STATE MODEL SYLLABUS FOR UNDER GRADUATE COURSE IN STATISTICS (Bachelor of Arts Examination)

UNDER

CHOICE BASED CREDIT SYSTEM

STATISTICS

Semester		CORE COURSE (14)	Ability Enhancement Compulsory Course (AECC) (2)	Skill Enhancement Course(SEC)	Elective: Discipline Specific DSE (4)	Elective: Generic (GE) (4)
I	CC 1	Descriptive Statistics	English Communication/ Odia/ Hindi	**SEC -II**		**GE-I** Statistical Methods
	CCII	Algebra				
II	CCIII	Probability and Probability	Environmental Studies			**GE-II** Introductory Probability
	CCIV	Calculus				
III	CCV	Sampling Distributions		**SEC -I**		**GE-III** Basics of Statistical Inference
	CCVI	Survey Sampling & Indian Official Statistics				
	CCVII	Mathematical Analysis				
IV	CCV III	Statistical Inference				**GE- IV** Applied Statistics
	CCIX	Linear Model				
	CCX	Statistical Quality Control				
V	CCXI	Stochastic Process & Queuing Theory			**DSE-I** Operations Research	
	CCX II	Statistical Computing Using C & R Programming			**DSE-II** Time Series Analysis	
VI	CCX III	Design Of Experiments			**DSE-III** Demography And Vital Statistics	
	CC XIV	Multivariate Analysis And Non Parametric Methods			**DSE-IV** Project Work / Econometrics	

STATISTICS-Honours

Core course – 14 papers, Discipline Specific Elective – 4 papers , Skill Enhancement Course-1(SEC-1)paper (out of the 2 papers)
Generic Elective for Non Statistics students – 4 papers. Incase University offers 2 subjects as GE, thenpapers 1 and 2 will be the GE paper.

Marks per paper - Midterm: 15 marks, End term: 60 marks, Practical:25 Total – 100 marks
Credit perpaper – 6 , Teaching hours per paper – 50 hours + 10 hours tutorial

PROGRAMME OBJECTIVES

The objectives of a 3 years (6 Semester) B.A./B.Sc. Statistics programme is:

1. To instill and cultivate the ability to use statistical methods in a variety of data-generating professions for real-world issues.
2. To teach students how to use software and programming languages to manage big data collections and do data analysis.
3. To impart a broad range of statistical skills, such as project management, problem-solving, and presentation, to prepare students for leadership positions in a variety of fields of study and industry.

CORE COURSES

CC-I: DESCRIPTIVE STATISTICS

Course Objectives: The learning objectives include:

1. Introduction of basic concept of statistics such as population, sample, presentation of data in tabular as well as in graphical manner.
2. Understanding the nature of data with the help of various statistical tools.
3. Introduction of correlation, regression and concept on fitting of curves.
4. To know the fundamental aspect of index numbers.

Course Outcomes (CO): After completion of this course, student will be able to understand -

1. The meaning of statistical population and sample.
2. Measures of location and dispersion.
3. Bivariate data, Significance of various coefficients of correlation.
4. Fitting of linear and nonlinear curve.
5. Construction of index numbers.

UNIT-I

Statistical Methods: Definition and scope of Statistics, concepts of statistical population and sample. Data: quantitative and qualitative, attributes, variables, scales of measurement nominal, ordinal, interval and ratio. Presentation: tabular and graphical, including histogram and ogives, consistency and independence of data with special reference to attributes.

UNIT-II

Measures of Central Tendency: mathematical and positional. Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation, Moments, absolute moments, factorial moments, skewness and kurtosis, Sheppard's corrections.

UNIT-III

Bivariate data: Definition, scatter diagram, simple, partial and multiple correlation (3 variables only), rank correlation. Simple linear regression, principle of least squares and fitting of polynomials and exponential curves.

UNIT-IV

Index Numbers: Definition, construction of index numbers and problems thereof for weighted and unweighted index numbers including Laspeyre's, Paasche's, Edgeworth- Marshall and Fisher's Ideal Index numbers. Errors in Index numbers. Chain index numbers, conversion of fixed based to chain based index numbers and vice-versa. Consumer price index numbers. Uses and limitations of index numbers.

TEXT BOOKS:

1. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edn. TheWorld Press, Kolkata.
2. Gupta, S. C. and Kapoor, V.K. (2008): Fundamentals Of Mathematical Statistics, 4thEdition (Reprint),Sultan Chand &Sons

SUGGESTED READINGS:

1. Miller, Irwin and Miller, Marylees(2006): John E.Freund's Mathematical Statistics with Applications,(7th Edn.), Pearson Education, Asia.
2. Mood, A.M. Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn.,(Reprint), Tata McGraw-Hill Pub. Co.Ltd.
3. Mukhopadhyay, P. (1999): Applied Statistics, New Central Book Agency,

LIST OF PRACTICALS:

1. Graphical representation of data.
2. Problems based on measures of central tendency.
3. Problems based on measures of dispersion.
4. Problems based on moments, skewness and kurtosis.
5. Karl Pearson and rank correlation coefficient.
6. Lines of regression, angle between lines and estimated values of variables.
   Calculate price and quantity index numbers using simple and weighted average of price relatives.

CC-II: ALGEBRA

Course Objectives: The learning objectives include:

1. Introduction of fundamental concepts of algebra.
2. Enhancement to learn the basic ideas of abstract algebra and techniques with proof in pure mathematics and further, it can be used in many other courses.

Course Outcomes (CO): After completion of this course, student will

1. Use the basic concepts of vector and matrix algebra, including linear dependence / independence, basis and dimension of a subspace, rank and nullity, for analysis of matrices and systems of linear equations.
2. Evaluate determinants and use them in solution to the system of linear equations.
3. Use the characteristic polynomial to compute the characteristic roots and characteristic vectors of a square matrix and use them in Cayley Hamilton theorem.

UNIT-I

Theory of equations, statement of the fundamental theorem of algebra and its consequences. Relation between roots and coefficients or any polynomial equations. Vector spaces, Subspaces, sum of subspaces, Span of a set, Linear dependence and independence, dimension and basis.

UNIT-II

Algebra of matrices - A review, theorems related to triangular, symmetric and skew symmetric matrices, idempotent matrices, Hermitian and skew Hermitian matrices, orthogonal matrices, singular and non- singular matrices and their properties. Trace of a matrix, unitary, involutory and nilpotent matrices.

UNIT-III

Determinants of Matrices: Definition, properties and applications of determinants for 3rd and higher orders, evaluation of determinants of order 3 and more using transformations. Adjoint and inverse of a matrix and related properties. Use of determinants in solution to the system of linear equations, row reduction and echelon forms, the matrix equations AX=B, solution sets of linear equations. Applications of linear equations.

UNIT-IV

Rank of a matrix, row-rank, column-rank, standard theorems on ranks, rank of the sum and the product of two matrices. Characteristic roots and Characteristic vector, Properties of characteristic roots, Cayley Hamilton theorem, and Quadratic forms.

TEXT BOOKS:

1. Gorakh Prasad: Differential Calculus, Pothishala Pvt. Ltd., Allahabad.
2. Gorakh Prasad: Integral Calculus, Pothishala Pvt. Ltd., Allahabad.

SUGGESTED READINGS:

1. Zafar Ahsan: Differential Equations and their Applications, Prentice-Hall of India Pvt. Ltd., NewDelhi (2nd Edition-2004).
2. Piskunov, N: Differential and Integral Calculus, Peace Publishers, Moscow.
3. Differential calculus by Das & Mukherjee, U.N Dhar Publication, Kolkatta, 2010.
4. Integral Calculus by Das & Mukherjee, U.N Dhar Publication, Kolkatta,2010.
5. Advanced Differential Equations by Md Raisinghania, S Chand & Company Pvt Ltd

LIST OF PRACTICALS:

1. Determination of Maxima &Minima
2. Using definite integral obtained the area under curve
3. Applications of differential equations
4. Applications Partial differential equations
5. Applications of Beta and Gamma function

CC-III: PROBABILITY AND PROBABILITY DISTRIBUTIONS

Course Objectives: The learning objectives include:

1. Introduction of concept of probability.
2. The concept of random variables and its functions.
3. Introduction of probability distributions.

Course Outcomes (CO): After completion of this course, student will have the clear understanding of

1. The theory of probability and its applications.
2. Calculation of probabilities relevant to multivariate distributions, including marginal and conditional probabilities and the covariance of two random variables.
3. The mathematical expectation and calculation of generating functions.
4. Recognize common probability distributions for discrete and continuous variables.

UNIT-I

Probability: Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability – classical, statistical, and axiomatic. Conditional Probability, laws of addition and multiplication, independent events, theorem of total probability, Bayes' theorem and its applications

UNIT-II

Random variables: discrete and continuous random variables, p.m.f., p.d.f. and c.d.f., illustrations and properties of random variables, univariate transformations with illustrations. Two dimensional random variables: discrete and continuous type, joint, marginal and conditional p.m.f, p.d.f., and c.d.f., independence of variables.

