

Syllabus For B.A./B.Sc.

**Statistics**

(School of Sciences)

Under the

**Choice Based Credit system**

(CBCS) 2016



B.A./B.Sc. 1<sup>st</sup> Semester

Course No. SOS/STAT/UG/C-101

Core Course<sup>1<sup>st</sup></sup> - Credit 4

### Core 1.1: Differential Calculus

Limit and Continuity ( $\epsilon$  and  $\delta$  definition), Types of discontinuities, Differentiability of functions, Successive differentiation,

Tangents and normals, Curvature, Asymptotes, Singular points, Rolle's theorem, Mean Value theorem //

#### Books Recommended

1. H. Anton, I. Bivens and S. Davis, Calculus, John Wiley and Sons, Inc., 2002.
2. G.B. Thomas and R.L. Finney, Calculus, Pearson Education, 2007.

### Core 1.2: Descriptive Statistics and Probability Theory

Nature of Statistics, Uses of Statistics, Statistics in relation to other disciplines. Concepts of a finite population and sample from a population, quantitative and qualitative data, discrete and continuous. Presentation of data by tables and by diagrams, frequency distributions for discrete and continuous graphical representation of a frequency distribution by histogram and frequency polygon, cumulative frequency distributions (inclusive and exclusive methods).

Measures of Central tendency: Mean, Median, Mode, Geometric Mean and Harmonic Mean: their properties

Measures of Dispersion: Range, Quartile Deviation, Mean Deviation, Standard Deviation and their properties, Coefficient of variation, Moments, Skewness and Kurtosis-cumulants,

Bivariate data: Scatter diagram, principle of least-square and fitting of polynomials and exponential curves. Correlation and regression. Karl Pearson coefficient of correlation, Lines of regression.

Random experiment, sample point and sample space, event, algebra of events, Definition of Probability: classical, relative frequency and axiomatic approaches to probability, merits and demerits of these approaches (only general ideas to be given). Theorem on probability, conditional probability, independent events, Bayes theorem and its applications. //

#### Books Recommended

1. J.E. Freund, Mathematical Statistics with Applications, 7th Ed., Pearson Education, 2009
2. A.M. Goon, M.K. Gupta and B. Dasgupta, Fundamentals of Statistics, Vol. I, 5th Ed., World Education, Kolkata, 2005.
3. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, 11th Ed., Sultan Chand Sons, 2007.
4. R.V. Hogg, A.T. Craig and J.W. Mekean, Introduction to Mathematical Statistics, 6th Ed., Pearson Education, 2005.



5. A.M. Mood, F.A. Graybill and D.C. Boes, Introduction to the Theory of Statistics, 3rd Ed., Tata McGraw Hill Publication, 2007.

### Core 1.3: Linear Programming

Introduction to Operational Research and overview of O.R. modeling

Introduction to Linear Programming Problem, Problem formulations, Graphical solution, Theory of Simplex method, Duality in Linear Programming, Economic interpretation of duality,

Assignment problem, Transportation problem and its mathematical formulation, northwest corner method least cost method. //

#### Books Recommended

1. G. Hadley, Linear Programming, Narosa, 2002.
2. Handy A. Taha, Operations Research- An Introduction, Prentice Hall, 8th edition, 2007.
3. F.S. Hillier, G.J. Lieberman, Introduction to operations research- Concepts and Cases, 9th Edition, Tata McGraw Hill, 2010.

### Practical — Credit 2

#### PRACTICAL/LAB. WORK:

##### 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. Fitting of polynomials, exponential curves.
7. Karl Pearson correlation coefficient.
8. Correlation coefficient for a bivariate frequency distribution.
9. Lines of regression, angle between lines and estimated values of variables.
10. Spearman rank correlation with and without ties.
11. Partial and multiple correlations.
12. Problems based on probability.
13. Problems based on Baye's theorem.
14. Mathematical formulation of L.P.P and solving the problem using graphical method
15. Simplex technique to solve L.P.P and reading dual solution from the optimal table
16. Allocation problem using Transportation model
17. Allocation problem using Assignment model
18. Problems based on Northwest corner method. //



B.A./B.Sc. II<sup>nd</sup> Semester

Course No. SOS/STAT/UG/C-201

Core Course - Credit 4

### Core 2.1: Differential Equations

First order exact differential equations, Integrating factors, rules to find an integrating factor. Basic theory of linear differential equations, Solving a differential equation by reducing its order. Linear homogeneous equations with constant coefficients. Order and degree of partial differential equations, Linear partial differential equation of first order, Lagrange's method.

#### Books Recommended

1. Shepley L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, 1984.
2. I. Sneddon, Elements of Partial Differential Equations, McGraw-Hill, International Edition. 1967.

