

WEST BENGAL STATE UNIVERSITY

**B.Sc. Statistics (Hons) &  
B.Sc. (General) with  
Statistics**

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Choice Based Credit System Syllabus

(With updated paper codes)

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# 1. Scheme for CBCS Curriculum

## • Scheme for CBCS Curriculum

Semester	Course Name	Course Detail	Credits
<b>I</b>	Ability Enhancement Compulsory Course – I	English communication / Environmental Science	2
	Core course – I <b>STSACOR01T</b>	Descriptive Statistics	4
	Core course – I Practical <b>STSACOR01P</b>	Descriptive Statistics Practical	2
	Core course – II <b>STSACOR02T</b>	Mathematical Analysis and Algebra-I	6
	Generic Elective – 1	TBD	4
	Generic Elective – 1 Practical	TBD	2
<b>II</b>	Ability Enhancement Compulsory Course – II	English communication / Environmental Science	2
	Core course – III <b>STSACOR03T</b>	Probability and Probability Distributions I	4
	Core course – III Practical <b>STSACOR03P</b>	Probability and Probability Distributions I Practical	2
	Core course – IV <b>STSACOR04T</b>	Mathematical Analysis and Algebra-II	6
	Generic Elective – 2	TBD	4
	Generic Elective – 2 Practical	TBD	2
<b>III</b>	Core course – V <b>STSACOR05T</b>	Probability and Probability Distributions II	4
	Core course – V Practical <b>STSACOR05P</b>	Probability and Probability Distributions II Practical	2
	Core course – VI <b>STSACOR06T</b>	Sampling distribution & Statistical Inference I	4
	Core course – VI Practical <b>STSACOR06P</b>	Sampling distribution & Statistical Inference I Practical	2

	Core course – VII <b>STSACOR07T</b>	Survey Sampling	4
	Core course – VII Practical <b>STSACOR07P</b>	Survey Sampling Practical	2
	Skill Enhancement Course – 1	TBD	2
	Generic Elective – 3	TBD	4
	Generic Elective – 3 Practical	TBD	2
<b>IV</b>	Core course – VIII <b>STSACOR08T</b>	Statistical Inference II	4
	Core course – VIII Practical <b>STSACOR08P</b>	Statistical Inference II Practical	2
	Core course – IX <b>STSACOR09T</b>	Linear Models	4
	Core course – IX Practical <b>STSACOR09P</b>	Linear Models Practical	2
	Core course – X <b>STSACOR10T</b>	Statistical Quality Control	4
	Core course – X Practical <b>STSACOR10P</b>	Statistical Quality Control Practical	2
	Skill Enhancement Course-2	TBD	2
	Generic Elective – 4	TBD	4
	Generic Elective – 4 Practical	TBD	2
<b>V</b>	Core course – XI <b>STSACOR11T</b>	Stochastic Process and Time Series	4
	Core course – XI Practical <b>STSACOR11P</b>	Stochastic Process and Time Series Practical	2
	Core course – XII <b>STSACOR12T</b>	Economic Statistics and Official Statistics	4
	Core course – XII Practical <b>STSACOR12P</b>	Economic Statistics and Official Statistics Practical	2
	Discipline Specific Elective – 1	TBD	4

	Discipline Specific Elective – 1 Practical	TBD	2
	Discipline Specific Elective – 2	TBD	4
	Discipline Specific Elective – 2 Practical	TBD	2
<b>VI</b>	Core course – XIII <b>STSACOR13T</b>	Design of Experiments	4
	Core course – XIII Practical <b>STSACOR13P</b>	Design of Experiments Practical	2
	Core course – XIV <b>STSACOR14T</b>	Multivariate Analysis and Non Parametric Methods	4
	Core course – XIV Practical <b>STSACOR14P</b>	Multivariate Analysis and Non Parametric Methods Practical	2
	Discipline Specific Elective – 3	TBD	4
	Discipline Specific Elective – 3 Practical	TBD	2
	Discipline Specific Elective – 4	TBD	4
	Discipline Specific Elective – 4 Practical	TBD	2

\*TBD: To be decided by the student among the available choices mentioned below.

### • Choices for Discipline Specific Electives

Discipline Specific Elective – 1 to 4			
<b>Sem V</b>	<b>STSADSE01T &amp; STSADSE01P</b>  Discrete data analysis (4+2)	<b>STSADSE02T &amp; STSADSE02P</b>  Large Sample Theory (4+2)	<b>STSADSE03T &amp; STSADSE03P</b>  Econometrics (4+2)
<b>Sem VI</b>	<b>STSADSE04T &amp; STSADSE04P</b>  Demography (4+2)	<b>STSADSE05T &amp; STSADSE05P</b>  Numerical Analysis and Monte Carlo Computation (4+2)	<b>STSADSE06P</b>  Project (6)

- **Choices for Skill Enhancement Courses**

Skill Enhancement Course-1 & Skill Enhancement Course-2 to be offered from STATISTICS	
Odd Semester	<b>STSSSEC01M</b> : Statistical Data Analysis Using C-programming and Software Packages
Even Semester	<b>STSSSEC02M</b> : Computation using R

- **Choices of Generic Electives (for Honours students of other disciplines)**

<b>Sem I</b>	<b>STSHGEC01T &amp; STSHGEC01P</b>  Statistical Methods (4+2)	<b>Sem II</b>	<b>STSHGEC03T &amp; STSHGEC03P</b>  Basics of Statistical Inference (4+2)
<b>Sem III</b>	<b>STSHGEC02T &amp; STSHGEC02P</b>  Introductory Probability (4+2)	<b>Sem IV</b>	<b>STSHGEC04T &amp; STSHGEC04P</b>  Applied Statistics (4+2)

## 2. Core Subjects Syllabus

- **STSA COR01T – Descriptive Statistics**

• Descriptive Statistics	
<b>60 class hours</b>	<b>4 Credits</b>
<b><i>Statistical Methods</i></b>	<b>14 Lectures</b>
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, column diagram and step diagrams. Stem and Leaf display.	



<b><i>Univariate data</i></b>	<b>12 Lectures</b>
Measures of Central Tendency: mathematical and positional. Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation.	
<b><i>Moments</i></b>	<b>14 Lectures</b>
Moments, absolute moments, factorial moments, Measures of skewness and kurtosis. Box Plot. Sheppard's corrections (without proof).	
<b><i>Bivariate data</i></b>	<b>20 Lectures</b>
Definition, scatter diagram, simple correlation, linear regression and principle of least squares, Fitting of polynomials and exponential curves, Spearman rank correlation, correlation ratio, intra-class correlation.	

## • **STSACOR01P – Descriptive Statistics Practical**

Descriptive Statistics Practical	
<b>60 class hours</b>	<b>2 credits</b>
<p><b><i>List of Practical</i></b></p> <ol style="list-style-type: none"> <li>1. Graphical representation of data.</li> <li>2. Problems based on measures of central tendency.</li> <li>3. Problems based on measures of dispersion.</li> <li>4. Problems based on combined mean and variance and coefficient of variation.</li> <li>5. Problems based on moments, skewness and kurtosis.</li> <li>6. Fitting of polynomials, exponential curves.</li> <li>7. Karl Pearson correlation coefficient.</li> <li>8. Correlation coefficient for a bivariate frequency distribution.</li> <li>9. Lines of regression, angle between lines and estimated values of variables.</li> <li>10. Spearman rank correlation with and without ties.</li> <li>11. Computation of correlation ratio.</li> <li>12. Computation of intra class correlation coefficient.</li> </ol>	
<b>Reference Books</b>	
<ul style="list-style-type: none"> <li>▶ Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I, &amp; II, 8th Edition. The World Press, Kolkata.</li> <li>▶ Yule G.U. and Kendall M.G.: An Introduction to the theory of Statistics.</li> <li>▶ Hogg and Tanis. : Probability and Statistical Inference.</li> </ul>	

• **STSACOR02T – Mathematical Analysis and Algebra-I**

Mathematical Analysis and Algebra-I	
<b>90 Class hours</b>	<b>6 Credits</b>
<b><i>Sequence and Series of real numbers</i></b>	
<b>20 Lectures</b>	
<p>Sequence of real numbers and their convergence, limits of sequences, Cauchy's general principle of convergence, Cauchy's first theorem on limits, monotonic sequences, limit superior and limit inferior of a bounded sequence.</p> <p>Infinite series, positive-termed series and their convergence. Comparison tests, D'Alembert's ratio test and Cauchy's <math>n^{\text{th}}</math> root test, (Statements and examples only). Absolute convergence of series, Leibnitz's test for the convergence of alternating series, Conditional convergence.</p>	
<b>Vector spaces</b>	
<b>20 Lectures</b>	
<p>Vector spaces, subspaces, sum of subspaces, Span. Linear dependence and independence, basis and dimension, dimension theorem. Orthogonal vectors, Gram-Schmidt orthogonalization, ortho-complement space. Null space and nullity.</p>	
<b><i>Algebra of Matrices and Determinants of Matrices</i></b>	
<b>30 Lectures</b>	
<p>A review, theorems related to triangular, symmetric and skew symmetric matrices, idempotent matrices, orthogonal matrices, singular and non-singular matrices and their properties. Trace of a matrix. Row space and column space of a matrix.</p> <p>Definition, properties and applications of determinants for 3<sup>rd</sup> and higher orders, evaluation of determinants of order 3 and more using transformations. Symmetric and Skew symmetric determinants, Circulant determinants and Vandermonde determinants for <math>n^{\text{th}}</math> order, Jacobi's Theorem. Product of determinants. Adjoint and inverse of a matrix and related properties. Use of determinants in solution to the system of linear equations.</p>	
<b>Theory of Equations</b>	
<b>20 Lectures</b>	
<p>Statement of the fundamental theorem of algebra and its consequences. Relation between roots and coefficients of any polynomial equations. Solutions of cubic and biquadratic equations when some conditions on roots of equations are given.</p>	

