SYLLABUS
FOR
B.SC. HONOURS IN STATISTICS

Under

Learning Outcomes based Curriculum Framework (LOCF)

Effective from the academic session 2020-2021

K A Z I N A Z R U L U N I V E R S I T Y

ASANSOL-713 340, PASCHIM BARDHAMAN

WEST BENGAL

SEMESTER I

Course Code: BSCHSTSC101
Course Name- Descriptive Statistics

Course Type: **Core** **(Theoretical & Practical)**	Course Details: **CC-1**			L-T-P: **4-0-4**	
Credit: **6**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

Course Learning Outcomes:

After the completion of course, the students will have

1. Knowledge of Statistics and its scope and importance in various areas such as Medical, Engineering, Agricultural and Social Sciences etc.
2. Information about various Statistical organizations in India and their functions for societal developments,
3. Knowledge of various types of data and their measurement scales, organization of data and evaluation of summary measures such as measures of central tendency and dispersion etc.
4. Knowledge of qualitative data including consistency of data and concepts of independence and association between two attributes,
5. Insights into preliminary exploration of different types of data.
6. An introduction to Programming in R and standard statistical software packages, namely, MINITAB, MATLAB, R, MATHEMATICA, SAS, S-SPLUS, STATISTIKA, etc. which they will be able to use in the subsequent practical courses and projects.

Contents(Theory):

Unit I

Introduction to Statistics, Meaning of Statistics as a Science, Importance of Statistics. Scope of Statistics in Industry, Biological sciences, Medical sciences, Economics, Social Sciences, Management sciences, Agriculture, Insurance, Information technology, Education and Psychology. Statistical organizations in India and their functions: CSO, ISI, NSS, IIPS (Devnar, Mumbai), Bureau of Economics and statistics.

Unit II

Population and Sample. Variables: Interval scale, ratio scale, discrete and continuous variables, difference between linear scale and circular scale. Primary and secondary data, Cross-sectional data, time series data, directional data. Notion of a statistical population: Finite population, infinite population, homogeneous population and heterogeneous population. Notion of a sample and a random sample. Summary Statistics. Review / Revision of Presentation of Data.

Unit III

Classification: Raw data and its classification, ungrouped frequency distribution, Sturges' rule, grouped frequency distribution, cumulative frequency distribution, inclusive and exclusive methods of classification, Open end classes, and relative frequency distribution. Measures of Central Tendency. Partition Values: Quartiles, Deciles and Percentiles (for ungrouped and grouped data), Stem-and-leaf display, Box Plot. Measures of Dispersion, Moments, Skewness and Kurtosis.

Unit IV

Theory of Attributes: Nominal scale, ordinal scale, classification, notion of manifold classification, dichotomy, class- frequency, order of class, positive class-frequency, negative class frequency, quanta class frequencies, ultimate class frequency, relationship among different class frequencies (up to three attributes), dot operator to find the relation between frequencies, fundamental set of class frequencies. Consistency of data up to 2 attributes. Concepts of independence and association of two attributes. Yule's coefficient of association (Q), $-1 \leq Q \leq 1$, interpretation. Examples and Problems.

Contents (Practical):

1. R programming, importing and exporting data, R functions, loops, conditional statements, R graphics.
2. Diagrammatic representation of statistical data problems based on simple and subdivided bar diagrams, pie diagrams.
3. Graphical representation of statistical data.
4. Computation of measures of central tendency and dispersion. Use of an appropriate measure and interpretation of results.
5. Moments, Measures of skewness and kurtosis, Box plot.
6. Theory of Attributes: Nominal scale, ordinal scale, classification.
7. Consistency of data up to 2 attributes. Concepts of independence and association of two attributes.
8. Yule's coefficient of association (Q), interpretation. Examples and Problems.

References:

1. Dalgaard, Peter(2008). Introductory Statistics with R. Statistics and Computing. Springer Science and Business Media..
2. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2013). Fundamental of Statistics, Vol I , World Press, Kolkata.
3. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2011). Fundamental of Statistics, Vol II, World Press, Kolkata.
4. Hanagal, D. D. (2009). Introduction to Applied Statistics: A Non-Calculus Based Approach. Narosa Publishing Comp. New Delhi.
5. Long, J. D. and Paul Teetor(2019). R Cookbook: Proven Recipes for Data Analysis, Statistics and Graphics. 2nd Edition
6. Miller, I. and Miller, M. (2006). John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
7. Mood, A.M. Graybill, F.A. and Boes, D.C. (2011). Introduction to the Theory of Statistics, 3rd Edn., Tata McGraw-Hill Pub. Co. Ltd.

Course Code: BSCHSTSC102
Course Name- Probability Theory and Distributions I

<table>
<tr><td rowspan="2">Course Type: Core
(Theoretical & Practical)</td><td colspan="3" rowspan="2">Course Details: CC-2</td><td colspan="2">L-T-P: 4-0-4</td></tr>
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<tr><td>30</td><td>10</td><td>20</td><td>40</td></tr>
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Course Learning Outcomes:

After the completion of course, the students will have:

1. Ability to distinguish between random and non-random experiments,
2. Knowledge to conceptualize the probabilities of events including frequentist and axiomatic approach. Simultaneously, they will learn the notion of conditional probability including the concept of Bayes' Theorem,
3. Knowledge related to concept of discrete random variable and its probability distribution including expectation and moments,
4. Knowledge of important discrete distributions such as Binomial, Poisson, Geometric, Negative Binomial and Hyper-geometric and their interrelations if any,

5. Acumen to apply standard discrete probability distribution to different situations.

Contents(Theory):

Unit I

Review of probability, conditional probability, and independence. Experiments/Models, Ideas of deterministic and non-deterministic models. Random Experiment, concept of statistical regularity. Definitions of - (i) Sample space, (ii) Discrete sample space: finite and countably infinite, (iii) Event, (iv) Elementary event, (v) Complement of an event. (vi) Certain event (vii) impossible event.

Unit II:

Concept of occurrence of an event. Algebra of events and its representation in set theory notation. Occurrence of following events. (i) at least one of the given events, (ii) none of the given events, (iii) all of the given events, (iv) mutually exclusive events, (v) mutually exhaustive events, (vi) exactly one event out of the given events. Classical definition of probability and its limitations. Probability model, probability of an event, equiprobable and non-equiprobable sample space, Axiomatic definition of probability. Definition of conditional probability of an event. Definition of independence of two events. Pairwise independence and mutual independence for three events. Multiplication theorem and its generalization.

Unit III

Bayes' Theorem: Partition of the sample space, Proof of Bayes' theorem. Applications of Bayes' theorem in real life. Concept and definition of a discrete random variable. Probability mass function (p.m.f.) and cumulative distribution function (c.d.f.) $F(\cdot)$ of discrete random variables, properties of c.d.f. Mode and median of a univariate discrete probability distribution. Mathematical Expectation (Univariate Random Variable), expectation of a function of a random variable, moment generating function (m.g.f.) and cumulant generating function (c.g.f.), Properties of m.g.f. and c.g.f.

Unit IV

Variance, standard deviation (s.d.) and Coefficient of variation (c.v.) of univariate probability distribution, effect of change of origin and scale on mean, variance and s.d., raw, central and factorial raw moments of univariate probability distributions and their interrelations (without proof). Coefficients of skewness and kurtosis based on moments. Some Standard Discrete Probability Distributions. Degenerate distribution (one-point distribution), mean and variance. Evaluation of p.m.f., c.d.f., mean, variance, m.g.f. and c.g.f. of the following distributions: Uniform discrete distribution, Bernoulli distribution, Binomial distribution, Poisson distribution, Geometric distribution, Negative binomial distribution, Hypergeometric distribution. Approximation of binomial to Poisson.

Contents (Practical):

1. Fitting of binomial distribution and computation of expected frequencies, mean variance, m.g.f.
2. Fitting of Poisson distribution and computation of expected frequencies, mean variance, m.g.f.
3. Fitting of geometric distribution and computation of expected frequencies, mean variance, m.g.f.
4. Fitting of hypergeometric distribution and computation of expected frequencies, mean variance, m.g.f.
5. Fitting of negative binomial distribution and computation of expected frequencies, mean variance, m.g.f.
6. Fitting of hypergeometric and negative binomial distributions and computation of expected frequencies.
7. Mutually exclusive events, conditional probability of an event, independence of two events, pairwise independence and mutual independence for three events.
8. Bernoulli Distribution: p.m.f., mean, variance, m.g.f.
9. Binomial Distribution: p.m.f., mean, variance, m.g.f.
10. Computation of inverse probability using Bayes' theorem.

References:

1. Chandra T. K. and Chatterjee(2001). A First Course in Probability.Narosa.
2. Dudewicz, E.J. and Mishra, S.N. (2008). Modern Mathematics Statistics, Wiley.
3. Hanagal, D. D. (2009). Introduction to Applied Statistics: A Non-Calculus Based Approach. Narosa Publishing Comp. New Delhi.
4. Johnson, S. and Kotz, S. (1972). Distribution in Statistics Vol. I-II & III, Houghton and Mifflin.
5. Lipschutz, S., Lipson, M. L. and Jain, K. (2010). Schaum's Outline of Probability. 2 nd Edition. McGraw Hill Education Pvt. Ltd, New Delhi.
6. Pitman, J. (1993). Probability. Narosa Publishing House
7. Rahman, N. A.(1983).Practical exercises in Probability and Statistics.Griffin.
8. Rao, C.R. (2009). Linear Statistical Inference and its Applications, 2ndEdition, Wiley Eastern.
9. Rohatgi, V.K. and Saleh, A.E. (2008). An introduction to Probability Theory and MathematicalStatistics, Wiley Eastern.

SEMESTER II

Course Code: BSCHSTSC201
Course Name- Statistical Methods-I

Course Type: **Core** **(Theoretical & Practical)**	Course Details: **CC-3**			L-T-P: **4-0-4**	
Credit: **6**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

CourseLearning outcomes:

After completion of the coursethe students will acquire

a. concept of random sample from a distribution, sampling distribution of a statistic, standard error of important estimates such as mean and proportions,
b. knowledge about important inferential aspects such as point estimation, test of hypotheses and associated concepts,
c. knowledge about inferences from Binomial, Poisson and Normal distributions as illustrations,
d. ability to use and interpret Normal probability and q-q plots for testing Normality of data
e. knowledge about Box Mueller transformation for simulations.
f. the ability to apply the relevant concepts to real- life problems.

Contents(Theory):

Unit I

Concept of random sample from a distribution, statistic and its sampling distribution, standard error of an estimate, standard errors of sample mean and proportion, sampling distribution of sum of Binomial, Poisson random variables and mean of normal distribution, requirement of a good estimator with examples.

Unit II

Formulation of inference problems with concrete illustrations: Point estimation: Different methods and criteria for good estimates. Data analytic illustrations.

Unit III

Tests of hypotheses: Simple, composite null and alternative hypotheses, critical region, types of error, level of significance, p-values, size and power of a test. Tests for parameters when sampling is done from one and two normal distributions. Tests for parameters of binomial and Poisson distributions.