### Core 2.2: Statistical Methods

Random variables: Discrete and continuous random variables, p.m.f., p.d.f. and c.d.f., illustrations of random variables and its properties; expectation of random variable and its properties. Moments and cumulants, moment generating function, cumulants generating function and characteristic function. Transformation in univariate and bivariate distributions. Bivariate probability distributions; marginal and conditional distributions; independence of variates (only general idea to be given). Point (or degenerate), binomial, Poisson, Geometric, negative binomial, Hypergeometric, Normal, Uniform, Exponential, Beta and Gama distributions. Statement and application of Chebychev's inequality, WLLN and SLLN, Central limit theorem (CLT) for i.i.d. variates, and its applications. De Moivre's Laplace Theorem.

#### Books Recommended

1. A.M. Goon, M.K. Gupta and B. Dasgupta, An outline of Statistical Theory (Vol. 1), 4th Ed., World Press, Kolkata, 2003.
2. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, 11th Ed., Sultan Chand and Sons, 2007.
3. R.V. Hogg, A.T. Craig, and J.W. Mckean, Introduction to Mathematical Statistics, 6th Ed. Pearson Education, 2005.
4. A.M. Mood, F.A. Graybill and D.C. Boes, Introduction to the Theory of Statistics, 3rd Ed., Tata McGraw Hill Publication, 2007.
5. V.K. Rohitagi and A.K. Md. E. Saleh, An Introduction to Probability and Statistics, 2nd Edition, John Wiley and Sons, 2009.
6. S.A. Ross, Introduction to Probability Models, 9th Ed., Academic Press, 2007.



## Unit 2.3: Mathematical Programming

(Unit 5) S.D. Sharma

Unconstrained and constrained optimization problems. Types of extrema and their necessary and sufficient conditions. Convex functions and their properties. Kuhn-Tucker optimality conditions. Quadratic Programming. Wolfe's Method.

### Books Recommended

1. Hamdy A. Taha, Operation research-An Introduction, Prentice Hall, 8th Ed., 2007.
2. Wayne L. Winston and M. Venkataramanana, Introduction to Mathematical Programming: Applications and Algorithm, 4th Ed., Duxbury Press, 2002.
3. S. Chandra, Jayadeva, Aparna Mehra, Numerical Optimization with Applications, Narosa Publication House, 2009.
4. A. Ravindran, D.T. Phillips and James J. Solberg, Operations Research-Principles and Practice, John Wiley and Sons, 2005.

### Practical — Credit 2

#### PRACTICAL/LAB. WORK:

##### 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. Fitting of normal distribution when parameters are given.
12. Fitting of normal distribution when parameters are not given.



### Core 3.1: Real Analysis

Finite and infinite sets, examples of countable and uncountable sets. Real line, bounded sets, suprema and infima. Concept of cluster points and statement of Bolzano-Weierstrass theorem.

Real Sequence. Bounded sequence, Cauchy convergence criterion for sequences. Cauchy's theorem on limit of monotone sequences and their convergence (monotone convergence theorem without proof). Infinite series. Cauchy convergence criterion for series, positive term series, geometric series.

Leibnitz's test (Tests of Convergence without proof). Definition and examples of absolute and conditional convergence.

#### Books Recommended

1. T.M. Apostol, Calculus (Vol. I), John Wiley and Sons (Asia) P. Ltd., 2002.
2. R.G. Bartle and D. R Sherbert, Introduction to Real Analysis, John Wiley and Sons (Asia) P. Ltd., 2000.
3. E. Fischer, Intermediate Real Analysis. Springer Verlag, 1983.
4. K.A. Ross, Elementary Analysis- The Theory of Calculus Series- Undergraduate Texts in Mathematics. Springer Verlag, 2003.

### Core 3.2: Statistical Inference

Estimation: Parameter space, sample space, point estimation, requirement of a good estimator, consistency, unbiasedness, efficiency, sufficiency, Minimum variance unbiased estimators. Cramer-Rao inequality (Statement only). Methods of estimation: maximum likelihood, leastsquares and minimum variance, statement of Rao-Blackwell theorem and lehmann-Scheffe theorem. Properties of maximum likelihood estimators (illustration). Interval Estimation: confidence intervals for the parameters of normal distribution, confidence intervals for difference of mean and for ratio of variances.

Testing of Hypothesis: Statistical Hypothesis, simple and composite hypotheses. Test of statistical hypothesis, null and alternative hypotheses. Critical region. Two kinds of errors, Level of significance and power of a test. MP test and region. Neyman-Pearson lemma (statement only). Likelihood ratio test, UMP test, UMPV test. Critical regions for simple hypothesis for one parameter.

