Syllabus for B.Sc. Honours in Statistics

Semester – I

Sl. No.	Course Code	Course Title	Classes per week			Credit	Full Marks
			L	T	P		
Core Courses							
1	MSSUGCC01	Descriptive Statistics	4	0	2	6	75
2	MSSUGCC02	Linear Algebra	4	0	2	6	75
Generic Elective(GE)/Interdisciplinary Courses(Any one)							
1	PHYUGGE01	Mechanics	5	1	0	6	75
2	MATUGGE01	Algebra	5	1	0	6	75
Ability Enhancement Compulsory Course(AECC)							
		Environmental Science	4	0	0	4	50
Total						22	275

Semester – II

Sl. No.	Course Code	Course Title	Classes per week			Credit	Full Marks
			L	T	P		
Core Courses							
1	MSSUGCC03	Mathematical Analysis	5	1	0	6	75
2	MSSUGCC04	Probability-I	5	1	0	6	75
Generic Elective(GE)/Interdisciplinary Courses(Any one)							
1	PHYUGGE02	Electricity and Magnetism	5	1	0	6	75
2	MATUGGE02	Calculus	5	1	0	6	75
3	CSCUGGE02	Programming for Problem Solving	4	0	2	6	75
Compulsory Subject							
	MSSUGAU01	Communicative English/Arabic & Islamic Studies	3	1	0	4	50
Total						22	275

Semester – III

Sl. No.	Course Code	Course Title	Classes per week			Credit	Full Marks
			L	T	P		
Core Courses							
1	MSSUGCC05	Probability-II	4	0	2	6	75
2	MSSUGCC06	Survey Sampling and Indian Official Statistics	4	0	2	6	75
3	MSSUGCC07	Sampling Distributions & Basics of Inference	4	0	2	6	75
Generic Elective(GE)/Interdisciplinary Courses(Any one)							
1	PHYUGGE03	Thermal Physics	5	1	0	6	75
2	MATUGGE03	Differential equation and Integral Transform	5	1	0	6	75
3	CSCUGGE03	Data Structure and Algorithm Analysis	5	1	0	6	75
Skill Enhancement Course (SEC)							
	MSSUGSE01	Statistical Data Analysis Using R / Research Methodology	4	0	0	4	50
Total						28	350

Semester – IV

Sl. No.	Course Code	Course Title	Classes per week			Credit	Full Marks
			L	T	P		
Core Courses							
1	MSSUGCC08	Statistical Inference	4	0	2	6	75
2	MSSUGCC09	Linear Models	4	0	2	6	75
3	MSSUGCC10	Demography and Vital Statistics	4	0	2	6	75
Generic Elective(GE)/Interdisciplinary Courses(Any one)							
1	PHYUGGE04	Waves and Optics	5	1	0	6	75
2	MATUGGE04	Probability and Statistics & Numerical Analysis	5	1	0	6	75
3	CSCUGGE04	Computer Architecture	5	1	0	6	75
Skill Enhancement Course (SEC)							
	MSSUGSE02	Monte Carlo Methods / Data Base Management Systems	4	0	0	4	50
Total						28	350

Semester – V

Sl. No.	Course Code	Course Title	Classes per week			Credit	Full Marks
			L	T	P		
Core Course							
1	MSSUGCC11	Index Numbers and Time Series Analysis	4	0	2	6	75
2	MSSUGCC12	Statistical Computing Calculus	4	0	2	6	75
Discipline Specific Electives (One from each group)							
3	MSSUGDS01	Statistical Quality Control	4	0	2	6	75
		Stochastic Processes and Queuing Theory	4	0	2	6	75
4	MSSUGDS02	Econometrics	4	0	2	6	75
		Operations Research	4	0	2	6	75
Total						24	300

Semester – VI

Sl. No.	Course Code	Course Title	Classes per week			Credit	Full Marks
			L	T	P		
Core Course							
1	MSSUGCC13	Design of Experiments	4	0	2	6	75
2	MSSUGCC14	Multivariate Analysis and Nonparametric Methods	4	0	2	6	75
Discipline Specific Elective (One from each group)							
3	MSSUGDS03	Financial Statistics	4	0	2	6	75
		Survival Analysis	4	0	2	6	75
4	MSSUGDS04	Project Work				6	75
Total						24	300

MSSUGCC01: Descriptive Statistics

Course Objectives	In this course will learn: • Data visualization. • Define and compute the various measures of central tendency and different measures of dispersion, their use in comparing variability of different distribution. • Explain the concept of skewness and kurtosis and the significance of its study. • Understand the meaning of the term correlation and significance of its study. • Understand the meaning of regression, and its role in statistical analysis. • Differentiate between variables and attributes.
Learning Outcomes	Upon completion of this course, students will be able to: • Have visual perception of different type of data, with help of Tables, Histogram, Charts, Graphs, etc. using Excel. • Apply correctly a variety of descriptive statistical techniques. • Develop the analytical understanding of cause and effect of regression models. • Interpret, in plain language, the application and outcomes of statistical techniques.

Theory	
Unit 1	**15L**
Statistics: Definition and scope. Concepts of statistical population and sample. Data: quantitative and qualitative, crosssectional and time-series, discrete and continuous. Scales of measurement: nominal, ordinal, interval and ratio. Presentation of data: tabular and graphical. Frequency distributions, cumulative frequency distributions and their graphical representations.	
Unit 2	**15L**
Measures of Central Tendency: Mean, Median, Mode. Measures of Dispersion: Range, Mean deviation, Standard deviation, Coefficient of variation, Lorenz Curve. Moments, skewness and kurtosis. Quantiles and measures based on them. Stem & Leaf diagram. Box Plot. Outliers.	
Unit 3	**18L**
Bivariate data: Definition, scatter diagram, simple correlation, linear regression, principle of least squares, fitting of polynomial and exponential curves, correlation ratio, correlation index, intraclass correlation. Rank correlation – Spearman's and Kendall's measures.	
Unit 4	**12L**
Analysis of Categorical Data: Contingency table, independence and association of attributes, measures of association - odds ratio, Pearson's and Yule's measure, Goodman-Kruskalgamma.	
PRACTICAL/LAB. WORK:	
1. Diagrammatic representation of data. 2. Problems based on construction of frequency distributions, cumulative frequency distributions and their graphical representations, stem and leaf plot. 3. Problems based on measures of central tendency. 4. Problems based on measures of dispersion. 5. Problems based on combined mean and variance and coefficient of variation.	

6. Problems based on moments, skewness and kurtosis. 7. Problems related to quantiles and measures based on them, construction of box plot. 8. Problems based on analysis of bivariate data. 9. Problems based on measures of rank correlation. 1. 10. Problems based on analysis of categorical data.

References:

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2002): Fundamentals of Statistics, Vol. I& II, 8th Edn. The World Press, Kolkata.
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
3. Mood, A.M., Graybill, F.A. andBoes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn. (Reprint), Tata McGraw-Hill Pub. Co. Ltd.
4. Tukey, J.W.(1977) : Exploratory Data Analysis, Addison-Wesley Publishing Co.
5. Agresti, A. (2010): Analysis of Ordinal Categorical Data, 2nd Edition, Wiley.
6. Freedman, D., Pisani, R. and Purves, R. (2014): Statistics, 4th Edition, W. W. Norton & Company

MSSUGCC02: Linear Algebra

Theory	
Unit 1	**15L**
Definition of vectors, operation of vectors (angle, distance etc.). Vector spaces, Subspaces, sum of subspaces, Span of a set, Linear dependence and independence, dimension and basis, dimension theorem. Extension of basis. Orthogonal vectors, Gram-Schmidt Orthogonalization. Algebra of matrices. Linear transformation. Elementary matrices and their uses, theorems related to triangular, symmetric and skew symmetric matrices, idempotent matrices, orthogonal matrices. Trace of a matrix.	
Unit 2	**20L**
Determinants of Matrices: Definition, properties and applications of determinants for 3rd and higher orders, evaluation of determinants of order 3 and more using transformations. Symmetric and Skew symmetric determinants, product of determinants. Use of determinants in solution to the system of linear equations. Adjoint and inverse of a matrix and related properties. Singular and non-singular matrices and their properties. The system of equations $A\mathbf{x} = \mathbf{b}$, conditions for consistency, uniqueness, infinite solutions, solution sets of linear equations, linear independence, Applications of linear equations.	
Unit 3	**10L**
Rank of a matrix, row-rank, column-rank, standard theorems on ranks, rank of the sum and the product of two matrices. Partitioning of matrices and simple properties.	
Unit 4	**15L**
Characteristic roots and Characteristic vectors, Properties of characteristic roots, Quadratic forms: Classification & canonical reduction.	
PRACTICAL/LAB. WORK:	
1. Problems related vectors and vector spaces. 2. Problems related to matrices. 3. Problems related to determinant of matrices.	

4. Problems on solution to a linear system of equations.
5. Problems on characteristic roots and characteristic vectors.
6. Problems related to quadratic forms.

References:

1. Lay David C (2000).: Linear Algebra and its Applications, Addison Wesley.
2. Schaum's Outlines (2006): Linear Algebra, Tata McGraw-Hill Edition, 3rdEdition.
3. Krishnamurthy, V., Mainra V.P. and Arora J.L.: An Introduction to Linear Algebra (II, III, IV, V).
4. Biswas, S. (1997): A Textbook of Matrix Algebra, New Age International.
5. Gupta,S.C(2008).: An Introduction to Matrices (Reprint). Sultan Chand & Sons.
6. Artin, M (1994): Algebra. Prentice Hall of India.
7. Datta, K.B (2002): Matrix and Linear Algebra. Prentice Hall of India Pvt. Ltd.
8. Hadley, G (2002) : Linear Algebra. NarosaPublishing House (Reprint).
9. Searle, S.R (1982).: Matrix Algebra Useful for Statistics. John Wiley &Sons.
10. Chakraborty, Arnab (2014): Linear Algebra, first edition. Sarat Book House.
11. Goon A.M. (1988): Vectors and Matrices, World Press.

