REVISED M.Sc. (STATISTICS) SYALLBUS W.E.F.SESSION 2011

(Paper STA-3046 and STA-4046 are special papers, STA-2066 is open and all other papers are core papers. Number of Lectures / Tutorials / Home Assignments per paper as per grading system scheme of University)

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Course outcomes for the papers highlighted semester wise

FIRST SEMESTER

Course code: STA1016 (core) Course Name: Real analysis

The students have acquired knowledge to

CO1: Understand and interpret the basic properties of the field of real numbers.

CO2: Explain a power series, test for its uniform convergence and identify some Probability distributions as special cases of Power series distribution.

CO3: Elaborate the basic properties of Multivariate Calculus with stress on differentiation and partial derivate of higher order.

CO4: Create appropriate algorithms for optimizing functions of many variables and changing the order of multiple integrals.

CO5: Perform differentiation under the integral sign through the use of Leibnitz rule and tackle some difficult integrals through this technique.

CO6: Identify the needs of special functions like Gamma, Beta, Hypergeometric, Bessel and Lagueree polynomials in the field of Mathematical analysis and Statistics and conclude on some of their properties like orthogonality and recurrence relations.

Course code: STA1026 (core) Course Name: Linear Algebra

The students have acquired knowledge to

CO1: Explain the basic concepts of basis and dimension for a linear space and subspace and revise their concepts on various operations on matrix theory.

CO2: Identify whether a set of vectors is linearly dependent or independent and to construct an orthogonal basis through the use of Gram Schmidt orthogonalization process. Calculate the shortest distance between a vector and a subspace through orthogonal projection.

CO3: Identify whether a system of homogeneous or non-homogeneous equation is consistent or not and be able to solve it. They will also learn to compute generalized inverse of a matrix and to operate with partitioned matrices.

CO4: Apply the principles of matrix algebra to linear transformation.

CO5: Calculate Eigen values and vectors for matrices, linear transformations and matrix polynomials. Understand some properties of eigen values and vectors, to use the eigen values and vectors to solve a system of linear differential equations, to optimize a quadratic form subject to a specific constraint and to carry out spectral decomposition of a matrix.

CO6: Understand the concept of Annihilating polynomial, minimum polynomial and the Cayley Hamilton theorem for matrix and linear transformation and their utility in computing the higher powers of a matrix.

CO7: Classify various quadratic forms on the basis of their ranks, eigen values and the determinant of the leading minors, to reduce a quadratic form into its canonical form and understand the Statistical version of the Cochran's theorem.

CO8: Relate some applications of Matrix theory to Statistics like

(a) Identifying the distributions of the sum of squares (quadratic forms) in the ANOVA table of some simple design of experiments through the use of Cochran's theorem.

(b) Understanding the relevance of the concepts of row space, column space and estimation space to Linear Estimation.

(c) Working with partitioned matrices in deriving the conditional distributions arising out of the multivariate Normal distributions and understanding the role of eigen values and vectors in Principal component analysis.

(d) The use of the spectral decomposition of a matrix in obtaining the higher transition probabilities of a Markov Chain.

Course code: STA1036 (core)
Course Name: Measure theory and Probability
Measure Theory

The students have gained proficiency in

CO1: Describing the concept of semi-algebra and algebra of subsets of Parent set; Justifying the statement "An algebra is a semi-algebra but the converse is not necessarily true".

CO2: Generating an algebra with the help any semi algebra constructed by pair wise disjoint sets, which is class of subsets of a parent set.

CO3: Explaining the concept of Monotone class and hence, showing that "every sigma algebra is a monotone class but every monotone class is not a sigma algebra".

Probability

The students have mastered the skills of

CO1: Explaining a measurable set and defining outer measure with respect to a measurable set; Elaborating the concept of simple function; establishing the relation between limit of an integral and integral of the limit.

CO2: Explaining the distribution function and its properties; Decomposition theorem.

CO3: Describing Cauchy's criterion for convergence; Proving the statement **"** a sequence of random variable cannot converge to two different random variables".

CO4: Justification of the use of inequalities in probability theory, detailed explanation of the Cramer inequality.

CO5: Elaboration of the concept of weak convergence and almost sure convergence; description of the central limit theorems of various forms**.**

Course code: STA1046 (core)
Course Name: Sample Survey

The students will acquire knowledge of

CO1: Illustrating the concept of population and sample, importance of sampling, principle underlying sampling and designing of large scale survey; Comparing between census and sample survey; revising the concept of SRSWR and SRSWOR.

CO2: Describing the estimation procedure of sample size with different types of allocation, construction of strata, determination of optimum number of strata, method of collapsed strata and post stratification in case of stratified random sampling.

CO3: Explaining the unequal probability sampling techniques viz. PPSWR and PPSWOR, different kind of estimator viz. Horvitz-Thompson, Hansen-Hurwitz, Desraj ordered estimator (for general as well as particular case), Murthy's estimator etc; Illustrating some other scheme of probability sampling like cluster, two stage and multistage sampling.

CO4: Elaborating the concept of ratio method of estimation suggested by Hartley-Ross, Jacknife estimator; concept of ratio estimator in stratified random sampling, combined ratio estimator, regression method of estimation and their optimum properties.

CO5: Providing a comprehensive account on systematic sampling including its application in population with linear trend, periodic trend, modified systematic sampling in presence of linear trend; drawing a comparison between stratified SRSWR and SRSWOR; describing some ideas on advanced concept of non-sampling errors and sampling technique like randomized response technique (Warner's model), quota sampling, distance sampling, snowball sampling, importance sampling, network sampling etc.

Course code: STA1056 (core)

Course Name: Practicals based on sample survey

The student will acquire hands on training to

CO1: Identify and implement the appropriate algorithms for drawing samples from populations using various sampling schemes.

CO2: Conduct analysis of a chosen sampling design with the primary objective of yielding an optimum estimate for the unknown population mean and to estimate its relative efficiency compared to the other competing sampling schemes.

SECOND SEMESTER

Course code: STA2016 (core)

Course Name: Distribution theory and Simulation

The students have gained knowledge on

CO1: Describing the basic tools of distribution theory like joint, marginal and conditional probability, function of random variables and their distributions using Jacobian of transformation and other tools which will help in deeper understanding of the subject.

CO2: Elaborating some basic distributions like Logarithmic, positive and negative multinomial distributions, probability distributions of extremes and its asymptotic distribution.

CO3: Describing order statistics and their properties; concept of censoring, truncation and weighted distributions; Mixture distributions and zero modified distributions: Mixed Poisson distribution and its properties, Mixture of Binomial distributions with examples.

CO4: Deriving some of the sampling distributions like non-central Chi square and F distributions and results on other related distributions and proving their properties.

CO5: Generating random variables from some basic distributions using Congruence method, inverse transform method and acceptance rejection method generation of random variables.

CO6: Evaluating single and multiple integrals using Monte Carlo simulation.

Course code: STA2026 (core)

Course Name: Statistical Inference-1 (Point and Interval Estimation)

The students have learnt

CO1: To justify the application of the concept of convergence in consistency; to explain the role of Weak Law of Large Numbers in understanding consistency.

CO2: To describe the concept of data condensation process; admission of sufficient statistics by Pitman-Koopman form of distributions.

CO3: To explain the concept of "completeness of a family" ; to illustrate the role of Laplace transform in determination of the completeness of a family; to establish the Lehmann Scheffe theorem; to distinguish between Lehmann Scheffe and Rao Blackwell theorem.

CO4: To elaborate the concept of maximum likelihood; to relate the CRLB estimator and uniqueness of the solution of the likelihood equation; to explain the method of moment and discuss its advantage and disadvantage over maximum likelihood estimate (MLE), method of moments and its advantage and disadvantage over MLE.

Course code: STA2036 (core)

Course Name: Linear Estimation and Design of experiments

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CO1: To describe the Gauss Markov set up of the Linear model; least square estimation of the parameters including their variance and covariance; testing of hypothesis for one or more than one

linear parametric functions including that of multiple comparisons; Analysis of variance with two concomitant variables.
CO2: To make observations/measurements so that the analysis of the experiments including the complicated ones can be carried out in a valid, effective and economic manner using advanced techniques.
CO3: To explain the working principle behind the missing plot technique, factorial and fractional experiments for studying the interaction effects among the various levels of the factors; partial and total confounding; response surface designs, the properties of the different designs and their analysis, which will help them to choose the appropriate design while carrying out field work and then proceed with the subsequent analysis.
CO4: To conduct a series of experiments independently at different places and/ or different times and combining their results for possible conclusion; construction and analysis of Balanced Incomplete Block Design (BIBD) and Partially Balanced Incomplete Block Design (PBIBD).

Course code: STA2046 (core)
Course Name: Computer Programming
The students have learnt
CO1: To describe the intricacies of number systems.
CO2: To use different data types available in C language together with their modifiers.
CO3: To code programs using the basic elements like control statements, loops, Arrays and Strings and functions.
CO4: To solve the memory access problems by using pointers.
CO5: To code C programs for basic statistical analysis.
CO6: To carry out basic statistical analysis using SPSS.

Course code: STA2056 (core)
Course Name: Practicals on Design of experiments, Estimation and Simulation
The student will acquire practical knowledge and get the hands on training to
CO1: Carry out analysis of the basic designs, designs with missing observations and some advanced designs like the factorial experiments (2^5 and 3^3), BIBD, PBIBD, ANOCOV and split plot designs.
CO2: Estimate parameters using various methods of estimation like MLE, MME and Method of Minimum Chi-square and to numerically solve the MLE/Method of Minimum Chi Square equations in cases where no closed form expression exists for the estimator.
CO3: Simulate random observations from the basic distributions and to evaluate approximately an integral using Monte Carlo simulation.

Course Code: STA2066 (Open) Course Name: **Statistical Methods with applications**
This course is for the students from disciplines other then Statistics and aims at imparting basic training on Statistical Data Analysis.
The students would have developed their knowledge to
CO1: Identify the tools in Statistics for basic data analysis in their domains of application.
CO2: Explain the distinguishing characteristics of Statistical data and produce the graphical summary of data.
CO3: Construct the appropriate measure of central tendency or measure of dispersion best suited to a situation.
CO4: Compute simple probabilities of events and identify the role of some probability distributions in describing a random phenomenon and interpret the basic properties of these distributions.
CO5: Infer on the population through the identification of an optimal estimator and conduct simple test of hypothesis.
CO6: Explain the basic principles of Sample survey and plan a survey using some selected sampling schemes.

