

GOVERNMENT ARTS COLLEGE (AUTONOMOUS)

SALEM-7

**Reaccredited with B Grade by NAAC
(Affiliated to Periyar University)**



M.Sc. STATISTICS

Regulations and Syllabus

(Effective from the Academic Year 2021-2022)

Department of Statistics

Vision

- ❖ To uplift the lifestyle of the poor and downtrodden students through this department which is a full-fledged center for statistical learning.

Mission

- ❖ To ensure overall development of the students by imparting training in curricular and co-curricular activities.

Program Educational Objectives (PEOs)	
On successful completion of the M.Sc., Statistics program, the graduate will be able to:	
PEO1	Get employment in government, public, private, industrial, health, business, banking, agricultural and educational sectors
PEO2	Expand their knowledge to set their career in research and higher studies
PEO3	Comprehend the statistical concepts and principles for interdisciplinary research
PEO4	Excel in statistical computing
PEO5	Acquire proficiency in adopting statistical software for data analysis
PEO6	Nurture advancement in statistical theory and applications

Program Specific Outcomes (PSOs)	
On successful completion of M. Sc., Statistics program, the students will be expected to:	
PSO1	Comprehend the theoretical aspects of statistics
PSO2	Recognize the application of statistics in diversified fields
PSO3	Develop computer programs and codes for statistical computation
PSO4	Utilize statistical software effectively for data analysis
PSO5	Understand the conditions and limitations of statistical methods in application
PSO6	Apply Statistical Concepts to real time modelling
PSO7	Identify areas which require solution through Statistical tools
PSO8	Develop Statistical applications using software for specific problems
PSO9	Acquire skills to track examinations which demand Critical Statistical thinking
PSO10	Understand the Significance of Statistical tools in administration

Program Outcomes (POs)	
On successful completion of the M. Sc., Statistics program, the graduates will be able to:	
PO1	Acquire adequate knowledge in theory and applications
PO2	Apply the concepts and principles in various fields
PO3	Acquire analytical skills for computation
PO4	Acquire software skills for statistical computation
PO5	Prepare to participate in competitive examinations at the state and national level
PO6	Acquire skills to meet the challenges in job placements
PO7	Acquire skills to pursue higher education
PO8	Gain effective skills to perform data analysis using statistical tools
PO9	Identify potential problem areas which require statistical solutions
PO10	Apply statistical methods to real time problems

MAPPING WITH PROGRAM OUTCOMES

COs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO1	S	S	M	S	S	S	S	S	M	S
CO2	S	S	M	S	S	S	S	S	M	S
CO3	S	S	M	S	S	S	S	S	M	S
CO4	S	S	M	S	S	S	S	S	M	S
CO5	S	S	L	S	L	S	S	S	M	S

Graduate Attributes (GA)

1. **Disciplinary knowledge:** Capable of demonstrating comprehensive knowledge and understanding of one or more disciplines that form a part of an undergraduate programme of study.
2. **Information/digital literacy:** Capability to use ICT in a variety of learning situations, demonstrate ability to access, evaluate, and use a variety of relevant information sources; and use appropriate software for analysis of data.
3. **Communication Skills:** Ability to express thoughts and ideas effectively in writing and orally; demonstrate the ability to listen carefully, read and write analytically, and present complex information in a clear and concise manner to different groups.
4. **Cooperation/Team work:** Ability to work effectively and respectfully with diverse teams; facilitate cooperative or coordinated effort on the part of a group.
5. **Leadership readiness/qualities:** Capability for mapping out the tasks of a team, formulating an inspiring vision, building a team who can help achieve the vision, and using management skills to guide people to the right destination, in a smooth and efficient way.
6. **Problem solving:** Capacity to extrapolate from what one has learned and apply their competencies to solve different kinds of non-familiar problems, rather than replicate curriculum content knowledge; and apply one's learning to real life situations.
7. **Analytical reasoning** :Ability to evaluate the reliability and relevance of evidence; identify logical flaws and holes in the arguments of others; **Scientific reasoning:** Ability to analyse, interpret and draw conclusions from quantitative/qualitative data; and critically evaluate ideas, evidence and experiences from an open-minded and reasoned perspective.
8. **Moral and ethical awareness/reasoning:** Ability to embrace moral/ethical values in conducting one's life; avoid unethical behaviour such as fabrication, falsification or misrepresentation of data or committing plagiarism, not adhering to intellectual property rights; appreciating environmental and sustainability issues.
9. **Multicultural competence:** Possess knowledge of the values and beliefs of multiple cultures and a global perspective; and capability to effectively engage in a multicultural society and interact respectfully with diverse groups.
10. **Self-directed learning:** Ability to work independently; identify appropriate resources required for a project, and manage a project through to completion.