Non-Parametric Tests: One sample and two sample sign test, Wald-Wolfowitz run test, run test for randomness, Median test and Wilcoxon-Mann-Whitney test (derivation not required, give stress on examples).



## Books Recommended

1. G. Casella and R.L. Berger, Statistical Inference, 2nd Ed., Thomson Duxbury, 2002
2. E.J. Dudewicz and S.N. Mishra, Modern Mathematical Statistics, John Wiley and Sons, 1988.
3. J.D. Gibbons and S. Chakraborty, Non Parametric Statistical Inference, 4th Ed., Marcel Dekker, CRC, 2003.
4. A.M. Goon, M.K. Gupta and B. Dasgupta, An Outline of Statistical Theory (Vol. I), 4th Ed., World Press, Kolkata, 2003. 5. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, 11th Ed., Sultan Chand and Sons, 2007.
5. M.G. Kendall and A. Stuart, The Advanced Theory of Statistics (Vol. III), Macmillan Publishing Co., Inc., 1977.
6. R.V. Hogg, A.T. Craig and J.W. Mekean, Introduction to Mathematical Statistics, 6th Ed. Pearson Education, 2005.
7. V.K. Rohtagi and A.K. Md. E. Saleh, An Introduction to Probability and Statistics, 2nd Ed., John Wiley and Sons, 2009.

## Core 3.3: Inventory Systems and Marketing Management

Concepts and problems in Inventory Systems, classification of Inventory Systems, different costs in Inventory Systems and method of their estimation. Deterministic Inventory models with and without lead time and with and without shortages. Inventory models with all units Quality Discounts. Single period stochastic inventory models. Production scheduling problems.

Concept of marketing and its role in organization. Marketing decisions, scientific marketing analysis. Uses and limitations of mathematical models in marketing, classification of market structure in competitive conditions. Demand elasticity, joint optimization of price, quality and promotional efforts. Pricing decisions, media allocation for advertisement. Brand switching analysis.

## Books Recommended

1. G. Hadley, T.M. Whitin, Analysis of Inventory Systems, D.B. Taraporevala and Sons, Published by arrangement with Prentice Hall Inc., 1979.
2. Zipkin, Foundations of Inventory Management, McGraw Hall Inc., 2000.
3. Donald Waters, Inventory Control, John Wiley, 2003.
4. Philip Kotler, Marketing Management, 13th Ed., Prentice Hall of India, 2008.
5. Tony Curtis, Marketing for Engineers, Scientists and Technologists, John Wiley & Sons Inc., 2008.
6. Graham J. Hooley and Michael K. Hassey, Quantitative Methods in Marketing, 2nd Ed., International Thomson Business Press, 1999.
7. Grahame R. Dowling, The Art and Science of Marketing –Marketing for Marketing Managers, Oxford University press, 2005.



## Practical — Credit 2

### PRACTICAL/LABWORK:

#### 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

### Skill Enhancement Course (SEC)

Course No. SOS/STAT/UG/SEC-3.01

#### Core Course - Credit 2

#### SEC 3.01. (choose one)

1. Logic and Sets
2. Integral Calculus

#### SEC 3.01.1: Logic and Sets

Introduction. propositions, truth table, negation, conjunction and disjunction. Propositional equivalences: Logical equivalences. Predicates and quantifiers: Introduction, Quantifiers, Binding variables and Negations.



Sets, subsets, Set operations, the laws of set theory and Venn diagrams. Empty set, properties of empty set. Standard set operations. Classes of sets. Power set of a set.

Difference and Symmetric difference of two sets, Set identities, Generalized union and intersections.

#### Books Recommended

1. R.P. Grimaldi, Discrete Mathematics and Combinatorial Mathematics, Pearson Education, 1993.
2. P.R. Halmos, Naive Set Theory, Springer, 1974.
3. E. Kamke, Theory of Sets, Dover Publishers, 1950.

#### SEC 3.01.2: Integral Calculus

Integration by Partial fractions, integration of rational and irrational functions. Properties of definite integrals.

Evaluation of areas and lengths of curves in the plane, valuation of volumes and surfaces of solids of revolution.

#### Books Recommended

1. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
2. H. Anton, I. Bivens and S. Davis, Calculus, John Wiley and Sons (Asia) P. Ltd, 2002.



### Core 4.1: Algebra

Definition and examples of groups, examples of abelian and non-abelian groups, the group  $Z_n$  of integers under addition modulo  $n$  and the group  $U(n)$  of units under multiplication modulo  $n$ .

Subgroups, cyclic subgroups, the concept of a subgroup generated by a subset and the commutator subgroup of group, examples of subgroups including the center of a group. Lagrange's theorem, order of an element

Definition and examples of rings, examples of commutative and non-commutative rings. Subrings and ideals, Integral domains and fields, examples of fields:  $Z_p$ ,  $Q$ ,  $R$ , and  $C$ . Field of rational functions.

