ANNAMALAI UNIVERSITY
MASTER OF SCIENCE

M.Sc. DEGREE COURSE in STATISTICS

(with effect from 2021 – 2022)

The Course of Study and the Scheme of Examinations

Sl. No.	*Study Components*		*ins. hrs / week*	*Credit*	*Title of the Paper*	*Maximum Marks*		
	Course Title					*CIA*	*Uni. Exam*	*Total*
SEMESTER I								
1.	Core	Paper-1	5	4	Mathematical Analysis	25	75	100
2.	Core	Paper-2	5	4	Measure and Probability Theory	25	75	100
3.	Core	Paper-3	5	4	Distribution Theory	25	75	100
4.	Core	Paper-4	5	4	Programming in R	25	75	100
	Core Practical	Practical-1	2	-	Statistical Practical – I	-	-	-
	Core Practical	Practical-2	2	-	Statistical Software Practical – I (Using R)	-	-	-
Internal Elective for same major students								
5.	Core Elective	Paper-1	3	3	**(to choose one out of 2)** A. Official Statistics B. Advanced Operations Research	25	75	100
External Elective for other major students (Inter/multi disciplinary papers)								
6.	Open Elective	Paper-1	3	3	**(to choose one out of 2)** A. Basic Statistics B. Operations Research	25	75	100
			30	**22**		**150**	**450**	**600**
SEMESTER II						*CIA*	*Uni. Exam*	*Total*
7.	Core	Paper-5	6	4	Sampling Theory	25	75	100
8.	Core	Paper-6	6	4	Estimation Theory	25	75	100
9.	Core Practical	Practical-1	4	3	Statistical Practical – I	40	60	100
10.	Core Practical	Practical-2	4	3	Statistical Software Practical – I (Using R)	40	60	100
Internal Elective for same major students								
11.	Core Elective	Paper-2	4	3	**(to choose one out of 2)** A. Linear Regression Analysis B. Actuarial Statistics	25	75	100
External Elective for other major students (Inter/multi disciplinary papers)								
12.	Open Elective	Paper-2	4	3	**(to choose one out of 2)** A. Probability and Statistics B. Indian Official Statistics	25	75	100
13.	*Field Study		-	2		100	-	100
14.	Compulsory Paper		2	2	**Human Rights**	25	75	100
			30	**24**		**305**	**495**	**800**
SEMESTER III						*CIA*	*Uni. Exam*	*Total*

15.	Core	Paper-7	6	4	Testing Statistical Hypotheses	25	75	100
16.	Core	Paper-8	6	4	Design and Analysis of Experiments	25	75	100
17.	Core	Paper-9	6	4	Multivariate Analysis	25	75	100
	Core Practical	Practical-3	3	-	Statistical Practical – II	-	-	-
	Core Practical	Practical-4	3	-	Statistical Software Practical – II (Using SPSS)	-	-	-
Internal Elective for same major students								
18.	Core Elective	Paper-3	3	3	**(to choose one out of 2)** A. Statistical Methods of Epidemiology B. Data Mining	25	75	100
External Elective for other major students (Inter/multi disciplinary papers)								
19.	Open Elective	Paper-3	3	3	**(to choose one out of 2)** A. Business Statistics B. Research Methodology	25	75	100
20.	**MOOC Courses		-	-		-	-	100
			30	**18**		**125**	**375**	**600**
SEMESTER IV						***CIA***	***Uni. Exam***	***Total***
21.	Core	Paper-10	6	5	Statistical Quality Control	25	75	100
22.	Core	Paper-11	6	4	Stochastic Processes	25	75	100
23.	Core Practical	Practical-3	3	3	Statistical Practical – II	40	60	100
24.	Core Practical	Practical-4	3	3	Statistical Software Practical – II (Using SPSS)	40	60	100
25.	Core	Project	6	5	Project with viva voce (Compulsory)	100 (75 Project +25 viva)		**100**
Internal Elective for same major students								
26.	Core Elective	Paper-4	3	3	**(to choose one out of 2)** A. Econometrics B. Biostatistics and Survival Analysis	25	75	100
External Elective for other major students (Inter/multi disciplinary papers)								
27.	Open Elective	Paper-4	3	3	**(to choose one out of 2)** A. Descriptive Statistics B. Statistical Methods for Researchers	25	75	100
			30	**26**		**205**	**495**	**700**
			120	**90**		**785**	**1915**	**2700**

Note:

- Evaluation of Core Practical : CIA : 25 Marks + Practical Record 15 Marks = 40 Marks
- $$ Evaluation of Project (50) + Project Viva-voce (25)
- ** A student has to complete at least 2 credits course through MOOC under SWAYAM portal in the subject category of Mathematical Sciences before end of THIRD semester. Website maintained by UGC : https://swayam.gov.in/
- Students can find e-books and e-materials through the website e-Pgpathsala maintained by UGC: http://epgp.inflibnet.ac.in/

*** Field Study**

There will be field study which is compulsory in the first semester of all PG courses with 2 credits. This field study should be related to the subject concerned with social impact. Field and Topic should be registred by the students in the first semester of their study along with the name of a mentor before the end of the month of August. The report with problem identification and proposed solution should be written in not less than 25 pages in a standard format and it should be submitted at the end of second semester. The period for undergoing the field study is 30 hours beyond the instructional hours of the respective programme. Students shall consult their mentors within campus and experts outside the campus for selecting the field and topic of the field study. The following members may be nominated for confirming the topic and evaluating the field study report.

(i). Head of the respective department

(ii). Mentor

(iii). One faculty from other department

****Mooc Courses**

Inclusion of the Massive Open Online Courses (MOOCs) with zero credits available on SWAYAM, NPTEL and other such portals approved by the University Authorities.

ANNAMALAI UNIVERSITY

ANNAMALAINAGAR - 608002

M.Sc. STATISTICS
SYLLABUS

(with effect from 2021 - 2022)

List of Core / Elective / Open Elective Subjects

Core Subjects

1. Mathematical Analysis
2. Measure and Probability Theory
3. Distribution Theory
4. Programming in R
5. Sampling Theory
6. Estimation Theory
7. Statistical Practical-I
8. Statistical Software Practical-I (Using R)
9. Testing Statistical Hypotheses
10. Design and Analysis of Experiments
11. Multivariate Analysis
12. Statistical Quality Control
13. Stochastic Processes
14. Statistical Practical-II
15. Statistical Software Practical-II (Using SPSS)
16. Project with Viva-voce

Core Elective Subjects (for students of Statistics)

1. A. Official Statistics
   B. Advanced Operations Research
2. A. Linear Regression Analysis
   B. Actuarial Statistics
3. A. Statistical Methods of Epidemiology
   B. Data Mining
4. A. Econometrics
   B. Biostatistics and Survival Analysis

Open Elective Subjects (for students of other departments)

1. A. Basic Statistics
   B. Operations Research
2. A. Probability and Statistics
   B. Indian Official Statistics
3. A. Business Statistics
   B. Research Methodology
4. A. Descriptive Statistics
   B. Statistical Methods for Researchers

CORE SUBJECTS

Name of the course/subject: M.Sc. Statistics **Semester: I**
Name of the Paper: Mathematical Analysis **Credits: 4** **Hours of teaching: 5**
Paper type: Core

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Course Objective(s)

To enable students to gain knowledge in real analysis and matrix theory towards better understanding of mathematical statistics.

Unit-1: Metric Space – open, closed sets – Intervals (rectangles), Real valued Continuous functions-Discontinuities - compact sets, Bolzano – Weirstrass theorem, Heine – Borel theorem.

Unit-2: Derivatives - maxima and minima - Riemann integral & Riemann – Stieltjes integral with respect an increasing integrator – properties of R. S. integral. Functions of several variables, constrained and unconstrained maxima – minima of functions, partial and total derivatives

Unit-3: Basic properties of matrices (orthogonal, idempotent, kronecker product, projection operators etc); Linear dependence, independence and rank of a matrix; characteristic roots and polynomial, multiplicity of characteristic roots; Cayley Hamilton theorem; inverse of a matrix and determinants;

Unit-4: Reduction of matrices, Echelon form, Hermite canonical form, diagonal reduction, rank factorization, triangular reduction Jordan form; Symmetric matrices and its properties; Decomposition - singular value decomposition, spectral decomposition, Cholesky decomposition.

Unit-5: Matrix differentiation; generalized inverse and its properties, Moore-Penrose inverse; Application of g-inverse; Quadratic forms, classification, definiteness, index and signature, extremum; transformation and reduction of quadratic form; applications of quadratic forms.

Text Books:

Unit-1 and 2 : Rangachari,M.S.(1996): Real Analysis, Part 1, NewCentury Book House.
Unit-3, 4 and 5: Rao, C.R. & Bhimasankaran, P.(1992) : Linear algebra, Tata McGraw Hill Pub. Co. Ltd.

Reference Books:

1. Apostol, T.M. (1985) : Mathematical Analysis, Narosa Publishing House Ltd., New Delhi
2. Royden, H.L.(1995) : Real analysis, 3ed., Prentice Hall of India.
3. Ash, R.B. (1972): Real analysis and probability, Academic press.
4. Biswas, S. (1984): Topics in Algebra of Matrices, Academic Publications.
5. Graybill, F.A. (1983): Matrices with application in Statistics, 2nd ed. Duxbury Press.
6. Searle, S.R. (1982): Matrix Algebra useful for Statistics, John Wiley and Sons, Inc.

Course outcomes

1. After studying unit-1, the student will be able to understand concepts of metric spaces, properties related to functions and discontinuities
2. After studying unit-2, the student will be able to understand concepts of Riemann integral and its properties, method of optimizing functions and concepts of derivatives.
3. After studying unit-3, the student will be able to understand various properties of matrices.
4. After studying unit-4, the student will be able to understand the methods of reducing and decomposing matrices.
5. After studying unit-5, the student will be able to understand matrix inversion, quadratic forms and its applications.

