Department of Statistics
Central University of Rajasthan

SYLLABUS

for

M. Sc./M.A. STATISTICS

Proposed to be implemented for the existing batch admitted in July 2018 and for students admitted in academic year 2019 and onwards

Department of Statistics
School of Mathematics Statistics and Computational Sciences
Central University of Rajasthan
Bandarsindri, NH-8, Kishangarh, Ajmer, Rajasthan-305801

Course Structure of M.Sc. Statistics

1. **Preamble:** The main objective of M.Sc. Statistics programme is to enhance theoretical and practical skills and provide advanced training in theoretical and applied statistics. The program is intended to prepare students for careers as practicing statisticians in the private and public sectors, to provide enhanced research expertise, and to strengthen the analytical and statistical training of students preparing for Ph.D. studies in statistics.

2. Learning outcome of this program,

After the completion of M.Sc. programme, students will:

I. Learn advance level basic concepts and statistical inference used in decision making which help them in their higher studies and solve involved decision-making problems.

II. Learn art of gathering information by sampling and designing experiments and analyzing it

III. Be able to assist researchers for drawing inferences using their experimental outcomes

IV. Be able to develop and validate models based on collected

3. Aim: The programme aims to produce Statisticians who are competent enough to work in the public sector and in the private sector under various capacities.

4. Career Options: The course is highly relevant for statisticians who want to pursue a professional career as Data Analysts, Data Scientists, or wish to pursue a career in Academics.

5. Duration: 4 Semesters (2 years). It is a two-year full-time program divided into four semesters.

Revised Course Structure M.Sc./M.A. Statistics *

Integrated M. Sc Semester-VII and M. Sc./M. A. Semester-I

Course Code	Title	C	L	T	P	Category
STA401	Probability Theory	4	3	0	1	Core
STA402	Distribution Theory	4	3	0	1	Core
STA403	Real Analysis and Linear Algebra	4	3	1	0	Core
STA404	Sampling Theory	4	3	0	1	Core
STA405	Statistical Quality Control	4	3	0	1	Core
STA481	Statistical Computing using R	2	0	0	2	Skill Enhancement
	Open Elective	3				
	Fitness/ Societal – at least	1				

C: Credit, L: Lectures, T: Tutorial, P: Practical

Integrated M. Sc Semester-VIII and M. Sc./M. A. Semester-II

Course Code	Title	C	L	T	P	Category
STA406	Estimation and Testing of Hypotheses	4	3	0	1	Core
STA407	Regression Analysis	4	3	0	1	Core
STA408	Stochastic Models	4	3	0	1	Core
STA409	Design of Experiments	4	3	0	1	Core
STA410	National Development Statistics	4	3	1	0	Core
STA482	Journal Presentation	1	1	0	0	Skill Enhancement
	Open Elective (From other Departments or SWYAM course etc)	3				
	Fitness/ Societal – at least	1				

C: Credit, L: Lectures, T: Tutorial, P: Practical

Integrated M. Sc Semester-IX and M. Sc./M. A. Semester-III

Course Code	Title	C	L	T	P	Category
STA501	Time Series Analysis & Forecasting	4	3	0	1	Core
STA502	Multivariate Analysis	4	3	0	1	Core
STA503	Survival Analysis	4	3	0	1	Core
	Open Elective (From other Departments or SWYAM course etc)	3				
	Elective-1	4				
	Elective-2	4				
STA 583	Empirical Analysis/Case Studies	2	0	0	6	Skill Enhancement
	Fitness/ Societal – at least	1				

C: Credit, L: Lectures, T: Tutorial, P: Practical

Integrated M. Sc Semester-X and M. Sc./M. A. Semester-IV

Course Code	Title	C	L	T	P	Category
STA582	Major Project	20				Skill Enhancement

C: Credit, L: Lectures, T: Tutorial, P: Practical

List of Elective Papers

Course Code	Title	C	L	T	P	Category
STA 531	Econometrics	4	3	1	1	Core
STA 532	Statistical Quality Management	4	3	0	1	Core
STA 533	Reliability Analysis	4	3	0	1	Core
STA 534	Extreme Value Theory	4	3	0	1	Core
STA 535	Bayesian Inference	4	3	0	1	Core
STA 583	Principal and Practices of Life and Health Insurance	4	3	1	0	Skill Enhancement
STA 584	Computer Intensive Statistical Methods	4	3	0	1	Skill Enhancement

C: Credit, L: Lectures, T: Tutorial, P: Practical

Note: The course structure is targeting to facilitate sequential learning and course structure is suggested for the four semesters. Students are free to take elective courses as per their choice. Depending on the prerequisites of individual courses, and other logistics. There may be slight reshuffle of the sequence of courses in 2^{nd}, 3^{rd} and 4^{th} semesters.

FIRST SEMESTER

PAPER CODE	**STA 401**
PAPER NAME	**Probability Theory**
CREDIT	**04(3 - 0 - 1)**
Objective	The main purpose is to introduce Probability Theory under Axiomatic approach and develop further theory and concepts including the limit behaviours.
Learning Outcome	**After the completion of paper student will be able to** ➢ Recognize the concept of field, sigma field, probability space, probability measure. ➢ List various inequalities. ➢ Describe and apply the independence of events. ➢ Apply the concept of convergence of sequences of random variables. ➢ Discuss Borel Cantelli lemma, Kolmogrov 0-1 law, Slustsky's theorem Law of Large Numbers, and CLT
Unit-1	
Classes of sets, field and sigma fields, limit of sequences of subsets, sigma field generated by a class of subsets, Borel fields. Probability measure on a sigma field, probability space, continuity of a probability measure. Real and vector-valued random variables.	
Unit-2	
Distribution functions of discrete rvs, continuous and mixed type rv, decomposition of a df. Expectation of rv and its properties. Linear properties of Expectations, Inequalities: Jensen's, Chebychevs, Markov, Hölders and Lyapounov inequalities.	
Unit-3	
Independent of two events and n(>2) events, sequence of independent events, independent class of events π-systems and □–systems of events, Dykin's theorem(without proof) independence of rvs of events. Borel zero- one law, Borel-Cantelli Lemma, Kolmogorov zero-one law.	
Unit-4	
Convergence of sequences of random variables. Convergence in distribution and in probability. Almost sure convergence and convergence in the r^{th} mean. Implication between modes of convergence. Slutsky's theorem. Monotonic convergence theorem and dominated convergence theorem. Fatous lemma. Law of large number: weak law of large number, Tchebychev and Khintchine theorem (with proof) and strong law of large number (without proof). Inversion, Continuity and Uniqueness theorems of Characteristics function. Demoivre-Laplace Central Limit Theorem, Liapounovs and Lindeberg's CLT (without proof).	
References	

1. Bhat, B. R. (1999). Modern Probability Theory, 2/e, New Age International, New Delhi.
2. Rao. B. L. S. Prakasa (2009). A First course in Probability and Statistics. World Scientific
3. Meyer, P.A. An Introduction to Probability and Its Applications. PHI
4. Rohatgi V.K & A.K. MD. EhsanesSaleh (2001): An Introduction to Probability Theory and Mathematical Statistics, 2nd. John Wiley and Sons.
5. C. W. Burrill (1972). Measure Integration and Probability. McGraw Hill, London

