Proposed Syllabus and Scheme of Examination

for

B. Sc. (Honours) Statistics

PROPOSED SCHEME FOR CHOICE BASED CREDIT SYSTEM IN

B.Sc. Honours (Statistics)

	CORE COURSE (14)	**Ability Enhancement Compulsory Course (AECC) (2)**	**Skill Enhancement Elective Course (SEEC) (2)**	**Elective: Discipline Specific DSE (4)**	**Elective: Generic (GE) (4)**
I	Descriptive Statistics(Theory+ Practical) Calculus	(English/MIL Communication) /Environmental Science			BSC-GE-1
II	Probability and Prob. Distributions(Theory+ Practical) Algebra	Environmental Science/ (English/MIL Communication)			BSC-GE-2
III	Sampling Distributions(Theory+ Practical) Statistical Inference (Theory+Practical) Mathematical Analysis		BSC-SEE-1		BSC-GE-3
IV	Survey Sampling & Indian Official Statistics (Theory + Practical) Linear Models(Theory+ Practical) Statistical Quality Control(Theory+ Practical)		BSC-SEE-2		BSC-GE-4
V	Stochastic Process and Queuing Theory (Theory+ Practical) Statistical Computing Using C/C++Programming(Theory+ Practical)			BSC-DSE-1 BSC-DSE-2	
VI	Design of Experiments (Theory+ Practical) Multivariate Analysis and Nonparametric Methods (Theory+ Practical)			BSC-DSE -3 BSC-DSE -4	

SEMESTER-I				
Paper Code	**Course Name**	**Type**	**Credits**	**Marks**
BSC-AEC-1	(English/MIL Communication) /Environmental Science	Ability Enhancement	2	25
BSC-CT-101	Descriptive Statistics (Theory)	Core Discipline	4	50
BSC-CP-101	Descriptive Statistics (Practical/Lab Work)	Core Discipline	2	25
BSC-CT-102	Calculus (Theory)	Core Discipline	5	75
	Calculus (Tutorial)		1	
BSC-GE-1	Any one from the List of Generic Elective / Interdisciplinary Courses from other Subjects	Generic Elective / Interdisciplinary	4	50
	Practical/Lab Work		2	25
SEMESTER- II				
BSC-AEC-2	Environmental Science/(English/MIL Communication)	Ability Enhancement	2	25
BSC-CT-201	Probability and Probability Distributions(Theory)	Core Discipline	4	50
BSC-CP-201	Probability and Probability Distributions (Practical/Lab Work)	Core Discipline	2	25
BSC-CT-202	Algebra (Theory)	Core Discipline	5	75
	Algebra (Tutorial)		1	
BSC-GE-2	Any one from the List of Generic Elective / Interdisciplinary Courses from other Subjects	Generic Elective / Interdisciplinary	4	50
	Practical/Lab Work		2	25
SEMESTER- III				
BSC-CT-301	Sampling Distributions(Theory)	Core Discipline	4	50
BSC-CP-301	Sampling Distributions (Practical/Lab Work)	Core Discipline	2	25
BSC-CT-302	Statistical Inference (Theory)	Core Discipline	4	50
BSC-CP-302	Statistical Inference (Practical/Lab. Work)	Core Discipline	2	25
BSC-CT-303	Mathematical Analysis (Theory)	Core Discipline	5	75
	Mathematical Analysis (Tutorial)		1	
BSC-SEE-1	Any one from the List of Skill Enhancement Electives	Skill Enhancement Electives	2	25
BSC-GE-3	Any one from the List of Generic Elective / Interdisciplinary Courses from other Subjects	Generic Elective / Interdisciplinary	4	50
	Practical/Lab Work		2	25
SEMESTER- IV				
BSC-CT-401	Survey Sampling & Indian Official Statistics (Theory)	Core Discipline	4	50
BSC-CP-401	Survey Sampling & Indian Official Statistics (Practical/Lab Work)	Core Discipline	2	25

BSC-CT-402	Linear Models (Theory)	Core Discipline	4	50
BSC-CP-402	Linear Models (Practical/Lab. Work)	Core Discipline	2	25
BSC-CT-403	Statistical Quality Control (Theory)	Core Discipline	4	50
BSC-CP-403	Statistical Quality Control (Practical/Lab. Work)	Core Discipline	2	25
BSC-GE-4	Any one from the List of Generic Elective / Interdisciplinary Courses from other Subjects	Generic Elective / Interdisciplinary	4	50
	Practical/Lab Work		2	25
SEMESTER- V				
BSC-CT-501	Stochastic Process and Queuing Theory (Theory)	Core Discipline	4	50
BSC-CP-501	Stochastic Process and Queuing Theory (Practical/Lab Work)	Core Discipline	2	25
BSC-CT-502	Statistical Computing using C/C++ Programming (Theory)	Core Discipline	4	50
BSC-CP-502	Statistical Computing using C/C++ Programming (Practical/Lab. Work)	Core Discipline	2	25
BSC-DSE-1	Any one from the List of Discipline Specific Electives	Discipline Specific Elective	4	50
	Practical/Lab Work		2	25
BSC-DSE-2	Any one from the List of Discipline Specific Electives	Discipline Specific Elective	4	50
	Practical/Lab Work		2	25
SEMESTER- VI				
BSC-CT-601	Design of Experiments(Theory)	Core Discipline	4	50
BSC-CP-601	Design of Experiments (Practical/Lab Work)	Core Discipline	2	25
BSC-CT-602	Multivariate Analysis and Nonparametric Methods (Theory)	Core Discipline	4	50
BSC-CP-602	Multivariate Analysis and Nonparametric Methods (Practical/Lab. Work)	Core Discipline	2	25
BSC-DSE-3	Any one from the List of Discipline Specific Electives	Discipline Specific Elective	4	50
	Practical/Lab Work		2	25
BSC-DSE-4	Any one from the List of Discipline Specific Electives	Discipline Specific Elective	4	50
	Practical/Lab Work		2	25

Core Papers (Credit: 6 each) (14 papers)

BSC-CT-101 Descriptive Statistics (Theory)
BSC-CP-101 Descriptive Statistics (Practical)
BSC CT-102 Calculus
BSC-CT-201 Probability and Probability Distributions (Theory)