Name of the course/subject: M.Sc. Statistics **Semester: I**
Name of the Paper: Measure and Probability Theory **Credits: 4 Hours of teaching: 5**
Paper type: Core

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Course Objective(s)

To enable students to gain knowledge in fundamental concepts and results related to measure theory and probability theory.

Unit-1: Measure Theory - Limits of sequence of sets, classes of sets – Field, Sigma Field and Monotone class, Measure and Measure Space – Measurable function

Unit-2: Lebesgue – Stieltjes measure, Measure integral and its properties, Dominated convergence theorem – Radon–Nikodymn theorem, almost everywhere convergence, convergence in measure and convergence in mean.

Unit-3: Events, sample space, different approaches to probability, random variables and random vector, Distribution functions of random variables and random vector, Expectation and moments, basic, Markov, Chebyshev's, Holder's, Minkowski's and Jensen's inequalities.

Unit-4: Independence of sequence of events and random variables, conditional probability, conditional expectation, Characteristic functions and their properties, inversion formula, convergence of random variables, convergence in probability, almost surely, in the r-th mean and in distribution, their relationships, convergence of moments, Helly-Bray theorem, continuity theorem and convolution of distributions.

Unit-5: Central limit theorem, statement of CLT, Lindeberg, Levy and Liapounov forms with proof and Lindeberg Feller's form examples. Khintchine's weak law of large numbers, Kolmogorov inequality, strong law of large numbers.

Text Books:

Unit-1 and 2: Parthasarthy, K.R. (1977): Introduction to probability and measure, MacMillan
Unit-3, 4, and 5: Bhat, B.R. (1985) : Modern probability theory, 2nd ed. Wiley Eastern.

Reference Books:

1. Chow, Y.S. and Teicher, H. (1979): Probability theory, Springer verlag.
2. Munroe, M.E. (1971): Measure and integration, 2nd ed. Addision Wesley.
3. Halmos, P.R. (1974): Measure theory, East-West.

Course outcomes

1. After studying unit-1, the student will be able to understand concepts of class, field and measurable space.
2. After studying unit-2, the student will be able to understand concepts of measure integrals and convergence.

3. After studying unit-3, the student will be able to understand various approaches for finding probability, concept of random variables and moments, results related to various inequalities.
4. After studying unit-4, the student will be able to understand the concept of independence, characteristic function and convergence of random variables.
5. After studying unit-5, the student will be able to understand various limit theorems and laws of large numbers.

Name of the course/subject: M.Sc. Statistics **Semester: I**
Name of the Paper: Distribution Theory **Credits: 4 Hours of teaching: 5**
Paper type: Core

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Course Objective(s)

To enable students to gain knowledge about various probability distributions (discrete and continuous case) and their properties and characterizations.

Unit-1 : Brief review of distribution theory, functions of random variables and their distributions using Jacobian of transformation, Laplace and Cauchy distribution, lognormal distribution, gamma, logarithmic series.

Unit-2: Bivariate distributions: Normal, exponential, Poisson; Compound, truncated and mixture of distributions, concepts of convolution.

Unit-3: Sampling distributions, non-central chi-square distribution, t and F distributions and their properties, distributions of quadratic forms under normality.

Unit-4: Order statistics their distributions and properties, Joint and marginal distributions of order statistics, extreme value and their asymptotic distributions, approximating distributions of sample moment, delta method.

Unit-5: Kolmogorov Smirnov distributions, life distributions, exponential, Weibull and extreme value distributions, Mills ratio, distributions classified by hazard rate.

Text Books:

Unit-1 and 2 : Rohatgi, V.K. and Md. Saleh, A.K. (2002): An introduction to probability & Statistics, John Wiley and Sons.
Unit-3: Mood, A.M. &Graybill, F.A. and Boes, D.C. : Introduction to the theory of statistics, McGraw Hill.
Unit 4 and 5: Robert V. Hogg, Joeseph McKean, Allen T Craig (2012): Introduction to mathematical Statistics, Pearson.

Reference Books:

1. Rao, C.R. (1973): Linear statistical inference and its applications, 2ed, Wiley Eastern.
2. Johnson, S. & Kotz,(1972): Distributions in Statistics, Vol. I, II & III, Houghton
3. Miffin. Dudewicz, E.J., Mishra, S.N. (1988) : Modern mathematical Statistics, John Wiley.

Course outcomes:

1. After studying unit-1, the student will be able to understand concepts and applications of univariate distributions.
2. After studying unit-2, the student will be able to understand concepts of and applications of bivariate, truncated and convoluted distributions.
3. After studying unit-3, the student will be able to understand various sampling distributions and their properties.

4. After studying unit-4, the student will be able to understand the concept of order statistics and their distributions.
5. After studying unit-5, the student will be able to understand life distributions and its applications.

Name of the course/subject: M.Sc.Statistics **Semester: I**
Name of the Paper: Programming in R **Credits: 4 Hours of teaching: 5**
Paper type: Core

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Course Objective(s)

To enable students to gain working knowledge on basic and advanced statistical functions available in R programming language

Unit-1:
R data types, Operations on matrices, dataframes, lists, setwd, read.table, read.csv, write.csv, creation of new variables, categorization, cut, factor; round, apply, creation of patterned variables-saving output to a file.

Unit-2:

Graphics in R- the plot command, histogram, barplot, boxplot- points, lines, segments, arrows, paste-inserting mathematical symbols in a plot, pie diagram, customization of plot-setting graphical parameters-text and mtext, the pairs command, colours and palettes, saving to a file.

Unit 3:

Basic Statistics- obtaining descriptive statistics, measures of correlation and association, generating samples from standard discrete and continuous distributions, one and two sample t-tests, F-test for equality of variances, chi-squared test of independence, fitting of distributions, qq plot.

Unit 4:

Matrix operations- addition, subtraction, multiplication, determinant, inverse, solving linear equations, computing eigenvalues, matrix decomposition- lu, qr and svd, finding g inverse, finding a basis, orthonormalization, finding rank.

Unit 5:

Linear model–fitting of linear model, goodness of fit measures, predicted values and residuals; residual plots, checking assumptions of the model, ANOVA table.

Text Books (for Units 1 to 5)

1. Purohit, S. G., Gore, S. D., and Deshmukh, S. R. (2009). Statistics Using R, Narosa Publishing House, NewDelhi.

Reference Books

1. Everitt, B. S., and Hothorn, T. (2010): A Handbook of Statistical Analyses Using R, Second Edition, Chapman and Hall/CRC Press.
2. Crawley, M.J. (2013): The R Book, John Wiley and Sons, Limited

E-Resources

www.r-project.org

Course outcomes

1. After studying unit-1, the student will be able to perform operations on matrices, lists and data frames.
2. After studying unit-2, the student will be able to plot diagrams and graphs in R.
3. After studying unit-3, the student will be able to perform statistical analysis in R.
4. After studying unit-4, the student will be able to perform matrix operations and manipulations in R.
5. After studying unit-5, the student will be able to fit linear models in R.

Name of the course/subject: M.Sc. Statistics **Semester: II**
Name of the Paper: Sampling Theory **Credits: 4 Hours of teaching: 6**
Paper type: Core

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Course Objective(s)

To enable students to understand various sampling schemes, their properties and applications

Unit-1

Population and Sample – Census and sample survey– sampling–sampling design–sampling and non-sampling errors–non-response and its effects–sample surveys– principal steps in sample survey-limitations of sampling – sampling schemes

Unit-2

Simple Random Sampling (with and without replacement): Notations and terminology - Estimates of population total, mean and their variances and standard errors – Pooling of estimates -Determination of sample size. Simple random sampling for attributes.

Unit-3

Stratified random sampling: Estimates of population total, mean and their variances-Related properties –Allocation of sample sizes – Neyman's proportional and optimum allocations-Comparison of stratified sampling with simple random sampling-Estimation of proportion under stratified random sampling.

Unit-4

Systematic sampling: Estimates of population total, mean, and their variances and standard errors – systematic sampling with linear trend–comparison of systematic sampling with stratified and simple random sampling– circular systematic sampling –Two stage sampling with equal number of second stage units and cluster sampling.

Unit-5

Varying Probability Sampling: Probability proportional to size(PPS)sampling (with and without replacement)–Stratified PPS–Selection procedures–Ordered and unordered estimates– Desraj, Horwitz–Thompson and Murthy's estimates. Ratio Estimates–Methods of estimation, approximate variance of the Ratio Estimate-Regression Estimators–Difference Estimators, Regression Estimators in Stratified Sampling.

Text Books

For Units 1 - 4

1. Cochran, W.G.(1977). Sampling Techniques, Third Edition, John Wiley & Sons, NY.

For Unit 5

2. Singh D. and Chowdhary,F.S.(2018).Theory and Analysis of Sample Survey Design, New Age International Private Ltd., New Delhi.

Reference Books

1. Des Raj (1978): Sampling Theory, Tata-McGrawHill, New Delhi.
2. Sukhatme, P. V. and Sukhatme, B. V. (1970): Sampling Theory of Surveys with Applications, Asia Publishing House, New Delhi.

3. Sampath,S.(2000): Sampling Theory and Methods, Narosa Publishing Company, New Delhi.
4. Murthy,M.N.(1967): Sampling Theory and Methods, Statistical Publishing Society, Calcutta.

Course outcomes

1. After studying unit-1, the student will be able to understand concepts related to census, sampling schemes and surveys.
2. After studying unit-2, the student will be able to understand concepts of simple random sampling scheme and its associated results.
3. After studying unit-3, the student will be able to understand stratified random sampling scheme and its associated results.
4. After studying unit-4, the student will be able to understand different systematic sampling schemes and its associated results.
5. After studying unit-5, the student will be able to understand different probability sampling schemes, ratio and regression estimators and their properties.