**Reference Books**

- ▶ Hadley G. (2002): Linear Algebra. Narosa Publishing House (Reprint).
- ▶ Searle S.R. (1982): Matrix Algebra Useful for Statistics. John Wiley & Sons.
- ▶ Narayan Shanti (2004): A Textbook of Matrices, S Chand & Co Ltd.
- ▶ Apostol T.M.: Mathematical Analysis
- ▶ Mapa S.K.: Real Analysis

- **STSACOR03T - Probability and Probability Distributions I**

Probability and Probability Distributions I	
60 class hours	4 Credits
<b>Probability</b>	<b>10 Lectures</b>
Introduction, random experiments, sample space, events and algebra of events. Sigma algebra of events. Definitions of Probability – classical, statistical and axiomatic.	
<b>Conditional Probability</b>	<b>10 Lectures</b>
Theorem of compound probability, theorem of total probability, Conditional probability and independence of event. Bayes theorem and its applications.	
<b>Random variables</b>	<b>20 Lectures</b>
Discrete random variables, p.m.f. and c.d.f., statement of properties of c.d.f, illustrations. Derivation of moments (discrete situation). Standard discrete probability distributions: binomial, Poisson, geometric, negative binomial, hypergeometric, uniform.	
<b>Continuous random variables</b>	<b>20 Lectures</b>
p.d.f. and c.d.f., illustrations and properties, univariate transformations with illustrations. Derivation of moments. Probability Inequalities: Markov and Chebyshev.	
Reference Books	
▶ Hogg, R.V., Tanis, E.A. and Rao J.M. (2009): Probability and Statistical Inference, Seventh Ed, Pearson Education, New Delhi.	
▶ Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.	

- ▶ Myer, P.L. (1970): Introductory Probability and Statistical Applications, Oxford & IBH Publishing, New Delhi .
- ▶ S.M. Ross : A First Course in Probability.
- ▶ K.L. Chung : Elementary Probability Theory with Stochastic Process.

### • STSACOR03P – Probability and Probability Distributions I Practical

#### Probability and Probability Distributions I Practical

**60 class hours**

**2 credits**

##### *List of Practical*

1. Numerical sums using classical definition of Probability.
2. Numerical sums on conditional probability.
3. Fitting of binomial distribution for given n and p.
4. Fitting of binomial distribution after computing mean and variance.
5. Fitting of Poisson distribution for given value of lambda.
6. Fitting of Poisson distribution after computing mean.
7. Fitting of negative binomial.
8. Fitting of suitable distribution.
9. Application problem based on binomial distribution
10. Application problem based on Poisson distribution.
11. Application problem based on negative binomial distribution.

### • STSACOR04T – Mathematical Analysis and Algebra-II

#### Mathematical Analysis and Algebra-II

**90 class hours**

**6 Credits**

##### *Properties of real valued functions*

**25 Lectures**

Limit, Continuity, Differentiability, Uniform Continuity and Boundedness of functions, Indeterminate forms, L'Hospital's rule. Rolle's and Lagrange's mean value theorems. Taylor's theorem and Lagrange's and Cauchy's form of remainder (without proof). Taylor's and Maclaurin's series expansion.

<b><i>Reimann Integration</i></b>	<b>15 Lectures</b>
Reimann Integration of Real valued Functions. Convergence of Integrals, Simple tests. Multiple Integration.	
<b><i>Sequence and series of functions</i></b>	<b>15 Lectures</b>
Pointwise & Uniform convergence. Simple tests, Properties of Uniformly convergent functions. Power series.	
<b>Continuous random variables</b>	<b>35 Lectures</b>
Row reduction and echelon forms. Partitioning of matrices and simple properties. Rank of a matrix, row-rank, column-rank, standard theorems on ranks, rank of the sum and the product of two matrices. Matrix equations $Ax=b$ , solution sets of linear equations. Applications of linear equations, inverse of a matrix.	
Characteristic roots and Characteristic vector, Properties of characteristic roots, Cayley Hamilton theorem, Quadratic forms: Classification and canonical reduction. Linear transformations. Applications of Linear Algebra in Statistics.	
<b>Reference Books</b>	
<ul style="list-style-type: none"> <li>▶ Hadley G.( 2002): Linear Algebra. Narosa Publishing House (Reprint).</li> <li>▶ Searle S.R.(1982): Matrix Algebra Useful for Statistics. John Wiley &amp; Sons.</li> <li>▶ Narayan Shanti (2004): A Textbook of Matrices, S Chand &amp; Co Ltd.</li> <li>▶ Apostol T.M.: Mathematical Analysis</li> <li>▶ Mapa S.K.: Real Analysis</li> </ul>	

• **STSACOR05T - Probability and Probability Distributions II**

<b>Probability and Probability Distributions II</b>	
<b>60 Lectures</b>	<b>4 Credits</b>
<b><i>Two dimensional random variables: Discrete</i></b>	<b>16 Lectures</b>
Discrete two dimensional random variable, joint, marginal and conditional, p.m.f. and c.d.f., statement of properties of c.d.f, independence of variables, trinomial distribution.	

<b>Two dimensional random variables: Continuous</b>	<b>14 Lectures</b>
<p>Continuous two dimensional random variable,, joint, marginal and conditional, p.d.f., and c.d.f.  Independence of two random variables, bivariate transformations with illustrations. Moments.  Conditional expectation and Conditional variance. Correlation coefficient.</p>	
<b>Generating Functions</b>	<b>14 Lectures</b>
<p>Moment generating function, cumulant generating function and characteristic function. Uniqueness and inversion theorems (without proof) along with applications.</p>	
<b>Standard continuous probability distributions</b>	<b>16 Lectures</b>
<p>Uniform, normal, exponential, Cauchy, beta, gamma, lognormal, logistic, double exponential and Pareto along with their properties and limiting/approximation cases. Bivariate Normal Distribution and its properties (Statement only).</p>	
<b>Reference Books</b>	
<ul style="list-style-type: none"> <li>▶ Hogg, R.V., Tanis, E.A. and Rao J.M. (2009): Probability and Statistical Inference, Seventh Ed, Pearson Education, New Delhi.</li> <li>▶ Miller, Irwin and Miller, Marylees (2006): John E. Freund’s Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.</li> <li>▶ Myer, P.L. (1970): Introductory Probability and Statistical Applications, Oxford &amp; IBH Publishing, New Delhi.</li> <li>▶ S.M. Ross: A First Course in Probability.</li> <li>▶ K.L. Chung: Elementary Probability Theory with Stochastic Process.</li> </ul>	

● **STSACOR05P – Probability and Probability Distributions II Practical**

<b>Probability and Probability Distributions II Practical</b>	
<b>60 class hours</b>	<b>2 Credits</b>
<p><b><i>List of Practical</i></b></p> <ol style="list-style-type: none"> <li>1. Problems based on the property of normal distribution.</li> <li>2. To find the ordinate for a given area for normal distribution.</li> <li>3. Application-based problems using normal distribution.</li> <li>4. Fitting of normal distribution when parameters are given.</li> <li>5. Fitting of normal distribution when parameters are not given.</li> <li>6. Fitting of some other continuous distributions.</li> </ol>	

• **STSACOR06T - Sampling distribution & Statistical Inference I**

Sampling distribution & Statistical Inference I	
60 Lectures	4 Credits
<b><i>Introduction</i></b>	<b>10 Lectures</b>
Definitions of random sample, parameter and statistic, sampling distribution of a statistic. Distributions of functions of random variables. Illustration through simple transformation and generating function technique.	
<b><i>Exact sampling distribution</i></b>	<b>26 Lectures</b>
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., mode, additive property and limiting form of $\chi^2$ distribution. 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. Sampling distributions of sample mean and sample variance when parent population is normal. Null distribution of sample correlation coefficient (statement only).	
Exact tests relating to Binomial proportion (s) and Poisson mean (s).	
<b><i>Testing and Confidence Intervals</i></b>	<b>16 Lectures</b>
Null and alternative hypotheses, level of significance, Type I and Type II errors, their probabilities and critical region- Tests of significance and confidence intervals based on $\chi^2$ , t and F distribution when samples are generated from Univariate and Bivariate normal population (s).	
<b><i>Order Statistics</i></b>	<b>8 Lectures</b>
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.	
<b>Reference Books</b>	
▶ Goon, A.M. Gupta, M.K. and Dasgupta, B. (2003): An outline of Statistical Theory, Vol. 1, 4 <sup>th</sup> Edn. World Press, Kolkata.	

- ▶ Rohatgi V.K. and Saleh, A. K. Md , E. (2009): An Introduction to Probability and Statistics, 2<sup>nd</sup> edition (Reprint), John Wiley and Sons.
- ▶ Hogg, R.V. and Tanis, E.A. (2009): A Brief Course in Mathematical Statistics. Pearson Education.
- ▶ Johnson, R.A. and Bhattacharya, G.K. (2001): Introduction to the theory of Statistics, 3<sup>rd</sup> edition (Reprint). Tata McGraw-Hill Pub. Co. Ltd.