### Books Recommended

1. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
2. M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
3. Joseph A Gallian, Contemporary Abstract Algebra, Narosa, 1999.
4. George E. Andrews, Number Theory, Hindustan Publishing Corporation, 1984.

### Core 4.2: Sample Surveys and Design of Experiments

Sample Surveys: Concepts of population and sample. Complete enumeration vs. sampling. Need for sampling. Principal and organizational aspects in the conduct of a sample survey. Properties of a good estimator. Sampling and non-sampling errors.

SRSWR & SRSWOR, determination of sample size. Stratified random sampling and different allocations. Systematic sampling. comparison of known sampling strategies under linear trend. Ratio and Regression estimators and their comparison with SRSWOR estimator.

Indian Official Statistics: Present Official Statistical System in India relating to census of population, agriculture, industrial production, and prices; methods of collection of official statistics, their reliability and limitation and the principal publications containing such statistics. Also the various agencies responsible for the data collection- C.S.O., N.S.S.O., Office of Registrar General, their historical development, main functions, and important publications.

Analysis of variance and covariance: Analysis of variance and covariance (with one concomitant variable) in one-way and two-way classified data with equal number of observations per cell



Design of experiments: Principles of experimentation, uniformity trails, completely randomized, Randomized block and Latin square designs. Missing plot technique.

Regression Analysis: Two variable linear model – estimation, testing and problems of predication. Predication of the estimated regression equation, interval estimation, variance estimation.

### Books Recommended

1. W.G. Cochran, Sampling Techniques. John Wiley and Sons, New York, 1997.
2. A.M. Goon, M.K. Gupta, and B. Dasgupta, Fundamentals of Statistics (Vol. II), 8th Ed., World Press, Kolkata, 2005.
3. A.M. Goon, M.K. Gupta and B. Dasgupta, An Outline of Statistical Theory (Vol. II), 3rd Ed., World Press, Kolkata, 2005.
4. S.C. Gupta and V.K. Kapoor, Fundamentals of Applied Statistics, 4th Ed., Sultan Chand and Sons, 2008.
5. A.M. Kshirsagar, A Course in Linear Models, Marcel Dekker, Inc., N.Y., 1983.
6. D.C. Montgomery, Designs and Analysis of Experiments, John Wiley and Sons, New York, 2001.
7. D.C. Montgomery, E.A. Peak and G.G. Vinning, Introduction to Linear Regression Analysis, 3rd Ed., John Wiley and Sons, 2006.
8. P. Mukhopadhyay, Theory and Methods of Surveys Sampling, Prentice Hall of India, 1998.
- ✓9. D. Singh and F.S. Chaudhary, Theory and Analysis of Sample Survey Designs, New Age International (P) Ltd., 1995.
- ✓10. P.V. Sukhatme, B.V. Sukhatme, S. Sukhatme and C. Ashok, Sampling Theory of Surveys with Applications, Iowa State University Press, Iowa, USA, 1984.

### Core 4.3: Network Analysis and Theory of Sequencing

Flows in networks. Maximal flow. Shortest path and travelling salesman problem. Construction of minimal spanning tree and its applications. Project management through PERT/CPM, Updating of PERT Charts. Project Crashing, Sequencing Problems. Processing n jobs through two/three machines. General n/m job-shop problem.

### Books Recommended

1. G. Hadley, Nonlinear and Dynamic Programming, Addison-Wesley, 1964.
2. A. Ravindran, D.T. Phillips and James J. Solberg, Operations Research-Principles and Practice, John Wiley and Sons, 2005.
3. R.K. Ahuja T. L. Magnanti, B. Orlin, Network Flows-Theory, Algorithm and Applications, Prentice Hall, NJ, 1993.
4. J.D. Wist, F.K. Levy, A Management Guide to PERT/CPM, 2nd Ed., PHI, 1967 (Reprint 2007).

### Practical – Credit 2

PRACTICAL/LAB. WORK:

11

512



## 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.
8. Analysis of a CRD
9. Analysis of an RBD
10. Analysis of an LSD
11. Analysis of an RBD with missing observation
12. Analysis of an LSD with missing observation

## Skill Enhancement Course (SEC)

Course No. SOS/STAT/UG/SEC-4.01

Credit 2

SEC 4.01. (choose one)

1. Portfolio Optimization
2. Bio-Mathematics

### SEC 4.01.1: Portfolio Optimization

Financial markets. Investment objectives. Measures of return and risk. Types of risks. Portfolio of assets. Mean-variance portfolio optimization- the Markowitz model and the two-fund theorem, risk-free assets and one fund theorem, efficient frontier. Portfolio performance evaluation measures.