GOVERNMENT ARTS COLLEGE(AUTONOMOUS), SALEM - 7

M.Sc. STATISTICS

For the candidates admitted from the academic year 2021-2022

S. No	Course Code	Title of the Course	Hours to be handled	Credits	Marks		
					I.A.	S.E.	Max
SEMESTER I							
1	21PST01	Core Course - I : Real Analysis and Linear Algebra	5	5	25	75	100
2	21PST02	Core Course - II : Distribution Theory	5	5	25	75	100
3	21PST03	Core Course - III : Sampling Techniques	5	5	25	75	100
4	21PSTP1	Core Practical - I : Linear Algebra and Multivariate Analysis	4	-	-	-	-
5	21PSTP2	Core Practical - II : Sampling Techniques and Design of Experiments	4	-	-	-	-
6	21PSTM1	Major Based Elective Course- I: Measure Theory	5	5	25	75	100
	21PSTM2	Major Based Elective Course- II: Official Statistics					
7	21RAC01	Research Acumen Course I: Intellectual Property Rights*	2	-	-	100	100
Total			30	20			500
Cum. Total				20			500
SEMESTER II							
1	21PST04	Core Course - IV : Probability Theory	5	5	25	75	100
2	21PST05	Core Course - V : Multivariate Analysis	5	5	25	75	100
3	21PST06	Core Course - VI : Design of Experiments	5	5	25	75	100
4	21PSTP1	Core Practical - I : Linear Algebra and Multivariate Analysis	4	4	40	60	100
5	21PSTP2	Core Practical - II : Sampling Techniques and Design of Experiments	4	4	40	60	100
6	21PSTM3	Major Based Elective Course-III : Programming in R	5	5	25	75	100
	21PSTM4	Major Based Elective Course - IV : Reliability Theory and Survival Analysis					
7	21RAC02	Research Acumen Course II: Research Writing*	2	-	-	100	100
Total			30	28			700
Cum. Total				48			1200

Government Arts College (Autonomous), Salem-636007
PG Regulations and Syllabus (2021-2022 onwards)

S. No.	Course Code	Title of the Course	Hours to be handled	Credits	Marks		
					I.A.	S.E.	Max
SEMESTER III							
1	21PST07	Core Course – VII: Statistical Estimation Theory	5	5	25	75	100
2	21PST08	Core Course – VIII : Demography	5	5	25	75	100
3	21PST09	Core Course – IX : Stochastic Processes	5	5	25	75	100
4	21PSTP3	Core Practical - III: Estimation Theory and Testing of Hypothesis	4	-	-	-	-
5	21PSTP4	Core Practical - IV: Statistical Software Practical using R	4	-	-	-	-
6	21PCMST	Interdisciplinary Course: Data Analysis using Excel	2	2	25	75	100
7	21PSTPR	Project Work (to be continued in Semester IV)	5	-	-	-	-
Total			30	17	-	-	400
Cum. Total				65			1600
SEMESTER IV							
1	21PST10	Core Course – X : Testing of Hypothesis	5	5	25	75	100
2	21PST11	Core Course – XI : Statistical Quality Control	5	5	25	75	100
3	21PST12	Core Course – XII : Operations Research	5	5	25	75	100
4	21PSTP3	Core Practical – III: Estimation Theory and Testing of Hypothesis	4	4	40	60	100
5	21PSTP4	Core Practical – IV: Statistical Software Practical using R	4	4	40	60	100
6	21RAC03	Research Acumen Course III: Research and Publication Ethics*	2	-	-	100	100
7	21PSTPR	Project Work	5	12	50	150	200
Total			30	35	--	--	800
Cum. Total				100			2400

For M.Com. Degree

S. No	Course Code	Title of the Course	Hours to be handled	Credits	Marks		
					I.A.	S.E.	Max
SEMESTER - I							
1	21PCEM1	Major Based Elective Course –I: Statistical Analysis	4	4	25	75	100
SEMESTER - II							
2	21PCEM3	Major Based Elective Course –III: Quantitative Techniques for Business Decisions	4	4	25	75	100

SEMESTER - I

21PST01	Core Course - I: Real Analysis and Linear Algebra
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OBJECTIVE

The main objectives of this course are to:

1. To understand the behavior of sequences and series of numbers in Euclidean and metric spaces.
2. To find the Eigen values and Eigen vectors.
3. To understand the concept of quadratic forms and G-inverse.

SYLLABUS

UNIT – I

Introduction to n-dimensional Euclidean space, open and closed sets, compact sets. Sequences: Types, limit supremum and limit infimum. Series: Convergent series, Cauchy's general principle of convergence. Bolzano Weierstrass theorem, Heine-Borel theorem.

UNIT – II

Sequences and series of functions, point wise convergence of functions, Uniform convergence of functions. Real valued function of several variables- Limits, continuity and derivability of functions

UNIT – III

Riemann-Stieltjes Integral (R-S): Upper and Lower R-S integral – Properties and Evaluation – Necessary and Sufficient condition for R-S Integral Fundamental theorem –Integration and Differentiation –First mean value theorem and Cauchy's mean value theorem for R-S integrals.

