Revised
SYLLABUS FOR
Bachelor of Science (Honours)

STATISTICS

THREE YEAR DEGREE COURSE
SEMESTER SYSTEM

(Under New UGC CBCS Guidelines)

COURSE STRUCTURE

SEMESTER	COURSE	COURSE NAME	COURSE CODE	CREDIT
I	Core 1	Descriptive Statistics and Probability Theory (Theory)	STC 1.11	4
		Descriptive Statistics (Practical)	STC 1.12	2
	Core 2	Calculus (Theory)	STC 1.21	5
		Calculus (Tutorial)		1
II	Core 3	Probability Distributions and Correlation Analysis (Theory)	STC 2.11	4
		Probability Distributions and Correlation Analysis (Practical)	STC 2.12	2
	Core 4	Algebra (Theory)	STC 2.21	5
		Algebra (Tutorial)		1
III	Core 5	Sampling Distributions (Theory)	STC 3.11	4
		Sampling Distributions (Practical)	STC 3.12	2
	Core 6	Survey Sampling & Indian Official Statistics (Theory)	STC 3.21	4
		Survey Sampling & Indian Official Statistics (Practical)	STC 3.22	2
	Core 7	Mathematical Analysis (Theory)	STC 3.31	5
		Mathematical Analysis (Tutorial)		1
	Skill Enhancement Course 1	Statistical-Data Analysis Using Software Packages (Practical)	STS 3.12	2
IV	Core 8	Statistical Inference (Theory)	STC 4.11	4
		Statistical Inference (Practical)	STC 4.12	2
	Core 9	Linear Models (Theory)	STC 4.21	4
		Linear Models (Practical)	STC 4.22	2
	Core 10	Statistical Quality Control (Theory)	STC 4.31	4
		Statistical Quality Control (Practical)	STC 4.32	2
	Skill Enhancement Course 2	Statistical Techniques for Research Methods	STS 4.11(a)	2
V	Core 11	Stochastic Processes and Queuing Theory (Theory)	STC 5.11	4
		Stochastic Processes and Queuing Theory (Practical)	STC 5.12	2
	Core 12	Statistical Computing Using C/C++Programming (Theory)	STC 5.21	4
		Statistical Computing Using C/C++Programming (Practical)	STC 5.22	2
	Discipline Specific Elective 1	Operations Research (Theory)	STD 5.11	4
		Operations Research (Practical)	STD 5.12	2
	Discipline Specific Elective 2	Time Series Analysis (Theory)	STD 5.21	4
		Time Series Analysis (Practical)	STD 5.22	2
VI	Core 13	Design of Experiments (Theory)	STC 6.11	4
		Design of Experiments (Practical)	STC 6.12	2
	Core 14	Multivariate Analysis and Index Numbers (Theory)	STC 6.21	4
		Multivariate Analysis and Index Numbers (Practical)	STC 6.22	2
	Discipline Specific Elective 3	Demography (Theory)	STD 6.11	4
		Demography (Practical)	STD 6.12	2

		Econometrics (Theory) OR	STD 6.21(a)	4
ST – 2	Discipline Specific Elective 4	Project Work	STD 6.21(b)	6
		Econometrics (Practical)	STD 6.22(a)	2

SEMESTER-I

CORE 1 (STC 1.11)
DESCRIPTIVE STATISTICSAND PROBABILITY THEORY

Theory Credit:4

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: Definition and requisite characteristics, Arithmetic mean, geometric mean and harmonic mean; Median, Mode and their merits, demerits and properties; Quartiles, deciles and percentiles.

UNIT III   Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation, Moments, absolute moments, factorial moments, Sheppard's corrections for moments; Skewness and kurtosis.

UNIT IV   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 V   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, bivariate transformations with illustrations.

Recommended Books and References:
1. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edn. The World Press, Kolkata.
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
3. 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.

CORE 1 (STC 1.12)
DESCRIPTIVE STATISTICS

Practical Credits: 2

1. Graphical representation of data.
2. Problems based on measures of central tendency.
3. Problems based on measures of dispersion.
4. Problems based on combined mean and variance and coefficient of variation.
5. Problems based on moments, skewness and kurtosis.

CORE 2 (STC 1.21)
CALCULUS

Theory Credit 5
Tutorial Credit: 1

UNIT I   Differential Calculus**:** Limits of function, continuous functions, properties of continuous functions, partial differentiation and total differentiation. Indeterminate forms: L-Hospital's rule, Leibnitz rule for successive differentiation. Euler's theorem on homogeneous functions.

UNIT II   Maxima and minima of functions of one and two variables, constrained optimization techniques (with Lagrange multiplier) along with some problems. Jacobian of transformation and related problems.

UNIT III   Integral Calculus**:** Review of integration and definite integral. Differentiation under integral sign, double and multiple integral, change of order of integration, transformation of variables. Beta and Gamma functions: properties and relationship between them.

UNIT IV   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 solvable for x, y, q, Equations of the first degree in x and y, Clairaut's equations. Higher Order Differential Equations**:** Linear differential equations of order n, Homogeneous and non-homogeneous linear differential equations of order n with constant coefficients, Different forms of particular integrals, Linear differential equations with non-constant coefficients.