Unit IV

Simulation using Box-Muller transformation. Normal approximation to i) binomial distribution ii) Poisson distribution.

Contents(Practical):

This course is based on topics in the course BSCHSTS201 and will provide practical knowledge to the students on various topics elaborated in the course so that they can The exercises to be covered are:

1. Drawing random samples from uniform, normal, exponential, and gamma distributions.

2. Point estimators. Finding Point estimates of the parameters of uniform, normal, exponential and gamma distributions.

3. Testing for parameters when sampling is done from one and two normal distributions.

4. Testing for parameters of binomial and Poisson distributions.

5. Testing for parameters of geometric and negative binomial distributions.

6. Testing for parameters of uniform, normal, exponential and gamma distributions.

7. Power of the test statistics.

8. Normal probability plot, q-q plot to test normality.

9. Simulation using Box-Muller transformation

References:

1. Freedman, D., Pisani, R. and Purves, R. (2014). Statistics. 4th Edition. Norton & Comp.

Hanagal, D. D. (2009). Introduction to Applied Statistics: A Non-Calculus Based Approach

2. Kendall, M.G. and Stuart, A. (1979). The Advanced Theory of Statistics, Vol. 2. Inference and Relationship. 4th Edition. Charles Griffin & Comp.
3. Kendall, M.G., Stuart, A. and Ord, J.K. (1994). The Advanced Theory of Statistics, Vol. 1. Distribution Theory. 6th Edition. Halsted Press (Wiley Inc.).

4. Kenney, J.F. and Keeping, E.S. (1947). Mathematics of Statistics. Part I. 2nd Edition. Chapman & Hall
5. Kenney, J.F. and Keeping, E.S. (1951). Mathematics of Statistics. Part II. 2nd Edition. Chapman & Hall.
6. Rao, C.R.(2009). Linear Statistical Inference and its Applications, 2nd Edition, Wiley Eastern
7. Tanner, M. (1990). An Investigation for a Course in Statistics. McMillan, New York.
8. Tanur, J.M. (1989) Statistics. A Guide to the Unknown. 3rd Edition, Duxbury Press.
9. Yule, G.U. and Kendall, M.G. (1973). An Introduction to the Theory of Statistics. 14th Edition. Charles Griffin & Co.

Course Code: BSCHSTSC202
Course Name- Probability Theory and Distributions-II

Course Type: **Core (Theoretical & Practical)**	Course Details: **CC-4**			L-T-P: **4-0-4**	
Credit: **6**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

Course Learning Outcomes:

This is an advanced level course designed to provide the students

1. knowledge about continuous random variables and their characteristics such as expectation, variance and higher order moments etc.,
2. knowledge about some probability inequalities, law of large numbers, Central Limit Theorem etc.,
3. ability to handle transformed random variables and derive associated distributions,
4. knowledge of important continuous distributions such as Uniform, Normal, Exponential and Gamma and relations with some other distributions,
5. practical knowledge on various topics elaborated in the course so that they can apply the relevant concepts to real life problems.

Contents (Theory):

Unit I

Continuous sample space: Definition, illustrations. Continuous random variable: Definition, probability density function (p.d.f.), cumulative distribution function (c.d.f.) properties of c.d.f. (without proof), probabilities of events related to r. v. Expectation of continuous random variable (r.v.), expectation of function of r.v., variance, moments, skewness, kurtosis.

Unit II

Chebyshev's inequality, Convergence in probability, Weak law of large numbers, Convergence in distribution, De-Moivre Laplace and Lindeberg-Levy Central Limit Theorems (C.L.T.). Moment generating function (M.G.F.): Definition and properties, Cumulant generating function, definition, properties. Probability distribution of transformation of r. v.

Unit III

Standard univariate continuous distributions: Uniform or Rectangular Distribution: Probability density function (p. d. f.), c. d. f., sketch of p. d. f. and c. d. f., mean, variance, symmetry. Distribution of $Y = F(X)$, where $F(X)$ is the c. d. f. of continuous r. v. X.

Unit IV

Normal Distribution: Probability density function (p. d. f.), p. d. f. Curve, identification of scale and location parameters, mean, variance, M.G.F., C.G.F., central moments, cumulants, median, mode, quartiles, mean deviation, additive property, computations of normal probabilities using normal probability integral tables, probability distribution of standard normal variable (S.N.V.), probability distribution of the mean of n i.i.d. r.v.s.

Unit V

Exponential Distribution:Probability density function (p. d. f.), mean, variance, M. G. F., C. G. F., c. d. f., graph of c. d. f., lack of memory property, median, quartiles.

Gamma Distribution**:** Probability density function (p. d. f.), special cases, M. G. F., C. G. F., moment, cumulants, mode, Relation between distribution function of Poisson and Gamma variates.

Contents(Practical):

1. Finding probabilities of events and cumulative distribution function (c.d.f.),
2. Expectation, expectation of function of r.v. E[g(X)], variance, moments, skewness, kurtosis.
3. Applications of Uniform, Normal, Exponential, Gamma Distributions.
4. Applications of central limit theorem for iidr.v.s with finite variance.

References:

1. Dudewicz, E.J. and Mishra, S.N. (1988). Modern Mathematics Statistics, Wiley.
2. Johnson, S. and Kotz, S. (1972). Distribution in Statistics Vol. I-II & III, Houghton and Mifflin.
3. Lipschutz, S., Lipson, M. L. and Jain, K. (2010). Schaum's Outline of Probability. 2 nd Edition. McGraw Hill Education Pvt. Ltd, New Delhi.
4. Mukhopadhyay, P. (2016). Mathematical Statistics. Books and Allied (P) Ltd.
5. Pitman, J. (1993). Probability. Narosa Publishing House.
6. Rao, C.R. (2009). Linear Statistical Inference and its Applications, 2nd Edition, Wiley Eastern

SEMESTER III

Course Code: BSCHSTSC301
Course Name- Statistical Methods-II

Course Type: **Core (Theoretical & Practical)**	Course Details: **CC-5**			L-T-P: **4-0-4**	
Credit: **6**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

Course Learning Outcomes:

This course will acquaint the students with

a. various basic concepts on sampling distributions and large sample tests based on normal distribution,
b. small sample tests based on chi-square, Student's and Snedecor's F distributions, chi-square test for goodness of fit, test of independence of two attributes.
c. Large-sample tests and confidence intervals.
d. knowledge of two dimensional discrete and continuous random variables, their associated distributions, characteristics, marginal and conditional distributions,
e. inferential knowledge regarding the parameters of Bivariate and Multivariate Normal distributions.

f. practical knowledge on various topics such as small sample and large sample tests, bivariate probability distributions, so that they can apply the relevant concepts to real life problems.

Contents (Theory):

Unit I

Sampling distributions of sample proportion, sample mean and sample variance. Central and non-central Chi-square, t and F distributions. Testing of equality of two means and two variances of two normal distributions, testing for the significance of sample correlation coefficient.

Use of central limit theorem for testing a single mean, single proportion, equality of two means and two proportions, Fisher's Z transformation and its uses, Pearson's chi-square test for goodness of fit, test of independence of two attributes.

Unit II

Logistic and probit analysis with data analytic illustrations. Distribution theory for linear and quadratic forms. Large-sample tests and confidence intervals. Variance stabilizing transformations. Chi-square tests for independence and homogeneity. Data analytic illustrations.

Unit III

Definition of two-dimensional discrete and continuous random variable, joint

p.m.f. and p.d.f., distribution function and properties, concept of identically distributed r.v.s. Computation of probabilities of events in bivariate probability distribution. Concepts of marginal and conditional probability distributions. Definition of raw and central joint moments, joint m.g.f , joint c.g.f.

Unit IV

Theorems on expectation. Conditional expectation and conditional variance, Variance of linear combination of variables. Definition of covariance, coefficient of correlation, independence and uncorrelatedness of two variables. Independence of two random variables, additive property of distribution. Examples and Problems.

Statistical inference for parameters in bivariate normal distribution, Statement of central limit theorem for i. i. d. r.vs with finite positive variance.

Contents (Practical):

1. Computation of covariance, coefficient of correlation, checking for independence and uncorrelatedness of two random variables.

2. Test of significance for correlation coefficient. Fisher's z –transformation.

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

4. Chi-square test for independence of attributes.

5. Student's t test for single mean and difference of means.

6. Computation of probabilities of events in bivariate probability distribution.

7. Finding marginal and conditional probability distributions.

8. Finding raw and central joint moments, joint m.g.f and joint c.g.f.

9. Problems on conditional expectation and conditional variance, Variance of linear combination of variables.

References:

1. Freedman, D., Pisani, R. and Purves, R. (2014). Statistics. 4th Edition. Norton & Comp.

2. Hanagal, D. D. (2009). Introduction to Applied Statistics: A Non-Calculus Based Approach. Narosa Publishing Comp. New Delhi.

3. Kendall, M.G. and Stuart, A. (1979). The Advanced Theory of Statistics, Vol. 2. Inference and Relationship. 4th Edition. Charles Griffin & Comp.

4. Kendall, M.G., Stuart, A. and Ord, J.K. (1994). The Advanced Theory of Statistics, Vol. 1. Distribution Theory. 6th Edition. Halsted Press (Wiley Inc.).

5. Kenney, J.F. and Keeping, E.S. (1947). Mathematics of Statistics. Part I. 2nd Edition. Chapman & Hall.

6. Kenney, J.F. and Keeping, E.S. (1951). Mathematics of Statistics. Part II. 2nd Edition. Chapman & Hall.

7. Tanner, M. (1990). An Investigation for a Course in Statistics. McMillan, New York.

8. Tanur, J.M. (1989) Statistics. A Guide to the Unknown. 3rd Edition, Duxbury Press.

9. Yule, G.U. and Kendall, M.G. (1973). An Introduction to the Theory of Statistics. 14th Edition. Charles Griffin & Comp.

Course Code: BSCHSTSC302
Course Name- Statistical Inference-I

Course Type: **Core** **(Theoretical & Practical)**	Course Details: **CC-6**	L-T-P: **4-0-4**

Credit: **6**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

Course Learning Outcomes*:*

After going through this course, the students will acquire

1. a fundamental understanding of Parametric models for developing relevant inferences on associated parameters,
2. knowledge of point and interval estimation procedures and different methods of point estimation,
3. to understand the Cramer-Rao Inequality, Rao Blackwell and Lehmann Scheffe theorems and their applications in obtaining Minimum Variance Unbiased and Minimum Variance Bound estimators,
4. to work on several standard examples to help them understand the various inherent concepts.
5. practical knowledge on techniques of estimation so that they can apply the relevant concepts to real life problems.

Contents (Theory):

Unit I

Parametric model, parameter, random sample and its likelihood, brief idea of statistics and their sampling distributions Point estimation: Properties of good estimators, mean square and minimum mean square error estimator, unbiasedness and minimum variance unbiased estimator, Cramer-Rao lower bound, amount of information.