Name of the course/subject: M.Sc. Statistics **Semester: II**
Name of the Paper: Estimation Theory **Credits: 4 Hours of teaching: 6**
Paper type: Core

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Course Objective(s)

To enable students to understand various concepts of point and interval estimation, Bayesian estimation and their associated results

Unit-1: Parametric point estimation – properties of estimators – Consistency and its different forms - Sufficient statistics, Factorization theorem, the existence and construction of minimal sufficient statistics, Minimal sufficient statistics and exponential family, sufficiency and completeness, sufficiency and invariance.

Unit-2: Unbiased estimation: Minimum variance unbiased estimation, locally minimum variance unbiased estimators, Rao Blackwell – theorem. Completeness- Lehmann Scheffe theorems, Necessary and sufficient condition for unbiased estimators

Unit-3: Cramer- Rao lower bound, Bhattacharya system of lower bounds in the one-parameter regular case. Chapman -Robbins inequality.

Unit-4: Maximum likelihood estimation, computational routines, strong consistency of maximum likelihood estimators, Asymptotic Efficiency of maximum likelihood estimators, Best Asymptotically Normal estimators, Method of moments.

Unit- 5: Interval estimation – Pivotal method of construction – shortest confidence intervals and their construction (minimum average width) – Baye's and minimax estimation: The structure of Baye's rules, Baye's estimators for quadratic and convex loss functions, minimax estimation.

Text Books

For Units 1 to 5

1. Rajagopalan, M. and Dhanavanthan, P. (2012): Statistical Inference, PHI Learning, New Delhi.

Reference Books

1. Lehmann, E.L and Casella G. (1998): Theory of Point Estimation, 2/e, Wiley Eastern Ltd.
2. B.K.Kale and K.Muralidharan (2015): Parametric Inference – An Introduction, Narosa Publishing House.
3. Kale, B.K. (1999): A First course on Parametric Inference, Narosa Publishing House.
4. Zacks,S. (1981): Parametric Statistical Inference, John Wiley, NY.
5. Srivastava, Khan and Srivastava (2014): Statistical Inference: Theory of Estimation, PHI, India
6. Rohatgi, V.K. and Md. Saleh, A.K. (2002): An introduction to probability & Statistics, John Wiley and Sons.

7. Gupta, S. C., and Kapoor, V. K. (2002), Fundamentals of Mathematical Statistics, Sultan Chand & Sons, New Delhi

Course outcomes

1. After studying unit-1, the student will be able to understand properties of estimators and concept of sufficient statistic and different ways of obtaining sufficient statistic.
2. After studying unit-2, the student will be able to understand concepts results pertaining to unbiased estimators and minimum variance unbiased estimators.
3. After studying unit-3, the student will be able to understand inequalities related to variance of unbiased estimators.
4. After studying unit-4, the student will be able to understand the methods of moment and maximum likelihood estimation and its associated properties.
5. After studying unit-5, the student will be able to understand the method of performing interval estimation and Bayes estimation.

Name of the course/subject: M.Sc. Statistics **Semester: II**
Name of the Paper: Statistical Practical-1 **Credits: 3 Hours of teaching: 4**
Paper type: Practical

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Course Objective(s)

To enable students to solve problems related to probability distributions, sampling techniques, methods of estimation and Markov chains using real life data

Problems relating to the following topics which are covered in Semester I and Semester II shall form the basis for practical:

1. **Distribution Theory** (problems related to standard discrete and continuous distributions)
2. **Sampling Theory** (problems related to simple random, stratified, linear systematic sampling schemes, ratio and regression estimators)
3. **Estimation Theory** (problems related to method of moments, maximum likelihood, interval estimation)
4. **Stochastic Processes** (problems related to transition probability, classification of states, time series modeling)

Text Books

Books prescribed in the respective core papers shall be used.

Note

The maximum marks for continuous internal assessment and end semester University examination for Statistical Practical-1 shall be fixed as 40 and 60, respectively. The continuous internal assessment shall involve test and record work. The question paper at the end semester examination shall consist of **four questions with internal choice**. A candidate shall attend all the four questions, each of which shall carry 15 marks. The examination shall be conducted at the end of Semester II.

Name of the course/subject: M.Sc. Statistics **Semester: II**
Name of the Paper: Statistical Software Practical-1(Using R) Credits:3 Hours of teaching:4
Paper type: Practical

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Course Objective(s)

To enable students to utilize the theoretical knowledge gained in the core papers and to develop computational and technical skills for real life applications emphasizing the importance of R programming.

Problems relating to the following topics shall form the basis for the practical.

1. Using R command-Operations on vectors, logical vector, index vector and matrices. Creating and Manipulation of data frames, using various user defined functions.
2. Matrix addition, multiplication, inverse, transpose, determinant and trace of matrix.
3. Construction of table with one or more variables.
4. Graphical procedures– Pie chart, Bar chart, Histograms and Boxplots.
5. Computation of various descriptive measures such as Measures of central tendency, measures of dispersion, skewness and kurtosis.
6. Sample selection under various sampling methods.
7. Calculations of probability functions and generation of random samples for various discrete and continuous distributions.
8. Computation of correlations and regression co-efficient. Fitting of Linear and non linear models.

Text Books

Books as prescribed in core paper Programming in R of semester I.

E-Resources

www.r-project.org

Note

The maximum marks for continuous internal assessment and end semester University examination for Statistical Software Practical-1(Using R) shall be fixed as 40 and 60, respectively. The continuous internal assessment shall involve test and record work. The question paper at the end semester examination shall consist of **four questions with internal choice**. A candidate shall attend all the four questions, each of which shall carry 15 marks.

Name of the course/subject: M.Sc. Statistics **Semester: I**
Name of the Paper: Official Statistics **Credits: 3 Hours of teaching: 3**
Paper type: Core Elective

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Course Objectives

To enable students to learn about Survey Organizations, to know about Data Collection, to study about Agriculture Statistics, to study the Index numbers, to study measures of national income

Unit-1: Statistical System in India: Central and State Government Organizations, Functions of Central Statistical Organization (CSO), National Sample Survey Organization (NSSO). Organization of large scale sample surveys. General and special data dissemination systems.

Unit-2: Official statistics: Meaning, methods of collection, limitations and reliability. Principal publications containing data on the topics such as population, agriculture, industry, trade, prices, labour and employment, transport and communications - Banking and finance.

Unit-3: System of Collection of Agricultural Statistics - Crop forecasting and estimation - Productivity, fragmentation of holdings - Support prices - Buffer stocks - Impact of irrigation projects**.** Statistics related to industries, foreign trade - Balance of payment - Inflation - Social statistics.

Unit-4: Index Numbers: Price, Quantity and Value indices. Price Index Numbers: Construction, Uses, Limitations, Tests for index numbers, Chain Index Number. Consumer Price Index, Wholesale Price Index and Index of Industrial Production – Construction of index numbers and uses.

Unit-5: National Income – Measures of national income - Income, expenditure and production approaches - Applications in various sectors in India. Measurement of income inequality: Gini's coefficient, Lorenz curves, Application of Pareto and Lognormal as income distribution.

Text Books

1. Allen R. G. D. (1975). Index Numbers in Theory and Practice, Macmillan.
2. Bhaduri, A. (1990). Macroeconomics: The Dynamics of Commodity Production, Macmillan India Limited, New Delhi.
3. Branson, W. H. (1992). Macroeconomic Theory and Policy, Third Edition, Harper Collins Publishers India (P) Ltd., New Delhi.
4. C. S. O. (1990). Basic Statistics Relating to the Indian Economy.
5. C.S.O. (1995). Statistical System in India.
6. C. S. O. (1999). Guide to Official Statistics.

Reference books

1. Goon A. M., Gupta M. K., and Dasgupta. B. (2001), Fundamentals of Statistics, Vol. 2, World Press, India.
2. Mukhopadhyay, P. (2011). Applied Statistics, Second Edition, Books & Allied Ltd, India.
3. Panse, V. G. (1964). Estimation of Crop Yields (FAO), Food and Agriculture Organization of the United Nations.

Course Outcomes

1. **After studied unit-1, the student will be able to know D**ifferent organizations
2. **After studied unit-2, the student will be able to know** Methods of Data Collection
3. **After studied unit-3, the student will be able to know** Crop forecasting
4. **After studied unit-4, the student will be able to know Index numbers**
5. **After studied unit-5, the student will be able to know** measures of national income.

Name of the course/subject: M.Sc. Statistics **Semester: I**
Name of the Paper: Advanced Operations Research **Credits: 3 Hours of teaching: 3**
Paper type: Core Elective

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Course Objectives

To enable students to learn various optimization techniques such as Integer programming, Dynamic Programming, Non-linear Programming, Stochastic Models, Inventory Models

Unit-1: Integer Programming – Pure and Mixed Integer programming problems – Cutting Plane Algorithm – Mixed Algorithm With proof. Additive and Zero One algorithm – Branch and Bound method

Unit-2: Dynamic Programming – Modelling and solving of recursive equations – Cargo Loading Model – Reliability Model – Warehousing Model – Investment Model. Solving of optimization problems of mathematical nature using dynamic programming models.

Unit-3: Non-Linear programming – Kuhn-Tucker conditions – Wolfe's and Beale's method – with proof – Simple applicaitons.

Unit-4: Stochastic programming – Chance constrained optimization problems – E, V and EV models – Simple applications.

Unit-5: Inventory models – Single item and multi-item (Deterministic and Nondeterministic) inventory models with and without back logs.

Text Books

1. Taha, H : Operations Research, Prentice Hall of India, 8th edition,2007
2. Rao. S.S. : Engineering Optimization, New Age International (P) Ltd, New Delhi 2004
3. Kambo,N S : Mathematical Programming techniques, Affiliated East-west Press Pvt. Ltd.1991
4. Sharma J K : Operations Research, Macmillan, New Delhi, 3rd Edition, 2007

Reference books

1. Manmohan, Kanti Swarup and Gupta, Operations Research – Prentice Hall – New Delhi

Course Outcomes

1. **After studied unit-1, the student will be able to know** Inter programming problem
2. **After studied unit-2, the student will be able to know** Dynamic programming
3. **After studied unit-3, the student will be able to know** Non-Linear Programming
4. **After studied unit-4, the student will be able to know S**tochastic programming
5. **After studied unit-5, the student will be able to know** Inventory models.