PAPER CODE	**STA 402**
PAPER NAME	**Distribution Theory**
CREDIT	**04(3 - 0 - 1)**
Objective	The main objective is to know the genesis of important distributions, their properties. Introducing of bivariate distributions, conditional and marginal distributions and distributions of Order Statistics.
Learning Outcome	**After the completion of paper student will be able to** ➢ Recognize the difference between Discrete and Continuous Distributions. ➢ Explain theoretical foundations of Statistical Distributions. ➢ Execute the concept of transformation of variables. ➢ Recognize the relation between various distributions. ➢ Apply various distributions to solve real life problems. ➢ Develop new distributions by employing the techniques like Compounding and Truncation ➢ Formulate distribution of order statistics.
Unit-1	
Review of Discrete and Continuous distributions. Weibull, Pareto, lognormal, Laplace, Cauchy, logistic, Rayleigh distribution their properties and applications.	
Unit-2	
Discrete and continuous bivariate random variables: Definitions, Computation of probabilities of various events, marginal, conditional, product moments and correlations. Conditional expectation and conditional variance. The p. d. f. of a bivariate normal distribution, Marginal and conditional distributions, conditional expectation and conditional variance, regression lines of Y on X and X on Y., independence and uncorrelated-ness imply each other, m. g. f and moments. Plotting of bivariate normal density function.	
Unit-3	
Functions of random variables and their distributions using Jacobian of transformation and other tools. Distribution of distribution function. Bivariate exponential distributions. Concept of a sampling distribution. Sampling distributions of t, χ^2 and F (central and non central), their properties and applications. Cochran's theorem. Independence of quadratic forms.	
Unit-4	
Compound, truncated and mixture distributions. Convolutions of two distributions. Order statistics: their distributions and properties. Joint, marginal and conditional distribution of order statistics. The distribution of sample range and sample median. Extreme values and their asymptotic distribution (statement only) with applications.	
References	
1. Rohatgi V.K & A.K. MD. EhsanesSaleh: An Introduction to Probability Theory and Mathematical Statistics, 2nd. John Wiley and Sons, 2001. 2. Johnson, Kotz and Balakrishna, Continuous univariate distributions, Vol- 1 IInd Ed, John Wiley and Sons 3. Johnson, Kemp and Kotz,Univariate discrete distributions, IIInd Ed, John Wiley and Sons 4. Mukhopadhyay P. (1996): Mathematical Statistics, New central Book Agency (P) Ltd. Calcutta. 5. Goon, Gupta & Das Gupta (1991): An Outline of Statistical Theory, Vol. I, World Press. 6. David, H. A., &Nagaraja, H. N. (1970). Order statistics. John Wiley & Sons, Inc..	

PAPER CODE	**STA 403**
PAPER NAME	**Real Analysis and Linear Algebra**
CREDIT	**04 (4 - 1 -0)**
Objective	The main purpose is to provide mathematical foundation for statistics courses to enhance their knowledge in Real Analysis and Linear algebra.
Learning Outcome	**After the completion of paper student will be able to** ➢ Practice Real Analysis and Linear algebra tools. ➢ Recognize the importance of sequences, series of functions ➢ Apply Matrix theory concepts in Multivariate Analysis, Linear Models and Designs of Experiments.

Unit-1

Review of basic differential and integral calculus. Elementary set theory, finite, countable and uncountable sets, Real numbers, limit point, interior point, open and closed subsets of R, supremum, infimum. convergence, limsup, liminf, Bolzano-Weisstrass theorem, Heine Borel theorem, continuity, uniform continuity, differentiability, Riemann sums and Riemann integral, Improper Integrals. Mean value theorem. Riemann-Stieltjes (R-S) integral of a bounded real valued function. Necessary and sufficient condition for R-S integrability. Properties of R-S integrals. Integration by parts. Change of variables in R-S integrals. Log Series Distribution

Unit-2

Sequences and series of functions, uniform convergence, Weierstrass test. Monotonic functions, types of discontinuity, functions of bounded variation. Functions of several variables, partial derivative, derivative as a linear transformation. Maxima and minima of functions of several variables. Lagrangian multipliers. Bivariate Binomial and Poisson.

Unit-3

Vector spaces, subspaces, linear dependence, basis, dimension, algebra of linear transformations. Algebra of matrices, rank and determinant of matrices, inverse matrices, generalized inverse of a matrix and its properties, linear equations, eigen values and eigenvectors and their applications. Cayley-Hamilton theorem. Spectral decomposition of a symmetric matrix.

Unit-4

Matrix representation of linear transformations. Orthogonal transformations. Orthogonal and idempotent matrices. Change of basis, inner product spaces, canonical forms, diagonal forms. Quadratic forms, reduction and classification of quadratic forms. MGF of Quadratic form. Independence of Quadratic form.

References

1. Searle, S. R. (1982). Matrix Algebra Useful for Statistics; John Wiley, New York.
2. RamachandraRao, A. and Bhimasankaram, P. (1992): Linear Algebra, Tata McGraw hill.
3. Trench William (2003). Introduction to Real Analysis , Pearson Education
4. Krishnamurthy V., Mainra V.P. and Arora J. L. (2009) An introduction to Linear Algebra, East-West Press Pvt Ltd.
5. Rudin, W. (1985). Principles of Mathematical Analysis, McGrawhill, New York.
6. Malik, S.C. and Arora, S. (1998). Mathematical Analysis, New Age, New Delhi.
7. Bartle,R.G.(1975) The Elements of Real Analysis, 2/e, John Wiley.

PAPER CODE	**STA 404**
PAPER NAME	**Sampling Theory**
CREDIT	**04(3 - 0 - 1)**
Objective:	The main objective is to provide the knowledge of concept of sample and population in statistics and the various sampling schemes. Estimation of population parameters and their respective standard errors.
Learning Outcome:	➢ Recall the basic concept of sampling and related terminologies. ➢ Extrapolate the idea of various types of sampling schemes, with their advantages and disadvantages, and estimation of population parameters with their standard errors. ➢ Recognize the importance of use of auxiliary information in the ratio and regression method of estimation. ➢ Conclude the need of double sampling scheme in real world. ➢ State the non-sampling errors and use of some estimation techniques with special reference to non- response problems.
Unit-1	
Fixed population and super-population approaches. Distinct features of finite population sampling, Probability sampling design and estimators along with basic statistical properties. Review of some important results in SRSWOR and SRSWR.	
Unit-2	
Estimation of population mean/Total in stratified population, Allocation problem in stratified random sampling in case of fixed cost and also for specified precision. Expression for variance of stratified sample mean in case of fixed cost, formation and construction of strata, Post stratification, Double sampling with post stratification, Deep stratification, Controlled sampling.	
Unit-3	
Unequal probability sampling: PPSWR/WOR methods (including Lahiri's scheme) and Des Raj estimator, Murthy estimator (for n=2). Horvitz Thompson Estimator of finite population total/mean, Expression for Variance (HTE) and its unbiased estimator, Issue of non-negative variance estimation.	
Unit-4	
Double sampling scheme, some double sampling estimators for mean using auxiliary character (Ratio, regression and product) method of estimation, Some unbiased ratio type estimators for population mean, Concept of cluster sampling, two stage sampling, Two phase sampling, Non-sampling error with special reference to non-response problems.	
References	
1. Cochran, W.G: Sampling Techniques, Wiley Eastern Ltd., New Delhi. 2. Sukhatme, P.V., Sukhatme, B.V. and Ashok A.: Sampling Theory of Surveys with Applications, Indian Society of Agricultural Statistics, New Delhi. 3. Murthy, M.N: Sampling Methods, Indian Statistical Institute, Kolkata. 4. Daroga Singh and Choudhary F.S.; Theory and Analysis of Sample Survey Designs,WileyEastern Ltd., New Delhi. 5. Mukhopadhay, Parimal: Theory and Methods of Survey Sampling, Prentice Hall.	