UNIT V   Formation and solution of a partial differential equations**.** Equations easily integrable. Linear partial differential equations of first order. Non-linear partial differential equation of first order and their different forms. Charpit's method. Homogeneous linear partial differential equations with constant coefficients. Different cases for complimentary functions and particular integrals. Non-homogeneous partial differential equations with constant coefficients. Classification of second order linear partial differential equations.

Recommended Books and References:
1. Gorakh Prasad: Differential Calculus, Pothishala Pvt. Ltd., Allahabad (14th Edition - 1997).
2. Gorakh Prasad: Integral Calculus, Pothishala Pvt. Ltd., Allahabad (14th Edition -2000).
3. Zafar Ahsan: Differential Equations and their Applications, Prentice-Hall of India Pvt. Ltd., New Delhi (2nd Edition -2004).
4. Piskunov, N: Differential and Integral Calculus, Peace Publishers, Moscow.
5. S.C. Gupta & V.K. Kapoor(2015) : Fundamental of Mathematical Statistics. Sultan Chand & Co. New Delhi

SEMESTER-II

CORE 3 (STC 2.11)
PROBABILITY DISTRIBUTIONS ANDCORRELATIONANALYSIS

Theory Credit: 4

UNIT I   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 II   Standard discrete probability distributions: Binomial, Poisson, geometric, negative binomial, Hypergeometric,

UNIT III   Standard continuous probability distributions: uniform, normal, exponential, beta and gamma along with their properties and limiting/approximation cases.

UNIT IV   Correlation and regression: Definition, scatter diagram, product moment correlation coefficient and rank correlation coefficient. Method of least square and Curve fitting (fitting of polynomials and exponential curves). Regression analysis: line of regression, regression coefficients and their properties.

UNIT V   Multiple and partial correlation (3 variables only). Properties of residual. Plane of regression. Intraclass correlation and correlation ratio
Theory of attributes: Introduction, class and class frequencies, consistency of data, independence of attributes, association of attributes, Yule's coefficient of association, coefficient of colligation.

Recommended Books and References:
1. Hogg, R.V., Tanis, E.A. and Rao J.M. (2009): Probability and Statistical Inference, Seventh Ed, Pearson Education, New Delhi.
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
3. Myer, P.L. (1970): Introductory Probability and Statistical Applications, Oxford & IBH Publishing, New Delhi.
4. S.C. Gupta & V.K. Kapoor(2015): Fundamental of Mathematical Statistics. Sultan Chand & Co. New Delhi.

CORE 3 (STC 2.12)
PROBABILITY DISTRIBUTIONS AND CORRELATION ANALYSIS

Practical Credits: 2

List of Practical
1. Fitting of binomial distributions for n and p = q = ½.
2. Fitting of binomial distributions for given n and p.
3. Fitting of binomial distributions after computing mean and variance.
4. Fitting of Poisson distributions for given value of lambda.
5. Fitting of Poisson distributions after computing mean.

6. Fitting of negative binomial.
7. Fitting of suitable distribution.
8. Application problems based on binomial distribution.
9. Application problems based on Poisson distribution.
10. Application problems based on negative binomial distribution.
11. Problems based on area property of normal distribution.
12. To find the ordinate for a given area for normal distribution.
13. Application based problems using normal distribution.
14. Fitting of normal distribution when parameters are given.
15. Fitting of normal distribution when parameters are not given.
16. Fitting of polynomials, exponential curves.
17. Karl Pearson correlation coefficient.
18. Correlation coefficient for a bivariate frequency distribution.
19. Lines of regression, angle between lines and estimated values of variables.
20. Spearman rank correlation with and without ties.
21. Partial and multiple correlations.
22. Planes of regression and variances of residuals for given simple correlations.

CORE 4 (STC 2.21)
ALGEBRA

Theory Credit 5
Tutorial Credit 1

UNIT I   Theory of equations, statement of the fundamental theorem of algebra and its consequences. Relation between roots and coefficients of any polynomial equation. Solutions of cubic and biquadratic equations when some conditions on roots of equations are given. Evaluation of the symmetric polynomials and roots of cubic and biquadratic equations.

UNIT II   Algebra of matrices - A review, theorems related to triangular, idempotent, involutory and nilpotent matrices, symmetric and skew symmetric matrices, Hermitian and skew Hermitian matrices and orthogonal matrices. Trace of a matrix, transpose of a matrix, unitary, adjoint and inverse of a matrix and related properties.

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. Symmetric and Skew symmetric determinants, Circulant determinants and Vandermonde determinants for n^{th} order, Jacobi's Theorem, product of determinants. 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, linear independence, 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. Generalized inverse (concept with illustrations), Partitioning of matrices and simple properties. Solutions of linear homogenous and non homogenous equation.

UNIT V   Vector spaces, Subspaces, sum of subspaces, Span of a set, Linear dependence and independence, dimension and basis, dimension theorem. Characteristic roots and

Characteristic vector, Properties of characteristic roots, Cayley Hamilton theorem, Quadratic forms.