CO7: Conclude on the relationship between variables through simple linear regression.
CO8: Explain the overall variation in an experimental process in terms of assignable and non-assignable cause of variation through the use of ANOVA.
CO9: Distinguish between different components of a time series and to eliminate trend through the use of the method of moving averages.

THIRD SEMESTER

Course code: STA3016 (core)
Course Name: Multivariate Analysis
The students have gained proficiency in
CO1: Summarizing multivariate data by the construction of its mean vector and variance covariance matrix; presenting an account on the Multivariate Normal distribution, its properties and drawing random samples from it; Computing Maximum Likelihood Estimators of its parameters and the distribution of the sample mean vector; Elucidating singular and spherical Multivariate Normal distribution.
CO2: Describing Wishart Matrix, its distribution and properties, deriving the distribution of the sample generalized variance.
CO3: Deriving the Null distribution of the sample correlation coefficient, partial and multiple correlation coefficients including the Non Null distribution of the sample correlation coefficient; stating their applications in testing and interval estimation.
CO4: Obtaining the Null distribution of Hotelling T^2 and illustrating its uses for testing of hypothesis based on the mean vector of Multivariate Normal distribution; constructing confidence ellipsoid for the mean vector; conducting Multivariate Linear Regression and Multivariate Analysis of Variance (MANOVA) for one and two way classified data.
CO5: Classification and discrimination procedures for discriminating between two multivariate Normal populations; describing and implementing some multivariate data reduction techniques like Principal Component analysis, Canonical Correlation Analysis and Factor Analysis using data from real-life.

Course code: STA3026 (core) Course Name: Statistical Inference –II (Testing of Hypothesis)
The students have gained knowledge of
CO1: Explaining the power function, test functions, two types of errors, unbiasedness, randomized and non-randomized tests; construction of the Most Powerful (MP) and Uniformly Most Powerful (UMP) tests using Neyman-Pearson Fundamental theorem and generalization of this theorem.
CO2: Recording the observations/measurements in such a manner that the testing of hypothesis procedure, including the complicated ones like similar regions can be carried out in an effective manner.
CO3: Describing the working principle behind the likelihood ratio tests, consistency, monotonicity, invariance of the tests, upon learning which the students will be able to apply the theory of testing of hypothesis to more advanced cases.
CO4: The technique of performing a Sequential Probability Ratio Test and assessing its efficiency; determination of their sizes, the OC function and the ASN.

Course code: STA3036

Course Name: Stochastic Processes and Time Series (core)
Stochastic Processes
The students have gain knowledge on
CO1: Explaining the concept and the properties of Markov chain; Describing a queuing process with the help of a Markov Chain.

CO2: Justifying the association of Markov Chain with conditional probability; describing the Markov Bernoulli chain; working out the correlation between present and most recent past states of the Markov Chain.
CO3: Generating Markov Chains so as to explain real life problems related to finance, education, health or atmospheric science; Describing stability of Markov chain and their applications.
CO4: Elaborating Markov Process with discrete state space viz. Poisson process and its generalizations, Birth and death process, Erlang process.

Time Series
Students have acquired knowledge to:
CO1: Explain the concept of stationarity in time series process, state the conditions under which a stochastic process is said to be weakly stationary, Solve numerical problems on stationarity, Explain the terms auto covariance function and autocorrelation function (ACF), Illustrate the uses of ACF with respect to seasonality and stationarity.
CO2: Explain an AR(1) and AR(p), MA(1), MA(q), ARMA (p,q) process and state the conditions for stationarity, invertibility, and characteristics of the ACF and PACF, Solve numerical problems on their stationarity and invertibility, Explain the term integrated stochastic process, Explain how to model non-stationary processes using the ARIMA model, Explain spectral densities, Apply linear filters to AR and MA processes.

Course code: STA3046 (Special paper-Option A)
Course Name: Actuarial Statistics –I
Students would have acquired knowledge to
CO1: List the optimum conditions for the establishment of the contract of insurance between the insurer and the insured in terms of the utility functions and the expected value principle.
CO2: Explain the two uncertainties in the domain of General insurance in terms of claim severity and claim number. They will also gather preliminary idea on how to model these claim severities through appropriate probability distributions and interpret the aggregate claim model as a tool for deciding on the optimal reserves to be maintained by the insurance company.
CO3: Synthesize the methodologies developed in the collective risk model to evaluate a compound distribution with emphasis on the compound Poisson distribution.
CO4: Analysis the surplus process in discrete and continuous time domain with a view of evaluating the probability of ultimate ruin in the framework of the collective risk model over an extended period.
CO5: Interpret the various concepts of Life Tables and Multiple Decrement Life tables in view of their roles in laying the foundation of the Life Contingency Mathematics.

Course code: STA3046 (Special paper-Option D)
Course Name: Demography –I
The students will have cognizance of
CO1: Providing some idea on recent census, Sample Registration System, National Family Health Survey, National Population policy and describing the demographic transition theory.
CO2: Describing various methods to reduce the irregularities in terms of coverage and content of demographic data, adjustment of age data through the use of Whipple and Myer's index; explaining method of smoothing and age and sex ratio analysis.
CO3: Formulating life table so as to measure mortality, constructing life table and establishing some analytical laws of mortality, analyzing life table from the prospective of Markov chain, distribution of life table functions and their estimation, describing multiple decrement life table with special reference to cause specific life table, providing some ideas on health expectancy.
CO4: Illustrating the various fertility measures from cohort data and justifying the human reproduction as a stochastic model, estimating fertility rates by indirect methods; elaborating stochastic models for reproductive distribution of time to first birth, estimating parameters of Shep's model; elucidating

stable population along with its analysis; description of the projection procedure of population by component and Leslie matrix method.

Course code: STA3046 (Special paper-Option E)
Course Name: Econometrics –I

Students have acquired knowledge to:

CO1: Write down the k-variate Linear Regression Model in Matrix notation, Interpret the multiple regression equation, understand the meaning of partial regression co-efficients, Perform estimation of the partial regression co-efficients using the Ordinary Least Squares method, Enumerate the co-efficient of determination R^2 and adjusted R^2 in matrix notation, Test the individual regression co-efficients, Test the overall significance of regression.

CO2: Explain the nature of dummy variables and dummy variable trap in regression analysis, Illustrate the use of ANOVA and ANOCOVA models in dummy variable regression analysis.

CO: Explain what happens if (i) the regressors are correlated (multicollinearity), (ii) the error variance is non-constant (heteroscedasticity), (iii) the error terms are correlated (autocorrelation), Infer their theoretical and practical consequences, Detect their presence and Process remedial actions.

CO4: Illustrate the nature Simultaneous Equation Models with examples, Derive the Inconsistency of OLS Estimators, State the Identification Problem.

Course code: STA3046 (Special paper-Option F)
Course Name: Operation Research –I (Queuing Theory)

The students have gained knowledge

CO1: To explain and describe characteristic features of a queuing system .

CO2: To categorize and describe queuing models.

CO3: To derive and numerically calculate quantitative metrics of performance of queuing systems.

CO4: To analyze queues with Poisson arrivals, single server and multi server exponential service requirements together with non Poisson Queues.

CO5: To obtain derivation of associated probability distributions.

CO6: To apply and extend queuing models to analyze real world problems.

Course code: STA3056 (Core) Course Name: Practicals on Multivariate Analysis Time Series and Testing of Hypothesis)

The students have gained practical knowledge in

CO1: Constructing the mean vector , variance-covariance matrix of Multivariate data, drawing inference on the mean vector using Hotelling T^2 statistic; drawing samples from bivariate and trivariate Normal distributions; applying some multivariate analysis techniques such as Multiple regression, Classification, MANOVA and data reduction techniques like principal component analysis, factor analysis and canonical correlation analysis to data arising in real-life.

CO2: Tracing the power curves for testing the parameters of the population of some of the common distribution; construction of Uniformly Most Powerful similar region for testing unknown parameters of normal distribution.

CO3: Calculating trend values by Moving Average method using different formulae, computing auto-covariance function and auto-correlation function of a time series; carrying out advanced time series analysis such as spectral analysis and periodogram analysis.

FOURTH SEMESTER

Course code: STA4016 (Core) Course Name: Non-Parametric Statistical Inference and Semi Parametric Methods and Decision Theory and Bayesian Inference

Non-Parametric Statistical Inference and Semi Parametric Methods

The students will have cognizance of

CO1: Description of the run test, Kolmogorov Smirnov one sample test, Sign test, Wilcoxon Signed Rank test for comparing two related samples, Kruskal Wallis test for testing whether samples originates from the same distribution.

CO2: Taking observations in such a way that the analysis of real-life situations using the relatively complex methods such as the two sample Kolmogorov-Smirnov test, Mann Whitney U test, Wilcoxon test can be carried out in a more efficient manner.

CO3: Describing the working rule of the semi-parametric methods such as partial likelihood, jackknifing and bootstrapping, so that they are able to tackle the real-life problems using them.

Decision Theory and Bayesian Inference

The students have acquired knowledge on

CO1: Differentiating between the frequentist approach and the Bayesian approach of statistical theory; framing a Bayesian decision problem; explaining the concept of prior and posterior distribution.

CO2: Estimation of the hyperparameters of a prior distribution, loss functions, Bayesian interval estimation; Carrying out Bayesian testing of hypothesis and Bayesian computation.

Course code: STA4026 (Core)

Course Name: Regression and Operation Research

Regression:

The students have learnt

CO1: To describe the role of regression to model natural and social phenomena.

CO2: To construct multivariable linear regression models .

CO3: To carry out model validation exercises.

CO4: To understand the role of residuals.

CO5: To process data so as to identify the variables of interest.

CO6: To be able to reconstruct a model if assumptions are not met.

CO7: To interpret regression coefficients and predictors.

Operation Research (Linear Programming Problems and Game theory)

CO1: To formulate a linear programming problem (LPP) from the description of real life scenario; to solve a general LPP and derive its properties; to explain the concept of duality of LPP; to formulate and then solve assignment problems and transportation problems so as to assign sources to destinations and jobs to machines/individuals, respectively, in an optimum manner.