### • STSACOR06P –Sampling distribution & Statistical Inference I Practical

Sampling distribution & Statistical Inference I Practical	
60 class hours	2 Credits
List of Practical	
<ol style="list-style-type: none"> <li>1. Testing of significance for single proportion and difference of two proportions.</li> <li>2. Testing of significance for single Poisson mean and difference of means of two independent Poisson distributions.</li> <li>3. Testing of significance and confidence intervals for single mean and difference of two means and paired tests.</li> <li>4. Testing if the population variance has a specific value and its confidence intervals</li> <li>5. Testing of significance and confidence intervals of correlation coefficient.</li> <li>6. Testing of equality of population variances for two independent normal populations and related confidence intervals.</li> <li>7. Testing of ratio of variances for bivariate normal population and related confidence interval.</li> </ol>	

### • STSACOR07T - Survey Sampling

Survey Sampling	
60 Lectures	4 Credits
Simple Random Sample	18 Lectures
<p>Concept of population and sample, complete enumeration versus sampling, sampling and non-sampling errors. Types of sampling: non-probability and probability sampling, basic principles of sample survey, simple random sampling with and without replacement, definition and procedure of</p>	



selecting a sample, estimates of population mean, total and proportion, variances of these estimates, estimates of their variances and sample size determination.

### **Stratified random sampling**

**12 Lectures**

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**

**12 Lectures**

Systematic Sampling, Technique, estimates of population mean and total, variances of these estimates ( $N=n \times k$  case). Comparison of systematic sampling with SRS and stratified sampling in the presence of linear trend and corrections.

### **Various Sampling Methods**

**18 Lectures**

Ratio and Regression methods of estimation in simple random sampling. Hartley-Ross estimator. Cluster sampling (equal-size clusters only) estimation of population mean and its variance, Concept of sub sampling. Two-stage sampling, Estimation of Population mean and variance of the estimate, comparison between two-stage, cluster and uni-stage sampling.

## • **STSACOR07P – Survey Sampling Practical**

### **Survey Sampling Practical**

**60 class hours**

**2 Credits**

#### **List of Practical**

1. To select a SRS with and without replacement.
2. For a population of size 5, estimate population mean, population mean square and population variance. Enumerate all possible samples of size 2 by WR and WOR and establish all properties relative to SRS.
3. For SRSWOR, estimate mean, standard error, the sample size
4. Stratified Sampling: allocation of sample to strata by proportional and Neyman's methods. Compare the efficiencies of above two methods relative to SRS.
5. Estimation of gain in precision in stratified sampling.
6. Comparison of systematic with stratified sampling and SRS in the presence of a linear trend.

7. Ratio and Regression estimation: Calculate the population mean or total of the population. Calculate mean squares. Compare the efficiencies of ratio and regression estimators relative to SRS.
8. Cluster sampling: estimation of mean or total, variance of the estimate, estimate of intra-class correlation coefficient, efficiency as compared to SRS.
9. Two stage sampling.

#### Reference Books

- ▶ Cochran, W.G. (1984): Sampling Techniques (3rd Ed.), Wiley Eastern.
- ▶ Sukhatme, P.V., Sukhatme, B.V. Sukhatme, S. (1984). Sampling Theories of Survey with Application, IOWA State University Press and Indian Society of Agricultural Statistics.
- ▶ Murthy, M.N. (1977): Sampling Theory & Statistical Methods, Statistical Pub. Society, Calcutta.
- ▶ Des Raj and Chandhok P. (1998): Sample Survey Theory, Narosa Publishing House.
- ▶ Goon A.M., Gupta M.K. and Dasgupta B. (2008): Fundamentals of Statistics, World Press.

### • STSACOR08T - Statistical Inference II

Statistical Inference II	
60 Lectures	4 Credits
<i>Estimation</i>	20 Lectures
Concepts of estimation, unbiasedness, mean square error, sufficiency, completeness and exponential family of distributions. Factorization theorem. Minimum variance unbiased estimator (MVUE), Rao-Blackwell and Lehmann-Scheffe theorems and their applications. Cramer-Rao inequality (statement and applications) and MVB estimators.	
<i>Methods of Estimation</i>	8 Lectures
Method of moments, method of maximum likelihood estimation, method of minimum Chi-square, basic idea of Bayes estimators.	
<i>Principles of test of significance</i>	14 Lectures
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).	

<i>Sequential Analysis</i>	<b>18 Lectures</b>
<p>Sequential probability ratio test (SPRT) for simple vs simple hypotheses. Fundamental relations among <math>\alpha</math>, <math>\beta</math>, A and B, determination of A and B in practice. Wald's fundamental identity and the derivation of operating characteristics (OC) and average sample number (ASN) functions. Examples based on Normal, Poisson, Binomial and Exponential distributions.</p>	
<b>Reference Books</b>	
<ul style="list-style-type: none"> <li>▶ Goon A.M., Gupta M.K.: Das Gupta.B. (2005), Fundamentals of Statistics, Vol. I, World Press, Calcutta.</li> <li>▶ Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2<sup>nd</sup>Edn. (Reprint) John Wiley and Sons.</li> <li>▶ Miller, I. and Miller, M. (2002) : John E. Freund's Mathematical Statistics (6th addition, low price edition), Prentice Hall of India.</li> <li>▶ Dudewicz, E. J., and Mishra, S. N. (1988): Modern Mathematical Statistics. John Wiley &amp; Sons.</li> <li>▶ Mood A.M, Graybill F.A., Boes D.C.:Introduction to the Theory of Statistics, McGraw Hill.</li> <li>▶ Bhat B.R, Srivenkatramana T and Rao Madhava K.S. (1997) Statistics: A Beginner's Text, Vol. I, New Age International (P) Ltd.</li> <li>▶ Snedecor G.W and Cochran W.G. (1967) Statistical Methods. Iowa State University Press.</li> </ul>	

### ● STSACOR08P – Statistical Inference II Practical

Statistical Inference II Practical	
<b>60 class hours</b>	<b>2 Credits</b>
<b>List of Practical</b>	
<ol style="list-style-type: none"> <li>1. Unbiased estimators (including unbiased but absurd estimators)</li> <li>2. Cramer-Rao inequality and MVB estimators</li> <li>3. Sufficient Estimators – Factorization Theorem, Rao-Blackwell theorem, Complete Sufficient estimators</li> <li>4. Lehman-Scheffe theorem and UMVUE</li> <li>5. Maximum Likelihood Estimation</li> <li>6. Estimation by the method of moments, minimum Chi-square</li> <li>7. Most powerful critical region (NP Lemma)</li> <li>8. Uniformly most powerful critical region</li> </ol>	

9. Unbiased critical region.
10. Power curves.
11. Likelihood ratio tests for simple null hypothesis against simple alternative hypothesis.
12. Likelihood ratio tests for simple null hypothesis against composite alternative hypothesis
13. Asymptotic properties of LR tests
14. SPRT procedure
15. OC function and OC curve
16. ASN function and ASN curve

### • STSACOR09T - Linear Models

Linear Models	
60 Lectures	4 Credits
<i>Multivariate Data</i>	12 Lectures
Multiple linear regression, multiple and partial correlations.	
<i>Gauss-Markov set-up</i>	14 Lectures
Theory of linear estimation, Estimability of linear parametric functions, Method of least squares, Gauss-Markov theorem, Estimation space and Error Space, Estimation of error variance. Tests of General Linear Hypotheses (statements only). Classification of Linear Models.	
<i>Regression analysis</i>	10 Lectures
Hypothesis testing in case of simple and multiple regression models.	
<i>Analysis of variance and covariance</i>	24 Lectures
Analysis of Variance in one-way and two-way classified data (with equal number of observations per cell) for fixed effect models. Analysis of covariance for one-way and two-way classified data with one concomitant variable.	
Reference Books	
▶ Goon, A.M., Gupta, M.K., and Dasgupta, B. (2002), Fundamental of Statistics, Volume 1, 8th Edn. The World Press, Kolkata.	
▶ Goon, A.M., Gupta, M.K., and Dasgupta, B. (2002), Fundamental of Statistics, Volume 2, 8th Edn. The World Press, Kolkata.	

- ▶ Scheffe, H, Linear Models
- ▶ Rao, C.R., Linear Statistical Inference.
- ▶ Mukhopadhyay, P. (2011): Applied Statistics, 2<sup>nd</sup> edition revised reprint, Books and Allied(P) Ltd.
- ▶ Weisburg, S (2005) Applied Linear Regression (Third edition), Wiley.
- ▶ Wu, C. F. J. and Hamada, M. (2009). Experiments, Analysis and Parameter Design Optimization (Second edition), John Wiley.
- ▶ Renchner, A.C. and Schaalje, G.B. (2008). Linear Models in Statistics (Second edition), John Wiley and Sons.

### • STSACOR09P – Linear Models Practical

Linear Models Practical	
60 class hours	2 Credits
<b>List of Practical</b>	
<ol style="list-style-type: none"> <li>1. Estimability in Gauss Markov Model.</li> <li>2. Simple linear regression.</li> <li>3. Multiple regression.</li> <li>4. Tests for linear hypothesis.</li> <li>5. Analysis of variance of one way classified data.</li> <li>6. Analysis of variance of a two way classified data with one observation per cell.</li> <li>7. Analysis of variance of two way classified data with equal number of observations per cell.</li> <li>8. Analysis of covariance of a one way classified data with one concomitant variable.</li> <li>9. Analysis of covariance of a two way classified data with one concomitant variable.</li> </ol>	

### • STSACOR10T - Statistical Quality Control

Statistical Quality Control	
60 Lectures	4 Credits
<b>Quality</b>	<b>14 Lectures</b>
<p>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</p>	

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.

### ***Control charts***

**18 Lectures**

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.

### ***Acceptance sampling plan for attributes***

**14 Lectures**

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.