PAPER CODE	**STA 405**
PAPER NAME	**Statistical Quality Control**
CREDIT	**04(3-0-1)**
Objective	The main purpose of this paper is to introduce the most important field of applied statistics that contributes to quality control in almost all industries.
Learning Outcome	**After the completion of paper student will able to** ➢ Distinguish between process control and product control. ➢ Sketch various control charts using appropriate control limits for real situation. ➢ Execute sampling inspection plans for attributes and variables.
Unit-1	**Lectures: 15**
Statistical Quality Control, Causes of Variation, Statistical basis for Control Charts,Selection of Control Limits, Warning limits, Effect of Sample Size on Control limits, Errors in Making Inferences from Control Charts, Control Chats for Variables and Attributes, Modified control chart.	
Unit-2	**Lectures:15**
Standardized Control Charts, Statistical process control with auto-correlated process data, Adaptive sampling procedures, Economic design of control chart, Cu-score charts, Control charts for Individual Units. Control Charts for Short Production Runs. Control Charts for Highly Conforming Processes.	
Unit-3	**Lectures: 15**
Producer's risk, Consumer's risk, Acceptance sampling plan, Single and double sampling plans by attributes, OC, ASN (and ATI), LTPD, AOQ and AOQL curves, Single sampling plan for variables (one sided specification, known and unknown cases), Lot-by-Lot Attribute Sampling Plans.	
Unit-4	**Practicals:**
Students will be required to do practical's, based on topics listed below, using R software: 1. Control charts for mean and range 2. Control charts for mean and standard deviation 3. Control charts for individual units 4. Control charts for short production runs 5. Lot-by-lot attribute sampling plans	
References	
1. D.C. Montgomery: Introduction to Statistical Quality Control. Wiley. 2. Wetherill, G.B. Brown, D.W.: Statistical Process Control Theory and Practice, Chapman & Hall. 3. Wetherill, G.B.: Sampling Inspection and Quality control, Halsteed Press. 4. Duncan A.J.: Quality Control and Industrial Statistics, IV Edision, Taraporewala and Sons. 5. Ott, E. R. : Process Quality Control (McGraw Hill)	

PAPER CODE	**STA 481**
PAPER NAME	**STATISTICAL COMPUTING USING R**
CREDIT	**2**
Objective	To learn the R software.
Learning Outcome	After the completion of paper student will able to ➢ Use R as a calculator and as a helping tool for the analysis. ➢ Apply R software for effective visualization. ➢ Perform simulation using R Software.
Unit-1	

The R Language - Getting R – Using R as a calculating environment -Arithmetic - Variables - Functions -Vectors - Missing data - Expressions and assignments -Logical expressions - Matrices - The workspace. Basic programming - Branching with if- Looping with for- Looping with while – Vector based programming - Program flow - Basic debugging - Good programming habits - Input and outputs: Text - Input from a file - Input from the keyboard - Output to a file –Plotting.

Unit-2	

Programming with functions: Functions - Scope and its consequences - Optional arguments and default values - Vector-based programming using functions - Recursive programming - Debugging functions -Sophisticated data structures - Factors –Data frames - Lists - The apply family. Graphics parameters: par -Graphical augmentation - Mathematical typesetting - Permanence - Grouped graphs: lattice - 3D-plots.

Unit-3	

Numerical methods- Root-finding - Fixed-point iteration -The Newton-Raphson method - The secant method - The bisection method - Numerical integration - Trapezoidal rule - Simpson's rule - Adaptive quadrature.

Unit-4	

Simulation: Simulating iid uniform samples, Congruential generators, Seeding, Simulating discrete random variables, Inversion method for continuous random variables, Rejection method, generation of normal variates: Rejection with exponential envelope, Box-Muller algorithm

References

1. Kundu, D. and Basu, A. (2004) Statistical computing – existing methods and recent developments, Narosa publishing house, New Delhi
2. Monahan, J.F. (2001) Numerical methods of statistics, Cambridge University Press.
3. Tattar Prabhanjan and Ramaiah, S. and Manjunath, B.G. A Course in Statistics with R, 1st Edition, Wiley
4. Lander J. P. (2014). R for Everyone: Advanced Analytics and Graphics, Pearson

SECOND SEMESTER

PAPER CODE	**STA 406**
PAPER NAME	**Estimation and Testing of Hypotheses**
CREDIT	**04(3 - 0 - 1)**
Objective:	The main purpose is to make an individual understand basic theoretical knowledge about fundamental principles of statistical inference.
Learning Outcome	**After the completion of paper student will able to** ➢ Employ different estimation techniques to solve inferential problems. ➢ List the properties of a good estimator. ➢ Develop estimators for estimating population parameter. ➢ Interpret basics of testing of hypothesis and perform calculation of type 1, type 2 error. ➢ Define Cramer Rao inequality, Rao Blackwell theorem, Lehmann – Scheffe theorem, Cramer Hazurbazar theorem. ➢ Apply the concept of MVBUE, MVUE, and UMVUE to analytically solve the inferential problems. ➢ Knowledge of construction of MP test and UMP test. ➢ Recognize the importance of Interval Estimation and its use.
Unit-1	
Criteria of a good estimator: unbiasedness, consistency, efficiency and sufficiency. Concept of mean squared error. Fisher-Neyman factorization theorem, Family of distributions admitting sufficient Statistic. Point estimation, Maximum likelihood method (MLE), moments, Least squares method. Method of minimum chi-square and percentiles. Properties of maximum likelihood estimator (with proof). Successive approximation to MLE, Method of scoring and Newton-Raphson method.	
Unit-2	
Cramer-Rao inequality and its attainment, Cramer-Huzurbazar theorem (statement only), Completeness and minimal sufficient statistic, Ancillary statistic, Basu theorem, Uniformly minimum variance unbiased estimator (UMVUE). Rao- Blackwell and Lehmann-Scheffe theorems and their applications, Review of convergences of random variables and their implications, Delta method and its application, Asymptotic efficiency and asymptotic estimator, consistent asymptotic normal (CAN) estimator.	
Unit-3	
Statistical Hypothesis, critical region, types of errors, level of significance, power of a test, Test function, Randomized and non-randomized tests, Most powerful test and Neyman-Pearson lemma. MLR family of distributions, unbiased test. Uniformly most powerful test. Uniformly most powerful unbiased test. Likelihood ratio test with its properties. SPRT, OC curve, ASN function, Wald's equation and problems.	
Unit-4	

Confidence interval, confidence level, construction of confidence intervals using pivots, Determination of confidence intervals based on large and small samples, uniformly most accurate one sided confidence interval and its relation to UMP test for one sided null against one sided alternative hypotheses.