CO2: To model competing strategic situations and represent them as rectangular games.

CO3: To state the characteristic features of a rectangular game together with its associated limitations.

C4: To illustrate the concepts of strategy and equilibrium.

C5: To solve games using graphical and linear programming techniques.

C6: To describe the role of regression to model natural and social phenomena

C7: To construct multivariable linear regression models

C8: To carry out model validation exercises.

C9: To understand the role of residuals.

C10: To process data so as to identify the variables of interest.

Course code: STA4036 (core)

Course Name: Demography and Statistics for National development.

Demography:

The students will have cognizance of

CO1: Providing some idea on recent census, Sample Registration System, National Family Health Survey, National Population policy and describing the demographic transition theory.

CO2: Describing various methods to reduce the irregularities in terms of coverage and content of demographic data, adjustment of age data through the use of Whipple and Myer's index, formulating life table so as to measure mortality, constructing life table and establishing some analytical laws of mortality.

CO3: Illustrating the various fertility measures from cohort data and justifying the human reproduction as a stochastic model; elucidating stable population along and it's analysis; description of the projection procedure of population by component and Leslie matrix method.

CO4: Elaborating the concept of migration in affecting the growth and decline of a population; and its estimation; evaluation of net migration under different situations.

Statistics for National Development:

Students have acquired knowledge to:

CO1: Explain the concept of National Income, GDP, GDP, NNP, Illustrate the various methods of estimation of National Income, State Pareto's Law of Income Distribution, Describe the criteria for measurement of inequality (anonymity, population, relative income and Dalton principles), Explain the Lorenz Curve with respect to the four criteria, Describe the complete measures of inequality (Range, Kuznets Ratio, Mean absolute deviation, Co-efficient of variation, Gini co-efficient), Write down and interpret Theil's T-statistic, Explain the conceptual issues in measuring poverty, Illustrate the measures of poverty including Amartya Sen's index and Kakwani's index.

CO2: Calculate Human Development Index, Gender Inequality Index, Multidimensional Poverty Index, Explain the Malthusian Theory of population, the optimum theory of population, the theory of demographic transition.

Course code: STA4046 (Special paper –Option A)

Course Name: Actuarial Statistics-II

CO1: Identify different types of Life Insurance models payable at the moment of death and those payable at the end of the year of death and calculate their actuarial present values.

CO2: Understand the role of Life annuities as a foundation for pension theory and to calculate their Actuarial present value.

CO3: List different types of Reinsurance and calculate the expected claim amount to be paid by the insurer and the reinsurer.

CO4: To incorporate the evidence of data and prior information in determining the credibility premium through Bayes and Empirical Bayes approach.

CO5: Use the principle of Experience rating to differentiate the policy holders in terms of the premium charged.

CO6: Create appropriate algorithms to project the future development of a run off triangle and justify its role as a reserving technique for outstanding claims.

Course code: STA4046 (Special paper–Option D)

Course Name: Demography-II

The students will acquire knowledge of

CO1: Describing stable population as an equilibrium state under the persistent fertility and mortality conditions and comparing with the stationary population and quasi stable population; explaining

Multistate demography as an extension of classical mathematical demography to the case of individuals grouped in various categories of demographic values; providing the concept of Multistate Life tables, Multiregional Life tables and Multiregional Stable population.

CO2: Providing a comprehensive knowledge on the methods of estimating basic demographic measures from incomplete data; explaining the construction procedure of model life table, Brass two parameter Logit system; describing different nuptiality measures and discussing their construction.

CO3: Elaborating the concept of internal and international migration, Stochastic models for migration and revising the phenomenon of social and occupational mobility from the perspective of Markov Chains; Illustrating the use of discrete branching process to render insights into population dynamics and destiny of human population.

CO4: Explaining the concepts of small area estimation and some applications of the Poisson Process in demography.

Course code: STA4046 (Special paper –Option E)

Course Name: Econometrics-II

The Students have gained knowledge to:

CO1: Explain Generalized Least Squares (GLS) estimators, their properties, feasible GLS estimators, Justify their use in place of OLS estimators under specific circumstances.

CO2: Explain how to perform regression on dummy dependent variable (Qualitative Response Regression Models), Illustrate the Linear Probability Model (LPM), Logit and Probit Models.

CO3: Develop Dynamic Econometric Models- Distributed Lag Models,: The Koyck Approach, Partial Adjustment and Adaptive Expectations Model .

CO4: Illustrate the nature of Recursive models, Perform Estimation of a Just Identified equation using the Method of Indirect Least Squares (ILS), Perform Estimation of an Over Identified equation using the Method of two stage Least Squares (2SLS).

Course code: STA4046 (Special paper –Option F)

Course Name: Operation Research II (Reliability Theory)

. The students have acquired knowledge on

CO1: Explaining the concept of reliability with reference to real life using examples; defining the related terms such as failure rate, failure density and cumulative failure rate.

CO2: Comparing exponential distribution with other distributions in respect of survival function, enumeration of the relation between mean and median of IFR Distribution.

CO3: Explaining the concept of Structure functions, coherent structure; reliability bounds of parallel and series structures using inclusion and exclusion methods; Describing a Parallel redundant standby system under Markovian set-up giving the outline of its assumption; Obtaining its probability of occurrence of number of renewals in a random interval in terms of Laplace transform; Enumerating the mean time to failure and reliability of the system.

CO4: Explaining the concept of censoring and its importance in life testing; Estimation of the mean life times and properties of the estimator when a number of systems are put on test under failure censored scheme with exponential failure time distribution; Estimation of the Reliability function.

Course code: STA4056 (Core) Course Name: Project

The student would have acquired knowledge to

CO1: Identify a social/ natural phenomenon with random variation and to extract some research question out of it which can be solved with the help of his knowledge on the Statistical concepts and methods.

CO2: Provide justification of his study and assess its social ramifications with a view of providing some vital input to the process of policy making at the regional level.

CO3: Or in case one opts for a theoretical study rather than an empirical one, he is expected to demonstrate the ability to probe deeper into a theoretical concept and extract out some new properties associated with it.

CO4: Identify the sample design to carry out the empirical analysis, collect data (primary or secondary as required), identify the proper statistical tools to analyze them, implement them with proper use of his computational skills and interpret the results in a scientific manner.
CO5: Justify the importance of his study and defend his findings while presenting the project before an audience of teachers and external examiners.

Semester wise Syllabus

First Semester

Paper STA-1016 Real Analysis & Special Functions

80+20 = 100 (6 credits)

Group-A

Real Analysis **60+15=75**

Unit 1: Real valued functions, continuous functions; uniform convergence tests for uniform convergence, Power series, Radius of convergence. Applications of power series.

Unit 2: Differentiation, partial derivatives of higher order, maxima minima of functions, functions of several variables, constrained maxima – minima of functions.

Unit 3: Multiple integrals and their evaluation, change of variables in multiple integrals, change of order of integration.

Unit 4: Uniform convergence of improper integrals, Differentiation and Integration within the integral sign.- Leibnitz Rule

Group: B

Special Functions **20+5=25**

Unit 5: Gamma and Beta Functions: Hypergeometic function, Bessel functions, Laguerre, and Jacobi polynomials..

References:

1. Apostol, T.M. (1985). Mathematical Analysis, Narosa, Indian Ed.
2. Courant, R. and John, F, (1965). Introduction to calculus and Analysis, Wiley.
3. Miller, K.S. (1957). Advanced Real Calculus, Harper, New York.
4. Rudin, Walter (1976). Principles of Mathematical Analysis, Mc Graw Hill.
5. Andrews, G.E., Askey, Richard and Roy, Ranjan (2000), Special functions Cambridge University Press,
6. Rainville, E.D. (1960). Special Functions, The Macmillan Company, New York.

STA-1026: Linear Algebra

80+20 = 100 (6 credits)

Unit 1: Fields, linear spaces, subspaces, linear dependence and independence, basis and dimension of a linear space, theory of linear equations. Introduction to Euclidian Space.

Inner product, Linear space with inner product, orthogonalization of vectors, orthonormal basis of a linear space.

Unit 2: Linear transformation, algebra of matrices, partitioned matrices.

Unit 3: Canonical forms, generalized inverse, Moore – Penrose innerse, Matrix equations.

Unit 4: Quadratic forms, Reduction of quadratic forms, Lagrange's method of transformation of a positive definite quadratic from, Cochran's theorem.

Unit 5: Characteristic polynomial, characteristic roots, Characteristic vectors, Hamilton – Cayley theorem, Spectral decomposition of matrices – symmetric and asymmetric.

Statistical applications of the algebra of matrices.

References:

1. Graybill, F.A. (1983). Matrices with applications in statistics, 2nd Ed. Wadsworth.
2. Rao, C.R. (1973). Linear statistical inference and its applications, 2nd ed. John Wiley and Sons, Inc.
3. Searle, S.R. (1982). Matrix Algebra useful for Statistics. John Wiley and Sons. Inc.

Paper STA-1036: Measure Theory & Probability

80+20 = 100 (6 credits)

First Half

Measure Theory **40+10=50**

Unit 1:
Measure – it's properties with examples, finite and sigma finite
Measures, Continuity theorem of Measure, Inclusion- Exclusion theorem of Measure, Probability space and conditional probability space, Lebesgue- Stieltjes measure, idea of product space and product measure.
Outer measure, outer measurability, class of outer measurable sets in a Sigma field.

Unit 2:
Construction of outer measure function, Lebesgue measure, Lebesgue Measurable sets and Lebesgue measure, extension of measure on a field, complete measure space.
Measurable transformation and function, random variable, simple and Elementary function, induced measure and distribution function, properties of measurable functions, measurable function as the limit of simple function.

References:

1. *Measure Theory and Probability* by A. K. Basu, Prentice Hall of India.
2. *Probability and Measure* by P. Billingsley, John Wiley.
3. *Measure Theory* by P. R. Halmos, Springer.

4. *Introduction to Measure and Integration* by M. E. Munroe, Addision-Wesley.
5. *An Introduction to Measure and Integration* by I. K. Rana, Narosa.
6. *Introduction to Measure and Probability* by Kingman J. F. C and Taylor S. J (1966), Cambridge University Press

Second Half

Probability **40+10=50**

Unit 1:

Distribution functions for univariate and multivariate, Expectation and moments, moment inequalities (Markov, Cramer, Holder & Jensen).
Characteristic function and properties of characteristic function of a random variables; Inversion Theorem, Uniqueness theorem. Bivariate and multivariate characteristic functions (definition & properties). Convolution theorem.