#### Books Recommended

1. F.K. Reilly, Keith C. Brown, Investment Analysis and Portfolio Management, 10th Ed., South-Western Publishers, 2011.
2. H.M. Markowitz, Mean-Variance Analysis in Portfolio Choice and Capital Markets, Blackwell, New York, 1987.

*Logic & Stats - 3*  
*Portfolio Optimization - 4*  
*Number Theory*  
*Group Theory*



3. D.G. Luenberger, Investment Science, 2nd Ed., Oxford University Press, 2011.

### SEC 4.01.2: Bio-Mathematics

**Mathematical Biology and the modeling process: an overview.** Continuous models: Malthus model, logistic growth, Gompertz growth, Qualitative analysis of continuous models, Steady state solutions, stability and linearization, multiple species communities and Routh-Hurwitz Criteria.

**Spatial Models:** One species model with diffusion, Discrete Models: Overview of difference equations, steady state solution and linear stability analysis, Introduction to Discrete Models.

#### Books Recommended

1. L.E. Keshet, Mathematical Models in Biology, SIAM, 1988.
- ✓ 2. J.D. Murray, Mathematical Biology, Springer, 1993.
- ✓ 3. Y.C. Fung, Biomechanics, Springer-Verlag, 1990.
4. F. Brauer, P.V.D. Driessche and J. Wu, Mathematical Epidemiology, Springer, 2008.
5. M. Kot, Elements of Mathematical Ecology, Cambridge University Press, 2001.



SEC 5.01 (choose one)

1. Number Theory
2. Theory of Equations

SEC 5.01.1: Number Theory

Division algorithm, Lame's theorem, linear Diophantine equation, fundamental theorem of arithmetic, linear congruences, complete set of residues.

Number theoretic functions, sum and number of divisors, totally multiplicative functions, definition and properties of the Dirichlet product.

Books Recommended

1. David M. Burton, Elementary Number Theory, 6th Ed., Tata McGraw-Hill Edition, Indian reprint, 2007.
2. Richard E. Klima, Neil Sigmon, Ernest Stitzinger, Applications of Abstract Algebra with Maple, CRC Press, Boca Raton, 2000.
- ✓ 3. Neville Robbins, Beginning Number Theory, 2nd Ed., Narosa Publishing House Pvt. Limited, Delhi, 2007.

SEC 5.01.2: Theory of Equations

General properties of polynomials, Graphical representation of a polynomials, General properties of equations.

Symmetric functions, Applications of symmetric function of the roots, Transformation of equations.

Books Recommended

- ✓ 1. W.S. Burnside and A.W. Panton, The Theory of Equations, Dublin University Press, 1954.
2. C. C. MacDuffee, Theory of Equations, John Wiley & Sons Inc., 1954.



B.A./B.Sc. V<sup>th</sup> Semester

Discipline Specific Electives (DSE)

Course No. SOS/STAT/UG/DSE-5.01

Credit 2

178

DSE 5A. (Choose one)

1. Matrices.
2. Vector Calculus and Analytical Geometry

#### DSE 5A.1: Matrices

$\mathbb{R}$ ,  $\mathbb{R}^2$ ,  $\mathbb{R}^3$  as vector spaces over  $\mathbb{R}$ . Standard basis for each of them. Concept of Linear Independence and examples of different bases.

Matrix form of basic geometric transformations. Interpretation of eigen values and eigenvectors for such transformations and eigen spaces as invariant subspaces. Matrices in diagonal form. Reduction to diagonal form upto matrices of order 3.

Computation of matrix inverses using elementary row operations. Rank of matrix. Solutions of a system of linear equations using matrices. Illustrative examples of above concepts from Geometry, Physics, Chemistry, Combinatorics and Statistics.

#### Books Recommended

1. A.I. Kostrikin, Introduction to Algebra, Springer Verlag, 1984.
2. S. H. Friedberg, A. L. Insel and L.F. Spence, Linear Algebra, Prentice Hall of India Pvt. Ltd., New Delhi, 2004.
3. Richard Bronson, Theory and Problems of Matrix Operations, Tata McGraw Hill, 1989.

#### DSE 5A.2: Vector Calculus and Analytical Geometry

Algebra of vectors, Differentiation and partial differentiation of a vector function. Derivative of sum, dot product and cross product of two vectors.

Classification of quadratic equations representing lines, parabola, ellipse and hyperbola. Spheres, Cylindrical surfaces. Illustrations of graphing standard quadric surfaces like cone, ellipsoid.