### **Introduction to Six-Sigma**

**14 Lectures**

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

### **Reference Books**

- ▶ Montgomery, D.C. (2009): Introduction to Statistical Quality control, 6<sup>th</sup> edition, Wiley India, Pvt Ltd
- ▶ Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol 2, 8<sup>th</sup> edition, The world Press, Kolkata
- ▶ Mukhopadhyay, P. (2011): Applied Statistics, 2<sup>nd</sup> edition revised reprint, Books and Allied(P) Ltd.
- ▶ Montgomery, D.C. and Runger, G.C. (2008): Applied Statistics and Probability for Engineers, 3<sup>rd</sup> edition reprint, Wiley India Pvt Ltd.
- ▶ Ehrlich, B. Harris (2002): Transactional Six sigma and Lean Servicing, 2<sup>nd</sup> edition, St Lucie Press
- ▶ Hoyle, David (1995): ISO Quality systems Handbook, 2<sup>nd</sup> edition, Butterworth Heinemann Publication.

- **STSACOR10P – Statistical Quality Control Practical**

Statistical Quality Control Practical	
<b>60 class hours</b>	<b>2 Credits</b>
<b>List of Practical</b>	
<ol style="list-style-type: none"> <li>1. Construction and Interpretation of statistical control charts  X-bar &amp; R chart  X-bar &amp; s-chart  np- chart  p-chart  c-chart  u- chart</li> <li>2. Single sample inspection plan: Construction and interpretation of OC, AQL, LTPD, ASN, ATI, AOQ, AOQL curves.</li> <li>3. Calculation of process capability and comparison of 3-sigma control limits with specification limits.</li> <li>4. Use a case study to apply the concept of six sigma application in DMAIC: practical application.</li> </ol>	

- **STSACOR11T - Stochastic Process and Time Series**

Stochastic Process and Time Series	
<b>60 Lectures</b>	<b>4 Credits</b>
<b><i>Markov Chain</i></b>	<b>10 Lectures</b>
Stochastic Process: Introduction and Stationary Process. Markov Chains: Definition of Markov Chain, transition probability matrix, order of markov chain, Markov chain as graphs, higher transition probabilities.	
<b><i>Time Series</i></b>	<b>18 Lectures</b>
Time Series as a Stochastic Process. Time Series data. Application of time series from various fields, Components of a times series, Decomposition of time series. Estimation of trend by free hand curve method, method of semi averages, fitting mathematical curves, and growth curves. Method of moving averages.	

<b><i>Estimation</i></b>	<b>14 Lectures</b>
Estimation of seasonal component by Method of simple averages, Ratio to Trend, Ratio to Moving Averages and Link Relative method. Harmonic Analysis. Variate component method.	
<b><i>Stationary Time series</i></b>	<b>18 Lectures</b>
Stationary Time series Weak stationarity, autocorrelation function and correlogram. Some Special Processes: Moving-average (MA) process and Autoregressive (AR) process of orders one and two, Estimation of the parameters of AR (1) and AR (2) – Yule-Walker equations. Simple Exponential smoothing.	
<b>Reference Books</b>	
<ol style="list-style-type: none"> <li>1. Gun Gupta and Dasgupta (2002) Fundamentals of Statistics Vol II, World Press</li> <li>2. Cooray TMJA(2008) Applied Time Series, Analysis and forecasting, Narosa Publishing house</li> <li>3. Chatfield C (2004) Analysis of Time Series, Chapman &amp; Hall</li> </ol>	

• **STSACOR11P – Stochastic Process and Time Series Practical**

<b>Stochastic Process and Time Series Practical</b>	
<b>60 class hours</b>	<b>2 Credits</b>
<b>List of Practical</b>	
<ol style="list-style-type: none"> <li>1. Determination of trend by curve fitting</li> <li>2. Determination of trend by moving averages</li> <li>3. Determination of seasonal indices by method of averages</li> <li>4. Harmonic Analysis</li> <li>5. Correlogram Analysis</li> <li>6. Fitting of AR 1 and AR 2 models</li> <li>7. Simple Exponential Smoothing</li> </ol>	



● **STSACOR12T - Economic Statistics and Official Statistics**

Economic Statistics and Official Statistics	
<b>60 Lectures</b>	<b>4 Credits</b>
<b><i>Index Numbers and National accounts</i></b>	<b>22 Lectures</b>
<p>Index Numbers, price, quantity and value indices, choice of weights, Various formulae and their comparisons. Tests of index numbers. Fisher's ideal index number. Chain Index Number. Consumer Price Index, Wholesale Price index &amp; Index of industrial Production- methods of construction and uses. Definition of national income. A brief account of product, expenditure and income approaches for estimation of National Income.</p>	
<b><i>Measurement of poverty and inequality and Social Statistics</i></b>	<b>16 Lectures</b>
<p>Measurement of poverty and inequality, Desirable properties and different descriptive measures including Gini's coefficient, Lorenz curve. Use of Pareto and Log Normal distributions. Measures of unemployment. Comparative Social Statistics, Indices related to human development and gender disparity.</p>	
<b><i>Official statistical</i></b>	<b>12 Lectures</b>
<p>Present official statistical system in India, Methods of collection of official statistics, their reliability and limitations. Role of Ministry of Statistics and Program Implementation (MoSPI).</p>	
<b><i>Different Government organizations</i></b>	<b>10 Lectures</b>
<p>Central Statistical Office (CSO), National Sample Survey Office (NSSO), and National Statistical Commission. Government of India's Principal publications containing data on the topics such as population, industry and finance.</p>	
<b>Reference Books</b>	
<ul style="list-style-type: none"> <li>▶ Mudgett Bruce D (1951): Index Numbers, N.Y : Wiley.</li> <li>▶ Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. II, 8th Edn. The World Press, Kolkata.</li> <li>▶ Nagar A.L, Das R.K (1997): Basic statistics, Oxford University Press.</li> <li>▶ Ramakumar R (2002) Technical Demography, New Age.</li> <li>▶ Guide to current Indian Official Statistics, Central Statistical Office, GOI, and New Delhi. <a href="http://mospi.nic.in/">http://mospi.nic.in/</a></li> </ul>	

- **STSACOR12P – Economic Statistics and Official Statistics Practical**

Economic Statistics and Official Statistics Practical	
60 class hours	2 Credits
<b>List of Practical</b>	
<ol style="list-style-type: none"> <li>1. Price and quantity index numbers using simple and weighted average of price relatives.</li> <li>2. To calculate the Chain Base index numbers.</li> <li>3. Problems on cost of living index numbers.</li> <li>4. Lorenz curve.</li> <li>5. Pareto and lognormal fitting.</li> <li>6. Measures of mortality.</li> <li>7. Life Tables.</li> <li>8. Measures of fertility and population growth.</li> <li>9. Population Estimation and Projection.</li> <li>10. Fitting of logistic equation by Rhode`s method.</li> </ol>	

- **STSACOR13T - Design of Experiments**

Design of Experiments	
60 Lectures	4 Credits
<b><i>Experimental designs</i></b>	<b>10 Lectures</b>
Experimental designs, Role, historical perspective. Terminologies: Experimental error, Basic principles, Uniformity trials, Fertility contour maps, Choice of size and shape of plots and blocks.	
<b><i>Basic designs</i></b>	<b>14 Lectures</b>
Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD) – Layout, Model and Analysis, Relative Efficiencies, Analysis with one missing observation.	
<b><i>Incomplete Block Designs</i></b>	<b>14 Lectures</b>
Balanced Incomplete Block Design (BIBD) – parameters, relationships among its parameters, incidence matrix and its properties.	

<b><i>Factorial experiments</i></b>	<b>22 Lectures</b>
Advantages, Notations and Concepts of $2^n$ factorial experiments- their design and analysis. Total and Partial confounding for $2^n$ ( $n \leq 5$ ), factorial experiments.	
<b>Reference Books</b>	
<ul style="list-style-type: none"> <li>▶ Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005): Fundamentals of Statistics. Vol. II, 8thEdn. World Press, Kolkata.</li> <li>▶ Mukhopadhyay, P. : Applied Statistics.</li> <li>▶ Cochran, W.G. and Cox, G.M. (1959): Experimental Design. Asia Publishing House.</li> <li>▶ Dey, A. (1986) : Theory of Block Designs, Wiley Eastern Limited.</li> <li>▶ Montgomery, D. C. (2008): Design and Analysis of Experiments, John Wiley.</li> <li>▶ Das, M.N. and Giri, N.C. (1986): Design and Analysis of Experiments. Wiley Eastern Ltd.</li> <li>▶ Kempthorne, O. (1965): The Design and Analysis of Experiments. John Wiley.</li> </ul>	

• **STSACOR13P – Design of Experiments Practical**

<b>Design of Experiments Practical</b>	
<b>60 class hours</b>	<b>2 Credits</b>
<b>List of Practical</b>	
<ol style="list-style-type: none"> <li>1. Analysis of CRD</li> <li>2. Analysis of an RBD</li> <li>3. Analysis of an LSD</li> <li>4. Analysis of an RBD with one missing observation</li> <li>5. Analysis of an LSD with one missing observation</li> <li>6. Intra Block analysis of a BIBD</li> <li>7. Analysis of <math>2^2</math> and <math>2^3</math> factorial in CRD and RBD</li> <li>8. Analysis of <math>2^2</math> and <math>2^3</math> factorial in LSD</li> <li>9. Analysis of a completely confounded two level factorial design in 2 blocks</li> <li>10. Analysis of a completely confounded two level factorial design in 4 blocks</li> <li>11. Analysis of a partially confounded two level factorial design</li> <li>12. Analysis of a single replicate of a <math>2^n</math> design</li> <li>13. Analysis of a fraction of <math>2^n</math> factorial design</li> </ol>	