Unit 2:

Weak Law of Large Numbers (WLLN) due to Bernoulli, Poisson, Chebyshev and Khintchine. Borel-Cantelli Lemma.

Unit 3:

Convergence of random variables- Convergence in probability-almost surely, Convergence in mean square and convergence in distribution.
Helly's theorem, Helly-Bray Theorem, Continuity theorem of characteristic functions, Slutky's theorem-convergence.

Unit 4:

Central Limit Theorem (CLT)- Lindeberg-Levy, Liapounouv and Lindeberg-Feller.
Conditional expectation, Martingales.

Unit 5:

Convergence of sequence of random variables, Three series criterion, Kolmogorov's inequality, Strong Law of Large Numbers (SLLN).

References:

1. Bhat B.R, Srivenkatraramana T and Pao Madhava K.S. (1997): Statistics: A Beginer's Text, Vol. II, New Age Internatioanl (P) Ltd.
2. Edward P.J, Ford J.S. and Lin (1974): Probability for Statistical Decision- Making, Prentice Hall.
3. Goon A.M., Gupta M.K. Dasgupta B. (1999): Fundamental of Statistics, Vol. II, World Press, Calcutta.
4. Mood A.M, Graybill F.A and Bose D.C (1974): introduction to the Theory of Statistics, McGraw Hill.
5. Feller W. An Introduction to Probability Theory and Its Applications, 3rd Ed. John Wiley.
6. Coke, Cramer and Clarke. Basic Statistical Computing, Chapman and Hall.
7. David, S (1996): Elementary Probability, Oxford Press.
8. Hoel P.G (1971): Introduction to Mathematical Statistics, Asia Publishing House.
9. Meyer P.L (1970): introductory Probability and Statistical Applications, Addision Wesley.

Paper STA-1046: Sample Survey

80+20 = 100 (6 credits)

Concepts of population and sample, need for sampling, census and sample surveys.
Basic concepts in sampling and designing of large scale surveys.

Simple random sampling with and without replacement.

Stratified random sampling, estimation with different type of allocation. The construction of strata No. of strata, Method of collapsed strata, Post Stratification

Unequal probability sampling : PPS wr/wor including Lahiri's scheme; Horvitz-Thompson, Hansen-Hurwitz and Des Raj estimators for general sample size, Murthy's estimator for a sample of size 2. (including Harpley-Ross and Jacknife estimatiors) combined ratio estimator.

Ratio method of Estimation including Hartley-Ross and Jacknife estimatiors. Combined ratio estimator.

Regrestion method of Estimation including its optimum property.

Cluster sampling, Two-stage and Multi-stage sampling, systematic sampling (including comparison of sys. Simple and stratified random sampling for population in random error. Population with linear trend, periodic variation, auto correlated population Modification of systematic sampling in presence of trend.)
Non sampling errors, Randomized response technique (Wamer's model only)
Basics of quota sampling, distance sampling, snowball sampling, network sampling, and Importance sampling.

***References**:*

1. Sukhatme: Sampling theory of surveys with application: Indian Society of Agricultural Statistics.
2. Cochran W.G.: Sampling Technique (Third edition): Weley Eastern.
3. Murthy MN: Sampling theory and Methods: Statistical publishing society kolkata
4. Des Raj and Chandok: Sampling design: Jata McGrow Hill
5. Singh D. and Choudhury F.S.: Theory and Analysis of Sample Survey Design: New Age International Publishers.
6. Mukhopadhyay, Parimal : Theory and Methods of Survey Sampling.

Paper STA-1056: Practical

80+20 = 100 (6 credits)

All practical should be done with the use of either R or Excel.

Sample Survey

Unit 1: Stratified random sampling with and without replacement; with equal and unequal probability under different types of allocation. (At least 5 practical)

Unit 2: Ratio and Regression methods of estimation. (At least 4 practical)

Unit 3: Cluster sampling with equal and unequal cluster size. (At least two practical)

Unit 4: Two-stage sampling with equal first stage units; two stage sampling with unequal first stage units Multi-stage sampling. (At least 2 Practical)

Unit 5: Systematic sampling. (At least 4 Practical)

Internal Assessment **20**

Marks of Internal assessment to be assessed on the basis of the experiments done using R.
Introduction to R programming Language.
Practical examples will be given on sample surveys and have to solve with the use of R / Excel.

Second semester

Paper STA-2016: Distribution Theory and Simulation

80+20 = 100 (6 credits)

Unit 1: **16**
Basic tools of distribution theory: Joint, marginal and conditional probability mass functions (pmf) and probability density functions (pdf); Moments (raw, central, and factorial) in terms of Stirling numbers; Functions of random variables and their distributions using Jacobian of transformation and other tools.

Unit 2: **16**
Basic distributions: Logarithmic, positive and negative multinomial, bivariate normal, bivariate exponential and multivariate normal distributions, Probability distributions of extremes and its asymptotic distributions.
Order statistics-their distributions and properties; Joint and marginal distributions of order statistics (discrete and continuous).

Unit 3: **16**
Censoring, Truncation and weighted distributions (use 10 types of weight functions). Truncated Binomial, Poisson, Logarithmic, Normal, Cauchy distributions. Intervened Poisson distributions.
Mixture distributions: Definition, finite mixtures, Zero modified distributions with examples, Mixed poisson distributions and its properties and examples of Poisson mixtures, Mixtures of Binomial distributions with examples.

Unit 4: **16**

Sampling distributions: Non-central chi-square, t, and F distributions their properties and their related distributions.

Unit 5: **16**

Simulation: generation of random numbers using congruence method, Evaluation of integrals using random numbers by Monte Carlo approach for single and multiple integrals, Generation of random variables: Inverse transform method, acceptance-rejection method, simulation of discrete random variates by inverse transform method, acceptance-rejection method: Markov Chain Monte Carlo (MCMC).

References:

1. Dudewicz, E.J.and Mishra, S.N.(1988): Modern Mathematical Statistics, Wiley, Int'l Students' Edition.
2. Rohatgi, V.K. (1984): An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern.
3. Rao, C.R. (1973): Linear Statistical Inference and Its Applications, 2/e, Wiley Eastern.
4. Johnson, N.L., Kemp, and Kotz, S. 2005, Univariate Discrete Distributions, Wiley, 3rd Ed.
5. Johnson, N.L., Kotz, S. and Balakrishnan, 2004, Univariate Continuous Distributions, Wiley, 2nd Ed., Vol. 1 & vol. 2.
6. Johnson, N.L., Kotz, S. and Balakrishnan, 2004, Multivariate Discrete Distributions, Wiley, 2nd Ed.

Paper STA-2026: Statistical Inference-1 (Point and Interval Estimation)

80+20 = 100 (6 credits)

Unit 1:

Concept of point estimation Properties of point estimators.

(i) Unbiasedness (ii) Sufficiency (iii) Completeness (iv) UR.VUE and Related theorems including Rao-Blackwell theorem, Lehmann Scheffe throrem. (v) Invariance of estimators Pitman estimator.

Unit 2: Bounds for variance of Estimators

(i) Rao-Cramer Lower bound

(ii) Rao-Cramer inequality for multiparameter case.

(iii) Bhattacharyya bound

(iv) Chapman Robins-Kiefer Lower bound.

Unit 3: Method of estimation

(i) Maximum likelihood and properties (ii) Method of moments (iii) Minimum chisquare (iv) Method of minium distance

Unit 4: Interval estimation

(i) Sampling from normal population (ii) Pivotal quantity method (iii) Statistical method.

Unit 5: Large sample theory,

(i) Consistency (ii) BAN (iii) CANE and related theorems (iv) Large sample properties of MLE, MME and Minium chi-square and related theorems.

Home assignment: Maximum likelihood interval (sampling from normal population). Sampling distributional and order statistics.

***References*:**

1. Kale B. K. (1999) *A First Course on Parametric Inference*

2. Rohatgi V. (1988) *An Introduction to Probability and Mathematical Statistics*, Wiley Eastern Limited. New Delhi, (Student Edition)
3. Rao, C. R. (1973) *Linear Statistical Inference and Its Application*, 2/e Wiley Eastern
4. Lehman. *Theory of Point Estimation.*
5. Goon, Gupta & Dasgupta. *An Outline of Statistical Theory* (Vol 2).
1. Saxena & Surindam . *Statistical Inference*

Paper STA-2036: Linear Models and Design of Experiment

80+20 = 100 (6 credits)

Linear Model: Gauss-Markov setup, Normal equations and least square estimator, Error and estimation space, variance and covariance of least square estimates, estimation of error variance, estimation with correlated observations, least square estimates with restriction an parameters.

Tests of hypotheses for one and more than one linear parametric functions ,Multiple comparison tests due to Tukey and Scheffe.

DOE: Analysis of variance with two con-comitant variables, AOCOV in general Gauss-Markov model.

Fixed , mixed and random effects models variance components estimation – study of various methods. Tests for variance components.

Missing plot technique including general theory and applications.

General factorial expt., factorial effects, best estimates and testing the significance of factorial effects 2^n (n=5,6) and 3^3 (n=2,3) factorial experiments. Complete and partial confounding. Fractional replication split plot design.

Incomplete block designs: Criteria for connectedness, balanced and orthogonality Balanced Incomplete block design (BIBD) idea of general Block design and c matrix Recovery of interblock information partially balanced incomplete block design (PBIBD) with 2 associated classes. Lattice designs. Youden square.

Design for study of response surfacet first and second order designs. introduction to Bio-Assay.

Analysis of group experiments

Construction of BIBD.

***References*:**

1. *Experimental Design*—Das & Giri.
2. *Design of Experiments*—Krempthone
3. *Linear Estimation*—Jorhi
4. *Applied Statistics*—Parimal Mukhopadhaya
5. Linear Statistical Inference and its applications – C.R. Rao.

Paper STA-2046: Computer Programming

80+20 = 100 (6 credits)

Unit 1: Algorithms and Basics of Programming 10

Preliminary idea of Algorithms, Flowcharts Compilers; Errors in floating point operations; Concept of structured programming; Representation of integer and real numbers.