Unit-5

Goodness of Fit test based on Chi Square Distribution and Application to contingency table. Non Parametric Tests: One and Two Sample Problem; one sample test: Sign test, Wilcoxon signed rank test. Two sample tests : Wald Wolfowitz Runs test, Mann Whitney U test, Median Test, Kolmogorov-Smirnov test, Spearman Rank Correlation test; Kendall's Rank correlation test: Kruskal Wallis Test

References

1. George Casella, Roger L. Berger, Statistical Inference, 2nd ed., Thomson Learning.
2. Mukhopadhyay P.: Mathematical Statistics, New central Book Agency (P) Ltd. Calcutta.
3. Rao, C.R.: Linear Statistical Inference and its Applications, 2nd ed, Wiley Eastern.
4. Rohatgi, V.K.: An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern.
5. Goon, Gupta & Das Gupta: An Outline of Statistical Theory, Vol. II, World Press.
6. Hogg, R.V. and Craig, A.T.: Introduction to Mathematical Statistics, McMillan.
7. Kale, B.K. : A First Course on Parametric Inference, Narosa Publishing House.
8. Lehmann, E.L. Testing Statistical Hypotheses, Student Editions.
9. Rajgopalan , M and Dhanavanthan, P (2012) Statistical Inference. PHI Learning, India
10. Manoj Kumar Srivastva, Adbul Hmid Khan, Namita Srivastva (2014). Statistical Inference: Theory of Estimation, PHI Learning, India
11. Gibbons J. D. and Chakraborti S. (2010). Non Parametric Statistical Inference. CRC Press.

PAPER CODE	**STA 407**
PAPER NAME	**Regression Analysis**
CREDIT	**04(3 – 0 – 1)**
Objective	The main purpose is to provide the theoretical foundations for the Linear Estimation Theory and Regression Analysis.
Learning Outcome	**After the completion of paper student will able to** ➢ Employ Regression technique to the statistical data analysis. ➢ Apply different methods to estimate and test the relation between the independent and dependent variables. ➢ Interpret and apply the concept of generalized linear model
Unit-1	
Linear Regression Model, Least squares estimation, Gauss Markov Theorem, Properties of the estimates, Distribution Theory, Maximum likelihood estimation, Estimation with linear restrictions, Generalised least squares; Hypothesis testing – likelihood ratio test, F-test; Confidence intervals.	
Unit-2	
Residual analysis, Departures from underlying assumptions, Effect of outliers, Collinearity, Non-constant variance and serial correlation, Departures from normality, Diagnostics and remedies.	
Unit-3	
Polynomial regression in one and several variables, Orthogonal polynomials, Indicator variables, Subset selection of explanatory variables, stepwise regression and Mallows Cp -statistics, Introduction to non-parametric regression.	
Unit-4	
Nonlinear Regression: Introduction to nonlinear regression, Least squares in the nonlinear case and estimation of parameters, Models for binary response variables, estimation and diagnosis methods for logistic and Poisson regressions. Prediction and residual analysis Generalized Linear model: link functions such as Poisson, binomial, inverse binomial, inverse Gaussian, gamma	
References	
1. Cameron, A. C. and P. K. Trivedi (1998). Regression Analysis of Count Data, Cambridge 2. Draper, N. R. and Smith, H. (1998). Applied Regression Analysis, John Wiley, Third Edition. 3. Hosmer, D. W. and Lemeshow, S. (1989). Applied Logistic Regression, Wiley. 4. Kleinbaum, D. G. & Klein, M. (2002). Logistic Regression: A Self-Learning Text, Springer 5. McCullagh, P. and Nelder, J. A. (1989). Generalized Linear Models, Chapman& Hall. 6. Montgomery, D. C., Peck, E. A. and Vining, G. G. (2003). Introduction to Linear Regression Analysis, Wiley. 7. Neter, J., W., and Kutner, M. H. (1985). Applied Linear Statistical Models, Wiley. 8. Ratkowsky, D. A. (1983). Nonlinear Regression Modelling, Marcel Dekker, London. 9. Ruppert, D., Wand, M. P. and Carroll, R. J. (2003) Semiparametric Regression, Cambridge University Press. 10. Seber, G. E. F. and Wild, C. J. (1989). Nonlinear Regression, Wiley. 11. Weisberg, S. (2005). Applied Liner Regression, Wiley. 12. Yan, X. and Su, X. G. (2009). Linear Regression Analysis: Theory & Computing, World Scientific.	

PAPER CODE	**STA 408**
PAPER NAME	**Stochastic Process**
CREDIT	**04(3 – 0 – 1)**
Objective	The main objective of the paper is to provide theoretical foundations of Stochastic Processes and to introduce different Stochastic/Random Processes and their applications.
Learning Outcome	**After the completion of paper student will able to** ➢ Classify general Stochastic Process. ➢ Define Markovian properties and its consequences. ➢ Interpret Poisson Process and its importance. ➢ Employ Branching processes to solve real life problems of stochastic nature.
Unit-1	
Definition and examples of stochastic process: Classification of general stochastic processes into discrete/continuous time, discrete/continuous state spaces, elementary problems, Random walk and Gambler's ruin problems, Counting process.	
Unit-2	
Markov chains: Definition and examples of Markov Chain, Transition probability matrix, classification of states, communicating classes, recurrence: non-recurrence, Irreducibility, Stationary distribution and its interpretation. Chapman-Kolmogorov equation, Stationary probability distribution and its applications. Computation of n-step transition probability matrix by spectral representation. Absorption probability and mean time to absorption.	
Unit-3	
Continuous time Markov Chain: Poisson process and related inter-arrival time distribution, compound Poisson process, Pure birth process, pure death process, birth and death process, problems, Renewal processes, Elementary renewal theorem (statement only)and its applications.	
Unit-4	
Galton -Watson branching processes: Definition and examples of discrete time branching process, Probability generating function and its properties, Offspring mean and probability of extinction. Introduction to Brownian motion process and its basic properties.	
References	
1. Kulkarni, Vidyadhar: Modeling and Analysis of Stochastic systems, G. Thomson Science and Professional. 2. Bhat, B.R.:. Stochastic Models: Analysis and Applications, (2nd New Age International, India). 3. Medhi J. : Stochastic processes, new Age International (P) Ltd. 4. Karlin S. and Taylor H.M. : A First Course in Stochastic Process, Academic Press 5. Hoel P.G., Port S.C. and Stone C.J.: Introduction to Stochastic Process, Universal Book Stall. 6. Parzen E. : Stochastic Process, Holden-Day 7. Cinlar E. Introduction to Stochastic Processes, Prentice Hall. 8. Adke S.R. and ManjunathS.M.:An Introduction to Finite Markov Processes, Wiley Eastern. 9. Ross S.M.: Stochastic Process, JohnWiley. 10. John G. Kemeny, J. Laurie Snell, Anthony W. Knapp: Denumerable Markov Chains.	