BSC-CP-201 Probability and Probability Distributions (Practical)
BSC CT-202 Algebra
BSC-CT-301 Sampling Distributions (Theory)
BSC-CP-301 Sampling Distributions (Practical)
BSC-CT-302 Survey Sampling and Indian Official Statistics (Theory)
BSC-CP-302 Survey Sampling and Indian Official Statistics (Practical)
BSC CT-303 Mathematical Analysis
BSC-CT-401 Statistical Inference (Theory)
BSC-CP-401 Statistical Inference (Practical)
BSC-CT-402 Linear Models (Theory)
BSC-CP-402 Linear Models (Practical)
BSC-CT-403 Statistical Quality Control (Theory)
BSC-CP-403 Statistical Quality Control (Practical)
BSC-CT-501 Stochastic Processes and Queuing Theory (Theory)
BSC-CP-501 Stochastic Processes and Queuing Theory (Practical)
BSC-CT-502 Statistical Computing Using C/C++ Programming (Theory)
BSC-CP-502 Statistical Computing Using C/C++ Programming (Practical)
BSC-CT-601 Design of Experiments (Theory)
BSC-CP-601 Design of Experiments (Practical)
BSC-CT-602 Multivariate Analysis and Nonparametric Methods (Theory)
BSC-CP-602 Multivariate Analysis and Nonparametric Methods (Practical)

Discipline Specific Elective Papers (Credit: 6 each) (4 papers to be selected)

BSC-DSE-51/61. Operations Research(Theory+ Practical)
BSC-DSE-52/62. Time Series Analysis (Theory+ Practical)
BSC-DSE-53/63. Econometrics(Theory+ Practical)
BSC-DSE-54/64. Demography and Vital Statistics (Theory+ Practical)
BSC-DSE-55/65. Actuarial Statistics(Theory+ Practical)
BSC-DSE-56/66. Survival Analysis and BioStatistics(Theory+ Practical)
BSC-DSE-57/67 Project Work (Sixth Semester)

Generic Elective Papers (GE) (Credit: 6 each) (4 papers of any discipline to be selected from other Departments/Disciplines)

Skill Enhancement Electives (Credit: 2 each) (2 papers to be selected)

BSC-SEE-31/41. Statistical-Data Analysis Using Software Packages
BSC-SEE-32/42. Statistical Data Analysis Using R
BSC-SEE-33/43. Statistical Techniques for Research Methods
BSC-SEE-34/44. Data Base Management Systems

Generic Elective Papers (GE) (Credit: 6 each) (Any four to be offered to other Departments/Disciplines)

BSA-GE-11/21/31/41. Statistical Methods
BSA-GE-12/22/32/42 Introductory Probability
BSA-GE-13/23/33/43. Basics of Statistical Inference
BSA-GE-14/24/34/44. Introduction to Operations Research
BSA-GE-15/25/35/45. Applied Statistics
BSA-GE-16/26/36/46 Research Methodology

Core Papers in Statistics

BSC-CT-101 Descriptive Statistics (Theory)
(Credit 4)

Course Objective: *A statistical survey usually consists of collection of data, scrutiny of data and finally the analysis of data. Thus it is necessary for a student of Statistics is to be familiar with these steps at the very beginning. This particular course is designed keeping this in mind. Here the students are first introduced with the different ways of collecting data, followed by different types of data structure, their representation styles and finally different statistical tools and techniques that can be applied on a data set.*

Learning Outcomes: *After completion of this course, the students will be able to*

(1) Scrutinize an arbitrary data set.
(2) Represent the data in tabular and diagrammatic form.
(3) Prepare the frequency distribution for qualitative and quantitative data.
(4) Find the summary measures, viz. the measures of central tendency, measure of dispersion, measures of skewness and kurtosis of a univariate data.
(5) Find the degree of association/correlation between the two concerned variables in case of a bivariate data.
(6) Fit linear and non-linear curves for predicting the value of one variable, given the value of another, in case of bivariate data.

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

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

UNIT III
Bivariate data: Definition, scatter diagram, simple correlation, rank correlation. Simple linear regression, principle of least squares andfitting of polynomials and exponential curves, Correlation index and Correlation ratio.

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

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.

BSC-CP-101 Descriptive Statistics (PRACTICAL/LAB. WORK) (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. 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. Planes of regression and variances of residuals for given simple correlations.
12. Planes of regression and variances of residuals for raw data.
13. Calculate price and quantity index numbers using simple and weighted average of price relatives.
14. To calculate the Chain Base index numbers.
15. To calculate consumer price index number.

STAT CT-102 – Calculus Credit 6

Course Objective: *This is a basic and prerequisite course for the students before study some statistical courses. For example: Jacobian, Beta-gamma integral, maxima-minima, transformation of variables and multiple integrals are helpful for the course probability distribution, sampling distribution and statistical inference. This course is designed into four units first two units mainly devoted into differential and integral calculus for one and two variables. Third and fourth units mainly focused on ordinary and partial differential equations.*

Learning Outcomes: *After completion of this course, the students will be able to*

(1) Analyze functions, limit, continuity and differentiability of one and two variables.
(2) Perform maxima-minima and constrained optimization of one and several variable functions.
(3) Solve the problems related to Jacobian, Beta-gamma integral, transformation of variables and multiple integrals.
(4) Analyze and solve a large class of ordinary differential equations.
(5) Analyze and solve a various types of partial differential equations including famous heat and wave equation.

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. Maxima and minima of functions of one and two variables, constrained optimization techniques (with Lagrange multiplier) along with some problems. Jacobian, concavity and convexity, points of inflexion of function, singular points.

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

UNIT III
Differential Equations**:** Exact differential equations, Integrating factors, change of variables,
Total differential equations, Differential equations of first order and first degree, Differential
equations of first order but not of first degree, Equations 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, Reduction of order method, The Cauchy-Euler's equation of order n, Legendre's linear equation.

UNIT IV:
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.

BSC-CT-201 Probability and Probability Distributions (Theory) Credit 4

Course Objective: *This is a fundamental course on probability theory. Students must have the knowledge of probability theory, random variables and their distributions to make further progress on statistical analysis. This course is designed into four units, the first units mainly devoted into the basics of probability theory and its applications. Second and third units mainly focused on various types of random variables in one and two dimension. The students can also get an idea about mathematical expectations and generating functions. In the fourth unit students will have a nice idea about several discrete and continuous distributions.*

Learning Outcomes: *After completion of this course, the students will be able to*

(1) Understand the random experiment, sample space and probability theory.