### Books Recommended

1. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
2. H. Anton, I. Bivens and S. Davis, Calculus, John Wiley and Sons (Asia) P. Ltd. 2002.
3. P.C. Matthew's, Vector Calculus, Springer Verlag London Limited, 1998.
4. S.L. Loney, The Elements of Coordinate Geometry, McMillan and Company, London.
5. R.J.T. Bill, Elementary Treatise on Coordinate Geometry of Three Dimensions, McMillan India Ltd., 1994.

### DSE 5B. (Choose one)

1. Advanced Statistical Methods
2. Statistical Methodology

#### DSE 5B.1: Advanced Statistical Methods

Theory of attributes: Consistency of data, conditions of consistency, independence and association of attributes, measure of association and contingency.

Sampling Distributions: Definition of random sample, parameter and statistic. Sampling distribution of a statistic, standard errors of sample mean, sample proportion and sample moments. Sampling distribution of sample mean and sample variance for normal distribution. Sampling distributions of Chi-square, t and F statistics, distribution of sample correlation coefficient  $r$  when  $\rho=0$ .

Tests of significance: Null and alternative hypotheses, level of significance and probabilities of Type I and Type II errors, critical region and power of test. Large sample test, use of CLT for testing single proportion and difference of two proportions, single mean and difference of two means. Standard deviation and difference of Standard deviations. Tests of significance based on Chi-square, t and F distributions.

Order Statistics: Distribution of r-th order statistic, smallest and largest order statistics.

### Books Recommended

1. A.M. Goon, M.K. Gupta and B. Dasgupta, An Outline of Statistical Theory (Vol. I), 4th Ed., World Press, Kolkata, 2003.
2. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, 11th Ed., Sultan Chand and Sons, 2007.
3. R.V. Hogg, A.T. Craig and J.W. McKean, Introduction to Mathematical Statistics, 6th Ed., Pearson Education, 2005.
4. P. Mukhopadhyay, Mathematical Statistics, 2nd Ed., Books and Allied (P) Ltd., 2000.
5. V.K. Rohtagi and A.K. Md. E. Saleh, An Introduction to Probability and Statistics, 2nd Ed., John Wiley and Sons, 2009.



## DSE 5B.2: Statistical Methodology

Bivariate Data: Scatter diagram, Principal of least squares and fitting of polynomial and exponential curves  
Correlation and regression: Karl Pearson coefficient of correlation, lines of regression, Spearman's rank correlation coefficient, multiple and partial correlations (for 3 variates only)

Limit theorems: Markov's inequality, Chebyshev's inequality, weak and strong laws of large numbers, central limit theorems (Lindeberg-Levy).

Order Statistics: Distribution of  $r$ -th order statistic, smallest and largest order statistics.

Sampling Distribution: Concept of random sample, parameter and statistic, sampling distribution of a statistic, standard errors of sample mean and sample proportion, sampling distribution of sample mean and sample variance for a normal population.

Hypothesis Testing: Simple, composite null and alternative hypothesis, level of significance, type I and II errors. Critical region and power of test, large sample test. Tests of significance based on chi-square, t and F Statistics.

### Books Recommended:

1. J.E. Freund, Mathematical Statistics with Applications, 7th Ed., Pearson Education, 2009.
2. A.M. Goon, M.K. Gupta and B. Dasgupta, Fundamentals of Statistics (Vol. I), 8th Ed., World Press, Kolkata, 2005.
3. A.M. Goon, M.K. Gupta and B. Dasgupta, Fundamentals of Statistics (Vol. II), 8th Ed., World Press, Kolkata, 2005.
4. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, 11th Ed., Sultan Chand and Sons, 2007.
5. R.V. Hogg, A.T. Craig and J.W. Mekean, Introduction to Mathematical Statistics, 6th Ed., Pearson Education, 2005.
6. A.M. Mood, F.A. Grabill and D.C. Boes, Introduction to the Theory of Statistics, 3rd Ed., Tata McGraw-Hill Pub. Co. Ltd., 2007.
7. S.M. Ross, Introduction to Probability Models, 9th Ed., Academic Press, 2007.

### DSE 5C. (Choose one)

1. Queueing and Reliability Theory
2. Optimization Techniques

### DSE 5C.1: Queueing and Reliability Theory

General concepts of queueing system, Measures of performance, Arrival and Service Processes, Single server and multi server models, channels in parallel with limited and unlimited queues M/M/1/K, Application of simple queueing decision models, Design and control models