Recommended Books and References:

1. Lay David C.: Linear Algebra and its Applications, Addison Wesley, 2000.
2. Schaum's Outlines: Linear Algebra, Tata McGraw-Hill Edition, 3rdEdition, 2006.
3. Krishnamurthy V., Mainra V.P. and Arora J.L.: An Introduction to Linear Algebra (II, III, IV, V).
4. Jain P.K. and Khalil Ahmad: Metric Spaces, Narosa Publishing House, New Delhi, 1973
5. Biswas, S. (1997): A Textbook of Matrix Algebra, New Age International, 1997.
6. Gupta S.C.: An Introduction to Matrices (Reprint). Sultan Chand & Sons, 2008.
7. Artin M.: Algebra. Prentice Hall of India, 1994.
8. Datta K.B.: Matrix and Linear Algebra. Prentice Hall of India Pvt. Ltd., 2002.
9. Hadley G.: Linear Algrbra. Narosa Publishing House (Reprint), 2002.
10. Searle S.R.: Matrix Algebra Useful for Statistics. John Wiley &Sons., 1982.

SEMESTER-III

CORE 5 (STC 3.11)
SAMPLING DISTRIBUTIONS

Theory Credit: 4

UNIT I   Limit laws: convergence in probability, almost sure convergence, convergence in mean square and convergence in distribution and their inter relations, 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, applications of C.L.T. and Liapunov Theorem (without proof).

UNIT II   Order Statistics: Introduction, distribution of the rth order statistic, smallest and largest order statistics. Joint distribution of rth and s^{th} order statistics, distribution of sample median and sample range.

UNIT III   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. Null and alternative hypotheses (simple and composite), Type I and Type II errors, their probabilities and critical region, level of significance and p-value, power of a test. 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-value approaches.

UNIT IV   Exact sampling distribution: Definition and derivation of p.d.f. of x2 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 x2 distribution. Tests of significance and confidence intervals based on distribution.

UNIT V   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 t 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. Distribution of $1/F(n_1,n_2)$. Relationship between t, F and x2 distributions. Test of significance and confidence Intervals based on t and F distributions.

Recommended Books and References:
1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2003): *An Outline of Statistical Theory*, Vol. I, 4th Edn. World Press, Kolkata.
2. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2ndEdn. (Reprint) John Wiley and Sons.
3. Hogg, R.V. and Tanis, E.A. (2009): *A Brief Course in Mathematical Statistics*. Pearson Education.
4. Johnson, R.A. and Bhattacharya, G.K. (2001): *Statistics-Principles and Methods*, 4thEdn. John Wiley and Sons.
5. 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.

CORE 5 (STC 3.12)
SAMPLING DISTRIBUTIONS

Practical Credits: 2

List of Practical
1. Testing of significance and confidence intervals for single proportion and difference of two proportions
2. Testing of significance and confidence intervals for single mean and difference of two means and paired 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 of fit.
7. Testing of independence of attributes.
8. Testing based on 2 X 2 contingency table without and with Yates' corrections.
9. Testing of significance and confidence intervals of an observed sample correlation coefficient.
10. Testing and confidence intervals of equality of two population variances

CORE 6 (STC 3.21)
SURVEY SAMPLING AND INDIAN OFFICIAL STATISTICS

Theory Credit: 4

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, post stratification and its performance. 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, variances in terms of correlation coefficient for regression method of estimation and their comparison with SRS. Cluster sampling (equal clusters only) estimation of population mean and its variance, comparison (with and without randomly formed clusters). Relative efficiency of cluster sampling with SRS in terms of intra class correlation. Concept of sub sampling.

UNIT IV   Two stage and multistage sampling, two phase and multi phase sampling (concept only); PPS Sampling, estimation of population total, mean and variance.

UNIT V   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. Indian agricultural statistics, Industrial statistics. Concept of National Accounts Statistics (GDP, NDP, GNP and NNP).

Recommended Books and References:

1. Cochran W.G. (1984): Sampling Techniques(3rd Ed.), Wiley Eastern.
2. Sukhatme, P.V., Sukhatme, B.V. Sukhatme, S. Asok,C.(1984). Sampling Theories of Survey with Application, IOWA State University Press and Indian Society of Agricultural Statistics
3. Murthy M.N. (1977): Sampling Theory & Statistical Methods, Statistical Pub. Society, Calcutta.
4. Des Raj and Chandhok P. (1998): Sample Survey Theory, Narosa Publishing House.
5. Goon A.M., Gupta M.K. and Dasgupta B. (2001): Fundamentals of Statistics (Vol.2), World Press.
6. Guide to current Indian Official Statistics, Central Statistical Office, GOI, New Delhi.
7. *http://mospi.nic.in/*

CORE 6 (STC 3.22)
SURVEY SAMPLING AND INDIAN OFFICIAL STATISTICS

Practical Credits: 2

List of Practical
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 Compare the 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. Calculate mean squares. Compare the efficiencies of ratio and regression estimators relative to SRS.

CORE 7 (STC 3.31)
MATHEMATICAL ANALYSIS

Theory Credit 5
Tutorial Credit 1

UNIT I   Real Analysis: Representation of real numbers as points on the line and the set of real numbers as complete ordered field. Bounded and unbounded sets, neighborhoods and limit points, Superimum and infimum, derived sets, open and closed sets, sequences and their convergence, limits of some special sequences and Cauchy's general principle of convergence, Cauchy's first theorem on limits, monotonic sequences, limit superior and limit inferior of a bounded sequence.