UNIT-III

Mathematical Expectation and Generating Functions: Expectation of single and bivariate random variables and its properties. Moments and Cumulants, moment generating function, cumulant generating function and characteristic function. Uniqueness and inversion theorems (without proof) along with applications. Conditional expectations.

UNIT-IV

Standard discrete probability distributions: Uniform, Binomial, Poisson, geometric, along with their properties and limiting/approximation cases. Standard continuous probability distributions: uniform, normal, exponential, beta and gamma along with their properties and limiting/approximation cases.

TEXT BOOKS:

1. Hogg,R.V.,Tanis,E.A.andRaoJ.M.(2009):ProbabilityandStatisticalInference, Seventh Ed, Pearson Education, NewDelhi.
2. Gupta, S. C. and Kapoor, V.K. (2008): Fundamentals Of Mathematical Statistics, 4thEdition (Reprint),Sultan Chand &Sons

SUGGESTED READINGS:

1. Miller,IrwinandMiller,Marylees(2006):JohnE.Freund'sMathematicalStatistics with Applications, (7thEdn.), Pearson Education,Asia.
2. Mood, A.M. Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn.,(Reprint), Tata McGraw-Hill Pub. Co.Ltd.
3. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I, 8th Edn. TheWorld Press,Kolkata.
4. Myer, P.L. (1970): Introductory Probability and Statistical Applications, Oxford & IBH Publishing,New Delhi

LIST OF PRACTICALS:

1. Fitting of binomial distributions
2. Fitting of Poisson distributions
3. Fitting of Normal distributions
4. Application problems based on binomial, Poisson and Normal distributions.

CC-IV: CALCULUS

Course Objectives: The aim of this course is

1. To compute and analyze limits, derivatives and integral functions.
2. To recognize the appropriate tools of calculus to solve applied problems.

3.

Course Outcomes (CO): After completion of this course, student will -

1. Understand the type of variable and useful in the development of the function.
2. Verify the value of the limit of a function at a point using the definition of the limit.
3. Understand the consequences of the Intermediate value theorem for continuous function.
4. Find derivatives of composite functions and obtain expression for higher order derivatives of a function using the rule of differentiation. Solve integrals and evaluation of multiple integrals with numerical problems.
5. Know the solution of differential equations and find the solution of different partial differential equations of first order.

UNIT-I

Differential Calculus: Limits of function, continuous functions, properties of continuous functions, partial differentiation and total differentiation (two variables). Indeterminate forms: L-Hospital's rule, Leibnitz rule for successive differentiation. Euler's theorem on homogeneous functions. Maxima and minima of functions of one and two variables. Transformations and Jacobians.

UNIT-II

Integral Calculus: Review of integration and definite integral. Differentiation under integral sign, double integral. Beta and Gamma functions: properties and relationship between them.

UNIT-III

Differential Equations: Exact differential equations, Integrating factors, change of variables, Total differential equations, Differential equations of first order and first degree, Differential equations of first order but not of first degree, Equations of the first degree in x and y, Clairaut's equations. Higher Order Differential Equations. Homogeneous differential equations of order n with constant coefficients.

UNIT-IV

Formation and solution of a partial differential equations. Equations easily integrable. Linear partial differential equations of first order. Homogeneous linear partial differential equations with constant coefficients. Different cases for complimentary functions and particular integrals.

TEXT BOOKS:

1. Krishnamurthy V., Mainra V.P. and Arora J.L.: An Introduction to Linear Algebra (II, III, IV, V).

SUGGESTED READINGS:

1. Biswas, S. (1997): A Textbook of Matrix Algebra, New Age International,1997.
2. Gupta S.C.: An Introduction to Matrices (Reprint). Sultan Chand & Sons,2008.
3. Datta K.B.: Matrix and Linear Algebra. Prentice Hall of India Pvt. Ltd.,2002.
4. Hadley G.: Linear Algrbra. Narosa Publishing House (Reprint),2002.
5. Searle S.R.: Matrix Algebra Useful for Statistics. John Wiley &Sons.,1982.
6. Schaum'sOutlines : Linear Algebra, Tata McGraw-Hill Edition, 3rdEdition,2006.

LIST OF PRACTICALS

1. Finding roots of an algebraic equations
2. Solution of linear equations by matrix method.

3. Rank and Inverse of a matrix
4. Characteristics roots and characteristics vector of a matrix.
5. Applications of matrices.

CC-V: SAMPLING DISTRIBUTIONS

Course Objectives: The learning objectives include:

1. Introduction of limit laws in probability and their applications in real life situations.
2. Understanding the concept of testing of hypothesis and their applications in various sampling distributions.

Course outcomes (CO): After completion of this course, student will

1. Understand the concept of convergence, common methods for evaluating an inequalities performance and test of significance. Understand the central limit theorem and large-sample approximations for common statistics.
2. Know the significance of testing of hypothesis using various sampling distributions and their applications in the various fields.
3. Formulate null and alternative hypotheses and apply small, large sample and non-parametric tests in real life problems.

UNIT-I

Limit laws: convergence in probability, almost sure convergence, convergence in mean square and convergence in distribution and their interrelations, Chebyshev's inequality, W.L.L.N., S.L.L.N. and their applications, De-Moivre Laplace theorem, Central Limit Theorem (C.L.T.) for i.i.d. variates, applicationsof C.L.T.

UNIT-II

Definitions of random sample, parameter and statistic, sampling distribution of a statistic, sampling distribution of sample mean, standard errors of sample mean, sample variance and sample proportion. Nulland alternative hypotheses, level of significance, Type I and Type II errors, their probabilities and critical region. Large sample tests for testing single proportion, difference of two proportions, single mean, difference of two means, standard deviation and difference of standard deviations by classical and p-valueapproaches.

UNIT-III

Exact sampling distribution: Definition and derivation of p.d.f. of $\chi 2$ with n degrees of freedom (d.f.)using m.g.f., nature of p.d.f. curve for different degrees of freedom, mean, variance, m.g.f., cumulant generating function, mode, additive property and limiting form of $\chi 2$ distribution. Tests of significanceand confidence intervals based on $\chi 2$ distribution.

UNIT-IV

Exact sampling distributions: Student's and Fishers t-distribution, Derivation of its p.d.f., nature of probability curve with different degrees of freedom, mean, variance, moments and limiting form of distribution. Snedecore's F-distribution: Derivation of p.d.f., nature of p.d.f. curve with different degrees of freedom, mean, variance and mode. Relationship between t, F and $\chi 2$ distributions. Test of significance and confidence Intervals based on t and F distributions.

TEXT BOOKS:

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2003): An Outline of Statistical Theory, Vol. I, 4thEdn. World Press, Kolkata.

SUGGESTED READINGS:

1. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2ndEdn.(Reprint) John Wiley and Sons.
2. Hogg, R.V. and Tanis, E.A. (2009): A Brief Course in Mathematical Statistics. Pearson Education.
3. Johnson, R.A. and Bhattacharya, G.K. (2001): Statistics-Principles and Methods, 4th Edn. John WileyandSons.
4. Mood, A.M., Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn.(Reprint).Tata McGraw-Hill Pub. Co.Ltd.

LIST OF PRACTICALS:

1. Testing of significance and confidence intervals for single proportion and difference of twoproportions
2. Testing of significance and confidence intervals for single mean and difference of two means andpaired tests.
3. Testing of significance and confidence intervals for difference of two standard deviations.
4. Exact Sample Tests based on Chi-Square Distribution.
5. Testing if the population variance has a specific value and its confidence intervals.
6. Testing of goodness off it.
7. Testing of independence of attributes.
8. Testing based on 2 X 2 contingency table without and with Yates'corrections.
9. Testing and confidence intervals of equality of two population variances.

CC-VI: SURVEY SAMPLING & INDIAN OFFICIAL STATISTICS

Course Objectives: The aim of this course is

1. To learn scientific aspects of sample survey.
2. To Learn variety of probability and non-probability sampling methods for selecting a sample from a population.
3. To know the present official statistical system in India.

Course outcomes (CO): After completion of this course, student will

1. Understand the basic principles underlying survey design and estimation.
2. Apply the different sampling methods such as simple random sampling, stratified sampling, systematic sampling and cluster sampling for designing and selecting a sample from a population.
3. Apply ratio, regression methods of estimation and cluster sampling to real-world issues.
4. Understand the concept of errors in survey sampling.
5. Determine the sample size and the effects of different types of sampling designs on confidence intervals.
6. Know the importance of various statistical offices in India.

UNIT-I

Concept of population and sample, complete enumeration versus sampling, sampling and non-sampling errors. Types of sampling: non-probability and probability sampling, basic principle of sample survey, simple random sampling with and without replacement, definition and procedure of selecting a sample, estimates of: population mean, total and proportion, variances of these estimates, estimates of their variances and sample size determination.