PAPER CODE	**STA 409**
PAPER NAME	**Design of experiments**
CREDIT	**04(3 – 0 – 1)**
Objective	The main objective is to provide the theoretical foundations for design and analysis of experiments.
Learning Outcome	**After the completion of paper student will able to** ➢ Use the idea involved in the CRD, RBD, LSD and BIBD in data analysis. ➢ Employ ANOCOVA technique to real world application. ➢ Use factorial experiments in the analysis of data set.
Unit-1	
Basic principle of experimental design, overview of RBD, CRD and LSD, Missing plot techniques in RBD with one and two missing observations, Analysis of LSD with one missing observation.	
Unit-2	
General theory of intra block analysis of block design, connectedness and balancing block design, incomplete block design, intra block analysis of BIBD and its properties.	
Unit-3	
Purpose of analysis of covariance. Practical situations where analysis of covariance is applicable. Model for analysis of covariance in CRD and RBD. Estimation of parameters (derivations are not expected).Preparation of analysis of covariance (ANOCOVA) table, test for $\beta = 0$, test for equality of treatment effects (computational technique only).	
Unit-4	
General description of factorial experiments, factorial effects, analysis of factorial experiment (2^n, 3^n), main and interaction effects, advantages and disadvantages, total and partial confounding, split plot experiment.	
References	
1. Goon, Gupta, Dasgupta: Fundamental of Statistics, Vol. I and II, The World Press Pvt. Ltd. Kolkata. 2. Montgomery, D.C.: Design and Analysis of Experiments, Wiley Eastern Ltd., New Delhi. 3. Cochran, W.G. and Cox, G.M.: Experimental Design, John Wiley and Sons, Inc., New York. 4. Gupta, S.C. and Kapoor, V.K. : Fundamentals of Applied Statistics, S. Chand & Sons, New Delhi. 5. Das, M.N. and Giri, N.C. : Design and Analysis of Experiments, Wiley Eastern Ltd., New Delhi. 6. Joshi, D. D.: Linear estimation and design of experiment. 7. Dey, Alok: Theory of block designs, Wiley Eastern.	

PAPER CODE	**STA 410**
PAPER NAME	**National Development Statistics**
CREDIT	**04(3 – 0 – 1)**
Objective	The main objective is to make individual understand the significance and role of statistics in national development.
Learning Outcome	**After the completion of paper student will able to** ➢ Recognize the role of statistics in National development. ➢ Discuss the need of Statistical System in India and its formulation.
Unit-1	
Economic development: Growth in per capital income and distributive justice, Indices of development, Human Development index, quality of life. Estimation of national income-product approach, income approach and expenditure approach.	
Unit-2	
Population growth in developing and developed countries, Population projection using Leslie matrix, Labour force projection	
Unit-3	
Poverty measurement-different issues, measures of incidence and intensity, combined measures e.q. indices due to Kakwani, Sen etc.	
Unit-4	
MOSPI- Statistical System of India: NSSO, CSO, NSSTA, NITI Ayoge, Different Institutions and committees are responsible for planning and execution of National Building.	
References	
1. Chatterjee, S.K.: Quality of life. 2. Chaubey, P. K.: Poverty Analysis, New Age International (P) Limited, Publishers. New Delhi. 3. Human Development Annual Report. 4. Sen, Amartya.: Poverty and Famines, Oxford University Press. 5. CSO. National Accounts Statistics- Sources and Health. 6. UNESCO: Principles of Vital Statistics Systems.	

PAPER CODE	**STA 482**
PAPER NAME	**Journal Presentation**
CREDIT	**1**
TOTAL HOURS	**10**
Objective: To development the logical skill for analyzing the data or understanding ingoing research	
	Guidelines for Empirical Analysis/Case Studies
Selection of paper: Students will work independently and select a published paper as per their area of interest and will present that paper in an open seminar in the presence of evaluation committee/faculties/students and other interested member. Department will announce the schedule of the presentation. **Evaluation:** Evaluation will be done by a notified evaluation committee and committee will recommend on satisfactory/non-satisfactory respective student.	

THIRD SEMESTER

PAPER CODE	**STA 501**
PAPER NAME	**Time Series Analysis & Forecasting**
CREDIT	**04(3 – 0 – 1)**
Objective	The main purpose is to teach the time series modelling and the concept of forecasting and future planning.
Learning Outcome	**After the completion of paper student will able to** ➢ Recognize different time series models such as MA, AR, ARMA and ARIMA models. ➢ Employ different time series models to forecast. ➢ Explain need of Multivariate Time series
Unit-1	
Basics of Time series: A model Building strategy, Time series and Stochastic process, stationarity, Auto correlation, meaning and definition–causes of auto correlation-consequence of autocorrelation–test for auto–correlation. Study of Time Series model and their properties using correlogram, ACF and PACF. Yule walker equations.	
Unit-2	
Time Series Models: White noise Process, Random walk, MA, AR, ARMA and ARIMA models, Box-Jenkins's Methodology fitting of AR(1), AR(2), MA(1), MA(2) and ARIMA(1,1) process. Unit root hypothesis, Co-integration, Dicky Fuller test unit root test, augmented Dickey – Fuller test.	
Unit-3	
Non-linear time series models, ARCH and GARCH Process, order identification, estimation and diagnostic tests and forecasting. Study of ARCH (1) properties. GARCH (Conception only) process for modelling volatility.	
Unit-4	
Multivariate Time series: Introduction, Cross covariance and correlation matrices, testing of zero cross correlation and model representation. Basic idea of Stationary vector Autoregressive Time Series with orders one: Model Structure, Granger Causality, stationarity condition, Estimation, Model checking.	
References	
1. Box, G. E. P. and Jenkins, G. M.: Time Series Analysis – Forecasting and Control, Holden – day, San Francisco. 2. Chatfield, C.: Analysis of Time Series, An Introduction, CRC Press. 3. Ruey S. Tsay :Analysis of Financial Time Series, Second Ed. Wiley& Sons. 4. Ruey S. Tsay :Multivariate Time series Analysis: with R and Financial Application, Wiley& Sons. 5. Montgeomery, D. C. and Johnson, L. A.:Forecasting and Time series Analysis, McGraw Hill. 6. Kendall, M. G. and Ord, J. K. :Time Series (Third edition), Edward Arnold. 7. Brockwell, P. J. and Davies, R. A. :Introduction to Time Series and Forecasting(second Edition – Indian Print). Springer. 8. Chatfield, C. :The Analysis of Time series: Theory and Practice. Fifth Ed. Chapman and Hall. 9. Hamilton Time Series Analysis 10. Jonathan, D. C. and Kung, S.C. :Time Series Analysis with R. Second Ed. Springer.	

