

# SYLLABUS

## DIBRUGARH UNIVERSITY THREE YEAR DEGREE PROGRAMME (Under CBCS)



# STATISTICS

*(Recommended by B.O.S. in Statistics, D.U. in its meeting held on 21.06.2022 and approved by U.G. Board in its meeting held on ..... and passed by the Academic Council meeting held on ..... and effective from the session ..... )*

## **PREAMBLE**

Statistics is the language of the uncertainties riddled with modern information age. Statistics facilitates the decision making process by quantifying the elements of chance or uncertainties. It's descriptive and inferential roles not only formulate the basis of the growth of almost all the disciplines of the contemporary world, but also provide an array of non- traditional employment avenues ranging from that of sport analysts to business analysts. The thrust of the course is to prepare students to enter into a promising professional life even after graduation, as also provide to them a platform for pursuing higher studies leading to post-graduate and subsequent doctorate degrees.

**Proposed Scheme for Choice Based Credit System in  
B.Sc. Honours (Statistics)**

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

## B. Sc. Honours (Statistics)

Paper Code	Course Name		Credits
<b>Semester I</b>			
STAT-AEC-1	English/MIL Communication) /Environmental Science	Ability Enhancement	2
STAT-C-101	Descriptive Statistics	Core Discipline	4
	Practical/Lab. work		2
STAT-C-102	Calculus	Core Discipline	5
	Tutorial		1
STAT-GE-1	Any one from the List of <b>Generic Elective / Interdisciplinary Courses</b> from other Subjects	Generic Elective / Interdisciplinary	4
	Practical/Lab. Work		2
<b>Semester II</b>			
STAT-AEC-2	Environmental Science/ (English/MIL Communication)	Ability Enhancement	2
STAT-C-201	Probability and Probability Distributions	Core Discipline	4
	Practical/Lab. work		2
STAT-C-202	Algebra	Core Discipline	4
	Practical/Lab. work		2
STAT-GE-2	Any one from the List of <b>Generic Elective / Interdisciplinary Courses</b> from other Subjects	Generic Elective / Interdisciplinary	4
	Practical/Lab. Work		2
<b>Semester III</b>			
STAT-C-301	Sampling Distributions	Core Discipline	4
	Practical/Lab. Work		2
STAT-C-302	Survey Sampling & Indian Official Statistics	Core Discipline	4
	Practical/Lab. Work		2
STAT-C-303	Mathematical Analysis	Core Discipline	4
	Practical/Lab. work		2
STAT-SEC-1	Any one from the List of Skill Enhancement Courses	Skill Enhancement Courses	2
STAT-GE-3	Any one from the List of <b>Generic Elective / Interdisciplinary Courses</b> from other Subjects	Generic Elective / Interdisciplinary	4
	Practical/Lab. Work		2
<b>Semester IV</b>			
STAT-C-401	Statistical Inference	Core Discipline	4
	Practical/Lab. Work		2
STAT-C-402	Linear Models	Core Discipline	4
	Practical/Lab. Work		2
STAT-C-403	Statistical Quality Control	Core Discipline	4
	Practical/Lab. Work		2
STAT-SEC-2	Any one from the List of Skill Enhancement Courses	Skill Enhancement Courses	2
STAT-GE-4	Any one from the List of <b>Generic Elective / Interdisciplinary Courses</b> from other Subjects	Generic Elective / Interdisciplinary	4
	Practical/Lab. Work		2
<b>Semester V</b>			
STAT-C-501	Stochastic Processes and Queuing Theory	Core Discipline	4
	Practical/Lab. Work		2
STAT-C-502	Statistical Computing Using C / C++ Programming	Core Discipline	4
	Practical/Lab. Work		2
STAT-DSE	Any two from the following Discipline Specific Elective (DSE) courses	Discipline Specific Elective	4
	STAT-DSE-1: Demography and Vital Statistics Practical/Lab. Work		4 2
	STAT-DSE-2: Operations Research Practical/Lab. Work		4 2
	STAT-DSE-3: Econometrics Practical/Lab. Work		4 2

<b>Semester VI</b>			
STAT-C-601	Design of Experiments	Core Discipline	4
	Practical/Lab. Work		2
STAT-C-602	Multivariate Analysis and Nonparametric Methods	Core Discipline	4
	Practical/Lab. Work		2
STAT-DSE-3	Any two from the following Discipline Specific Elective (DSE) courses	Discipline Specific Elective	4
	STAT-DSE-4: Time Series Analysis		2
	Practical/Lab. Work		4
	STAT-DSE-5: Survival Analysis and Biostatistics		2
	Practical/Lab. Work		4
STAT-DSE-6: Project Work		6	

**\* Project Work will be offered in the Sixth Semester**

## B. Sc. Honours (Statistics)

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

STAT-C-101 Descriptive Statistics (Theory+ Practical)

STAT C-102 Calculus

STAT-C-201 Probability Distributions (Theory+ Practical)

STAT C-202 Algebra (Theory+ Practical)

STAT-C-301 Sampling Distributions (Theory+ Practical)

STAT-C-302 Survey Sampling and Indian Official Statistics (Theory+ Practical)

STAT C-303 Mathematical Analysis (Theory+ Practical)

STAT-C-401 Statistical Inference (Theory+ Practical)

STAT-C-402 Linear Models (Theory+ Practical)

STAT-C-403 Statistical Quality Control (Theory+ Practical)

STAT-C-501 Stochastic Processes and Queuing Theory (Theory+ Practical)

STAT-C-502 Statistical Computing Using C/C++ Programming (Theory+ Practical)

STAT-C-601 Design of Experiments (Theory+ Practical)

STAT-C-602 Multivariate Analysis and Nonparametric Methods (Theory+ Practical)

### Discipline Specific Elective (DSE) (Credit: 6 each)

#### 5<sup>th</sup> Sem: (2 papers to be selected)

1. Demography and Vital Statistics (Theory+ Practical)
2. Operations Research(Theory+ Practical)
3. Econometrics(Theory+ Practical)

#### 6<sup>th</sup> Sem: (2 papers to be selected)

1. Time Series Analysis(Theory+ Practical)
2. Survival Analysis and Biostatistics(Theory+ Practical)
3. Project Work (Sixth Semester)

### Skill Enhancement Courses (SEC) (Credit: 2 each) (2 papers to be selected)

1. Statistical-Data Analysis Using Software Packages
2. Statistical Data Analysis Using R
3. Statistical Techniques for Research Methods