UNIT-II

Stratified random sampling: Technique, estimates of population mean and total, variances of these

estimates, proportional and optimum allocations and their comparison with SRS. Practical difficulties in allocation, estimation of gain in precision. Systematic Sampling: Technique, estimates of population mean and total, variances of these estimates (N=nxk). Comparison of systematic sampling with SRS and stratified sampling in the presence of linear trend and corrections.

UNIT-III

Introduction to Ratio and regression methods of estimation, first approximation to the population mean and total (for SRS of large size), variances of these estimates and estimates of these variances, comparison with SRSWOR. Cluster sampling (equal clusters only) estimation of population mean and its variance

UNIT-IV

Present official statistical system in India, Methods of collection of official statistics, their reliability and limitations. Role of Ministry of Statistics & Program Implementation (MoSPI), Central Statistical Office (CSO), National Sample Survey Office (NSSO), and National Statistical Commission. Government of India's Principal publications containing data on the topics such as population, industry and finance

TEXT BOOKS:

1. Sukhatme,P.V., Sukhatme,B.V. Sukhatme,S. Asok,C.(1984). Sampling Theories of Survey WithApplication, IOWA State University Press and Indian Society of Agricultural Statistics
2. Guide to current Indian Official Statistics, Central Statistical Office, GOI, New Delhi.

SUGGESTED READINGS:

1. Cochran W.G. (1984):Sampling Techniques(3rd Ed.), Wiley Eastern.
2. Murthy M.N. (1977): Sampling Theory & Statistical Methods, Statistical Pub. Society, Calcutta.
3. Des Raj and Chandhok P. (1998): Sample Survey Theory, Narosa Publishing House.
4. Goon A.M., Gupta M.K. and Das gupta B. (2001): Fundamentals of Statistics (Vol.2), World Press.

LIST OF PRACTICALS:

1. To select a SRS with and without replacement.
2. For a population of size 5, estimate population mean, population mean square and population variance.Enumerate all possible samples of size 2 by WR and WOR and establish all properties relative to SRS.
3. For SRSWOR, estimate mean, standard error, the sample size
4. Stratified Sampling: allocation of sample to strata by proportional and Neyman's methods Comparethe efficiencies of above two methods relative to SRS
5. Estimation of gain in precision in stratified sampling.
6. Comparison of systematic sampling with stratified sampling and SRS in the presence of a linear trend.
7. Ratio and Regression estimation: Calculate the population mean or total of the population. Calculatemean squares. Compare the efficiencies of ratio and regression estimators relative to SRS.
8. Cluster sampling: estimation of mean or total, variance of the estimate, estimate of intra-classcorrelation coefficient, efficiency as compared to SRS.

CC-VII: MATHEMATICAL ANALYSIS

Course Objectives: The aim of the course is to

1. Introduce the basic ideas of real analysis, such as sequences and series of real numbers, as well as the continuity, differentiability, and convergence of real valued functions.
2. Acquire knowledge of the fundamentals of numerical integration and analysis.

Course Outcomes (CO): After completion of this course, student will

1. Explain the basic characteristics of real numbers that constitute the basis for real analysis's formal development.
2. Understand the rigorous reasoning that develops the theory that forms the basis of actual analysis.
3. Comprehend the limits and how to apply them to differentiation, integration, series, and sequences.
4. Know the different interpolation formulae and numerical integration rules and their mathematical justifications for fundamental findings in practical analysis.
5. Apply rigorous mathematical analytical techniques and an understanding of abstract concepts to address real-world issues.

UNIT-I

Real Analysis: Representation of real numbers as points on the line and the set of real numbers as completeordered field. Bounded and unbounded sets, neighborhood sand limit points, Superimum and infimum, open and closed sets, sequences and their convergence. Infinite series, positive termed series and their convergence, Comparison test, D'Alembert's ratio test, Cauchy's nth root test, Raabe'stest. Gauss test, Cauchy's condensation test and integral test (Statements and Examples only).

UNIT-II

Review of limit, continuity and differentiability, uniform Continuity and bounded ness of a function. Rolle's and Lagrange's Mean Value theorems. Taylor's theorem with lagrange's and Cauchy's form of remainder(without proof). Taylor's and Maclaurin's series expansions.

UNIT-III

Numerical Analysis: Factorial, finite differences and interpolation. Operators, E and divided difference. Newton's forward, backward and divided differences interpolation formulae. Lagrange's interpolation formulae. Central differences, Gauss and Stirling interpolation formulae.

UNIT-IV

Numerical integration. Trapezoidal rule, Simpson's one-third rule, three-eights rule, Weddle's rule with error terms. Stirling's approximation to factorial n. Solution of difference equations of first order.

TEXT BOOKS:

1. Malik S.C. and Savita Arora: Mathematical Analysis, Second Edition, Wiley Eastern Limited, NewAge International Limited, New Delhi,1994.
2. Goel B. S. and Mittal S. K. : Numerical Analysis, Pragati Prakashan, ND,2008

SUGGESTED READINGS:

1. Somasundram D. and Chaudhary B.: A First Course in Mathematical Analysis, Narosa PublishingHouse, New Delhi,1987.
2. Shanti Narayan: A course of Mathematical Analysis, 12th revised Edition, S. Chand & Co. (Pvt.) Ltd.,New Delhi,1987.
3. Singal M.K. and Singal A.R.: A First Course in Real Analysis, 24th Edition, R. Chand & Co., NewDelhi,2003.

4. Bartle,R.G.andSherbert,D.R.(2002):Introduction to Real Analysis(3rdEdition), John Wiley and Sons(Asia) Pte. Ltd.,Singapore.
5. Jain,M. K., Iyengar, S. R. K. and Jain, R. K. (2003): Numerical methods for scientific and engineeringcomputation, New age International Publisher, India.

LIST OF PRACTICALS

1. Interpolation with equal and unequal intervals.
2. Problems on Lagrange's interpolation
3. Numerical Integration (Trapezoidal, Simpson's and Weddle's method)
4. Stirling's approximation

CC-VIII: STATISTICAL INFERENCE

Course Objectives: The aim of the course is to

1. Determine appropriate point estimators for the parameters of a random variable's distribution and provide a precision measure for them.
2. Acquire computational abilities to use diverse statistical inferential methodologies.

Course outcomes (CO): After completion of this course, student will

1. Understand the notion of point estimation and the concept of MVUE, MVB estimators.
2. Obtain the sufficient statistic, minimal sufficient statistic, M.L.E, moment estimator of the parameter.
3. Formulate null and alternative hypotheses and apply small, large sample and non-parametric tests in real life problems.
4. Understand the SPRT and its fundamental aspects in practice.

UNIT-I

Estimation: Concepts of point estimation, Criterion of a good estimator, unbiasedness, sufficiency, consistency and efficiency. Factorization theorem. Complete statistic. Minimum variance unbiased estimator (MVUE), Rao-Blackwell and Lehmann-Scheffe theorems and their applications. Cramer-Rao inequality and MVB estimators (statement and applications).

UNIT-II

Methods of Estimation: Method of moments, method of maximum likelihood estimation, method of minimum Chi-square, basic idea of Bayes estimators

UNIT-III

Principles of test of significance: Null and alternative hypotheses (simple and composite), Type-I and Type-II errors, critical region, level of significance, size and power, best critical region, most powerful test, uniformly most powerful test, Neyman Pearson Lemma (statement and applications to construct mostpowerful test). Likelihood ratio test, properties of likelihood ratio tests (without proof).

UNIT-IV

Sequential Analysis: Sequential probability ratio test (SPRT) for simple vs simple hypotheses. Fundamental relations among α, β, A and B, determination of A and B in practice. Wald's fundamental identity and the derivation of operating characteristics (OC) and average sample number (ASN) functions,examples based on binomial and normal distributions.

TEXT BOOKS:

1. Goon A.M., Gupta M.K.: Das Gupta.B. (2005), Fundamentals of Statistics, Vol. I,

World Press,Calcutta.
2. Gun, A.M., Gupta, M.K. and Dasgupta, B.: An Outline of Statistical Theory, Vol.II, (4^{th}ed.), WorldPress.

SUGGESTED READINGS:

1. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2ndEdn.(Reprint) John Wiley and Sons.
2. Miller, I. and Miller, M. (2002) : John E. Freund's Mathematical Statistics (6^{th} addition, low priceedition), Prentice Hall ofIndia.
3. Dudewicz, E. J., and Mishra, S. N. (1988): Modern Mathematical Statistics. John Wiley &Sons.
4. Mood A.M, Graybill F.A. and Boes D.C,: Introduction to the Theory of Statistics, McGrawHill.
5. Bhat B.R, Srivenkatramana T and Rao Madhava K.S. (1997) Statistics: A Beginner's Text, Vol. I,New Age International (P)Ltd.

