.G. (1981). Survival Analysis, John Wiley & Sons.
5. Piantadosi. S. (1997): Clinical Trials: A Methodologic Perspective. Wiley and Sons.
6. Friedman, L. M. Furburg, C. Demets, D. L. (1998): Fundamentals of Clinical Trials. Springer Verlag.
7. Marubeni. E. and Valsecchi. M. G. (1994): Analyzing Survival Data from Clinical Trials and Observational Studies, Wiley and Sons.

ST–FE-404: BIG DATA ANALYTIC TECHNIQUES (100 MARKS)

Course Objectives: The main objective of this paper is to introduce some advanced statistical computing techniques to extract information, visualization and knowledge about various industries

Course Learning outcomes:

After successful completion of this course, a student will be able to:

- understand Sampling and resampling techniques
- understand the concepts of bootstrapping and its applications
- learn advance regression modelling viz., ridge and lasso regression
- apply classification and regression tree methods
- understand applications of linear discriminant function and principle of component analysis

UNIT-I

Resampling Techniques: Introduction to Jackknife and Bootstrap-methods for estimating bias, standard error and distribution function based on iid random variables, standard examples, Bootstrap confidence intervals

UNIT-II

Generalization of Linear Regression- Ridge Regression, Partial least squares, LASSO and Least angle regression, Tree based methods- Classification and Regression Trees (CART), Patient rule induction method (PRIM), Multivariate Adaptive Regression Splines (MARS).

UNIT-III

Principal Components Regression, Generalization of Linear Discriminant Analysis- Flexible Discriminant Analysis Penalized Discriminant Analysis, Mixture Discriminant Analysis.

UNIT-IV

Generalization of Principal Component Analysis- Kernel Principal Components, Sparse Principal Component Analysis, Independent Component Analysis (ICA). Multidimensional Scaling and its Applications.

Books Recommended

1. B.Efron&R.J.Tibshirani : An introduction to bootstrap Springer Science (1993)
2. T.Hastie, R.Tibshirani&J.Friedman: The Elements of Statistical Learning.
3. B.L.Friedman, et al. : Classification and Regression Trees
4. A.Hyvarinen, et al. : Independent Component Analysis
5. R.Stephen & E.Richard : Independent Component Analysis –Principles and Practice
6. R.A.Johnson & D.W.Wichern : Applied Multivariate Statistical Analysis
7. Marubeni. E. and Valsecchi. M. G. (1994): Analyzing Survival Data from Clinical Trials and Observational Studies, Wiley and Sons.

ST-C- 405: INDUSTRY EXPOSURE AND PROJECT WORK (100 MARKS)

Industry Exposure – Study Tour Report : 20 Marks
Seminar Presentation : 20 Marks
Project Report : 40 Marks
Viva Voce on Reports : 20 Marks

Remark – Industry Exposure is not compulsory. Those, who will not undertake the tour, will be evaluated for their Project work out of 60 Marks.

The students have to visit an industry or any higher educational institution of repute for enhancing their data analytic skills with their own support before the completion of their final semester examination and submit a brief report of the outcome of their visit to the department. The outcome report will be prepared individually. However, they can prepare by consulting their respective faculty supervisor / guide.

The supervisors are to be allotted to the students before the end of second semester examination and they have to prepare a seminar paper and also a project paper under his/her guidance.

Each student has to give one seminar presentation before the students and faculties on any area of Statistics with his/her interest carrying 20 Marks.

Course objectives: The main objective of this course is to prepare students how to carry out statistical analysis independently.

Course outcomes: After undertaking Industry Exposure Tour and/or project work, a student will be able to:

- analyse statistical data
- write reports based on analysis of data
- secure employment for him/her