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

1. Statistical Methods
2. Introductory Probability
3. Sample Survey
4. Basics of Statistical Inference
5. Introduction to Operations Research
6. Applied Statistics
7. Mathematical Economics
8. Research Methodology

**Core Papers in Statistics**  
**STAT-C-101 Descriptive Statistics**

Marks: 100 [In-sem : 20 (12T+8P) + End Sem. : 80 (Theory : 55 Practical : 25)]

**Credit 6**

**Course learning outcomes:** *After completing this course, students should have developed a clear understanding of the fundamental concepts of statistics, handling various types of data and their graphical representation, measures of location and dispersion, bivariate data, significance of various coefficients of correlation, fitting of linear/nonlinear curve and index numbers.*

**UNIT I**

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

10 (5L + 1T)

**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.

20(9L + 2T)

**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.

15 (7L + 1T)

**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.

10 (5L + 1T)

**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, Delhi.
4. Barman. M. P., Hazarika. J, Bora. T (2021): Statistical Methods, Mahaveer Pub, Dibrugarh.

**PRACTICAL/LAB. WORK:**

25 (7L = 14 Class)

**List of Practicals**

1. Graphical representation of data.
2. Problems based on measures of central tendency.
3. Problems based on measures of dispersion.
4. Problems based on combined mean and variance and coefficient of variation.
5. Problems based on moments, skewness and kurtosis.
6. Fitting of polynomials, exponential curves.
7. Karl Pearson correlation coefficient.
8. Correlation coefficient for a bivariate frequency distribution.
9. Lines of regression, angle between lines and estimated values of variables.
10. Spearman rank correlation with and without ties.

11. Partial and multiple correlations.
12. Planes of regression and variances of residuals for given simple correlations.
13. Planes of regression and variances of residuals for raw data.
14. Calculate price and quantity index numbers using simple and weighted average of price relatives.
15. To calculate the Chain Base index numbers.
16. To calculate consumer price index number.

- **T= Tutorial**
- **L= Lecture**



**Core Papers in Statistics**

**STAT C-102 – Calculus**

Marks: 100 [In-sem: 20(12T+8P) + End Sem. : 80(Theory: 80)]

**Credit 6**

**Course learning outcomes:** *Upon successful completion of this course, students will be able to compute limits, derivatives, integrals, differential equation and partial differential equations.*

**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. 25(10L+2T)

**UNIT II**

Integral Calculus: Review of integration and definite integral. Differentiation under integral sign (Leibnitz rule with examples only), double integral, change of order of integration, transformation of variables. Beta and Gamma functions: properties and relationship between them. 20 (9L+2T)

**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 linear differential equations of order n with constant coefficients 20 (9L+2T)

**UNIT IV**

Formation and solution of simple partial differential equations. Linear partial, partial differential equations of first order. Non linear partial differential equation of first order and their different forms. 15 (6L+1T)

**SUGGESTED READINGS:**

1. Gorakh Prasad: Differential Calculus, Pothishala Pvt. Ltd., Allahabad (14th Edition - 1997).
2. Gorakh Prasad: Integral Calculus, Pothishala Pvt. Ltd., Allahabad (14th Edition -2000).
3. Zafar Ahsan: Differential Equations and their Applications, Prentice-Hall of India Pvt. Ltd., New Delhi (2nd Edition -2004).
4. Piskunov, N: Differential and Integral Calculus, Peace Publishers, Moscow.

**Core Papers in Statistics**  
**STAT-C-201 Probability Distributions**

Marks : 100 [In-sem : 20 (12T+8P) + End Sem. : 80 (Theory : 55 Practical : 25)]

**Credit 6**

**Course learning outcomes:** *After completing the course, students should have developed knowledge of the role of probability and its distributions in statistical analyses. It also helps to make objective decisions based on samples drawn from the populations that the distributions represent.*

**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. 10 (5L+1T)

**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. 10 (5L+1T)

**UNIT III**

Mathematical Expectation and Generating Functions: Expectation of single and bivariate random variables and its properties. Moments and Cumulants, moment generating function, cumulant generating function and characteristic function. Uniqueness and inversion theorems (without proof) along with applications. Conditional expectations. 15 (7L+1T)

**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. 20 (9L+2T)

**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:**

25 (7L = 14 Class)

**List of Practicals**

1. Fitting of binomial distribution.
2. Fitting of Poisson distribution.
3. Fitting of geometric distribution.
4. Fitting of negative binomial distribution.
5. To find the ordinate for a given area for normal distribution.
6. Fitting of normal distribution.
7. Fitting of exponential distribution.

**Core Papers in Statistics**

**STAT C- 202- Algebra**

Marks : 100 [In-sem : 20 (12T+8P) + End Sem. : 80 (Theory : 55 Practical : 25)]

**Credit 6**

**Course learning outcomes:** *After completing this course, students should have developed a clear understanding of the study of algebra. It helps the student to understand the theory of equations, algebra of matrices, determinants of matrices, rank, characteristic roots and vectors.*

**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, Span of a set, Linear dependence and independence, dimension and basis, dimension theorem (without proof). 10 (5L+1T)

**UNIT II**

Algebra of matrices - Types of Matrices: triangular, symmetric and skew symmetric matrices, idempotent matrices, Hermitian and skew Hermitian matrices, orthogonal matrices, singular and non-singular matrices related results and their properties. Trace of a matrix, unitary, involutory and nilpotent matrices. 10 (5L+1T)

**UNIT III**

Determinants of Matrices: Definition, properties and applications of determinants for 3rd and 4<sup>th</sup> orders, evaluation of determinants of order 3 and 4 using transformations. Symmetric and Skew symmetric determinants, Circulant determinants and Vandermonde determinants for nth order, Jacobi's Theorem, product of determinants. Adjoint and inverse of a matrix and related properties. solution of linear system of equations (homogeneous and non homogeneous), linear independence, Applications of linear equations, inverse of a matrix. 20(8L+2T)

**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, useful Properties of characteristic roots, Cayley-Hamilton theorem, Quadratic forms definition and classifications; Linear orthogonal transformation. (Basic ideas) 15 (6L+2T)

**SUGGESTED READINGS:**

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

**List of Practicals/ Lab work:****25 (7L = 14 Class)**

1. Problems related to linearly independence and dependence.
2. Determination of rank of a matrix of order  $4 \times 4$ .
3. Inverse of a matrix of order  $4 \times 4$ .
4. Solution of system of equations.
5. Problems related to quadratic forms.
6. Determination of eigen values and vectors.