LIST OF PRACTICALS:

1. Unbiased estimators (including unbiased but absurd estimators)
2. Consistent estimators, efficient estimators and relative efficiency of estimators.
3. Maximum Likelihood Estimation
4. Most powerful critical region (NPLemma)
5. Uniformly most powerful critical region
6. Unbiased critical region
7. Power curves
8. OC function and OC curve , ASN function and ASN curve

CC-IX: LINEAR MODEL

Course Objectives: The aim of the course is

1. To have a better comprehension of the limits of the linear and non-linear regression models.
2. To acquire the skills necessary to create regression models and apply them appropriately to the particular viewpoint data.

Course Outcomes (CO): After completion of this course, student will

1. Use a simple linear regression model with real-world examples.
2. Know theory of linear estimation and the use of least square methods.
3. Gain an understanding of normality, homoscedasticity, collinearity and multiple linear regression models with applications.
4. Analyse and validate the model and examine the residual diagnostic.

UNIT-I

Gauss-Markov set-up: Theory of linear estimation, Estimability of linear parametric functions, Method of least squares, Gauss-Markov theorem, Estimation of error variance.

UNIT-II

Regression analysis: Simple regression analysis, Estimation and hypothesis testing in case of simple and multiple regression models, Concept of model matrix and its use in estimation.

UNIT-III

Analysis of variance: Definitions of fixed, random and mixed effect models, analysis of variance and covariance in one-way classified data for fixed effect models, Analysis of variance and covariance in two-way classified data with one observation per cell for fixed effect models.

UNIT-IV

Model checking: Prediction from a fitted model, Violation of usual assumptions concerning normality, Homoscedasticity and collinearity, Diagnostics using quantile- quantile plots.

TEXT BOOKS:

1. Draper, N.R. and Smith, H.: Applied Regression Analysis, John Wiley &Sons.
2. Sengupta, D, Linear model: an integrated approach, World Scientific Pub.

SUGGESTED READINGS:

1. Weisberg, S. (2005). Applied Linear Regression (Third edition).Wiley.
2. Wu, C. F. J. And Hamada, M. (2009). Experiments, Analysis, and Parameter Design Optimization(Second edition), John Wiley.
3. Renchner, A. C. And Schaalje, G. B. (2008). Linear Models in Statistics (Second edition), John Wileyand Sons

LIST OF PRACTICALS:

1. Estimability when X is a full rank matrix and not a full rank matrix
2. Simple Linear Regression
3. Multiple Regression
4. Tests for Linear Hypothesis
5. Orthogonal Polynomials
6. Analysis of Variance of a one way classified data
7. Analysis of Variance of a two way classified data with one observation per cell
8. Analysis of Covariance of a one way classified data

CC-X: STATISTICAL QUALITY CONTROL

Course Objectives: The aim of the course is to

1. Acquire knowledge of statistical quality control methods utilised by many sectors, including control charts, acceptance sample plans, and so on.
2. Gain insight into advanced control charts, Voice of customers and the six-sigma concept.

Course Outcomes (CO): After completion of this course, student will

1. Apply the idea of control charts to the production process monitoring and gain a basic understanding of it.
2. Implement sampling plan and acceptance strategies during the production process.
3. Understand and use the concepts of six sigma, ISO 9000 series standards and TQM.

UNIT-I

Quality: Definition, dimensions of quality, historical perspective of quality control and improvements starting from World War II, historical perspective of Quality Gurus and Quality Hall of Fame. Quality system and standards: Introduction to ISO quality standards, Quality registration. Statistical Process Control - Seven tools of SPC, chance and assignable Causes of quality variation. Statistical Control Charts- Construction and Statistical basis of 3-σ Control charts, Rational Sub-grouping.

UNIT-II

Control charts for variables: X-bar & R-chart, X-bar & s-chart. Analysis of patterns on control chart, estimation of process capability. Control charts for attributes: np-chart, p-chart, c-chart and u-chart. Comparison between control charts for variables and control charts for attributes.

UNIT-III

Acceptance sampling plan: Principle of acceptance sampling plans. Single and Double sampling plan their OC, AQL, LTPD, AOQ, AOQL, ASN, ATI functions with graphical interpretation, use and interpretationof Dodge and Romig's sampling inspection plan tables.

UNIT-IV

Introduction to Six-Sigma: Overview of Six Sigma, Lean Manufacturing and Total Quality Management (TQM). Organizational Structure and Six Sigma training plans- Selection Criteria for Six-Sigma roles and training plans. Voice of customers (VOC): Importance and VOC data collection.

TEXT BOOKS:

1. Montogomery, D. C. (2009): Introduction to Statistical Quality Control, 6th Edition, Wiley India Pvt.Ltd.

SUGGESTED READINGS:

1. Goon A.M., Gupta M.K. and Das gupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edn.The World Press, Kolkata.
2. Mukhopadhyay,P(2011):Applied Statistics,2nd edition revised reprint, Booksand Allied(P)Ltd.
3. Montogomery, D. C. and Runger, G.C. (2008): Applied Statistics and Probability for Engineers, 3rdEdition reprint, Wiley India Pvt.Ltd.
4. Ehrlich, B.Harris(2002):Transactional Six Sigma and Lean Servicing,2ndEdition, St. Lucie Press.
5. Hoyle, David (1995): ISO Quality Systems Handbook, 2nd Edition, Butterworth HeinemannPublication.

LIST OF PRACTICALS:

1. Construction and interpretation of statistical control charts
2. X-bar &R-chart
3. X-bar &s-chart
4. np-chart, p-chart, c-chart and u-chart
5. Single sample inspection plan: Construction and interpretation of OC, AQL, LTPD, ASN, ATI, AOQ,AOQL curves

CC-XI: STOCHASTIC PROCESS & QUEUING THEORY

Course Objectives: The aim of the course is to

1. Learn and understand the predictive approach of stochastic processes.
2. Develop the capability to analyze and apply certain fundamental stochastic processes to real life.

Course outcomes (CO): After completion of this course, student will

1. Acquire knowledge on probability distributions.
2. Understand the stochastic processes, Markov chains, Transition probability matrix and various types of states.
3. Explain Poisson process and apply it in real life situations.
4. Have knowledge on queuing models.

UNIT-I

Probability Distributions: Generating functions, Bivariate probability generating function. Stochastic Process: Introduction, Stationary Process.

UNIT-II

Markov Chains: Definition of Markov Chain, transition probability matrix, order of Markov chain, Markovchain as graphs, higher transition probabilities. Generalization of independent Bernoulli trials, classification of states and chains,

UNIT-III

Poisson Process: postulates of Poisson process, properties of Poisson process, inter- arrival time, pure birthprocess, Yule Furry process, birth and death process, pure death process.

UNIT-IV

Queuing System: General concept, Characteristics of queuing models, steady state distribution, queuing model, M/M/1 with finite and infinite system capacity, waiting time distribution (without proof).

TEXT BOOKS:

1. Medhi, J. (2009): Stochastic Processes, New Age International Publishers
2. Kanti Swarup, Gupta, P.K. and Manmohan (2007): Operations Research, 13th Edition, Sultan Chandand Sons.

SUGGESTED READINGS:

1. Basu, A.K. (2005): Introduction to Stochastic Processes, Narosa Publishing.
2. Bhat,B.R.(2000): Stochastic Models: Analysis and Applications, New Age International Publishers.
3. Taha, H. (1995): Operations Research: An Introduction, Prentice- Hall India.
4. Karlin, S and Taylor H.M, A first course in Stochastic Process. Academic Press;

LIST OF PRACTICALS:

1. Calculation of transition probability matrix
2. Identification of characteristics of reducible and irreducible chains.
3. Identification of types of classes
4. Calculation of probabilities for given birth and death rates and vice-versa
5. Calculation of Probability and parameters for (M/M/1) model and change in behaviour of queue as Ntends to infinity.

CC-XII: STATISTICAL COMPUTING USING C & R PROGRAMMING

Course Objectives: The aim of the course is

1. To grasp the basics of C language and apply it for analysis.
2. To learn the statistical analysis using 'R' free and open source software.

Course Outcomes (CO): After completion of this course, student will

1. Understand the fundamental concepts of C programming language.
2. Acquire knowledge of various data types, operators, library functions, Input/Output operations.
3. Explain decision making, branching and looping structure.
4. Use of arrays in looping structure.
5. Know the user defined functions, recursion functions.
6. Get an idea of storage class of variables.
7. Understand basics of R environment and do descriptive statistical analysis in R.

UNIT-I

History and importance of C. Components, basic structure programming, Keywords and Identifiers and execution of a C program. Data types: Basic data types, Enumerated data types, derived data types. Constants and variables: declaration and assignment of variables, Symbolic Constants, overflow and underflow of data. Operators and Expressions: Arithmetic, relational, logical, assignment, increment/decrement, operators, precedence of operators in arithmetic, relational and logical expression. Implicit and explicit type conversions in expressions, library functions. Managing input and output operations: reading and printing formatted and unformatted data

UNIT-II

Decision making and branching - if…else, nesting of if…else, else if ladder, switch, conditional operator. Looping in C: for, nested for, while, do…while, jumps in and out of loops. Arrays: Declaration and initialization of one-dim and two-dim arrays. Character arrays and strings: Declaring and initializing string variables, reading and writing strings from Terminal (using scanf and printf only).