Name of the course/subject: M.Sc. Statistics **Semester: II**
Name of the Paper: Linear Regression Analysis **Credits: 3 Hours of teaching: 3**
Paper type: Core Elective

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Course Objectives

To enable students to learn about Least square estimation, removal of heteroscedasticity, to study about Multicollinearity, to study the Robust Estimators, to study Binomial, Poisson regression and Logistics regressions

Unit-1: Linear models, Estimation – Least square estimation of parameters and properties (BLUE), Gauss Markov theorem – Estimation by MLE, Testing – general linear hypothesis and sub hypothesis, Interval estimation – classification of linear models (Fixed, random and mixed).

Unit-2: Model Adequacy checking – Residual analysis, detection and treatment of outliers, Transformation to correct model adequacies – variance stabilizing transformation, transformation to achieve linearity, removal of heteroscedasticity – principle of weighted least squares.

Unit-3: Multicollinearity – Sources and effects of multicollinearity, multicollinearity diagnostics, methods of dealing with multicollinearity, impact on forecasting.

Unit-4: Robust estimators – need for robust regression, types of estimators, properties and computational aspects of robust regression.

Unit-5: Generalized Linear models – models with Binary response variable, estimation and testing in a logistic regression model, Poisson regression, link functions, estimation and inference in the GLM.

Text Books

1. D.C. Mongomery et al (2003) -. Introduction to Linear Regression Analysis (3^{rd} ed.) Wiley & Sons

Reference books

1. P.McCullagh and J.A. Nelder (1989) 2^{nd} ed Generalised Linear Models, Chapman and Hall, London
2. Doshi, D.D. (1987) : Linear estimation and design of experiments, Wiley Eastern Ltd. Searle, S.R. (1971) Linear Models John Wiley,NY
3. Anand M. Kshirsagar(1983) A Course on Linear Models, Marcel dekker, NY

Course Outcomes

1. **After studied unit-1, the student will be able to know** Estimation (BLUE)
2. **After studied unit-2, the student will be able to know** Residual Analysis
3. **After studied unit-3, the student will be able to know** Multicollinearity
4. **After studied unit-4, the student will be able to know** Robust estimators
5. **After studied unit-5, the student will be able to know** GLM.

Name of the course/subject: M.Sc. Statistics **Semester: II**
Name of the Paper: Actuarial Statistics **Credits: 3 Hours of teaching: 3**
Paper type: Core Elective

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Course Objectives

To enable students to learn about Compund Interest, present values, annuities, to know about Mortality table, to study about Average yield on Funds, to study premiums and loading effect, to study Policy Values

Unit-1: Elements of Compound Interest (nominal and effective rates of interests). Annuities certain, Present values, accumulated amounts, deferred annuities – Simple problems.

Unit- 2: Redemption of loans, Sinking funds, The Average yield on the life fund of an insurance office. Simple Problems

Unit-3: The mortality table – construction, characteristics and uses of mortality table . The features of Indian assured lives, Orientals 1925-1935 mortality tables. The LIC (1961-64) table and the LIC(1970-73) table – Simple Problems.

Unit-4: Premiums, general principles, natural premiums, level premiums, office premiums, loading for expenses. With profit and without profit premiums, adequacy of premiums relative consistency

Unit-5: Life office valuation, General principles, Policy values, Retrospective and prospective methods of valuation of liabilities. (net premium, gross premium and bounds reserve) Sources of surplus principle method of surplus.

Text Books

1. Federation of Insurance Institutes study courses: Mathematical Basic of the Life Assurance.

Reference Books

1. Donald D.W.A. (2016). Compound Interest and Annuities-Certain, Cambridge University Press, UK.
2. Neil, A. (1977). Life Contingencies, Heinemann for the Institute of Actuaries and the Faculty of Actuaries.
3. Deshmukh, S.R. (2009). Actuarial Statistics, Pune University Press.
4. Gupta, S. C., and Kapoor, V. K. (2014). Fundamentals of Applied Statistics, Fourth Edition, Sultan Chand & Sons, New Delhi

Course Outcomes

1. **After studied unit-1, the student will be able to know** Present values and annuities
2. **After studied unit-2, the student will be able to know** Insurance sectors
3. **After studied unit-3, the student will be able to know** Mortality table and LIC table
4. **After studied unit-4, the student will be able to know** Premiums and Profits
5. **After studied unit-5, the student will be able to know** Net Premium and Surplus.

Open Elective Subjects (for students of other departments)

Name of the course/subject: PG **Semester: I**
Name of the Paper: Basic Statistics **Credits: 3 Hours of teaching: 3**
Paper type: Open Elective

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COURSE OBJECTIVES

To enable the students to analyze the given data and make them solve simple real life problems related to descriptive measures in statistics.

UNIT I:
Collection of data – Primary and Secondary data – Methods of Collecting Primary data – Drafting the Questionnaire – Pretesting the Questionnaire – Specimen Questionnaire – Sources of Secondary data – Editing Primary and Secondary data – Precautions in the use of Secondary data.

UNIT II:
Classification of data – Meaning and Objectives of Classification – Types of Classification – Formation of a Discrete Frequency Distribution - Formation of a Continuous Frequency Distribution – Tabulation of data – Parts of a Table – General rules of Tabulation – Types of Tables.

UNIT III:
Presentation of data – Significance of Diagrams and Graphs – General rules for Constructing Diagrams – Types of Diagrams – Graphs – Graphs of Frequency Distributions.

UNIT IV:
Measure of Central tendency – Objectives of Averaging – Requisites of a Good Average – Types of Averages – Arithmetic Mean – Median – Mode – Geometric Mean – Harmonic Mean – trimmed mean

UNIT V:
Measures of variation - Significance of Measuring Variation – Properties of a Good Measure of Variation- Methods of Studying Variation – range – standard deviation – variance – coefficient of variations

Text Books

1. Gupta, S. P. (2012). Statistical Methods, Sultan Chand & Sons, New Delhi.
2. Gupta, S C., and Kapoor, V. K. (2018). Fundamentals of Mathematical Statistics, Eleventh Edition, Sultan Chand & Sons, New Delhi.

Reference Books

1. Goon, A. M., Gupta, M. K., and Das Gupta, B. (2013). Fundamentals of Statistics, Vol.1, World Press Private Ltd, Calcutta.
2. Rohatgi, V. K. (1988). An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern (India) Ltd., New Delhi.

COURSE OUTCOMES

1. **After studied unit-1, the student will be able to know** various methods of data collection
2. **After studied unit-2, the student will be able to know** various methods of classification
3. **After studied unit-3, the student will be able to know** various presentations of data
4. **After studied unit-4, the student will be able to know** measure of central tendency
5. **After studied unit-5, the student will be able to know** measure of variation

Name of the course/subject: PG **Semester: I**
Name of the Paper: Operations Research **Credits: 3 Hours of teaching: 3**
Paper type: Open Elective

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Course Objectives

To enable students to learn optimization techniques such as graphical method, simplex programming, transportation and assignment problem, network model, queueing models and decision theory

UNIT-1: Introduction to OR – Meaning and scope – Characteristics – models in OR.LPP-Formulation graphical method – Simplex method- Big M Method application in Business – merits and Demerits.

UNIT-2: Transportation model – basic feasible solution – formulation, solving a TP. Assignment models – formulation – solution.

UNIT-3: Network analysis – work break down analysis – construction – numbering of event. Time Calculation – critical path, slack, float – application.

UNIT-4: Queuing models- elements of queuing system – characteristics of queuing model.

UNIT-5: Decision theory – statement of Baye's theorem application. Probability – decision trees. Game theory meaning and characteristics – saddle point – Dominance property.

Text Books

1. V.K.Kapoor, Introduction to Operational Research – Sultan Chand & sons – New Delhi

Reference Books

1. P.K.Gupta and Man Mohan, Problems in Operations Research – Sultan Chand & sons – New Delhi
2. Hamdy A Taha, Operation Research – An Introduction prentice Hall of India- New Delhi.

Course Outcomes

1. After studied unit-1, the student will be able to know solving graphical and simplex programming problems
2. After studied unit-2, the student will be able to know solving transportation and assignment problems
3. After studied unit-3, the student will be able to know solving network models
4. After studied unit-4, the student will be able to know solving various queueing models.
5. After studied unit-5, the student will be able to know decision theory and games.

Name of the course/subject: PG **Semester: II**
Name of the Paper: Probability and Statistics **Credits: 3 Hours of teaching: 3**
Paper type: Open Elective

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Course Objectives

To enable students to learn probability and distributions, estimation of parameters and testing of hypothesis, time series analysis and statistical quality control techniques.

Unit-1

Sample spaces – Events – Probability axioms – Conditional Probability – Independent events – Baye's formula - simple problems - Random variables - Distribution functions – Marginal distributions, Conditional distribution – Expectation – Conditional expectation and Conditional Variance. Moment generating functions.

Unit-2

Probability distributions – Binomial, Poisson, geometric, uniform, exponential, normal distributions – computation of mean, variance and simple problems.

Unit-3

Estimation - Point estimation – Characteristics of estimation – Interval estimation – Interval estimates of Mean, Standard deviation, proportion, Tests for means, variances and proportions – ANOVA.

Unit-4

Time series analysis - Components of time Series – Methods of measuring Trend and Seasonal variations – correlation and regression - problems related to simple regression.

Unit-5

Statistical quality control – Statistical basis for control charts – Control limits – Control Charts for variables – X-bar, R Charts, Charts for defective – P, nP Charts – Charts for defects – C Charts.

Text Books

1. Trivedi, K. S. (1982). Probability and Statistics with Reliability, Queueing & Computer Applications, Prentice Hall, NJ..
2. Gupta, S C., and Kapoor, V. K. (2002). Fundamentals of Mathematical Statistics, Eleventh Edition, Sultan Chand & Sons, New Delhi..