Unit 2: Programming in C 50

Basic element of a C program; Modules of Functions; Arithmetic operators; Precedence rules; Different data types-Integer, floating point, double precision and character; Constants and Variables; Formatted input & output; Relational and Logical operations; IF-ELSE statement, WHILE statement; FOR statement, DO statement, nesting; Arrays; String fundamentals; Structure basics, arrays of structures; Simple file operations- creating, opening, closing, reading, writing into files; Standard Library and user defined functions.

Concept of pointers, passing parameters to functions as painters.

Unit 3: Analysis with SPSS 20

Introduction to SPSS, creation of database in SPSS, Data analysis using SPSS, Experiments on Regression and Design of experiment.

***References**:*

1) *A First Book of C: Fundamentals of C Programming*. G J Bronson, J. Menconi. Jaico Publishing House.

2) *Illustrated C Programming*. J Emmett Beam. BPB Publications.

3) Let us C . Yashavant Kanetkar.

4) Manual of SPSS.

Paper STA-2056: Practical

80+20 = 100 (6 credits)

All practicals should be done with the use of R/Excel/SPSS/C.

Topics from Design of Experiments 60

Statistical Inference I 20

Paper STA-2066: Statistical Methods with applications

80+20 = 100 (6 credits)

Learning outcomes: After successful completion of this course, a student who is not trained in Statistics and has major in other domains is expected to be proficient enough to use basic Statistical tools for the purpose of basic statistical data analysis in their domains.

Unit 1: Descriptive Statistics Credit : 3

Idea about different types of Statistical data, time series data, non time series data, tabular and diagrammatic representation, frequency table, graphical representation, examples from real life data **Measures of Central Tendency:** Different types of measures of central tendency, their definitions, properties, merits and demerits, simple theorems and results (with no mathematical derivations), simple examples, concept of Quantiles, Deciles Percentiles, Weighted AM **Measures of Dispersion** : Different types of measures of dispersion, their definitions, properties, merits and demerits (special emphasis to be given on variance and standard deviation),examples, coefficient of Variation, Skewness and Kurtosis, **Correlation and Regression** : idea on scatter plots, Pearsonian's correlation coefficient, its properties, examples, concept of regression, lines of regression with examples, rank correlation, idea of multiple and partial correlation (3 variables only) with examples**. Time Series Analysis**: Different components of a Time Series and the method of moving average for eliminating trend.

Unit 2: Probability and Distribution Credit: 1

Idea of permutation and combination, Basic ideas on set theory, concept of Probability and associated terminologies, classical definition of probability, theorems on total, addition and compound probability, simple examples illustrating the evaluation of probability by definition and use of these theorems , concept of random variable, discrete random variables and continuous random variables, probability mass function and probability density function, Mathematical expectation, Binomial, Poisson and Normal distributions, their mean and variance, examples.

Unit 3: **Sample Survey and Tests of significance**: Credit: 2

Sample Survey: Idea of different types of population and samples, Concept of parameters and statistics, unbiased estimates, sampling distribution, SRSWR, SRSWOR, Stratified Random sampling ,how to draw a sample using SRSWR, SRSWOR and Stratified Random Sampling techniques, **Tests of Significance:** Concept of null hypothesis and alternative hypothesis, critical region, large sample tests : test for single mean, equality between two means and test of proportionality, basic ideas on χ^2, t and F distributions with applications, **: Analysis of Variance:** Analysis of Variance for one way and two way classification, Design of experiments, associated terminologies, Principles of Design of experiments, CRD and RBD

Recommended Books:

(1) Statistical Methods: An Introductory Text by Jyoti Prasad Medhi, Publisher: New Age International
(2) An Outline of Statistical Theory (Volume 1 and Volume 2) by A.M. Gun, M.K. Gupta and B. Dasgupta, Publisher: World Press
(3) Fundamental Of Mathematical Statistics by S.C. Gupta and V.K. Kapoor, Publisher: Sultan Chand and Sons
(4) Fundamental of Applied Statistics by S.C. Gupta, Publisher: Sultan Chand and Sons
(5) Statistics for Dummies by Deborah J Rumsey, Publisher: For Dummies

References:

(1) Probability and Statistics for Engineering and the Sciences by Jay L Devore, Publisher: Cengage Learning
(2) Business Statistics by J.K. Sharma, Publisher: Pearson Education India
(3) Essentials of Statistics for the Social and Behavioral Sciences by Barry H Cohen and R Brooke Len Publisher: Wiley
(4) Introduction to Statistics for Biology by Robin H Macleery, Trudy A Watt and Tom Hart, Publisher: Chapman and Hall

(5) Statistics: A Guide to the unknown by J.M. Tanur et al (Editors) , San Francisco Holden Day

THIRD SEMESTER

80+20 = 100 (6 credits)

Paper STA-3016: Multivariate Analysis

Unit 1: 16

Types of measurement of data,data transformation; Multivariate normal distribution (also singular and spherical), random sampling from a multivariate normal distribution, Maximum likelihood estimators of parameters, Distribution of sample mean vector.

Unit 2: 16

Wishart matrix- its distribution and properties, Distribution of sample generalized variance, Null and non-null distribution of sample correlation coefficient. Null distribution of partial and multiple correlation coefficient. Distribution of sample regression coefficients. Application in testing and interval estimation.

Unit 3: 16

Null distribution of Hotelling's T^2 statistic. Application in tests on mean vector for one or more multivariate normal populations and also on equality of the components of a mean vector in a multivariate normal population.

Unit 4: 16

Multivariate linear regression model-estimation of parameters, tests of linear hypotheses about regression coefficients. Likelihood ratio test criterion, Multivariate analysis of variance (MANOVA) of one and two way classified data.

Unit 5: 16

Classification and discrimination procedures for discrimination between two multivariate normal populations- sample discriminant function, tests associated with discriminant functions, probabilities of misclassification and their estimation. Classification into more than two multivariate normal populations.

Principal component, Dimension reduction, Canonical variables and Canonical correlation – definition, use, estimation and computation. Factor Analysis.

***References**:*

1. Anderson, T. W. (1983): *An Introduction to Multivariate Statistical Analysis*, John Wiley.
2. Giri, N. C. (1977) *Multivariate Statistical inference*, Academic Press.
3. Kshirsager A.M. (1972): *Multivariate Analysis*, Marcel Dekker
4. Rao, C. R. (1972): *Linear Statistical inference and its Application*, John Wiley.
5. Srivastava & khatri (1979): *An introduction to Multivariate Statistics*, North-Holland.
6. Johnson & Wichern (1992): *Applied Multivariate Statistical Analysis*, Prectice Hall
7. Chakravarti, Lahe & Roy. *A Hand Book of Methods of Applied Statistics , Vol 1*, John Wiley

Paper STA-3026: Testing of Hypothesis (Inference 2)

80+20 = 100 (6 credits)

Unit 1:

Basic concepts: critical region, power function, randomised and non-randomised tests. Neyman-Pearson Fundamental Lemma and Generalisation. MP and UMP tests. Neyman-Pearson theorem. Consistency, monotonicity and invariance principle of tests and their construction.

Unit 2:

UMPU- tests. Type A, Type A_1 critical regions. Optimum Region and Sufficient statistic. Similar Regions.

Unit 3:

Likelihood Ratio Tests. Asymptotic distribution of Likelihood ratio.

Randomised test: Test function. Neyman-Pearson theorem. Monotone Likelihood Ratio.

Unit 4:

Sequential Analysis: Wald's Sequential Probability Ratio Test (SPRT). Properties of SPRT. Efficiency of SPRT. The Fundamental Identity of Sequential Analysis. OC Function. ASN.

(Five questions are to be answered taking at least one from each unit.)

References:

1. George Cassella & Roger L. Berger (1994): *Statistical Inference*. Wadsworth & Brooks, California.
2. Parimal Mukhopadhyay (1996): *Mathematical Statistics*. New Central Book Agency, Kolkata.
3. C. R. Rao (1974): *Linear Statistical Inference and its Applications*. Wiley Eastern Private Limited, New Delhi.
4. Lehman, E. L. (1959): *Testing Statistical Hypotheses*. John Wiley.
5. Kendal, M. G. & Stuart, A (1960): *The Advanced Theory of Statistics*. Vol 2. Charles Griffin, London.
6. Goon, A. M., Gupta, M. K., and Dasgupta (1987): *An Outline of Statistical Theory*. Vol.-II, World Press.

Paper STA-3036: Stochastic Processes & Time Series

80+20 = 100 (6 credits)

First Half

Stochastic Processes **40+10=50**

Unit 1:

Stochastic Process: Concept and definition, Specification of Stochastic process, Stationary Processes.

Unit 2:

Markov Chain: Definition, Higher Transition Probabilities, Generalization of independent Bernoulli trials, Sequence of chain dependent trials, Classification of states and chains. Determination of higher transition probabilities , Stability of Markov System, Graph theoretic approach, Markov chain with Denumerable number of states, Reducible chains, Non homogeneous chains.

Unit 3:
Poisson Process and related distributions: Generalization of Poisson Process, Birth- Death process. Markov Process with discrete state space and continuous time. Randomisation (Uniformization) Derived Markov Chains. Erlang Process.

References:

1. Adke, S. R and Manjunath S. M (1984) *An Introduction to Finite Markov Processes*.
2. Bhat B. R (2000) *Stochastic Models: Analysis and Applications*, New Age International India.
3. Cinler, E (1975) *Introduction to Stochastic Processes*, Prentice Hall.
4. Hoel, P.G, Port,S.C, Stone, C.J (1972) *Introduction to Stochastic Processes*, Houghton Miffin and Co.
5. Medhi, J (1982) *Stochastic Processes*, Wiley Eastern.
6. Ross, Stochastic Process, John Wiley.

Second Half

Time Series **40+10=50**

Unit 1:
Discrete parametric stochastic processes, Stationary processes, auto-covariance and auto-correlation, Moving A verage (MA), Linear processes, auto-regressive process, Introduction to ARMA processes, Forecasting stationary time series.

Unit 2:
ARMA Models: ARMA (p,q) processes, The auto-correlation function and partial auto-correlation function of an ARMA (p,q) process, Partial auto-correlation function, Forecasting ARMA processes.