**Core Papers in Statistics**  
**STAT-C-301 Sampling Distributions**

Marks : 100 [In-sem : 20 (12T+8P) + End Sem. : 80 (Theory : 55 Practical : 25)]

**Credit 6**

**Course learning outcomes:** *After studying this course, the student will be able to understand the basic concepts of sampling distributions, the Central Limit Theorem and when to apply it, sampling distributions, namely chi-square, Student -t, and Snedecor's F-distributions and use them to make conclusions about problems that arise in applied statistics and develop the distributions of various order statistics.*

**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. 12 (6L+1T)

**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.

14 (8L+1T)

**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.

14 (8L+1T)

**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.

**\*only Central distributions**

15 (8L+1T)

**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.

**PRACTICAL/LAB. WORK:**

**25 (7L = 14 Class)**

**List of Practicals**

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

**Core Papers in Statistics**

**STAT-C-302 Survey Sampling and Indian Official Statistics**

Marks : 100 [In-sem : 20 (12T+8P) + End Sem. : 80 (Theory : 55 Practical : 25)]

**Credit 6**

**Course learning outcomes:** *After completing this course, students should have a clear understanding of the sample surveys, its needs and objectives, various sampling techniques, drawing of an appropriate sample and interpret the result, official statistical system in India and functions of different agencies.*

**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.

17 (9L+1T)

**UNIT II**

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

18 (9L+1T)

**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.

10 (6L+1T)

**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), National Statistical Office (NSO) and National Statistical Commission. Government of India's Principal publications containing data on the topics such as population, industry and finance.

10 (5L+1T)

**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. New Delhi
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/>

**List of Practicals**

1. To select a SRS with and without replacement.
2. For a population of size 5, estimate population mean, population mean square and population variance. Enumerate all possible samples of size 2 by WR and WOR and establish all properties relative to SRS.
3. For SRSWOR, estimate mean, standard error, the sample size
4. Stratified Sampling: allocation of sample to strata by proportional and Neyman's methods  
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.



**Core Papers in Statistics**

**STAT C- 303- Mathematical Analysis**

Marks : 100 [In-sem : 20 (12T+8P) + End Sem. : 80(Theory : 55 Practical : 25)]

**Credit 6**

**Course learning outcomes:** *On successful completion of this course, students will be able to describe the fundamental properties of the real numbers that lead to the formal development of real analysis. Also, demonstrate an understanding of limits and how that are used in sequences, series and differentiation, rigorous mathematical proofs of basic results in real analysis and finally, applications of abstract ideas and regions methods in mathematical analysis can be applied to important practical problems.*

**UNIT-I**

Real Analysis: Real Numbers. 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. 15 (8L+1T)

**UNIT-II**

Infinite series, positive termed series and their convergence, Comparison test, D'Alembert's ratio test, Cauchy's nth 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. 15(8L+T)

**UNIT-III**

Review of limit, continuity and differentiability, uniform Continuity and boundedness of a function. Rolle's and Lagrange's Mean Value theorems. Taylor's theorem with lagrange's and Cauchy's form of remainder(without proof). Taylor's and Maclaurin's series expansions of  $\sin x$ ,  $\cos x$ ,  $\log(1+x)$ . 10(4L+1T)

**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. Numerical integration. Trapezoidal rule, Simpson's one-third rule, three-eighth rule, Weddle's rule with error terms. Difference equations of first order and their solutions. Solution of Transcendental equations with NR method. 15 (6L+1T)

**SUGGESTED READINGS**

1. Malik S.C. and Savita Arora, (1994): Mathematical Analysis, Second Edition, Wiley Eastern Limited, New Age International Limited, New Delh.
2. Somasundram D. and Chaudhary B. (1987): A First Course in Mathematical Analysis, Narosa Publishing House, New Delhi,.
3. Gupta S.L. and Nisha Rani, (1995): Principles of Real Analysis, Vikas Publ. House Pvt. Ltd., New Delhi.
4. Appostol T.M. (1987): Mathematical Analysis, Second Edition, Narosa Publishing House, New Delhi.
5. Shanti Narayan, (1987): A course of Mathematical Analysis, 12th revised Edition, S. Chand & Co. (Pvt.) Ltd., New Delhi.
6. Singal M.K. and Singal A.R., (2003): A First Course in Real Analysis, 24th Edition, R. Chand & Co., New Delhi.
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

**List of Practicals/ Lab Work:**

**25 (7L = 14 Class)**

1. Determination of missing terms.
2. Interpolation using Newton's forward, backward, divided difference and Lagrange's formula.
3. Numerical integration using Trapezoidal, Simpson's  $1/3^{\text{rd}}$  rule,  $3/8^{\text{th}}$  rule, Weddle's rule.
4. Solution of transcendental equations using Newton-Raphson method.

**Core Papers in Statistics**  
**STAT-C-401 Statistical Inference**

Marks : 100 [In-sem : 20(12T+8P) + End Sem. : 80 (Theory : 55 Practical : 25)]

**Credit 6**

**Course learning outcomes:** *After completing this course, students should have possessed skills concerning the small sample and large sample tests, point and interval estimators, testing of hypothesis, estimation theory and analyze and interpret the data vis-a-vis statistical inference in data analysis.*

**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). 15 (8L+1T)

**UNIT II**

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

10 (5L+1T)

**UNIT III**

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). 15 (8L+1T)

**UNIT IV**

Sequential Analysis: Sequential probability ratio test (SPRT) for simple null vs simple alternative hypotheses. Fundamental relations among  $\alpha$ ,  $\beta$ , A and B, determination of A and B in practice. Wald's fundamental identity (sans proof) and the derivation of operating characteristics (OC) and average sample number (ASN) functions, examples based on normal, Poisson, binomial and exponential distributions. 15 (8L+1T)

**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. 2ndEdn. (Reprint) John Wiley and Sons.
3. Miller, I. and Miller, M. (2002) : John E. Freund's Mathematical Statistics (6th addition, low price edition), Prentice Hall of India.
4. Dudewicz, E. J., and Mishra, S. N. (1988): Modern Mathematical Statistics. John Wiley & Sons.
5. Mood A.M, Graybill F.A. and Boes D.C.:- Introduction to the Theory of Statistics, McGraw Hill.
6. Bhat B.R, Srivenkatramana T and Rao Madhava K.S. (1997) Statistics: A Beginner's Text, Vol. I, New Age International (P) Ltd.
7. Snedecor G.W and Cochran W.G.(1967) Statistical Methods. Iowa State University Press.