Unit II

Consistency of estimators and sufficient conditions for consistency, relative efficiency of an estimator, unbiased estimator, sufficiency, factorization theorem, concept of complete sufficient statistics, Rao-Blackwell and Lehmann Scheffe theorems.

Unit III

Minimum variance unbiased estimators for the parameters of binomial, Poisson and normal families. Cramer-Rao inequality and MVB estimators. Methods of estimation: Moments, maximum likelihood, minimum chi-square, least squares with examples, BAN and CAN estimators.

Unit IV

Point estimators of measures of location, dispersion and other useful parameters. Concepts of confidence interval and confidence coefficient, confidence intervals for the parameters of univariate normal, two independent normal distributions and exponential distributions.

Contents(Practical)

1. Checking the unbiasedness using suitable empirical examples to prove that the sample mean is an unbiased estimator of population mean.

2. Checking the unbiasedness of sample variance and sample mean square as an estimator of population variance.

3. Graphically representing some standard discrete and continuous distributions for different values of their parameters and illustration of how their shapes change.

4. Evaluation of sufficient statistics for some standard distributions.

5. Consistent estimators, efficient estimators, and relative efficiency of estimators.

6. Calculation of UMVUE.

7. Calculating by the method of maximum likelihood for Binomial, Poisson and Normal parameters and obtaining variances of these estimates.

8. Calculation of asymptotic distribution of maximum likelihood estimators.

9. Calculations of Minimum chi-square, Moment estimators for standard distributions.

10. Calculation of Interval estimates, for mean and variance of normal distribution.

References:

1. Bickel, P.J. and Doksum, K.A. (2000). Mathematical Statistics, Second Edition, Prentice Hall.

2. Casella, G. and Berger, R.L. (2001). Statistical Inference, Second Edition, Cengage Learning.

3. Gupta, M.K., Gun, A.M., and Dasgupta, B. (2013). An Outline of Statistical Theory, Vol. 2. The World Press Publishers Pvt. Ltd., Calcutta.

4. Hogg, R.V., McKean J.W. and Craig, A.T. (2006). Introduction to Mathematical Statistics, Paperback Edition, Pearson.

5. Kale, B.K. (2005). A First Course on Parametric Inference. Alpha Science International Ltd.

6. Mood, A.M., Graybill, F.A. and Boes, D.C. (2011). Introduction to the Theory of Statistics, 3rd Edition., (Indian Edition), Tata McGraw-Hill Pub. Co. Ltd.

7. Rajagopalan, M. and Dhanavanthan, P. (2012). Statistical Inference. PHI Learning Pvt. Ltd., New Delhi.

8. Rao, C.R. (2009). Linear Statistical Inference and its Applications, Second Edition, Wiley.

9. Rohatgi, V. K. and Saleh A.K.M.E. (2008). An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern.

Course Code: BSCHSTSC303
Course Name- Linear Algebra

<table>
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<tr><td>Practical</td><td>Theoretical</td><td>Practical</td><td>Theoretical</td></tr>
<tr><td>30</td><td>10</td><td>20</td><td>40</td></tr>
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Course Learning Outcomes*:*

The students shall

1. learn about vector spaces, linear independence of vectors, basis, dimension.
2. linear transformations and matrices, matrix operations, matrices with special structures
3. learn about rank and inverse of a matrix, determinants and elementary matrices.
4. study systems of linear homogeneous and non-homogeneous equations-conditions and methods of solvability.
5. get an idea of quadratic forms of different types and their canonical reduction.
6. get an idea of characteristic roots and vectors.
7. be able to use and apply results in linear algebra to regression techniques and other advanced topics in Statistics, Econometrics, Operations Research, etc.
8. use results in linear algebra to present real-life situations in asystematic form.

Contents (Theory)

Unit I

Definition of vectors, operation of vectors (angle, distance etc.). Vector Spaces over the field of real numbers, subspaces, linear span,linear dependence and independence, dimension and basis and related theorems.Orthogonal vectors, Gram-Schmidt Orthogonalization. Algebra of matrices. Linear transformation. Matrices with special structures: symmetric and skew symmetric, diagonal, scalar, identity, triangular and related theorems. Idempotent and orthogonal matrices. Trace of a matrix. Elementary operations on matrices. Partitioned matrices.

Unit II

Rank and inverse of a matrix and their properties. Null space of a matrix. Theorems on rank of sum and product of two matrices.Singular and non-singular matrices. Inverse of a partitioned matrix. Reduction of matrices to echelon form and Hermite canonical form.

Unit III

System of linear equations**Ax=b-** conditions for consistency, uniqueness of solution, infinite solutions. Solution of the system Ax=b. Applications.Determinants of matrices- Definition, properties and evaluation of determinants of order 3 or above. Cramer's rule for solution of the system Ax=b. Adjoint and inverse of a square matrix.

Unit IV

Properties of Characteristic polynomial of a matrix, characteristic roots and characteristic vectors.Quadratic forms, their classification and canonical reduction.

Contents (Practical)

Problems on

1. operations on vectors, subspaces, linear independence of vectors, basis and Gram-Schmidt orthogonalization process.
2. finding the rank and inverse of a matrix by elementary row operations, transformation of matrices, transforming matrix.
3. evaluation of determinants of matrices.
4. solution of linear system of equations Ax=b by sweep-out method and method of pivotal condensation.
5. finding characteristic roots and vectors of matrices
6. quadratic forms.

References:

1. Artin, M. (1994): Algebra. Prentice Hall of India.
2. Biswas, S. (1997): A Textbook of Matrix Algebra, New Age International
3. Chakraborty, Arnab (2014): Linear Algebra, first edition. Sarat Book House.
4. Datta, K.B (2002): Matrix and Linear Algebra. Prentice Hall of India Pvt. Ltd.
5. Gun,A.M. (1988): Vectors and Matrices, World Press
6. Gupta, S.C. (2008).: An Introduction to Matrices (Reprint). Sultan Chand & Sons.
7. Hadley, G (2002) : Linear Algebra. Narosa Publishing House (Reprint).
8. Rao, A.R. and Bhimasankaram, P. (1996): Linear Algebra
9. Rao, C.R. (2009). Linear Statistical Inference and its Applications, Second Edition, Wiley.
10. Schaum's Outline Series (2006): Linear Algebra, Tata McGraw-Hill Edition, 3rdEdition
11. Searle, S.R (1982).: Matrix Algebra Useful for Statistics. John Wiley &Sons.

Course Code: BSCHSTSSE301
Course Name- Computational Techniques and R Programming

Course Type: SE **(Practical)**	Course Details: SEC-1			L-T-P: 0-0-8	
Credit: 4	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30		20	

***Course Learning Outcomes**:*

This is a Practical Paper. After going through this course, the students will get acquainted with

1. various basic concepts related to computer architecture and its organization, various peripheral devices,
2. languages: machine language, assembly language and high- level languages,
3. ideas on operating systems, linker, loader and compiler etc.,
4. R programming with some basic notions for developing their own simple programs and visualizing graphics in R.

Contents:

Unit I

Computer basics: Introduction and brief history of evolution of computers, Classification of computers: special purpose and general purpose; analog, digital and hybrid; Super, mainframe etc.

Unit II

Organization of general- purpose digital computers: CPU, main memory and peripherals. Mass storage devices and other I/O devices. Computer languages: Machine code language (machine language), assembly language and high-level languages. Software: Operating systems, linker, loader, compiler, interpreter and assembler.

Unit III

Computer programming:Algorithm and flow-chart. Storage of information: concepts of records and files. File organization: sequential, relative and indexed.

Unit IV

Programming with R: Introduction to R, Data types in R (numeric, logical, character, complex etc.), R objects: vector, matrix, array, list, data frame, factor, and time series. Arithmetic, logical and relational operators, explicit and implicit looping, functions and functional programming in R, Lexical scoping rules in R, benefits of Lexical scoping, other scoping rules, debugging facility in R. Few important mathematical, statistical and graphical functions in R.

References:

1. Chambers, J. (2008). Software for Data Analysis: Programming with R, Springer.

2. Crawley, M.J. (2017). The R Book, John Wiley & Sons.

3. Eckhouse, R.H. and Morris, L.R. (1975). Minicomputer Systems Organization, Programming and Applications, Prentice-Hall.

4. Matloff, N. (2011). The Art of R Programming, No Starch Press, Inc.

5. Peter N. (1986). Inside the IBM PC, Prentice-Hall Press

SEMESTER IV

Course Code: BSCHSTSC401
Course Name- Regression Analysis

Course Type: **Core** **(Theoretical & Practical)**	Course Details: **CC-8**			L-T-P: **4-0-4**	
Credit: **6**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

***Course Learning Outcomes**:*

After completion of the course, the students shall

1. know about correlation and regression techniques, the two very powerful tools in statistics,
2. get an idea of Linear, Polynomial and Multiple Linear regression,
3. learn about regression diagnostics, multicollinearity, residual plots and estimation and tests for regression coefficients.
4. study concept of coefficient of determination and inference on partial and multiple correlation coefficients.

Contents (Theory):

Unit I

Correlation: Bivariate data, Scatter diagram and interpretation. Concept of correlation between two variables, positive correlation, negative correlation, no correlation. Covariance between two variables: Definition, computation, effect of change of origin and scale.

Unit II

Karl Pearson's coefficient of correlation (r): Definition, computation for ungrouped data and interpretation. Properties : (i) $-1 \delta r \delta 1$ (with proof), (ii) Effect of change of origin and scale (with proof). Spearman's rank correlation coefficient: Definition, computation and interpretation (without ties), Spearman's rank correlation coefficient (derivation of formula in case of without ties). In case of ties, compute Karl Pearson's correlation coefficient between ranks. (Spearman's rank correlation coefficient formula with correction forties not expected.). Examples and Problems.

Unit III

Linear Regression: Meaning of regression, difference between correlation and regression, simple linear regression model, Estimation of regression parameters by least squares method (fitting of regression model), Interpretation of parameters. Concept of residual, Residual plots, comparison of two models on the basis of residual sum of squares. Regression diagnostics. Tests for regression coefficients. Polynomial regression: Estimation of regression parameters by least squares method, Interpretation of parameters. Concept of residual, Residual plots.

Unit IV

Estimation of regression parameters by least square method, Interpretation of parameters. Determination of appropriate model by plotting Y versus X. Multiple linear regression: Estimation of regression parameters by least square method, Interpretation of parameters. Concept of coefficient of determination. Multicollinearity. Inference on partial and multiple correlation coefficients.

Contents (Practical):

1. Calculation of coefficient of correlation.

2. Calculation spearman rank correlation coefficient.

3. Simple linear regression, residuals, estimate of intercept, regression coefficients.

4. Residual plots, regression diagnostics.

5. Multiple linear regression and regression estimates.

6. Calculation of multiple correlation coefficient.

7. Calculation of partial correlation coefficient.

8. Polynomial regression and regression estimates.

References

1.Draper, N. R. and Smith, H. (1998). Applied Regression Analysis. 3rdEdition. John Wiley.