MSSUGCC03: Mathematical Analysis

Theory	
Unit 1	**25L**
Representation of real numbers as points on a line, Algebraic, Field Structure, Order Structure and Completeness properties of **R** (Concepts only) , Archemedian Property , Bounded and unbounded sets, neighbourhood of a point, Supremum and infimum, Topological properties of real line. Functions, Countable, Uncountable sets and Uncountability of **R**.	
Unit 2	**25L**
Sequences and their convergence, Subsequences, monotonic sequences, bounded sequences, squeeze theorem Limits of some special sequences such as r^n, $\left(1+\frac{1}{n}\right)^n$ & $n^{\frac{1}{n}}$, Concept of limsup and liminf.	
Unit 3	**25L**
Infinite series, positive termed series and their convergence, Comparison test, ratio test and root test. Absolute convergence of series, Leibnitz's test for the convergence of alternating series, Conditional convergence, Rearrangement and Riemann's Theorem (Statement only).	

References:

1. R.G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons
2. (Asia) Pvt. Ltd., Singapore, 2002.
3. 2. Gerald G. Bilodeau , Paul R. Thie, G.E. Keough, An Introduction to Analysis, 2nd Ed., Jones
4. & Bartlett, 2010.

5. 3. Brian S. Thomson, Andrew. M. Bruckner and Judith B. Bruckner, Elementary Real Analysis,
6. Prentice Hall, 2001.
7. 4. S.K. Berberian, A First Course in Real Analysis, Springer Verlag, New York, 1994.
8. 5. S. Shirali, H. L. Vasudeva, An Introduction to Mathematical Analysis, Alpha Science International Ltd, 2013.

MSSUGCC04: Probability –I

Course objectives	In this course students will learn • Various concepts of probability: definition of probability, independence of two or more events, finding probabilities • Random variables and its distributions • Expectations and moments of a random variable • Probability inequalities and their applications • Generating function and its role as an alternate characterization of a distribution. • Characterization and identification of distribution using generating functions • Deriving distributions of some linear function of a set of independent random variables
Learning Outcomes	At the end of the course a student will be able to • Find probability using set theory, permutations and combinations • Solve problems related to the distribution of a random variable, cumulative distribution function etc. • Find various moments of a distribution and their role • Solve problems related to probability inequalities • Solve problems related to generating functions • Derive the distribution of sum and average of independent random variables • Identify a distribution from generating functions

Theory	
Unit 1	**30L**
Probability: Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability – classical, statistical regularity. Limitations of Classical definition. Probability of union and intersection of events, Probability of occurrence of exactly m and at least m events out of n events, Examples based on classical approach and repeated trials, Kolmogorov's Axiomatic definition.	
Unit 2	**15L**
Conditional Probability, laws of addition and multiplication, theorem of total probability, Bayes' theorem and its applications, independent events.	
Unit 3	**20L**

Random variables, distribution function and properties, p.m.f., p.d.f., illustrations and properties of random variables. Mathematical Expectation and properties. Probability generating function. Moments, Dispersion, Skewness, Kurtosis and Quantiles. Cauchy-Swartz Inequality, inequalities related to moments and measures of skewness and kurtosis.	
Unit 4	**10L**
Moment generating function, Cumulant generating function and Characteristic function. Uniqueness and inversion theorems (without proof) along with applications. Gambler's ruin problem.	

References:

1. Chung, K.L. (1983): Elementary Probability Theory with Stochastic Process, Springer / Narosa.
2. Feller, W. (1968): An Introduction to Probability Theory & its Applications, John Wiley.
3. Goon, A.M., Gupta, M.K. &Dasgupta, B. (1994): An Outline of Statistical Theory (Vol-1), World
4. 4. Press. Parzen, E. (1972): Modern Probability Theory and its Applications, John Wiley .
5. Uspensky, J.V. (1937): Introduction to Mathematical Probability,McGraw Hill.
6. Cacoullos, T. (1973): Exercises in Probability. Narosa.
7. Rahman, N.A. (1983): Practical Exercises in Probability and Statistics
8. Griffen. Ross, S. (2002): A First Course in Probability, Prentice Hall.

MSSUGCC05 Probability-II

Course objectives	In this course students will learn • Various univariate discrete and continuous distributions and their examples in real life and their statistical properties • Two dimensional random variables: discrete as well as continuous type, joint, marginal and conditional distributions • Convergence of sequence of random variables: Almost sure convergence, Convergence in probability, Convergence in distribution, mean-square convergence • Weak law and Strong law of large numbers • Central limit theorem for iid random variables and applications.
Learning Outcomes	At the end of the course a student will be able to • Solve problems related to various discrete as well as continuous distributions • Fit a data set to a distribution such as binomial, Poisson etc. • Solve problems related to bivariate distributions • Solve problem related to probability inequalities • To check convergence of a sequence of random variables • Derive the asymptotic distributions

Theory	
Unit 1	**20L**

Standard discrete probability distributions: Binomial, Poisson, geometric, negative binomial, hypergeometric, uniform. Standard continuous probability distributions: uniform, normal, exponential, Cauchy, beta, gamma, lognormal, logistic, double exponential and Pareto along with their properties and limiting/approximation cases. Truncated distributions.	
Unit 2	**5L**
Standard Probability Inequalities (Univariate Cases) : Markov's & Chebyshev's (one- and two- sided) inequalities, Jensen's Inequality, Holder's Inequality.	
Unit 3	**15L**
Two dimensional random variables: discrete type, joint, marginal and conditional p.m.f and c.d.f., statement of properties of c.d.f, independence of variables, Sum-law and Product-law of expectation, trinomial distribution. Bivariate c.d.f and p.d.f. and generating functions in continuous case. Marginal and Conditional distributions, Independence, Conditional Expectation, Correlation and Regression. Theorems on sum and product of expectations of random variables .Bivariate Normal Distribution (BVN).	
Unit 4	**20L**
Limit laws: Sequence of random variables, convergence in probability, almost sure convergence, convergence in mean square and convergence in distribution and their interrelations, W.L.L.N., S.L.L.N and their applications, De-Moivre Laplace Limit theorem, Statement of Central Limit Theorem (C.L.T.) for i.i.d. variates, applications of C.L.T.	
PRACTICAL/LAB. WORK:	
1. Fitting of binomial distributions for n and p = q = ½. 2. Fitting of binomial distributions for given n and p. 3. Fitting of binomial distributions after computing mean and variance. 4. Fitting of Poisson distributions for given value of mean 5. Fitting of Poisson distributions after computing mean. 6. Fitting of negative binomial distribution. 7. Fitting of suitable discrete distributions 8. Application problems based on binomial distribution. 9. Application problems based on Poisson distribution. 10. Application problems based on negative binomial distribution. 11. Problems based on area property of normal distribution. 12. To find the ordinate for a given area for normal distribution. 13. Application based problems using normal distribution. 14. Fitting of normal distribution when parameters are given. 15. Fitting of normal distribution when parameters are not given. 16. Problems similar to those in 11 to 15 in cases of other continuous distributions. 17. Application based Problems on trinomial distributions 18. Application based Problems on bivariate normal distributions	

References:

1. Chung, K.L. (1983): Elementary Probability Theory with Stochastic Process, Springer / Narosa.
2. Feller, W. (1968): An Introduction to Probability Theory & its Applications, John Wiley.
3. Goon, A.M., Gupta, M.K. &Dasgupta, B. (1994): An Outline of Statistical Theory (Vol-1), World Press.
4. Parzen, E. (1972): Modern Probability Theory and its Applications, John Wiley .
5. Uspensky, J.V. (1937): Introduction to Mathematical Probability,McGraw Hill.
6. Cacoullos, T. (1973): Exercises in Probability. Narosa.

7. Rahman, N.A. (1983): Practical Exercises in Probability and Statistics.

MSSUGCC06 Survey Sampling and Indian Official Statistics

Course objectives	In this course a student will learn • Population, Sample and their definitions and examples • Need for Sampling • Planning and execution of sample surveys. • Judgment and probability sampling schemes. • Simple Random Sampling with and without replacement • Stratified Random Sampling. • Understand institutional, legal and organizational aspects of official statistics in India. • Understand the functioning of official statistics.
Learning Outcomes	At the end of the course a student will be able to • Draw random numbers • Organize a sample survey • Determination of sample size • Prepare questionnaire • Do the analysis of the data and write report • Determine the proper sampling method • Collect and integrate information from a variety of sources, assessing its meaning, accuracy, and timeliness; discuss the bias and variance of possible measurement and estimation procedures and recognize the agendas of points of view of various surveyors of data and analysis.

Theory	
Unit 1	**15L**
Concept of population and sample, complete enumeration versus sampling, sampling and non-sampling errors. Types of sampling: non-probability and probability sampling, basic principle of sample survey, simple random sampling with and without replacement, definition and procedure of selecting a sample, estimates of: population mean, total and proportion, variances of these estimates, estimates of their variances and sample size determination.	
Unit 2	**15L**
Stratified random sampling: Technique, estimates of population mean and total, variances of these estimates, proportional and optimum allocations and their comparison with SRS.Practical	

difficulties in allocation, estimation of gain in precision, post stratification and its performance. Systematic Sampling: Technique, estimates of population mean and total, variances of these estimates (N=nxk). Comparison of systematic sampling with SRS and stratified sampling in the presence of linear trend and corrections.	
Unit 3	**20L**
Introduction to Ratio and regression methods of estimation, first approximation to the population mean and total (for SRS of large size), variances of these estimates and estimates of these variances, variances in terms of correlation coefficient for regression method of estimation and their comparison with SRS. Cluster sampling (equal clusters only) estimation of population mean and its variance, comparison (with and without randomly formed clusters). Relative efficiency of cluster sampling with SRS in terms of intra class correlation. Concept of sub sampling.	
Unit 4	**10L**
Present official statistical system in India, Methods of collection of official statistics, their reliability and limitations. Role of Ministry of Statistics & Program Implementation (MoSPI), Central Statistical Office (CSO), National Sample Survey Office (NSSO), and National Statistical Commission. Government of India's Principal publications containing data on the topics such as population, industry and finance.	
PRACTICAL/LAB. WORK:	
1. To select a SRS with and without replacement. 2. For a population of size 5, estimate population mean, population mean square and population variance. Enumerate all possible samples of size 2 by WR and WOR and establish all properties relative to SRS. 3. For SRSWOR, estimate mean, standard error, the sample size 4. Stratified Sampling: allocation of sample to strata by proportional and Neyman's methods Compare the efficiencies of above two methods relative to SRS 5. Estimation of gain in precision in stratified sampling. 6. Comparison of systematic sampling with stratified sampling and SRS in the presence of a linear trend. 7. Ratio and Regression estimation: Calculate the population mean or total of the population. Calculate mean squares. Compare the efficiencies of ratio and regression estimators relative to SRS. 8. Cluster sampling: estimation of mean or total, variance of the estimate, estimate of intra-class correlation coefficient, efficiency as compared to SRS.	