Unit 3:
Spectral Analysis: Spectral densities of MA, AR, ARMA, Time-invariant linear filters, The spectral density of an ARMA.

Unit 4:
Nonstationary and seasonal time series models: Auto-regressive integrated moving average (ARIMA) models for nonstationary time series, Identification techniques, Forecasting ARIMA models, seasonal ARIMA models.

References:

1. Anderson, T.W.(1971), Statistical Analysis of Time Series, Wiley, NY
2. Box, G.E.P and Jenkins, G.M.(1976). Time series Analysis-Forecasting and Control, Holden-day, SanFransisco.
3. Brokckwell, P.J. and Davis, R.A.(1996). Introduction to Time Series and Forecasting, Springer, New York.
4. Medhi, J. (2009). Stochastic Processes, 3rd Ed., New Age International Publishers, New Delhi, India.

Special paper **(Any *One*)**

Paper STA-3046: Special Paper (Option A)

80+20 = 100 (6 credits)

Paper STA-3046: Actuarial Statistics –I

Group-A
Risk Theory

Introduction to insurance systems.

Risk theory: Utility theory and the economics of insurance, individual risk models for a short term, common loss distributions. Collective risk models for a single period and for an extended period, ruin theory, applications.

GROUP-B
Life Contingency Mathematics-I
Mortality and Life Tables: Survival models, life tables.
Multiple decrement tables.
Stationary Population.
Mortality estimation: exposure to risk, approximation for incomplete data.
Smoothing /graduation: Parametric, tabular and graphical methods, tests of graduation.
Population Projections.

***References*:**

1. Bowers et al. 1997. *Actuarial Mathematics*. Second Edition. Society of Actuaries.
2. Rob Kaas Marc Goovaerts, Jan Dhaene and Michel Denuit (2008) Modern Actuarial Risk Theory using R, Springer.
3. Slud, E.V. (2001). Actuarial Mathematics and Life-Table Statistics, University of Maryland, USA.

Paper STA-3046: Special Paper (Option B)

Bio-Statistics **80+20 = 100 (6 credits)**

First Half

Demography **40+10=50**

Basic idea, Demographic transition theory, Evaluation and adjustment of age data, indexes of age preference: Whipple's index, Myre's index, smoothing of age data, construction of complete and abridged life table by Chiang's methods, life table from the perspective of Markov chain, Multiple decrement life table, - cause specific life table, multistage life table, health expectancy, Statistical theory of life table, Competing risk, structure of population, Mathematical models in fertility and Human reproduction, population projection by the matrix method.

***References*:**
The methods and materials of Demography: Stockwel & Saigel
The life table and its applications: C.L. Chiang
Life tables and their applications: Namboodiri and Suchindran
Technical Demography: Ramkumar

Second Half

Epidemiology **40+10=50**

Introduction: Definition and Scope of epidemiology.
Measuring health and disease: Definitions of health and disease, measures of disease frequency, Comparing disease occurrence.
Type of Study: Observational epidemiology, Experimental epidemiology, potential errors in epidemiological studies.
Causation in Epidemiology. Epidemiology and prevention: The scope of prevention, levels of prevention, Screening.
Communicable disease epidemiology: epidemic and epidemic disease, chain of infection.
Clinical epidemiology: Definitions of normality and abnormality, diagnostic tests, Effectiveness of treatment, prevention in clinical practice.
Environmental and occupational epidemiology
Public health surveillance
Epidemiology, health services and health policy.
Epidemic processes: Simple and General. Chain binomial models

References:
Basic Epidemiology: R. Beaglehole, R. Bonita and T. Kjellstrom. WHO. 1993
Principles of Epidemiology. Self _study Course. U. S. Department of Health and Human Services. 1992
The Elements of Stochastic Processes: NTJ BaileyJohn Wiley and Sons. 1990.

Paper STA-3046 Special Paper (Option C)

80+20 = 100 (6 credits)

First Half
Data Mining

KNOWLEDGE DISCOVERY AND DATA MINING

UNIT 1:
Introduction to Data Mining and Data Mining Techniques
Statistical perspective on data mining
Genetic algorithms
Unit 2:
Problems and procedures of classification
Probabilities of misclassification
Decision Trees
Statistical based algorithms
Distance based algorithms
Neural Networks- Based algorithms
Unit 3:
Clustering

Similarity and distance measures
Hierarchical algorithms
Partitional algorithms
Vectors quantization

Unit 4:

Supervised Learning Methods
Fisher Linear Discriminate
Artificial Neural Networks
Extension of regression models and regression trees

Unit 5:

Databases
Introduction to databased
Relational databases
Data warehouses
Introduction to online analytical data processing

Unit 6:

Unsupervised learning methods
Univariate and multivariate data
K-means problem
Expectation Maximization
Dimension reduction and feature selection

Unit 7:

Association rules and prediction; data attributes, applications to electronic commerce.

Unit 8:

Temporal Mining
Modelling temporal events
Time series
Pattern detection

Marks 20 will be given on the performance and the number of assignments during the semester period.

Note on practical/tutorials: Each practical session should correspond to two teaching hours. Practical work should be done on statistical packages and using R programming language.
Note on prerequisites: This course assumes successful completion of Computer intensive Statistical Methods. The students will be encouraged who has the knowledge of computer programming and statistical packages like SPSS, Strata, Statistica etc.

***References*:**

1. A. Berson and S.J. Smith (1997). Data Warehousing, Data Mining. And OLAP Mc Graw- Hill.
2. L. Breiman, J.H.Friedman, R.A. Olshen, and C.J. Stone (1984). Classification and Regression Trees. Wadsworth and Brooks/Cole.
3. J. Han and M.Kamber (2000). Data Mining; Concepts and Techniques. Morgan Gaufmann.
4. T.M. Mitchell (1997). Machine Learning. Mc Graw-Hill
5. B.D.Ripley (1996). Pattern Recognition and Neural Networks. Cambridge University Press.
6. M.H. Dunham (2004). Data Mining: Introductory and Advanced Topics, Pearson Education Pvt. Ltd. Singapore.

Paper STA-3046 Special Paper (Option D)

80+20 = 100 (6 credits)

Demography I

Unit 1:

Demographic Transition Theory: Evaluation and Adjustment of Age data, Digit Preference – Whipple's index, Meyer's index, blended method, Age and sex Ratio analysis, Chandrasekhar Deming Method. Method of Smoothing.

Unit 2:

Infant mortality, Adjusted infant mortality rates, Life Tables: Constuction by Chiang's method, Life table from the prospective of Markov chain Distribution of life table functions and their estimation, Multiple decrement life table with special reference to cause specific life table, Competing risks, Idea of healthy life expectancy.

Unit 3:

Estimation of fertility rates by indirect methods, Stochastic models for reproductive distribution of time to first birth, inter live birth intervals and number of births, estimation of parameters Shep's model.

Unit 4:

Population projection by matrix method. Detailed discussion on Lesic matrix. Evaluation of projection, Idea of projecting socio-economic characteristics.

References:

1. Shryock, H. S, Seigal, J. S and Associates (1997) Methods and Materials of Demography, Academic Press Inc., London
2. Chiang, C. L (1968) Introduction to Stochastic Process in Biostatistics, John Wiley
3. Keyfitz, N (1977) Applied Mathematical Statistics, Springer Verlag.
4. Cox P. R (1970) Demography, Cambridge University Press
5. Spiegelman, M (1969) Introduction to Demographic Analysis, Harvard University Press.

Paper STA-3046 Special Paper (Option E)

80+20 = 100 (6 credits)

Econometrics I

Unit 1:

Nature of econometrics,The general linear mode (GLM) and its extensions. Ordinary least squares (OLS) estimation and prediction. Generalised least squares (GLS) estimation and prediction. Aitken's Theorem of GLS-Feasible GLS and its properties. Heteroscedasticity, Test and solution, Dummy variables and seasonal adjustment.

Unit 2:

Auto correlation, its consequences, tests and solution. Theil BLUS procedure Estimation and prediction Multicollinearity problem, it's implication and solution.

Unit 3:

Distributed Lag Models. Concept –Koyck Model partial Adjustment and Adaptive Expectation Models-Estimation of Models with a Lagged Dependent Variable. Test of Autocorrelation in Auto Regressive

Models. Linear regression with stochastic regressors. Instrumental variable estimation. Error in variables.

Unit 4:
Simultaneous Linear Equation Models: Structural form and Reduced form. Identification problem – Order and Rank conditions of indentification. Identification through Restrictions on the covariance Matrix and structusal Disturbance - Recursive Models- Methods of Estimation.

Unit 5:
Estimation in simultaneous equations model. Recursive systems. 2 SLS Estimators. Limited information estimators, K-class estimators. 3SLS estimation. Full information maximum likelihood (FIML) Methods with properties- Monte carlo studies and simulation. Predictin and simultaneous confidence intervals.

***References*:**

1. Johnston J : Econometric methods, Third edition, Mc Graw Hill
2. Gujarathi : Basic Econometrics, McGraw Hill
3. Cramer J.S: Empirical Econometrics, North Holland
4. Koutsoyiannis: Theory of Econometrics, Macmillan Press
5. Theil H: Introduction to the theory and practice of Econometrics, John Wiley.
6. Desai M: Applied Econometrics, Mc Grqw Hill.

Paper STA-3046: Special Paper (Option F)

80+20 = 100 (6 credits)

Operation Research - I

Queuing theory:

UNIT 1:
(a) General concept: Basic Characteristics of A Queue, Notations, Transient and Steady state, Little's formula (without proof), idea of PASTA.
(b) M/M/1 model: Steady state distribution, waiting time distribution,
(c) Steady state Distribution of M/M/1/k.

UNIT 2:
(a) M/M/c model: Steady state distribution, distribution of waiting time .
(b) Steady state distribution of the following models : M/M/c/c, M/M/c//m (m>c).
(c) Idea of network models, Markovian two station series model with infinite queue capacity.

UNIT 3:
Bulk Queues
(a) Steady State Distribution and Waiting Time Distribution of M/M(1,b)/1, M/G(1,b)/1 models;
(b) Steady State Distribution of M/G(1 , b)/1 and M/G(a , b)/1 models.