2. Hosmer, D. W., Lemeshow, S. and Sturdivant R.X. (2013). Applied Logistic Regression, Wiley Blackwell.

3. Montgomery, D. C., Peck, E. A. and Vining, G. G. (2013). Introduction to Linear Regression Analysis. 5th Edition. Wiley.

4. Neter, J., Kutner, M. H., Nachtsheim, C.J. and Wasserman, W. (1996). Applied Linear Statistical Models, 4th Edition, Irwin USA.

Course Code: BSCHSTSC402
Course Name: Statistical Inference-II

Course Type: **Core** **(Theoretical & Practical)**	Course Details: **CC-9**			L-T-P: **4-0-4**	
Credit: **6**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

***Course Learning Outcomes**:*

This course will provide the students with a knowledge of

1. advanced level topics in statistical inference on testing of statistical hypotheses for both randomized and non-randomized tests,
2. using Neyman- Pearson Lemma and finding Uniformly Most Powerful Test,
3. likelihood ratio test and its applications,
4. confidence interval estimation and their relationships with testing,
5. order statistics and their distributions,
6. Wald's Sequential Probability Ratio Test and concepts of ASN and OC functions,
7. Sequential estimation with examples based on standard probability distributions,
8. statistical decision problem including the concept of loss and risk functions, Bayes and Minimax Decision rules.
9. obtaining UMP tests.

Contents(Theory):

Unit I

Statistical hypotheses, critical region, size and power of a test, most powerful test, randomized and non-randomized test, Neyman Pearson lemma and its applications, uniformly most powerful unbiased test, likelihood ratio test and its applications, functions of UMP with simple illustration.

Unit II

Confidence Intervals: Criteria for goodness, pivotal quantities, relationship with tests of hypotheses, illustrations. Theory of order statistics: Formulation of the problems, order statistics and their distributions.

Unit III

Tests and confidence intervals for population quantiles. Estimation of location and scale parameters. Sequential Analysis: Need for sequential tests. Wald's SPRT, ASN, OC function. Brief idea of sequential estimation, examples based on normal, Poisson, binomial and exponential distributions.

Unit IV

Elements of decision problems: Loss function, risk function, estimation and testing viewed as decision problems. Bayes and minimax rules. Examples based on loss function, risk function, estimation and testing problems.

Contents (Practical):

1. Calculation of Type I and Type II error probabilities.

2. Calculation of size of critical region, power of the test for the mean of a normal distribution with known and unknown variance and plotting graph of the power function.

3. Calculation of size of most powerful critical region (NP lemma).

4. Evaluating shortest confidence interval for mean of normal distribution when variance is known/unknown.

5. Evaluating shortest confidence interval for variance of normal distribution when mean is known/unknown.

6. Calculation of power of the test for the Bernoulli distribution with probability (p) in case of simple hypothesis and power curves and plotting the graph of the power function.

7. Calculation of likelihood ratio test (LRT) for simple hypothesis.

8. Calculation of likelihood ratio test (LRT) for composite hypothesis.

9. Calculation of asymptotic properties of LRT.

10. Sequential probability ratio test for the given hypothesis, esp. For Bernoulli trials. Calculation of ASN and OC curve.

References:

1. Bickel, P.J. and Doksum, K.A. (2000). Mathematical Statistics, Second Edition, Prentice Hall.

2. Casella, G. and Berger, R.L. (2001). Statistical Inference, Second Edition, Cengage Learning.

3. D'Abrera, H.J.M. and Lehmann, E. L. (2006). Non-parametrics: Statistical Methods Based on Ranks. Prentice Hall.

4. Gupta, M.K., Gun, A.M., and Dasgupta, B. (2013). An Outline of Statistical Theory, Vol. 2. The World Press Publishers Pvt. Ltd., Calcutta.

5. Hogg, R.V., McKean J.W. and Craig, A.T. (2006). Introduction to Mathematical Statistics, Paperback Edition, Pearson.

6. Kale, B.K. (2005). A First Course on Parametric Inference. Alpha Science International Ltd.

7. Mood, A.M., Graybill, F.A. and Boes, D.C. (2011). Introduction to the Theory of Statistics, 3rd Edition., (Indian Edition), Tata McGraw-Hill Pub. Co. Ltd.

8. Rajagopalan, M. and Dhanavanthan, P. (2012). Statistical Inference. PHI Learning Pvt. Ltd., New Delhi.

9. Rao, C.R. (2009). Linear Statistical Inference and its Applications, Second Edition, Wiley.

10. Rohatgi, V. K. and Saleh A.K.M.E. (2008). An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern.

Course Code: BSCHSTSC403
Course Name: Numerical Analysis and Real Analysis

<table>
<tr><td>Course Type: Core
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100</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
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<tr><td>30</td><td>10</td><td>20</td><td>40</td></tr>
</table>

Course Learning Outcomes*:*

At the end of the course the students shall

1. demonstrate knowledge of different numerical methods, essential for providing Mathematical support to the Statisticians where intractability becomes severe,
2. be able to learn various difference, interpolation formulae, (c) be in a position to find solutions to equations using Bisection, Newton Raphson and Regula Falsi Methods,
3. handle numerical differentiation and integration,

4. be able to find solutions to difference equations of first order and linear difference equations with constant coefficients,
5. haveknowledge about the concepts of real analysis that are necessary for advanced courses in probability and statistics.

Contents(Theory):

Unit I

Numerical Analysis: Factorial with positive and negative index. Operators: Shift operator, forward difference, backward difference, central difference, average, differential and interrelations between them. Finite differences of order n, divided differences of order n and interpolation.

Unit II

Interpolation: Newton's forward, backward and divided difference interpolation formulae with error term. Lagrange's interpolation formula. Central difference formulae: Gauss and Stirling's formulae.

Unit III

Inverse interpolation: Lagrange's inverse interpolation formula, Method of successive approximation and method of reversion of series. Summation of finite series.

Finding Root of an Equation: Bisection, Regula Falsi and Newton Raphson Methods. Numerical differentiation.

Unit IV

Numerical integration: Newton-Cote's integration formula, Trapezoidal rule, Simpson's one-third rule, Simpson's three-eighth rule and Weddle's rule with error term. Euler-Maclaurin's summation formula. Stirling's approximation to factorial n. Solution of difference equations of first order with variable coefficients and linear difference equations with constant coefficients.

Unit V

Introduction to Real Analysis: Bounded and unbounded sets, neighbourhood of a point, Supremum and infimum, Functions, Limit, Continuity, Differentiability, Rolle's theorem, Lagrange mean value theorem, Taylor series, Countable, Uncountable sets and Uncountability of **R**. Sequence and series of real numbers, their convergence.

Unit-VI

Maxima and minima for functions of several variables, Constrained maximization and minimization – use of Lagrange multiplier, Multiple integrals, Transformation of Variables and Jacobian, Polar and Orthogonal transformations.

Contents(Practical):

1. Newton's forward, backward and divided difference interpolation formulae with error term.

2. Lagrange's interpolation formula, Central difference formulae.

3. Lagrange's inverse interpolation.

4. Trapezoidal rule, Simpson's one –third rule and Simpson's three-eighth rule.

5. Weddle's rule with error terms.

6. Stirling's approximation to factorial n.

7. Euler-Maclaurin's summation formula.

8. Solution of difference equations of first order with variable coefficients and linear difference equations with constant coefficients.

References:

1. Bartle, R.G. and Sherbert, I D. R. Introduction to Real Analysis, 3rd Ed., John Wiley and Sons.

2. Berberian, S.K. (1994). A First Course in Real Analysis, Springer Verlag, New York.

3.Bradie, B. (2006). A friendly introduction to Numerical Analysis, Pearson Education, India.

4. Gerald, C. F. and Wheatly, P. O. (2005). Applied Numerical Analysis, Pearson Education, India.

5. Hilderbrand, F.B. (1987). Introduction to Numerical Analysis, Second Edition, Dover Publications.

6. Jain, M.K., Iyengar, S.R. K. and Jain, R.K. (2007). Numerical Methods for Scientific and Engineering Computation, Second Edition, Wiley Eastern Ltd.

7. Krishnamoorthy, E.V. and Sen, S.K. (2001). Numerical Algorithms: computations in Science and Engineering. East West Press, New Delhi.

8. Saxena, H.C. (2005). Finite Differences and Numerical Analysis, 15th Revised Edn. (Reprint). S. Chand & Co.

9. Scarborough, J.B. (1966). Numerical Mathematical Analysis, 6th Edition. Oxford and IBH.

10.Shirali, S. andH. L. Vasudeva (2013). An Introduction to Mathematical Analysis, Alpha Science International Ltd.

11.Thomson, Brian S., Andrew. M. Bruckner and Judith B. Bruckner (2001). Elementary Real Analysis, Prentice Hall.

Course Code: BSCHSTSSE401
Course Name- Computational Statistics and Database Management System

Course Type: SE **(Practical)**	Course Details: SEC-2			L-T-P: **0-0-8**	
Credit: 4	Full Marks: **50**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30		20	

***Course Learning Outcomes**:*

This is a Practical course. It will expose the students to

1. various computational algorithms relevant to statisticians as support system,
2. codes preferably using R language,
3. linear congruential and mid-square methods for uniform generator,
4. inverse transform method for simulating various probability distributions and stochastic models,
5. database management system with special emphasis on significance of topic to the statisticians,
6. entity relationship, Relational, Hierarchical and Network Models,
7. practical assignments on above mentioned topics.

Contents:

Practical exercises are based on the topics mentioned below:

Unit I

Graphical methods with applications: histogram, Quantile based plot (boxplot and Q-Q plot), scatter diagram, time series plot, autocorrelation plot. Computation of the normal integral, Student's t-integral, non-central t integral, Gamma, Beta integral for positive real numbers. Computation of incomplete beta and incomplete gamma integral, computation of Bessel function and modified Bessel fun

Unit II

Generation of uniform random numbers (mid-square method and linear congruential generator). Simulation of probability distributions and stochastic models (Inverse transformation method only). Applications of simulation techniques.

Unit III

Introduction. Purpose of database systems. Database abstraction. Data models. Instances and schemes. Data independence. Data definition and data manipulation languages. Database manager, Administrators and users.

Unit IV

Entity relationship model, Entities and entity sets. Relationships and relationship sets, Attributes, Mapping constraints, Keys, Entity relationship diagram. Reducing E-R diagrams to tables. Aggregation, Design of an E-R database scheme. Relational models. Structure of relational database. Distributed database. Relational algebra. Relational commercial languages. SQL. Relational database design. Query languages and query processing. Crash recovery. Concurrency control. Hierarchical model. Network model.

References:

1. Date, C.J. (1981). Introduction to Database Systems, Addison-Wesley.

2. Kennedy W. J. & Gentle J. E. (1980). Statistical Computing, Marcel Dekker.

3. Korth, H.F. and Silberschatz, A. (2010). Database System Concepts, McGraw-Hill.

4. Ross, S.M. (2012). Simulation. Academic Press.

5. William H. P. and William T. V. (1992). Numerical Recipes in C: The Art of Scientific Computing, Cambridge University Press.