**PRACTICAL/LABWORK:**

**25 (7L = 14 Class)**

**List of Practicals**

1. Maximum likelihood estimators.
2. Estimation by method of moments for the binomial, Poisson, exponential, normal

distributions.

3. Comparison of method of moments and maximum likelihood estimators for the continuous uniform distribution.
4. Computation of Type- I and Type-II errors.
5. Application of NP lemma: construction of MP and UMP tests.
6. Drawing power curves for the tests of equality of normal mean ( $s$ ).
7. Likelihood ratio test:  
    Single-sample and two-sample testing problems.
8. Sequential testing procedure: Construction of OC, ASN function and drawing of OC, ASN curve.

**Core Papers in Statistics**  
**STAT-C-402 Linear Models**

Marks : 100 [In-sem : 20 (12T+8P) + End Sem. : 80 (Theory : 55 Practical : 25)]

**Credit 6**

**Course learning outcomes:** *After completing this course, students should have developed clear understanding methods of least squares, regression analysis, analysis of variance and model checking.*

**UNIT I**

Gauss-Markov set-up: Theory of linear estimation, Estimability of linear parametric functions, Method of least squares, Gauss-Markov theorem with proof

10 (5L+1T)

**UNIT II**

Regression analysis: Simple regression analysis, Estimation and hypothesis testing in case of simple and multiple regression models (Matrix and scalar versions) and estimation.

15 (8L+2T)

**UNIT III**

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

20 (9L+2T)

**UNIT IV**

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

10 (5L+1T)

**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.

**PRACTICAL/LAB. WORK:**

**25 (7L = 14 Class)**

**List of Practicals**

1. To compute the distribution of Quadratic forms
2. To fit simple Linear Regression model
3. To fit the Multiple Regression model
4. Tests for Linear Hypothesis
5. Lack of fit
6. Orthogonal Polynomials
7. Analysis of Variance of a one way classified data
8. Analysis of Variance of a two way classified data with one observation per cell
9. Analysis of Covariance of a one way classified data
10. Analysis of Covariance of a two way classified data

**Core Papers in Statistics**  
**STAT-C-403 Statistical Quality Control**

Marks : 100 [In-sem : 20(12T+8P) + End Sem. : 80 (Theory : 55 Practical : 25)]

**Credit 6**

**Course learning outcomes:** *This course will help students to learn techniques and approach of SQC being used in industry to manufacture goods and services of high quality at low cost and also give exposure to Sampling Inspection Plans.*

**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- $\sigma$  Control charts, Rational Sub-grouping. 15 (6L+2T)

**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. 15 (6L+2T)

**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. 15 (6L+2T)

**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). 10 (5L+1T)

**SUGGESTED READING:**

1. Montgomery, 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. Montgomery, 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.

**PRACTICAL/LAB. WORK:**

25 (7L = 14 Class)

**List of Practicals**

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.

**Core Papers in Statistics**

**STAT-C-501 Stochastic Processes and Queuing Theory**

Marks : 100 [In-sem : 20 (12T+8P) + End Sem. : 80 (Theory : 55 Practical : 25)]

**Credit 6**

**Course learning outcomes:** *By the end of this course students should be able to compute probabilities of transition between states and return to the initial state after long time intervals in Markov chains. Identify classes of states in Markov chains and characterize the classes. Determine limit probabilities in Markov chains after an infinitely long period*

**UNIT I**

Probability Distributions: Generating functions, Bivariate probability generating function.  
Stochastic Process: Introduction, Stationary Process. 10 (5L+1T)

**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. 20 (9L+2T)

**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. 12 (6L+1T)

**UNIT IV**

Queuing System: General concept, steady state distribution, queuing model, M/M/1 with finite and infinite system capacity, waiting time distribution in stationary cases only (without proof). 13 (6L+1T)

**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.

**PRACTICAL/LAB. WORK**

**25 (7L = 14 Class)**

**List of Practicals**

1. Calculation of transition probability matrix
2. Identification of characteristics of reducible and irreducible chains.
3. Identification of types of classes
4. Identification of ergodic transition probability matrix
5. Stationarity of Markov chain and graphical representation of Markov chain
6. Calculation of probabilities for given birth and death rates and vice versa
7. Calculation of probabilities for Birth and Death Process
8. Computation of inter-arrival time for a Poisson process.
9. Calculation of Probability and parameters for (M/M/1) model and change in behaviour of queue as N tends to infinity.



**Core Papers in Statistics**

**STAT-C-502 Statistical Computing Using C Programming**

Marks : 100 [In-sem : 20(12T+8P) + End Sem. : 80 (Theory : 55 Practical : 25)]

**Credit 6**

**Course learning outcomes:** *After completing this course, students should have developed a clear understanding of the programming skills using the C language and its roles in problem solving.*

**UNIT I**

History and importance of C. Components, basic structure programming, character set, C tokens, Keywords and Identifiers and execution of a C program. Data types: Basic data types, Enumerated data types, derived data types. Constants and variables: declaration and assignment of variables,

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 20 (9L+2T)

**UNIT II**

Decision making and branching - if...else, nesting of if...else, else if ladder, switch, conditional operator. Looping in C for, nested for, while, do...while, jumps in and out of loops.

Arrays: Declaration and initialization of one-dim and two-dim arrays. Character arrays and strings: 12 (6L+1T)

**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. 12 (6L+1T)

**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. 11 (6L+1T)

**SUGGESTED READING:**

1. Kernighan, B.W. and Ritchie, D. (1988): C Programming Language, 2<sup>nd</sup> 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

**PRACTICAL/ LAB WORK**

25 (7L = 14 Class)

(Using C/C++ Programming Language)

### **List of Practicals**

1. Plot of a graph  $y = f(x)$
2. Roots of a quadratic equation (with imaginary roots also)
3. Sorting of an array and hence finding median
4. Mean, Median and Mode of a Grouped Frequency Data
5. Variance and coefficient of variation of a Grouped Frequency Data
6. 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. Testing equality of two variances (F- Test)
15. Multiple and Partial correlation.
16. Compute ranks and then calculate rank correlation(without tied ranks)
17. Fitting of linear regression model

**Core Papers in Statistics**  
**STAT-C-601 Design of Experiments**

Marks : 100 [In-sem : 20 (12T+8P) + End Sem. : 80 (Theory : 55 Practical : 25)]

**Credit 6**

**Course learning outcomes:** *After completing this course, students should have developed a clear understanding of the various designs of experiments in statistical studies.*

**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 single missing observation. 15 (7L+2T)

**UNIT II**

Incomplete Block Designs: Balanced Incomplete Block Design (BIBD) – parameters, relationships among its parameters, incidence matrix and its properties,

10 (4L+1T)

**UNIT III**

Factorial experiments: advantages, notations and concepts,  $2^2$ ,  $2^3 \dots 2^n$  and  $3^2$  factorial experiments, design and analysis,

15 (7L+2T)

**UNIT IV**

Total and Partial confounding for  $2^n$  ( $n \leq 5$ ). Factorial experiments in a single replicate.

