DEPARTMENT OF STATISTICS
KOHIMA SCIENCE COLLEGE, JOTSOMA(AUTONOMOUS)
GOVERNMENT OF NAGALAND

In the Board of Studies (BOS) meeting of Department of Statistics held on 19th July,2021 through Google Meet at 12pm with University nominee Prof. Mithilesh Kumar Sinha from Dept. of Economics Nagaland University as the Chairperson and faculty members after thorough consultation have decided to make the following modifications and place it to the Academic Council for approval.

1.CORE-8 (STC-4.11)

Unit-4: Topics on Likelihood Ratio Test viz. Tests for mean and variance of one, two and several independent normal population are added (shifted form Unit-5 of Core-10).

2. CORE-10 (STC-4.31)

Unit-1: topics on chance and assignable causes of variation shifted to Unit-2.

Unit-5: topics on Likelihood Ratio tests shifted to Unit-4 of Core-8.

3. Core-14 (STC 6.21)

Unit-1: (i) Topics on Moment Generating Function(M.G.F.) and examples of Bivariate Normal are   added.

        (ii) Topics on Mean vector and Dispersion matrix, Marginal and Conditional distributions of Multivariate Normal Distribution (MND) shifted to Unit-2.

        (iii) topics on Multiple and Partial Correlation Coefficient and their properties deleted.

4. DSE-3 (STD 6.11)

Unit-1: Since the topics on Migration are figured in Unit-5 also in details, so it has been decided to delete it from Unit-1.

5. SEC-1 (Practical)

Topics on Microsoft Excel and other Statistical Software packages viz. PSPP, STATA & R have been added in addition to SPSS, Mintab & Matlab, out of which atleast one of the software packages to be taught.

6.SEC-2 (Theory)

Entire topics comprising 5 units have been restructures after thorough discussion with the teachers concerned and subject expert.

7. GE-3 (STG 3.11)

Unit-2: Topics on Neyman Pearson Lemma are added and Tests of Hypothesis for the parameters of a normal distribution (one and two sample problems) deleted.

Unit-3: (i)Whole unit is restructured as Tests of Significance and the topics on Non-Parametric Tests   deleted completely since it was observed that the said topic is not relevant for Generic   students and a more relevant topics of practical utility in higher studies have been added.

    (ii) Numerical problems on the restructured unit have also been incorporated in practical.

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Submitted by

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KOHIMA SCIENCE COLLEGE (AUTONOMOUS) JOTSOMA, NAGALAND

STATISTICS SYLLABUS (MODIFIED-2021)

(HONOURS PAPERS & GENERIC PAPERS)

FOR

THREE YEARS B. SC. COURSE
UNDER
CHOICE BASED CREDIT SYSTEM (CBCS)
TO BE IMPLEMENTED
FROM NEXT ACADEMIC SESSION

DEPARTMENT OF STATISTICS
KOHIMA SCINECE COLLEGE (AUTONOMOUS), JOTSOMA

Core papers and Discipline Specific Elective Papers (Credit: 6 each) (Total=21 papers)

STC-1.11 Descriptive Statistics and Probability Theory (Theory) - No changes
STC-1.12 Descriptive Statistics and Probability Theory (Practical)
STC-1.21 Calculus (Theory) - No changes
STC-   Calculus (Tutorial)
STC-2.11 Probability Distributions and Correlation Analysis (Theory) - No changes
STC-2.12 Probability Distributions and Correlation Analysis (Practical)
STC-2.21 Algebra (Theory) - No changes
STC-   Algebra (Tutorial)
STC-3.11 Sampling Distributions (Theory) - No changes
STC-3.12 Sampling Distributions (Practical)
STC-3.21 Survey Sampling and Indian Official Statistics (Theory) - No changes
STC-3.22 Survey Sampling and Indian Official Statistics (Practical)
STC-3.31 Mathematical Analysis (Theory) - No changes
STC-   Mathematical Analysis (Tutorial)
STC-4.11 Statistical Inference (Theory) – Modification done
STC-4.12 Statistical Inference (Practical)
STC-4.21 Linear Models (Theory)
STC-4.22 Linear Models (Practical)
STC-4.31 Statistical Quality Control (Theory) – Modification done
STC-4.32 Statistical Quality Control (Practical)
STC-5.11 Stochastic Processes and Queuing Theory (Theory)
STC-5.12 Stochastic Processes and Queuing Theory (Practical)
STC-5.21 Statistical Computing Using C/C++ Programming (Theory)
STC-5.22 Statistical Computing Using C/C++ Programming (Practical)
STD-5.11 Operations Research (Theory) - No changes
STD-5.12 Operations Research (Practical)
STD-5.21 Time Series Analysis (Theory) - No changes
STD-5.22 Time Series Analysis (Practical)
STC-6.11 Design of Experiments (Theory) - No changes
STC-6.12 Design of Experiments (Practical)
STC-6.21 Multivariate Analysis and Index Number (Theory) - Modification done
STC-6.22 Multivariate Analysis and Index Number (Practical)
STD-6.11 Demography (Theory) - Modification done
STD-6.12 Demography (Practical)
STD-6.21(a) Econometrics (Theory) – No changes
STD-6.22(a) Econometrics (Practical)
STD-6.21(b) (Project Work)   - No changes