SEMESTER V

Course Code: BSCHSTSC501
Course Name- Sampling Techniques

Course Type: **Core (Theoretical & Practical)**	Course Details: **CC-11**			L-T-P: **4-0-4**	
Credit: **6**	Full Marks:	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

	100				

Course Learning Outcomes*:*

After going through this course, the students will acquire

1. basic knowledge of complete enumeration and sample, sampling frame, sampling distribution, sampling and non-sampling errors, principal steps in sample surveys, limitations of sampling etc.,
2. introduced to various statistical sampling schemes such as simple, stratified, systematic and pps sampling,
3. an idea of conducting the sample surveys and selecting appropriate sampling techniques,
4. knowledge about comparing various sampling techniques.
5. practical knowledge of sampling techniques so that they can apply the relevant concepts to real- life problems.

Contents (Theory):

Unit I

Basic concepts: population and sample, census and sample survey, sampling frame, sampling distribution, standard error, sampling design, sampling and non-sampling errors, sample surveys, principles of sample survey, principal steps in sample survey, limitations of sampling, Sample survey versus complete enumeration survey.

Unit II

Simple Random Sampling (with and without replacement): Notations and terminology, various probabilities of selection. Random numbers tables and its uses. Methods of selecting simple random samples, lottery method, method based on random numbers. Estimates of population total, mean and their variances and standard errors, determination of sample size, simple random sampling of attributes.

Unit III

Probability proportional to size (PPS) sampling- Definition and terminology, cumulative total method and Lahiri's methods of selecting PPS sampling with and without replacement. Systematic sampling:linear systematic sampling, estimates of population total, mean, and their variances and standard errors. Systematic sampling with linear trend. Circular systematic sampling, concepts and examples. Comparison of systematic sampling with simple random sampling.

Unit IV

Stratified random sampling: principles of stratification, notations, estimation of population mean and variances, cost function, allocation techniques, proportional and optimum allocations. Comparison of stratified sampling with simple random sampling.

Contents (Practical):

1. Simple Random Sampling – Lottery, random number method and other related problems, Sample size calculation.

2. Probability Proportional to Size Sampling: Cumulative total method &Lahiri's method.

3. Systematic Sampling – Problems related to Linear and Circular systematic sampling.

4. Problems related to Systematic sampling with Linear Trend.

5. Stratified Random Sampling – Problems related to Different types of allocation.

6. Stratified Random Sampling – Problems related to Optimum allocation and other related problems.

7. Sample size calculations.

References:

1. Ardilly, P. and Yves T. (2006). Sampling Methods: Exercise and Solutions. Springer.

2. Cochran, W.G. (2007). Sampling Techniques. (Third Edition). John Wiley & Sons, New Delhi

3. Des Raj. (1976). Sampling Theory. Tata McGraw Hill, New York. (Reprint 1979)

4. Mukhopadyay, P. (2007). Survey Sampling. Narosa Publisher, New Delhi.

5. Sampath, S. (2005). Sampling Theory and Methods, 2nd Edition, Alpha Science International Ltd.

6. Singh, D. and Choudhary, F.S. (1977). Theory and Analysis of Sample Survey Designs. Wiley Eastern Ltd, New Delhi. (Reprint 1986)

7. Sukhatme, P.V. and Sukhatme, B.V. (1970). Sampling Theory Surveys with Applications (Second Edition). Iowa State University Press.

8. Thompson, S.K. (2012). Sampling. John Wiley & Sons.

Course Code: BSCHSTSC502
Course Name: Statistical Quality Control and Reliability

Course Type: **Core (Theoretical & Practical)**	Course Details: **CC-12**			L-T-P: **4-0-4**	
Credit: **6**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

***Course Learning Outcomes**:*

The students will be able to

1. construct group control chart,
2. draw charts for variables and attributes,
3. draw CUMSUM chart,
4. understand single and double sampling inspection plans, OC and ASN functions,
5. get introduced to notion of censored data, Type I, Type II and random censoring schemes,
6. get an idea of important lifetime distributions such as for exponential, Weibull, gamma and lognormal distributions.
7. compute MLEs of exponential distribution for complete and censored data,
8. compute MLEs of lognormal distributions,
9. compute MLEs of gamma and Weibull distributions using iterative procedure,
10. fit exponential and Weibull distributions for a given lifetime dataset,
11. find interval estimates for the parameters of exponential, Weibull, gamma and lognormal distributions.
12. Test reliability hypotheses for exponential and Weibull distributions,
13. evaluate system reliability for series, parallel, k out of n systems.

Contents(Theory):

Unit I

Introduction to SQC.Quality of a product, need for quality control, basic concept of process control, process capability and product control, general theory of control charts, causes of variation in quality, control limits, sub grouping summary of out of control criteria. Charts for

attributes: p chart, np chart, c-chart, V chart. Charts for variables: R, (Xbar, R), (Xbar, σ) charts. Single and double sampling inspection plans, OC and ASN functions.

Unit II

Life testing and reliability theory: Basic concepts of life testing experiments, reliability, hazard function, mean time to failure and their relationships. Elementary notion of censored data, type I, type II and random censoring schemes, Poisson process.

Unit III

Parametric distributions: exponential, Weibull, gamma, and lognormal as lifetime distributions, point and interval estimation procedures for the above distributions. Testing reliability hypothesis for exponential and Weibull distributions.

Unit IV

System Reliability: Evaluation of reliability function and mean time to system failure for Series, Parallel, k-out of-n, series-parallel, parallel-series and Bridge system configurations.

Contents (Practical):

1. Construction of group control chart.

2. Draw an R chart and a modified R chart.

3. CUMSUM chart.

4. Computation of MLE of exponential, lognormal distributions.

5. Computation of MLE of exponential distribution for censored data.

6. Computation of MLE of Gamma and Weibull distributions using iterative procedure.

7. Fitting of Exponential and Weibull distributions for a given lifetime dataset.

8. Plotting of Survival function and hazard rate function for exponential, Weibull, Gamma and lognormal distributions.

References:

1. Banks, J. (1989). Principles of Quality Control. John Wiley & Sons, New York.

2. Barlow, R. E. and Proschan, F. (1974). Statistical Theory of Reliability and Life Testing Probability Models, Holt Rinehart and Winston.

3. Duncan, A.J. (1974). Quality Control and Industrial Statistics, 4th Edition, Taraporewala& Sons.

4. Montgomery, D.C. (2012). Introduction to the Statistical Quality Control, 7nd Edition, John Wiley & Sons.

5. Schilling, E.G. and Ott, E.R. (1975). Process Quality Control. McGraw Hill.

Course Code: BSCHSTSDSE501
Course Name: Applied Statistics

Course Type: DSE **(Theoretical & Practical)**	Course Details: DSEC-1 & 2			L-T-P: **4-0-4**	
Credit: **6**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

***Course Learning Outcomes**:*

After going through this course, the students will have an idea of

1. income distributions and their fitting in real life situations,
2. making demand projections,
3. construction and uses of price index numbers, and important price index numbers such as CPI, WPI, IIP.
4. commonly used measures of demography pertaining to its three basic aspects, viz. the fertility, mortality and migration,
5. various data collection methods enabling them to have a better insight in policy making, planning and systematic implementation,
6. Construction and implication of life tables,
7. Population growth curves, population estimates and projections,
8. Real data implementation of various demographic concepts as outlined above through practical assignments.

Contents (Theory):

Unit I

Analysis of income and allied size distributions: Pareto and log-normal distributions, genesis, specification and estimation, Lorenz curve, Gini coefficient.

Demand analysis: Classification of commodities, Engel curve analysis using cross-section and time series data, Engel curves incorporating household characteristics, demand projection, specific concentration curves.

Index numbers:Definition of index numbers, price and quantity index numbers; their construction, Laspeyres', Paasche's and Fisher's index numbers. Value index. Tests of index numbers. Fixed-base and chain-base index numbers. Consumer price index number, Wholesale price index number and index of industrial production. Uses of price index numbers.

Unit II

Sources of demographic data, census, registration, ad hoc surveys, hospital records, demographic profiles of the Indian census. Measurement of Mortality and Life Table: Crude death rate, Standardized death rates, Age-specific death rates, Infant Mortality rate, Death rate by cause, Complete life table and its main features, Uses of life table.

Unit III

Measurement of Fertility: Crude birth rate, general fertility rate, age specific birth rate, total fertility rate, gross reproduction rate, net reproduction rate. Rates and ratios. Measures of mortality. Life Table – construction and applications.

Unit IV

Stable and stationary population. Measures of fertility and reproduction. Indian data. Standardization of vital rates. Population growth curves, population estimates and projections. Measures of migration. Use of demographic data for policy formulation.

Contents (Practical):

1. Fitting of Engel curves and calculation of income elasticity of demand.

2. Fitting of Pareto's law for income distribution for a given Income dataset, for entire range as well as specific range.

3. Fitting of a Lorenz curve for a given Income dataset and computation of the concentration ratio using graphical method.

4.Exercises in index numbers.

5 Calculation of Crude birth rate; General fertility rate; Age specific fertility rate; Total fertility rate; Gross reproduction rate; Net reproduction rate.

6 Calculation of Infant mortality rate, Crude death rate, Age specific death rates.

7. Computation of standardized birth and death rates.

8. Construction of life tables.

9. Population growth curves, population estimates and projections.

References:

1. Allen, R.G.D. Allen (1975).Index Numbers in Theory and Practice. Macmillan.
2. Benjamin, B. (1959). Health and Vital Statistics. Allen and Unwin.
3. Cramer, J.S. (1969). Empirical Econometrics. North Holland Pub. Co.
4. Karmel, P.H. and Polasek, M. (1957). Statistics for Economists. Pitman Publishing.

5. Klein, L.R. (1962). An Introduction to Econometrics. Prentice Hall.

6. Mishra, B.D. (2004). An Introduction to the Study of Population. South Asian hers

7.Mudgett, B.D.(1951). Index Numbers. John Wiley.

8. Mukhopadhyay, P. (1994). Applied Statistics. New Central Book Agency Pvt. Ltd.

Calcutta.