(2) Know the one / two dimensional random variables and their properties in discrete / continuous framework.
(3) Recognize various discrete as well as continuous distributions and their properties.

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

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

UNIT III
Mathematical Expectation and Generating Functions: Expectation of single and bivariate random variables and its properties. Moments and Cumulants, moment generating function, cumulant generating function and characteristic function. Conditional expectations.

UNIT IV
Standard probability distributions: Binomial, Poisson, geometric, negative binomial, hypergeometric, uniform, normal, exponential, Cauchy, beta and gamma along with their properties and limiting/approximation cases.

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

BSC-CP-201 Probability and Probability Distributions (PRACTICAL/LAB. WORK) (2 Credit)

List of Practical
1. Fitting of binomial distributions for n and p = q = ½.
2. Fitting of binomial distributions for given n and p.
3. Fitting of binomial distributions after computing mean and variance.
4. Fitting of Poisson distributions for given value of lambda.
5. Fitting of Poisson distributions after computing mean.
6. Fitting of negative binomial.
7. Application problems based on binomial distribution.
8. Application problems based on Poisson distribution.
9. Application problems based on negative binomial distribution.
10. Problems based on area property of normal distribution.
11. To find the ordinate for a given area for normal distribution.
12. Application based problems using normal distribution.
13. Fitting of normal distribution when parameters are given.
14. Fitting of normal distribution when parameters are not given.

BSC CT- 202- Algebra **Credit 6**

Course Objective: *This is also a basic and prerequisite course for the students before study the courses like multivariate analysis, linear models and stochastic process. This course is designed into four units first two units mainly devoted into vector space, matrix theory and theory of equations. Third and fourth units mainly focused on determinant, system of linear equations, rank of a matrix and eigenvalues.*

Learning Outcomes: *After completion of this course, the students will be able to*

(1) Solve polynomials up to fourth degree and have a nice idea about its various properties.
(2) Understand the concept of vector space and its dimension.
(3) Classify various types of matrices and their important properties.
(4) Analyze and solve various types of determinants, quadratic forms and system of linear equations.
(5) Interpret the rank related properties of a matrix and its eigenvalues.

UNIT I

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

UNIT II

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

UNIT III

Determinants of Matrices: Definition, properties and applications of determinants for 3_{rd} 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.
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, inverse of a matrix.

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. Characteristic roots and Characteristic vector, Properties of characteristic roots, Cayley Hamilton theorem, Quadratic forms, Linear orthogonal transformation and their diagonalization

SUGGESTED READINGS:

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

BSC-CT-301 Sampling Distributions(Theory) Credit 4

Course Objective: *The ultimate goal of Statistics is to infer about the population characteristics, based on the corresponding sample analogues. Since the sample quantities are random, it is required to find their exact or asymptotic probability distributions. Understanding of some basic tools and techniques are prerequisite for these. This course is designed keeping focus on these and mandatory for performing any sort of statistical inference.*

Learning Outcomes: *After completion of this course, the students will be able to*

1) *Get an idea about the properties of Central Chi-square, t and F distributions.*
2) *Understand the concept of sampling fluctuation.*
3) *Derive the sampling distribution of different sample entities like the sample mean, sample variance in case of sampling from a Normal population.*
4) *Derive the sampling distribution of sample order statistics*
5) *Understand the concepts of law of large numbers and the central limit theorem.*

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).

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 II

Definitions of random sample, parameter and statistic, sampling distribution of a statistic, sampling distribution of sample mean, standard errors of sample mean, sample variance and sample proportion. Null and alternative hypotheses, level of significance, Type I and Type II
errors, their probabilities and critical region. Large sample tests, use of CLT 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 III

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

UNIT IV

Exact sampling distributions: Student's and Fishers t-distribution, Derivation of its p.d.f., nature of probability curve with different degrees of freedom, mean, variance, moments and limiting form of 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 $\chi 2$ 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.

BSC-CP-301 Sampling Distributions (PRACTICAL/LAB. WORK) (2 Credit)

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

BSC-CT-302 Statistical Inference (Theory) Credit 4

Course Objective: *To impart the concepts and principles of statistical inference viz. estimation and testing of hypothesis. Make the students understand the properties and methods of parametric estimation and hypothesis testing procedures.*

Learning Outcomes: *After completing the course students will be able to explain and /or perform:*

1) *What is statistical inference, its types, and desirable properties of an estimator and how to find a good estimate from a sample data for the practical use.*
2) *They should also be able to carry out various optimum tests for examining a hypothesis regarding a population parameter and apply that idea for carrying out research and or analysis of real-life data.*

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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

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. 2nd 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.

BSC-CP-302 Statistical Inference (PRACTICAL/LABWORK) (2 Credits)

List of Practical

1. Unbiased estimators (including unbiased but absurd estimators)
2. Consistent estimators, efficient estimators and relative efficiency of estimators.
3. Cramer-Rao inequality and MVB estimators
4. Sufficient Estimators – Factorization Theorem, Rao-Blackwell theorem, Complete Sufficient estimators
5. Lehman-Scheffe theorem and UMVUE
6. Maximum Likelihood Estimation
7. Asymptotic distribution of maximum likelihood estimators
8. Estimation by the method of moments, minimum Chi-square
9. Type I and Type II errors
10. Most powerful critical region (NP Lemma)
11. Uniformly most powerful critical region
12. Unbiased critical region
13. Power curves
14. Likelihood ratio tests for simple null hypothesis against simple alternative hypothesis
15. Likelihood ratio tests for simple null hypothesis against composite alternative hypothesis
16. Asymptotic properties of LR tests
17. SPRT procedure
18. OC function and OC curve
19. ASN function and ASN curve

BSC-CT- 303- Mathematical Analysis Credit 6

Course Objective: *This is also an intermediate level mathematical course for the students. Since the analytical parts of statistics mostly rely upon mathematical analysis, so students must know the theory of mathematical analysis. Numerical analysis also helps on various fields of statistics. This course is designed into four units first two units mainly devoted into real number system, sequence and series of real numbers. Third unit introduced the idea of Rolle's theorem, mean value theorem, Taylor's theorem and their applications. Fourth unit mainly focused on numerical analysis and its application.*

Learning Outcomes: *After completion of this course, the students will be able to*

(1) Understand the concept of sequence, series and their convergence.
(2) Expand functions using Taylor's series and their various properties.
(3) Analyze and solve various problems regarding Rolle's and Mean Value Theorem.
(4) Understand various numerical techniques to compute integration, interpolation etc.