UNIT II   Infinite series, positive termed series and their convergence, Comparison test, D'Alembert's ratio test, Cauchy's n[th] root test, Raabe's test. Gauss test, Cauchy's condensation test and integral test (Statements and Examples only). Absolute convergence of series, Leibnitz's test for the convergence of alternating series, Conditional convergence.

UNIT-III   Review of limit, continuity and differentiability, uniform Continuity and boundedness 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 of $\sin x$, $\cos x$, e^x, $\log(1+x)$

UNIT IV   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. Solution of difference equations of first order.

UNIT V   Numerical integration. Trapezoidal rule, Simpson's one-third rule, three-eights rule, Weddle's rule with error terms. Stirling's approximation to n!. Solutions of transcendental equations: Iteration method, regula-falsi and Newton-Raphson method.

Recommended Books and References:
1. Malik S.C. and Savita Arora: Mathematical Analysis, Second Edition, Wiley Eastern Limited, New Age International Limited, New Delhi, 1994.
2. Somasundram D. and Chaudhary B.: A First Course in Mathematical Analysis, Narosa Publishing House, New Delhi, 1987.
3. Gupta S.L. and Nisha Rani: Principles of Real Analysis, Vikas Publ. House Pvt. Ltd., New Delhi, 1995.
4. Appostol T.M.: Mathematical Analysis, Second Edition, Narosa Publishing House, NewDelhi, 1987.
5. Shanti Narayan: A course of Mathematical Analysis, 12th revised Edition, S. Chand & Co. (Pvt.) Ltd., New Delhi, 1987.
6. Singal M.K. and Singal A.R.: A First Course in Real Analysis, 24th Edition, R. Chand & Co., New Delhi, 2003.
7. Bartle, R. G. and Sherbert, D. R. (2002): Introduction to Real Analysis (3rd Edition), John Wiley and Sons (Asia) Pte. Ltd., Singapore.
8. Ghorpade, Sudhir R. and Limaye, Balmohan V. (2006): A Course in Calculus and RealAnalysis, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint.
9. Jain,M. K., Iyengar, S. R. K. and Jain, R. K. (2003): Numerical methods for scientific and engineering computation, New age International Publisher, India.
10. Mukherjee, Kr. Kalyan (1990): Numerical Analysis. New Central Book Agency.
11. Sastry, S.S. (2000): Introductory Methods of Numerical Analysis, 3rd edition, Prentice Hall of India Pvt. Ltd., New Delhi.

SEMESTER-IV

CORE 8 (STC 4.11)
STATISTICAL INFERENCE

Theory Credit: 4

UNIT I   Estimation: Concepts of estimator and estimate, criterion of a good estimator: consistency, unbiasedness, efficiency and sufficiency. Factorization theorem. Complete statistic, Minimum variance unbiased estimator (MVUE).

UNIT II   Cramer-Rao inequality and MVB estimators (statement and applications), Rao-Blackwell theorem. Interval estimation- confidence interva1 and confidence limits.

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

UNIT IV   Best critical region, most powerful test, uniformly most powerful test, Neyman Pearson Lemma (statement and applications to construct most powerful test). Likelihood ratio test, properties of likelihood ratio tests (without proof).

UNIT V   Nonparametric Tests: Introduction and Concept, Test for randomness based on total number of runs, Empirical distribution function, Kolmogrov Smirnov test for one sample, Sign tests- one sample and two samples, Wilcoxon-Mann-Whitney test, Kruskal-Wallis test.

Recommended Books and References:
1. Goon A.M., Gupta M.K.: Das Gupta.B. (2005), Fundamentals of Statistics, Vol. I, World Press, Calcutta.
2. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2ndEdn. (Reprint) John Wiley and Sons.
3. Miller, I. and Miller, M. (2002): John E. Freund's Mathematical Statistics (6th addition, low price edition), Prentice Hall of India.
4. Dudewicz, E. J., and Mishra, S. N. (1988): Modern Mathematical Statistics. John Wiley & Sons.
5. Mood A.M, Graybill F.A. and Boes D.C.: Introduction to the Theory of Statistics, McGraw Hill.
6. Bhat B.R, Srivenkatramana T and Rao Madhava K.S. (1997) Statistics: A Beginner's Text, Vol. I, New Age International (P) Ltd.
7. Snedecor G.W and Cochran W.G. (1967) Statistical Methods. lowa State University Press.

CORE 8 (STC 4.12)
STATISTICAL INFERENCE

Practical Credits: 2

List of Practical
1. Unbiased estimators (including unbiased but absurd estimators)
2. Consistent estimators, efficient estimators and relative efficiency of estimators.
3. Cramer-Rao inequality and MVB estimators
4. Sufficient Estimators – Factorization Theorem, Rao-Blackwell theorem, Complete Sufficient estimators

5. Lehman-Scheffe theorem and UMVUE
6. Maximum Likelihood Estimation
7. Asymptotic distribution of maximum likelihood estimators
8. Estimation by the method of moments, minimum Chi-square
9. Type I and Type II errors
10. Most powerful critical region (NP Lemma)
11. Uniformly most powerful critical region
12. Unbiased critical region
13. Power curves
14. Likelihood ratio tests for simple null hypothesis against simple alternative hypothesis
15. Likelihood ratio tests for simple null hypothesis against composite alternative hypothesis
16. Asymptotic properties of LR tests
17. Test for randomness based on total number of runs,
18. Kolmogrov Smirnov test for one sample.
19. Sign test: one sample, two samples, large samples.
20. Wilcoxon-Mann-Whitney U-test
21. Kruskal-Wallis test

CORE 9 (STC 4.21)
LINEAR MODELS

Theory Credit: 4

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: Test for the relationship between two variables, linearity of regression, test for polynomial regression, test for multiple linear regression model, test for the homogeneity of a group of regression coefficients.