Skill Enhancement Papers
STS-3.11(a) Statistical Data Analysis Using Software Packages (Practical) - modification done
STS-4.11(a) Statistical Techniques for Research Methods (Theory) - modification done

Generic Elective Papers
STG 1.11Statistical Methods (Theory) - No changes
STG 1.12Statistical Methods (Practical)
STG 2.11 Introductory Probability (Theory) - No changes
STG 2.12 Introductory Probability (Practical)
STG 3.11 Basics of Statistical Inference (Theory) - Modification done
STG 3.12 Basics of Statistical Inference (Practical) – Modification done
STG 4.11 Applied Statistics (Theory) - No changes
STG 4.12 Applied Statistics (Practical)

CORE PAPERS

SEMESTER-I

Core-1 (STC-1.11): Descriptive Statistics and 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.

SUGGESTED READING:

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 and Probability Theory (Practical)

List of Practical   **Credit 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 6 (Theory- 5+ Tutorial-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.

SUGGESTED READINGS:
1. Gorakh Prasad: Differential Calculus, Pothishala Pvt. Ltd., Allahabad (14th Edition - 1997).
2. Gorakh Prasad: Integral Calculus, PothishalaPvt. 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 and Correlation Analysis (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

UNIT V: 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.

SUGGESTED READING:

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)
Credit 2

List of Practical
1. Fitting of binomial distributions for n and $p = q = \frac{1}{2}$.
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 6 (Theory- 5+ Tutorial-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.

SUGGESTED READINGS:

1. Lay David C.: Linear Algebra and its Applications, Addison Wesley, 2000.
2. Schaum's Outlines : Linear Algebra, Tata McGraw-Hill Edition, 3^{rd}Edition, 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 sth 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 χ^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 χ^2 distribution. Tests of significance and confidence intervals based on χ^2-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 χ^2 distributions. Test of significance and confidence Intervals based on t and F distributions.

SUGGESTED READING:
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*, 4th Edn. 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)   Credit 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).

SUGGESTED READING:
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)

Credit 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 6 (5+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 sinx, cosx, 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.

SUGGESTED READINGS

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 Real Analysis,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 Del

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). Likelihood ratio(LR) test- tests for mean and variance of one, two and several independent normal population;

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.

SUGGESTED READINGS:
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. 2[nd]Edn. (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)

List of Practical   **Credit 2**

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 two way 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.

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 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)
List of Practical   **Credit 2**

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,

UNIT II: Statisitcal Quality Control: concepts, chance and assignable Causes of variation; Statistical Control Charts- Construction and Statistical basis of 3-σ Control charts, Rational Sub-grouping, Control charts for variables: X-bar & R-chart, σ -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: Sequential Analysis: Wald's Sequential probability ratio test (SPRT). 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,
SUGGESTED READING:
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)

Credit 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.

SUGGESTED READING:
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)

List of Practical   **Credit 2**
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.

SUGGESTED READING:

1. Kernighan, B.W. and Ritchie, D. (1988): C Programming Language, 2ndEdition,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)
(Using C/C++ Programming Language)

Credit 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.

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. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005): Fundamentals of Statistics. Vol. II, 8^{th}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)

Credit 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, m.g.f. of BVN, Examples of BVN.

UNIT II: Multivariate Normal distribution and its properties; Derivation of MND & determination of the constant; m.g.f. of MND; Sampling distribution for mean vector and variance- covariance matrix. Mean vector & Dispersion matrix, Marginal & Conditional distributions;

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.