Sample  
Random Sample  
1 2 3



### Books Recommended

1. R.B. Cooper, Introduction to Queuing Theory, 2nd Ed., North Holland, 1981.
2. D. Gross, C. M. Harris, Fundamentals of Queuing Theory, 3rd Ed., John Wiley and Sons Inc. P. Ltd 2002.
3. U.N. Bhat, An Introduction to Queuing Theory: Modelling and Analysis in Applications, 2nd Edition, Science, Kluwer Academic Publishers, Birkhauser Boston, 2008.
4. U.N. Prabhu, Foundations of Queuing Theory, International Series in Operations Research & Management Science, Kluwer Academic Publishers, 2nd Ed., 2002.
5. John G. Rau, Optimization and Probability in Systems Engineering, V.N. Reinhold Co., 1970.
6. Riccardo Manzini, Alberto Regattieri, Hoang Pham, Emilio Ferrai, Maintenance for Industrial Systems, Springer-Verlag, London Limited, 2010.
7. P.K. Kapur, R.B. Garg, S. Kumar, Contributions to Hardware and Software Reliability, World Scientific, Singapore, 1999.

### DSE SC.2: Optimization Techniques

Dynamic Programming: Multistage decision processes, Bellman's principle of optimality, Selective dynamic programming applications involving additive and multiplicative separable returns for objective as well as constraint functions.

Goal Programming: Weighted and pre-emptive goal programming, graphical solution

Decision Analysis: Decision making under risk – Decision tree analysis, Posterior (Bayesian) probabilities, Decision under uncertainty: criterion of pessimism, criterion of optimism, Laplace criterion, criterion of realism, criterion of regret.

### Books Recommended

1. Hamdy A. Taha, Operations Research-An Introduction, Prentice Hall, 8th Ed., 2008
2. S. Chandra, Jayadeva, Aparna Mehra, Numerical Optimization with Application, Narosa Publishing House, 2009.



B.A./B.Sc. VI<sup>th</sup> Semester

Skill Enhancement Course (SEC)

Course No. SOS/STAT/UG/SEC-6.01

Credit 2

SEC 6.01 (choose one)

1. Mathematical Finance

2. Understanding Probability and Statistics through Practicals

### SEC 6.01.1: Mathematical Finance

Basic principles: Comparison, arbitrage and risk aversion, Interest (simple and compound, discrete and continuous), time value of money, inflation.

Asset return, short selling, portfolio return, (brief introduction to expectation, variance, covariance and correlation).

#### Books Recommended:

1. David G. Luenberger, Investment Science, Oxford University Press, Delhi, 1998.
2. John C. Hull, Options, Futures and Other Derivatives, 6th Ed., Prentice-Hall India, Indian reprint, 2006
3. Sheldon Ross, An Elementary Introduction to Mathematical Finance, 2nd Ed., Cambridge University Press, USA, 2003.

### SEC 6.01.2: Understanding Probability and Statistics through Practicals

Practical/ Lab work to be performed on a computer using Excel.

Practicals should broadly cover the following areas:

- (i) Fitting of Binomial, Poisson, Negative Binomial, Normal Distributions.
- (ii) Applications of Chi-square, t and F Distributions.
- (iii) Calculation of correlation coefficient, Rank Correlation, etc.
- (iv) Fitting of polynomial and regression curves.

(v) Methods of estimation (MLE and method of Moments)

(vi) Selecting a simple random sample using random number tables.

**Books Recommended:**

1. Robert V. Hogg, Joseph W. McKean and Allen T. Craig, *Introduction to Mathematical Statistics*, Pearson Education, Asia, 2007.
2. Irwin Miller and Marylees Miller, John E. Freund, *Mathematical Statistics with Applications*, 7th Ed. Pearson Education, Asia, 2006.
- ✓ 3. Sheldon Ross, *Introduction to Probability Models*, 9th Ed., Academic Press, Indian Reprint, 2007



B.A./B.Sc. VI<sup>th</sup> Semester

Discipline Specific Electives (DSE)

Course No. SOS/STAT/UG/DSE-6.01

Credit 2

DSE 6A. (choose one)

1. Complex Analysis

2. Linear Algebra

#### DSE 6A.1: Complex Analysis

Limits, Limits involving the point at infinity, continuity. Properties of complex numbers, regions in the complex plane, functions of complex variable, mappings, Derivatives, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability.

Analytic functions, examples of analytic functions, Cauchy-Goursat theorem, Cauchy integral formula.

Liouville's theorem and the fundamental theorem of algebra.

Laurent series and its examples, absolute and uniform convergence of power series.

#### Books Recommended

1. James Ward Brown and Ruel V. Churchill, Complex Variables and Applications, 8th Ed., McGraw – Hill International Edition, 2009.
- ✓ 2. Joseph Bak and Donald J. Newman, Complex analysis, 2nd Ed., Undergraduate Texts in Mathematics, Springer-Verlag New York, Inc., New York, 1997.

#### DSE 6A.2: Linear Algebra

Vector spaces, subspaces, algebra of subspaces, quotient spaces, linear combination of vectors, linear span, linear independence, basis and dimension.