• **STSACOR14T – Multivariate Analysis and Non Parametric Methods**

<b>Multivariate Analysis and Non Parametric Methods</b>	
<b>60 Lectures</b>	<b>4 Credits</b>
<b>Bivariate Normal Distribution (BVN)</b>	<b>12 Lectures</b>
<p>P.d.f. of BVN, properties of BVN, marginal and conditional p.d.f. of BVN.</p> <p>Random Vector: Probability mass/density functions, Distribution function, Mean vector &amp; Dispersion matrix, Marginal and Conditional distributions.</p>	
<b>Chemical Equilibrium</b>	<b>22 Lectures</b>
<p>Multinomial Distribution, Multivariate Normal distribution and its properties. Sampling distribution for mean vector and variance- covariance matrix (Statement only). Multiple and partial correlation coefficient and their properties.</p>	
<b>Applications of Multivariate Analysis</b>	<b>12 Lectures</b>
<p>Applications of Multivariate Analysis, Discriminant Analysis, Principal Components Analysis.</p>	
<b>Nonparametric Tests</b>	<b>14 Lectures</b>
<p>Nonparametric Tests, Introduction and Concept, Test for randomness based on total number of runs, Empirical distribution function, Kolmogorov Smirnov test for one sample, Sign tests- one sample and two samples, Wilcoxon-Mann-Whitney test, Kruskal-Wallis test.</p>	
<b>Reference Books</b>	
<ul style="list-style-type: none"> <li>▶ Anderson, T.W. (2003): An Introduction to Multivariate Statistical Analysis, 3<sup>rd</sup>Edn., John Wiley.</li> <li>▶ Muirhead, R.J. (1982): Aspects of Multivariate Statistical Theory, John Wiley.</li> <li>▶ Kshirsagar, A.M. (1972) :Multivariate Analysis, 1<sup>st</sup>Edn. Marcel Dekker.</li> <li>▶ Johnson, R.A. and Wichern, D.W. (2007): Applied Multivariate Analysis, 6<sup>th</sup>Edn., Pearson &amp; Prentice Hall</li> <li>▶ Mukhopadhyay, P. :Mathematical Statistics.</li> <li>▶ Gibbons, J. D. and Chakraborty, S (2003): Nonparametric Statistical Inference. 4<sup>th</sup> Edition. Marcel Dekker, CRC.</li> </ul>	

- **STSACOR14P – Multivariate Analysis & Non Parametric Methods Practical**

<b>Multivariate Analysis &amp; Non Parametric Methods Practical</b>	
<b>60 Class Hours</b>	<b>2 Credits</b>
<b>List of Practical</b>	
<ol style="list-style-type: none"> <li>1. Multiple Correlation</li> <li>2. Partial Correlation</li> <li>3. Bivariate Normal Distribution,</li> <li>4. Multivariate Normal Distribution</li> <li>5. Discriminant Analysis</li> <li>6. Principal Components Analysis</li> <li>7. Test for randomness based on total number of runs,</li> <li>8. Kolmogrov Smirnov test for one sample.</li> <li>9. Sign test: one sample, two samples, large samples.</li> <li>10. Wilcoxon-Mann-Whitney U-test</li> <li>11. Kruskal-Wallis test</li> </ol>	

### 3. Department Specific Electives Subjects Syllabus

- **STSADSE01T - Discrete data analysis**

<b>Discrete data analysis</b>	
<b>60 Lectures</b>	<b>4 Credits</b>
<b>Measures of association</b>	<b>18 Lectures</b>
<p>Introduction to Categorical Data, 2 X 2 contingency table, notion of independence &amp; association, ideas of complete and absolute association. Yules measures of association and colligation, Cramer's measure of association, Extension to kx1 contingency table: Pearson's chi-square, Kendall's <math>\tau</math> and <math>\tau_b</math>, Goodman-Kruskal's <math>\gamma</math>.</p>	
<b>Comparing proportions in 2x2 tables</b>	<b>12 Lectures</b>

Difference of proportions, relative risk, odds ratio, log odds ratio; types of observational studies.

### Generalized linear Model

20 Lectures

Generalized linear Model, Components of a generalized linear model, Random component, systematic component, Link function.

Generalized linear model for binary data, Logistic and probit regression model, Multiple logistic regression. Model fitting by using score function.

### Model for contingency table

10 Lectures

Log linear model of independence for two way table, Interpretation of the parameters in independence model, saturated model for two way table. The log-linear-logistic connection.

### Reference Books

- ▶ Goon A.M., Gupta M.K., Dasgupta, B. (2005), Fundamentals of Statistics, Vol II, World Press, Calcutta.
- ▶ P. McCullagh & J.A. Nelder. (1995), Generalized Linear Models. Chapman and Hall.
- ▶ J.F. Simonoff: Analyzing Categorical Data.
- ▶ S.E. Fienberg: The Analysis of Cross Classified data
- ▶ Michael S. Lewis Beck. : Basic Statistics.
- ▶ Agresti, A.(2007), An Introduction to Categorical data analysis. Wiley.

## • STSADSE01P – Discrete data analysis Practical

### Discrete data analysis Practical

60 Class Hours

2 Credits

### List of Practical

1. Regression diagnostics
2. Measures of association for 2x2 contingency table.
3. Relative risk, odds ratio
4. Measures of association for kx1 contingency table.
5. Fitting a logit model
6. Fitting a probit model
7. Fitting of multiple logistic regression.

- **STSadSE02T – Large Sample Theory**

<b>Large Sample Theory</b>	
<b>60 Lectures</b>	<b>4 Credits</b>
<b><i>Limit Theorems</i></b>	<b>14 Lectures</b>
Convergence in Probability, Weak Laws of Large Numbers and their applications, Convergence in Distribution, relation between two kind of convergence, Slutsky's Theorem, De-Moivre-Laplace Limit Theorem. Normal approximation to Poisson distribution, Statement of Central Limit Theorem (iid case) and its use in test and confidence interval for binomial proportions and Poisson means.	
<b><i>Standard Errors of Statistics and Variance Stabilization</i></b>	<b>24 Lectures</b>
Derivation and uses of large sample standard error of sample moments, Standard deviation, Coefficient of Variation, $b_1$ & $b_2$ measures, Correlation coefficient. Asymptotic distribution of sample quantiles. Transformation of Statistics, Derivation and use of $\sin^{-1}$ , square root, logarithmic & Fisher's Z- transformations.	
<b><i>Asymptotic Property of Estimators</i></b>	<b>10 Lectures</b>
Consistency Asymptotic efficiency, ARE, CAN and BAN estimators. Properties of MLE (statement only) and their uses in testing and confidence interval.	
<b><i>Pearsonian <math>\chi^2</math></i></b>	<b>12 Lectures</b>
Large Sample distribution of Pearsonian $\chi^2$ statistic, its uses (goodness of fit, independence, homogeneity). Yates' correction in a 2x2 contingency table.	
<b>Reference Books</b>	
<ul style="list-style-type: none"> <li>▶ A.M.Gun, M.K. Gupta &amp; B.Dasgupta: An Outline of Statistical Theory (Vol.1&amp;2)</li> <li>▶ P. Mukhopadhyay : Mathematical Statistics.</li> <li>▶ V.K. Rohatgi &amp; A.K.M.E. Saleh: An Introduction to Probability and Statistics.</li> <li>▶ C.R. Rao: Linear Statistical Inference and its Application.</li> <li>▶ R.V. Hogg and A.T. Craig: Introduction to Mathematical statistics.</li> </ul>	

- **STSADSE02P – Large Sample Theory Practical**

<b>Large Sample Theory Practical</b>	
<b>60 Class Hours</b>	<b>2 Credits</b>
<b>List of Practical</b>	
<ol style="list-style-type: none"> <li>1. Testing of significance and confidence intervals for single proportion and difference of two proportions using CLT.</li> <li>2. Testing of significance and confidence intervals for single Poisson mean and difference of two Poisson means using CLT.</li> <li>3. Testing of significance and confidence intervals concerning sample standard deviation, coefficient of variation and correlation coefficient (both single sample, two sample cases).</li> <li>4. Testing of significance and confidence intervals using variance stabilizing transformations.</li> <li>5. Determination of the minimum sample size required to achieve normality by sample proportion, mean and standard deviation.</li> <li>6. Tests for goodness of fit, independence and homogeneity using Pearsonian chi-square statistic.</li> </ol>	

- **STSADSE03T – Econometrics**

<b>Econometrics</b>	
<b>60 Lectures</b>	<b>4 Credits</b>
<b><i>What is Econometrics</i></b>	<b>12 Lectures</b>
Comparing mathematical and econometric model with illustrative examples – consumption and production function. Stages of econometric methodology, Review of simple linear regression model	
<b><i>Heteroscedasticity</i></b>	<b>16 Lectures</b>
Nature of heteroscedasticity – illustrative examples, OLS method under heteroscedasticity and its consequences, detecting heteroscedasticity – residual plot, Glejser test, Goldfeld-Quandt test, remedial measure through variable transformation and generalized least squares (GLS).	
<b><i>Autocorrelation</i></b>	<b>14 Lectures</b>



Nature of autocorrelation – illustrative examples, OLS method under autocorrelation – AR(1) model, detecting autocorrelation – residual plot, Runs test, Durbin-Watson test, GLS method for correcting autocorrelation.

### ***Multicollinearity***

**18 Lectures**

Nature of multicollinearity – illustrative examples, OLS method under perfect multicollinearity and its consequences, detecting multicollinearity – thumb rules based on  $R^2$ , pair-wise and partial correlations, remedial measures via more data, dropping and transformation of variables.

### **Reference Books**

- ▶ G.S. Maddala: Introduction to Econometrics
- ▶ D.N. Gujarati: Basic Econometrics
- ▶ J. Johnston and J. Dinardo: Econometric Methods

## • **STSADSE03P – Econometrics Practical**

### **Large Sample Theory Practical**

**60 Class Hours**

**2 Credits**

### **List of Practical**

1. Fitting of ordinary linear regression equations with diagnostics.
2. Tests of heteroscedasticity.
3. Fitting of regression equation after making adjustments for heteroscedasticity.
4. Tests of autocorrelation.
5. Fitting of regression equation after making adjustments for autocorrelation.
6. Tests of multicollinearity.
7. Fitting of regression equation after making adjustments for multicollinearity.