References:

1. Cochran, W.G. (1984): SamplingTechniques (3rd Ed.), Wiley Eastern.
2. Sukhatme, P.V., Sukhatme, B.V. Sukhatme, S. Asok, C. (1984). Sampling Theories of Survey With Application, IOWA State University Press and Indian Society of Agricultural Statistics
3. Murthy, M.N. (1977): Sampling Theory & Statistical Methods, Statistical Pub. Society, Calcutta.
4. Des Raj and Chandhok P. (1998): Sample Survey Theory, Narosa Publishing House.

MSSUGCC07 Sampling Distributions & Basics of Inference

Course Objectives	Distribution of sample statistic (such as, sample mean, sample variance and sample proportion) and the pattern of variability of sample statistic will be explored in this course. Different properties of chi-square distribution, t-distribution and F-distribution will be discussed.
Learning Outcomes	Students will learn different properties of sample statistic and it can be used in testing of hypothesis. They can perform the hypothesis testing for population mean, variance and the testing for goodness of fit.

Theory	
Unit 1	**20L**
Definitions of random sample, parameter and statistic, sampling distribution of a statistic, sampling distribution of sample mean, standard errors of sample mean, sample variance and sample proportion. Null and alternative hypotheses, level of significance, Type I and Type II errors, their probabilities and critical region. Large sample tests, use of CLT for testing single proportion, difference of two proportions, single mean, difference of two means, standard deviation and difference of standard deviations by classical and p-value approaches.	
Unit 2	**10L**
Order Statistics: Introduction, distribution of the rth order statistic, smallest and largest order statistics. Joint distribution of rth and sth order statistics, distribution of sample median and sample range.	
Unit 3	**15L**
Exact sampling distribution: Definition and derivation of p.d.f. of $\chi 2$ with n degrees of freedom (d.f.) using m.g.f., nature of p.d.f. curve for different degrees of freedom, mean, variance, m.g.f., cumulant generating function, mode, additive property and limiting form of $\chi 2$ distribution. Tests of significance and confidence intervals based on distribution.	
Unit 4	**15L**
Exact sampling distributions: Student's and Fishers t-distribution, Derivation of its p.d.f., nature of probability curve with different degrees of freedom, mean, variance, moments and limiting form of t distribution. Snedecore's F-distribution: Derivation of p.d.f., nature of p.d.f. curve with different degrees of freedom, mean, variance and mode. Distribution of $1/F(n_1,n_2)$. Relationship between t, F and $\chi 2$ distributions. Test of significance and confidence Intervals based on t and F distributions.	
PRACTICAL/LAB. WORK:	
1. Testing of significance and confidence intervals for single proportion and difference 1. of two proportions 2. Testing of significance and confidence intervals for single mean and difference of two means and paired tests. 3. Testing of significance and confidence intervals for difference of two standard deviations. 4. Exact Sample Tests based on Chi-Square Distribution. 5. Testing if the population variance has a specific value and its confidence intervals. 6. Testing of goodness of fit. 7. Testing of independence of attributes. 8. Testing based on 2 X 2 contingency table without and with Yates' corrections.	

9. Testing of significance and confidence intervals of an observed sample correlation coefficient.
10. Testing and confidence intervals of equality of two population variances

References:

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2003): An Outline of Statistical Theory, Vol. I, 4th Edn. World Press, Kolkata.
2. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2ndEdn. (Reprint) John Wiley and Sons.
3. Hogg, R.V. And Tanis, E.A. (2009): A Brief Course in Mathematical Statistics. Pearson Education.
4. Johnson, R.A. and Bhattacharya, G.K. (2001): Statistics-Principles and Methods, 4th Edn. John Wiley and Sons.
5. Mood, A.M., Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn. (Reprint).Tata McGraw-Hill Pub. Co. Ltd.

MSSUGCC08 Statistical Inference

Theory	
Unit 1	**20L**
Estimation: Concepts of estimation, unbiasedness, sufficiency, consistency and efficiency. Factorization theorem. Complete statistic, Minimum variance unbiased estimator (MVUE), Rao-Blackwell and Lehmann-Scheffe theorems and their applications. Cramer-Rao inequality and MVB estimators(statement and applications). Methods of Estimation: Method of moments, method of maximum likelihood estimation, method of minimum Chi-square, basic idea of Bayes estimators.	
Unit 2	**20L**
Concept of test function and randomized test, Review of level of significance, power and power curve. Most powerful test, uniformly most powerful test, Neyman- Pearson Lemma (statement and proof of sufficiency part only) and its applications to construct uniformly most powerful test, unbiased test (definition only). Likelihood ratio test, properties of likelihood ratio tests (without proof).	
Unit 3	**5L**
Confidence intervals, Confidence set, Shortest length confidence interval, Concepts of Uniformly Most Accurate (UMA) confidence sets, relationship with tests of hypotheses.	
Unit 4	**15L**
Delta Method, Derivation and uses of large sample standard error of sample moments, Standard deviation, Coefficient of Variation, b1 & b2 measures, Correlation coefficient. Asymptotic distribution of sample quantiles. Transformations of Statistics to stabilize variance: derivation and uses of Sin-1, square root. Uses of logarithmic and z-transformations. Large sample tests for binomial proportions, Poisson means (single and two independent samples cases) and correlation coefficients. Large Sample distribution of Pearsonian $\chi 2$ –statistic and its uses.	
PRACTICAL/LAB. WORK:	
1. Maximum Likelihood Estimation 2. Estimation by the method of moments, minimum Chi-square 3. Most powerful critical region (NP Lemma) 4. Uniformly most powerful critical region 5. Unbiased critical region 6. Power curves	

7. Likelihood ratio tests for simple null hypothesis against simple alternative hypothesis
8. Likelihood ratio tests for simple null hypothesis against composite alternative hypothesis
9. Asymptotic properties of LR tests
10. Testing of significance and confidence intervals for single proportion and difference of two proportions using CLT.
11. Testing of significance and confidence intervals for single Poisson mean and difference of two Poisson means using CLT.
12. Testing of significance and confidence intervals concerning sample standard deviation, coefficient of variation and correlation coefficient (both single sample and two sample cases).
13. Testing of significance and confidence intervals using variance stabilizing transformations.
14. Determination of the minimum sample size required to achieve normality by sample proportion, mean and standard deviation.
15. Tests for goodness of fit, independence and homogeneity using Pearsonian chi-square statistic.

References:

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2003): An Outline of Statistical Theory, Vol. I, 4th Edn. World Press, Kolkata.
2. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2ndEdn. (Reprint) John Wiley and Sons.
3. Hogg, R.V. And Tanis, E.A. (2009): A Brief Course in Mathematical Statistics. Pearson Education.
4. Johnson, R.A. and Bhattacharya, G.K. (2001): Statistics-Principles and Methods, 4th Edn. John Wiley and Sons.
5. Mood, A.M., Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn. (Reprint).Tata McGraw-Hill Pub. Co. Ltd.

Course Objective	1. Introduce the concept of estimation of parameters 2. Know the basic concepts of Testing of Hypotheses (Large Sample Tests and small sample test) 3. Know the confidence interval construction methods. 4. Introduce the concept of variance stabilizing transformation and large sample distributions.
Learning Outcomes	1. Calculate the problems related to point estimation. 2. Formulate hypothesis tests in some common models (including Normal models), correctly using the terms null hypothesis, alternative hypothesis, test statistic, rejection region and significance level. 3. Justify and make use of the Likelihood Ratio Test and the Generalised Likelihood Ratio tests. 4. Testing of significance and confidence intervals using variance stabilizing transformations. 5. Tests for goodness of fit, independence and homogeneity using Pearsonian chi-square statistic.

MSSUGCC09 Linear Models

Theory	
Unit 1	**10L**
Gauss-Markov set-up: Theory of linear estimation, Estimability of linear parametric functions, Method of least squares, Gauss-Markov theorem, Estimation of error variance.	
Unit 2	**15L**

Regression analysis: Simple regression analysis, Estimation and hypothesis testing in case of simple and multiple regression models, Concept of model matrix and its use in estimation.	
Unit 3	**25L**
Analysis of variance: Definitions of fixed, random and mixed effect models, analysis of variance and covariance in one-way classified data for fixed effect models, analysis of variance and covariance in two-way classified data with one observation per cell for fixed effect models.	
Unit 4	**10L**
Model checking: Prediction from a fitted model, Violation of usual assumptions concerning normality, Homoscedasticity and collinearity, Diagnostics using quantile-quantile plots.	
PRACTICAL/LAB. WORK:	
1. Estimability when X is a full rank matrix and not a full rank matrix 2. Distribution of Quadratic forms 3. Simple Linear Regression 4. Multiple Regression 5. Tests for Linear Hypothesis 6. Bias in regression estimates 7. Lack of fit 8. Orthogonal Polynomials 9. Analysis of Variance of a one way classified data 10. Analysis of Variance of a two way classified data with one observation per cell 11. Analysis of Covariance of a one way classified data 12. Analysis of Covariance of a two way classified data	

References:

1. Weisberg, S. (2005). Applied Linear Regression (Third edition). Wiley.
2. Wu, C. F. J. And Hamada, M. (2009). Experiments, Analysis, and Parameter Design Optimization (Second edition), John Wiley.
3. Renchner, A. C. And Schaalje, G. B. (2008). Linear Models in Statistics (Second edition), John Wiley and Sons.
4. Scheffe, H. (1959): The Analysis of Variance, John Wiley.
5. Goon, A.M., Gupta, M.K., Das Gupta, B. (2005). Outline of Statistics, Vol.II, World Press, Calcutta.

Course Objective	1. Introduce the concept of Gauss-Markov set-up and theory of linear estimation. 2. Know the details of Simple regression analysis. 3. Introduce ANOVA for one way and two way classified data. 4. Learn the basics of Model adequacy checking for regression model.
Learning Outcomes	1. Calculate and interpret the correlation between two variables. 2. Determine whether the correlation is significant. 3. Calculate the simple linear regression equation for a set of data and know the basic assumptions behind regression analysis. 4. Determine whether a regression model is significant. 5. Recognize regression analysis applications for purposes of description and prediction. 6. Calculate and interpret confidence intervals for the regression analysis. 7. Recognize some potential problems if regression analysis is used incorrectly.