Linear Algebra

UNIT – IV

Characteristic roots and vectors: Cayley-Hamilton theorem, minimal polynomial, similar matrices, algebraic and geometric multiplicity of characteristic roots. Spectral decomposition of a real symmetric matrix, reduction of pair of real symmetric matrix.

UNIT – V

Real quadratic forms: Reduction and classification of quadratic forms. Rank, index and signature of quadratic forms. Generalized inverse of a matrix, Moore- Penrose G- inverse in the solution of a system of linear equations, applications of MP inverse for the solution of optimization problems.

TEXT BOOKS

1. Apostol, T.M. (2003), Calculus, Second Edition, John Wiley and Sons, New York.
2. Datta, K.B (1991), Matrix and Linear Algebra, Prentice Hall of India Pvt. Ltd., New Delhi.
3. Goldberg, Richard.R (1970), Methods of Real Analysis, Oxford and IBM Publishing Co. Pvt.Ltd., New Delhi.
4. Walter Rudin, (1987), Real and Complex analysis, Tata McGraw Hill Book Publishing Company, New York

REFERENCE BOOKS

1. Malik, S.C., Savitha Arora (1992), Mathematical Analysis 2nd edition, New Age International Pvt. Ltd. Publishers, New Delhi.
2. Miller, K.S. (1957), Advanced Real Calculus, Charper, New York.
3. Rao, A,R and P. BhimaShankaran,(1992), Linear Algebra, Tata McGraw Hill Book Publishing company, New York.
4. Rao, C.R and S.K. Mitra (1971), Generalized inverse of matrices and its applications, JohnWiley and Sons, New Delhi.

WEB RESOURCES

1. <https://youtu.be/dxoArRt7lww>
2. <https://youtu.be/MHDUCp40Acg>
3. www.statsoft.com
4. www.realseries.com

COURSE OUTCOMES

On successful completion of the course, students will be able to

S. NO.	COURSE OUTCOME	BLOOMS VERB
CO1	Understand the knowledge for derivability, continuity and convergence of sequences and series	Remember to Apply
CO2	Apply various methods and interpret the matrix properties with Eigen values and Eigen vectors.	Remember to Evaluate
CO3	Apply the classification of quadratic forms and find the nature of quadratic forms	Analyze, Evaluate
CO4	Derive the characteristic roots and vectors	Analyze, Evaluate
CO5	Analyze the usefulness of applications of MP inverse for the solution of optimization problems	Understand, Create

MAPPING WITH PROGRAM OUTCOMES

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	S	S	S	S	S	M	S
CO2	S	S	M	S	S	S	S	S	M	S
CO3	S	S	M	S	S	S	S	S	M	S
CO4	S	S	M	S	S	S	S	S	M	S
CO5	S	S	L	S	L	S	S	S	M	S

S- Strong; M-Medium; L-Low

SEMESTER - I

21PST02	Core Course - II: Distribution Theory
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OBJECTIVE

The main objectives of this course are to:

1. To study the methods of deriving the distributions of functions of random variables.
2. To understand bivariate and multivariate distributions.
3. To derive the compound and truncated distributions
4. To understand the distribution of quadratic forms.
5. To understand the properties of the distribution of order statistics.

SYLLABUS

UNIT – I

Distribution of sum, difference, quotient and product of two dimensional independent random variables using Jacobian of transformation – concept of delta method – approximating distributions of sample moments.

UNIT – II

Bivariate Normal – Moment Generating Function-Marginal and Conditional distributions. Moments-Distribution of correlation coefficient when population correlation coefficient is equal to zero, Distribution of regression coefficients.

UNIT – III

Compound, truncated and mixture distributions: Left truncated Binomial-Left truncated Poisson-Left and Right truncated Normal distributions– Non-central t, F and chi-square distributions.

UNIT – IV

Distribution of Quadratic forms in normal random variables, their mean and variance, Independence of Quadratic forms, Independence of linear and Quadratic forms, Fisher-Cochran's theorem.

UNIT – V

Order Statistics: Distribution and properties – Joint and marginal distributions - distribution of median and range – extreme values and their asymptotic distributions – applications.

TEXT BOOKS

1. Johnson and Kotz(1970), Distribution in Statistics, Vol I, II and III, Wiley, U.P, India.
2. Kendall, M.C., and Stuart, A.(1963), The Advanced theory of Statistics Vol I – Distribution theory, Charles Griffin and Company Ltd, London.

REFERENCE BOOKS

1. Anderson,T.W (1983), An introduction to multivariate statistical analysis, 2nd edition, John wiley, New Jersey, Canada.
2. Hogg R.V and A.T.Craig (1972), An introduction to mathematical statistics, 3rd edition, Amerind, New york, London.
3. Kshirsagar, A. M. (1972), Multivariate analysis, Mancell Dekker, New york.
4. Rohatgi, V.K. (1988), An introduction to probability theory and Mathematical Statistics, Wiley Eastern Ltd, New Delhi.
5. Rao, C.R. (1973),Linear Statistical Inference and its applications, 2nd edition, Wiley Eastern, New Delhi.