9. Ramkumar, R. (1986). Technical Demography. John Wiley & Sons.

10. Srinivasan, K. (1998). Demographic Techniques and Applications. Sage Publications.

11. Srivastava O.S. (1983). A TextBook of Demography. Vikas Publishing House.

12. Shryock, H.S. (1971). The Methods and Materials in Demography. U.S. Bureau of Statistics

Course Code: BSCHSTSDSE502
Course Name: Time Series Analysis

<table>
<tr><td>Course Type: DSE
(Theoretical & Practical)</td><td colspan="2">Course Details: DSEC-1 & 2</td><td colspan="2">L-T-P: 4-0-4</td></tr>
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<tr><td>30</td><td>10</td><td>20</td><td>40</td></tr>
</table>

Course Learning Outcomes*:*

This course is meant to acquaint the students with some important but useful concepts on topics in time series analysis so that the students can get an important background material for taking up an advanced course in financial econometrics and data analysis. After completion of this course, the students will know about

1. time series data, its applications to various fields and components of time series,
2. fitting and plotting of various growth curves such as modified exponential, Gompertz and logistic curve,
3. fitting of trend by Moving Average method,
4. measurement of Seasonal Indices by Ratio-to-Trend, Ratio-to-Moving Average and Link Relative methods,
5. calculation of variance of random component by variate component method,
6. forecasting by exponential smoothing and short term forecasting methods such as Box Jenkins Method and Bayesian forecasting,
7. weak stationarity, autocorrelation and correlogram,
8. applications to real data by means of laboratory assignments.

Contents (Theory):

Unit I

Introduction to times series data, application of time series from various fields, Components of a times series, Decomposition of time series. Trend: Estimation of trend by free hand curve method, method of semi averages, fitting various mathematical curves, and growth curves.

Unit II

Trend Cont.: Method of moving averages. Detrending. Effect of elimination of trend on other components of the time series. Seasonal Component: Estimation of seasonal component by Method of simple averages, Ratio to Trend.

Unit III

Seasonal Component cont.: Ratio to Moving Averages and Link Relative methods. Deseasonalization. Cyclic Component: Harmonic Analysis. Some Special Processes: Moving-average (MA) process and Autoregressive (AR) process of orders one and two, Estimation of the parameters of AR (1) and AR (2) – Yule-Walker equations.

Unit IV

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

Contents (Practical):

1. Fitting and plotting of modified exponential curves.

2. Fitting and plotting of Gompertz curve.

3. Fitting and plotting of logistic curves.

4. Fitting of trend by Moving Average method.

5. Measurement of Seasonal Indices Ratio-to-Trend method.

6. Measurement of Seasonal Indices Ratio-to-Moving Average method.

7. Measurement of seasonal indices Link Relative method.

8. Calculation of variance of random component by variate difference method.

9. Forecasting by exponential smoothing.

10. Forecasting by short term forecasting methods.

References:

1. Box, G.E.P., Jenkins, G.M., Reinsel, G.C. and Ljung, G.M. (2015). Time Series Analysis: Forecasting and Control. 5th Edition. John Wiley & sons, Inc.

2. Brockwell, P.J. and Davis, R.A. (2003). Introduction to Time Series Analysis. Springer.

3. Chatfield, C. (2001). Time Series Forecasting., Chapman & Hall.

4. Fuller, W.A. (1996). Introduction to Time Series. 2nd Edition. Wiley.

5. Kendall, M.G. and Ord, J.K. (1990). Time Series. 3rd edition. Edward Arnold.

6. Montgomery, D.C., Jennings, C.L. and Kulahci, M. (2012). Introduction to Time Series Analysis and Forecasting, John Wiley.

7. Mukhopadhyay, P. (2011). Applied Statistics, 2nd ed. Revised reprint, Books and Allied Pvt. Ltd

Course Code: BSCHSTSDSE503
Course Name: Econometrics

<table>
<tr><td>Course Type: DSE
(Theoretical & Practical)</td><td colspan="2">Course Details: DSEC-1 & 2</td><td colspan="2">L-T-P: 4-0-4</td></tr>
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<tr><td>30</td><td>10</td><td>20</td><td>40</td></tr>
</table>

Course Learning Outcomes*:*

Thecourseoneconometricswillprimarilyfocusontheuseofstatisticalmodellingandthe

relevantanalysestoeconomicdataproblems.Thestudentswillgetathoroughideaof

(a) variousimportanteconometricmodelsandrelevantmodelbuildingconce pts ineconometrics
(b) general linear models and estimation of inherent modelparameters
(c) multicollinearity,itsdetectionandconsequencesandrelatedinferentialaspects
(d) someadvancedconceptsofgeneralisedleastsquaresestimation,autocorrelati on, itsconsequences,detectionandstrategyforreducingautocorrelation,
(e) heteroscedasticityanditsinherentconceptsincludingitsconsequences,
(f) some inferential aspects onheteroscedasticity,
(g) practical aspects and real data illustration of the related problems.

Contents (Theory):

Unit I

Introduction:Objectivebehindbuildingeconometricmodels,natureofeconometrics,mod el building, role of econometrics, structural and reduced forms. General linear model (GLM). Estimation under linearrestrictions.

Unit II

Multicollinearity: Introduction and concepts, detection of multicollinearity, consequences, tests and solutions of multicollinearity, specification error.

Unit III

Generalized least squares estimation, Aitken estimators. Autocorrelation: concept, consequences of auto correlated disturbances, detection and solution of autocorrelation.

Unit IV

Heteroscedastic disturbances: Concepts and efficiency of Aitken estimator with OLS estimator under heteroscedasticity. Consequences of heteroscedasticity. Tests and solutions of heteroscedasticity. Autoregressive and Lag models, Dummy variables, Qualitative data.

Contents (Practicals):

1. Problems based on estimation of General linearmodel.
2. Testing of parameters of General linearmodel.

3. Forecasting of General linearmodel.
4. Problems concerning specificationerrors.
5. Problems related to consequences ofMulticollinearity.
6. Diagnostics ofMulticollinearity.
7. Problems related to consequences of Autocorrelation(AR(I)).
8. Diagnostics ofAutocorrelation.
9. EstimationofproblemsofGenerallinearmodelunderAutocorrelation.
10. Problems related to consequencesHeteroscedasticity.
11. Diagnostics ofHeteroscedasticity.
12. EstimationofproblemsofGenerallinearmodelunderHeteroscedasticdistanceterms.
13. ProblemsrelatedtoGenerallinearmodelunder(AitkenEstimation).
14. Problems on Autoregressive and Lagmodels.

References:

1. Gujarati,D.andSangeetha,S.(2007).BasicEconometrics,4thEdition,McGrawHi ll Companies.
2. Johnston,J.(1972).EconometricMethods,2ndEdition,McGrawHillInternational.
3. Koutsoyiannis,A.(2004).TheoryofEconometrics,2ndEdition,PalgraveMacmil lan Limited.
4. Maddala,G.S.andLahiri,K.(2009):IntroductiontoEconometrics,4thEdition,Jo hn Wiley &Sons.

SEMESTER VI

Course Code: BSCHSTSC601
Course Name– Design of Experiments

Course Type: **Core (Theoretical & Practical)**	Course Details: **CC-13**			L-T-P: **4-0-4**	
Credit: **6**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

Course Learning Outcomes*:*

The students will be in a position to

1. carry out one- way and two way- Analysis of Variance (ANOVA),
2. understand the basic terms used in design of experiments,
3. use appropriate experimental designs to analyse the experimental data,
4. analyse 2^2 and 2^3 factorial experiments,
5. apply Multiple range tests, the LSD test or the multiple t–test, Student-Newman-Keuls test, Duncan's multiple range test, Tukey's test, Multiple F tests, Fisher's least significant difference test, Scheffe's test,
6. visualize the scope of experimental designs in getting valid and efficient results.
7. decide to select an appropriate experimental design and analyse the same to give statistical interpretation of the experimental results obtained

Contents (Theory):

Unit I

Analysis of variance: Definition, assumption for ANOVA test, one-way and two-way classifications for fixed effect model with one observation per cell. Introduction to design of experiments: terminology, experiment, treatment, experimental units, blocks, experimental error, replication, precision and accuracy, need for design of experiment, size and shape of plots and blocks.

Unit II

Fundamental principles of design of experiments: Randomization, Replication and Local control. Completely randomized design (CRD), Randomized Complete Block Design (RCBD), Latin square design (LSD) and their layout and analyses. Missing plot technique for RCBD and LSD, missing plot techniques for one observation per cell in RCBD. Analysis of covariance in CRD and RCBD with one concomitant variable: concepts and examples, transformations.

Unit III

Multiple range tests, the LSD test or the multiple t – test, Student-Newman-Keuls test, Duncan's multiple range test, Tukey's test, comments on multiple range tests. Multiple F tests, Fisher's least significant difference test, Scheffe's test, comments on multiple F tests.

Unit IV

Factorial experiments:Definition, advantages and limitations, main effects and interaction effects, concepts of 22 and 23 factorial experiments, Yate's procedure for computation of factorial effect totals and their analyses.

Contents (Practical):

In all the practical exercises, description of each method and interpretation of the results are important.

1. One-way analysis of variance, Multiple range tests – The LSD test or the multiple t – test, Student-Newman-Keuls test, Duncan's multiple range test, Tukey's test.

2. Multiple F tests- Fisher's least significant difference test, Scheffe's test, Comments on multiple F tests.

3. Completely Randomized Design (CRD), Randomized Complete Block Design (RCBD) – methods, analysis and interpretation.

4. Latin Square Design – methods, analysis and interpretation.

5. Analysis of covariance in CRD and RCBD.

6. Missing plot technique (single value) in RCBD.

7. Data Transformation – Logarithmic, Square-Root and ArcSine.

8. Analysis and Interpretations of 2^2 and 2^2 factorial experiment using Yate's procedure.

References:

1. Cochran, W. G. and Cox, G. M. (1957). Experimental Design. John Wiley & Sons, New York.

2. Das, M. N. and Giri, N. S. (1986). Design and Analysis of Experiments (2nd Edition). Wiley.

3. Dean, A. and Voss, D. (1999). Design and Analysis of Experiments. Springer-Verlag, New York.

4. Federer, W.T. (1955). Experimental Design: Theory and Applications. Oxford & IBH Publishing Company, Calcutta, Bombay and New Delhi.

5. Joshi, D.D. (1987). Linear Estimation and Design of Experiments. New Age International (P) Ltd. New Delhi.

6. Montgomery, D.C. (2017). Design and analysis of Experiments, 9th Edition. John Wiley & Sons.

Course Code: BSCHSTSC602

Course Name– Non-Parametric Inference

Course Type: **Core** **(Theoretical & Practical)**	Course Details: **CC-14**			L-T-P: **4-0-4**	
Credit: **6**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

***Course Learning Outcomes**:*

This course will help the students to

1. use different nonparametric/distribution-free tests when data don't meet the assumptions of parametric tests,
2. understand importance of different non-parametric test procedures, their applications and interpretation,
3. toanalyse data using various non-parametric tests.
4. analyse categorical data using logistic regression models.

Contents (Theory):

Unit I

Introduction, concepts of nonparametric/distribution free method one-sample case:Binomial test, Chi-Square Goodness-of-fit test, Kolmogorov–Smirnov one sample test, One-sample runs test for randomness, sign test, Wilcoxon's signed rank test, theory and applications.

Unit II

Two-sample case: median test, Wilcoxon-Mann-Whitney test, Mood test, Freund-Ansari test, Kolmogorov–Smirnov two-sample test, Siegel-Tukey test for scale differences, theory & applications. Unit III

The Cochran Q test for k related samples: Friedman test by ranks, extended median test, Kruskal-Wallis one-way analysis of variance by ranks, Jonckheere test for ordered alternatives. Theory and applications of these tests.