	8. Analysis of Variance of a one way classified data 9. Analysis of Variance of a two way classified data with one observation per cell 10. Analysis of Covariance of a one way classified data 11. Analysis of Covariance of a two way classified data

MSSUGCC10 Demography and Vital Statistics

Theory	
Unit 1	**15L**
Population Theories: Coverage and content errors in demographic data, use of balancing equations and Chandrasekharan-Deming formula to check completeness of registration data. Adjustment of age data, use of Myer and UN indices, Population composition, dependency ratio.	
Unit 2	**15L**
Introduction and sources of collecting data on vital statistics, errors in census and registration data. Measurement of population, rate and ratio of vital events. Measurements of Mortality: Crude Death Rate (CDR), Specific Death Rate (SDR), Infant Mortality, Rate (IMR) and Standardized Death Rates.	
Unit 3	**15L**
Stationary and Stable population, Central Mortality Rates and Force of Mortality. Life(Mortality) Tables: Assumption, description, construction of Life Tables and Uses of Life Tables.	
Unit 4	**15L**
Abridged Life Tables; Concept and construction of abridged life tables by Reed-Merrell method, Greville's method and King's Method. Measurements of Fertility: Crude Birth Rate (CBR), General Fertility Rate (GFR), Specific Fertility Rate (SFR) and Total Fertility Rate (TFR). Measurement of Population Growth: Crude rates of natural increase, Pearl's Vital Index, Gross Reproduction Rate (GRR) and Net Reproduction Rate (NRR).	
PRACTICAL/LAB. WORK:	
1. To calculate CDR and Age Specific death rate for a given set of data 2. To find Standardized death rate by:- (i) Direct method (ii) Indirect method 3. To construct a complete life table 4. To fill in the missing entries in a life table 5. To calculate probabilities of death at pivotal ages and use it construct abridged life table using (i) Reed-Merrell Method, (ii) Greville's Method and (iii) King's Method 6. To calculate CBR, GFR, SFR, TFR for a given set of data 7. To calculate Crude rate of Natural Increase and Pearle's Vital Index for a given set of data 8. Calculate GRR and NRR for a given set of data and compare them	

References:

1. Mukhopadhyay, P. (1999): Applied Statistics, New Central Book Agency, Calcutta.
2. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. II,9th Edition World Press, Kolkata.

3. Gupta, S. C. and Kapoor, V.K. (2008): Fundamentals Of Applied Statistics, 4th Edition (Reprint), Sultan Chand & Sons.

Course Objective	1. Understand the basics of demography. 2. Understand the core social demographic variables, and how these variables influence population growth, composition, and structure. 3. Use of different mortality rate as demographic tools in understanding public health issues knowledge attitude and practices. 4. Know the concept and construction of abridged life tables. 5. Identify appropriate sources of data, perform basic demographic analyses using various techniques and ensure their comparability across populations.
Learning Outcomes	1. To find Standardized death rate by:- (i) Direct method (ii) Indirect method 2. To construct a complete life table 3. To fill in the missing entries in a life table 4. Calculate probabilities of death at pivotal ages and use it construct abridged life table using (i) Reed-Merrell Method, (ii) Greville's Method and (iii) King's Method 5. Calculate CBR, GFR, SFR, TFR for a given set of data 6. Calculate Crude rate of Natural Increase and Pearle's Vital Index for a given set of data 7. Calculate GRR and NRR for a given set of data and compare them

MSSUGCC11 Index Numbers and Time Series Analysis

Theory	
Unit 1	**12L**
Index Numbers: Weighted means, price and quantity index numbers, choice of weights, Laspeyres' and Paasche's index numbers. Tests of index numbers and Fisher's ideal index number. Consumer price Index, Wholesale price index number and index of industrial production.	
Unit 2	**12L**
Stochastic Process: Introduction and Stationary Process. Introduction to time series data, application of time series from various fields. Modelling time series as deterministic function plus IID errors: Components of a time series (trend, cyclical and seasonal patterns, random error) Decomposition of time series. Estimation of trend: free hand curve method, method of moving averages, fitting various mathematical curves and growth curves. Effect of elimination of trend on other components of the time series.	
Unit 3	**12L**
Estimation of seasonal component by Method of simple averages, Notions of multiplicative models: ratio to Trend. Introduction to stochastic modelling: Concept of stationarity. Illustration of how a stationary time series may show temporal patterns. Stationarity in mean.	

Unit 4	**24L**
Box-Jenkins modelling: Moving-average (MA) process and Autoregressive (AR) process of orders one and two.ACF and its graphical use in guessing the order of MA processes. Estimation of the parameters of AR (1) and AR (2) using least square and Yule-Walker equations. Forecasting: Exponential smoothing methods.	
PRACTICAL/LAB. WORK:	
1. Plotting a real life time series, and detecting various features (trend, periodic behaviours etc). Suggested data sets: a) Sun spot data b) Dollar-Rupee exchange rates c) Stock market data 2. Fitting and plotting of mathematical curves: 3. modified exponential curve 4. Gompertz curve 5. Fitting of trend by Moving Average Method. 6. Plotting detrended series. 7. Measurement of Seasonal indices Ratio-to-Moving Average method. 8. Plotting ACF of a given time series. 9. Using Yule-Walker equation and Least squares to fit AR (1) and AR (2) models to real life data 10. Forecasting by exponential smoothing. 11. Calculation of price and quantity index numbers. 12. Construction of Consumer and wholesale price index numbers.	

References:

1. Chatfield C. (1980): The Analysis of Time Series –An Introduction, Chapman & Hall.
2. Kendall M.G. (1976): Time Series, Charles Griffin.
3. Brockwell and Davis (2010):Introduction to Time Series and Forecasting (Springer Texts in Statistics) ,2nd Edition.
4. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2002): Fundamentals of Statistics, Vol. II, 8th Edn. The World Press, Kolkata.
5. Mudgett B.D. (1951): Index Numbers, John Wiley .
6. Allen R.G.D. (1975): Index Numbers in Theory and Practice, Macmillan.
7. Nagar A.L. & Das R. K. (1976): Basic Statistics.

Course Objective	1. Understand the concept of different index numbers. 2. Basics of stationary process. 3. Know the details of time series and their components. 4. Know the concept of estimation of different components of time series data. 5. Know the basics of Box-Jenkins approach. 6. Understand the details of Moving-average (MA) process and Autoregressive (AR) process of orders one and two.
Learning Outcomes	1. Differentiate among simple index numbers, unweighted aggregate price index numbers, weighted aggregate price index numbers, Laspeyres price index numbers, and Paasche price index numbers by defining and

	calculating each. 2. Understand and apply the concept of stationarity to the analysis of time series data in various contexts (such as actuarial studies, climatology, economics, finance, geography, meteorology, political science, and sociology). 3. Run and interpret time-series models and regression models for time series. 4. Using Yule-Walker equation and Least squares to fit AR (1) and AR (2) models to real life data. 5. Use the Box-Jenkins approach to model and forcast time-series data empirically. 6. Forecasting by exponential smoothing.

MSSUGCC12 Statistical Computing and Calculus

Theory	
Unit 1	**15L**
Polynomial approximation, Weierstrass Theorem (Statement). Difference Table, Newton's Forward and Backward interpolation formulae and Lagrange's general interpolation formula, Error terms. Numerical Differentiation and its applications. Numerical Integration: Trapezoidal and Simpson's 1/3 rules. Approximation of numbers and functions. Absolute and Relative errors. Interpolation:	
Unit 2	**15L**
Numerical solution of equations: method of fixed point iteration and Newton-Raphson method in one unknown, Conditions of convergence, rates of convergence. Extension of the iteration method to two unknowns (without convergence). Stirling's approximation to factorial n.	
Unit 3	**25L**
Review of limit, continuity and differentiability. Indeterminate form, L' Hospital's rule. Rolle's and Lagrange's Mean Value theorems. Taylor's theorem with lagrange's form of remainder(without proof). Taylor's series expansions of sinx, cosx, $\boldsymbol{ex}$, $(\mathbf{1} + \boldsymbol{x})$, log (1+x). Maxima and Minima of Functions. Successive Differentiation.	
Unit 4	**15L**
Integral Calculus: definite integral (definition). Statements of properties, Fundamental Theorem of Integral Calculus. Improper Integral, Beta and Gamma functions: properties and relationship between them.	
PRACTICAL/LAB. WORK:	
1. Plot of a graph y = f(x). 2. Roots of a quadratic equation (with imaginary roots also). 3. Sorting of an array and hence finding median. 4. Mean, Median and Mode of a Grouped Frequency Data. 5. Variance and coefficient of variation of a Grouped Frequency Data. 6. Preparing a frequency table. 7. Random number generation from uniform, exponential,calculate sample mean and variance	

and compare with population parameters.
8. Matrix addition, subtraction, multiplication, Transpose,Trace , Rank and Determinant.
9. Fitting of Binomial, Poisson distribution.
10. Compute ranks and then calculate rank correlation(without tied ranks).
11. Fitting of lines of regression.
12. Numerical methods: Interpolation by Lagrange formula, Solving one-variable equations using Newton-Raphson and Iteration methods.
13. Trapezoidal and Simpson 1/3 rdrule for numerical integration with convergence.
14. Solving a linear system of equation.
15. Storing the C output in a file

References:

1. Kernighan, B.W. and Ritchie, D.(1988): CProgramming Language,2ndEdition, Prentice Hall. Balagurusamy, E. (2011): Programming in ANSI C, 6th Edition Tata McGraw Hill.
2. Gottfried, B.S. (1998): Schaum's Outlines: Programming with C, 2ndEdition, TataMcGraw Hill.
3. Jain, M. K., Iyengar, S. R. K. and Jain, R. K. (2003): Numerical methods for scientific and engineering computation, New age International Publisher, India.
4. Mukherjee, Kr. Kalyan (1990): Numerical Analysis. New Central Book Agency.
5. Sastry, S.S. (2000): Introductory Methods of Numerical Analysis, 3rd edition, Prentice Hall of India Pvt. Ltd., New Del.
6. Scarborough, J.B. (1966): Numerical Mathematical Analysis. Oxford and IBH Publishing.
7. Ghorpade, Sudhir R. and Limaye, Balmohan V. (2006): A Course in Calculus and Real Analysis, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint.