Fractional factorial experiments: Construction of one-half and fractions of  $2^n$  ( $n \leq 5$ ) factorial experiments 15 (6L+2T)

**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.

**PRACTICAL/LAB. WORK:**

**25 (7L = 14 Class)**

**List of Practicals**

1. Analysis of a CRD
2. Analysis of an RBD
3. Analysis of an LSD
4. Analysis of an RBD with one missing observation
5. Analysis of an LSD with one missing observation
6. 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

**Core Papers in Statistics**

**STAT-C-602 Multivariate Analysis and Nonparametric Methods**

Marks : 100 [In-sem : 20 (12T+8P) + End Sem. : 80 (Theory : 55 Practical : 25)]

**Credit 6**

**Course learning outcomes:** *After completing this course, students should have developed a clear understanding of the bivariate and multivariate normal distributions and 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. 10 (5L+1T)

**UNIT II**

Multivariate Normal distribution and its properties. Sampling distribution for mean vector and variance-covariance matrix (sans deduction). Multiple and partial correlation coefficient and their properties. 15 (6L+2T)

**UNIT III**

Applications of Multivariate Analysis: Discriminant Analysis: introduction, properties and assumptions, Principal Components Analysis: Introduction and properties and Factor Analysis: Concepts.

15(6L+2T)

**UNIT IV**

Nonparametric Tests: Introduction and Concept, Test for randomness based on total number of runs, Empirical distribution function, Kolmogorov Smirnov test for one sample, Sign test and signed Rank test, Wilcoxon-Mann-Whitney test, Kruskal-Wallis test.

15 (6L+2T)

**SUGGESTED READING:**

1. Anderson, T.W. (2003): An Introduction to Multivariate Statistical Analysis, 3rdEdn., John Wiley
2. Muirhead, R.J. (1982): Aspects of Multivariate Statistical Theory, John Wiley.
3. Kshirsagar, A.M. (1972) :Multivariate Analysis, 1stEdn. Marcel Dekker.
4. Johnson, R.A. and Wichern, D.W. (2007): Applied Multivariate Analysis, 6thEdn., Pearson & Prentice Hall
5. Mukhopadhyay, P. :Mathematical Statistics.
6. Gibbons, J. D. and Chakraborty, S (2003): Nonparametric Statistical Inference. 4th Edition. Marcel Dekker, CRC.
7. Conover. W. J. , Practical Non parametric methods, John wiley

**PRACTICALS/ LAB WORK:**

**25 (7L = 14 Class)**

**List of Practicals**

1. To compute Multiple Correlation
2. To compute Partial Correlation
3. To compute Bivariate Normal Distribution,
4. To compute Multivariate Normal Distribution
5. Simple application of Discriminant Analysis
6. Data reduction Principal Components Analysis and Factor Analysis
7. Test for randomness based on total number of runs,
8. Kolmogorov Smirnov test for one sample.
9. Sign test: one sample, two samples, large samples.

10. To test the Wilcoxon-Mann-Whitney U-test
11. To test the Kruskal-Wallis test

**DSE Papers in Statistics**

**STAT-DSE-1 Demography and Vital Statistics**

Marks : 100 [In-sem : 20 (12T+8P) + End Sem. : 80 (Theory : 55 Practical : 25)]

**Credit 6**

**Course learning outcome:** *After completing this course, students should have developed a clear understanding of the vital statistics and demography, sources of data collection and errors therein, measurement of mortality, fertility, population growth and life tables, their construction and uses.*

**UNIT I**

Nature and scope of Demography. Population theories – Malthus, Natural and Biological, Demographic transition. Demographic data- sources, coverage and content errors. Use of balancing equations and Chandrasekharan-Deming formula to check completeness of registration data. Adjustment of age data- Myer and UN indices. Population composition, dependency ratio. 15 (7L+2T)

**UNIT II**

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 Rates (SDR), Infant Mortality Rate (IMR) and Standardized Death Rates. 15 (7L+2T)

**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. Abridged Life Tables; Concept and construction of abridged life tables by Reed-Merrell method, Greville's method and King's Method. 10 (4L+1T)

**UNIT IV**

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). 15 (7L+2T)

**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.: Demography through Problems S-Verlag New york.

**PRACTICAL/LAB. WORK:**

**25 (7L = 14 Class)**

**List of Practicals**

1. To calculate CDR and Age Specific death rate for a given set of data
2. To find Standardized death rate by:- (i) Direct method (ii) Indirect method
3. To construct a complete life table
4. To fill in the missing entries in a life table
5. To 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

**DSE Papers in Statistics**  
**STAT-DSE-2 Operations Research**

Marks : 100 [In-sem : 20 (12T+8P) + End Sem. : 80 (Theory : 55 Practical : 25)]

**Credit 6**

**Course learning outcomes:** *After studying this course student will be able to impart knowledge of the concepts, building mathematical models, techniques constructively and solving them to make effective decisions making. Also, simultaneous-move games, dominant, pure and mixed strategies, and best responses in game theory. The role of inventory, costs of an inventory system, order quantity and an ABC analysis of inventory items.*

**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.

20 (8L+2T)

**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.

17 (7L+2T)

**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 of  $2 \times 2$ ,  $2 \times n$ ,  $n \times 2$  rectangular game with mixed strategy.