UNIT-III

User- defined functions: A multi-function program using user-defined functions, definition of functions, return values and their types, function prototypes and calls. Category of Functions : no arguments and no return values, arguments but no return values, arguments with return values, no arguments but returns a value, functions that return multiple values.

UNIT-IV

Introducing R: Getting R, Running R program, Finding your way in R, Command packages, Starting Out: Reading and Getting Data into R, Viewing Named Objects, Types of Data Items, Structure of Data Items, Examining Data Structure, Saing Your Work in R, Working with objects: Manipulating

objects, Viewing Objects, Constructing data objects, Different forms of Data Objects. Descriptive Statistics and Tabulation.

TEXT BOOKS:

1. Kanetkar Y. P. Let us C ; BPB Publications; 15thedition.
2. Gardener, M. Beginning R: The Statistical Programming Language, WileyIndia

SUGGESTED READINGS:

1. Balagurusamy, E. (2011): Programming in ANSI C, 6th Edition, Tata McGraw Hill.
2. Kernighan, B.W. and Ritchie, D. (1988): C Programming Language,2nd Edition, Prentice Hall.
3. Gottfried,B.S.(1998): Schaum's Outlines: Programming with C, 2nd Edition,Tata Mc Graw Hill

LIST OF PRACTICALS:

1. Plot of a graph y =f(x)
2. Roots of a quadratic equation (with imaginary roots also)
3. Sorting of an array and hence finding median
4. Mean, Median and Mode of a Grouped Frequency Data
5. Variance and coefficient of variation of a Grouped Frequency Data
6. Value of n! using recursion
7. Matrix addition, subtraction, multiplication Transpose and Trace
8. t-test for difference of means
9. Paired t-test
10. F-ratio test

CC-XIII: DESIGN OF EXPERIMENTS

Course Objectives: The aim of the course is

1. To learn ANOVA and the basic principles in the design of experiments.
2. To learn different tests for comparing pairs of treatment means, factorial experiments, confounding and BIBD with solving real life examples.
3. To learn the applications of different designs in agriculture.

Course Outcomes (CO): After completion of this course, student will

1. Compare the pairs of treatment means using ANOVA.
2. Analyze the data using CRD, RBD and LSD.
3. Construct factorial experiments and apply confounding in real life problems.
4. Understand the analysis of BIBD and its applications in agriculture, business and industries.

UNIT-I

Analysis of variance (ANOVA) for one way and two way classified data (one observation per cell) Experimental designs: Role, historical perspective, terminology, experimental error, basic principles, uniformity trials, fertility contour maps, choice of size and shape of plots and blocks.

UNIT-II

Basic designs: Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD) – layout, model and statistical analysis, relative efficiency, analysis with missing observations.

UNIT-III

Factorial experiments: advantages and disadvantages, notations and concepts, 2^2, 2^3 … 2^n and 3^2 factorial experiments, design and its analysis and applications.

UNIT-IV

Total and Partial confounding for 2^n ($n \leq 5$), 3^2 and 3^3. Factorial experiments in a single replicate. Advantages and disadvantages. Balanced Incomplete Block Design (BIBD)m– parameters, relationships among its parameters.

TEXT BOOKS:

1. Gupta, S. C. and Kapoor, V.K. (2008): Fundamentals of Applied Statistics, 4th Edition (Reprint),Sultan Chand &Sons
2. Goon, A.M., Gupta, M.K.and Das gupta, B.(2005):Fundamentals of Statistics. Vol. II, 8thEdn. WorldPress, Kolkata.

SUGGESTED READINGS:

1. Cochran, W.G. and Cox, G.M. (1959): Experimental Design. Asia Publishing House.
2. Das, M.N. and Giri, N.C. (1986): Design and Analysis of Experiments. Wiley Eastern Ltd.
3. Kempthorne, O. (1965): The Design and Analysis of Experiments. John Wiley.
4. Montgomery, D. C. (2008): Design and Analysis of Experiments, John Wiley.

LIST OF PRACTICALS:

1. Analysis of a CRD
2. Analysis of an RBD
3. Analysis of an LSD
4. Analysis of an RBD with one missing observation
5. Analysis of an LSD with one missing observation
6. Analysis of 2^2 and 2^3 factorial in CRD and RBD
7. Analysis of a completely confounded two level factorial design in 2blocks
8. Analysis of a completely confounded two level factorial design in 4blocks
9. Analysis of a partially confounded two level factorial design

CC -XIV: MULTIVARIATE ANALYSIS AND NON PARAMETRIC METHODS

Course Objectives: The aim of the course is

1. Acquire and cultivate a scientific perspective for handling multidimensional datasets and applying it to research data analysis.
2. To comprehend how univariate approaches may be extended to multivariate frameworks and to gain proficiency in the use of dimension reduction strategies utilised in data analysis.
3. Acquire knowledge of various nonparametric tests.

Course Outcomes (CO): After completion of this course, student will

1. Understand the concept of bivariate normal distribution.
2. Recognise multivariate normal distributions and their practical uses.
3. Know the concept of nonparametric test and its uses.

UNIT-I

Bivariate Normal Distribution (BVN): P.d.f. of BVN, properties of BVN, marginal and conditional p.d.f. of BVN. Multivariate Data: Random Vector: Probability mass/density functions, Distribution function, Mean vector & Dispersion matrix, Marginal & Conditional distributions.

UNIT-II

Multivariate Normal distribution and its properties. Sampling distribution for mean vector and variance- covariance matrix. Multiple and partial correlation coefficient and their properties.

UNIT-III

Nonparametric Tests: Introduction and Concept, Parametric versus non-parametric tests, advantages and disadvantages of non-parametric tests. Test for randomness based on total number of runs, Empirical distribution function, Kolmogrov Smirnov test for one sample, Sign tests- one sample.

UNIT-IV

Kolmogrov Smirnov two samples test, Wilcoxon signed rank tests, Wilcoxon-Mann- Whitney U test, Kruskal-Wallis test.

TEXT BOOKS:

1. Bhuyan, KC., Multivariate Analysis and its Applications, New Central Book Agency (P) Limited
2. Gun, A.M., Gupta, M.K. and Das gupta, B.: An Outline of Statistical Theory, Vol.II, (4thed.), WorldPress.

SUGGESTED READINGS:

1. Johnson, R.A. and Wichern, D.W. (2007): Applied Multivariate Analysis, 6thEdn., Pearson & PrenticeHall
2. Anderson, T.W. (2003): An Introduction to Multivariate Statistical Analysis, 3rdEdn., JohnWiley
3. Kshirsagar, A.M. (1972):Multivariate Analysis, 1stEdn. Marcel Dekker.
4. Mukhopadhyay, P.: Mathematical Statistics. Books and Allied (P)Ltd
5. Gibbons, J.D. and Chakraborty, S(2003):Non parametric Statistical Inference.4th Edition. MarcelDekker, CRC.

LIST OF PRACTICALS:

1. Multiple Correlation
2. Partial Correlation
3. Bivariate Normal Distribution
4. Test for randomness based on total number of runs,
5. Kolmogrov Smirnov test for one sample.
6. Sign test: one sample, two samples, large samples.
7. Wilcoxon-Mann-Whitney U-test
8. Kruskal-Wallis test

DESCIPLINE SPECIFIC ELECTIVE (DSE)
DSE-I:OPERATIONS RESEARCH

Course Objectives: The aim of the course is

1. To learn the fundamental concepts of Operations Research.
2. To gain knowledge of sophisticated techniques in operations research courses that are applied in the systems approach to engineering and management, giving them the necessary instruments for the mathematical modelling of problems involving decision-making, with a focus on the roles of risk and uncertainty.

Course Outcomes (CO): After completion of this course, student will

1. Understand basics and formulation of linear programming problems and appreciate their limitations; solve linear programming problems using graphical method.
2. Apply simplex method to solve real life problems.
3. Solve artificial variable technique, duality theory, revised simplex method, sensitivity analysis, transportation and assignment problems.
4. Understand the concept of Game theory, inventory models with real life applications.

UNIT-I

Introduction to Operations Research, phases of O.R., model building, various types of O.R. problems. Linear Programming Problem, Mathematical formulation of the L.P.P, graphical solutions of a L.P.P. Simplex method for solving L.P.P. Charne's M-technique for solving L.P.P. involving artificial variables. Special cases of L.P.P. Concept of Duality in L.P.P: Dual simplex method.

UNIT-II

Transportation Problem: Initial solution by North West corner rule, Least cost method and Vogel's approximation method (VAM), MODI's method to find the optimal solution, special cases of transportation problem. Assignment problem: Hungarian method to find optimal assignment problem.

UNIT-III

Game theory: Rectangular game, minimax-maximin principle, solution to rectangular game using graphical method, dominance and modified dominance property to reduce the game matrix and solution to rectangular game with mixed strategy. Networking: Shortest route and minimal spanning tree problem.