PAPER CODE	**STA 502**
PAPER NAME	**Multivariate Analysis**
CREDIT	**04(3 – 0 – 1)**
Objective	The main objective is to introduce the concept of analyzing multivariate data and to increase familiarity with the handling of multivariate data**.**
Learning Outcomes	**After the completion of paper student will able to** ➢ Describe properties of multivariate normal distribution. ➢ Analyze multivariate data sets. ➢ Interpret multivariate hypothesis tests and drawing appropriate conclusions. ➢ Execute data reduction techniques.
Unit-1	
Concept of random vector and random matrix. Multivariate distribution function and marginal and conditional distribution. Review of Multivariate Normal Distribution (MVND) and its properties. Distribution of sample means vector and its independence. Estimation of parameters of MVND. Multiple linear equations, Multiple correlation, partial correlation in multiple setup and Distribution of sample multiple and partial correlation in null case. Partial and multiple correlation coefficients, their maximum likelihood estimators (MLE).	
Unit-2	
Wishart distribution and its properties. Hoteling's T^2 and its applications. Hotelling's T^2statistic as a generalization of square of Student's statistic. Distance between two populations, Mahalanobis D^2 statistic and its relation with Hotelling's T^2 statistic.	
Unit-3	
• Classification problem, discriminant analysis. • Principle component analysis. • Canonical correlation.	
Unit-4	
• Factor Analysis. • Cluster Analysis	
References	
1. Kshirsagar A. M. : Multivariate Analysis. Maral-Dekker. 2. Johnosn, R.A. and Wichern. D.W.:Applied multivariate Analysis. 5thAd.Prentice –Hall. 3. Anderson T. W.: An introduction to Multivariate statistical Analysis2nd Ed. John Wiely. 4. Morrison D.F.: Multivariate Statistical Methods McGraw-Hill. 5. Giri, N. C. (2014). Multivariate statistical inference. Academic Press.	

PAPER CODE	**STA 503**
PAPER NAME	**Survival Analysis**
CREDIT	**04(3 – 0 – 1)**
Objective	The main objective of this paper is to introduce different concepts and applications of survival analysis.
Learning Outcome	**After the completion of paper student will able to** ➢ Define various lifetime models. ➢ Distinguish between Parametric Inference and Non-Parametric Inference. ➢ Interpret the concept of Frailty and its use in real world applications
Unit-1	
Survival Characteristics and Parametric Models: Survival function, quantiles, hazard rate, cumulative hazard function, and mean residual life, Parametric models for study of event time data: Exponential, Weibull, extreme value, gamma, Pareto, logistic, log-logistic, normal, log–normal and mixture models -their survival characteristics. **Parametric Inference**: Longitudinal studies. Censoring mechanisms- type I, type II and left right and interval censoring. Likelihood function under censoring and estimation. Tests based on LR, MLE.	
Unit-2	
Nonparametric Inference: Actuarial and Kaplan–Meier estimators. Treatment of ties. Self-consistency property and asymptotic properties of K–M estimator (statement). Pointwise confidence interval for S(t). Nelson-Aalen estimator of cumulative hazard function and estimation of S(t) based on it. Two–sample methods. Comparison of survival functions: Log rank and Tarone-Ware tests.	
Unit-3	
Semi-parametric Inference: Explanatory variables- factors and variates. Cox proportional hazards model. The partial likelihood and estimation of regression coefficients and their standard errors. Breslow's estimator, Statement of asymptotic properties of the estimator. Confidence interval for regression coefficients. Wald, Rao and likelihood tests for β. Accelerated life model. Model selection criteria and comparison of nested models (-2logL, AIC, BIC). Using information on prognostic variables in a competing risks model.	
Unit-4	
Concept of frailty. Shared frailty models. Identifiability of frailty models. Various frailty models. Gamma, positive stable, inverse Gaussian, power variance function, compound Poisson and compound negative binomial shared frailty models. Frailty regression models. Bivariate and correlated frailty models. Additive frailty models. Reversed hazard rates, Cox's proportional reversed hazards model.	
References	
Books Recommended 1. Cox, D.R. and Oakes, D. (1984). Analysis of Survival Data, Chapman and Hall. 2. Deshpande, J.V. and Purohit S.G. (2005). Life Time Data: Statistical Models and Methods, Word Scientific. 3. Duchateau, L. and Johnson, P. (2008). The Frailty Model. Springer: New York. 4. Gross A.J. and Clark, V. A. (1975) Survival Distributions: Reliability Applications in the Biomedical Sciences, John Wiley and Sons. 5. Hanagal, D. D. (2011). Modeling Survival Data Using Frailty Models. CRC Press: New York. 6. Hougaard, P. (2000). Analysis of Multivariate Survival Data. Springer: New York. 7. Wienke, A. (2011). Frailty Models in Survival Analysis, CRC Press: New York.	

PAPER CODE	**STA 504**
PAPER NAME	**Empirical Analysis/Case Studies**
CREDIT	**2**

Objective: To development the logical skill for analyzing the data or understanding the real situation

Learning Outcomes:

Guidelines for Empirical Analysis/Case Studies

Duration: Students will work in whole semester and before start of EoSE will present his/her work in an open seminar in the presence of evaluation committee/faculties/students and other interested member. Department will announce the schedule of the presentation.

Topic: It will be decided by the students independently as per their interest of the project.

Evaluation: Evaluation will be done by a notified evaluation committee and committee will recommend on satisfactory/non-satisfactory.

ELECTIVE PAPERS

PAPER CODE	**STA 531**
PAPER NAME	**Econometrics**
CREDIT	**04 (3-0-1)**
Objective	The main objective is to introduce branch which is an integration of mathematics, statistics, and economics used to deal with econometric models.
Learning Outcome	**After the completion of paper student will able to** ➢ Recognize various properties and possible problems of econometric models. ➢ Use the concept estimation and testing of hypothesis in econometric models. ➢ Apply Simultaneous Equation Models.
Unit-1	
Introduction of Econometrics, Multiple Linear Regression Model, Model with non-spherical disturbances, Test of Auto- correlation, restricted regression estimator, Errors in variables, Dummy variables, Logit and Probit Models	
Unit-2	
Seemingly unrelated regression equation (SURE) model and its Estimation, Simultaneous equations model, concept of structural and reduced forms problem of identification, rank and order condition of identifiability.	
Unit-3	
Methods of estimation of simultaneous equation model: indirect least squares, two stage least squares and limited information maximum likelihood estimation, idea of three stage least squares and full information maximum likelihood estimation, and prediction	
Unit-4	
Panel data models: Estimation in fixed and random effect models, Panel data unit root test	
References	
1. Apte, P.G.: Textbook of Econometrics, Tata McGraw Hill. 2. Gujarathi, D.: Basic Econometrics; McGraw Hill. 3. Johnston, J.: Econometrics Methods. Third edition, McGraw Hill. 4. Srivastava, V.K. and Giles D. A. E.: Seemingly unrelated regression equations models, Marcel Dekker. 5. Ullah, A. and Vinod, H.D.: Recent advances in Regression Methods, Marcel Dekker. 6. D. M. Nachane (2006). Econometrics: Theoretical Foundations and Empirical Perceptive. Oxford University Press. 7. Maddala, G. S. (2002). Introduction to Econometrics, Third Edition, John Wiley	