Reference Books

1. Montogomery, D, C., and Johnson, .L. A. (1976). Forecasting and Time Series Analysis, McGraw Hill, NY.
2. Besterfield, D. H. (1998). Quality Control, Fifth Edition, Prentice Hall, NJ.

Course Outcomes

1. **After studied unit-1, the student will be able to know** basics of probability
2. **After studied unit-2, the student will be able to know** various distributions

3. After studied unit-3, the student will be able to know estimation of parameters and testing of hypothesis

4. After studied unit-4, the student will be able to know time series analysis.

5. After studied unit-5, the student will be able to know various statistical quality control charts

Name of the course/subject: PG **Semester: II**
Name of the Paper: Indian Official Statistics **Credits: 3 Hours of teaching: 3**
Paper type: Open Elective

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Course Objectives

To enable students to learn about functions of Indian Official statistical system, functioning of various statistical organizations and applications of statistics.

Unit-1: Statistical System in India: Central and State Government Organizations, Functions of Central Statistical Organization (CSO), National Sample Survey Organization (NSSO) - Sampling fundamentals – sampling and non-sampling errors - large scale sample surveys.

Unit-2: Official statistics: Meaning, methods of collection, limitations and reliability. Principal publications containing data on the topics such as population, agriculture, industry, trade, prices, labour and employment, transport and communications - Banking and finance.

Unit-3: System of Collection of Agricultural Statistics - Crop forecasting and estimation - Productivity, fragmentation of holdings - Support prices - Buffer stocks - Impact of irrigation projects – Industrial statistics.

Unit-4: Index Numbers - Price, Quantity and Value indices. Price Index Numbers: Construction, Uses, Limitations, Tests for index numbers - Consumer Price Index, Wholesale Price Index and Index of Industrial Production – Construction of index numbers and uses.

Unit-5: National Income – Measures of national income - Income, expenditure and production approaches – Applications in various sectors in India - Wage Statistics – Trade Statistics – Financial Statistics

Text Books

1. Saluja, M.R (1972): Indian official statistical systems: Statistical publishing society, Calcutta and The Indian Econometric Society, Hyderabad.
2. Central Statistical Organisation (1995), Statistical System in India, Ministry of Statistics and Programme Implementation, India
3. Central Statistical Organisation (1999), Guide to Official Statistics, Ministry of Statistics and Programme Implementation, India.

Reference Books

1. Goon A. M., Gupta M. K., and Dasgupta. B. (2001), Fundamentals of Statistics, Vol. 2, World Press, India.
2. Allen R. G. D. (1975). Index Numbers in Theory and Practice, Macmillan.
3. Bhaduri, A. (1990). Macroeconomics: The Dynamics of Commodity Production, Macmillan India Limited, New Delhi.
4. Branson, W. H. (1992). Macroeconomic Theory and Policy, Third Edition, Harper Collins Publishers India (P) Ltd., New Delhi.

Course Outcomes

1. After studied unit-1, the student will be able to know functioning of statistical organization in India.
2. After studied unit-2, the student will be able to know concept of official statistics
3. After studied unit-3, the student will be able to know agricultural and industrial statistics
4. After studied unit-4, the student will be able to know index numbers and its usages.
5. After studied unit-5, the student will be able to know national income and its measures

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SEMESTER III

PAPER - 7
TESTING STATISTICAL HYPOTHESES

Course Objectives

To enable students to learn about Hypotheses testing, to determine critical regions, to study parametric tests, non-parametric tests and sequential probability ratio test and applications in standard distributions

Unit-1:

Testing of hypotheses: simple and composite hypotheses, two types of errors, level of significance, randomized and non-randomised tests, power and size of a test. Most powerful test Neyman-Pearson lemma. Monotone likelihood ratio property - Uniformly most powerful tests. Applications to standard statistical distributions.

Unit-2:

Generalization of Neyman-Pearson fundamental lemma (statement only). Unbiased tests - Construction of uniformly most powerful unbiased tests for one-parameter and multi-parameter exponential families - Applications to standard statistical distribution - Similar regions. Locally most powerful (LMP) test - LMP unbiased test.

Unit-3:

Invariance - maximal invariant statistic - invariant test. Likelihood ratio (LR) test - asymptotic distribution of LR test statistic-consistency of LR test - Construction of LR tests for standard statistical distributions. Analysis of variance (one-way).Bartlett's test for homogeneity of variances.

Unit-4:

U statistic and its property as an estimator of its expected value. Tests for goodness of fit-Chi-square and Kolmogorov-Smirnov tests. Test for randomness. Wilcoxon's signed-rank test. Kolmogorov-Smirnov two sample test. Mann-Whitney U test. Kruskal-Wallis test.

Unit-5:

Introduction to sequential procedures - Stopping times - Wald's equation - SPRT: termination property, approximation to stopping bounds and applications to standard distributions. Statement of Wald's fundamental identity - OC and ASN functions and their plotting.

Text Books

1. Rohatgi, V. K. (1976). Introduction to Probability Theory and Mathematical Statistics, John Wiley & Sons, NY.
2. Lehmann, E. L. (1986). Testing Statistical Hypotheses, Second Edition, John Wiley & Sons, NY.
3. Goon, A. M., Gupta, M. K., Das Gupta. B. (1973). An outline of Statistical Theory, Vol. II, World Press, Calcutta.
4. Rajagopalan, M., and Dhanavanthan, P. (2012). Statistical Inference, PHI Learning Pvt., Ltd., New Delhi.
5. Gupta, S. C., and Kapoor, V. K. (2002), Fundamentals of Mathematical Statistics, Sultan Chand & Sons, New Delhi.

Reference Books:

1. Conover, W. J. (1980). Practical Nonparametric Statistics, Second Edition, John Wiley & Sons, NY.
2. Gibbons, J. D. and Chakrabarthi, S. (2010). Nonparametric Statistical Inference, Fifth Edition, Chapman and Hall/CRC Press, FL.
3. Kale, B. K. (1999). A First Course on Parametric Inference, Narosa Publishing House, New Delhi.
4. Wald, A. (1982) Sequential Analysis .John Wiley & Sons, NY.

Course Outcomes

1. **After studied unit-1, the student will be able to know** Testing of hypotheses
2. **After studied unit-2, the student will be able to know** Neyman-Pearson fundamental lemma
3. **After studied unit-3, the student will be able to know** Likelihood ratio (LR) test
4. **After studied unit-4, the student will be able to know** Test for randomness
5. **After studied unit-5, the student will be able to know** SPRT

PAPER - 8

DESIGN AND ANALYSIS OF EXPERIMENTS

Course Objectives

To enable students to learn about ANOVA, construction of CRD, RBD, LSD, to study missing plot techniques, factorial design, to study response surface methodology.

Unit-1: Review of basic designs – Concept of orthogonal latin squares - Graeco Latin squares and its analysis of variance – multiple comparisons – multiple range tests – Duncan's Multiple range test – Tukey's test.

Unit-2: Factorial experiments - study of 2^n and 3^n factorial experiments and their analysis - complete and partial confounding – Confounding in 2^n and 3^n analysis - asymmetric factorials experiments.

Unit-3: General block design and its information matrix (C), criteria for connectedness, balancing and orthogonality – analysis of BIBD – parametric relations – Intrablock analysis of BIBD-Analysis of PBIBD with two associate classes - Lattice Design –analysis; Youden design – intrablock analysis;

Unit-4: Split plot designs – strip-plot design - Two stage nested designs-Analysis of covariance with one and two covariates.

Unit-5: Response surface methodology - first order and second order rotatable designs and its applications - concept of fractional factorial experiments.

Text Books

1. Das, M.N. and Giri, N. (1979) : Design and analysis of experiments, Wiley Eastern.
2. John, P.W.M. (1971) : Statistical design and analysis of experiments, Macmillan.
3. Montgomery, C.D. (2001) : Design and analysis of experiments, John Wiley, New York.
4. Gupta, S.C. and V.K. Kapoor (1978): Fundamentals of Applied Statistics, Sultan Chand & Sons.

Reference Books:

1. Robert, O. Kuelhl (2000) : Design of experiments. Statistical principles of research design and analysis, Duxbury.
2. Federer, W.T.(1963) : Experimental design; Theory and application, Oxford & IBH publishing Co.

Course Outcomes

1. **After studied unit-1, the student will be able to know** Basics of ANOVA
2. **After studied unit-2, the student will be able to know** Factorial Experiments
3. **After studied unit-3, the student will be able to know** BIBD and PBIBD
4. **After studied unit-4, the student will be able to know** ANACOVA
5. **After studied unit-5, the student will be able to know** RS methodology

PAPER - 9

MULTIVARIATE ANALYSIS

Course Objectives

To enable students to learn about Multivariate Distributions, to determine moments, to study about MLE properties, to study about various multivariate data analysis techniques such as Discriminant analysis, cluster analysis, Principal Components, Factor analysis.

Unit-1:

Multivariate Normal Distributions - Marginal and Conditional Distributions - Characteristic Function and Moments - Distribution of Linear Combinations of Multivariate Normal Vector - Determination of Mean and Covariance Matrix of Multivariate Normal Distribution.

Unit-2:

Maximum likelihood estimators of the parameters of multivariate normal distribution - Distribution of sample mean vector - Necessary and sufficient conditions for a quadratic form to be distributed as a chi - square distribution - Inference concerning the sample mean vector when covariance matrix is known.

Unit-3:

Wishart Distribution – Characteristic function and properties. Hotelling's T^2 Distribution – Properties and Applications - Two sample problems with unequal covariance matrices - Likelihood Ratio Criterion - Mahalanobis D^2 Distribution - Relationship between T^2 and D^2 statistics – Behrens-Fisher problem.

Unit-4:

Discriminant Analysis: Objectives and assumptions - Fisher’s Discriminant Function - Problem of Classification with Two or More Populations - Cluster Analysis: Objectives, Assumptions, Research design – Formation of clusters – Clustering algorithm.