## • **STSADSE04T - Demography**

### **Demography**

**60 Lectures**

**4 Credits**

### ***Introduction***

**12 Lectures**

Demographic events and processes. Sources of population data, Census and registration. Errors in census and registration data. Rates and ratios of vital events.

### ***Measurements of mortality***

**14 Lectures**

Crude death rate (CDR), Specific death rate (SDR), Infant mortality rate (IMR) and Standardized death rates. Life (Mortality) tables: assumption, description and uses. Stable and Stationary population.

### ***Measurements of Fertility***

**18 Lectures**

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).

### **Estimation**

**16 Lectures**

Population estimation, Projection and Forecasting: Use of AP and GP methods for population estimates. Fitting of population curve for population forecasting using Rhode's method.

### **Reference Books**

- ▶ A.M.Gun, M.K. Gupta & B.Dasgupta: Fundamental of Statistical Theory (Vol.1&2)
- ▶ P. Mukhopadhyay : Applied Statistics.

## • **STSadSE04P – Demography Practical**

### **Large Sample Theory Practical**

**60 Class Hours**

**2 Credits**

### **List of Practical**

1. Computation of Crude Birth Rate.
2. Computation of different Fertility Rate.
3. Computation of Reproduction Rate.
4. Computation of Vital index.
5. Fitting of population curve for population forecasting.
6. Computation of Mortality rate.
7. Preparation of Life Table.

- **STSadSE05T - Numerical Analysis and Monte Carlo Computation**

Numerical Analysis and Monte Carlo Computation	
<b>60 Lectures</b>	<b>4 Credits</b>
<b><i>Numerical Analysis</i></b>	<b>14 Lectures</b>
Finite differences and interpolation. Operators $\Delta$ and $E$ . Newton's forward and backward interpolation formulae. Lagrange's interpolation formulae.	
<b>Numerical Integration and Solution of Equation</b>	<b>16 Lectures</b>
Numerical Integration, Gauss quadrature, Trapezoidal rule, Simpson's one-third rule with error terms. Stirling's approximation to factorial $n$ . Solution of equations in a single variable- Bisection, Iteration and Newton Raphson method.	
<b>Simulation</b>	<b>14 Lectures</b>
Using the computer for random number generation (treated as a black box). A brief look at some popular approaches (no mathematical justification needed). Simulating a coin toss, a die roll and a card shuffle. CDF inversion method. Simulation from standard distributions. Finding probabilities and moments using simulation.	
<b>Monte Carlo</b>	<b>16 Lectures</b>
Monte Carlo integration. Basic idea of importance sampling. (MCMC not included). Generating from Binomial and Poisson distributions, and comparing the histograms to the PMFs.  Generating from Uniform (0, 1) distribution, and applying inverse CDF transforms. Simulating Gaussian distribution using Box-Muller method. Approximating the expectation of a given function of a random variable using simulation. Graphical demonstration of the Law of Large Numbers. Approximating the value of pi by simulating dart throwing.	
<b>Reference Books</b>	
▶ F. B. Hildebrand: Introduction to Numerical Analysis, Tata McGrawHill	
▶ J. B. Scarborough: Numerical Mathematical Analysis, Oxford & IBH	

- **STSADSE05P: Numerical Analysis Monte & Carlo Computation Practical**

<b>Numerical Analysis and Monte Carlo Computation Practical</b>	
<b>60 Class Hours</b>	<b>2 Credits</b>
<b>List of Practical</b>	
<ol style="list-style-type: none"> <li>1. Computation of Numerical Integration.</li> <li>2. Simulation using MCMC.</li> </ol>	

- **STSADSE06P - Project**

<b>Communication Electronics</b>	
<b>180 Class hours</b>	<b>6 Credits</b>
<ul style="list-style-type: none"> <li>○ 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.</li> <li>○ 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.</li> </ul>	
<b>List of Assignments</b>	
To be selected by supervisor.	
<b>Reference Books</b>	
▶ To be given by supervisor	

## 4. Skill Enhancement Course

- **STSSSEC01M: Statistical Data Analysis Using C-programming and Software Packages**

Statistical Data Analysis Using C-programming and Software Packages	
<b>30 class hours</b>	<b>2 Credits</b>
<b>UNIT I</b>	
<p>Basic idea and elementary operations in C Language, Use of pointers and Files. Illustration through the following programming problems:</p> <ol style="list-style-type: none"> <li>1. Computation of summary measures in statistics for univariate and bivariate data.</li> <li>2. Selection sorting: Computation of quantiles.</li> <li>3. Matrix Operations &amp; solution of linear equations.</li> <li>4. Spearman's rank correlation.</li> <li>5. Generation of samples from Binomial, Exponential, Normal, Chi square, t and F distributions.</li> </ol>	
<b>UNIT II</b>	
<p>Learn how to load data, plot a graph viz. histograms (equal class intervals and unequal class intervals), box plot, stem-leaf, frequency polygon, pie chart, ogives with graphical summaries of data. Generate automated reports giving detailed descriptive statistics, correlation and lines of regression.</p>	
<b>UNIT III</b>	
<p>Random number generation and sampling procedures. Fitting of polynomials and exponential curves. Application Problems based on fitting of suitable distribution, Normal probability plot.</p>	
<b>UNIT IV</b>	
<p>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.</p>	

### Reference Books

- ▶ Moore, D.S. and McCabe, G.P. and Craig, B.A. (2014): Introduction to the Practice of Statistics, W.H. Freeman
- ▶ Cunningham, B.J (2012): Using SPSS: An Interactive Hands-on approach
- ▶ Cho, M,J., Martinez, W.L. (2014) Statistics in MATLAB: A Primer, Chapman and Hall/CRC
- ▶ Fundamentals of Computers: V. Rajaraman; Prentice Hall of India  
C Language and numerical methods: C Xavier; New Age International

## ● STSSSEC02M - Computation using R

### Computation using R

**30 class hours**

**2 Credits**

#### UNIT I

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

#### UNIT II

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

#### UNIT III

Random number generation and sampling procedures. Fitting of polynomials and exponential curves. Application Problems based on fitting of suitable distribution, Normal probability plot.

#### UNIT IV

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

### Reference Books

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

## 5. General Elective

- **STSHGEC01T - Statistical Methods**

Statistical Methods	
<b>60 Lectures</b>	<b>4 Credits</b>
<b>Introduction</b>	<b>20 Lectures</b>
<p>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.</p>	
<b>Measures of Central Tendency</b>	<b>20 Lectures</b>
<p>Measures of Central Tendency, mathematical and positional. Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation, moments, skewness and kurtosis.</p>	
<b>Bivariate data</b>	<b>20 Lectures</b>
<p>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.</p>	
<b>Theory of attributes</b>	<b>10 Lectures</b>
<p>Theory of attributes, consistency of data, independence and association of attributes, measures of association and contingency.</p>	
<b>Reference Books</b>	
<ul style="list-style-type: none"> <li>▶ Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I &amp; II, 8th Edn. The World Press, Kolkata.</li> <li>▶ Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.</li> <li>▶ 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.</li> </ul>	

- **STSHGEC01P – Statistical Methods Practical**

<b>Statistical Methods Practical</b>	
<b>60 class hours</b>	<b>2 Credits</b>
<b>List of Practical</b>	
<ol style="list-style-type: none"> <li>1. Graphical representation of data</li> <li>2. Problems based on measures of central tendency</li> <li>3. Problems based on measures of dispersion</li> <li>4. Problems based on combined mean and variance and coefficient of variation</li> <li>5. Problems based on moments, skewness and kurtosis</li> <li>6. Fitting of polynomials, exponential curves</li> <li>7. Karl Pearson correlation coefficient</li> <li>8. Partial and multiple correlations</li> <li>9. Spearman rank correlation with and without ties.</li> <li>10. Correlation coefficient for a bivariate frequency distribution</li> <li>11. Lines of regression, angle between lines and estimated values of variables.</li> <li>12. Checking consistency of data and finding association among attributes.</li> </ol>	

- **STSHGEC02T - Introductory Probability**

<b>Introductory Probability</b>	
<b>60 Lectures</b>	<b>4 Credits</b>
<b>Introduction</b>	<b>20 Lectures</b>
<p>Probability: Introduction, random experiments, sample space, events and algebra of events.</p> <p>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.</p>	



<b>Random Variables</b>	<b>12 Lectures</b>
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.	
<b>Convergence in probability</b>	<b>8 Lectures</b>
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.).	
<b>Probability distributions</b>	<b>20 Lectures</b>
Standard probability distributions: Binomial, Poisson, geometric, negative binomial, hypergeometric, uniform, normal, exponential, beta, gamma.	
<b>Reference Books</b>	
<ul style="list-style-type: none"> <li>▶ Hogg, R.V., Tanis, E.A. and Rao J.M. (2009): Probability and Statistical Inference, Seventh Ed, Pearson Education, New Delhi.</li> <li>▶ Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.</li> <li>▶ Myer, P.L. (1970): Introductory Probability and Statistical Applications, Oxford &amp; IBH Publishing, New Delhi.</li> </ul>	

• **STSHGEC02P – Introductory Probability Practical**

<b>Introductory Probability Practical</b>	
<b>60 class hours</b>	<b>2 Credits</b>
<b>List of Practicals</b>	
<ol style="list-style-type: none"> <li>1. Fitting of binomial distributions for <math>n</math> and <math>p = q = \frac{1}{2}</math> given</li> <li>2. Fitting of binomial distributions for <math>n</math> and <math>p</math> given</li> <li>3. Fitting of binomial distributions computing mean and variance</li> <li>4. Fitting of Poisson distributions for given value of lambda</li> </ol>	