PAPER CODE	**STA 532**
PAPER NAME	**Statistical Quality Management**
CREDIT	**04(3-0-1)**
Objective	The main objective of this course is to understand the procedure which seeks to improve the quality of the output of a particular industrial process.
Learning Outcome	**After the completion of paper student will able to** ➢ Identify and remove the cause of defects through different statistical quality management techniques. ➢ Practice how to minimize the variability in manufacturing and business process.
Unit-1	**Lectures: 15**
Cumulative Sum Control Charts for Monitoring Process Mean and Process Variability, Tabular and V-Mask Methods, Moving average and Exponentially Weighted Moving Average Control Charts, Acceptance Control Charts. Economic design of $\bar{X}$–chart. Multivariate control charts and Generalized Variance Chart.	
Unit-2	**Lectures:15**
Acceptance sampling plans for inspection by variables for two sided specifications. Continuous Sampling plans. Bayesian sampling plans, Multiple sampling plans, Sequential sampling plan, The Dodge-Roaming sampling plan, Designing a variables sampling plan with a specified OC curve, Other variables sampling procedures. Continuous Sampling Plan	
Unit-3	**Lectures: 15**
Specifications and Process Capability, Capability Ratio, Process Capability Indices:C_p,C_{pk}, C_{pm}, C_{pmk} estimation, confidence intervals and test of hypotheses for normally distributed characteristics. Process capability analysis using control chart, Process Capability Analysis for Non-normal Distributions, Process Capability Analysis using a Nonparametric Approach.	
Unit-4	**Practicals:**
Students will be required to do practical's based on topics listed below, using R software: 1. Cumulative sum control chart 2. Moving average control chart 3.Exponentially weighted moving average control chart 4. Sampling plans for variables 5. Process capability analysis procedure	
References	
1. D.C. Montgomery: Introduction to Statistical Quality Control. Wiley. 2. Wetherill, G.B. Brown, D.W.: Statistical Process Control Theory and Practice, Chapman & Hall. 3. Wetherill, G.B.: Sampling Inspection and Quality control, Halsteed Press. 4. Duncan A.J.: Quality Control and Industrial Statistics, IV Edision, Taraporewala and Sons. 5. Ott, E. R.: Process Quality Control (McGraw Hill)	

PAPER CODE	**STA 533**
PAPER NAME	**Reliability Analysis**
CREDIT	**04(3-0-1)**
Objective	To impart the concept of reliability and how statistical and probabilistic theories are applied to model and explain life of a mechanical component along with prediction of the same.
Learning Outcome	**After the completion of paper student will able to** ➢ Explain the operation time of a mechanical component and its Modelling. ➢ Perform how to predict the reliability of a component, system and of a finished product. ➢ Explain the nature of the lifetime of an item as well.
Unit-1	**Lectures: 15**
Reliability concepts and measures, components & systems: coherent systems, reliability of the Coherent systems. Cuts and paths, modular decomposition, bounds on system reliability; structural and reliability importance of components.	
Unit-2	**Lectures:15**
Reliability estimation based on failure time in various censored life tests. Stress-strength reliability and its estimation. Notions of ageing, IFR, IFRA, NBU, DMRL and NBUE and their duals, loss of memory property of the exponential distribution. Closures of these classes under formation of Coherent systems, Convolution and Mixtures.	
Unit-3	**Lectures: 15**
Univariate shock models and life distribution arising out of them. Bivariate shock models, common bivariate exponential distribution and their properties. Maintenance and replacement policies; availability of repairable systems; modeling of a repairable system by a non-homogeneous Poisson process.	
Unit-4	**Practicals:**
Students will be required to do practical's, based on topics listed below, using R software: 1. Components and System Reliability 2. Reliability of the coherent system 3.Reliability estimation based on failure time 4. Maintenance and replacement policies 5. Modeling of a repairable system	
References	
1. Sinha, S. K. and Kale, B. K. (1983): Life Testing and Reliability Estimation, Wiley Eastern Limited. 2. Barlow R.E. and Proschan F. (1985): Statistical Theory of Reliability and Life testing: Holt, 3. Rinehart and Winston. 4. Lawless J.F. (1982): Statistical model and Methods of Life time data, John Willey. 5. Bain L.J. and Engelhardt (1991): Statistical Analysis of Reliability and Life testing Models, MarcelDekker. 6. Nelson, W. (1982): Applied Life Data Analysis, John Willey.	

PAPER CODE	**STA 534**
PAPER NAME	**Extreme Value Theory (Elective)**
CREDIT	**04(3-0-1)**
Objective	Main Objective of this course is to introduce the concept extremal behaviour of the random variable and learn different procedures to identify the governing extremal Laws.
Learning Outcome	**After the completion of paper student will able to** ➢ Recognize the behavior of order Statistics and distribution of their functions. ➢ Inspect the limiting behavior of sample maxima and its convergence. ➢ diagnose the procedure to identify the domain of attractions.
Unit-1	**Lectures: 15**
Order Statistics: Distribution of first and last order statistics, Distribution of a single order statistic, Joint distribution of two consecutive order statistics, Distribution of Range, spacing between two order statistics, ratio of two order statistics. Illustrative examples considering different family of distributions.	
Unit-2	**Lectures:15**
Fluctuations of Maxima - Limit distribution of linearly normalized maxima, Weak convergence of maxima. Maximum Domains of attraction and Norming constants – The maximum domains of attractions of extreme value distributions. Von Mises' theorem. Fluctuations of univariate upper order statistics. The Generalized Extreme Value Distribution, The Generalized Pareto Distribution	
Unit-3	**Lectures: 15**
Diagnostic procedure to identify maximum domains of attractions: Hill Plot, Probability Paper Plot, Zipf's plot, QQ Plot, Mean Excess Plot, Sum Plot. Illustration contains different classes of distributions. Test for identification of max domain of attractions: Hasofer and Wang's test, Segers and Teugels test, Ratio between Maximum to sum of excess.	
Unit-4	**Practicals:**
Analysis the Hydrology, Insurance, Finance, Geology, Environment, Meteorology, Seismic dataset by graphical diagnostic procedure and fitting of suitable extreme value distribu	
References	

1. Embrechts, P., Kluppelberg, C., &Mikosch, T. (1999). Modellingextremal events. British Actuarial Journal, 5(2), 465-465.
2. Beirlant, J., Goegebeur, Y., Segers, J., &Teugels, J. L. (2006). Statistics of extremes: theory and applications. John Wiley & Sons.
3. Kotz, S., &Nadarajah, S. (2000). Extreme value distributions: theory and applications. World Scientific.
4. Castillo, E., Hadi, A. S., Balakrishnan, N., &Sarabia, J. M. (2005). Extreme value and related models with applications in engineering and science