WEB RESOURCES

1. <https://nptel.ac.in/courses/111/104/111104073/>
2. <https://nptel.ac.in/content/storage2/courses/111104073/Module14/Lecture42.pdf>
- 3.<https://www.youtube.com/watch?v=XIWIOQVKXpI>

COURSE OUTCOMES

On successful completion of the course, students will be able to

S. NO.	COURSE OUTCOME	BLOOMS VERB
CO1	Apply the concept of transformations to find the distribution of function of random variables.	Apply
CO2	Understand the properties of Bivariate Normal Distribution	Understand
CO3	Derive the properties and apply the results of compound and truncated distributions.	Analyse
CO4	Explain the need for non-central distributions and derive the properties of the same.	Understand and Apply
CO5	Derive the distribution and properties of order statistics and apply the same to real life problems	Evaluate

MAPPING WITH PROGRAM OUTCOMES

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	L	S	S	S	S	S	S
CO2	S	S	S	L	S	S	S	S	M	S
CO3	S	S	S	L	S	S	S	S	S	S
CO4	S	S	S	L	S	S	S	S	M	S
CO5	S	S	S	L	S	S	S	S	S	S

S- Strong; M-Medium; L-Low

SEMESTER - I

21PST03	Core Course - III: Sampling Techniques
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OBJECTIVE

The main objectives of this course are to:

1. Understand the need for sample surveys Unders
2. Identify an appropriate method of conducting sample survey Identif
3. Estimate the parameters using an appropriate method of sampling Estimat
4. Convey some extended concepts in sampling to encourage the students in industrial and research aspects Convey
5. Motivate the students in carrying out the field projects in scientific manner and statistical skills Motiva

SYLLABUS

UNIT- I

Sample surveys: Principal steps in a sample survey, drafting a questionnaire, types of questions, question sequence. Errors in surveys – non response, types of non-response, call backs, a mathematical model of the effects of call backs. Interpenetrating subsample. Randomized response technique, Warner’s model– unrelated questionnaire method.

UNIT - II

Ratio Estimator: Auxillary variate, Bias, Variance of the ratio estimator, comparison of ratio estimator with SRS – conditions under which the ratio estimator is a BLUE, definition of BLUE, model unbiasedness (concept only) – Ratio estimator in Stratified Random Sampling – unbiased ratio type estimator (Hartley & Ross).

UNIT - III

Regression Estimator: Regression estimators with pre assigned “b” – sample estimate variance – bias – regression estimates when b is computed from the sample, relationship between b and B – Regression estimates in Stratified Random Sampling.

Cluster sampling: Equal cluster sampling - estimation of mean and its variance, relative efficiency of cluster sampling with SRS, Systematic sampling viewed as cluster sampling.

UNIT - IV

Unequal probability sampling: Cumulative total and Lahiri's methods. Estimation in PPS sampling with replacement and without replacement, General selection procedure. Ordered estimator: Des Raj, Unordered estimators: Hurwitz - Thompson estimator and Murthy's estimators.

UNIT - V

Two Stage Sampling: Estimation of population total, variance of the estimated mean.

Double Sampling (DS): Double sampling for stratification– estimated variance, DS for ratio estimator– estimated variance, DS for Regression estimator – variance and bias.

TEXT BOOKS

1. Cochran, W.G. (1977): Sampling Techniques, Wiley Ltd, New York.
2. Sampath, S. (2005), Sampling theory and methods 2nd edition, Narosa Publishing House, New Delhi.

REFERENCE BOOKS

1. Murthy, M.N. (1977), Sampling theory and methods, Statistical Publishing Society, Calcutta.
2. Des Raj (1978), Sampling Theory, Tata McGraw Hill Book Publishing company, New York.
3. Singh D and Choudhary F.S. (1986), Theory and analysis of sample survey designs, Wiley Eastern Ltd, New Delhi.

WEB RESOURCES

1. <https://nptel.ac.in/courses/111/104/111104073/>
2. <https://nptel.ac.in/content/storage2/courses/111104073/Module14/Lecture42.pdf>
3. <https://youtu.be/3UFelQO7JS0>
4. <https://youtu.be/UOrcWM0-3Vk>
5. http://182.18.165.51/Fac_File/STUDY183@421833.pdf

COURSE OUTCOMES

On successful completion of the course, students will be able to

S. NO.	COURSE OUTCOME	BLOOMS VERB
CO1	Understand the importance of sampling and sample surveys	Understand
CO2	Adopt suitable sampling methods for given situations	Understand, Apply
CO3	Observe the effectiveness of sample surveys	Remember, Analyse
CO4	Design and perform sample surveys	Apply, Evaluate
CO5	Draw random samples using various sampling methods and study the properties	Remember, Apply, Evaluate, Create

MAPPING WITH PROGRAM OUTCOMES

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	L	S	M	S	M	S	S
CO2	M	S	M	L	S	M	S	M	S	S
CO3	S	S	M	L	S	M	S	M	S	S
CO4	S	S	M	L	S	M	S	M	S	S
CO5	S	S	M	L	S	M	S	M	S	S

S- Strong; M-Medium; L-Low

SEMESTER - I

21PSTM1	Major Based Elective Course – I: Measure Theory
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OBJECTIVE

1. Understand the concept of Algebra of Sets and Measurable functions.
2. Explore the basic and advance concepts available in measure Integration and Reimann integral.
3. understand the application of Fubini,'s theorem & Radon Nikodyn theorem in probability.