Unit IV

Concept of Indicator Variables, categorical data analysis, logistic regression models, models with binary response. Theory and Applications

Contents (Practical):

(*In all the practical exercises, description of each method and interpretation of the results are important*.)

1. Single-sample case – Binomial test, Chi-Square goodness-of-fit test, The Kolmogorov – Smirnov one sample test.

2. The one-sample runs test for randomness – The Sign test – Wilcoxons Signed Rank Test.

3. Two-Sample Case – Median test, Wilcoxon-Mann-Whitney U-test, Mood test, Freund-Ansari test. 4. Kolmogorov – Smirnov two-sample test, Siegel-Tukey test for scale differences.

5. The Cochran Q test for k related samples, Friedman test by ranks, extended median test.

6. Kruskal-Wallis One-Way Analysis of variance by ranks.

7. Jonckhreere test for ordered alternatives. Theory and applications of these tests.

8. Logistic Regression Model. References: As specified in CC-8

References:

1. Cochran, W. G. and Cox, G. M. (1957). Experimental Design. John Wiley & Sons, New York.

2. Das, M. N. and Giri, N. S. (1986). Design and Analysis of Experiments (2nd Edition). Wiley.

3. Dean, A. and Voss, D. (1999). Design and Analysis of Experiments. Springer-Verlag, New York.

4. Federer, W.T. (1955). Experimental Design: Theory and Applications. Oxford & IBH Publishing Company, Calcutta, Bombay and New Delhi.

5. Joshi, D.D. (1987). Linear Estimation and Design of Experiments. New Age International (P) Ltd. New Delhi.

6. Montgomery, D.C. (2017). Design and analysis of Experiments, 9th Edition. John Wiley & Sons.

Course Code: BSCHSTSDSE601
Course Name– Clinical Trials and Epidemiology

Course Type: **DSE** **(Theoretical & Practical)**	Course Details: **DSEC-3 & 4**			L-T-P: **4-0-4**	
Credit: **6**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

Course Learning Outcomes:

The course is of applied nature and will provide the students with

(a) the basic idea of various terminologies in epidemiology, clinical trial experiments involving different phases etc.,

(b) the ethics, principles and conduct of clinical trial experiments with an overall view of Phase I-IV trials,

(c) various data management and data collection systems for a good clinical trial practice,

(d) population pharmacokinetics and pharmacodynamics models applicable in clinical trials,

(e) various clinical trial designs commonly employed in practice,

(f) design and monitoring of Phase III trials with various stopping rule, the inferential aspects including classical methods of interval estimation and hypothesis testing etc.,

(g) design and analysis of epidemiological studies including case-control and cohort study designs, (h) sufficient practical knowledge by means of laboratory assignments on different types of real life data sets.

Contents (Theory):

Unit I

Introduction to clinical trials: the need and ethics of clinical trials, bias and random error in clinical studies, conduct of clinical trials, overview of Phase I – IV trials, multicentre trials. Data management: data definitions, case report forms, database design, data collection systems for good clinical practice. Bioavailability, bioequivalence, area under curve, rate of absorption of drug, rate of elimination, maximum concentration of drug and time of maximum concentration of drug. Pharmacokinetics and pharmacodynamics.

Unit II

Design of clinical trials: parallel group versus cross-over designs; cross-sectional versus longitudinal designs, wash-out period, control arms, single arms, active control, placebo; observational trials: prospective, retrospective; case-control, matching, cohort studies, quantitative methods in screening.

Unit III

Design and monitoring of phase III trials with sequential stopping, design of bioequivalence trials. Inference for 2X2 crossover design, classical methods of interval hypothesis testing for bioequivalence. Introduction to Meta-analysis of clinical trials. Introduction to modern epidemiology, principles of epidemiologic investigation, surveillance and disease monitoring in populations.

Unit IV

Epidemiologic measures: organizing and presenting epidemiologic data, measure disease frequency, measures of effect association, causation and causal inference. Design and analysis of epidemiologic studies: types of studies, case-control studies, cohort studies, quantitative methods in screening.

Contents (Practical):

1. Data preparation, cleaning and obtaining summary measures from clinical data.

2. Computation of odds ratio, Attributable Risk, risk ratio and relative risk.

3. Computation of bioavailability, bioequivalence, area under curve, rate of absorption of drug, rate of elimination, maximum concentration of drug and time of maximum concentration of drug.

4. Calculation of test of significance of cross-over effects, treatments effects and sequence of treatment effects.

5. Systematic representation of epidemiological data using statistical packages.

6. Computation of disease frequency.

7. Calculation of effect association of disease using various measures.

8. Calculation of causation and causal inference for given epidemiological data.

References:

1. Chow, S.C. and Liu, J.P. (2004). Design and Analysis of Clinical Trials. 2nd Edition. Marcel Dekker.

2. Chow, S.C. and Liu, J.P. (2009). Design and Analysis of Bioavailability and Bioequivalence. 3rd Edition. CRC Press.

3. Fleiss, J.L. (1989). The Design and Analysis of Clinical Experiments. Wiley and Sons.

4. Friedman, L.M., Furburg, C. and Demets, D.L. (1998). Fundamentals of Clinical Trials. Springer.

5. Jekel, J.F., Elmore, J.G. and Katz, D.L. (1996). Epidemiology, Biostatistics and Preventive Medicine. WB Saunders Co.

6. Jennison, C. and Turnbull, B.W. (1999). Group Sequential Methods with Applications to Clinical Trials. CRC Press.

7. Marubeni, E. and Valsecchi, M.G. (1994). Analyzing Survival Data from Clinical Trials and Observational Studies. Wiley and Sons.

8. McNeil, D. (1996). Epidemiological Research Methods, Wiley and Sons.

9. Piantadosi, S. (1997). Clinical Trials: A Methodologic Perspective. Wiley and Sons.

10. Rothman, K.J. and Geenland, S. (1988). Modern Epidemiology. Lippincott-Raven.

11. Selvin, S. (1996). Statistical Analysis of Epidemiologic Data. Oxford University Press.

Course Code: BSCHSTSDSE602
Course Name – Survival Analysis

<table>
<tr><td>Course Type: DSE
(Theoretical & Practical)</td><td colspan="2">Course Details: DSEC-3 & 4</td><td colspan="2">L-T-P: 4-0-4</td></tr>
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100</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
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<tr><td>30</td><td>10</td><td>20</td><td>30</td></tr>
</table>

Course Learning Outcomes:

Thecoursegivestheapplicationofstatisticsinhandlingsurvivaldata.Thestudentswillknow about conceptsof

(a) Type-I (time), Type-II (order) and randomcensoring,
(b) SurvivalFunction,Failurerate,meanresiduallife,TotaltimeonTest,

(c) applicationsofexponential,gamma,Weibulldistributions,lognormal,Pareto,linear failure rate distributions to lifetimedata,

(d) ageingpropertiesofIFR,IFRA,DMRL,NBU,NBUEandHNBUEandDualclasses.

(e) Actuarial and Kaplan –Meier estimator of survivalfunction,

(f) Cox's proportional hazards and competing riskmodels,

(g) tests forexponentiality,

(h) Reallifetimedataimplementationofvariousconceptsasoutlinedabovethrough practicalassignments.

Contents (Theory):

Unit I

Concepts of Type-I (time), Type-II (order) and random censoring, Survival Function, Failurerate, mean residual life and their elementary properties. Total time on Test, bathtub failure rate.Life distributions: exponential, gamma, Weibull, lognormal, Pareto, linear failure rate.

Unit II

Ageingclasses(IFR,IFRA,DMRL,NBU,NBUEandHNBUE)andtheirproperties,Dual classes, Interrelations between different ageingclasses.

Unit III

Estimation of survival function – Actuarial estimator, Kaplan –Meier estimator, Cox's proportional hazards model, competing risks model.

Unit IV

DefinitionofUstatistics,testsforexponentialityversuspositiveageingclasssuchasIFR, IFRA,NBU.

Contents (Practical):

1. ExamplesofType-I(time),Type-II(order)andrandomcensoring.
2. FindingSurvivalFunction,Failurerate,meanresiduallife,TotaltimeonTest.
3. Applications of exponential, gamma, Weibulldistributions.
4. Applications of lognormal, Pareto, linear failure ratedistributions.
5. Problemsonageingproperties,IFR,IFRA,DMRL,NBU,NBUEandHNBUE and Dualclasses.

6. ExamplesforActuarialestimatorandKaplan–Meierestimatorofsurvivalfunction.
7. Applications of Cox's proportional hazardsmodel.
8. Applications of competing risksmodel.
9. Tests forexponentiality.

References:

1. Cox,D.R.andOakes,D.(1984).AnalysisofSurvivalData.TaylorandFrancis.
2. Crowder, M. J.(2001).Classical Competing Risks. Chapman &Hall/CRC Press, London.
3. Deshpande, J. V. and Purohit, S.G. (2015). Lifetime Data: Statistical Models and Methods. 2nd Edition. WorldScientific.
4. Gross,A.J.&Clark,V.A.(1976).SurvivalDistributions-ReliabilityApplicationsin Bio- medical Sciences. John Wiley andSons.
5. Hanagal,D.D.(2011).ModelingSurvivalDataUsingFrailtyModels.Chapman & Hall. NewYork.
6. Kalbfleisch, J.D. and Prentice, R.L. (1980). The Statistical Analysis of Failure TimeData.John Wiley and Sons.
7. Miller,R.G.(1998).SurvivalAnalysis.SecondEdition.WileyInterscience.

Course Code: BSCHSTSDSE603
Course Name – Project Work

Course Type: **DSE (Practical)**	Course Details: **DSEC-3 & 4**			0-0-12	
Credit: **6**	Full Marks: **100**	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		60		40	

Course Learning Outcomes:

At the end of this project, students will be in a position to

1. analyse and interpret and take appropriate decisions in solving real life problems using statistical tools.
2. use different Statistical packages for graphical interface, data analysis and interpretation,

3. write a systematic Statistical project report.

Contents:

Students will opt for a compulsory industrial/ socio-economic/ health-related Project in Semester VI. A copy of rules and regulations regarding completion and submission of the project work by a student and assessment of the project work to make available in the Department of Statistics in each university. Students should use advanced statistical tools in their project and submit the dissertation at the end of the semester. There will be subsequent presentations and seminars by the students along with project supervisor, internal subject expert and Head of the Department. The grades on the presentation and evaluation of the project will be given by the subject expert and project supervisor allotted to the student. The project has to be completed within a semester.