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 such as 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. Indeterminate form, L' Hospital's rule.

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

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, 12_{th} revised Edition, S. Chand & Co. (Pvt.) Ltd., New Delhi, 1987.
6. Singal M.K. and Singal A.R.: A First Course in Real Analysis, 24_{th} 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

BSC-CT-401 Survey Sampling and Indian Official Statistics (Theory) Credit 4

Course Objectives: *This is an applied course and it has a huge impact in our society. Sampling techniques is a powerful tool mainly used in real-life situations to get an idea about the whole population. This course is designed into four units first three units mainly aims for the concept of sample and various sampling techniques. The fourth unit focused on the statistical system and their functions in India.*

Learning Outcomes: *After completion of this course, the students will be able to*

(1) Understand the concept of population, sample, non-probability, probability sampling and basic principle of sample survey.
(2) Apply various sampling techniques in real-life studies as well as in different research field.
(3) Realize the present official statistical system in India.
(4) Understand role of Ministry of Statistics & Program Implementation.

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

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.

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/

BSC-CP-401 Survey Sampling and Indian Official Statistics (PRACTICAL/LAB WORK): (2 Credits)

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. Cluster sampling: estimation of mean or total, variance of the estimate, estimate of intra-class correlation coefficient, efficiency as compared to SRS.

BSC-CT-402 Linear Models (Theory) Credit 4

Course Objective: *To make them understand what a linear model is and how various real-life problems can be expressed and analyzed using linear models.*

Learning Outcomes: *After completion of this course, the students will be able to*

1) *Understand and be proficient at theoretical developments in the analysis of linear models, including linear and quadratic forms, least squares, linear hypothesis testing, analysis of variance, etc.*
2) *Apply the results from linear model theory in further advanced topics, such as nonparametric models, multivariate analysis, high-dimensional inference, etc.*

UNIT I

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

UNIT II

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

UNIT III

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

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

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.

BSC-CP-402 Linear Models (PRACTICAL/LAB.WORK)
Credit 2

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

BSC-CT-403 Statistical Quality Control (Theory)
Credit 4

Course Objectives: *The main objectives of the quality control module are to control of material reception, internal rejections, clients, claims, providers and evaluations of the same corrective actions are related to their follow-up. These systems and methods guide all quality activities. It is used to establish a controlled manufacturing process by the use of statistical techniques to reduce process variation. A decrease in variation will lead to: better quality; lower costs (waste, scrap, rework, claims, etc.); more insight into the capability of the process.*

Learning Outcomes: *On completion of the course, students will be able to:*

1. *Understand the general idea of quality and monitoring of industrial experiments.*
2. *Understand basic difference between process control and product control*
3. *Familiar with control chart techniques and acceptance sampling plan.*
4. *Familiar with six-sigma methodology.*

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

UNIT II
Control charts for variables: X-bar & R-chart, X-bar & s-chart. 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 III
Acceptance sampling plan: Principle of acceptance sampling plans. Single and Double sampling plan their OC, AQL, LTPD, AOQ, AOQL, ASN, ATI functions with graphical interpretation, use and interpretation of Dodge and Romig's sampling inspection plan tables.

UNIT IV
Introduction to Six-Sigma: Overview of Six Sigma, Lean Manufacturing and Total Quality Management (TQM). Organizational Structure and Six Sigma training plans- Selection Criteria for Six-Sigma roles and training plans. Voice of customers (VOC): Importance and VOC data collection. Critical to Quality (CTQ).Introduction to DMAIC using one case study:
Define Phase, Measure Phase, Analyse Phase, Improve Phase and Control Phase.

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. Ehrlich, B. Harris (2002): Transactional Six Sigma and Lean Servicing, 2nd Edition, St. Lucie Press.
6. Hoyle, David (1995): ISO Quality Systems Handbook, 2nd Edition, Butterworth Heinemann Publication.

BSC-CP-403 Statistical Quality Control (PRACTICAL/LAB. WORK) 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.

BSC-CT-501 Stochastic Process and Queuing Theory (Theory)
Credit 4

Course Objectives: *It is a very basic course enabling students to understand the transition from fundamental probability theory to stochastic process. It covers the rudimentary structure of discrete time and continuous time stochastic process followed by evolving of queuing theory from it.*

Learning Outcomes: *On completion of the course, students will be able to:*

1. *A bridging concept between fundamental probability theory and stochastic process*
2. *Markov model*
3. *Discrete time Markov chain and classifications*
4. *Poisson process and its applications*
5. *Genesis of queueing theory from Poisson process*

UNIT I
Probability Distributions: Generating functions, Bivariate probability generating function.
Stochastic Process: Introduction, Stationary Process.
UNIT II
Markov Chains: Definition of Markov Chain, transition probability matrix, order of Markov chain, 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.

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.

BSC-CP-501 Stochastic Process and Queuing Theory (Practical/Lab Work)
Credit 2

List of Practical

1. Calculation of transition probability matrix
2. Identification of characteristics of reducible and irreducible chains.
3. Identification of types of classes
4. Identification of ergodic transition probability matrix
5. Stationarity of Markov chain and graphical representation of Markov chain
6. Computation of probabilities in case of generalizations of independent Bernoulli trials
7. Calculation of probabilities for given birth and death rates and vice versa
8. Calculation of probabilities for Birth and Death Process
9. Calculation of probabilities for Yule Furry Process
10. Computation of inter-arrival time for a Poisson process.
11. Calculation of Probability and parameters for (M/M/1) model and change in behaviour of queue as N tends to infinity.
12. Calculation of generating function and expected duration for different amounts of stake.
13. Computation of probabilities and expected duration between players

BSC-CT-502 Statistical Computing Using C/C++ Programming(Theory) Credit 4

Course Objectives: *Now a day's programming has become the key of statistical learning. In order to flourish the theoretical knowledge, the popular computational problems should be illustrated using a programming language. In this course, the most popular programming language C is offered to the students.*

Learning Outcomes: *After completion of this course, the students will be able to*

(1) Execute basic programs in C / C++.
(2) Implement the application of control structures in program.
(3) Write program using loop structure and functions.
(4) Read data from a file and store the outputs in a file.
(5) Get idea about pointers, structure and preprocessor macro.
(6) Write various programs on statistical and numerical computation.