UNIT-IV

Inventory Management: ABC inventory system, characteristics of inventory system. EOQ Model and its variations, with and without shortages, Quantity Discount Model with price breaks.

TEXT BOOKS:

1. KantiSwarup, Gupta, P.K. and Manmohan (2007): Operations Research, 13th Edition, Sultan Chand andSons.

SUGGESTED READINGS:

1. Taha, H. A. (2007): Operations Research: An Introduction, 8th Edition, Prentice Hall ofIndia.
2. Hadley, G: (2002) : Linear Programming, Narosa Publications
3. Hillier, F.A and Lieberman, G.J. (2010): Introduction to Operations Research Concepts and cases, 9thEdition, Tata Mc Graw Hill

LIST OF PRACTICALS:

1. Mathematical formulation of L.P.P and solving the problem using graphical method, Simplextechnique and Charne's Big M method involving artificial variables.
2. Identifying Special cases by Graphical and Simplex method and interpretation (Unbounded, Infeasibleand alternate solution)
3. Allocation problem using Transportation model
4. Allocation problem using Assignment model
5. Problems based on game matrix

DSE-II: TIME SERIES ANALYSIS

Course Objectives: The aim of the course is

1. To learn and develop scientific view to understand the time series data and its analysis.
2. To learn trend analysis by different methods.
3. To acquire knowledge on stationary and non-stationary, and seasonal and non-seasonal time series models.

Course Outcomes (CO): After completion of this course, student will

1. Understand the concept of time series with its components and able to compute trend by different methods.
2. Eliminate trend and seasonality using different methods to convert the time series into stationary.
3. Know auto regressive, moving average process and their application to forecast time-series data empirically.
4. Understand the stationarity, auto correlation, correlogram moving average and their applications.

UNIT-I

Introduction to times series data, application of time series from various fields, Components of a times series, Decomposition of time series. Trend: Estimation of trend by freeh and curve method, method of semi averages, fitting a various mathematical curve, and growth curves.

UNIT-II

Trend Cont.: Method of moving averages. Detrending. Effect of elimination of trend on other components of the time series. Seasonal Component: Estimation of seasonal component by Method of simple averages,Ratio to Trend.

UNIT-III

Seasonal Component cont: Ratio to Moving Averages and Link Relative method, Deseasonalization. Cyclic Component: Harmonic Analysis. Some Special Processes: Moving-average (MA) process and Autoregressive (AR) process of orders one and two, Estimation of the parameters of AR (1) and AR (2) –Yule-Walker equations

UNIT-IV

Stationary Time series: Weak stationarity, auto correlation function and correlogram of moving average. Its applications. Random Component: Variate component method. Forecasting: Exponential smoothing methods,

TEXT BOOKS:

1. Kendall M.G. (1976): Time Series, Charles Griffin.
2. Brockwell, P.J. and Davis, R. A. (2003). Introduction to Time Series Analysis, Springer

SUGGESTED READINGS:

1. Gupta, S. C. and Kapoor, V.K. (2008): Fundamentals of Applied Statistics, 4th Edition (Reprint),Sultan Chand &Sons
2. Chatfield C. (1980): The Analysis of Time Series –An Introduction, Chapman & Hall.
3. Mukhopadhyay P. (2011): Applied Statistics, 2nd ed. Revised reprint, Books and Allied

LIST OF PRACTICALS:

1. Fitting and plotting of modified exponential curve
2. Fitting and plotting of Gompertz curve
3. Fitting and plotting of logistic curve
4. Fitting of trend by Moving Average Method
5. Measurement of Seasonal indices Ratio-to-Trend method
6. Measurement of Seasonal indices Ratio-to-Moving Average method
7. Measurement of seasonal indices Link Relative method
8. Forecasting by exponential smoothing

DSE-III: DEMOGRAPHY AND VITAL STATISTICS

Course Objectives: The aim of the course is

1. To identify appropriate sources of data and to perform basic demographic analyses using various techniques across populations.
2. To learn the main theories used to understand population studies and societal change.

Course Outcomes (CO): After completion of this course, student will

1. Understand the interdisciplinary nature of demography, balancing equation, use of Whipple's, Myers and UN indices.
2. Understand the measures of mortality and fertility.
3. Describe the concept of life tables and measurement of population growth.

UNIT-I

Population Theories: Coverage and content errors in demographic data, use of balancing equations and Chandrasekharan-Deming formula to check completeness of registration data. Adjustment of age data, use of Myer and UN indices, Population composition, dependency ratio.

UNIT-II

Introduction and sources of collecting data on vital statistics, errors in census and registration data. Measurement of population, rate and ratio of vital events. Measurements of Mortality: Crude Death Rate (CDR), Specific Death Rate (SDR), Infant Mortality, Rate (IMR) and Standardized Death Rates.

UNIT-III

Stationary and Stable population, Central Mortality Rates and Force of Mortality. Life (Mortality)Tables:Assumption, description, construction of Life Tables and Uses of Life Tables.

UNIT-IV

Abridged Life Tables; Concept and construction of abridged life tables by Reed-Merrell method, Measurements of Fertility: Crude Birth Rate (CBR), General Fertility Rate (GFR), Specific Fertility Rate(SFR) and Total Fertility Rate (TFR). Measurement of Population Growth: Crude rates of natural increase, Pearl's Vital Index, Gross Reproduction Rate (GRR) and Net Reproduction Rate (NRR).

TEXT BOOKS:

1. Pathak, K.B. and Ram, F.: Techniques of Demography Analysis, Himalayan Publishers
2. Gun,A.M., Gupta,M.K. and Dasgupta, B.(2008):Fundamentals of Statistics, Vol. II, 9th Edition, WorldPress.

SUGGESTED READINGS:

1. Mukhopadhyay P. (1999): Applied Statistics, Books and Allied (P)Ltd.
2. Biswas, S. (1988): Stochastic Processes in Demography & Application, Wiley Eastern Ltd.
3. Croxton, Fredrick E., Cowden, Dudley J. and Klein, S. (1973): Applied General Statistics, 3rd Edition.Prentice Hall of India Pvt. Ltd.
4. Keyfitz N., Beckman John A.: Demography through Problems S-Verlag Newyork.

LIST OF PRACTICALS:

1. To calculate CDR and Age Specific death rate for a given set of data
2. To find Standardized death rate by:- (i) Direct method (ii) Indirect method

3. To construct a complete life table
4. To fill in the missing entries in a life table
5. To calculate probabilities of death at pivotal ages and use it construct a bridged life table
6. To calculate CBR, GFR, SFR, TFR for a given set of data
7. To calculate Crude rate of Natural Increase and Pearle's Vital Index for a given set of data
8. Calculate GRR and NRR for a given set of data and compare them

DSE-IV:
PROJECT WORK

A student has to opt for any one of the following:

I. PROJECTWORK
II. ECONOMETRICS

Objective: The aim of the course is to initiate students to write and present a statistical report, under the supervision of a faculty, on some area of social interest. The project work will provide handson training to the students to deal with data emanating from some real-life situation and propel them to do well on some theory or relate it to some theoretical concepts. The project should be prepared basing on the own idea and interpretation of the student. It should not be copied from anywhere. A student has to consult his / her supervisor for the preparation of the project.

While writing a project, a student has to present two seminars before the faculties / supervisor from thedepartment.

Seminar - I (Based on Introduction and Review of literature, Methodology): - 10 Marks Seminar - II(Based on Analysis, Interpretation and Conclusion) : - 10 Marks
Project Report: - 60 Marks
Viva- Voce (after submission of Project Report): 20 Marks

DSE-IV: ECONOMETRICS

Course Objectives: The aim of the course is

1. To judge the validity of the economic theories.
2. To carry out evaluation of economic theories in numerical terms.
3. To extract useful information about important economic policy issues from the available data.

Course Outcomes (CO): After completion of this course, student will

1. Understand the fundamental concepts of econometrics.
2. Understand multicollinearity with its applications.
3. Know the GLS method of estimation and concept of autocorrelation.
4. Understand concept of heteroscedasticity.

UNIT-I

Introduction: Objective behind building econometric models, nature of econometrics, model building, role of econometrics, structural and reduced forms. General linear model (GLM). Estimation under linear restrictions.

UNIT-II

Multicollinearity: Introduction and concepts, detection of multicollinearity, consequences, tests and solutions of multi-collinearity, specification error.

UNIT-III

Generalized least squares estimation, Aitken estimators. Autocorrelation: concept, consequences of autocorrelated disturbances, detection and solution of autocorrelation.

UNIT-IV

Heteroscedastic disturbances: Concepts and efficiency of Aitken estimator with OLS estimator underheteroscedasticity. Autoregressive models, Dummy variables, Qualitative data.