10 (5L+1T)

**UNIT IV**

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

8 (3L+1T)

**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

**PRACTICAL/ LAB WORK**

25 (7L = 14 Class)

(Preferably using TORA/WINQSB/LINGO)

**List of Practicals**

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. Identify the following Special cases by Graphical and Simplex method
  - Degenerate solution
  - Unbounded solution
  - Alternate solution
  - Infeasible solution
3. Allocation problem using Transportation model
4. Allocation problem using Assignment model



5. Problems based on game matrix
  - a. Graphical solution to  $m \times 2$ ,  $2 \times n$ ,  $2 \times 2$  rectangular game
  - b. Mixed strategy
6. To find optimal inventory policy for EOQ models and its variations

**DSE Papers in Statistics  
STAT-DSE-3 Econometrics**

Marks : 100 [In-sem : 20 (12T+8P) + End Sem. : 80 (Theory : 55 Practical : 25)]

**Credit 6**

**Course Learning Outcomes:** Better understanding of Econometric models and its estimation, under different incompatible situations. Concepts of multicollinearity, autocorrelation and heteroscedasticity and their consequences. Concepts of Simultaneous equation models.

**UNIT I**

Introduction: Econometric models and its essences. General linear model (GLM) and its estimation. Simultaneous equation model: structural and reduced forms. 15 (7L+2T)

**UNIT II**

Multicollinearity: Introduction and concepts, detection of multicollinearity, consequences, detection and remedies of multicollinearity, specification errors. 15 (7L+2T)

**UNIT III**

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

15 (7L+2T)

**UNIT IV**

Heteroscedastic disturbances: Concepts and efficiency of Aitken estimator with OLS estimator under heteroscedasticity. Consequences of. Tests and solutions of heteroscedasticity. Autoregressive and Lag models. 10 (5L+1T)

**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.
5. Parashar Anil K. & Singh H. P., Singh S. P. (1991): Econometrics and Mathematical Economics, S.Chand & Company, New Delhi.

**PRACTICAL /LAB WORK**

**25 (7L = 14 Class)**

**List of Practicals**

1. Problems based on estimation of General linear model
2. Testing of parameters of General linear model
3. Forecasting of General linear model
4. Problems concerning specification errors
5. Problems related to consequences of Multicollinearity
6. Problems based on Diagnostics of Multicollinearity
7. Problems related to consequences of Autocorrelation (AR(I))
8. Problems based on 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.

**DSE Papers in Statistics**  
**STAT-DSE-4 Time Series Analysis**

Marks : 100 [In-sem : 20 (12T+8P) + End Sem. : 80 (Theory : 55 Practical : 25)]

**Credit 6**

*Course Learning Outcome:* Components of time series, Estimation of trend seasonality, method of Moving Averages, Ratio to trend method, ratio to moving average and link relative method, Probability models for time series: stationarity; Moving average (MA), Autoregressive (AR); Estimating the autocorrelation function and correlogram; Forecasting: Exponential smoothing, Box-Jenkins method.

**UNIT I**

Introduction to time 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.

14 (6L+2T)

**UNIT II**

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.

14 (6L+2T)

**UNIT III**

Seasonal Component cont: Ratio to Moving Averages and Link Relative method, Deseasonalization. Cyclic Component: Harmonic Analysis. Some Special Stochastic Processes: Moving- average (MA) process and Autoregressive (AR) process of orders one and two.

15 (7L+2T)

**UNIT IV**

Random Component: Variate component method. Stationary Time series: Weak stationarity, autocorrelation function and correlogram. Forecasting: Exponential smoothing methods of forecasting; Box-Jenkins method.

12 (6L+2T)

**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

**PRACTICAL / LAB WORK**

**25 (7L = 14Class)**

**List of Practicals**

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

**DSE Papers in Statistics**

**STAT-DSE-5 Survival Analysis and Biostatistics**

Marks : 100 [In-sem : 20 (12T+8P) + End Sem. : 80 (Theory : 55 Practical : 30)]

**Credit 6**

**Course learning outcomes:** *After completing this course, students should have developed a clear understanding of the proper interpretation of scientific data generated in the biological studies.*

**UNIT I**

Survival Analysis: survival distributions and their applications exponential, gamma, Weibull, Rayleigh, lognormal, density functions 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: Kaplan-Meier methods for estimating survival function and variance of the Estimator. 22 (11L+2T)

**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. 12 (4L+1T)

**UNIT III**

Basic concepts of Epidemiology. Stochastic Epidemic Models: Simple epidemic models, general epidemic model definition and concept (without derivation). Duration of an epidemic. 12 (4L+1T)

**UNIT IV**

Clinical Trials : definition, ethics, masking and blinding, phases, Randomized control trial. Screening test and ROC curve (specificity-sensitivity based) 9(4L+1T)

**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 2nd Central 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.

**PRACTICAL / LAB WORK**

**25 (7L = 14 Class)**

**List of Practicals**

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

**DSE Papers in Statistics**  
**STAT-DSE-6 Project Work**  
**Marks 100 [In-sem : 20 + End Sem. : 80]**

**Credit 6**

**Objective:** The aim of the course is to initiate students to write and present a statistical report, under the supervision of a faculty, on some area of human interest. The project work will provide hands on training to the students to deal with data emanating from some real life situation and propel them to dwell on some theory or relate it to some theoretical concepts.

**Course learning outcomes:** *After completing this course, students should have developed a clear understanding of the writing and presenting 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.*

**Generic Elective**

**STAT-GE-1 Statistical Methods**

Marks : 100 [In-sem : 20 (12T+8P) + End Sem. : 80 (Theory : 55 Practical : 25)]

**Credit 6**

**Course learning outcomes:** *After completing this course, students should have developed a clear understanding of the fundamental concepts of statistics, handling various types of data and their graphical representation, measures of location and dispersion, bivariate data, significance of various coefficients of correlation, fitting of linear/nonlinear curve and index numbers.*

**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. 10 (5L+1T)

**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. 18 (8L+2T)

**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. 17 (7L+2T)

**UNIT IV**

Theory of attributes, consistency of data, independence and association of attributes, measures of association and contingency. 10 (5L+1T)

**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.
4. Barman. M. P., Hazarika. J, Bora. T (2021): Statistical Methods, Mahaveer Pub, Dibrugarh

**PRACTICAL/ LAB WORK**

**25 (7L = 14 Class)**

**List of Practicals**

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



**Generic Elective**

**STAT-GE-2 Introductory Probability**

Marks : 100 [In-sem : 20 (12T+8P) + End Sem. : 80 (Theory : 55 Practical : 25)]

**Credit 6**

**Course learning outcomes:** *After completing the course, students should have developed knowledge of the role probability and its distributions in statistical analyses. It also helps to make objective decisions based on samples drawn from the populations that the distributions represent.*