Linear transformations, null space, range, rank and nullity of a linear transformation, matrix representation of a linear transformation, Isomorphisms.

## Books Recommended

1. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra, 4th Ed., Prentice Hall of India Pvt. Ltd., New Delhi, 2004.
2. David C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.
3. S. Lang, Introduction to Linear Algebra, 2nd Ed., Springer, 2005.
4. Gilbert Strang, Linear Algebra and its Applications, Thomson, 2007.

## DSE 6B. (choose one)

1. Econometrics
2. Applied Statistics

### DSE 6B.1: Econometrics

Nature and Scope of Econometrics.

Statistical Concepts Normal distribution; chi-square, t and F-distributions; estimation of parameters; properties of estimators; testing of hypotheses; defining statistical hypotheses; distributions of test statistics; testing hypotheses related to population parameters; Type I and Type II errors; power of a test; tests for comparing parameters from two samples.

Simple Linear Regression Model: Two Variable Case Estimation of model by method of ordinary least squares; properties of estimators; goodness of fit; tests of hypotheses; scaling and units of measurement; confidence intervals; Gauss-Markov theorem; forecasting.

Multiple Linear Regression Model Estimation of parameters; properties of OLS estimators; goodness of fit -  $R^2$  and adjusted  $R^2$ ; partial regression coefficients; testing hypotheses - individual and joint; functional forms of regression models; qualitative (dummy) independent variables.

Violations of Classical Assumptions: Consequences, Detection and Remedies Multicollinearity; heteroscedasticity; serial correlation.

Specification Analysis Omission of a relevant variable; inclusion of irrelevant variable; tests of specification errors.

## Books Recommended

1. Jay L. Devore, Probability and Statistics for Engineers, Cengage Learning, 2010.
2. John E. Freund, Mathematical Statistics, Prentice Hall, 1992.
3. Richard J. Larsen and Morris L. Marx, An Introduction to Mathematical Statistics and its Applications, Prentice Hall, 2011.
4. D.N. Gujarati and D.C. Porter, Essentials of Econometrics, 4th Ed., McGraw Hill, International Edition, 2009.
5. Christopher Dougherty, Introduction to Econometrics, 3rd Ed., Oxford University Press, 2007.



6. Jan Kmenta, Elements of Econometrics, 2nd Ed., Khosla Publishing House, 2008.

## DSE 6B.2: Applied Statistics

Economics Statistics: Time Series Analysis-economic time series, different components, Illustrations, additive and multiplicative models, determination of trend, analysis of seasonal fluctuations, Index numbers-criteria for a good index number, Different types of index numbers, Construction of index numbers of prices and qualities, Cost of living index number, Uses and limitations of index numbers.

Statistical Quality Control: Importance of statistical methods in industrial research and practice, determination of tolerance limits, general theory of control charts, process and product control, causes of variation in quality, control limits, summary of out of control criteria, charts for attributes-p-chart, np-chart, c-chart; charts for variables-  $\bar{X}$ , R and s-charts, principles of acceptance sampling, problem of lot acceptance, producer's and consumer's risks, single sampling instruction plan and its OC and ASN functions, concepts of AQL, LTPD, AOQL, ATI functions; Dodge and Romig Tables.

Demographic Methods: Sources of demographic data-census, register, ad hoc surveys, hospital records, demographic profiles of Indian census, questionnaire, errors in these data and their adjustment, Measurements of Mortality-CDR, SDR (w.r.t. age and sex), IMR, standardized death rate, complete life table, its main features and uses, Measurements of fertility and reproduction CBR, General, Age-specific and total fertility rates, GRR, NRR.

### Books Recommended

1. A.M. Goon, M.K. Gupta and B. Dasgupta, An Outline of Statistical Theory (Vol. II), Pit Publ. World Press, Kolkata, 2003.
2. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, 11th Ed., Sultan Chand and Sons, 2007.
3. P. Mukhopadhyay, Mathematical Statistics, 2nd Ed. Books and Allied (P) Ltd., 2000.
4. F.E. Croxton and D.J. Cowden, Applied General Statistics, Prentice Hall of India, 1969.
5. M.G. Kendall and A. Stuart, The Advanced Theory of Statistics (Vol. III), Macmillan Publishing Co. Inc., 1977.
6. D.C. Montgomery, Introduction to Statistical Quality Control, John Wiley and Sons, New York, 1996

### DSE 6C. (choose one)

1. Integer Programming and Theory of Games
2. Forecasting

### DSE 6C.1: Integer Programming and Theory of Games

Integer Linear Programming, Modeling using pure and mixed integer programming, Branch and Bound Technique, Gomory's Cutting Plane Algorithm.