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. Implicit and explicit type conversions in expressions, library functions. Managing input and output operations: reading and printing formatted and unformatted data

UNIT II

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

UNIT III

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

UNIT IV

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, 2nd Edition,Prentice Hall.
2. Balagurusamy, E. (2011): Programming in ANSI C, 6th Edition, Tata McGraw Hill.
3. Gottfried, B.S. (1998): Schaum's Outlines: Programming with C, 2nd Edition, Tata McGraw Hill

BSC-CP-502 Statistical Computing Using C/C++ Programming(PRACTICAL/ LAB WORK) 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

BSC-CT-601 Design of Experiments (Theory) Credit 4

Course Objectives:

The objective of the course is to develop a systematic method to determine the relationship between factors affecting a process and the output of that process. It is used to find cause-and-effect relationships. This information is needed to manage process inputs in order to optimize the output.

Learning Outcomes: *On completion of the course, students will be able to:*

1. *Understand the general idea of experiments and hence planning/layout of conducting experiments.*
2. *Understand basic principles of experiment and some basic designs like, CRD, RBD and LSD.*
3. *Familiar with incomplete block designs and their applications.*
4. *Familiar with factorial experiments for industrial and other uses.*

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, analysis with missing observations.

UNIT II

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 III

Factorial experiments: advantages, notations and concepts, 2^2, $2^3 \ldots 2^n$ and 3^2 factorial experiments, design and analysis, Total and Partial confounding for 2^n ($n \leq 5$), 3^2 and 3^3. Factorial experiments in a single replicate.

UNIT IV

Split-plot and Strip-plot design.

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, 8thEdn. 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.

BSC-CP-601 Design of Experiments (PRACTICAL /LAB. WORK) 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 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

BSC-CT-602 Multivariate Analysis and Nonparametric Methods(Theory) Credit 4

Course Objectives: *This course comprises two parts-the first one deal with different measures of multivariate data analysis and the other one delineate the fundamental concepts of nonparametric methods. This nonparametric part, we believe, stimulate the students as it emancipates the statistical techniques without any parametric assumptions.*

Learning Outcomes:

1. *Different measures of associations valid for multivariate data-multiple correlation, partial correlation, multiple regression*
2. *Multivariate distributions-multinomial, multivariate Poisson, multivariate hyper geometric*
3. *Multivariate normal and its characterizations, concentration ellipsoid*
4. *Nonparametric tests of locations, tests of dispersions, nonparametric one way ANOVA*
5. *Applications of nonparametric tests.*

UNIT I
Bivariate Normal Distribution (BVN): p.d.f. of BVN, properties of BVN, marginal and conditional p.d.f. of BVN.
Multivariate Data: Random Vector: Probability mass/density functions, Distribution function, Mean vector & Dispersion matrix, Marginal & Conditional distributions.
UNIT II
Multivariate Normal distribution and its properties. Sampling distribution for mean vector and variance- covariance matrix. Multiple and partial correlation coefficient and their properties.
UNIT III
Applications of Multivariate Analysis: Discriminant Analysis, Principal Components Analysis and Factor Analysis.
UNIT IV
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 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.

BSC-CP-602 Multivariate Analysis and Nonparametric Methods(PRACTICALS/ LAB WORK) Credit 2

List of Practical
1. Multiple Correlation
2. Partial Correlation
3. Bivariate Normal Distribution,
4. Multivariate Normal Distribution
5. Discriminant Analysis
6. Principal Components Analysis
7. Factor Analysis
8. Test for randomness based on total number of runs,
9. Kolmogrov Smirnov test for one sample.
10. Sign test: one sample, two samples, large samples.
11. Wilcoxon-Mann-Whitney U-test
12. Kruskal-Wallis test

DSE Papers in Statistics

BSC-DSET-1 Operations Research (Theory) Credit 4

Course Objectives: *The objective of the course is to provide basic idea about operations research and utilizing optimization techniques as its basic tools. Use of statistical and mathematical tools in operations research and their applications to decision making process is primary concern. Role of operations research under different constraint conditions are to be studied.*

Learning Outcomes: *On completion of the course, students will be able to:*

1. *Formulate the problem in operations research.*
2. *Establish the relationship between the variables and constraints by constructing the model.*
3. *Identify the possible alternative solutions and select the optimal one.*
4. *Install, test and establish the optimal solution.*
5. *Learn the tools like Linear Programming Problems, Transportation, assignment, and game gamming.*
6. *Familiar with different inventory models.*

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.

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

STAT-DSEP-1 Operations Research (PRACTICAL/ LAB WORK) (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

BSC-DSET-2 Time Series Analysis (Theory) Credit 4

Course Objectives: *Time series data is widespread. The structure and analysis of time series data has been unraveled through this course.*

Learning Outcomes: *On completion of the course, students will be able to:*

1. *Knowledge on different components of time series – extraction of those components.*
2. *Presence of time components through various diagrams*
3. *Basic time series modelling-AR(1), AR(2), MA(1) and MA(2)*
4. *Method of forecasting, exponential smoothing*

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. Some Special Processes: Moving-average (MA) process and Autoregressive (AR) process of orders one and two, Estimation of the parameters of AR (1) and AR (2) – Yule-Walker equations.

UNIT IV

Random Component: Variate component method. Forecasting: Exponential smoothing methods, Short term forecasting methods: Brown's discounted regression, Box-Jenkins method and Bayesian forecasting. Stationary Time series: Weak stationarity, autocorrelation
function and correlogram of moving average.

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

BSC-DSEP-2 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.

BSC-DSET-3 Econometrics (Theory) Credit 4

Course Objectives: *To impart the knowledge of problems with violation of different assumptions while modelling real-life economic problems to solve using statistical theories and how to find solutions to those.*

Learning Outcomes: *After finishing this paper the students should be able to identify the assumption(s) being violated in a real-life (economic) dataset and to remove the issue from it and model the data for practical use.*

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.

BSC-DSEP-3 Econometrics (Practical) Credit 2

List of Practical

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

BSC-DSET-4 Demography and Vital Statistics (Theory) Credit 4

Course Objectives: *The scientific nature of demography proves the following four objectives of demography. These are to achieve knowledge about the size, composition, organization and distribution of the population. To describe the past evolution, present distribution and future changes in the population of an area.*

Learning Outcomes: *On completion of the course, students will be able to:*

1. *Coverage and content errors in demographic data*
2. *Measure of fertility, stochastic model for reproduction*
3. *Measures of mortality.*
4. *Life table functions and their applications.*
5. *Population growth and population projection.*

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

Abridged Life Tables; Concept and construction of abridged life tables by Reed-Merrell method, 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).