UNIT 4:
(a) M/G/1 model: Pollaczek Khinchin and Pollaczek Khinchin Transform Formulae;
(b) Steady state distribution and distribution of waiting time of GI/M/1 model;
(c) Steady State Distribution of M/D/1 and M/D/c model.

NOTE: Standard performance measures of all the above models are to be discussed.

References:

1. Medhi, J, *Stochastic Models in Queuing Theory*, Academic Press.
2. Gross, D and Harris, C. M. *Fundamental of Queuing Theory*, Wiley
3. Kashyap, B. R.K and Chaudhry, M. L. *An Introduction to Queuing Theory*.

Paper STA-3046: Special Paper (Option G)

80+20 = 100 (6 credits)

Survival Analysis -I

Unit 1:
Concept of time, Order and random censoring, likelihood in mese cases, Life distribution-Exponential, Gamma, Weibull, Lognormal, Pareto, Linear Failure rate, Parametric inference (point estimation, confidence intervals, scores, LR MLE tests (Rao-Wilks-Wald) for these distribution.

Unit 2:
Life tables, Failure rate mean residual life and their elementary properties. Ageing classes and their properties. Bath tub Failure rate.
Unit 3:
Estimation of survival function- Actuarial estimator, Kaplan-Meier Estimator, Estimation under the assumption of IFR/DFE.

References:

1. Cox D. R. And Oakes (1984): Champman and Hall. New York
2. Gross A. J. and Clark V. A. (1975): *Survival distribution: Reliability applieasis in Biomedical sciences* John Wiley and Sons.
3. Elandt- Johnson, R. E. Johnson N.L.: *Survival models and Data Analysis*, John Wiley and sons.
4. Miller- R.G.(1981): Survival Analysis.
5. Kalbfleisen, John Wiley, J. D. and Prentice R.T (1980): *The statistical Analysis of failure Data,* John Wiley.

Paper STA-3056: Practical

80+20 = 100 (6 credits)

All practical should be done by use of R/ Excel/ SPSS/ C

Topics from
Testing of Hypothesis (Inference 2),
Time Series, and
Multivariate Analysis.

FOURTH SEMESTER

Paper STA-4016: Non Parametric Statistical Inference and Semi Parametric methods and Decision Theory and Bayesian Inference

80+20 = 100 (6 credits)

First Half **40+10=50**

Non Parametric Statistical Inference and Semi Parametric methods

Unit 1:
Tests Based on Runs: Idea, Different lemmas E® and Var ®. Tests based on the length of longest run.
The Empirical distn function, Related theorems and corollaries. The kolmogorov-Smirnov (KS) one sample test Related theorems and applications.

Unit 2:
Kernel and symmetric kernel. Detailed study on one sample V statistic. The General two sample problem. The K.S two sample test, Maan-Whitney U test.

Unit 3:
Linear Rank statistics its distributional Propertics.
Wilcoxon tes. Kruskal – Wallis one way ANOVA test.

Unit 4:
Semi Parametric Methods:
Introduction to cox proportional hazard model. Partial likelihood, concepts of jackknifing and Bootstrapping with examples.

References:

1. Gibbons J.D (1985) Non Parametric Statistical Inference 2nd Ed. Marcel Dekker Inc.
2. Mukhopadhay P (1996) Mathematical Statistics New central Book Agency (Kolkata)
3. Seigel sidney : Non Parametric Statistics fore Behavioural Science Mc. Graw Hill.
4. Alho, J.M and Spencer B.D (2008). Statistical Demography and Forecasling Springer.

Second Half

Decision Theory and Bayesian Inference **40+10=50**

Unit 1:
Elements of Decision Theory: Introduction, Basic Concepts, Bayes and Minimax Decision rules. Different types of loss function. Estimation of Parameters: Bayes estimate and Minimax estimate. Point estimation, Interval estimation and Testing of Hypothesis as Decision Problem.

Unit 2:
Subjective and Frequentist Probability. Advantages of being Bayesian Bayes theorem. Subjective prior distribution of a parameter. Computation of posterior distribution. Natural Conjugate family of priorts for amodel. Hyper parameters of a prior form conjugate family. Conjugate families for (i) exponential familymodels, (ii) models admitting sufficient statistics of fixed dimension. Non informative, improper and invariant priors. Jeffrey's invariant prior. Bayesian point estimation: as a prediction problem from

posterior distribution. Bayes estimators for (i) absolute error loss, (ii) squared error loss, and (iii) 0-1 loss.

Unit 3:
Bayesian interval estimation: Credible intervals. High posterior density regions. Interpretation of the confidence coefficient of an interval and its comparison with the interpretation of the confidence coefficient of a classical confidence interval. Bayesian testing of Hypothesis: Specification of the appropriate form of the prior distribution for a Bayesian testing of hypothesis problem. Bayesian Computation: Analytic approach, E-M algorithm, MCMC, Gibbs sampling.

References:

1. An outline of Statistical Theory Vol.II: AM Gun, MK Gupta, B Dasgupta. World Press.
2. Mathematical Statistics: Parimal Mukhopadhyay: New Central Book Agency
3. Statistical Decision Theory and Bayesian Analysis: JO Berger, Springer Verlag
4. Bayesian Parametirc Inference. A K Bansal. Narosa Publishing House
5. An Introduction to Bayesian Analysis Theory and Methods. J K Ghosh, M Delampady and T. Samanta
6. Bayesian Statistics: An Introduction. Peter Lee. Arnold, London.

Paper STA-4026: Regression & Operations Research

80+20 = 100 (6 credits)

GROUP-A

Regression **28+7=35**

Multiple Regression: Univariate & Multivariate. Hypothesis Testing in multiple linear regression; Regression without intercept terms, use of R^2 & R^2 adjusted; Residual Analysis plots; Computational techniques for variable selection (without derivation) :- Stepwise regression, Mellows C_P statistic purpose & use; Multi-co linearity – effects, detection and remedies; Autocorrelation: consequences and tests.

References:

1. Introduction to Linear Regression Analysis Douglas C Montgomery, E. A Peck, G. Geoffrey Vining.
2. Econometrics – Johnston.

GROUP-B

Operations Research **52+13=65**

Linear Programming Problems **26+7 = 33**

(This is with the part called Operations Research that includes Game Theory)

Linear inequalities:
The general linear programming problem, Properties of the solutions to a linear programming problem.

Generation of extreme points development for an optimum feasible solution, the simplex algorithm, the artificial variable technique, the two – phase algorithm.
Duality in linear programming, the symmetric and asymmetric duals.
Application of linear programming, the assignment problem, the transportation problem.

Reference:

1. Gass SL. Linear Programming John Wiley.

Game Theory **26+6 = 32**

Introduction to Game theory: Two person Zero sum game; The minimax-Minimin Principle; saddle points; Game without saddle point; Pure and Mixed strategies; Solution procedure of 2 x 2 game; Graphical solution procedure; Equivalence of Rectangular game and linear programming.

***References*:**

1. Swarup, K and Gupta, P.K: Operation Research, Mac Mohan
2. Ravindran, A, Phillips, D.T and Slosberg, J.J. Operation Research
3. Hiller and Libermann : Operation Research:

Paper STA-4036: Demography and Statistics for National Development

80+20 = 100 (6 credits)

First Half

Demography **40+10=50**

Unit 1:
Demographic transition theory Idea of recent census, SRS, NFHS (III) (For India and Assam)
Coverage and content errors in demographic data use of balancing equns and Chandra Sekharan Deming formula, Adjustment of age data use of whipple, Myer indices.

Unit 2:
Life tables and its application Methods of construction of abridged life table (Greville and Chiang methods) Gompertz, Maklham curve. Fertility measures from cohort data. Stochastic modules for reproduction.

Unit 3:
Stable population model Population projection (component methods and Idea of Leslie matrix)

Unit 4:
Migration concept and Estimation National Population Policy.

References:

1. Methods and Materials of Demography Swason et al
2. Introduction to stochastic Processes in Bio Statistics-Chiang (1968) John Wiley
3. Keyfitz N. (1977) Applied Mathematical Demography, Springer Verlag.

Second Half

Statistics for National Development **40+10=50**

Unit-1:
Economic Development:: Estimation of National Income (Product approach, income approach, expenditure approach). Pareto's law of income distribution, log normal distribution, income inequality. Measuring inequality in incomes: Lorenz Curve, Gini coefficient, Theil's measure.

Unit 2:
Poverty measurement-different issues, measure of incidence and intensity, combined measures e.g. indices due to kakwani, Sen etc.

Unit 3:
Human Development: Indicators of Human a Development, major problems of Human Resource Devlopment. Human Development Index (HDI) and its variants. Gender Inequality in Human Resource Development - Exploration, Measurement and Incidence of Gender Inequality. Concept of Human Poverty Index (HPI).

Unit 4:
Population Theory: The Malthusian Theory of Population, Optimum Theory of Population, Theory of Demographic Transition, Population growth in developing and developed countries. Labour force Projection.

References:

1. CSO (1980): National Accounts Statistics-Sources and Health
2. Keyfitz N: Applied Mathematical Demography, Springer Verlag
3. Sen, A. (1997): *Poverty and Inequality*
4. Bhende A and Kanitkar R: Principles of Population Studies
5. UNESCO*: Principles for Vital Statistics Systems Series M-12*
6. UNDP Human Development Reports, Oxford University Press
7. Asian Development Bank: Asian Development Outlook.

Special Paper **(One)**

Paper STA-4046: Special Paper (Option A)

80+20 = 100 (6 credits)

Actuarial Statistics –II

GROUP-A

Introduction to pricing and reserving techniques in General Insurance

Joint insurance.
Reinsurance: deductibles, retention limits, proportional and excess of loss/stop-loss reinsurance.

Credibility Theory: credibility premium, credibility factor, Bayesian and empirical approaches, applications to credibility premiums for standard models.

Special topics: Experience rating, runoff triangles

GROUP-B

Life Insurance Mathematics-II

Actuarial Statistics: Life insurance, life annuities, net premiums, net premium reserves, mortality profit/loss and Theiele's equation.

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References:

1. Bowers et al. 1997. *Actuarial Mathematics*. Second Edition. Society of Actuaries.
2. Rob Kaas Marc Goovaerts, Jan Dhaene and Michel Denuit (2008) Modern Actuarial Risk Theory using R, Springer.
3. Trowbridge, C. L. (1989). Fundamental Concepts of Actuarial Science, Actuarial Education and Research Fund, USA.
4. Slud, E.V. (2001). Actuarial Mathematics and Life-Table Statistics, University of Maryland, USA.