5. Fitting of Poisson distributions after computing mean
6. Application problems based on binomial distribution
7. Application problems based on Poisson distribution
8. Problems based on area property of normal distribution
9. To find the ordinate for a given area for normal distribution
10. Application based problems using normal distribution
11. Fitting of normal distribution when parameters are given
12. Fitting of normal distribution when parameters are not given

- **STSHGEC03T - Basics of Statistical Inference**

<b>Basics of Statistical Inference</b>	
<b>60 Lectures</b>	<b>4 Credits</b>
<b>Statistical Inference</b>	<b>20 Lectures</b>
<p>Estimation of population mean, confidence intervals for the parameters of a normal distribution (one sample and two sample problems).</p> <p>The basic idea of significance test. Null and alternative hypothesis. Type I &amp; 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).</p>	
<b>Categorical data</b>	<b>10 Lectures</b>
<p>Categorical data: Tests of proportions, tests of association and goodness-of-fit using Chisquare test, Yates' correction.</p>	
<b>Nonparametric Inference</b>	<b>12 Lectures</b>
<p>Tests for the significance of correlation coefficient. Sign test for median, Sign test for symmetry, Wilcoxon two-sample test.</p>	
<b>Analysis of variance</b>	<b>18 Lectures</b>

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

### Reference Books

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

## • STSHGEC03P – Basics of Statistical Inference Practical

### Basics of Statistical Inference Practical

**60 class hours**

**2 Credits**

### List of Practical

1. Estimators of population mean.
2. Confidence interval for the parameters of a normal distribution (one sample and two sample problems).
3. Tests of hypotheses for the parameters of a normal distribution (one sample and two sample problems).
4. Chi-square test of proportions.
5. Chi-square tests of association.
6. Chi-square test of goodness-of-fit.
7. Test for correlation coefficient.
8. Sign test for median.
9. Sign test for symmetry.

10. Wilcoxon two-sample test.
11. Analysis of Variance of a one way classified data
12. Analysis of Variance of a two way classified data.
13. Analysis of a CRD.
14. Analysis of an RBD.

- **STSHGEC04T - Applied Statistics**

<b>Applied Statistics</b>	
<b>60 Lectures</b>	<b>4 Credits</b>
<b>Time Series</b>	<b>15 Lectures</b>
<p>Economic Time Series: Components of time series, Decomposition of time series- Additive and multiplicative model with their merits and demerits, Illustrations of time series.</p> <p>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.</p>	
<b>Index numbers</b>	<b>15 Lectures</b>
<p>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.</p>	
<b>Statistical Quality Control</b>	<b>15 Lectures</b>
<p>Statistical Quality Control: Importance of statistical methods in industrial research and practice. Determination of tolerance limits. Causes of variations in quality: chance and assignable. General theory of control charts, process &amp; product control, Control charts for variables: X- bar and R-charts. Control charts for attributes: p and c-charts.</p>	
<b>Demography</b>	<b>15 Lectures</b>
<p>Demographic Methods: Introduction, measurement of population, rates and ratios of vital</p>	

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.

### Reference Books

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, 4<sup>th</sup> Edition(Reprint), Sultan Chand & Sons
4. Montgomery, D. C. (2009): Introduction to Statistical Quality Control, 6th Edition, Wiley India Pvt. Ltd.

## • STSHGEC04P – Applied Statistics Practical

### Applied Statistics Practical

60 class hours

2 Credits

### List of Practical

1. Measurement of trend: Fitting of linear, quadratic trend, exponential curve and plotting of trend values and comparing with given data graphically.
2. Measurement of seasonal indices by Ratio-to-trend method and plotting of trend values and comparing with given data graphically.
3. Construction of price and quantity index numbers by Laspeyre's formula, Paasche's formula, Marshall-Edgeworth's formula, Fisher's Formula. Comparison and interpretation.
4. Construction of wholesale price index number, fixed base index number and consumer price index number with interpretation
5. Construction and interpretation of X bar & R-chart.
6. Construction and interpretation p-chart (fixed sample size) and c-chart
7. Computation of measures of mortality
8. Completion of life table.
9. Computation of measures of fertility and population growth

## 6. Scheme for CBCS Curriculum B.Sc. (General)

### Program with *Statistics* as one of the disciplines

#### Scheme for CBCS Curriculum

Semester	Course Name	Course Detail	Credits
<b>I</b>	Ability Enhancement Compulsory Course – I	English communication / Environmental Science	2
	Core course – I (from Statistics)	<b>STSGCOR01T</b> : Statistical Methods	4
		<b>STSGCOR01P</b> : Statistical Methods Practical	2
	Core course – II	DSC 2A (from Discipline 2)	6
Core course – III	DSC 3A (from Discipline 3)	6	
<b>II</b>	Ability Enhancement Compulsory Course – II	English communication / Environmental Science	2
	Core course – IV (from Statistics)	<b>STSGCOR02T</b> : Introductory Probability	4
		<b>STSGCOR02P</b> : Introductory Probability Practical	2
	Core course – V	DSC 2B (from Discipline 2)	6
Core course – VI	DSC 3B (from Discipline 3)	6	
<b>III</b>	Core course – VII (from Statistics)	<b>STSGCOR03T</b> : Basics of Statistical Inference	4
		<b>STSGCOR03P</b> : Basics of Statistical Inference Practical	2
	Core course – VIII	DSC 2C (from Discipline 2)	6
	Core course – IX	DSC 3C (from Discipline 3)	6
	Skill Enhancement Course – 1	TBD	2
<b>IV</b>	Core course – X (from Statistics)	<b>STSGCOR04T</b> : Applied Statistics	4
		<b>STSGCOR04P</b> : Applied Statistics Practical	2
	Core course – XI	DSC 2D (from Discipline 2)	6
	Core course – XII	DSC 3D (from Discipline 3)	6
	Skill Enhancement Course-2	TBD	2

<b>V</b>	Skill Enhancement Course-3	TBD	2
	Discipline Specific Elective – 1	TBD (from Statistics)	6
	Discipline Specific Elective – 2	TBD (from Discipline 2)	6
	Discipline Specific Elective – 3	TBD (from Discipline 3)	6
<b>VI</b>	Skill Enhancement Course-4	TBD	2
	Discipline Specific Elective – 4	TBD (from Statistics)	6
	Discipline Specific Elective – 5	TBD (from Discipline 2)	6
	Discipline Specific Elective – 6	TBD (from Discipline 3)	6

\*TBD: To be decided by the student among the available choices mentioned below.

### Choices for Discipline Specific Electives (from Statistics)

<b>Sem V</b>	<b>STSGDSE01T &amp; STSGDSE01P :</b> Research Methodology (4+2)	<b>STSGDSE02T :</b> Operations Research (4+2)
<b>Sem VI</b>	<b>STSGDSE03T &amp; STSGDSE03P :</b> Survival Analysis and Biostatistics (4+2)	<b>STSGDSE04T :</b> Financial Statistics (4+2)

### Choices for Skill Enhancement Courses (from Statistics)

Identical with those offered for B. Sc. with Statistics Honours program
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## Syllabus for Core Courses (from Statistics)

Syllabus for <b>STSGCOR01T: Statistical Methods</b> is identical with that of <b>STSHGEC01T – Statistical Methods</b> offered for Honours program
Syllabus for <b>STSGCOR01P : Statistical Methods Practical</b> is identical with that of <b>STSHGEC01P – Statistical Methods Practical</b> offered for Honours program
Syllabus for <b>STSGCOR02T: Introductory Probability</b> is identical with that of <b>STSHGEC02T – Introductory Probability</b> offered for Honours program
Syllabus for <b>STSGCOR02P: Introductory Probability Practical</b> is identical with that of <b>STSHGEC02P – Introductory Probability Practical</b> offered for Honours program
Syllabus for <b>STSGCOR03T: Basics of Statistical Inference</b> is identical with that of <b>STSHGEC03T – Basics of Statistical Inference</b> offered for Honours program
Syllabus for <b>STSGCOR03P: Basics of Statistical Inference Practical</b> is identical with that of <b>STSHGEC03P – Basics of Statistical Inference Practical</b> offered for Honours program
Syllabus for <b>STSGCOR04T: Applied Statistics</b> is identical with that of <b>STSHGEC04T – Applied Statistics</b> offered for Honours program
Syllabus for <b>STSGCOR04P: Applied Statistics Practical</b> is identical with that of <b>STSHGEC04P – Applied Statistics Practical</b> offered for Honours program