Course Objective	1. Know the details of Numerical Methods, specially polynomial approximations, differentiations and integrations. 2. Basics of Numerical solution of equations. 3. Basics of differential calculus for finding maxima and minima of functions. 4. Know the concept of Integral calculus. 5. Details of Beta and Gamma functions.
Learning Outcomes	1. Demonstrate understanding of common numerical methods and how they are used to obtain approximate solutions to otherwise intractable mathematical problems. 2. Apply numerical methods to obtain approximate solutions to mathematical problems. 3. Derive numerical methods for various mathematical operations and tasks, such as interpolation, differentiation, integration and the solution of linear and nonlinear equations. 4. Find maximum and minimum value of functions. 5. Uses of Gamma and Beta functions and their realtionships.

MSSUGCC13 Design of Experiments

Theory	
Unit 1	**6L**
Experimental designs: Role, historical perspective, terminology: Treatments, Experimental units & Blocks, Experimental error, Basic principles of Design of Experiments (Fisher). Uniformity trials, fertility contour maps, choice of size and shape of plots and blocks in Agricultural experiments. Uses in Industrial Experiments.	
Unit 2	**25L**
Basic designs: Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD) – layout, model and statistical analysis, relative efficiency. Analysis with one missing observation in RBD and LSD.	
Unit 3	**20L**
Factorial experiments: advantages, notations and concepts. 2^n experiments: design and analysis. Total and Partial confounding for 2^n (n≤5). Factorial experiments in a single replicate.	
Unit 4	**9L**
Split Plot Designin RBD and Strip arrangements, Groups of experiments with RBD and LSD.	
PRACTICAL/LAB. WORK:	
1. Analysis of a CRD. 2. Analysis of an RBD. 3. Analysis of an LSD. 4. Analysis of an RBD with one missing observation. 5. Analysis of an LSD with one missing observation. 6. Analysis of □^□ and□^□ factorial in CRD and RBD. 7. Analysis of a completely confounded two- level factorial design in 2 blocks. 8. Analysis of a completely confounded two- level factorial design in 4 blocks. 9. Analysis of a partially confounded two- level factorial design. 10. Analysis of a single replicate of a □^□ design. 11. Analysis of Split Plot and Strip Plot designs. 12. Analysis of Groups of experiments in RBD and LSD	

References:

1. Cochran, W.G. and Cox, G.M. (1959): Experimental Design. Asia Publishing House.
2. Das, M.N. and Giri, N.C. (1986): Design and Analysis of Experiments. Wiley Eastern Ltd.
3. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005): Fundamentals of Statistics. Vol. II, 8thEdn. World Press, Kolkata.
4. Kempthorne, O. (1965): The Design and Analysis of Experiments. John Wiley.
5. Montgomery, D. C. (2008): Design and Analysis of Experiments, John Wiley.
6. Wu, C. F. J. And Hamada, M. (2009). Experiments, Analysis, and Parameter Design Optimization (Second edition), John Wiley.
7. Dean, A.M. and Voss, D. (1999): Design and Analysis of Experiments. Springer Texts in Statistics

Course Objective	1. Define Design of Experiments (DOE) and describe its purpose, importance, and benefits. 2. Define key terms associated with DOE and explain how to conduct a well-designed statistical experiment. 3. Describe the basic designs and their applications. 4. Define a full factorial experiment and show how to calculate the main and

	interaction effects. 5. Demonstrate total and partial confounding in a factorial design. 6. Explain the role of split plot design.
Learning Outcomes	1. Explain the key concepts of DOE, and why it is used. 2. Calculate treatment effects of a basic and factorial design. 3. Analyze complete and partial confounding in a factorial design. 4. Analysis of Split Plot designs. 5. Analysis of Groups of experiments in RBD and LSD.

MSSUGCC14 Multivariate Analysis and Nonparametric Methods

Theory	
Unit 1	**20L**
Multivariate Data: multiple regression, multiple and partial correlation coefficients. Random Vector: Probability mass/density functions, Distribution function, mean vector & Dispersion matrix, Marginal & Conditional distributions. Multiple and partial correlation coefficient.	
Unit 2	**15L**
Multivariate Normal distribution and its properties. Multinomial Disrtribution and its properties. Tests for Multiple and partial correlation coefficients.	
Unit 3	**10L**
Applications of Multivariate Analysis: Principal Components Analysis and Factor Analysis (Application Oriented discussion, derivations not required)	
Unit 4	**15L**
Nonparametric Tests: Introduction and Concept, Test for randomness based on total number of runs, Empirical distribution function, One Sample Tests: Kolmogrov- Smirnov, Sign, Signed rank.Wilcoxon-Mann-Whitney test.Kruskal-Wallis test.	
PRACTICAL/LAB. WORK:	
1. Test for Multiple Correlation. 2. Test for Partial Correlation. 3. Multivariate Normal Distribution. 4. Principal Components Analysis. 5. Factor Analysis. 6. Test for randomness based on total number of runs. 7. Kolmogorov -Smirnov test for one sample. 8. Sign test . 9. Signed rank test. 10. Wilcoxon-Mann-Whitney test. 11. Kruskal-Wallis test.	

References:

1. Anderson, T.W. (2003): An Introduction to Multivariate Statistical Analysis, 3rdEdn., John Wiley
2. Muirhead, R.J. (1982): Aspects of Multivariate Statistical Theory, John Wiley.
3. Kshirsagar, A.M. (1972): Multivariate Analysis, 1stEdn. Marcel Dekker.
4. Johnson, R.A. And Wichern, D.W. (2007): Applied Multivariate Analysis, 6thEdn., Pearson & Prentice Hall .
5. Mukhopadhyay, P.: Mathematical Statistics.
6. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2002): Fundamentals of Statistics, Vol. I, 8th Edn. The World Press, Kolkata.
7. Gibbons, J. D. and Chakraborty, S (2003): Nonparametric Statistical Inference. 4th Edition. Marcel Dekker, CRC.
8. Rohatgi, V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2ndEdn. (Reprint) John Wiley and Sons.

Course Objective	1. Know the basics of multivariate data and multiple regressions. 2. Introduction of multivariate normal and multinomial distributions and their properties. 3. Idea of Principal Components Analysis and Factor Analysis. 4. Introduction of some non-parametric tests.
Learning Outcomes	1. Explain the key concepts multiple regression and related terms associated with it. 2. Derive some properties of multivariate normal and multinomial distributions. 3. Test for Multiple and partial Correlation. 4. Application of Principal Components Analysis and Factor Analysis. 5. Application of some nonparametric tests.

MSSUGDS01 Statistical Quality Control

Theory	
Unit 1	**10L**
Quality: Definition, dimensions of quality, Difference between product control and process control, Statistical Process Control - Seven tools of SPC, chance and assignable Causes of quality variation.	
Unit 2	**20L**
Statistical Control Charts - Construction and Statistical basis of 3-σ Control charts, Rational Sub-grouping, Control charts for variables: X-bar & R-chart, X-bar & s-chart. Control charts for attributes: np chart, p-chart, c-chart and u-chart. Comparison between control charts for variables and control charts for attributes. Analysis of patterns on control chart, Estimation of process capability.	
Unit 3	**20L**
Definitions related to product control, Acceptance sampling plan, Principle of acceptance sampling plans, Single sampling plan - their OC, AQL, LTPD, AOQ, AOQL, ASN, ATI functions with graphical interpretation, Double sampling plan - their OC, AQL, LTPD, AOQ, AOQL, ASN, ATI functions with graphical interpretation, use and interpretation of Dodge and Roming sampling	

inspection plan tables.	
Unit 4	**10L**
Introduction to Six-Sigma: Overview of Six Sigma, Lean Manufacturing and Total Quality Management (TQM), Introduction to ISO quality standards: ISO 9001, ISO 14001, BIS.	
PRACTICAL/LAB. WORK:	
1. Construction and interpretation of statistical control charts a. X-bar & R-chart b. X-bar & s-chart c. np-chart d. p-chart e. c-chart f. u-chart 2. Single sample inspection plan: Construction and interpretation of OC, AQL, LTPD, ASN, ATI, AOQ, AOQL curves 3. Calculation of process capability	

References:

1. Montogomery, D. C. (2009): Introduction to Statistical Quality Control, 6th Edition, Wiley India Pvt. Ltd.
2. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. II, 8th Edn. The World Press, Kolkata.
3. Mukhopadhyay, P (2011): Applied Statistics, 2nd edition revised reprint, Books and Allied (P) Ltd.
4. Montogomery, D. C. and Runger, G.C. (2008): Applied Statistics and Probability for Engineers, 3rd Edition reprint, Wiley India Pvt. Ltd.
5. Ehrlich,B.Harris(2002):Transactional Six Sigma and Lean Servicing, 2nd Edition St. Lucie Press.
6. Hoyle, David (1995): ISO Quality Systems Handbook, Heinemann Publication. 2nd Edition, Butterworth.

Course Objective	1. Know the definition and dimension of quality. 2. Introduction of product control and process control, Statistical Process Control. 3. Know the different control charts and their comparison. 4. Introduction of product control and different sampling plan. 5. Basics of six-sigma methods.
Learning Outcomes	1. Explain the seven tools of SPC. 2. Construction and interpretation of statistical control charts X-bar & R-chart, X-bar & s-chart, np-chart, p-chart, c-chart, u-chart. 3. To estimate of process capability. 4. Apply different sampling plan related to product control and their characteristics. 5. Know the complete overview of six-sigma method.

OR

Stochastic Processes and Queuing Theory

Theory	
Unit 1	**5L**
Probability Distributions: Generating functions, Bivariate probability generating function. Stochastic Process: Introduction, Stationary Process.	
Unit 2	**25L**
Markov Chains: Definition of Markov Chain, transition probability matrix, order of Markov chain, Markov chain as graphs, higher transition probabilities. Generalization of independent Bernoulli trials, classification of states and chains, stability of Markov system, graph theoretic approach.	
Unit 3	**15L**
Poisson Process: postulates of Poisson process, properties of Poisson process, inter-arrival time, pure birth process, Yule Furry process, birth and death process, pure death process.	
Unit 4	**15L**
Queuing System: General concept, steady state distribution, queuing model, M/M/1 with finite and infinite system capacity, waiting time distribution (without proof). Gambler's Ruin Problem: Classical ruin problem, expected duration of the game.	
PRACTICAL/LAB. WORK:	
1. Calculation of transition probability matrix 2. Identification of characteristics of reducible and irreducible chains. 3. Identification of types of classes 4. Identification of ergodic transition probability matrix 5. Stationarity of Markov chain and graphical representation of Markov chain 6. Computation of probabilities in case of generalizations of independent Bernoulli trials 7. Calculation of probabilities for given birth and death rates and vice versa 8. Calculation of probabilities for Birth and Death Process 9. Calculation of probabilities for Yule Furry Process 10. Computation of inter-arrival time for a Poisson process. 11. Calculation of Probability and parameters for (M/M/1) model and change in behavior of queue as N tends to infinity. 12. Calculation of generating function and expected duration for different amounts of stake. 13. Computation of probabilities and expected duration between players.	