SYLLABUS

UNIT - I

Algebra of sets –Countable Sets – Field- σ –Field , Monotone Field –Monotonic class-Minimal class - Minimal σ –Field generated by the class of subsets - Borel sets- Borel Field - Borel σ –Field.

UNIT - II

Set functions –Countably additive set functions-Finitely additive set functions , Measure functions – Properties of Measure functions –Outer measure functions-Extension measure- Completion of a measure function (concept only).

UNIT - III

Lebesque measure function and its properties, Lebesque – Stieltjes measure- Examples- Measurable functions, Borel measurable functions, Approximation theorems.

UNIT - IV

Measure integration -Properties of integrals, concept of Reimann integral, Lebesque integral and Reimann – Stieltjes integral. Sequence of measurable functions. Mode of convergence of measurable functions. Monotone and dominated convergence theorems.

UNIT -V

Product measure - Product measure functions-Properties- Product measure theorem, Fubini's theorem (concept) and its applications in probability. Radon -Nikodyn theorem (concept) and its applications.

TEXT BOOKS

1. Bhat , B. R. (2009), Modern Probability theory, Wiley Eastern Ltd., New Delhi.
2. Basu, A. K. (2012). Measure Theory and Probability, Prentice Hall India Learning Private Limited, New Delhi.
3. Halmos, P. R. (1978). Measure Theory, (First Edition in 1950), Second Printing, SpringerVerlag, NY.

REFERENCE BOOKS

1. Ash, Robert B.(2005), Catherine A. Doleans Date, Probability and measure theory, 2nd edition, Elsevier, New Delhi.
2. De Berra ,G.(1987), Measure theory and Integration, New Age International Pvt. Ltd., New Delhi.
3. Munroe, M.E (1953), Measure and Integration, Addition Wesley Ltd., New Delhi.

WEB RESOURCES

1. <http://nptel.ac.in/courses/111/101/111101005>
2. <http://nptel.ac.in/courses/111/102/111102111>
- 3 . <http://nptel.ac.in/courses/111/102/111102111>

COURSE OUTCOMES

On successful completion of the course, students will be able to

S. NO.	COURSE OUTCOME	BLOOMS VERB
CO1	Understand the meaning of measure and probability	Remember
CO2	Comprehend the concepts of sets, functions, measure and probability space	Understand
CO3	Provide basic and advanced applications of measure and probability	Apply
CO4	Identify application of inequalities in probability theory	Analyze
CO5	Explore the application of law of large numbers and central limit theorems	Evaluate

MAPPING WITH PROGRAM OUTCOMES

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	M	L	S	S	S	M	M	M
CO2	S	M	M	L	S	S	S	M	M	M
CO3	S	M	M	L	S	S	S	M	M	M
CO4	M	M	M	L	S	S	S	M	M	M
CO5	S	M	M	L	S	S	S	M	M	M

S- Strong; M-Medium; L-Low

SEMESTER – I

21PSTM2	Major Based Elective Course – II: Official Statistics
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OBJECTIVE

1. To understand the statistical systems.
2. To understand the official statistical system.
3. Understand the functioning of government and policies.
4. Promote human resource development in the official statistics and encourage research and development in theoretical and applied statistics.
5. Execute the data handling tasks in various government records

SYLLABUS

UNIT - I

Introduction to Indian and International statistical systems - Role, function and activities of Central and State statistical organizations - Organization of large scale sample surveys - Role of National Sample Survey Organization - General and special data dissemination systems.

UNIT - II

Population growth in developed and developing countries - Evaluation of performance of family welfare programmes - Projections of labour, force and manpower - Scope and content of population census of India.

UNIT - III

System of collection of Agricultural Statistics - Crop forecasting and estimation - Productivity, fragmentation of holdings - Support prices - Buffer stocks - Impact of irrigation projects.

UNIT - IV

Statistics related to industries - Foreign trade - Balance of payment - Cost of living – Inflation - Educational and other social statistics.

UNIT - V

Indian official statistics: Present official statistical system in India - Methods of collection of official statistics - Principal publications containing data on the topics such as population, agriculture, industry, trade, prices, labour and employment, transport and communications - Various official agencies responsible for data collection and their main functions.