SUGGESTED READING:
1. Anderson, T.W. (2003): An Introduction to Multivariate Statistical Analysis, 3rd Edn., John Wiley
2. Muirhead, R.J. (1982): Aspects of Multivariate Statistical Theory, John Wiley.
3. Kshirsagar, A.M. (1972) :Multivariate Analysis, 1st Edn. Marcel Dekker.
4. Johnson, R.A. and Wichern, D.W. (2007): Applied Multivariate Analysis, 6th Edn., 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-6.21): Multivariate Analysis and Index Number (Practical)

List of Practical   **Credit 2**

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 (DSE) Papers

DSE-I (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).

SUGGESTED READING:

1. Taha, H. A. (2007): Operations Research: An Introduction, 8th Edition, Prentice Hall of India.
2. KantiSwarup, 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

STD-5.12: Operations Research (Practical)
(Using TORA/WINQSB/LINGO)

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.

DSE-II (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.

SUGGESTED READING:
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

STD-5.22: Time Series Analysis (Practical)

Credit 2

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.

DSE-III (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.

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.

SUGGESTED READING:
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.

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).

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.

SUGGESTED READING:

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.

STD-6.22(a): Econometrics (Practical)

List of Practical   **Credit 2**

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.

OR

DSE-IV (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.

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Generic Elective Papers

(GE-1) (STG-1.11): Statistical Methods (Theory)

Credit 4

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: arithmetic mean, geometric mean, harmonic mean, median and mode with properties and merit, demerits, quartiles, deciles and percentiles.

UNIT III: Measures of Dispersion: range, quartile deviation, mean deviation and standard deviation, their definitions and properties, uses and merits, demerits, absolute and relative measures of dispersions, Raw and central moments and their relations,Sheppard's correction for moments and factorial moments, Measures of 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: Theory of attributes, consistency of data, independence and association of attributes, measures of association and contingency.

SUGGESTED READING:
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.

STG-1.12: Statistical Methods (Practical)

Credit 2

List of Practical
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
6. Finding the class frequencies of attributes, examine the independency of attributes.
7. Checking consistency of data and finding association among attributes.

(GE-2) (STG-2.11): Introductory Probability (Theory)

Credit 4

UNIT I: 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 II: Multiple and partial correlation (3 variables only), Properties of residual, Plane of regression.

UNIT III: Random Variables: Discrete and continuous random variables, p.m.f., p.d.f. ,c.d.f. Illustrations of random variables and its properties. Expectation, variance, moments and moment generating function. Convergence in probability, almost sure convergence, Chebyshev's inequality, weak law of large numbers

UNIT IV: Standard discrete probability distributions: Binomial, Poisson, hypergeometric and geometric.

UNIT V: Standard continuous probability distributions: uniform, normal and exponential.

SUGGESTED READING:
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

STG-2.12: Introductory Probability (Practical)

Credit 2

List of Practical

1. Fitting of binomial distributions for n and p = q = ½ given
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. To find the ordinate for a given area for normal distribution

10. Application based problems using normal distribution
11. Fitting of normal distribution when parameters are given
12. Fitting of normal distribution when parameters are not given
13. Karl Pearson correlation coefficient
14. Partial and multiple correlations
15. Spearman rank correlation with and without ties.
16. Correlation coefficient for a bivariate frequency distribution
17. Lines of regression, angle between lines and estimated values of variables.

(GE-3) (STG-3.11): Basics of Statistical Inference (Theory)

Credit 4

UNIT I: Estimation Theory: parameter and statistic, estimator and estimate, properties of good estimator – consistency, unbiasedness, efficiency and sufficiency; Method of Maximum Likelihood Estimation (MLE).

UNIT II: Testing of hypothesis: Hypothesis, Null and alternative hypothesis, Simple and Composite hypothesis, Type I and Type II errors, level of significance, p-value, power of a test, Neyman Pearson lemma

UNIT III: Tests of Significance (Restructured)- t-test: one sample and two sample test, paired t-test, test of significance of correlation coefficient; Z-test: single and two mean test; F-test: test of variance; χ^2-test: test of goodness of fit and test of association, Yate's correction.

UNIT IV: Sample Survey: census and survey, basic principles of sample survey, principal steps in sample survey, sampling and non-sampling error, types of sampling-simple random sampling-with and without replacement, stratified random sampling and systematic sampling (concept only).

UNIT V: Analysis of variance, one-way and two-way classification with one observation per cell, Design of experiment: treatment, plot and block, basic principles of design of experiments, completely randomized design (CRD) and randomized block design (RBD).