References:

1. Medhi, J. (2009): Stochastic Processes, New Age International Publishers.
2. Basu, A.K. (2005): Introduction to Stochastic Processes, Narosa Publishing.
3. Bhat,B.R.(2000): Stochastic Models: Analysis and Applications, New AgeInternational Publishers.
4. Taha, H. (1995): Operations Research: An Introduction, Prentice- Hall India.
5. Feller, William (1968): Introduction to probability Theory and Its Applications, Vol I,3rd Edition, Wiley International.

Course Objective	1. Introduction of stochastic process. 2. Know the details of Markov chain.

	3. Introduction to Poisson process. 4. Know the basics of queuing system.
Learning Outcomes	1. Calculation of transition probability matrix. 2. Identification of characteristics of reducible and irreducible chains. 3. Identification of types of classes and ergodic transition probability matrix. 4. Stationary of Markov chain and graphical representation of Markov chain. 5. Calculation of probabilities for Birth and Death Process 6. Calculation of probabilities for Yule Furry Process 7. Computation of inter-arrival time for a Poisson process. 8. Calculation of Probability and parameters for (M/M/1) model and change in behavior of queue as N tends to infinity.

MSSUGDS02: Econometrics

Theory	
Unit 1	**15L**
Introduction: Objective behind building econometric models, nature of econometrics, model building, role of econometrics, structural and reduced forms. Estimation under linear restrictions. Dummy variables, Qualitative data.	
Unit 2	**15L**
Multicollinearity: Introduction and concepts, detection of multicollinearity, consequences and solutions of multicollinearity.	
Unit 3	**15L**
Autocorrelation: Concept, consequences of auto correlated disturbances, detection and solution of autocorrelation. Generalized least squares estimation.	
Unit 4	**15L**
Heteroscedastic disturbances: Concepts and efficiency of Aitken estimator with OLS estimator under heteroscedasticity. Consequences of heteroscedasticity. Tests and solutions of heteroscedasticity. Errors in variables: Correlation between error and regressors. Instrumental variable method (Single-equation model with one explanatory variable)	
PRACTICAL/LAB. WORK:	
1. Problems related to consequences of Multicollinearity. 2. Diagnostics of Multicollinearity. 3. Problems related to consequences of Autocorrelation (AR(I)). 4. Diagnostics of Autocorrelation. 5. Problems related to consequences Heteroscedasticity. 6. Diagnostics of Heteroscedasticity. 7. Estimation of problems of General linear model under Heteroscedastic distance terms. 8. Problems on Autoregressive models. 9. Problems on Instrumental variable.	

References:

1. Gujarati, D. and Sangeetha, S. (2007): Basic Econometrics, 4th Edition McGraw Hill Companies.
2. Johnston, J. (1972): Econometric Methods, 2nd Edition, McGraw Hill International.
3. Koutsoyiannis, A. (2004): Theory of Econometrics, 2nd Edition, , Palgrave Macmillan Limited.
4. Maddala, G.S. and Lahiri, K. (2009): Introduction to Econometrics, 4th Edition, John Wiley & Sons.

Course Objective	1. Introduction to econometric models. 2. Basics of estimation under linear restrictions. 3. Concepts of multicolinearity. 4. Defining autocorrelation and generalized least square estimation. 5. Details of Heteroscedastic disturbances. 6. Introduction to Instrumental variable method.
Learning Outcomes	1. Problems related to consequences of Multicollinearity. 2. Diagnostics of Multicollinearity. 3. Solving the problems related to consequences of Autocorrelation (AR(I)). 4. Diagnostics of Autocorrelation. 5. Solving the problems related to consequences Heteroscedasticity and its diagnostics. 6. Estimation of problems of General linear model under Heteroscedastic distance terms. 7. Solving the problems on Autoregressive models and Instrumental variable.

OR

Operations Research

Theory	
Unit 1	**12L**
Introduction and Historical Background, Phases of Operations Research, model building, various types of O.R. problems. Linear Programming Problem, Requirements of LPP, Mathematical Formulation of LPP, Graphical Methods to Solve Linear Programming Problems. Convex sets, Extreme point.	
Unit 2	**12L**
Simplex method for solving L.P.P. Charne's M-technique for solving L.P.P. involving artificial variables. Special cases of L.P.P. Concept of Duality in L.P.P: Dual simplex method.	
Unit 3	**18L**
Introduction, Formulation of Transportation Problem (TP). Initial solution by North West corner rule, Least cost method and Vogel's approximation method (VAM), MODI's method to find the optimal solution, special cases of transportation problem. Assignment problem: Hungarian method to find optimal assignment, special cases of assignment problem.	
Unit 4	**18L**

Game theory: Introduction, Competitive Situations, Characteristics of Competitive Games. Rectangular game, Two-Person Zero-Sum game, minimax-maximin principle, solution to rectangular game using graphical method, dominance and modified dominance property to reduce the game matrix and solution to rectangular game with mixed strategy.
PRACTICAL/LAB. WORK:
1. Mathematical formulation of L.P.P and solving the problem using graphical method, Simplex technique and Charne's Big 2. M method involving artificial variables. 3. Identifying Special cases by Graphical and Simplex method and interpretation a. Degenerate solution b. Unbounded solution c. Alternate solution d. Infeasible solution 4. Allocation problem using Transportation model. 5. Allocation problem using Assignment model. 6. Problems based on game matrix. 7. Graphical solution to mx2 / 2xn rectangular game. 8. Mixed strategy.

References:

1. Taha, H. A. (2007): Operations Research: An Introduction, 8 Hall of India.
2. KantiSwarup, Gupta, P.K. and Manmohan (2007): Operations Research, 13th Edition, Sultan Chand and Sons.
3. Hadley, G: (2002) : Linear Programming, Narosa Publications.
4. Hillier, F.A and Lieberman, G.J. (2010): Introduction to Operations Research- Concepts and cases, 9th Edition, Tata McGraw Hill.

Course Objective	1. Introduction to Linear programming problem and related terms associated with LPP. 2. Basics of simplex method. 3. Concepts of duality. 4. Introduction of Transportation problem. 5. Details of Game theory.
Learning Outcomes	1. Mathematical formulation of L.P.P and solving the problem using graphical method, Simplex technique and Charne's Big M method involving artificial variables. 2. Identifying Special cases by Graphical and Simplex method and interpretation of degenerate solution, unbounded solution, alternate solution and infeasible solution. 3. Solve allocation problem using Transportation model. 4. Solve allocation problem using Assignment model. 5. Solve the problems based on mixed game strategy.

MSSUGDS03 Financial Statistics

Theory	

Unit 1	**10L**
Probability review: Real valued random variables, expectation and variance, skewness and kurtosis, conditional probabilities and expectations. Discrete Stochastic Processes, Binomial processes, General random walks, Geometric random walks, Binomial models with state dependent increments.	
Unit 2	**10L**
Tools Needed For Option Pricing: Wiener process, stochastic integration, and stochastic differential equations. Introduction to derivatives: Forward contracts, spot price, forward price, future price. Call and put options, zero-coupon bonds and discount bonds.	
Unit 3	**20L**
Pricing Derivatives: Arbitrage relations and perfect financial markets, pricing futures, put-call parity for European options, relationship between strike price and option price. Stochastic Models in Finance: Discrete time process- binomial model with period one.	
Unit 4	**20L**
Stochastic Models in Finance: Continuous time process- geometric Brownian motion. Ito's lemma, Black-Scholes differential equation, Black-Scholes formula for European options, Hedging portfolios: Delta, Gamma and Theta hedging. Binomial Model for European options: Cox-Ross-Rubinstein approach to option pricing. Discrete dividends.	
PRACTICAL/LAB. WORK:	
1. To verify "no arbitrage" principle 2. To verify relationship between spot price, forward price, future price 3. To price future contracts 4. To verify put-call parity for European options 5. To construct binomial trees and to evaluate options using these trees 6. To price options using black – Scholes formula 7. To hedge portfolios using delta and gamma hedging 8. To hedge portfolios theta hedging 9. Pricing of call options using binomial model 10. Computation of dividends on call options as a percentage of stock price. 11. Computation of dividends on call options as a fixed amount of money. 12. Pricing of put options using binomial model 13. Call-put parity for options following binomial models. 14. Effect of dividends on put options.	

References:

1. Bhat,B.R.(2000): Stochastic Models: Analysis and Applications, New AgeInternational Publishers.
2. Taha, H. (1995): Operations Research: An Introduction, Prentice- Hall India.
3. Feller, William (1968): Introduction to probability Theory and Its Applications, Vol I,3rd Edition, Wiley International.
4. Chatfield C. (1980): The Analysis of Time Series –An Introduction, Chapman & Hall.
5. Kendall M.G. (1976): Time Series, Charles Griffin.
6. Brockwell and Davis (2010):Introduction to Time Series and Forecasting (Springer Texts in Statistics) ,2nd Edition.

Course Objective	1. Review of discrete stochastic process. 2. Introduction to wiener process, stochastic integration and stochastic differential equation.

	3. Introduction to derivatives and related terms. 4. Details of pricing of derivatives. 5. Uses of some stochastic models in finance.
Learning Outcomes	1. Solving problems associated withwiener process, stochastic integration and stochastic differential equation. 2. Understand relationship between spot price, forward price, future price. 3. Calculate price future contracts. 4. Verify put-call parity for European options. 5. Construction binomial trees and to evaluate options using these trees. 6. Derive price options using black – Scholes formula. 7. To hedge portfolios using delta and gamma hedging. 8. Pricing of call options using binomial model. 9. Computation of dividends on call options as a percentage of stock price. 10. Call-put parity for options following binomial models. 11. Calculate effect of dividends on put options.