## Syllabus for Discipline Specific Electives (from Statistics)

- **STSGDSE01T - Research Methodology**

<b>Research Methodology</b>	
<b>60 Lectures</b>	<b>4 Credits</b>



<b>UNIT I</b>	<b>15 Lectures</b>
<p>Introduction to research, meaning of research, role of research in important areas, process of research, types of research, Unit of analysis, characteristics of interest. Research problem as a hypothesis testing. Sampling Techniques: Introduction to sampling, advantage of sampling over census, simple random sampling, sampling frame, probabilistic aspects of sampling, stratified random sampling, other methods of sampling, sampling design, non-probability sampling methods.</p>	
<b>UNIT II</b>	<b>15 Lectures</b>
<p><b>Data:</b> Introduction, primary and secondary data, methods of collecting primary data, merits and demerits of different methods of collecting primary data, designing a questionnaire, pretesting a questionnaire, editing of primary data, technique of interview, collection of secondary data, scrutiny of secondary data.</p> <p><b>Data Processing:</b> Introduction, editing of data, coding of data, classification of data, tables as data presentation devices, graphical presentation of data.</p>	
<b>UNIT III</b>	<b>15 Lectures</b>
<p><b>Data Analysis:</b> An overview on techniques in univariate, bivariate and multivariate data. <b>Models and Model Building:</b> role of models, types of models, objectives of modeling, model building/ model development, model validation, simulation models</p>	
<b>UNIT IV</b>	<b>15 Lectures</b>
<p><b>Formats of Reports:</b> introduction, parts of a report, cover and title page, introductory pages, text, reference section, typing instructions, copy reading, proof reading.</p> <p><b>Presentation of a report:</b> introduction, communication dimensions, presentation package, audio-visual aids, presenter's poise.</p>	
<b>Reference Books</b>	
<ol style="list-style-type: none"> <li>1. Kotahri, C.R (2009): Research Methodology: Methods and Techniques, 2<sup>nd</sup> Revised Ed. Reprint, New Age International Publishers</li> <li>2. Lilien, Gary L. and Philip Kotler, 1983. Marketing Decision Making; A Model Building Approach, Harper &amp; Row, New York.</li> <li>3. Shenoy, GVS, et al., (1983). Quantitative Techniques for Managerial Decision Making, Wiley Eastern</li> </ol>	

- **STSGDSE01P – Research Methodology Practical**

<b>Digital, Analog Circuits and Instruments</b>	
<b>60 class hours</b>	<b>2 Credits</b>
<b>List of Practical</b>	
Submit a Research Report based on empirical study on some real life situation. The student will personally collect, analyze, interpret the data and prepare a report under the supervision of a faculty.	

- **STSGDSE02T - Operations Research**

<b>Operations Research</b>	
<b>60 Lectures</b>	<b>4 Credits</b>
<b>UNIT I</b>	<b>8 Lectures</b>
Introduction to Operations Research, phases of O.R., model building, various types of O.R. problems. Linear Programming Problem, Mathematical formulation of the L.P.P, graphical solutions of a L.P.P. Simplex method for solving L.P.P. Charne's M-technique for solving L.P.P. involving artificial variables. Special cases of L.P.P. Concept of Duality in L.P.P: Dual simplex method. Post-optimality analysis.	
<b>UNIT II</b>	<b>15 Lectures</b>
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.	
<b>UNIT III</b>	<b>15 Lectures</b>
Game theory: Rectangular game, minimax-maximin principle, solution to rectangular game using graphical method, dominance and modified dominance property to reduce the game matrix and solution to rectangular game with mixed strategy. Networking: Shortest route and minimal spanning tree problem.	

<b>UNIT IV</b>	<b>15 Lectures</b>
Inventory Management: ABC inventory system, characteristics of inventory system. EOQ Model and its variations, with and without shortages, Quantity Discount Model with price breaks.	
<b>Reference Books</b>	
<ol style="list-style-type: none"> <li>1. Taha, H. A. (2007): Operations Research: An Introduction, 8th Edition, Prentice Hall of India.</li> <li>2. KantiSwarup, Gupta, P.K. and Manmohan (2007): Operations Research, 13th Edition, Sultan Chand and Sons.</li> <li>3. Hadley, G: (2002) : Linear Programming, Narosa Publications</li> <li>4. Hillier, F.A and Lieberman, G.J. (2010): Introduction to Operations Research- Concepts and cases, 9th Edition, Tata McGraw Hill</li> </ol>	

### ● STSGDSE02P– Operations Research Practical

Operations Research Practical	
<b>60 class hours</b>	<b>2 Credits</b>
<b>List of Practical</b>	
<ol style="list-style-type: none"> <li>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.</li> <li>2. Identifying Special cases by Graphical and Simplex method and interpretation <ol style="list-style-type: none"> <li>a. Degenerate solution</li> <li>b. Unbounded solution</li> <li>c. Alternate solution</li> <li>d. Infeasible solution</li> </ol> </li> <li>3. Post-optimality <ol style="list-style-type: none"> <li>a. Addition of constraint</li> <li>b. Change in requirement vector</li> <li>c. Addition of new activity</li> <li>d. Change in cost vector</li> </ol> </li> <li>4. Allocation problem using Transportation model</li> <li>5. Allocation problem using Assignment model</li> <li>6. Networking problem <ol style="list-style-type: none"> <li>a. Minimal spanning tree problem</li> <li>b. Shortest route problem</li> </ol> </li> <li>7. Problems based on game matrix <ol style="list-style-type: none"> <li>a. Graphical solution to <math>m \times 2 / 2 \times n</math> rectangular game</li> <li>b. Mixed strategy</li> </ol> </li> <li>8. To find optimal inventory policy for EOQ models and its variations</li> <li>9. To solve all-units quantity discounts model</li> </ol>	

• **STSGDSE03T – Survival Analysis and Biostatistics**

<b>Survival Analysis and Biostatistics</b>	
<b>60 Lectures</b>	<b>4 Credits</b>
<b>Preliminary Topics</b>	<b>20 Lectures</b>
<b>UNIT I</b>	
Survival Analysis: Functions of survival times, survival distributions and their applications: exponential, gamma, Weibull, Rayleigh, lognormal, death density function for a distribution having bath-tub shaped hazard function. Censoring Schemes: Type I, Type II and progressive or random censoring with biological examples. Estimation of mean survival time and variance of the estimator for Type I and Type II censored data with numerical examples. Non-parametric methods: Actuarial and Kaplan-Meier methods for estimating survival function and variance of the Estimator.	
<b>UNIT II</b>	<b>15 Lectures</b>
Competing Risk Theory: Indices for measurement of probability of death under competing risks and their inter-relations. Estimation of probabilities of death using maximum likelihood principle and modified minimum Chi-square methods. Theory of independent and dependent risks. Bivariate normal dependent risk model.	
<b>UNIT III</b>	<b>10 Lectures</b>
Stochastic Epidemic Models: Simple epidemic models, general epidemic model definition and concept (without derivation). Duration of an epidemic.	
<b>UNIT IV</b>	<b>15 Lectures</b>
Statistical Genetics: Introduction, concepts-Genotype, Phenotype, Dominance, Recessiveness, Linkage and Recombination, Coupling and Repulsion. Mendelian laws of Heredity, Random mating, Gametic Array .relation between genotypic array and gametic array under random mating. Distribution of genotypes under random mating. Clinical Trials: Planning and design of clinical trials, Phase I, II and III trials. Single Blinding.	
<b>Reference Books</b>	
<ol style="list-style-type: none"> <li>1. Lee, E.T. and Wang, J.W. (2003): Statistical Methods for Survival data Analysis, 3rd Edition, John Wiley and Sons.</li> <li>2. Biswas, S. (2007): Applied Stochastic Processes: A Biostatistical and Population Oriented Approach, Reprinted 2ndCentral Edition, New Central Book Agency.</li> <li>3. Kleinbaum, D.G. (1996): Survival Analysis, Springer.</li> </ol>	

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.

• **STSGDSE03P – Survival Analysis and Biostatistics Practical**

### Survival Analysis and Biostatistics Practical

**60 class hours**

**2 Credits**

#### List of Practical

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

- **STSGDSE04T - Financial Statistics**

<b>Financial Statistics</b>	
<b>60 Lectures</b>	<b>4 Credits</b>
<b>UNIT I</b>	<b>15 Lectures</b>
Probability review: Real valued random variables, expectation and variance, skewness and kurtosis, conditional probabilities and expectations. Discrete Stochastic Processes, Binomial processes, General random walks, Geometric random walks, Binomial models with state dependent increments.	
<b>UNIT II</b>	<b>15 Lectures</b>
Tools Needed For Option Pricing: Wiener process, stochastic integration, and stochastic differential equations. Introduction to derivatives: Forward contracts, spot price, forward price, future price. Call and put options, zero-coupon bonds and discount bonds.	
<b>UNIT III</b>	<b>15 Lectures</b>
Pricing Derivatives: Arbitrage relations and perfect financial markets, pricing futures, put-call parity for European options, relationship between strike price and option price. Stochastic Models in Finance: Discrete time process- binomial model with period one.	
<b>UNIT IV</b>	<b>15 Lectures</b>
Stochastic Models in Finance: Continuous time process- geometric Brownian motion. Ito's lemma, Black-Scholes differential equation, Black-Scholes formula for European options, Hedging portfolios: Delta, Gamma and Theta hedging. Binomial Model for European options: Cox-Ross-Rubinstein approach to option pricing. Discrete dividends.	
<b>Reference Books</b>	
1. Franke, J., Hardle, W.K. And Hafner, C.M. (2011): Statistics of Financial Markets: An Introduction, 3rdEdition, Springer Publications.	
2. Stanley L. S. (2012): A Course on Statistics for Finance, Chapman and Hall/CRC.	

- **STSGDSE04P – Financial Statistics Practical**

<b>Financial Statistics Practical</b>	
<b>60 class hours</b>	<b>2 Credits</b>
<b>List of Practical</b>	
<ol style="list-style-type: none"><li>1. To verify “no arbitrage” principle</li><li>2. To verify relationship between spot price, forward price, future price</li><li>3. To price future contracts</li><li>4. To verify put-call parity for European options</li><li>5. To construct binomial trees and to evaluate options using these trees</li><li>6. To price options using black – Scholes formula</li><li>7. To hedge portfolios using delta and gamma hedging</li><li>8. To hedge portfolios theta hedging</li><li>9. Pricing of call options using binomial model</li><li>10. Computation of dividends on call options as a percentage of stock price.</li><li>11. Computation of dividends on call options as a fixed amount of money.</li><li>12. Pricing of put options using binomial model</li><li>13. Call-put parity for options following binomial models.</li><li>14. Effect of dividends on put options.</li></ol>	