**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. 15 (6L+2T)

**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. 12 (5L+1T)

**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.). 10 (5L+1T)

**UNIT IV**

Standard probability distributions: Binomial, Poisson, geometric, negative binomial, uniform, normal, exponential, beta, gamma. 18 (7L+2T)

**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:**

**25 (7L = 14 Class)**

**List of Practicals**

1. Fitting of binomial distributions for  $n$  and  $p = q = \frac{1}{2}$  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. Problems based on area property of normal distribution
7. Fitting of normal distribution when parameters are given
8. Fitting of normal distribution when parameters are not given

**Generic Elective  
STAT-GE-3 Sample Survey**

Marks : 100 [In-sem : 20 (12T+8P) + End Sem. : 80 (Theory : 55 Practical : 25)]

**Credit 6**

**Course learning outcomes:** *After completing this course, students should have a clear understanding of the sample surveys, its need and objectives, various sampling techniques, drawing of an appropriate sample and interpret the result, official statistical system in India and functions of different agencies.*

**UNIT I**

Concept of population and sample, parameter and statistic, Census and sample survey (sampling unit and sampling frame. Needs for sampling). Steps in a sample survey. Probability and non-probability sampling. Sampling and non-sampling errors. Limitations of sampling.

15 (6L + 1T)

**UNIT II**

Basic methods of sampling . SRS with and without replacement. Selection of random sample using lottery method & random numbers table. Estimation of population mean, total and proportion.

15 (6L + 2T)

**UNIT III**

Stratified random sampling – necessity, estimation of population mean, total and proportional and their variances. Allocation of samples into different strata using proportional method, Idea of Linear & Circular Systematic sampling, PPS sampling, Cluster sampling with equal size of clusters- illustration with examples.

15 (6L + 2T)

**UNIT IV**

Idea of two –stage, multi stage and multi phase sampling – their uses. Needs of determination of sample size, simple examples in SRS and stratified random sampling. Acquaintance with the working of NSSO & NFHS : objective, questionnaire, sampling design, methods of field investigation.

10 (5L + 1T)

**SUGGESTED READING:**

1. Cochran William G. (1984): Sampling Techniques, Third Edition, Wiley India Pvt. Ltd, New Delhi
2. Gupta, S.C , Kapoor V.K. ( 2007 ) : Fundamentals of Applied Statistics, Forth Edition, Sultan Chand & Sons.
3. Murthy M.N. : Sampling Theory and Methods, Statistical Publishing Society, Calcutta
4. Sampath S. : Sampling Theory and Methods, Narosa Publishing House
5. Sukhatme B.V. : Sample Survey Methods and its Applications, Indian Society of Agricultural Statistics
6. Des Raj : Sample Survey Theory, Narosa Publishing House
7. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C (1984) : Sampling Theory of Surveys with Applications, Iowa State University Press, Iowa, USA
8. Murthy M.N. (1977) : Sampling Theory and Methods, Statistical Pub. Soc. Calcutta
9. Des Raj & Chandhok P (1998) : Sample Survey Theory, Narosa Publishing House

10. Mukhopadhyay. P (1998) : Theory and Methods of Survey Sampling, Prentice Hall
11. NSSO Publications

**PRACTICAL/LAB WORK**

**25 (7L = 14 Class)**

**List of Practicals**

1. To select a SRS 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 WOR and establish all properties relative to SRS.
3. For SRSWOR : estimation of mean, standard error, the sample size
4. Stratified Sampling: allocation of sample to strata by proportional method
5. Estimation of gain in precision in stratified sampling.
6. Preparation of questionnaire, sample size determination for mean, proportion with primary data ( $n < 100$ )

**Generic Elective**

**STAT-GE-4 Basics of Statistical Inference**

Marks : 100 [In-sem : 20 (12T+8P) + End Sem. : 80 (Theory : 55 Practical : 25)]

**Credit 6**

**Course learning outcomes:** *After completing this course, students should have possessed skills concerning the small sample and large sample tests, testing of hypothesis, estimation theory and analyze and interpret the data vis-à-vis statistical inference in data analysis.*

**UNIT I**

Sampling distribution. Estimate, estimator, estimation. Criteria of good estimator. 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 hypotheses. 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). 15 (7L+2T)

**UNIT II**

Tests for the significance of correlation coefficient. Categorical data: Tests of proportions, tests of association and goodness-of-fit using Chi-square test, Yates' correction. 12 (5L+1T)

**UNIT III**

Sign test for median, Sign test for symmetry, Wilcoxon two-sample test. 10 (4L+1T)

**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. 18 (7L+2T)

**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 Macmillan New York.

**PRACTICAL/LAB WORK**

**25(7L = 14 Class)**

**List of Practicals**

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.

**Generic Elective**

**STAT-GE-5 Introduction to Operations Research**

Marks : 100 [In-sem : 20 (12T+8P) + End Sem. : 80 (Theory : 55 Practical : 25)]

**Credit 6**

**Course Learning Outcome:** *Students completing this course will be able to formulate real-world problems as a linear programming model. It will also develop formulation skills in transportation models and finding solutions and understand the basics in the field of 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. 15 (7L+2T)

**UNIT II**

Optimum solution to a L.P.P: slack and surplus variables, Simplex method, concept of artificial variables Graphically identifying special cases of L.P.P. Concept of duality in L.P.P. 16 (7L+2T)

**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. 12 (5L+1T)

**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 ( $2 \times 2$ ,  $2 \times n$ ,  $2 \times 2$ ) 12 (5L+1T)

**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** **25 (7L = 14 Class)**

**List of Practicals**

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:  $m \times 2 / 2 \times n$  rectangular and Mixed strategy

**Generic Elective**

**STAT-GE-6 Applied Statistics**

Marks : 100 [In-sem : 20 (12T+8P) + End Sem. : 80 (Theory : 55 Practical : 25)]

**Credit 6**

**Course Learning Outcome:** After completing this course, students should have a clear understanding of educational and psychological statistics, index numbers, statistical quality control and demographic methods.