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.

BSC-DSEP-4 Demography and Vital Statistics (Practical/Lab Work) 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

BSC-DSET-5 Actuarial Statistics (Theory) Credit 4

Course Objectives: *The aim of Actuarial Statistics is to provide grounding in mathematical and statistical methods that are of relevance for actuarial work. It is a discipline that assesses financial risks in the insurance and finance fields. It applies the mathematics of probability and statistics to define, analyze and solve the financial implications of uncertain future events.*

Learning Outcomes: *On completion of the course, students will be able to:*

1. *Equipped with knowledge of statistical distributions, methods to summarize data, the principles of statistical inference, regression models (including generalized linear models).*
2. *Accustomed with individual and aggregate claims and their applications.*
3. *Know utility functions and their uses in insurance.*
4. *Life table functions and their applications.*
5. *Life insurance calculation.*

UNIT I

Introductory Statistics and Insurance Applications: Discrete, continuous and mixed probability distributions. Insurance applications, sum of random variables. Utility theory: Utility functions, expected utility criterion, types of utility function, insurance and utility theory.

UNIT II

Principles of Premium Calculation: Properties of premium principles, examples of premium principles. Individual risk models: models for individual claims, the sum of independent claims, approximations and their applications.

UNIT III

Survival Distribution and Life Tables: Uncertainty of age at death, survival function, time-until-death for a person, curate future lifetime, force of mortality, life tables with examples, deterministic survivorship group, life table characteristics, assumptions for fractional age, some analytical laws of mortality.

UNIT IV

Life Insurance: Models for insurance payable at the moment of death, insurance payable at the end of the year of death and their relationships. Life annuities: continuous life annuities, discrete life annuities, life annuities with periodic payments. Premiums: continuous and discrete premiums.

SUGGESTED READING:

1. Dickson, C. M. D. (2005): Insurance Risk And Ruin (International Series On Actuarial Science), Cambridge University Press.
2. Bowers, N. L., Gerber, H. U., Hickman, J. C., Jones, D. A. And Nesbitt, C. J. (1997): Actuarial Mathematics, Society Of Actuaries, Itasca, Illinois, U.S.A.

BSC-DSEP-5 Actuarial Statistics (Practical/Lab Work) (Using Spreadsheet/R) **Credit 2**

List of Practical

1. Risk computation for different utility models
2. Discrete and continuous risk calculations
3. Calculation of aggregate claims for collective risks
4. Calculation of aggregate claim for individual risks
5. Computing Ruin probabilities and aggregate losses
6. Annuity and present value of contract
7. Computing premium for different insurance schemes
8. Practical based on life models and tables

BSC-DSET-6 Survival Analysis and Biostatistics(Theory) Credit 4

Course Objectives: *This course is designed for the applications of statistics in Biology and Clinical trials. The aim of this course is to enable students to analyze data from studies in which individuals are followed up until a particular event occurs - e.g. death, cure, relapse - making use of follow-up data for those who do not experience the event, with proper attention to underlying assumptions and a major emphasis on the practical interpretation and communication of results.*

Learning Outcomes: *After the completion of this course, the students will be able to*

1. *Collaborate with Health scientists*
2. *Apply basic methods for estimation and statistical inference when working with censored data.*
3. *Get a chance to do research in the area of Statistical genetics, Epidemiology, Drug development.*
4. *Get a job in pharmacy industry.*

UNIT I

Survival Analysis: Functions of survival times, survival distributions and their applications-exponential, gamma, Weibull, Rayleigh, lognormal, death density function for a distribution having bath-tub shaped hazard function.

Censoring Schemes: Type I, Type II and progressive or random censoring with biological examples. Estimation of mean survival time and variance of the estimator for Type I and Type II censored data with numerical examples. Non-parametric methods: Actuarial and Kaplan-Meier methods for estimating survival function and variance of the Estimator.

UNIT II

Competing Risk Theory: Indices for measurement of probability of death under competing risks and their inter-relations. Estimation of probabilities of death using maximum likelihood principle and modified minimum Chi-square methods. Theory of independent and dependent risks. Bivariate normal dependent risk model.

UNIT III

Stochastic Epidemic Models: Simple epidemic models, general epidemic model definition

and concept (without derivation). Duration of an epidemic.

UNIT IV

Statistical Genetics: Introduction, concepts-Genotype, Phenotype, Dominance, Recessiveness, Linkage and Recombination, Coupling and Repulsion. Mendelian laws of Heredity, Random mating, Gametic Array .relation between genotypic array and gametic array under random mating. Distribution of genotypes under random mating. Clinical Trials: Planning and design of clinical trials, Phase I, II and III trials. Single Blinding

SUGGESTED READING:

1. Lee, E.T. and Wang, J.W. (2003): Statistical Methods for Survival data Analysis, 3rd Edition, John Wiley and Sons.
2. Biswas, S. (2007): Applied Stochastic Processes: A Biostatistical and Population Oriented Approach, Reprinted 2ndCentral Edition, New Central Book Agency.
3. Kleinbaum, D.G. (1996): Survival Analysis, Springer.
4. Chiang, C.L. (1968): Introduction to Stochastic Processes in Bio Statistics, John Wiley and Sons.
5. Indrayan, A. (2008): Medical Biostatistics, 2nd Edition Chapman and Hall/CRC.