UNIT III   Analysis of variance (ANOVA): Introduction and assumptions. Definitions of fixed, random and mixed effect models, analysis of variance in one-way and two-way classified data with one and two observations per cell for fixed effect model

UNIT IV   Analysis of Covariance (ANCOVA): Introduction, layout, statistical analysis and computational short cuts for one way and twoway classified data with single observation per cell.

UNIT V   Econometrics: Introduction: Objective behind building econometric models, nature of econometrics, model building, role of econometrics, structural and reduced forms. General linear model (GLM) (concept only). Multicolinearity: Introduction and concepts, detection of multicolinearity, concept of generalized least squares estimation, Autocorrelation: concept, consequences of autocorrelated disturbances, detection and solution of autocorrelation.

Recommended Books and References:
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 Wiley and Sons.
4. Gujarati, D. and Sangeetha, S. (2007): Basic Econometrics, 4th Edition, McGraw Hill Companies.

CORE 9 (STC 4.22)
LINEAR MODELS

Practical Credits: 2

List of Practical
1. Estimability when X is a full rank matrix and not a full rank matrix
2. Distribution of Quadratic forms
3. Simple Linear Regression
4. Multiple Regression
5. Tests for Linear Hypothesis
6. Bias in regression estimates
7. Lack of fit
8. Analysis of Variance of a one way classified data
9. Analysis of Variance of a two way classified data with one observation per cell
10. Analysis of Covariance of a one way classified data
11. Analysis of Covariance of a two way classified data

CORE 10 (STC 4.31)
STATISTICAL QUALITY CONTROL

Theory Credit: 4

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.

UNIT II   Statistical Control Charts- Construction and Statistical basis of 3-σ Control charts, Rational Sub-grouping, Control charts for variables: X-bar & R-chart, X-bar & s-chart.

UNIT III   Control charts for attributes: np-chart, p-chart, c-chart and u-chart. Comparison between control charts for variables and control charts for attributes. Analysis of patterns on control chart, estimation of process capability.

UNIT IV   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 interpretation of Dodge and Romig's sampling inspection plan tables.

UNIT V   Likelihood ratio(LR) test- tests for mean and variance of one, two and several independent normal population; Sequential Analysis: Wald's 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 normal, Poisson, binomial and exponential distributions.

Recommended Books and References:

1. Montogomery, D. C. (2009): Introduction to Statistical Quality Control, 6th Edition, Wiley India Pvt. Ltd.
2. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edn. The World Press, Kolkata.
3. Mukhopadhyay, P (2011):Applied Statistics, 2nd edition revised reprint, Books and Allied(P) Ltd.
4. Montogomery, D. C. and Runger, G.C. (2008): Applied Statistics and Probability for Engineers, 3rd Edition reprint, Wiley India Pvt. Ltd.
5. Hoyle, David (1995): ISO Quality Systems Handbook, 2nd Edition, Butterworth Heinemann Publication.
6. Fundamentals of Mathematical Statistics (2011): Gupta S.C. and Kapoor V.K., Sultan Chand and Co., New Delhi
7. Fundamentals of Applied Statistics (2011): Gupta S.C. and Kapoor V.K., Sultan Chand and Co., New Delhi

CORE 10 (STC 4.32)
STATISTICAL QUALITY CONTROL

Practical Credits: 2

List of Practical
1. Construction and interpretation of statistical control charts X-bar & R-chart X-bar & s-chart np-chart p-chart c-chart u-chart
2. Single sample inspection plan: Construction and interpretation of OC, AQL, LTPD, ASN, ATI, AOQ, AOQL curves
3. Calculation of process capability and comparison of 3-sigma control limits with specification limits.
4. Use a case study to apply the concept of six sigma application in DMAIC: practical application.
5. SPRT procedure
6. OC function and OC curve
7. ASN function and ASN curve

SEMESTER-V

CORE 11 (STC 5.11)
STOCHASTIC PROCESSES AND QUEUING THEORY

Theory Credit: 4

UNIT I   Probability Distributions: Generating functions, Bivariate probability generating function. Stochastic Process: Introduction, Stationary Process. Hazard and Survival functions

UNIT II   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, stability of Markov system, graph theoretic approach.

UNIT III   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.

UNIT IV   Queuing System: General concept, steady state distribution, queuing model, M/M/1 with finite and infinite system capacity, waiting time distribution (without proof). Gambler's Ruin Problem: Classical ruin problem, expected duration of the game.

UNIT V   Demand Analysis: Demand and supply functions, Price elasticity of demand and supply, income elasticity of demand; Types of data required for estimating elasticity: family budget data and time series data; Pareto's law of income distribution; Engel's law and Engel's curve; Lorentz curve.