TEXT BOOKS

1. Allen R. G. D. (1975). Index Numbers in Theory and Practice, Macmillan.
2. Mukhopadhyay, P. (2011). Applied Statistics, Second Edition, Books & Allied Ltd, India.
3. Basic Statistics Relating to the Indian Economy (CSO),1990.
4. Family Welfare Year book. Annual Publication of D/o Family Welfare.
5. Guide to Official Statistics (CSO), 1999.
6. Monthly Statistics of Foreign Trade in India, DGCIS, Calcutta and other Govt. Publications.
7. Principles and accommodation of National Population Censuses, UNESCO.
8. Statistical System in India (CSO) 1995.

REFERENCE BOOKS

1. Bhaduri, A. (1990). Macroeconomics: The Dynamics of Commodity Production, Macmillan India Limited, New Delhi.
2. Branson, W. H. (1992). Macroeconomic Theory and Policy, Third Edition, Harper Collins Publishers India (P) Ltd., New Delhi.
3. Goon A. M., Gupta M. K., and Dasgupta. B. (2001), Fundamentals of Statistics, Vol. 2, World Press, India.
4. Panse, V. G. (1964). Estimation of Crop Yields (FAO), Food and Agriculture Organization of the United Nations.

WEB RESOURCES

1. <https://www.classcentral.com/course/swayam-macro-economics-19942>
2. <https://www.classcentral.com/course/swayam-economics-of-health-and-health-care-14023>
3. www.mospi.nic.in and censusindia.gov.in

COURSE OUTCOMES

On successful completion of the course, students will be able to

S.No	Course Outcome	Blooms Verb
CO1	Understand the fundamentals of measurement in official statistics	Remember
CO2	Evaluate the methods for data collection, analysis and interpretation of health, social and economic	Understand
CO3	Use appropriate methods for presenting and preparing commentaries on official statistics	Apply & Analyze
CO4	Execute the tasks in agricultural and economic statistics	Evaluate
CO5	Overcome the limitations that arises from measurement and processes of statistical production	Create

MAPPING WITH PROGRAMME OUTCOMES

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	L	L	S	M	M	L	M	S
CO2	S	S	L	L	S	M	M	S	L	S
CO3	S	S	L	L	S	M	M	S	L	L
CO4	S	S	L	L	S	M	M	L	S	M
CO5	S	S	L	L	S	M	M	L	S	L

*S-Strong; M-Medium; L-Low

Semester- I

21RAC01	Research Acumen Course I : Intellectual Property Rights
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OBJECTIVES

1. This course aims to provide an introductory study to the subject of Intellectual Property Rights, which is one of the basic pillars of modern Research and Development.
2. The focus of the course will be the study of certain structures called Patents, Copyrights and related rights, Trademarks, Geographical Indications, Industrial designs, Layout Designs of integrated circuits, Trade Secrets and Plant Varieties.
3. Introduction to IPR gives to student a good maturity and enables to build intellectual thinking and skill.

LEARNING OUTCOMES

Students should achieve mastery of the topics listed below.

1. This means that they should know all relevant definitions, correct statements of the major structures and examples and non-examples of the various concepts.
2. The students should be able to demonstrate their mastery by solving problems related to these concepts

SYLLABUS

UNIT-I

Introduction - International Intellectual Property Regime - New dimensions and issues for Resolution - IPR in developing countries - Impact of stronger IPR in developing countries

UNIT-II

Categories of intellectual property - Patents – Patentable invention – Novelty – Utility - Inventive step/non-obviousness - Not-patentable inventions - Inventions and discoveries

UNIT – III

Patent application - Form of application - Types of patent specification - Contents of specification

UNIT-IV

Procedure for obtaining patents – Publication - Request for examination – Examination - Search for anticipation by previous publication and by prior claim - Opposition proceedings to grant of patents - Grant of patents - Grant of patents to be subjected to certain conditions

UNIT-V

Rights of patentee - Register of patents - Renewal fee – Restoration - Drafting of patent specification in patent application - Parts of the complete specification –

BOOKS FOR SUPPLEMENTARY READING AND REFERENCE

1. Open Source Book “Introductory **Intellectual Property Rights**” by Sakthivel Lakshmana Prabu, Timmadonu Narasimman Kuppusami Suriyaprakash and Rathina sabapathy Thirumurugan, (<http://dx.doi.org/10.5772/intechopen.69359>)
2. Open Source Book “HANDBOOK ON INTELLECTUAL PROPERTY RIGHTS IN INDIA” by Rajkumar S. Adukia (<http://rishabhacademy.com>)
3. Open Source Book “HANDBOOK ON INTELLECTUAL PROPERTY RIGHTS - Basic information on concepts related to Intellectual Property Rights – 3rd Edition” by Origin IP Solutions LLP (<http://www.origiin.com>, <http://www.origiinipa.com>)

ADDITIONAL WEB RESOURCES

1. en.wikipedia.org/wiki/, 2. wiki.answers.com

SEMESTER - II

21PST04	Core Course - IV: Probability Theory
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OBJECTIVE

1. To understand the process of describing a random variable through probability space.
2. To understand the behavior of large numbers.
3. To understand the various forms of Central Limit Theorems

SYLLABUS

UNIT – I

Probability measure – properties – discrete probability space and general probability space, conditional probability space. Functions and inverse functions – Random variable – induced probability space by the random variable.