OR

Survival Analysis

Theory	
Unit 1	**15L**
Survival Analysis: Functions of survival times, survival distributions and their applications-exponential, gamma, Weibull, Rayleigh, lognormal distributions, and distribution having bath-tub shaped hazard function. Mean Residual Time.	
Unit 2	**15L**
Censoring Schemes: Type I, Type II and progressive or random censoring with biological examples. Estimation of mean survival time and variance of the estimator for Type I and Type II censored data with numerical examples.	
Unit 3	**15L**
Non-parametric methods: Actuarial and Kaplan-Meier methods for estimating survival function and variance of the Estimator.	
Unit 4	**15L**
Competing Risk Theory: Indices for measurement of probability of death under competing risks and their interrelations. Estimation of probabilities of death using maximum likelihood principle and modified minimum Chi-square methods.	
PRACTICAL/LAB. WORK:	
1. To estimate survival function 2. To determine death density function and hazard function 3. To identify type of censoring and to estimate survival time for type I censored data 4. To identify type of censoring and to estimate survival time for type II censored data 5. To identify type of censoring and to estimate survival time for progressively type I censored data 6. Estimation of mean survival time and variance of the estimator for type I censored data 7. Estimation of mean survival time and variance of the estimator for type II censored data 8. Estimation of mean survival time and variance of the estimator for progressively type I	

censored data

9. To estimate the survival function and variance of the estimator using Non-parametric methods with Actuarial methods
10. To estimate the survival function and variance of the estimator using Non-parametric methods with Kaplan-Meier method
11. To estimate Crude probability of death
12. To estimate Net-type I probability of death
13. To estimate Net-type II probability of death
14. To estimate partially crude probability of death
15. 15. To estimate gene frequencies

References:

1. Lee, E.T. and Wang, J.W. (2003): Statistical Methods for Survival data Analysis, 3rd Edition, John Wiley and Sons.
2. Kleinbaum, D.G. (1996): Survival Analysis, Springer. Chiang, C.L. (1968): Introduction to Stochastic Processes in Bio Statistics, John Wiley and Sons.
3. Indrayan, A. (2008): Medical Biostatistics, 2nd Edition Chapman and Hall/CRC.

Course Objective	1. The objectives of this course are to study the different models from Survival Analysis, to provide the construction of parametric and non-parametric estimators of survival distributions, and probability density functions based on incomplete data. 2. The models with right-censored, truncated and interval censored data will be considered. 3. The properties and constructions of several goodness-of-fit tests based on the modified empirical processes are studied. 4. Introduction to Competing Risk Theory.
Learning Outcomes	1. Describe many practical models by means of the counting processes based on the censored and truncated observation. 2. Ability to recognize the difference between parametric and non-parametric survival models. 3. Able to estimate survival function, cumulative hazard rate function using the so-called Kaplan-Meier estimator and Nelson-Aalen estimators, respectively. 4. Understanding of the Cox proportional hazard model and its connection to the log linear model. 5. Investigate the constructions of confidence intervals and the asymptotic properties of goodness-of-fit tests for one-sample and two-sample problems under random censorship. 6. Test hypotheses when modeling the survival time distributions using R-programming codes.

MSSUGDS07 Project Work

Objective	

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

MSSUGSE01: Statistical Data Analysis Using R

Unit 1	**5L**
Introduction to R: Installation, commandline environment, overview of capabilities, brief mention of open source philosophy. R as a calculator: The four basic arithmetic operations. Use of parentheses nesting up to arbitrary level. The power operation. Evaluation of simple expressions. Quotient and remainder operations for integers. Standard functions, e.g., sin, cos, exp, log.	
Unit 2	**5L**
The different types of numbers in R: Division by zero leading to Infor -Inf. NaN. NA. No need to go into details. Variables. Creating a vector using c(), seq() and colon operator. How functions map overvectors. Functions to summarise a vector: sum, mean, sd, medianetc. Extracting a subset from the vector (by index, by property). R as a graphing calculator: Introduction to plotting. Plot(), lines(), abline(). No detailsabout the graphics parameters except colour and line width.Barplot, Pie chart and Histogram. Box plot. Scatter plot and simple linear regression using lm(y~x).	
Unit 3	**5L**
Matrix operations in R: Creation. Basic operations. Extracting submatrices. Loading data from a file: read.table() and read.csv(). Mention of head=TRUE and head=FALSE. Dataframes. Mention that these are like matrices, except that different columns may be of different types.	
Unit 4	**5L**
Problems on discrete and continuous probability distributions.	

References:

1. Gardener, M (2012) Beginning R: The Statistical Programming Language, Wiley Publications.
2. Braun W J, Murdoch D J (2007): A First Course in Statistical Programming with R. Cambridge University Press. New York.
3. A simple introduction to R by Arnab Chakraborty (freely available at http://www.isical.ac.in/~arnabc/) R for beginners by Emmanuel Paradis (freely available at https://cran.r-project.org/doc/contrib/Paradisrdebuts_en.pdf).

OR

Research Methodology

Unit 1	**5L**
What is Research? Role of Research in important areas. Characteristics of Scientific Method. Process of research: Stating Hypothesis or Research question, Concepts & Constructs, Units of analysis & characteristics of interest, Independent and Dependent variables, Extraneous or Confounding variables. Measurements and scales of Measurements. Types of research: Qualitative & Quantitative Research, Longitudinal Research, Survey & Experimental Research.	
Unit 2	**5L**
Survey Methodology and Data Collection, sampling frames and coverage error, non-response.	
Unit 3	**5L**
Review of various techniques for data analysis covered in core statistics papers, techniques of interpretation, precaution in interpretation.	
Unit 4	**5L**
Develop a questionnaire, collect survey data pertaining to a research problem (such as gender discriminations in private v/s government sector, unemployment rates, removal of subsidy, impact on service class v/s unorganized sectors), questions and answers in surveys, Internal & External validity, , interpret the results and draw inferences. Formats and presentations of Reports – an overview.	

References:

1. Kothari, C.R. (2009): Research Methodology: Methods and Techniques, 2nd Revised Edition reprint, New Age International Publishers.
2. Kumar, R (2011): Research Methodology: A Step – by – Step Guide for Beginners, SAGE publications.

Course Objective	1. To familiarize participants with basic of research and the research process. 2. To enable the participants in conducting research work and formulating research synopsis and report. 3. To familiarize participants with Statistical packages such as SPSS/EXCEL. 4. To impart knowledge for enabling students to develop data analytics skills and meaningful interpretation to the data sets so as to solve the business/Research problem.
Learning Outcomes	1. Develop understanding on various kinds of research, objectives of doing research, research process, research designs and sampling. 2. Have basic knowledge on qualitative research techniques. 3. Have adequate knowledge on measurement & scaling techniques as well as the quantitative data analysis. 4. Have basic awareness of data analysis-and hypothesis testing procedures.

MSSUGSE02: Monte Carlo Methods

Unit 1	**5L**
Using the computer for random number generation. (treated as a black box) A brief look at some popular approaches (nomathematical justification needed). Simulating a coin toss, a die roll and a card shuffle.	
Unit 2	**5L**
CDF inversion method. Simulation from standard distributions. Finding probabilities and moments using simulation.	
Unit 3	**5L**
Monte Carlo integration. Basic idea of importance sampling. MCMC not included.	
Unit 4	**5L**
Generating from Binomial and Poisson distributions, and comparing the histograms to the PMFs. Generating from Uniform(0,1) distribution, and applying inverse CDF transforms. Simulating Gaussian distribution using Box-Muller method. Approximating the expectation of a given function of a random variable using simulation. Graphical demonstration of the Law of Large Numbers. Approximating the value of pi by simulating dart throwing.	

References:

1. Shonkwiler, Ronald W. and Mendivil, Franklin (2009):Explorations in Monte Carlo Methods (Undergraduate Texts in Mathematics)
2. Carsey,Thomas M. and Harden, Jeffrey J. (2014):Monte Carlo Simulation and Resampling Methods for Social Science.

OR

Data Base Management Systems

Unit 1	**5L**
Introduction: Overview of Database Management System, Introduction to Database Languages, advantages of DBMS over file processing systems.	
Unit 2	**5L**
Relational Database Management System: The Relational Model, Introduction to SQL: Basic Data Types, Working with relations of RDBMS: Creating relations e.g. Bank, College Database (create table statement).	
Unit 3	**5L**
Modifying relations (alter table statement), Integrity constraints over the relation like Primary Key , Foreign key, NOT NULL to the tables, advantages and disadvantages of relational Database System.	
Unit 4	**5L**
Database Structure: Introduction, Levels of abstraction in DBMS, View of data, Role of Database users and administrators, Database Structure: DDL, DML, Data Manager (Database Control System).Types of Data Models Hierarchical databases, Network databases, Relational databases,	

Object oriented databases.

References:

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

Course Objective	1. To explain basic database concepts, applications, data models, schemas and instances. 2. To demonstrate the use of constraints and relational algebra operations. 3. Describe the basics of SQL and construct queries using SQL. 4. To emphasize the importance of normalization in databases. 5. To facilitate students in Database design. 6. To familiarize issues of concurrency control and transaction management.
Learning Outcomes	1. Apply the basic concepts of Database Systems and Applications. 2. Use the basics of SQL and construct queries using SQL in database creation and interaction. 3. Design a commercial relational database system (Oracle, MySQL) by writing SQL using the system. 4. Analyze and Select storage and recovery techniques of database system.

MSSUGGE01 Statistical Methods

Course Objectives	This course aims to give a basic introductory exposure to the students who had chosen statistics as generic elective. It exposes the students towards the basics of statistical methods, especially the empirical data analysis, which will help them to understand their core subject very well.
Learning Outcomes	Upon learning the course, the students will learn the techniques like measures of central tendency, dispersion for handling univariate data and correlation and regression for bivariate data analysis. Categorical data analysis is also included. Several diagrammatic representations are taught which would help them to build an excellent understanding towards learning from data.

Theory	
Unit 1	**20L**
Introduction: Definition and scope of Statistics, concepts of statistical population and sample. Data: quantitative and qualitative, attributes, variables, scales of measurement - nominal, ordinal, interval and ratio. Presentation: tabular and graphic, including histogram and ogives.	
Unit 2	**10L**
Measures of Central Tendency: mathematical and positional. Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation, moments, skewness and kurtosis.	
Unit 3	**15L**
Bivariate data: Definition, scatter diagram, simple, partial and multiple correlation (3 variables only), rank correlation. Simple linear regression, principle of least squares and fitting of polynomials and exponential curves.	
Unit 4	**15L**
Theory of attributes, consistency of data, independence and association of attributes, measures of association and contingency.	
PRACTICAL/LAB. WORK:	
1. Graphical representation of data 2. Problems based on measures of central tendency 3. Problems based on measures of dispersion 4. Problems based on combined mean and variance and coefficient of variation 5. Problems based on moments, skewness and kurtosis 6. Fitting of polynomials, exponential curves 7. Karl Pearson correlation coefficient 8. Partial and multiple correlations 9. Spearman rank correlation with and without ties. 10. Correlation coefficient for a bivariate frequency distribution 11. Lines of regression, angle between lines and estimated values of variables. 12. Checking consistency of data and finding association among attributes.	