DSE-IV (P) LIST OF PRACTICALS:

1. Problems based on estimation of General linear model
2. Testing of parameters of General linear model
3. Forecasting of General linear model
4. Problems related to consequences of Multi co linearity
5. Diagnostics of Multi co linearity
6. Problems related to consequences of Autocorrelation(AR(I))
7. Diagnostics of Autocorrelation
8. Problems related to consequences Heteroscedasticity
9. Diagnostics of Heteroscedasticity

TEXT BOOKS:

1. Gujarati, D. and Sangeetha, S. (2007): Basic Econometrics, 4th Edition, McGraw Hill Companies.
2. Maddala, G.S. and Lahiri, K. (2009): Introduction to Econometrics, 4th Edition, John Wiley &Sons.

SUGGESTED READINGS:

1. Johnston,J.(1972):Econometric Methods, 2nd Edition, Mc Graw Hill International.
2. Koutsoyiannis, A. (2004): Theory of Econometrics, 2nd Edition, Palgrave Macmillan

GENERIC ELECTIVE

GE-I STATISTICAL METHODS

Course Objectives: The learning objectives include:

1. Introduction of basic concept of statistics such as population, sample, presentation of data in tabular as well as in graphical manner.
2. Understanding the nature of data with the help of various statistical tools.
3. Introduction of correlation, regression, theory of attributes and their applications.

Course Outcomes (CO): After completion of this course, student will

1. Understand the scope of statistics and its multidisciplinary aspects.
2. Measure the data and present it through histogram and ogives.
3. Acquire the knowledge on measures of central tendency and their applications.
4. Correlate and regress the data by different methods.
5. Understand the measures of association of attributes.

UNIT-I

Introduction: Definition and scope of Statistics, concepts of statistical population and sample. Data: quantitative and qualitative, attributes, variables, scales of measurement - nominal, ordinal, interval and ratio. Presentation: tabular and graphic, including histogram and ogives.

UNIT-II

Measures of Central Tendency: mathematical and positional. Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation, moments, skewness and kurtosis.

UNIT-III

Bivariate data: Definition, scatter diagram, simple and rank correlation. Simple linear regression, principleof least squares and fitting of polynomials, Applications.

UNIT-IV

Theory of attributes, consistency of data, independence and association of attributes, measures of association and contingency

TEXT BOOKS:

1. Gupta, S. C. and Kapoor, V.K. (2008): Fundamentals Of Mathematical Statistics, 4thEdition (Reprint),Sultan Chand &Sons
2. Goon, A.M., Gupta M.K. & Das Gupta, Fundamentals of statistics, Vol.-I & II (2005).

SUGGESTED READINGS:

1. Miller, Irwin and Miller, Marylees(2006):John E. Freund's Mathematical Statistics with Applications,(7th Edn.), Pearson Education, Asia.
2. Mood, A.M. Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn.,(Reprint), Tata McGraw-Hill Pub. Co. Ltd.

GE-1(P)

LIST OF PRACTICALS:

1. Graphical representation of data
2. Problems based on measures of central tendency
3. Problems based on measures of dispersion

4. Problems based on moments, skewness and kurtosis
5. Fitting of polynomials, exponential curves
6. Karl Pearson correlation coefficient
7. Spearman rank correlation with and without ties.
8. Correlation coefficient for a bivariate frequency distribution
9. Lines of regression, and estimated values of variables.
10. Checking consistency of data and finding association among attributes.

GE-II: INTRODUCTORY PROBABILITY

Course Objectives: The aim of this course is

1. To understand the uncertain circumstances in logical way.
2. To describe in detail how the basic theory of statistical distribution is established, as well as what are considered to be Standard Distributions by Statistical Practice.

Course Outcomes (CO): After completion of this course, student will

1. Understand the essential aspects of probability and how it is used in society.
2. Be familiar with the most frequent discrete or continuous probability distributions and their application in real life.
3. Calculate the marginal and conditional distribution from the joint distribution.

UNIT-I

Probability: Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability – classical, statistical, and axiomatic. Laws of addition and multiplication of probability.

UNIT-II

Conditional Probability, independent events, theorem of total probability, Bayes' theorem and its applications.

UNIT-III

Random Variables: Discrete and continuous random variables, p.m.f., p.d.f. ,c.d.f. Illustrations of randomvariables and its properties. Expectation, variance, moments and moment generating function.

UNIT-IV

Standard probability distributions: Binomial, Poisson, geometric, uniform, normal, exponential, beta,gamma and their applications.

TEXT BOOKS:

1. Gupta, S. C. and Kapoor, V.K. (2008): Fundamentals Of Mathematical Statistics, 4thEdition (Reprint),Sultan Chand &Sons
2. Goon, A.M., Gupta M.K. & Das Gupta, Fundamentals of statistics, Vol.-I & II (2005).

SUGGESTED READINGS:

1. Hogg,R.V.,Tanis,E.A.andRaoJ.M.(2009):ProbabilityandStatisticalInference, Seventh Ed, Pearson Education, NewDelhi.
2. Miller,IrwinandMiller,Marylees(2006):JohnE. Freund's Mathematical Statistics with Applications,(7th Edn.), Pearson Education, Asia.

GE-II PRACTICAL

LIST OF PRACTICALS:

1. Fitting of binomial distributions for n and p = q = ½given
2. Fitting of binomial distributions for n and p given
3. Fitting of binomial distributions computing mean and variance
4. Fitting of Poisson distributions for given value of lambda
5. Fitting of Poisson distributions after computing mean
6. Application problems based on binomial distribution
7. Application problems based on Poisson distribution
8. Problems based on area property of normal distribution
9. Application based problems using normal distribution

GE-III: BASICS OF STATISTICAL INFERENCE

Course Objectives: The aim of this course is

1. To learn the development of null and alternative hypotheses.
2. To learn types of errors, large and small sample tests and non-parametric tests.
1. To grasp the basic principles in the design of simple experiments.

Course Outcomes (CO): After completion of this course, student will:

1. Formulate null and alternative hypotheses and apply small, large sample and non-parametric tests in real life problems.
2. Compute probabilities of types of error.
3. Study the basic principles of design of experiments and compare the pairs of treatment means using ANOVA.

UNIT-I

Estimation of population mean, confidence intervals for the parameters of a normal distribution (one sample and two sample problems). The basic idea of significance test. Null and alternative hypothesis. Type I & Type II errors, level of significance. Tests of hypotheses for the parameters of a normal distribution (one sample and two sample problems).

UNIT-II

Small sample tests; t-test, F-test, Categorical data: Tests of proportions, tests of association and goodness-of-fit using Chi-square test, Yates' correction.

UNIT-III

Tests for the significance of correlation coefficient. Sign test for median, Sign test for symmetry, Wilcoxontwo-sample test.

UNIT-IV

Analysis of variance, one-way and two-way classification for one observation per cell. Brief exposure of three basic principles of design of experiments, treatment, plot and block. Analysis of completely randomized design, randomized complete block design and latin square designs.

TEXT BOOKS:

1. Gupta, S. C. and Kapoor, V.K. (2008): Fundamentals of Applied Statistics, 4th Edition(Reprint), Sultan Chand &Sons
2. Goon, A.M., Gupta M.K. & Das Gupta, Fundamentals of statistics, Vol.-I & II (2005).

SUGGESTED READINGS:

1. Daniel, Wayne W., Bio-statistics: A Foundation for Analysis in the Health Sciences. JohnWiley(2005).
2. Das, M. N. &Giri, N. C.: Design and analysis of experiments. John Wiley.
3. Dunn, O.J Basic Statistics: A primer for the Biomedical Sciences .(1964, 1977) by JohnWiley.
4. Goldstein, A Biostatistics-An introductory text (1971). The Mac million New York.

GE-III (PRACTICAL)

LIST OF PRACTICALS:

1. Tests of hypotheses for the parameters of a normal distribution (one sample and two sampleproblems).
2. Chi-square tests of association.
3. Chi-square test of goodness-of-fit.

4. Test for correlation coefficient.
5. Sign test for median.
6. Wilcoxon two-sample test.
7. Analysis of Variance of a one way classified data
8. Analysis of Variance of a two way classified data.
9. Analysis of aCRD.
10. Analysis of anRBD.

GE-IV: APPLIED STATISTICS

Course Objectives: The aim of this course is

1. To learn and develop scientific view to understand the time series data and its analysis.
2. To know the fundamental aspects of index numbers with its application.
3. Acquire knowledge of statistical quality control methods utilised by many sectors, including control charts, acceptance sample plans, and so on.
4. To identify appropriate sources of data and to perform basic demographic analyses using various techniques across populations.

Course Outcomes (CO): After completion of this course, student will

1. Understand the concept of time series with its components and able to compute trend by different methods.
2. Get an idea about index numbers, its use in economics and business or other aspects.
3. Apply the idea of control charts to the production process monitoring and gain a basic understanding of it.
4. Describe the measures of mortality, fertility, population growth and uses of life table.

UNIT-I

Economic Time Series: Components of time series, Decomposition of time series- Additive and multiplicative model with their merits and demerits, Illustrations of time series. Measurement of trend by method of free-hand curve, method of semi-averages and method of least squares (linear, quadratic and modified exponential).Measurement of seasonal variations by method of ratio to trend.