SUGGESTED READING:

1. Daniel, Wayne W., Bio-statistics: A Foundation for Analysis in the Health Sciences. John Wiley (2005).
2. Goon, A.M., Gupta M.K. & Das Gupta, Fundamentals of statistics, Vol.-I & II (2005).
3. Dass, M. N. &Giri, N. C.: Design and analysis of experiments. John Wiley.
4. Dunn, O.J Basic Statistics: A primer for the Biomedical Sciences .(1964, 1977) by John Wiley.
5. Bancroft, Holdon Introduction to Bio-Statistics (1962) P.B. Hoebar New York.
6. Goldstein, A Biostatistics-An introductory text (1971). The Macmillion New York.

(STG-3.12): Basics of Statistical Inference (Practical)

Credit 2

List of Practical
1. Estimators of population mean.
2. Confidence interval for the parameters of a normal distribution (one sample and two sample problems).
3. Tests of hypotheses for the parameters of a normal distribution (one sample and two sample problems).
4. Chi-square test of proportions.
5. Chi-square tests of association.
6. Chi-square test of goodness-of-fit.
7. Z-test, t-test
8. t-test for one sample
9. t-test for two sample
10. paired t-test
11. Analysis of Variance of a one way and two way classified data
12. Analysis of a CRD and RBD
13. Problems on SRS and Stratified random sampling

(GE-4) (STG-4.11): Applied Statistics (Theory)

Credit 4

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, Methods of measuring trend, Measurement of seasonal variations by method of ratio to trend.

UNIT II: Index numbers: Definition, Criteria for a good index number, Construction of index numbers, different types of index numbers, Time and Factor reversal test, consumer price index number, Uses and limitations of index numbers.

UNIT III: Statistical Quality Control (SQC): definition, purpose and importance of SQC, Causes of variations in quality: chance and assignable, general theory of control charts, process and 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, IMR, standardized death rates.
Life (mortality) tables: definition of its main functions and uses, Measurement of fertility: CBR, GFR, and TFR.

UNIT V: Demand Analysis: Demand and supply functions, Price elasticity of demand and supply, income elasticity of demand; Pareto's law of income distribution; Engel's law and Engel's curve.

SUGGESTED READING:
1. Mukhopadhyay, P. (1999): Applied Statistics, New Central Book Agency, Calcutta.
2. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. II, 9th Edition World Press, Kolkata.
3. Gupta, S. C. and Kapoor, V.K. (2008): Fundamentals Of Applied Statistics, 4th Edition(Reprint), Sultan Chand & Sons
4. Montogomery, D. C. (2009): Introduction to Statistical Quality Control, 6th Edition, Wiley India Pvt. Ltd.

(STG-4.12): Applied Statistics (Practical)

Credit 2

List of Practical

1. Measurement of trend: Fitting of linear, quadratic trend, exponential curve and plotting of trend values and comparing with given data graphically.
2. Measurement of seasonal indices by Ratio-to-trend method and plotting of trend values and comparing with given data graphically.
3. Construction of price and quantity index numbers by Laspeyre's formula, Paasche's formula, Marshall-Edgeworth's formula, Fisher's Formula. Comparison and interpretation.
4. Construction of wholesale price index number, fixed base index number and consumer price index number 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. Construction of life table
9. Computation of measures of fertility and population growth
10. Problems on demand and supply functions.

Skill Enhancement Elective Papers

STS-3.11 (a): 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, PSPP, STATA, R, MS Excel, 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.

SUGGESTED READING:
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 (Restructured)

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:

Research: Meaning, objective, motivation, types of research, significance of research. Research Methods versus Methodology, Research and Scientific Method, Research Process, Criteria of Good Research. Research problems: definition, selection and necessity of defining research problems.

UNIT II:

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

Measurement in Research:Measurement Scales, Tests of Sound Measurement.

UNIT III

Methods of Data Collection: Collection of Primary Data: Observation Method, Interview Method. Collection of Data through Questionnaires, Collection of Data through Schedules, Difference between Questionnaires and Schedules, Some Other Methods of Data Collection, Collection of Secondary Data, Selection of Appropriate Method for Data Collection, Case Study Method.

UNIT IV

Statistics in data analysis: Census and Sample Survey, Steps in Sampling Design, Different Types of Sample Designs(detailed discussion not necessary), Sample Size and its Determination;

Different types of statistical analysis (concept only, detailed discussion not necessary): Descriptive statistics (Mean, SD etc.), Explanatory analysis (correlation), Causal analysis (Regression), Inferential statistics (hypothesis testing using t-test, Z-test, F-test, Chi-square test), predictive analysis (regression analysis).

UNIT V

Processing, Data Analysis and Interpretation: Processing Operations, Some Problems in Processing, Elements/Types of Analysis, Meaning of Interpretation, Technique of Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report.

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.

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