Recommended Books and References:
1. Medhi, J. (2009): Stochastic Processes, New Age International Publishers.
2. Basu, A.K. (2005): Introduction to Stochastic Processes, Narosa Publishing.
3. Bhat, B.R. (2000): Stochastic Models: Analysis and Applications, New Age International Publishers.
4. Taha, H. (1995): Operations Research: An Introduction, Prentice- Hall India.
5. Feller, William (1968): Introduction to probability Theory and Its Applications, Vol I, 3rd Edition, Wiley International.

CORE 11 (STC 5.12)
STOCHASTIC PROCESSES AND QUEUING THEORY

Practical Credits: 2

List of Practical
1. Calculation of transition probability matrix
2. Identification of characteristics of reducible and irreducible chains.
3. Identification of types of classes
4. Identification of ergodic transition probability matrix
5. Stationarity of Markov chain and graphical representation of Markov chain
6. Computation of probabilities in case of generalizations of independent Bernoulli trials
7. Calculation of probabilities for given birth and death rates and vice versa

8. Calculation of probabilities for Birth and Death Process
9. Calculation of probabilities for Yule Furry Process
10. Computation of inter-arrival time for a Poisson process.
11. Calculation of Probability and parameters for (M/M/1) model and change in behaviour of queue as N tends to infinity.
12. Calculation of generating function and expected duration for different amounts of stake.
13. Computation of probabilities and expected duration between players.
14. Fitting of demand curve.
15. Fitting of Pareto's curve.

CORE 12 (STC 5.21)
STATISTICAL COMPUTING USING C/C++ PROGRAMMING

Theory Credit: 4

UNIT I   History and importance of C/C++. Components, basic structure programming, character set, C/C++ tokens, Keywords and Identifiers and execution of a C/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.

UNIT II   Implicit and explicit type conversions in expressions, library functions. Managing input and output operations: reading and printing formatted and unformatted data
Decision making and branching - if...else, nesting of if...else, else if ladder, switch, conditional operator.

UNIT III   Looping in C/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 IV   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. Recursion function, Inline function, Passing arrays to functions, Storage class of Variables.

UNIT V   Pointers: Declaration and initialization of pointer variables, accessing the address of a variable, accessing a variable through its pointer, pointer expressions, pointer increments/decrement and scale factor. Pointers and arrays, arrays of pointers, pointers as function arguments, functions returning pointers
Structure: Definition and declaring, initialization, accessing structure members, copying and comparison of structure variables, array of structures, structure pointers. Dynamic memory allocation functions: malloc, calloc and free.
Pre processors: Macro substitution, macro with argument
File inclusion in C/C++: Defining and opening a file (only r, w and a modes), closing a file, I/O operations on files-fscanf and fprintf functions.

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

CORE 12 (STC 5.22)
STATISTICAL COMPUTING USING C/C++ PROGRAMMING

Practical Credits: 2

List of Practical
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. Preparing a frequency table
7. Value of n! using recursion
8. Random number generation from uniform, exponential, normal (using CLT) and gamma distribution, calculate sample mean and variance and compare with population parameters.
9. Matrix addition, subtraction, multiplication Transpose and Trace
10. Fitting of Binomial, Poisson distribution and apply Chi-square test for goodness of fit
11. Chi-square contingency table
12. t-test for difference of means
13. Paired t-test
14. F-ratio test
15. Multiple and Partial correlation.
16. Compute ranks and then calculate rank correlation(without tied ranks)
17. Fitting of lines of regression

SEMESTER-VI

CORE 13 (STC 6.11)
DESIGN OF EXPERIMENTS

Theory Credit: 4

UNIT I   Experimental designs: Role, historical perspective, terminology, experimental error, basic principles, uniformity trials, fertility contour maps, choice of size and shape of plots and blocks. Basic designs: Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD) – layout, model and statistical analysis, relative efficiency,

UNIT II   Missing plot technique: analysis of RBD and LSD with one and two missing observations. Split plot design- concept and analysis.

UNIT III   Incomplete Block Designs: Balanced Incomplete Block Design (BIBD) – parameters, relationships among its parameters, incidence matrix and its properties, Symmetric BIBD, Resolvable BIBD, Affine Resolvable BIBD, Intra Block analysis, complimentary BIBD, Residual BIBD, Dual BIBD, Derived BIBD.

UNIT IV   Factorial experiments: advantages, notations and concepts, 2^2, 2^3, 2^n ($n \leq 5$) and 3^2 factorial experiments – design and analysis; Advantages of factorial over simple experiment with example.

UNIT V   Confounding in Factorial experiment: Concept of confounding in a design of experiment, confounding subgroups, determination of suitable confounding subgroups, complete and partial confounding with examples for 2^n ($n \leq 5$); Orthogonality of a design: Distinction between orthogonality and confounding.

Recommended Books and References:
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. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005): Fundamentals of Statistics. Vol. II, 8th Edn. World Press, Kolkata.
4. Kempthorne, O. (1965): The Design and Analysis of Experiments. John Wiley.
5. Montgomery, D. C. (2008): Design and Analysis of Experiments, John Wiley.