Unit-5:

Principal components: Objectives – Extraction of principal components - Factor analysis: Objectives – Estimation of factor loadings - Canonical variables and canonical correlations: Determination of canonical correlation coefficients. Concepts of multidimensional scaling and correspondence analysis.

Text Books

1. Anderson, T.W. (2003). An Introduction to Multivariate Statistical Analysis, Third Edition, Wiley – Interscience, NY.
2. Johnson, R. A., and Wichern, D. W. (2013). Applied Multivariate Statistical Analysis Sixth Edition, Pearson New International Edition.
3. Jambu, M., and Lebeaux, M.-O. (1983). Cluster Analysis and Data Analysis, North- Holland, NY.

Reference books:

1. Kshirsagar, A. M. (1972), Multivariate Analysis, Marcel Decker, Inc., NY.

2. Morrison, D. F. (2004). Multivariate Statistical Methods, Fourth Edition, Duxbury Press, CA,
3. Afifi, A. A., and Azen, S. P. (1979): Statistical Analysis - A Computer Oriented Approach, Second Edition, Academic Press, NY.
4. Giri, N. C., (1977). Multivariate Statistical Inference, Academic Press, NY..
5. Rencher, A. C., (2002), Methods of Multivariate Analysis, Second Edition, John Wiley & Sons, NY.

Course Outcomes

1. **After studied unit-1, the student will be able to know** Multivariate distributions
2. **After studied unit-2, the student will be able to derive** Characteristic function
3. **After studied unit-3, the student will be able to know** Moments of the distribution
4. **After studied unit-4, the student will be able to understand** dimension reduction
5. **After studied unit-5, the student will be able to know** Canonical Correlation.

CORE ELECTIVE

PAPER - 3

(to choose one out of 2)

A. STATISTICAL METHODS OF EPIDEMIOLOGY

Course Objectives

To enable students to learn about Mortality and Reliability, to know about Cohort Studies, to study about Statistical techniques in Epidemiology, to study about clinical experiments, to study Cross over design and life tables

Unit-1: Measures of disease frequency: Mortality / morbidity rates, incidence rates, prevalence rates. Source of mortality / morbidity statistics – hospital records, vital statistics records. Measures of secrecy or validity: sensitivity index, specificity index. Measure of reliability. Epidemiologic concepts of diseases: Factors which determine the occurrence of diseases, models of transmission of infection, incubation period, disease spectrum and herd immunity

Unit-2: Observational studies in Epidemiology: Retrospective (case control) & prospective (cohort or longitudinal) studies. Measures of association: Relative risk, attributable risk.

Unit-3: Statistical techniques used in analysis: Cornfield and Garts method, Mantel – Haenszel method. Conditional and unconditional matching. Analysis of data from matched samples, logistic regression approach.

Unit-4: Experimental Epidemiology: Clinical and community trials Statistical techniques: Methods for comparison of two treatments. Crossover design with Garts and McNemars test. Randomization in a clinical trials, sequential methods in clinical trials, clinical life tables, assessment of survivability in clinical trials.

Unit-5: Mathematical modeling in Epidemiology: (deterministic and stochastic) simple epidemic model, generalized epidemic model, Read-Frost and Green-wood models, models for carrier borne and host vector diseases. Estimation of latent and infectious periods, geographical spread of the disease, simulation of an epidemic.

Text Books

1. Kahn, H.A., Sempose, C.T.(1989) : Statistical methods in Epidemiology, Oxford University press

Reference books:

1. Daley, D.J., Gani, J.(1999) : Epidemic modeling an introduction, cambridge.

Course Outcomes

1. **After studied unit-1, the student will be able to know** Models of Infection
2. **After studied unit-2, the student will be able to know** measures of association
3. **After studied unit-3, the student will be able to know** Analysis of Data
4. **After studied unit-4, the student will be able to know** Clinical trials
5. **After studied unit-5, the student will be able to know** Simulation.

PAPER - 3

B. DATA MINING

Course Objectives

To enable students to learn about Mining tools, to know about Data Warehouse, to study about Data Cleaning, KDD, to retrieve Knowledge, to study Fuzzy Data base.

Unit-1: Introduction – An expanding universe of data – production factor – data mining – data mining verses query tools – data mining in marketing – practical applications. Learning: Introduction – self learning – machine learning and methodology of science – concept learning.

Unit-2: Data mining and the data warehouses: Introduction – need – decision support system – integration with data mining – client / server data warehousing – multi processing machine – cost justification.

Unit-3: Knowledge discovery process: Introduction – data selection – cleaning – enrichment – coding – data mining and its techniques – reporting.

Unit-4: KDD environment: Introduction – different forms of knowledge – getting started – data selection – cleaning – enrichment – coding – reporting - ten golden rules.

Unit-5: Customer profiling – predicting bid behavior of pilots – learning of compression of data sets – noise and redundancy – fuzzy database – the traditional theory – relation to tables – statistical dependencies – data mining primitives.

Text Books

1. Adriaans, P., and Zantinge, D. (1996). Data Mining, First Edition, Addison Wesley Professional, London.
2. Soman, K. P., Diwakar, S., and Ajay, V. (2006). Data Mining: Theory and Practice, PHI Learning Pvt. Ltd., New Delhi.
3. Delmater, R., and Hancock, M. (2001). Data Mining Explained, Digital Press, MA.

Reference Books

1. Hand, D., Mannila, H., and Smyth, P. (2001). Principles of Data Mining, MIT Press, London.

Course Outcomes

1. **After studied unit-1, the student will be able to know** Machine Learning
2. **After studied unit-2, the student will be able to know** Client and Server Data Storage
3. **After studied unit-3, the student will be able to know** Data Mining Techniques
4. **After studied unit-4, the student will be able to know** KDD
5. **After studied unit-5, the student will be able to know** Fuzzy and Relational tables.

OPEN ELECTIVE

PAPER - 3

(to choose one out of 2)

A. BUSINESS STATISTICS

Course Objectives

To enable students to learn basics of statistics and statistical methods such as functions of statistics, various statistical measures, parametric tests, time series analysis and index numbers in the context of solving business problems

UNIT-1: Introduction – meaning and definition of statistics – collection and tabulation of statistical data – presentation of statistical data – graphs and diagram – measures of central tendency – Arithmetic mean, median, mode, harmonic mean, geometric mean and trimmed mean.

UNIT-2: Measures of variation – standard deviation, mean deviation – median deviation - quartile deviation – skewness and kurtosis – Lorenz curve. Simple correlation – scatter diagram – Karl pearson's correlation – Rank correlations – Regressions.

UNIT-3: Sampling methods – simple, stratified and systematic. Hypothesis testing – Fundamental ideas – Large sample Test – small sample tests – t, F, Chi – square (without proof) – simple problems.

UNIT-4: Analysis of Time series – components of time series - methods of measuring trend – simple averages – moving average – exponential smoothing - methods of measuring seasonal variations.

UNIT-5: Index numbers – Laspeyre and Paasche index numbers – Fisher ideal index numbers – Marshall and Edgeworth index numbers – Factor and time reversal test - consumer's price index and cost of living index.

Text Books

1. Agarwal, B. L. (2013). Basic Statistics, New Age International Private Limited, New Delhi.
2. Gupta, S. P. (2005). Statistical Methods, Fourth edition, Sultan Chand & Sons, New Delhi

Reference Books

1. Goon, A. M., Gupta, M. K., and Das Gupta, B. (2013). Fundamentals of Statistics, Vol.1, World Press Private Ltd, Calcutta.
2. Rohatgi, V. K. (1988). An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern (India) Ltd., New Delhi.
3. Agarwal, B.L. (2011). Programmed Statistics, New Age International Publishers, New Delhi.

Course Outcomes

1. **After studied unit-1, the student will be able to know** basic statistics
2. **After studied unit-2, the student will be able to know** various statistical measures
3. **After studied unit-3, the student will be able to know** parametric methods and it usage
4. **After studied unit-4, the student will be able to know** methods of time series analysis

5. After studied unit-4, the student will be able to know methods of index numbers

OPEN ELECTIVE

PAPER - 3

B. RESEARCH METHODOLOGY

Course Objectives

To enable students to learn the basics of research, research design, sampling design, scaling techniques, collection and presentation of data, analysis of data with parametric tests and report writing

UNIT-1: Introduction to Research – Types of Research – Research Process- Formulating research problem – Research Design – Basic principles of experimental Design.

UNIT-2: Sampling Design – census – sample survey – selection of random sample - sampling techniques - Measurement and Scaling Techniques – Measurement Scales – Characteristics of sound measurement tool - Important scaling technique – scale construction techniques.

UNIT-3: Methods of data collection – Collection of data - Primary and secondary sources, survey observation, experimentation- details and evaluation - Questionnaires – schedules, data entry, tabulation and diagrammatical representation of data.

UNIT-4: Processing and Analysis of data : Measures of Central tendency – dispersion – skewness and kurtosis – simple correlation and regression - Hypothesis testing – Statistical significance, statistical testing procedure – t test – chisquare test – z test - ANOVA.

UNIT-5: Interpretation and Report writing – significance of report writing – steps in writing report – layout of research report – types of reports – precautions for writing research reports.

Text Books

1. Kothari, C.R. (2011). Research Methodology, Methods and Techniques , second revised edition, New age international Pvt limited, New Delhi
2. Pannerselvam, R (2006). Research Methodology, Prentice-Hall of India Pvt Ltd, New Delhi.

Reference Books

1. Anderson J. et.al,(1977). Thesis and Assignment writing, Wiley Eastern Ltd.
2. Donald R Cooper (2001). Business Research Methods 7th Ed, McGraw Hill.