UNIT – II

Distribution function – properties – Decomposition theorem – correspondence theorem – distribution function of vector random variable. Conditional distribution function – properties – concept of independence – Kolmogorov 0-1 law – Borel Cantelli Lemma.

UNIT – III

Expectation and moments – properties, conditional expectation – properties. Inequalities: Markov, Holder, Jensen, Chebychev and Liapounov- Convergence of sequence of random variables – mode of convergence and their relationship.

UNIT – IV

Characteristic function of the random variable – properties – Inversion theorem – examples – Uniqueness theorem, Levy continuity theorem (statement). Law of large numbers – WLLN for independent and iid case – SLLN for independent and iid case.

UNIT – V

Weak and complete convergence of distribution function – Helly Bray theorem. Central Limit Theorem (CLT) - Generalization of LLN, CLT for independent random variables –

Liapounov's form – Lindeberg – Feller CLT, CLT for iid random variables – Lindeberg - Levy theorem.

TEXT BOOKS

1. Basu, A. K. (2012) Measure Theory and Probability, Prentice Hall India Learning Private Limited, New Delhi.
2. Bhat, B. R. (2009) Modern Probability Theory – An Introductory Text Book, Third Edition (Reprint), New Age International Private Ltd
3. Halmos, P. R. (1978). Measure Theory, (First Edition in 1950), Second Printing, Springer – Verlag. NY.

REFERENCE BOOKS

1. De Barra, G. (2000), Measure Theory and integration, New Age International Private Ltd, New Delhi.
2. Rohatgi, V. K. and Saleh, A.K.M.E. (2015), An Introduction to Probability and Statistics, Third Edition, John Wiley & Sons, NY.

WEB RESOURCES

1. www.statsoft.com
2. www.investopedia.com

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1. <https://nptel.ac.in/courses/111/101/111101005/>
2. <https://nptel.ac.in/courses/111/102/111102111/>

COURSE OUTCOMES

On successful completion of the course, students will be able to

S. NO.	COURSE OUTCOME	BLOOMS VERB
CO1	Understand the meaning of probability measure, probability space and distribution function	Remember, Understand
CO2	To have an understanding of the nature of chance and variation in real life situation apply the measure and probability	Understand, Analyze
CO3	To understand the fail behavior of a random variable and the behavior of the average of independent random variable in various field. Apply in real life problem	Apply, Analyze, Evaluate
CO4	To know how a sequence of probability converges and how a sequence of random variables in the limit	Apply, Analyze, Evaluate
CO5	Explore the applications of central limit theorem (CLT) and analyze various research problem in different fields.	Apply, Analyze, Evaluate

MAPPING WITH PROGRAM OUTCOMES

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	S	M	M	S	M	S
CO3	S	S	M	S	S	M	M	S	S	S
CO3	S	S	M	M	S	M	S	S	M	S
CO4	S	S	S	M	S	M	M	S	M	S
CO5	S	S	S	M	M	S	M	M	M	S

S- Strong; M-Medium; L-Low

SEMESTER - II

21PST05

Core Course – V : Multivariate Analysis

OBJECTIVE

The main objectives of this course are to:

1. To study the multiple characteristics of the sample objects
2. To understand the parameters of multivariate normal distribution, Multiple regression
3. To understand the basic ideas in multivariate statistics.

SYLLABUS

UNIT – I

Maximum likelihood estimators for parameters of multivariate normal distribution – Total, Partial and Multiple correlations – Regressions. Distributions of sample mean vector and Covariance matrix of multivariate normal distribution

UNIT – II

Hotelling's T^2 statistic – its null distribution and relation with likelihood ratio test criterion. Mahaloabis D^2 , S^2 – Wishart matrix – its distribution and properties.

UNIT – III

Testing for mean vectors of one and two multivariate normal distribution with dispersion matrix known and unknown (using LR test). Classification and discrimination procedures among two multivariate normal populations only.

UNIT – IV

Fisher's Discriminant function – Sample discriminant function – Tests associated with discriminant function– Concept of cluster analysis – Hierarchical and non-hierarchical methods – Simple problems.

UNIT – V

Principal component analysis –Maximum likelihood estimates of the Principal components and their variances. Canonical correlation and variables – definition, uses, estimation and computation – factor analysis – Orthogonal factor model, principal component solution to factor model.

TEXT BOOKS

1. Anderson, T.W (1983), Introduction to Multivariate Statistical Analysis, 2nd edition, Johnwiley and sons, Inc., publications, New Delhi
2. Johnson and Wichern (1996), Applied multivariate statistical analysis, 3rd edition, PHI Pvt. Ltd, India.
3. Morrison, Donald. F (1978), Multivariate Statistical methods, 2nd edition, Tata McGraw HillInternational, New York.
4. Rao, C.R (1973), Linear Statistical Inference and its applications, 2nd edition, wileyeastern,New Delhi.