K A Z I N A Z R U L U N I V E R S I T Y

ASANSOL-713 340, PASCHIM BARDHAMAN

WEST BENGAL

Pool of Generic elective in Statistics

[Students of a Particular Honours department will choose one Generic Elective Paper of any other existing Honours Department except his/her Department from the pool provided below]

Semester I

Course Code: BSCHSTSGE101

Course Name: Introduction to Statistics

Course Type: **GE** **Theory & Practical**	Course Details: GE-1			L-T-P: **4-0-4**	
Credit: **6**	Full Marks: 100	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

Course Learning Outcomes:

The student will acquire the knowledge of

1. various techniques used in summarization, presentation and analysis of different types of Statistical data,
2. various summary measures of central tendency, dispersion, moments, skewness and kurtosis.
3. simple and rank correlation, Partial and Multiple correlation coefficients up to three variables.
4. fitting of linear and quadratic regressions using principle of least squares.
5. measures of association for 2 x 2 and r x s contingency tables.
6. have knowledge on theoretical as well as practical approach.

Contents (Theory):

Unit I:

Introduction: Definition and scope of Statistics, concepts of statistical population and sample. Scales of measurement -nominal, ordinal, interval and ratio. Variables and attributes, Diagrammatical Representation of Data, Summarization of Data: Frequency Distribution and Graphical Presentation.

Unit II:

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

Unit III:

Bivariate data: Definition, scatter diagram, simple correlation, rank correlation. Trivariate Data: Partial and Multiple correlation coefficients.

Unit IV:

Fitting of linear and quadratic regression using principle of least squares. Theory of attributes and consistency of data, independence and association of attributes, measures of association and contingency for 2 x 2 contingency tables.

Contents (Practical):

1. R programming, importing and exporting data, R functions, loops, conditional statements, Rgraphics.

2. Diagrammatical representation of data, Summarization of data: Frequency
3. Distribution and graphical Presentation.
4. Measures of central tendency: mathematical and positional.
5. Measures of dispersion: range, quartile deviation, mean deviation, standard
6. Deviation, coefficient of variation, moments, measures of skewness and kurtosis.
7. Scatter diagram, simple correlation, rank correlation.
8. Partial and Multiple correlation coefficients.
9. Fitting of linear and quadratic regression using principle of least squares.
10. Measures of association for 2 x 2 contingency tables.

References:

1. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2013). Fundamental of Statistics, Vol I, World Press, Kolkata.
2. Hanagal, D. D. (2009). Introduction to Applied Statistics: A Non-Calculus Based Approach. Narosa Publishing Comp. New Delhi.
3. Miller, I. and Miller, M. (2006). John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
4. Mood, A.M. Graybill, F.A. and Boes, D.C. (2011). Introduction to the Theory of Statistics, 3rd Edn., (Indian Edition), Tata McGraw-Hill Pub. Co. Ltd.
5. Larry Gonick , Woollcott Smith: The Cartoon Guide to Statistics***(4th edition).***

Semester II

Course Code: BSCHSTSGE201

Course Name: Introduction to Probability Theory and Distributions

Course Type: **Theory & Practical**	Course Details: GE-2			L-T-P: **4-0-4**	
Credit: **6**	Full Marks: 100	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

Course Learning Outcomes:

The students will get to know about

1. writing of sample space, events and algebra of events and finding Probability of events, conditional Probability and applications of Theorem of total probability and Bayes'Theorem.
2. Discrete and continuous Random Variables, Probability mass function (p.m.f.) and Probability density function (p.d.f.), Cumulative distribution function (c.d.f.)
3. Expectation, variance, moments and moment generating function.
4. problem solving pertaining to binomial, Poisson, geometric, negative binomial, hypergeometric, uniform, normal, exponential, beta, gamma distributions.
5. fitting of Binomial, Poisson and Normal distributions
6. Chebyshev's inequality, Convergence in probability, Weak law of large numbers, Convergence in distribution, De-Moivre Laplace and Lindeberg-Levy Central Limit Theorems (C.L.T.),
7. various aspects as outlined above through practical assignments.

Contents (Theory):

Unit I :

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

Unit II :

Random Variables: Discrete and continuous random variables, Probability mass function(p.m.f.), Probability density function (p.d.f.), Cumulative distribution function (c.d.f.)
Illustrations of random variables and their properties. Expectation, variance, moments and moment generating function.

Unit III :

Standard probability distributions: Binomial, Poisson, geometric, negative binomial, hypergeometric, uniform, normal, exponential, beta, gamma and their applications. Fitting of Binomial, Poisson and Normal Distributions

Unit IV :

Chebyshev's inequality, Convergence in probability, Weak law of large numbers, Convergencein Distribution, De-Moivre Laplace and Lindeberg-Levy Central Limit Theorems (C.L.T.).

Contents (Practical):

1. Fitting of Binomial distribution.
2. Fitting of Poisson distribution.
3. Fitting of Normal distribution.
4. Fitting of Exponential distribution.

References:

1. Hanagal, D. D. (2009). Introduction to Applied Statistics: A Non-Calculus Based Approach. Narosa Publishing Comp. New Delhi.
2. Hogg, R.V., Tanis, E.A. and Rao J.M. (2009). Probability and Statistical Inference, Seventh Ed, Pearson Education, New Delhi.
3. Meyer, P.L. (1970). Introductory Probability and Statistical Applications, Oxford & IBH Publishing, New Delhi.
4. Miller, I. and Miller, M. (2006). John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
5. Rohatgi, V. K. and Saleh A.K.M.E. (2008). An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern.

Semester III

Course Code: BSCHSTSGE301

Course Name: Introduction to Statistical Inference

Course Type: **Theory & Practical**	Course Details: GE-3			L-T-P: **4-0-4**	
Credit: **6**	Full Marks: 100	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

Course Learning Outcomes:

The students will get an exposure to

1. techniques of estimation and testing of hypotheses for mean, variance, proportions, correlation coefficient, association and goodness of fit, confidence intervals for the parameters of a normal distribution (one and two-sample problems),

2. Test of significance for correlation coefficient, Fisher's z –transformation, Tests of proportions, tests of association and goodness-of-fit using Chi-square test, Yates' correction,
3. Analysis of variance technique for one and two way classifications.
4. Analysis of commonly used experimental designs such as CRD, RCBD etc.,
5. Non-parametric tests such as Sign test for median and symmetry, Wilcoxon twosampletest,
6. Practical applications through laboratory assignments.

Contents (Theory):

Unit I:

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

Unit II:

Test of significance for correlation coefficient. Fisher's z –transformation,Categorical data: Tests of proportions, tests of association and goodness-of-fit using Chisquaretest, Yates' correction.

Unit III:

Analysis of variance, one-way and two-way classifications. Brief exposure of three basicprinciples of design of experiments, treatment, plot and block. Analysis of completelyrandomized design, randomized complete block design.

Unit IV:

Basic idea of non-parametric tests, sign test for median, sign test for symmetry, Wilcoxon two-sample test.

Contents (Practical):

1. Estimation of population means,
2. Finding confidence intervals for the parameters of a normal distribution (one and twosample problems).
3. Tests of hypotheses for the parameters of a normal distribution (one and two-sample problems).
4. Test of significance for correlation coefficient, Fisher's z –transformation.
5. Tests of proportions, tests of association and goodness-of-fit using Chi-square test, Yates' correction.
6. Analysis of variance (one-way and two-way classifications).

7. Sign test for median and sign test for symmetry.
8. Wilcoxon two-sample test.

References:

1. Chap, T.L. and Eberly, L.E. (2016). Introductory Biostatistics. Wiley.
2. Daniel Wayne W. and Cross, C.L. (2013). Bio-statistics: A foundation for Analysis in the Health Sciences. John Wiley.
3. Das, M.N. and Giri, N.C. (1986). Design and analysis of experiment, Second Edition. John Wiley.
4. Dunn, O. J. and Clarke V.A. (2009). Basic Statistics: A Primer for the Biomedical Sciences, Fourth Edition. John Wiley.
5. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2013). Fundamental of Statistics, Vol I. World Press, Kolkata.
6. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2011). Fundamental of Statistics, Vol II. World Press, Kolkata.
7. Hanagal, D. D. (2009). Introduction to Applied Statistics: A Non-Calculus Based Approach. Narosa Publishing Comp. New Delhi.
8. Pagano, M. and Gauvreau, K. (2018). Principles of Biostatistics, Second Edition. Chapman and Hall/CRC.

Semester IV

Course Code: BSCHSTSGE401

Course Name: Introduction to Applied Statistics

Course Type: **Theory & Practical**	Course Details: GE-4			L-T-P: **4-0-4**	
Credit: **6**	Full Marks: 100	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		30	**10**	20	**40**

Course Learning Outcomes:

The course will expose the students to

1. time series, index numbers, quality control and demographic methods, different methods of measurements in time series
2. computation of different types of index numbers, consumer price index number,
3. quality control charts for variables and attributes helpful in industry for maintaining quality,
4. measures of fertility and mortality useful for helping the govt. to make decisions,

5. practical applications of the various concepts outlined above.

Contents (Theory):

Unit I :

Economic Time Series: Component of time series, Decomposition of time series-Additiveand multiplicative models with their merits and demerits, Illustrations of time series.Measurement of trend by method of free-hand curve. Method of semi-average and method ofleast squares (linear, quadratic and modified exponential) Measurement of seasonal variationsby method of ratio to trend.

Unit II:

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

Unit III:

Statistical Quality Control: Importance of statistical methods in industrial research andpractice. Determination of tolerance limits. Causes of variations in quality: chance andassignable causes. General theory of control charts, process & product control, control chartsfor variables: $\bar{}$and R-charts. Control charts for attributes: p and c charts

Unit IV :

Demographic Methods: Introduction to measurement of population, rates and ratios of vitalevents. Measurement of mortality: Crude Death Rate (CDR), Standardised Death Rate (SDR)(w.r.t. age and sex). Measurement of fertility and reproduction: Crude Birth Rate (CBR),Gross Fertility Rate (GFR) and Total fertility rate (TFR).Life (mortality) tables: definition of its main functions and uses, Measurement of populationgrowth: Gross Reproduction Rate (GRR), Net Reproduction Rate (NRR).

Contents (Practical):

1. Measurement of trend by method of free-hand curve. Method of semi-average and method of least squares (linear, quadratic and modified exponential) Measurement ofseasonal variations by method of ratio to trend.
2. Computation of different types of index numbers, consumer price index number.
3. X and R charts.
4. p and c charts

5. Computation of Crude Death Rate (CDR), Standardised Death Rate (SDR) (w.r.t. Ageand sex).
6. Computation of Crude Birth Rate (CBR), Gross Fertility Rate (GFR) and Totalfertility rate (TFR).
7. Completion of a life table by computing values of different functions.
8. Computation of Gross Reproduction Rate (GRR), Net Reproduction Rate (NRR).

References:

1. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2011). Fundamental of Statistics, Vol II. World Press, Kolkata.
2. Gupta, S.C. and Kapoor, V.K. (2008). Fundamentals of Applied Statistics. 4th Edition (Reprint), Sultan Chand & Sons.
3. Montgomery, D.C. (2009). Introduction to Statistical Quality Control. 6th Edition, Wiley India Pvt. Ltd.
4. Mukhopadhya, P. (1999). Applied Statistics. New Central Book Agency, Calcutta.