Course Outcomes

1. After studied unit-1, the student will be able to know basics of research and its formulation

2. After studied unit-2, the student will be able to know sampling design, sampling techniques and scaling techniques

3. After studied unit-3, the student will be able to know methods of data collection and visualization

4. After studied unit-4, the student will be able to know parametric tests and its usage

5. After studied unit-5, the student will be able to know report writing

SEMESTER IV

PAPER - 10

STATISTICAL QUALITY CONTROL

Course Objectives

To enable students to learn about Process Control Techniques, to determine control limits, to study attribute and variable control charts, to study Sampling Plans for attributes, to study Sampling Plans for variables

Unit-1: Dimensions of Quality, Pareto and Ishikawa diagrams, Standardization of Quality, Shewart Control chart for attributes and variables OC curve and ARL of Control charts, Control charts for variables

Unit-2: Modified Control Charts; Moving average and EWMA charts; CUSUM charts. Capability Indices Cp, Cpk and Cpm- estimation and confidence intervals of capability indices for Normally distributed characteristics

Unit-3: Product Control Techniques - Acceptance sampling plans for attribute inspection; single, double and sequential sampling plans, Efficiency measures OC function derivations, ASN, ATI, AOQ.

Unit-4: Variable Sampling Plan for Process Parameter, Sampling by Variables for Proportion Nonconforming Acceptance Sampling Plan For Variables for one-sided and two-sided specifications, X Bar Method, K-Method, M- Method**,** Mil-Std and IS plans, Sampling Schemes.

Unit-5: Sampling by Attributes - Operating procedure – measures – Determination of parameters – Designing of Continuous Sampling Plans; Chain Sampling plan, Skip-Lot Sampling Plan, Dodge-Romig Plans – Reliability Models – Hazard Function – MLE of Reliability based on exponential model. Type I and II Censoring – Reliability Estimations.

Text Books:

1. Montgomery, D.C. (2008) : Introduction to Statistical Quality Control, John Wiley, 6^{th} Ed.
2. E.G.Schilling (2009): Acceptance Sampling in Quality Control, CRC Press 2^{nd} Ed.

Reference books:

1. Grant, L. and Leavenworth, S. (1996) : Statistical quality control, McGraw Hill. 7^{th} Ed.
2. Murthy, M.N. (1989) : Excellence through Quality & Reliability, Applied statistical centre.
3. Thomas P.Ryan (2000) : Statistical Methods for Quality Improvement 2ed., John Wiley

Course Outcomes

1. After studied unit-1, the student will be able to know Process Control
2. After studied unit-2, the student will be able to know Control Charts
3. After studied unit-3, the student will be able to know Acceptance Sampling Plans
4. After studied unit-4, the student will be able to know Variable Sampling Plans
5. After studied unit-5, the student will be able to know Parameters and Reliability Determination

PAPER - 11

STOCHASTIC PROCESSES

Course Objective(s)

To enable students to understand various concepts of Markov process, Markov chain, branching process, renewal process and stationary process and their associated results

Unit-1

Introduction to Stochastic Processes-Classification of Stochastic Processes, Markov Processes– Markov Chain-Transition Probabilities, Transition Probability Matrix. Chapman-Kolmogorov Equations, Calculation of n-step Transition Probability and its limit.

Unit-2

Classification of States – Recurrent and Transient States, Transient Markov Chain, Random Walk and Gambler's Ruin Problem. Continuous Time Markov Process: Poisson Processes, Birth and Death Processes, Kolmogorov's Differential Equations, Applications.

Unit-3

Branching Processes – Galton-Watson Branching Process – Properties of Generating Functions - Extinction Probabilities – Distribution of Total Number of Progeny, concept of Weiner Process.

Unit-4

Renewal Processes – Renewal Process in Discrete and Continuous Time–Renewal Interval– Renewal Function and Renewal Density –Renewal Equation–Renewal theorems: Elementary Renewal Theorem. Probability Generating Function of Renewal Processes.

Unit-5

Stationary Processes: Discrete Parameter Stochastic Process–Application to Time Series, Auto-covariance and Auto-correlation functions and their properties, Moving Average, Autoregressive, Autoregressive Moving Average, Autoregressive Integrated Moving Average Processes. Basic ideas of residual analysis, diagnostic checking, forecasting.

Text Books

For Units 1 to 3

1. Karlin,S. and Taylor,H.M.(1975):A First Course in Stochastic Processes, Second Edition, Academic Press, Inc., NY

For Units 4 and 5

2. Medhi,J.(2017): Stochastic Processes, Fourth Edition, New Age International Private Ltd., New Delhi.

Reference Books

1. Box,G.E.P.,Jenkins,G.M.andReinsel,G.C.(1994)TimeSeriesAnalysis;Forecasting and Control. Third Edition, Prentice Hall, Englewood Cliff, NJ.
2. Granger,C.W.J., and Newbold,P.(1984): Forecasting Econometric Time Series, Second Edition, Academic Press Inc., NY.
3. Anderson,T.W.,(1994):The Statistical Analysis of Time Series, Wiley Interscience
4. Adke,S.R., and Manjunath,S.A.(1984):An Introduction to Finite Markov Processes, Wiley Eastern, New Delhi.
5. Parzen, E. (2015): Stochastic Processes, Dover Publications.

Course outcomes

1. After studying unit-1, the student will be able to understand Markov process, concept of transition probability matrix and derivation of Chapman – Kolmogorov equations.
2. After studying unit-2, the student will be able to understand concepts of continuous time Markov process and its applications.
3. After studying unit-3, the student will be able to understand the concept of branching process and its variants.
4. After studying unit-4, the student will be able to understand the concept of renewal process and its properties.
5. After studying unit-5, the student will be able to understand the concept of stationary process and its application to time series modeling.

CORE PRACTICAL – III
STATISTICAL PRACTICAL-II

Course Objective(s)

To enable students to solve problems related to hypothesis testing, analysis of experimental designs, multivariate data analysis, and statistical quality control techniques.

Problems relating to the following topics which are covered in Semester III and Semester IV shall form the basis for practical:

1. **Testing of Statistical Hypotheses** (problem related to computing α, β, $1-\beta$, construction of MPT, Construction of UMP curve under standard distributions, Construction of Likelihood ratio test for mean, variances, construction of SPRT, OC and ASN functions of standard discrete and continuous distributions)

2. **Design and Analysis of Experiments** (problem related to CRD, RBD, Missing Plot Techniques, Factorial experiments 2^3, 3^2, confounding, BIBD, PBIBD, Youden squares, ANACOVA, Split plot designs, rotatable designs)

3. **Multivariate Analysis** (problems related to computation of mean and covariance of multivariate normal distribution, testing equality mean vectors of two multivariate normal populations, Hotelling T^2, Mahalanobis D^2 – Principal Component Analysis – Factor Analysis – Canonical Correlation Analysis)

4. **Statistical Quality Control** (problems related to Control charts for variables and attributes – EWMA charts – CUSUM charts – Single, Double Sampling – OC, ASN, ATI and AOQ).

Text Books

Books prescribed in the respective core papers shall be used.

Note

The maximum marks for continuous internal assessment and end semester University examination for Statistical Practical-II shall be fixed as 40 and 60, respectively. The continuous internal assessment shall involve test and record work. The question paper at the end semester examination shall consist of **four questions with internal choice**. A candidate shall attend all the four questions, each of which shall carry 15 marks. The examination shall be conducted at the end of Semester IV.

CORE PRACTICAL – IV
Statistical Software Practical-II(Using SPSS)

Course Objective(s)

To enable students to utilize the theoretical knowledge gained in the core papers and to develop computational and technical skills for real life applications emphasizing the importance of SPSS programming.

Problems relating to the following topics shall form the basis for the practical.

1. Classification, diagrams, graphical representation of data and descriptive statistical measures
2. Calculation of probabilities under various distributions and generating random samples from probability distributions
3. Correlation and regression: Simple, partial and multiple correlation coefficients, simple linear and multiple regression, curve fitting, time series and forecasting models
4. Confidence intervals for mean, variance and proportions, tests of significance based on normal, t, chi-square, F and Z statistics
5. Non-parametric tests: Run, sign and median tests, test based on Kruskal – Wallis statistic, Friedman's test
6. Experimental Design: One way ANOVA-two way ANOVA-factorial designs– Multiple comparison tests
7. Principal component analysis, factor analysis, cluster analysis and discriminant analysis
8. Statistical Quality Control charts – Determination of parameters for constructing basic control charts, such as $\bar{X}$, R, S, p and c charts.

Text Books

Books prescribed in the respective core papers shall be used.

Note

The maximum marks for continuous internal assessment and end semester University examination for Statistical Software Practical-II shall be fixed as 40 and 60, respectively. The continuous internal assessment shall involve test and record work. The question paper at the end semester examination shall consist of **four questions with internal choice**. A candidate shall attend all the four questions, each of which shall carry 15 marks.

PROJECT WITH VIVA-VOCE

Course Objective(s)

To enable students to utilize the theoretical knowledge gained in the core papers and to develop computational and technical skills for real life applications by collecting primary / secondary data and performing analyses and submitting their findings in the form of dissertation / project.

Note

All the admitted candidates shall have to carry out a project work during the fourth semester under the supervision of the faculty of the Department of Statistics in the College. The core project may be individual / group project (Not exceeding five members in a group). Candidates shall have to submit three copies of the report of the project work at the end of the fourth semester at least two weeks before the last working day and shall have to appear for a viva-voce examination. The report shall be evaluated and viva-voce examination shall be conducted jointly by an External Examiner and the Project Guide. The maximum marks for the project report and viva – voce examination shall be fixed as 100, which is split with the following components:

Internal Assessment Marks by the Project/Dissertation Guide	:	25 marks
Evaluation of Project/Dissertation Report jointly by the External Examiner and the Guide	:	50 marks
Conduct of Viva-Voce Examination by the external examiner	:	25 marks

CORE ELECTIVE
PAPER - 4

(to choose one out of 2)

A. ECONOMETRICS

Course Objectives

To enable students to learn about types of Econometrics, to know about Test for Autocorrelation, to study about Linear Regression Models, to study indirect least square technique, to study K-class estimators

Unit-1: Introduction to Econometrics- Meaning and Scope – Methodology of Econometrics – Nature and Sources of Data for Econometric analysis – Types of Econometrics.