BSC-DSEP-6 Survival Analysis and Biostatistics(Practical/Lab Work) Credit 2

List of Practical

1. To estimate survival function
2. To determine death density function and hazard function
3. To identify type of censoring and to estimate survival time for type I censored data
4. To identify type of censoring and to estimate survival time for type II censored data
5. To identify type of censoring and to estimate survival time for progressively type I censored data
6. Estimation of mean survival time and variance of the estimator for type I censored data
7. Estimation of mean survival time and variance of the estimator for type II censored data
8. Estimation of mean survival time and variance of the estimator for progressively type I censored data
9. To estimate the survival function and variance of the estimator using Non-parametric methods with Actuarial methods
10. To estimate the survival function and variance of the estimator using Non-parametric methods with Kaplan-Meier method
11. To estimate Crude probability of death
12. To estimate Net-type I probability of death
13. To estimate Net-type II probability of death
14. To estimate partially crude probability of death
15. To estimate gene frequencies

BSC-DSE-7 Project Work **Credit 6**

Course Objectives: *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.*

Learning Outcomes: *On completion of the course, students will be able to:*

1. *Develop plans with relevant people to achieve the project's goals.*
2. *Break work down into tasks and determine handover procedures.*
3. *Identify links and dependencies, and schedule to achieve deliverables.*
4. *Estimate and cost the human and physical resources required, and make plans to obtain the necessary resources.*

Generic Elective

BSA-GE-1 Statistical Methods **Credit 6**

Course Objectives: *A statistical survey usually consists of collection of data, scrutiny of data and finally the analysis of data. Thus it is necessary for a student of Statistics is to be familiar with these steps at the very beginning. This particular course is designed keeping this in mind. Here the students are first introduced with the different ways of collecting data, followed by different types of data structure, their representation styles and finally different statistical tools and techniques that can be applied on a data set.*

Learning Outcomes: *After completion of this course, the students will be able to*

(1) Scrutinize an arbitrary data set.
(2) Represent the data in tabular and diagrammatic form.
(3) Prepare the frequency distribution for qualitative and quantitative data.
(4) Find the summary measures, viz. the measures of central tendency, measure of dispersion, measures of skewness and kurtosis of a univariate data.
(5) Find the degree of association/correlation between the two concerned variables in case of a bivariate data.
(6) Fit linear and non-linear curves for predicting the value of one variable, given the value of another, in case of bivariate data.

UNIT I

Introduction: Definition and scope of Statistics, concepts of statistical population and sample. Data: quantitative and qualitative, attributes, variables, scales of measurement - nominal,

ordinal, interval and ratio. Presentation: tabular and graphic, including histogram and ogives.

UNIT II

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

UNIT III

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

UNIT IV

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.

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. Partial and multiple correlations
9. Spearman rank correlation with and without ties.
10. Correlation coefficient for a bivariate frequency distribution
11. Lines of regression, angle between lines and estimated values of variables.
12. Checking consistency of data and finding association among attributes.

BSA-GE-2 Introductory Probability **Credit 6**

Course Objectives: *This is a fundamental course on probability theory. Students must have the knowledge of probability theory, random variables and their distributions to make further progress on statistical analysis. This course is designed into four units, the first units mainly devoted into the basics of probability theory and its applications. Second and third units mainly focused on various types of random variables, expectation, generating functions, convergence and central limit theorems. In the fourth unit students will have a nice idea about several discrete and continuous distributions.*

Learning Outcomes: *After completion of this course, the students will be able to*

(1) Understand the random experiment, sample space and probability theory.
(2) Know the one dimensional random variables and their properties in discrete / continuous framework.
(3) Grasp the idea of convergence in probability and central limit theorem.
(4) Recognize various discrete as well as continuous distributions and their properties.

UNIT I

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

UNIT II

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

UNIT III

Convergence in probability, almost sure convergence, Chebyshev's inequality, weak law of large numbers, De-Moivre Laplace and Lindeberg-Levy Central Limit Theorem (C.L.T.).

UNIT IV

Standard probability distributions: Binomial, Poisson, geometric, negative binomial, hypergeometric, uniform, normal, exponential, beta, gamma.

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

PRACTICAL/LAB. WORK:

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

BSA-GE-3 Basics of Statistical Inference Credit 6

Course Objectives: *This is a fundamental course on statistical inference. Students must have the knowledge of probability theory, random variables and their distributions to make further progress on statistical analysis. This course is designed into four units, the first units mainly devoted into the basics of estimation theory and testing of hypothesis. Second unit focused on categorical data and its associated testing. Third unit contains various non-parametric testing procedures. In the fourth unit students will have a nice idea about analysis of variance and design of experiment.*

Learning Outcomes: *After completion of this course, the students will be able to*

(1) Understand the estimation theory and hypothesis testing.
(2) Analyze the categorical data and its associated testing.
(3) Grasp the idea of non-parametric testing procedures such as Sign test, Wilcoxon test, etc .
(4) Perform the analysis of variance technique and application of design of experiment.

UNIT I

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

UNIT II

Categorical data: Tests of proportions, tests of association and goodness-of-fit using Chi-square test, Yates' correction.

UNIT III

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

UNIT IV

Analysis of variance, one-way and two-way classification. Brief exposure of three basic principles of design of experiments, treatment, plot and block. Analysis of completely randomized design, randomized complete block design. Bioassay.

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.

PRACTICAL/LAB WORK

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. Test for correlation coefficient.
8. Sign test for median.
9. Sign test for symmetry.
10. Wilcoxon two-sample test.
11. Analysis of Variance of a one way classified data
12. Analysis of Variance of a two way classified data.
13. Analysis of a CRD.
14. Analysis of an RBD.

BSA-GE-4 Introduction to Operations Research Credit 6

Course Objectives:

The objective of the course is to provide basic idea about operations research and utilizing optimization techniques as its basic tools. Use of statistical and mathematical tools in operations research and their applications to decision making process is primary concern. Role of operations research under different constraint conditions are to be studied.

Learning Outcomes: *On completion of the course, students will be able to:*

1. *Formulate the problem in operations research.*
2. *Establish the relationship between the variables and constraints by constructing the model.*
3. *Identify the possible alternative solutions and select the optimal one.*
4. *Install, test and establish the optimal solution.*
5. *Learn the tools like Linear Programming Problems, Transportation, assignment, and game theory.*

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.

UNIT II

Optimum solution to a L.P.P: Simplex method, concept of artificial variables and Charne's big M-technique. Graphically identifying special cases of L.P.P. Concept of duality in L.P.P.

UNIT III

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. Assignment problem: Hungarian method to find optimal assignment.

UNIT IV

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

SUGGESTED READING:

1. Taha, H. A. (2007): Operations Research: An Introduction, 8th Edition, Prentice Hall of India.
2. SwarupKanti, Gupta, P.K. and Manmohan (2007): Operations Research, 13th Edition, Sultan Chand and Sons.
3. Ravindran, A, Phillips, D.T., Solberg,J.J.(2005): Operations Research- Principles and Practice, John Wiley & Sons.