PAPER CODE	**STA 535**
PAPER NAME	**Bayesian Inference**
CREDIT	**04(3-0-1)**
CREDIT	**04**
Objective	To know Bayesian approach to solve statistical decision problems and use Bayesian techniques for computation.
Learning Outcome	**After the completion of paper student will able to** ➢ Theorize the statistical inference under Bayesian framework. ➢ Recognize the different types of priors and posterior distributions and its applications. ➢ Employ certain loss function to draw the posterior based inferences.
Unit-1	
Basic elements of Statistical Decision Problem. Expected loss, decision rules (non-randomized and randomized). Overview of Classical and Bayesian Estimation. Advantage of Bayesian inference, Prior distribution, Posterior distribution, Subjective probability and its uses for determination of prior distribution. Importance of non-informative priors, improper priors, invariant priors. Conjugate priors, construction of conjugate families using sufficient statistics, hierarchical priors. Admissible and minimax rules and Bayes rules.	
Unit-2	
Point estimation, Concept of Loss functions, Bayes estimation under symmetric loss functions, Bayes credible intervals, highest posterior density intervals, testing of hypotheses. Comparison with classical procedures. Predictive inference. One- and two-sample predictive problems.	
Unit-3 and 4	
Bayesian approximation techniques: Normal approximation, T-K approximation, Monte-Carlo Integration, Accept-Reject Method, Idea of Markov chain Monte Carlo technique.	
References	
1. Berger, J. O. : Statistical Decision Theory and Bayesian Analysis, Springer Verlag. 2. Robert, C.P. and Casella, G. : Monte Carlo Statistical Methods, Springer Verlag. 3. Leonard, T. and Hsu, J.S.J. : Bayesian Methods, Cambridge University Press. 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. Gemerman, D. : Markov Chain Monte Carlo: Stochastic Simulation for Bayesian Inference, Chapman Hall. 7. Box, G.P. and Tiao, G. C.: Bayesian Inference in Statistical Analysis, Addison-Wesley.	

PAPER CODE	**STA 585**
PAPER NAME	**Principles & Practice of Life and Health Insurance**
CREDIT	**04(3 - 1-0)**
Objective	The main objective is to introduce the basics and concepts of insurance.
Learning Outcome	**After the completion of paper student will able to** ➢ Define the basic concepts of insurance. ➢ Express the importance of awareness in investment and insurance.
Unit-1	
Types of investments and saving, Insurance, Shares, Bonds, Annuities, Mutual and Pension Fund. Origin, Development and Present Status of Insurance, Risk Management,	
Unit-2	
Principles of Insurance, Types of Insurance Contracts, Classification of Insurance., Classification of insurance in life and non-life insurance, micro insurance, social insurance and general insurance (motor, marine, fire, miscellaneous), Types of insurance plans: whole life, term, endowment.	
Unit-3	
Conventional non-participating life insurance, Linked accumulating non-participating contracts , Non-linked Accumulating Non-participating Contracts, Participating Life Insurance, Different Distribution Methods, Profit Distribution Strategies, With-profit polices, Dividends and Bonus Method	
Unit-4	
The actuarial role in life office management: Introduction, product pricing, analysis of surplus, monitoring and uploading the assumptions in the control cycle. Further uses of models in Actuarial management.	
References	
1. Principles and Practice if Life Insurance, ICAI, New Delhi 2. Black & Skipper: Life and Health Insurance, Pearson Education 3. Harrington, Scott E. & Gregory R. : Risk Management and Insurance: 2nd ed., Tata McGraw Hill Publicating Company Ltd. New Delhi 4. Philip Booth et al.: Modern actuarial theory and practice, Second edition, Chapman and Hall/CRC	

PAPER CODE	**STA 586**
PAPER NAME	**Computer Intensive Statistical Methods**
CREDIT	**04**
Objective	The main objective of this paper is to make students understand computational intensive methods for doing statistical inference.
Learning Outcome	**After the completion of paper student will able to** ➢ Report the basic ideas of Random Number Generation, Resampling and Simulation Methods. ➢ Apply computational methods, such as Monte Carlo simulations, the EM algorithm to real world data sets. ➢ Execute hierarchical Bayesian models to formulate and solve complex statistical problems.
Unit-1	**Lectures: 11**
Resampling Techniques: Re sampling paradigms, bias-variance trade-off. Bootstrap methods, estimation of sampling distribution, confidence interval, variance stabilizing transformation. Jackknife and cross-validation. Jackknife in sample surveys. Jackknife in regression under heteroscedasticity. Permutation tests.	
Unit-2	**Lectures:11**
Missing Values and Imputations Techniques: Missing values and types of missingness, imputations methods for missing values, single and multiple imputations. EM Algorithm and Applications: EM algorithm for incomplete data, EM algorithm for mixture models, EM algorithm for missing values, stochastic EM algorithm.	
Unit-3	**Lectures: 11**
Smoothing techniques: Kernel estimators, nearest neighbor estimators, orthogonal and local polynomial estimators, wavelet estimators. Splines. Choice of bandwidth and other smoothing parameters.	
Unit-4	**Lectures: 12**
Bayesian computing, Markov Chain Monte Carlo. Simulation using MCMC, Particle filtering, MCMC methods for missing values.	
References	

1. Buuren, Stef van (2012). Flexible Imputation of Missing Data. Chapman and Hall.
2. Chihara, L. and Hesterberg, T. (2011) Mathematical Statistics with Resampling andR. Wiley.
3. Davison, A.C. and Hinkley, D.V. (1997) Bootstrap methods and their Applications. Chapman and Hall.
4. Efron, B. and Tibshirani. R.J. (1994); An Introduction to the Bootstrap. Chapman
5. and Hall.
6. Christensen R, Johnson, W., Branscum A. and Fishman, G.S. (1996) Monte Carlo:Concepts, Algorithms, and Applications. Springer.
7. Gilks, W. R., Richardson, S., and Spiegelhalter, D. (eds.) (1995) Markov Chain MonteCarlo in Practice. Chapman and Hall.
8. Good, P. I. (2005) Resampling Methods: A Practical Guide to Data Analysis. BirkhauserBosel.
9. Hanson T. E. (2011). Bayesian Ideas and Data Analysis: An Introduction for Scientistsand Statisticians, Chapman Hall.
10. Jim, A. (2009). Bayesian Computation with R, 2nd Edn, Springer.
11. Kennedy W. J. Gentle J. E. (1980) Statistical computing. Marcel Dekker.
12. McLachlan, G.J. and Krishnan, T. (2008) The EM Algorithms and Extensions. Wiley.
13. Rubinstein, R.Y. (1981); Simulation and the Monte Carlo Method. Wiley.
14. Shao J. and Tu, D. (1995); The Jackknife and the Bootstrap. Springer Verlag.
15. Tanner, M.A. (1996); Tools for Statistical Inference, Third edition. Springer.

SEMESTER-IV

Course Code	**STA 584**
Course Name	**Project**
Credits	**24**

Guidelines for project

- **Project duration:** Students may start preliminary work related to their project after second semester.
- **Project Guide:** Teachers from the Department of Statistics and/or organization where student is going to visit for field work or training. Each project group will be guided by concerned teacher (guide) for 8 hour per week throughout the IV semester.
- **Project Topic:** Students in consultation with the guide will decide project topic. The modification on the title may be permitted after the pre-presentation as advised during the seminar in consultation with the supervisor. Project work may be carried out in a group of students depending upon the depth of fieldwork/problem involved.
- **Project report:** Project report should be submitted in typed form with binding within the time as stipulated be the Department.
- **Project evaluation:** Project evaluation will be based on
  - (i) Continuous evaluation of the work, Project report and final presentation–30 Marks awarded by supervisor
  - (ii) Final presentation - 20 marks awarded other faculty member of the department except the supervisor
  - (iii) Viva-voce and final presentation - 50 marks awarded by external expert