References:

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2002): Fundamentals of Statistics, Vol. I& II, 8th Edn. The World Press, Kolkata.

2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
3. Mood, A.M., Graybill, F.A. andBoes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn. (Reprint), Tata McGraw-Hill Pub. Co. Ltd.
4. Tukey, J.W.(1977) : Exploratory Data Analysis, Addison-Wesley Publishing Co.
5. Agresti, A. (2010): Analysis of Ordinal Categorical Data, 2nd Edition, Wiley.
6. Freedman, D., Pisani, R. and Purves, R. (2014): Statistics, 4th Edition, W. W. Norton & Company
7. Snedecor G.W and Cochran W.G. (1967) Statistical Methods. Iowa State University Press.

MSSUGGE02 Introductory Probability

Course Objective	1. Introduction to random experiment and sample space. 2. Defining probability through classical, statistical, and axiomatic approach. 3. Understand Bayes Theorem . 4. Defining random variables and their properties. 5. Basics of Convergence in probability and Central Limit Theorem. 6. Details of standard probability distributions.
Learning Outcomes	1. Solve some basic problems in probability. 2. Application of Bayes theorem. 3. Finding expectation, variance, moments and moment generating function of a random variable. 4. Understand Convergence in probability and central limit theorem. 5. Fitting of standard distributions.

Theory	
Unit 1	**20L**
Probability: Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability – classical, statistical, and axiomatic. Conditional Probability, laws of addition and multiplication, independent events, theorem of total probability, Bayes' theorem and its applications.	
Unit 2	**10L**
Random Variables: Discrete and continuous random variables, p.m.f., p.d.f. ,c.d.f. Illustrations of random variables and its properties. Expectation, variance, moments and moment generating function.	
Unit 3	**15L**
Convergence in probability, almost sure convergence, Chebyshev's inequality, weak law of large numbers, De-Moivre Laplace and Lindeberg-Levy Central Limit Theorem (C.L.T.).	
Unit 4	**15L**
Standard probability distributions: Binomial, Poisson, geometric, negative binomial, hypergeometric, uniform, normal, exponential, beta, gamma.	
PRACTICAL/LAB. WORK:	
1. Fitting of binomial distributions for n and p = q = ½ given 2. Fitting of binomial distributions for n and p given	

3. Fitting of binomial distributions computing mean and variance 4. Fitting of Poisson distributions for given value of lambda 5. Fitting of Poisson distributions after computing mean 6. Application problems based on binomial distribution 7. Application problems based on Poisson distribution 8. Problems based on area property of normal distribution 9. To find the ordinate for a given area for normal distribution 10. Application based problems using normal distribution 11. Fitting of normal distribution when parameters are given 12. Fitting of normal distribution when parameters are not given

References:

1. Chung, K.L. (1983): Elementary Probability Theory with Stochastic Process, Springer / Narosa.
2. Feller, W. (1968): An Introduction to Probability Theory & its Applications, John Wiley.
3. Goon, A.M., Gupta, M.K. &Dasgupta, B. (1994): An Outline of Statistical Theory (Vol-1), World Press.
4. Parzen, E. (1972): Modern Probability Theory and its Applications, John Wiley .
5. Uspensky, J.V. (1937): Introduction to Mathematical Probability,McGraw Hill.
6. Cacoullos, T. (1973): Exercises in Probability. Narosa.
7. Rahman, N.A. (1983): Practical Exercises in Probability and Statistics
8. Griffen. Ross, S. (2002): A First Course in Probability, Prentice Hall.
9. Malik S.C. and Savita Arora (1994): Mathematical Analysis, Second Edition, Wiley Eastern Limited, New Age International Limited, New Delhi.
10. Somasundram, D. And Chaudhary, B (1987.: A First Course in Mathematical Analysis, Narosa Publishing House, New Delhi.

MSSUGGE03 Basics of Statistical Inference

Course Objective	1. Learn the basics of point estimation and hypothesis testing. 2. Introduction to categorical data. 3. Details of some non-parametric test. 4. Basics of Analysis of variance, one-way and two-way classification. 5. Introduction to design of experiments.
Learning Outcomes	1. Solve some problems in point estimation and hypothesis testing 2. Calculate association in categorical data. 3. Able to test the association and goodness-of-fit using Chisquare test. 4. Application to some non-parametric test. 5. Application of ANOVA in design of experiments.

Theory	
Unit 1	**25L**
Estimation of population mean, confidence intervals for the parameters of a normal distribution (one sample and two sample problems). The basic idea of significance test. Null and alternative hypothesis. Type I & Type II errors, level of significance, concept of p-value. Tests of hypotheses for the parameters of a normal distribution (one sample and two sample problems).	

Unit 2	**10L**
Categorical data: Tests of proportions, tests of association and goodness-of-fit using Chisquare test, Yates' correction.	
Unit 3	**10L**
Tests for the significance of correlation coefficient. Sign test for median, Sign test for symmetry, Wilcoxon two-sample test.	
Unit 4	**15L**
Analysis of variance, one-way and two-way classification. Brief exposure of three basic principles of design of experiments, treatment, plot and block. Analysis of completely randomized design, randomized complete block design.	
PRACTICAL/LAB. WORK:	
1. Estimators of population mean. 2. Confidence interval for the parameters of a normal distribution (one sample and two sample problems). 3. Tests of hypotheses for the parameters of a normal distribution (one sample and two sample problems). 4. Chi-square test of proportions. 5. Chi-square tests of association. 6. Chi-square test of goodness-of-fit. 7. Test for correlation coefficient. 8. Sign test for median. 9. Sign test for symmetry. 10. Wilcoxon two-sample test. 11. Analysis of Variance of a one way classified data 12. Analysis of Variance of a two way classified data. 13. Analysis of a CRD. 14. Analysis of an RBD.	

References:

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2003): An Outline of Statistical Theory, Vol. I, 4th Edn. World Press, Kolkata.
2. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2ndEdn. (Reprint) John Wiley and Sons.
3. Hogg, R.V. And Tanis, E.A. (2009): A Brief Course in Mathematical Statistics. Pearson Education.
4. Johnson, R.A. and Bhattacharya, G.K. (2001): Statistics-Principles and Methods, 4th Edn. John Wiley and Sons.
5. Mood, A.M., Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn. (Reprint).Tata McGraw-Hill Pub. Co. Ltd.

MSSUGGE04 Applied Statistics

Course Objective	1. Know the concept of time series and their components. 2. Defining different types of index numbers. 3. Introduction to statistical quality control.

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

Theory	
Unit 1	**25L**
Economic Time Series: Components of time series, Decomposition of time series- Additive and multiplicative model with their merits and demerits, Illustrations of time series. Measurement of trend by method of free-hand curve, method of semi-averages and method of least squares (linear, quadratic and modified exponential).Measurement of seasonal variations by method of ratio to trend.	
Unit 2	**10L**
Index numbers: Definition, Criteria for a good index number, different types of index numbers. Construction of index numbers of prices and quantities, consumer price index number. Uses and limitations of index numbers.	
Unit 3	**10L**
Statistical Quality Control: Importance of statistical methods in industrial research and practice. Determination of tolerance limits. Causes of variations in quality: chance and assignable. General theory of control charts, process & product control, Control charts for variables: X- bar and R-charts. Control charts for attributes: p and c-charts.	
Unit 4	**15L**
Demographic Methods: Introduction, measurement of population, rates and ratios of vital events. Measurement of mortality: CDR, SDR (w.r.t. Age and sex), IMR, Standardized death rates. Life (mortality) tables: definition of its main functions and uses. Measurement of fertility and reproduction: CBR, GFR, and TFR. Measurement of population growth: GRR, NRR.	
PRACTICAL/LAB. WORK:	
1. Measurement of trend: Fitting of linear, quadratic trend, exponential curve and plotting of trend values and comparing with given data graphically. 2. Measurement of seasonal indices by Ratio-to-trend method and plotting of trend values and comparing with given data graphically. 3. Construction of price and quantity index numbers by Laspeyres' formula, Paasche's formula, Marshall-Edgeworth's formula, Fisher's Formula - Comparison and interpretation. 4. Construction of wholesale price index number, fixed base index number and consumer price index number with interpretation	

5. Construction and interpretation of X bar & R-chart
6. Construction and interpretation p-chart (fixed sample size) and c-chart
7. Computation of measures of mortality
8. Completion of life table
9. Computation of measures of fertility and population growth

References:

1. Chatfield C. (1980): The Analysis of Time Series –An Introduction, Chapman & Hall.
2. Kendall M.G. (1976): Time Series, Charles Griffin.
3. Brockwell and Davis (2010):Introduction to Time Series and Forecasting (Springer Texts in Statistics) ,2nd Edition.
4. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2002): Fundamentals of Statistics, Vol. II, 8th Edn. The World Press, Kolkata
5. Mudgett B.D. (1951): Index Numbers, John Wiley.
6. Allen R.G.D. (1975): Index Numbers in Theory and Practice, Macmillan
7. Nagar A.L. & Das R. K. (1976): Basic Statistics.
8. Montogomery, D. C. (2009): Introduction to Statistical Quality Control, 6th Edition, Wiley India Pvt. Ltd.
9. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. II, 8th Edn. The World Press, Kolkata.
10. Mukhopadhyay, P (2011): Applied Statistics, 2nd edition revised reprint, Books and Allied (P) Ltd.
11. Montogomery, D. C. and Runger, G.C. (2008): Applied Statistics and Probability for Engineers, 3rd Edition reprint, Wiley India Pvt. Ltd.
12. Ehrlich,B.Harris(2002):Transactional Six Sigma and Lean Servicing, 2nd Edition St. Lucie Press.
13. Hoyle, David (1995): ISO Quality Systems Handbook, Heinemann Publication. 2nd Edition, Butterworth