**UNIT I**

**Educational and Psychological Statistics :**

Scaling individual test items in terms of difficulty (scaling); scaling scores on a test - scores and standard scores, normalizing the frequency distribution : the T scale, constructing a T scale, advantages of T scale; the Staning scale, comparison T scores and standard scores, percentile scaling; scaling judgments. Examples. 12 (5L + 1T)

**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. Base shifting, Splicing and deflating of Index numbers. 13 (5L+1T)

**UNIT III**

Statistical Quality Control: Importance of statistical methods in industrial research and practice. 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. 15 (7L+2T)

**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. 15 (7L+2T)

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

**PRACTICAL/LAB WORK**

**25 (7L = 14 Class)**

**List of Practicals**

1. Standardization of Raw scores

2. Comparison of performance of students using Z scores
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



## B. Sc. Honours (Statistics)

### Generic Elective

#### STAT-GE-7 Mathematical Economics

Marks : 100 [In-sem : 20 (12T+8P) + End Sem. : 80 (Theory : 55 Practical : 25)]

#### Credit 6

**Course Learning Outcome:** After completing this course, students should have a clear understanding of time series analysis, demand and supply analysis, the production function, input-output analysis and income distribution.

#### 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. 13 (5L+1T)

#### UNIT II

##### **Demand and Supply Analysis :**

Laws of Demand and Supply of demand, Price elasticity of Demand, Significance of elasticity of Demand, Price elasticity of Supply, Demand and Supply function with constant Price elasticity. Types of Data required for estimating elasticity – Family budget data and Time series data, Engel’s Curve, different forms of Engel Curve and their estimation using least squares methods.

Utility function and its maximization – Simple (Direct) method and the method of Lagrange’s multiplier ; Examples up to two commodities only. 20 (9L + 2T)

#### UNIT III

##### **The production function :**

Meaning and Nature of Production function; the law of variable proportion; Isoquants; marginal technical rates of substitution; producer equilibrium; expansion path; the elasticity of substitution; Euler’s theorem; homogeneous production function; Cobb-Douglas production function and their properties. 12 (5L + 1T)

#### UNIT IV

##### **Input – Output Analysis and Income Distribution :**

Meaning of Input-Output, Assumptions, Leontief’s static Model - the technological coefficient matrix, the viability of the system (the Hawkins –Simon conditions). Solution for two industries (real life examples).

Pareto’s law of Income Distribution – Formulation of the problem; curves of concentration and its derivation – Gini’s coefficient, Line of equal distribution.

10 (5L + 2 T)

#### **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. Chiang Alpha C. (1984) : Fundamental Methods for Mathematical Economics, 3<sup>rd</sup> Edition, McGraw Hill International Editions.

**PRACTICAL/LAB WORK**

**25 (7L = 14 Class)**

**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. Fitting of different forms Engel's function and Estimation of Price / Income elasticity
4. Fitting of Pareto's Income Distribution and Calculation of Gini's Coefficient
5. Fitting of Cobb-Douglas production function
6. Input Output analysis for two industries

**GE Papers in Statistics**

**STAT-GE-8 Research Methodology**

Marks : 100 [In-sem : 20 (12T+8P) + End Sem. : 80 (Theory : 55 Practical : 25)]

**Credit 6**

**Course Learning Outcome:** After completing this course, students should have a clear understanding of various sampling techniques, methods of collecting data, data processing, sampling methods, formats and presentation of reports.

**UNIT I**

Sampling Techniques: sampling, advantage of sampling over census, sampling frame, errors in sampling, non sampling errors, error reduction techniques, sample size determination, probabilistic and non probabilistic sampling. 10 (5L+1T)

**UNIT II**

Data: 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: editing of data, coding of data, classification of data, tables as data presentation devices, graphical presentation of data. 20 (9L+2T)

**UNIT III**

Methods of sampling: simple random sampling stratified random sampling with proportional allocation, other methods of sampling, sampling design, non probability sampling methods, simulation models. 15 (7L+1T)

**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. 10 (5L+1T)

**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**

**25 (7L = 14 Class)**

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 Course**

**STAT-SEC-1 Statistical-Data Analysis Using Software Packages**

Marks: 50 [In-sem 06 (Theory) + 04 (Practical) + End Sem 26 (Theory) + 14 (Practical)]

**Credit 2**

**Course learning outcomes:** *After completing this course, students should have possessed software skills of SPSS and its roles in data handling, computation, analysis and graphical interpretation.*

**UNIT I**

Data loading, plot viz. histograms (equal class intervals and unequal class intervals), box plot, stem-leaf, frequency polygon, pie chart, ogives with graphical summaries of data.

6 (3L)

**UNIT II**

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

6 (3L)

**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.

7 (3L)

**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.

7 (3L)

**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

**PRACTICAL/LAB WORK**

**14 (7L +2T)**

**List of Practical**

1. Coding, editing, Calculation of descriptive statistics
2. Plotting of histograms, box plot, frequency polygon, pie chart, ogives
3. Analysis: t-test for one sample, two sample, F-test, Chi-square test, confidences interval, p-value and interpretation of results.
4. Calculation of correlation and regression
5. Fitting of polynomials and exponential curves
6. Application Problems based on fitting of suitable distribution, Normal probability plot

**Skill Enhancement Course  
STAT-SEC-2 Statistical Data Analysis Using R**

Marks: 50 [In-sem 06 (Theory) + 04 (Practical) + End Sem 26 (Theory) + 14 (Practical)]

**Credit 2**

**Course learning outcomes:** *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'.*

**UNIT I**

Data Loading, bar charts, pie charts, histograms (equal class intervals and unequal class intervals), frequency polygon, ogives, box plot, stem-leaf. 6 (3L)

**UNIT II**

Generate automated reports giving detailed descriptive statistics, lines of regression and correlation. 6 (3L)

**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. 7 (3L)

**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. 7 (3L)

**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

**PRACTICAL/LAB WORK**

**14 (7L +2T)**

**List of Practicals**

1. Assign of data, Import-export data and simple addition, subtraction, multiplication and division sum.
2. Coding, editing, Calculation of descriptive statistics
3. Plotting of histograms, box plot, frequency polygon, pie chart, ogives
4. Analysis: t-test for one sample, two sample, Chi-square test, confidences interval, p-value and interpretation of results.
5. Calculation of correlation and regression
6. Fitting of polynomials and exponential curves
7. Application Problems based on fitting of suitable distribution, Normal probability plot

**Skill Enhancement Course**

**STAT-SEC-3 Statistical Techniques for Research Methods**

Marks: 50 [In-sem 10 + End-sem 40]

**Credit 2**

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

**UNIT I**

Introduction: Meaning, objection and motivation in research, types of research, research approach, significance of research. Research problems: definition, selection and necessity of research problems. 10 (5L)

**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. 10 (5L)

**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. 10 (5L)

**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. 10(5L)

10(5L)

**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.

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