PRACTICAL/LAB WORK: Using TORA/WINQSB/LINGO

List of Practical

1. Mathematical formulation of L.P.P and solving the problem using graphical method
2. Simplex technique to solve L.P.P and reading dual solution from the optimal table
3. Charne's Big M method involving artificial variables.
4. Identifying Special cases: Degenerate solution, Unbounded solution, Alternate solution and Infeasible solution by Graphical method and interpretation
5. Allocation problem using Transportation model
6. Allocation problem using Assignment model
7. Networking : Shortest route problem
8. Problems based on game matrix: mx2 / 2xn rectangular and Mixed strategy

BSA-GE-5 Applied Statistics **Credit 6**

Course Objectives: *This course is designed for students who will come from other disciplines.*

Learning Outcomes: *This course is designed in such a way that after the completion of this course, students from other disciplines can start doing some elementary analysis of data.*

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

Demographic Methods: Introduction, measurement of population, rates and ratios of vital events. Measurement of mortality: CDR, SDR (w.r.t. Age and sex), IMR, Standardized death rates.

Life (mortality) tables: definition of its main functions and uses. Measurement of fertility and reproduction: CBR, GFR, and TFR. Measurement of population growth: GRR, NRR.

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.

PRACTICAL/LAB WORK

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. Completion of life table
9. Computation of measures of fertility and population growth

BSA-GE-6 Research Methodology **Credit 6**

Course Objectives: *Research Methodology is an important course mainly intended towards the students aims for research in future. This course also gives an idea about the project writing and making its content. This course is designed into four units, the first two units mainly devoted into the basics of research and data collection. In the last unit students will have a nice idea about the analysis of data and making the reports.*

Learning Outcomes: *After completion of this course, the students will be able to*

1) *Understand the various aspect of research.*
2) *Collect and process primary and secondary data.*
3) *Understand the importance of data analysis in the field of research.*
4) *Write down the report of their corresponding findings.*

UNIT I

Introduction to research, meaning of research, role of research in important areas, process of research, types of research, Unit of analysis, characteristics of interest. Research problem as a hypothesis testing

Sampling Techniques: Introduction to sampling, advantage of sampling over census, simple random sampling, sampling frame, probabilistic aspects of sampling, stratified random sampling, other methods of sampling, sampling design, non probability sampling methods

UNIT II

Data**:** Introduction, primary and secondary data, methods of collecting primary data, merits and demerits of different methods of collecting primary data, designing a questionnaire, pretesting a questionnaire, editing of primary data, technique of interview, collection of secondary data, scrutiny of secondary data,

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

UNIT III

Data Analysis: An overview on techniques in univariate, bivariate and multivariate data

Models and Model Building: role of models, types of models, objectives of modeling, model building/ model development, model validation, simulation models

UNIT IV

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

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

SUGGESTED READING:

1. Kotahri, C.R (2009): Research Methodology: Methods and Techniques, 2nd Revised Ed. Reprint, New Age International Publishers
2. Lilien, Gary L. and Philip Kotler, 1983. Marketing Decision Making; A Model Building Approach, Harper & Row, New York.
3. Shenoy, GVS, et al., (1983). Quantitative Techniques for Managerial Decision Making, Wiley Eastern

PRACTICAL/LAB WORK

Submit a Research Report based on empirical study on some real life situation. The student will personally collect, analyse, interpret the data and prepare a report under the supervision of a faculty.

Skill Enhancement Elective

BSC-SEE-1 Statistical-Data Analysis Using Software Packages Credit 2

Course Objectives: *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., R, Python, SPSS, Minitab, Matlab, for statistical computing.*

Learning Outcomes: *After completion of this course, the students will be able to*

1) *Load data, perform various descriptive statistics and plot using programming.*
2) *Find correlation and fit regression line.*
3) *Generate random numbers and have an idea on basic statistical inferences.*

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

UNIT IV
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

BSC-SEE-2 Statistical Data Analysis Using R Credit 2

Course Objectives: *This course will review and expand upon core topics in probability and statistics through the study and practice of data analysis and graphical interpretation using `R'.*

Learning Outcomes: *After completion of this course, the students will be able to*

1) *Analyze data sets.*
2) *Get a chance to do some hands on training based on theoretical knowledge they receive from other courses.*
3) *Carry out research in a more efficient way and get a better job prospect.*

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

UNIT IV

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. Gardener, M (2012) Beginning R: The Statistical Programming Language, Wiley Publications.
2. Braun W J, Murdoch D J (2007): A First Course in Statistical Programming with R. Cambridge University Press. New York

BSC-SEE-3 Statistical Techniques for Research Methods Credit 2

Course Objectives:

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.

Learning Outcomes: *After completion of this course, the students will be able to*

(1) Understand the significance of research and different types of research.
(2) Survey Methodology and Data Collection.
(3) Processing, Data Analysis and Interpretation.
(4) Develop a questionnaire.
(5) Collect survey data pertaining to a research problem.

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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

SUGGESTED READING:

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.

BSC-SEE-4 Data Base Management Systems **Credit 2**

Course Objectives:

This skill based course is structured to enhance database handling, data manipulation and data processing skills through SQL. The course will enable its beneficiaries develop data centric computer applications.

Learning Outcomes: On completion of the course, students will be able to:

6. Get an overview of Database Management System.
7. Accustomed with Relational Database Management System.
8. Know advantages and disadvantages of RDBMS and modify accordingly.
9. Acquainted with Data Structure.

UNIT I
Introduction: Overview of Database Management System, Introduction to Database Languages, advantages of DBMS over file processing systems.

UNIT II
Relational Database Management System: The Relational Model, Introduction to SQL: Basic Data Types, Working with relations of RDBMS: Creating relations e.g. Bank, College Database (create table statement)

UNIT III
Modifying relations (alter table statement), Integrity constraints over the relation like Primary Key , Foreign key, NOT NULL to the tables, advantages and disadvantages of relational Database System

UNIT IV
Database Structure: Introduction, Levels of abstraction in DBMS, View of data, Role of Database users and administrators, Database Structure: DDL, DML, Data Manager (Database Control System).Types of Data Models Hierarchical databases, Network databases, Relational databases, Object oriented databases

SUGGESTED READING:

1. Gruber, M(1990): Understanding SQL, BPB publication
2. Silberschatz, A, Korth, H and Sudarshan,S(2011) "Database System and Concepts", 6th Edition McGraw-Hill.
3. Desai, B. (1991): Introduction to Database Management system, Galgotia Publications.