CORE 13 (STC 6.12)
DESIGN OF EXPERIMENTS

Practical Credits: 2

List of Practical
1. Analysis of a CRD
2. Analysis of an RBD
3. Analysis of an LSD
4. analysis of an RBD with one and two missing observation
5. Analysis of an LSD with one missing observation
6. Intra Block analysis of a BIBD

7. Analysis of 2^2 and 2^3 factorial in CRD and RBD
8. Analysis of 2^2 and 2^3 factorial in LSD
9. Analysis of a completely confounded two level factorial design in 2 blocks
10. Analysis of a completely confounded two level factorial design in 4 blocks
11. Analysis of a partially confounded two level factorial design
12. Analysis of a single replicate of a 2^n design
13. Analysis of a fraction of 2^n factorial design

CORE 14 (STC 6.21)
MULTIVARIATE ANALYSIS AND INDEX NUMBERS

Theory Credit: 4

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   Educational and Psychological Statistics: Scaling of individuals for items in terms of difficulty, Z-score, standard score normalized scores, t-score and percentile score; Scaling of ratings in terms of normal probability curve; Test theory , Methods of estimating test reliability; Effect of test length on reliability of a test, validity of test scores, Intelligent quotient and its construction.

UNIT IV   Index Numbers-I: Definition, construction of index numbers and problems thereof for weighted and unweighted index numbers including Laspeyre's, Paasche's, Edgeworth-Marshall and Fisher's. Chain index numbers, conversion of fixed based to chain based index numbers and vice-versa.

UNIT V   Index Numbers-II: Cost of living (Consumer price) index number, problems in the construction of consumer price index number and its uses; Wholesale price index number. Index of Industrial Production, agricultural production.

Recommended Books and References:
1. Anderson, T.W. (2003): An Introduction to Multivariate Statistical Analysis, 3rdEdn., John Wiley
2. Muirhead, R.J. (1982): Aspects of Multivariate Statistical Theory, John Wiley.
3. Kshirsagar, A.M. (1972): Multivariate Analysis, 1stEdn. Marcel Dekker.
4. Johnson, R.A. and Wichern, D.W. (2007): Applied Multivariate Analysis, 6thEdn., Pearson & Prentice Hall
5. Mukhopadhyay, P.: Mathematical Statistics.
6. Gibbons, J. D. and Chakraborty, S (2003): Nonparametric Statistical Inference. 4th Edition. Marcel Dekker, CRC.
7. Fundamentals of Applied Statistics (2011): Gupta S.C. and Kapoor V.K., Sultan Chand and Co., New Delhi

CORE 14 (STC 6.22)
MULTIVARIATE ANALYSIS AND INDEX NUMBERS

Practical Credits: 2

List of Practical
1. Bivariate Normal Distribution and Multivariate Normal Distribution
2. Discriminant Analysis and Principal Components Analysis
3. Factor Analysis
4. Calculate price and quantity index numbers using simple and weighted average of price relatives.
5. To calculate the Chain Base and consumer price index numbers.

DISCIPLINE SPECIFIC ELECTIVE

DISCIPLINE SPECIFIC ELECTIVE 1 (STD 5.11)
OPERATIONS RESEARCH

Theory Credit: 4

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. Post-optimality analysis

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, special cases of 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.

UNIT V   Network Analysis: Idea of network node, activities, dummy activity, construction of network diagram; CPM-Network scheduling using CPM, determination of different types of floats and slacks, determination of Critical path; PERT; Basic definition of PERT and its usefulness; brief idea of optimistic time, pessimistic time and most likely time (PERT calculations are not required).

Recommended Books and References:
1. Taha, H. A. (2007): Operations Research: An Introduction, 8th Edition, Prentice Hall of India.
2. Kanti Swarup, Gupta, P.K. and Manmohan (2007): Operations Research, 13th Edition, Sultan Chand and Sons.
3. Hadley, G: (2002): Linear Programming, Narosa Publications
4. Hillier, F.A and Lieberman, G.J. (2010): Introduction to Operations Research-Concepts and cases, 9th Edition, Tata McGraw Hill

DISCIPLINE SPECIFIC ELECTIVE 1 (STD 5.12)
OPERATIONS RESEARCH
(Using TORA/WINQSB/LINGO)

Practical Credit 2

List of Practical
1. Mathematical formulation of L.P.P and solving the problem using graphical method, Simplex technique and Charne's Big M method involving artificial variables.

2. Identifying Special cases by Graphical and Simplex method and interpretation
   a. Degenerate solution
   b. Unbounded solution
   c. Alternate solution
   d. Infeasible solution
3. Post-optimality
   a. Addition of constraint
   b. Change in requirement vector
   c. Addition of new activity
   d. Change in cost vector
4. Allocation problem using Transportation model
5. Allocation problem using Assignment model
6. Networking problem
   a. Minimal spanning tree problem
   b. Shortest route problem
7. Problems based on game matrix
   a. Graphical solution to mx2 / 2xn rectangular game
   b. Mixed strategy
8. To find optimal inventory policy for EOQ models and its variations
9. To solve all-units quantity discounts model.
10. Problems related to Network analysis.

DISCIPLINE SPECIFIC ELECTIVE 2 (STD 5.21)
TIME SERIES ANALYSIS

Theory Credit: 4

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 free hand 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. Multicolinearity: Nature, Estimation of parameters and detection of multicolinearity.

UNIT IV   Autocorrelation and Autoregression: 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. Stationary Time series: Weak stationarity, autocorrelation function and correlogram of moving average.