Paper STA-4046: Special Paper (Option B)

80+20 = 100 (6 credits)

Bio-statistics –II

First Half

Statistical Genetics & Survival Analysis **40+10=50**

Statistical Genetics

Basic biological concepts in genetics (relevant to this course)
Mendel's law, Hardy Weinberg equilibrium. Mating tables, estimation of allele frequency (dominant/ co-dominant cases). Approach to equilibrium for X-linked gene, natural selection, mutation, genetic drift, equilibrium when both natural selection and mutation are operative.

Survival Analysis
Basic concepts of survival time distributions, brief idea of some survival distributions, detailed discussion on censoring and truncation.
Non-parametric estimation of basic qualities for right censored data – Product limit estimator, Nalson-Aalen estimator.
Two sample problem – Gahen's generalized Wilcoxon test, The Cox-Mantel test, The log Rank test.

Second Half

Clinical Trials **40+10=50**

Introduction: The rational of Clinical trials. The Historical Development of Clinical trials.
Organization and Planning. The Justification of Randomized Controlled Trails.
Methods of Randomization: Stratified randomization, Unequal randomization Blinding and Placebos.
Crossover Trails. The size of a clinical trial. Monitoring Trial progress.
Forms and Data management. Protocol Deviations.
Basic Principles of Statistical Analysis: Describing the data, Significance tests, estimation and confidence limits. Publication and interpretation of findings.

References:

1. Clinical Trials: A Practical Approach: S. J. Pocock. John Wiley & Sons. 1986
2. Fundamentals of Clinical Trials: L M Friedman, C D Furberg, and D L DeMets. Springer. 1999.

Paper STA-4046: Special Paper (Option C)

80+20 = 100 (6 credits)

Computational Mathematics

(*Those who have taken Data Mining in 3rd Semester as Special paper will have to take this paper as Optional paper in 4th Semester*)

Unit 1: Elementary Theory of Errors

Sources and Classification of Errors, Valid Significant Digits, Errors of sums, differences, products and quotients, Errors of powers and roots.

Unit 2: Matrix Algebra

Step Matrices and Operations involving them, Inversion of matrices by Partitioning into Blocks, The Algorithm of Successive Bordering; Krylov's algorithm of Expansion of a Characteristic Determinant, Krylov's algorithm of computing eigenvectors, The Leverrier-Faadeev algorithm, Danilevsky's algorithm of finding eigenvectors, Iterative algorithm of finding the First Eigenvalue of a matrix.

Unit 3: System of Linear Equations

Basic Elimination Algorithm, Gaussian Elimination Scheme, Gauss-Jordan Algorithm, Cholesky's algorithm, Iterative Scheme or the Algorithm of Successive Approximation, Seidel's Algorithm.

Unit 4: Nonlinear Equations

Method of Chords, Newton's method, Combination of the Method of Chords and Newton's Method, Algorithm of two-point Interpolation, The algorithm of False Positions, Horner's algorithm, Determination of number of real roots of an algebraic equation.

Unit 5: Interpolation and Extrapolation

Approximation theory, Polynomial interpolation, Lagrange's Interpolating Polynomial, Newton's Interpolating Polynomial, Aitken's Iterated Interpolation, Optimal-Interval Interpolation, Trigonometric Interpolation, Backward Interpolation.

Unit 6: Numerical Differentiation and Integration

Basic Formulas of Numerical Differentiation, Peculiarities of Numerical Differentiation, basic Quadrature Formulae, Newton-Cotes Quadrature, Compounded Quadrature.

Unit 7: Ordinary Differential Equation

Method of Successive Approximation, Euler's Method, Euler-Cauchy Algorithm, Successive Euler-Cauchy Algorithm, R-K Algorithm, Adam's algorithm, Milne's algorithm, Second Order differential equation, Boundary Value Problems.

References:

1. Danilina, W. I, Dubrovska'ya, N.S, Kvasha, O.P and Smirnov: *Computational Mathematics*, Mir Publishers, Moscow.
2. Jain, M.K, Iyenger, S.R.K and Jain, R.K: *Scientific and Engineering Computation*, New Age International (P) Ltd., Guwahati
3. Atkinson, K: *Elementary Numerical Analysis*, Wiley, N.Y.
4. Burden, R.L and Fairs, J.D: *Numerical Analysis*, PWS, Kent.

Paper STA-4046: Special Paper (Option D)

80+20 = 100 (6 credits)

Demography (II)

Unit 1

Theory of stable population,One sex model. Concept of stationary, stable and quasi stable population

Unit 2:

Multistate Demography. Multistate life tables, Multiregional life tables, Multiregional stable population.

Unit 3:

Methods of estimating basic demographic measures from incomplete data, Brass two parameter logit system, Nuptiality; Different measures nuptiality tables- net and gross Hanjal's method.

Unit 4:

Migration: Internal and international migration. Models for migration. Stochastic models for migration and for social and occupational mobility based on Markov Chain.

Unit 5:

Discrete Branching Process: Basic theory, Probability of extinction, Branching process as a population model. Survival Distribution.

Unit 6: Idea of sample area sampling use of poisson process in Demography

References:

1. Shryock, H. S, Seigal, J. S and Associates (1997) *Methods and Materials of Demography*, Academic Press Inc., London
2. Chiang, C. L (1968) *Introduction to Stochastic Process in Biostatistics*, John Wiley
3. Keyfitz, N (1977) *Applied Mathematical Statistics*, Springer Verlag.
4. Cox P. R (1970*) Demography*, Cambridge University Press
5. Spiegelman, M (1969) *Introduction to Demographic Analysis*, Harvard University Press.
6. Namboodiri and Suchindran (1986) –Life Table and its applications Academic Press.

Paper STA-4046: Special Paper (Option E)

80+20 = 100 (6 credits)

Econometrics (II)

Unit1: Errors in variables

Lagged variables & Qualitative –dependent variables. Distributed lag models.

Unit2: Simultaneous Equation Models

consequences of simultaneous relations-simultaneous bias (simultaneous equation bias) & its solution; Reduced form method or Indirect Least Squares (ILS). Identification problems- rules of identification, identifying restrictions, Tests for identification.

Unit3: Simultaneous equation methods:

Reduced form method or Indirect Least Squares (ILS), Method of instrumental variable (IV), Recursive System, Two-stage Least Squares (2SLS), K-class Estimators, Three stage Least Squares (3SLS).

Unit4: Mixed Estimation Methods

Restricted Least Squares (RLS), Method of principal components. Maximum Likelihood Methods (MLM), Limited Information Maximum Likelihood (LIML), Full Information Maximum Likelihood (FIML).

References:

1. *Econometric Methods* by J. Johnston, International Student Edition (3rd Ed.).
2. *Theory of Econometrics* by A. Koutsoyiannis, Macmillan.
1. 3. *Quantitative Techniques in Econometrics* by K. Bez, Kalyani Publishers, New Delhi-Ludhiana.
3. *Principles of Econometrics* by Henri Theil, John Wiley & Sons.
4. *Introduction to Econometrics (Principles and Application)* by G. M. K. Madani, Oxford & IBH Publications, 6th Ed.
5. *Elements of Econometrics* by Kmanta Jan, The Macmillan Co., New York.
6. *Regression & Econometric Methods* by Huang D, john Wiley & Sons, New York.
7. *Basic Econometrics* by Damodar N. Gujarati, McGraw Hill International Edition, 2nd Ed.

Paper 4.4: Special Paper (Option F)

80+20 = 100 (6 credits)

Paper 4.4: Operation Research (II)

Reliability Theory:

Unit 1: Concept and Measures

Unit 2: Notion of Ageing, Hazard rate, IFR and DFR distributions and related Theorems

Unit 3: Structure Function, Coherent Systems, Component and Systems, Cuts And Paths, Reliability of Coherent Systems.

Unit 4: Life distributions (Exponential, Gamma, Weibull etc.)

Unit 5: Stress- Strength Model.

Unit 6: Replacement and Maintenance Policies, System Reliability under Markovian setup (Series, Parallel and Multistate systems) , Repairable Systems and their Availability.

Unit 7: Life Testing Problems, Censoring and Truncated cases, Estimation of Average Life, Discussion of different procedure followed in life testing Experiments related to Exponential, Weibull and Gamma Distributions, Bayesian Inference in Reliability theory.

References:

1. Barlow, R.E,Proschan,F(1980) Statistical Theory of Reliability and LifeTesting, Holt, Rinehart and Winston.
2. Lawless, J. F (1982) Statistical Models and Methods of Life Time Data, John Wiley.
3. Bain L.J and Engelhardt (1991) Statistical Analysis of Reliability and Life Testing Models, Marcel Dekker.
4. Nelson W. (1982) Applied Life Data Analysis, John Wiley.
5. Zacks S. Reliability Theory, Springer

Paper STA-4046: Special Paper (Option G)

80+20 = 100 (6 credits)

Survival Analysis (II)

Unit 1:
Test of exponentiality against non-parametric classes- total time on test. Deshpande test.

Unit 2:
Two sample problem- Gehan test, Log rank test. Mantel- Hanzel test, Tarone-Ware.

Unit 3:
Semi parametric regression for failure rate- Cox's proportional hazard model with one and several covariates. Rank test for the regression coefficient.

Unit 4:
Competing risks model, parametric non-parametric inference for this model.

Unit 5:
Multiple decrement life table.

References:

1. Cox D. R. And Oakes (1984): Champman and Hall. New York.
2. Gross A. J. and Clark V. A. (1975): *Survival distribution: Reliability analysis in Biomedical sciences* John Wiley and Sons.
3. Elandt- Johnson, R. E. Johnson N.L.: *Survival models and Data Analysis*, John Wiley and sons.
4. Miller- R.G.(1981): Survival Analysis.
5. Kalbfleisen, John Wiley, J. D. and Prentice R.T (1980): *The statistical Analysis of failure Data,* John Wiley.

Paper STA-4056: Project

80+20 = 100 (6 credits)

Projects should be done by the use of R/ Excel/ SPSS/ C.

Supervisor's internal Mark	40
External Examiner's Mark	40
Internal Assessment	20