Unit-2: Aitken's Generalised Least Squares(GLS) Estimator, Heteroscedasticity, Auto-correlation, Multicollinearity, Tests for auto-correlation- Tools for Handling Multicollinearity

Unit-3: Linear Regression with Stochastic Regressors, Errors in Variable Models and Instrumental Variable Estimation, Independent Stochastic linear Regression, Auto regression, Linear regression, Lag Models

Unit-4: Simultaneous Linear Equations Model : Structure of Linear Equations Model, Identification Problem, Rank and Order Conditions, Single Equation and Simultaneous Equations, Methods of Estimation- Indirect Least squares, Least Variance Ratio and Two-Stage Least Square

Unit-5: Statistical Inference in Simultaneous Equations Models : Conditions for Identification, Asymptotic properties of Two-Stage Least Squares Estimator, Limited Information Maximum Likelihood and K-Class Estimators, Methods of Three- Stage Least Squares.

Text Books

1. Johnston, J. (1997). Econometric Methods, Fourth Edition, McGraw Hill
2. Gujarathi, D., and Porter, D. (2008). Basic Econometrics, Fifth Edition, McGraw-Hill

Reference books

1. Intriligator, M. D. (1980). Econometric Models-Techniques and Applications, Prentice Hall.
2. Theil, H. (1971). Principles of Econometrics, John Wiley.
3. Walters, A. (1970). An Introduction to Econometrics, McMillan and Co.
4. Wooldridge, J. (2016). Introductory Econometrics. Cengage Learning, sixth edition

Course Outcomes

1. **After studied unit-1, the student will be able to know** Econometric models
2. **After studied unit-2, the student will be able to know** Tools for Multicollinearity
3. **After studied unit-3, the student will be able to know** Stochastic Linear Regression
4. **After studied unit-4, the student will be able to know** Simultaneous Eq. Models
5. **After studied unit-5, the student will be able to know** Two Stages LS techniques.

CORE ELECTIVE
PAPER - 4

B. BIOSTATISTICS AND SURVIVAL ANALYSIS

Course Objectives

To enable students to learn about types of Clinical Trials, to know about Test for Multiple regression, to study about Survival Analysis and life time distributions, to study Kaplan-Meier and Cox Models.

Unit-1: Introduction to Biostatistics - Clinical Trials - Goals of Clinical Trials - Phases of Clinical Trials- Classification of Clinical Trials - Randomization: Fixed Allocation, Simple, Blocked, Stratified, Baseline Adaptive and Response Adaptive - Blinding: Single, Double and Triple - Designs for Clinical Trials: Parallel Groups Design, Cluster Randomization Designs, Crossover Designs.

Unit-2: Multiple Regression – Assumptions – uses – Estimation and interpretation of coefficients – Testing the regression coefficients – Coefficient of determination – Testing model adequacy. Logistic regression: Introduction – Logistic regression model – relative risk – logit – odds ratio – properties of odds ratio – relationship between odds ratio and relative risk – Maximum Likelihood estimates and interpretation – Test for coefficients - Test of overall regression and goodness of fit using Maximum Likelihood technique – Inference for Logistic regression – Deviance statistics, Wald test, LR test and score test.

Unit-3: Introduction to Survival analysis - terminology and functions of survival analysis - goals - Basic data layout - Censoring-different types of censoring - Parametric survival models based on basic life time distributions - Exponential, Weibull, Gamma and Log- logistic.

Unit-4: Kaplan-Meier's method - general features - the log rank test for two groups, several groups - alternatives to the log rank test - Cox PH model and its features - ML estimation of the Cox PH model-Hazard Ratio-adjusted survival curves-Cox likelihood.

Unit-5: Evaluating the proportional Hazards Assumptions - Overview - graphical approach - log-log plots - Observed versus expected plots- time - dependent covariates - Stratified Cox Procedure - hazard function - Extension of the Cox PH Model - hazard ratio formula - extended Cox likelihood.

Text Books

1. Chow, S. C., and Liu, J. P. (2004). Design and Analysis of Clinical Trials: Concepts and Methodologies, Second Edition, Wiley – Interscience, John Wiley & Sons, NJ.
2. Friedman, l. M., Furberg, C. D., and DeMets, D. L. (2010), Fundamentals of Clinical Trials, Fourth edition, Springer – Verlag, NY.
3. Das, M. N., and Giri, N. C. (2011). Design and Analysis of Experiments, Second Edition, New Age International Private Ltd., New Delhi.
4. Lee, E. T., and Wang, J. W. (2013). Statistical methods for Survival Data Analysis, Fourth Edition, Wiley, NY.
5. *van* Belle, G., Fisher, L. D., Heagerty, P. J., and Lumley, T. (2004). Bio Statistics - A Methodology for the Health Science, Second edition, Wiley, NY.
6. Daniel, W. W. (2013). Bio Statistics: Basic Concepts and Methodology for the Health Sciences, Tenth Edition, John Wiley & Sons, NY.

Reference books

1. Kleinbaum, D. G., and Klein, M. (2012): Survival Analysis: A Self-Learning Text, Third Edition, Springer – Verlag, NY.
2. Klein, J. P. and Moeschberger, M. L. (2003). Survival analysis: Techniques for Censored and Truncated data, Second Edition, Springer – Verlag, NY.

Course Outcomes

1. **After studied unit-1, the student will be able to know** Clinical Trials
2. **After studied unit-2, the student will be able to know** Regression Models
3. **After studied unit-3, the student will be able to know** life time distributions
4. **After studied unit-4, the student will be able to know** Survival Analysis
5. **After studied unit-5, the student will be able to know** hazard rate and functions.

OPEN ELECTIVE
PAPER - 4

(to choose one out of 2)

A. DESCRIPTIVE STATISTICS

Course Objectives

To enable students to learn basic statistics, function of statistics, elementary probability, random variables, computation of correlation and regression coefficients

Unit-1

Origin-Scope-Functions, limitations, uses and Misuses of statistics. Classification and Tabulation of data, Diagrammatic and graphic representation of data.

Unit-2

Measure of Central tendency–Measures of Dispersion-relative measures of dispersion-Skewness and Kurtosis-Lorenz's curve.

Unit-3

Elementary Probability space-Statistical probability Axiomatic approach to probability-Finitely additive and countable additive probability functions-Addition and multiplication theorems-Conditional probability-Bayes theorem-Simple problems.

Unit-4

Random variables-Discrete and continuous random variables-Distribution function and probability density function of a random variable-Expectation of a random variable-Addition and product theorems- Evaluation of standard measures of location, dispersion, Skewness and Kurtosis.

Unit-5

Simple linear correlation and regression-Regression equations-their properties spearman's Rank correlation Co-efficient.

Text Books

1. Gupta, S C., and Kapoor, V. K. (2014). Fundamentals of Mathematical Statistics, Eleventh Edition, Sultan Chand & Sons, New Delhi
2. Gupta, S. P. (2014). Statistical Methods, Sultan Chand & Sons, New Delhi.
3. Goyal, J. K., and Sharma, J. N. (2014), Mathematical Statistics, Krishna Prakashan Private Limited, Meerut.

Reference Books

1. Goon, A. M., Gupta, M. K., and Das Gupta, B. (2013). Fundamentals of Statistics, Vol.1, World Press Private Ltd, Calcutta.
2. Rohatgi, V. K. (1988). An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern (India) Ltd., New Delhi.

Course Outcomes

1. **After studied unit-1, the student will be able to know** functions of statistics
2. **After studied unit-2, the student will be able to know** various statistical measures
3. **After studied unit-3, the student will be able to know** concept of probability
4. **After studied unit-4, the student will be able to know** random variable and its usage
5. **After studied unit-5, the student will be able to know** correlation and regression

OPEN ELECTIVE
PAPER - 4

B. STATISTICAL METHODS FOR RESEARCHERS

Course Objectives

To enable students to learn function of statistics, elementary probability and distributions, correlation and regression coefficients, parametric and nonparametric tests.

Unit-1

Definition of Statistics and its applications in various disciplines - Collection of Data - Classification, Tabulation and graphical representation of data- Construction of univariate and Bivariate frequency distribution-measures of central tendency-measures of dispersion - coefficient of variation.

Unit-2

Random experiment-sample space-events-mathematical and statistical definition of probability-conditional probability-Baye's theorem-random variable-distribution function- moments-Binomial distribution-Poisson distribution-normal distribution and their properties

Unit-3

Scatter diagram-Karl Pearson's coefficient of correlation - concurrent deviation method-coefficient of determination-Spearman's Rank correlation-Linear regression-regression lines.

Unit-4

Tests of significance-types of hypotheses-two types of errors-critical region-level of significance, small sample tests based on t, F distribution, Chi-square test of goodness of fit, contingency table-test of independence of factors-Large sample tests.

Unit-5

Test of equality of several population means, one way and two way analysis of variance. Non-parametric tests- Sign, Run and Median tests-two sample rank test.

Text Books

1. Gupta, S C., and Kapoor, V. K. (2014). Fundamentals of Mathematical Statistics, Eleventh Edition, Sultan Chand & Sons, New Delhi
2. Gupta, S. P. (2014). Statistical Methods, Sultan Chand & Sons, New Delhi.
3. Agarwal, B. L. (2013). Basic Statistics, New Age International Private Limited, New Delhi.

Reference Books

1. Goon, A. M., Gupta, M. K., and Das Gupta, B. (2013). Fundamentals of Statistics, Vol.1, World Press Private Ltd, Calcutta.
2. Rohatgi, V. K. (1988). An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern (India) Ltd., New Delhi.

Course Outcomes

1. **After studied unit-1, the student will be able to know** descriptive statistics
2. **After studied unit-2, the student will be able to know** various distributions
3. **After studied unit-3, the student will be able to know** correlation and regression
4. **After studied unit-4, the student will be able to know** parametric tests and its usage
5. **After studied unit-5, the student will be able to know** non-parametric tests and its usage