UNIT-II: Index numbers: Definition, Criteria for a good index number, different types of index numbers.Construction of index numbers of prices and quantities, consumer price index number. Uses and limitations of index numbers.

UNIT-III: Statistical Quality Control: Importance of statistical methods in industrial research and practice. Determination of tolerance limits. Causes of variations in quality: chance and assignable. Generaltheory of control charts, process & product control, Control charts for variables: X- bar and R-charts. Control charts for attributes: p and c-charts

UNIT-IV: Demographic Methods: Introduction, measurement of population, rates and ratios of vital events. Measurement of mortality: CDR, SDR (w.r.t. Age and sex), IMR, Standardized death rates. Life (mortality)tables: definition of its main functions and uses. Measurement of fertility and reproduction: CBR, GFR, and TFR. Measurement of population growth: GRR, NRR

TEXT BOOKS:

1. Gupta, S. C. and Kapoor, V.K. (2008): Fundamentals of Applied Statistics, 4th Edition (Reprint),Sultan Chand & Sons

SUGGESTED READINGS:

1. Mukhopadhyay,P.(1999): Applied Statistics, New Central Book Agency, Calcutta.
2. Gun,A.M.,Gupta,M.K. and Das gupta,B.(2008):Fundamental of Statistics, Vol. II, 9th Edition WorldPress, Kolkata.
3. Montogomery, D. C. (2009): Introduction to Statistical Quality Control, 6th Edition, Wiley IndiaPvt. Ltd.

GE-IV(P)

LIST OF PRACTICALS:

1. Measurement of trend: Fitting of linear, quadratic trend, exponential curve and plotting of trend valuesand comparing with given data graphically.
2. Measurement of seasonal indices by Ratio-to-trend method and plotting of trend values and comparingwith given data graphically.
3. Construction of price and quantity index numbers by Laspeyre's formula, Paasche's formula, Fisher'sFormula. Comparison and interpretation.
4. Construction of wholesale price index number, fixed base index number and consumer price indexnumber with interpretation
5. Construction and interpretation of X bar &R-chart
6. Construction and interpretation p-chart (fixed sample size) and c-chart
7. Computation of measures of mortality
8. Completion of life table
9. Computation of measures of fertility and population growth

SEC-1 STATISTICAL-DATA ANALYSIS USING SOFTWARE PACKAGES

This course will review and expand upon core topics in statistics and probability, particularly by initiating the beneficiaries of the course to at least one of the software packages viz., SPSS, STATA or Minitab forstatistical computing.

UNIT-I

Learn how to load data, plot a graph viz. histograms (equal class intervals and unequal class intervals),boxplot, stem-leaf, frequency polygon, pie chart, gives with graphical summaries of data

UNIT-II

Data Processing: Introduction, editing of data, coding of data, classification of data, tables as data presentation devices.

UNIT-III

Simple analysis and create and manage statistical analysis projects, import data, code editing, Generate automated reports giving detailed descriptive statistics, correlation and lines of regression.

UNIT-IV

Random number generation and sampling procedures. Fitting of polynomials and exponential curves.Application Problems based on fitting of suitable distribution, Normal probability plot.

TEXT BOOKS/ SUGGESTED READINGS:

1. Moore, D.S. and McCabe, G.P. and Craig, B.A. (2014): Introduction to the Practice of Statistics, W.H.Freeman
2. Cunningham, B.J (2012):Using SPSS: An Interactive Hands—on approach
3. Cho, M,J., Martinez, W.L. (2014) Statistics in MATLAB: A Primer, Chapman and Hall/CRC

SEC-I: STATISTICAL TECHNIQUES FOR RESEARCH METHODS

Statistical Techniques provide scientific approaches to develop the domain of human knowledge largely through empirical studies. The course aims at enabling students understand basic concepts and aspects related to research, data collection, analyses and interpretation.

UNIT-I

Introduction: Meaning, objection and motivation in research, types of research, research approach, significance of research. Research problems: definition, selection and necessity of research problems.

UNIT-II

Survey Methodology and Data Collection, inference and error in surveys, the target populations, sampling frames and coverage error, develop a questionnaire, methods of data collection, non-response, questions and answers in surveys.

UNIT-III

Processing, Data Analysis and Interpretation: Review of various techniques for data analysis covered in core statistics papers, techniques of interpretation, precaution in interpretation.

UNIT-IV

Formats of Reports: introduction, parts of a report, cover and title page, introductory pages, text, referencesection, typing instructions, copy reading, proof reading.

Presentation of a report: introduction, communication dimensions, presentation package, audio-visual aids, presenter's poise.

TEXT BOOKS/ SUGGESTED READINGS:

1. Kothari, C.R. (2009): Research Methodology: Methods and Techniques, 2nd Revised Edition reprint,New Age International Publishers.
2. Kumar,R(2011):Research Methodology: A Step-by-Step Guide for Beginners, SAGE publications.

List of Equipments Required for the Laboratory of +3 Syllabus

1. Computers (22 inches) with CPU
2. UPS
3. Computer tables with corresponding chair.
4. Wall Projector.
5. One White Board.
6. Inverter.
7. AC.
8. Microsoft Office.
9. SPSS.

New Modules Requiring Training About the Revised +3 CBCS Syllabus & Duration ofTraining for Four Weeks.

Moudle-1: Gauss-Markov set-up: Theory of linear estimation, Estimability of linear parametric functions, Method of least Squares, Gauss-Markov theorem, Estimation of error variance.

Moudle-2: Regression analysis: Simple regression analysis, Estimation and hypothesis testing incase of simple and multiple regression models, Concept of model matrix and its use in estimation.

Module 3: Analysis of variance, Definitions of fixed, random and mixed effect models, Analysis of variance and covariance in one-way classified data with one observation per cell for fixed effect models.

Module 4: Model checking; Prediction from a fitted model, Violation of usual assumptions concerning normality, Homoscedasticity and co linearity, Diagnostics using quantile plots.

Module 5: Probability Distributions: Generating functions, Bivariate probability generating function, Stochastic Process: Introduction, Stationary Process.

Module 6: Markov Chains: Definition of Markov Chain, transition probability matrix, order of Markov chain, Markov chain as graphs, higher transition probabilities. Generalization of independent Bernoulli trials, classification of states and chains.

Module 7: Poisson Process: postulates of Poisson process, properties of Poisson process, inter-arrival time, pure birth process, Yule Furry process, birth and death process, pure death process.

Module 8: History and importance of C. Components, basic structure programming, Keywords and Identifiers and execution of a C program. Data types: Basic data types, Enumerated data types, derived data types. Constants and variables: declaration and assignment of Variables, Symbolic Constants, overflow and underflow of data, Operators and Expressions, Implicit and explicit type conversions in expressions. Library functions, managing input and output operations. Reading and printing formatted and unformatted data.

Module 9: Bivariate Normal Distribution (BVN): p.d.f of BVN, properties of BVN, marginal and conditional p.d.f. of BVN. Multivariate Data: Random Vector: Probability mass/density functions. Distribution Functions. Mean Vector & Dispersion matrix, Marginal & Conditional distributions.

Module10. Multivariate Normal Distribution and its properties. Sampling distribution for mean vector and variance-covariance matrix. Multiple and partial correlation coefficient and their properties.

Module 11. VAM and MODI's method of Solution of Transportation problem, Hungarian method of Solution of Assignment problem, solution of mixed strategy game, shortage route and minimal spanning tree problem, ABC inventory model and quantity discount model with price break.

Module 12: Harmonic Analysis. Some special process: Moving-average (MA) process and Autoregressive (AR), process orders one and two, Estimation of the parameters of AR
(1) and AR (2)--Yule-Walker equations.

Module 13: Stationary Time series: Weak stationarity, autocorrelation function and correlogram of moving average. Its applications. Random Component: Variate component method. Forecasting: Exponential smoothing methods.

Text Books for Teachers:

1. Draper, N.R. and Smith, H.: Applied Regression Analysis. John Wiley & Sons.
2. Sengupta, D, Linear model: an integrated approach, World Scientific Pub.
3. Medhi, J. (2009): Stochastic Processes, New Age International Publishers.
4. KantiSwarup, Gupta, P.K. and Manmohan (2007): Operations Research, 13th Edition, SultanChand and Sons.
5. Kanetkar Y. P. Let us C : BPB Publications: [5th edition,
6. Bhuyan, K C., Mulitivariate Analysis and its Application, New Central Book Agency (P) Limited.
7. Gun, A.M., Gupta, M.K. and Dasgupta, B.: An Outline of Statistical Theory, Vol. II, (4thed.),World Press.
8. Kanti Swarup. Gupta, P.K. and Manmohan (2007): Operations Research, 13th Edition, SultanChand and Sons.
9. Kendall M.G, (1976): Time Series. Charles Griffin.
10. Brockwell, PJ: and Davis, R. A, (2003). Introduction to Time Series Analysis.Springer