UNIT V   Random Component: Variate component method. Forecasting: Exponential smoothing methods, Short term forecasting methods: Brown's discounted regression, Box-Jenkins method and Bayesian forecasting.

Recommended Books and References:
1. Kendall M.G. (1976): Time Series, Charles Griffin.
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

DISCIPLINE SPECIFIC ELECTIVE 2 (STD 5.22)
TIME SERIES ANALYSIS

Practical Credit: 4

List of Practical
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. Calculation of variance of random component by variate difference method
9. Forecasting by exponential smoothing
10. Forecasting by short term forecasting methods.

DISCIPLINE SPECIFIC ELECTIVE 3 (STD 6.11)
DEMOGRAPHY

Theory Credit: 4

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.
Migration: definition and kind of migration, estimation of migration rates, components of migration.

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. Double and multiple decrement life table, indirect estimation of life expectancy, model life tables.

UNIT IV Abridged Life Tables; Concept and construction of abridged life tables by Reed-Merrell method, Greville's method and King's 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).

UNIT V Migration: Definition and kind of migration, estimation of migration rates, components of migration, migration streams, rural to urban migration, internal and international migration, differential migration, population distribution.

Recommended Books and References:
1. Mukhopadhyay P. (1999): Applied Statistics, Books and Allied (P) Ltd.
2. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. II, 9th Edition, World Press.
3. Biswas, S. (1988): Stochastic Processes in Demography & Application, Wiley Eastern Ltd.
4. Croxton, Fredrick E., Cowden, Dudley J. and Klein, S. (1973): Applied General Statistics, 3rd Edition. Prentice Hall of India Pvt. Ltd.
5. Keyfitz N., Beckman John A.: Demogrphy through Problems S-Verlag New york.
6. Bhende A.A. Kanitkar Tara: Principles of Population Studies, Himalayan Publishing House, Mumbai-400004.

DISCIPLINE SPECIFIC ELECTIVE 3 (STD 6.12)
DEMOGRAPHY

Practical Credit: 2

List of Practical
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 abridged life table using (i) Reed-Merrell Method, (ii) Greville's Method and (iii) King's Method
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
9. To calculate the probability of dying from a particular cause of death (multiple decrement life table).

DISCIPLINE SPECIFIC ELECTIVE 4 (STD 6.21(a))
ECONOMETRICS

Theory Credit: 4

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 multicollinearity, 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 under heteroscedasticity. Consequences of heteroscedasticity. Tests and solutions of heteroscedasticity. Autoregressive and Lag models, Dummy variables, Qualitative data.

Recommended Books and References:

1. Gujarati, D. and Sangeetha, S. (2007): Basic Econometrics, 4th Edition, McGraw Hill Companies.
2. Johnston, J. (1972): Econometric Methods, 2nd Edition, McGraw Hill International.
3. Koutsoyiannis, A. (2004): Theory of Econometrics, 2nd Edition, Palgrave Macmillan Limited,
4. Maddala, G.S. and Lahiri, K. (2009): Introduction to Econometrics, 4th Edition, John Wiley & Sons.

DISCIPLINE SPECIFIC ELECTIVE 4 (STD 6.22(a))
ECONOMETRICS

Practical Credit: 2

List of Practical

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 concerning specification errors
5. Problems related to consequences of Multicollinearity
6. Diagnostics of Multicollinearity
7. Problems related to consequences of Autocorrelation (AR(I))
8. Diagnostics of Autocorrelation
9. Estimation of problems of General linear model under Autocorrelation
10. Problems related to consequences Heteroscedasticity
11. Diagnostics of Heteroscedasticity
12. Estimation of problems of General linear model under Heteroscedastic distance terms
13. Problems related to General linear model under (Aitken Estimation)
14. Problems on Autoregressive and Lag models.

DISCIPLINE SPECIFIC ELECTIVE 4 (STD 6.21(b))
PROJECT WORK

Credit-6

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 human interest. The project work will provide hands on training to the students to deal with data emanating from some real life situation and propel them to dwell on some theory or relate it to some theoretical concepts.

SKILL ENHANCEMENT ELECTIVE

SKILL ENHANCEMENT COURSE 1 (STS 3.12)
STATISTICAL-DATA ANALYSIS USING SOFTWARE PACKAGES

Practical Credit: 2

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, Minitab, Matlab, for statistical computing.

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

UNIT II   Generate automated reports giving detailed descriptive statistics, correlation and lines of regression.

UNIT III   Random number generation and sampling procedures. Fitting of polynomials and exponential curves.

UNIT IV   Application Problems based on fitting of suitable distribution, Normal probability plot.

UNIT V   Simple analysis and create and manage statistical analysis projects, import data, code editing, Basics of statistical inference in order to understand hypothesis testing and compute p-values and confidence intervals.

Recommended Books and References:
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

SKILL ENHANCEMENT COURSE (STS 4.11)
STATISTICAL TECHNIQUES FOR RESEARCH METHODS

Theory Credit:2

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   Research design and measurement and scaling technique: Meaning of research design, need for research design, features of a good design, different research designs. Developing a research plan.

UNIT III Develop a questionnaire, collect survey data pertaining to a research problem (such as gender discriminations in private v/s government sector, unemployment rates, removal of subsidy, impact on service class v/s unorganized sectors), interpret the results and draw inferences.

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

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

Recommended Books and References:
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.