REFERENCE BOOKS

- 1.Giri, N.C (1977), Multivariate statistical inference, Academic press.
- 2.Kendall,M.G.,Stuart,A. and Ord,K.J.(1973). The Advanced Theory of Statistics, (Fourth Edition), Vol.2, Charles Griffin company Ltd.

WEB RESOURCES

1. <https://youtu.be/Wxqeyhpsw6A>
2. <https://youtu.be/M-ZuuKemqbQ>
3. www.multivariateanalysis.com
4. www.statsoft.com

COURSE OUTCOMES

On successful completion of the course, students will be able to

S. NO.	COURSE OUTCOME	BLOOMS VERB
CO1	Understand the knowledge of cluster analysis, principal component analysis and factor analysis	Remember to Apply
CO2	Apply the variable reduction methods to study the real life problems using cluster analysis, principal component analysis and factor analysis.	Remember to Evaluate
CO3	Apply the classification techniques to real life problems.	Analyze, Evaluate
CO4	Analyse the hypothesis for multiple characteristics.	Analyze to Create
CO5	Create the testing methodology based on Wilk' s criterion for their further research	Understand, Create

MAPPING WITH PROGRAM OUTCOMES

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	S	S	S	S	S	M	S
CO2	S	S	M	S	S	S	S	S	M	S
CO3	S	S	M	S	S	S	S	S	M	S
CO4	S	S	M	S	S	S	S	S	M	S
CO5	S	S	L	S	L	S	S	S	M	S

S- Strong; M-Medium; L-Low

SEMESTER - II

21PST06

Core Course - VI: Design of Experiments

OBJECTIVE

1. Practice the students to understand the theoretical concepts of linear model and its type.
2. To make the students to understand the importance of various experimental design
3. To make students for developing the mathematical model of experimental design as per the objective of research problem in various fields.

SYLLABUS

UNIT – I

Linear models – Types of linear models – estimability of linear parametric functions - generalised Gauss – Markov theorem on linear estimation (BLUE) – fixed, mixed and random effect models – ANOVA for one way and two way classified data – ANOCOVA for one way and two way classifications with one concomitant variable.

UNIT – II

Introduction to design of experiments – Relative efficiency of CRD, RBD and LSD – Need and scope of split plot and strip plot designs and analysis.

Factorial experiments – analysis of symmetric 2^n , $n < 4$ and 3^n , $n < 4$ designs.

UNIT – III

Asymmetric factorial ($p \times q$) experiments - construction and analysis of confounded (complete and partial) symmetric factorial - fractional replication-symmetric factorial (2^5), (2^6). Split plot design as main effects confounded factorial effect.

UNIT – IV

Incomplete Block designs – concept of connectedness, balancedness and orthogonality – BIBD and its parametric relations – Information(C) matrix and criteria for connectedness of block designs – Intra and inter block analysis of BIBD – Youden square design and its intra block analysis.

UNIT – V

PBIBD with ‘m’ associate classes - classifications and parametric relations of PBIBD (2) – Intra block analysis of PBIBD (2) – Lattice design – linear and second order response surface design (Need and scope) – Taguchi’s contribution to design and quality engineering – Taguchi’s philosophy - the Taguchi approach to parameter design.

TEXT BOOKS

1. Montgomery, D. C. (2012). Design and Analysis of Experiments, Eighth Edition, John Wiley & Sons, NY.
2. Das, M. N. and Giri, N.C. (2011). Design and Analysis of Experiments, Second Edition, New Age International private Ltd., New Delhi
3. Graybill. F. A. (1961): An Introduction to Linear Statistical Models, McGraw hill Co., London.
4. Graybill. F. A. (2000). Theory and Applications of Linear Models, Duxbury Press, First Edition, MA.
5. Peterson, R. G. (1985). Design and analysis of experiments, Marcel Dekker, New York.
6. Paneerselvam, R. (2012). Design and Analysis of Experiments, PHI Learning Private Ltd., New Delhi.

REFERENCE BOOKS

1. Fisher, R. A. (1966). The Design of Experiments, 8th Edition, Oliver and Boyd, London.
2. Federer, W. T. (1967). Experimental Design: Theory and Application, Indian Edition, Oxford and IBH Publishing Co., New Delhi
3. Kempthorne, O. (1965). The Design and Analysis of Experiments, Wiley Eastern India Limited, New Delhi.
4. Cochran, W. G. and Cox, G. M. (1992). Experimental Designs, Second Edition, John Wiley & Sons, New York.
5. Nigam, A. K., Puri, P. D., and Gupta, V. K. (1988). Characterizations and Analysis of Block Designs, John Wiley & Sons, NY.
6. John, P. W. M. (1971). Statistical Design of Experiments, Mecomillan Co., NY.
7. Joshi, D. D. (1987). Linear Estimation and Design of Experiments, First Edition, New Age International(P) Ltd, New Delhi.
8. Searle, S.R. and Gruber, M. H. J. (2016). Linear Models, Second Edition, John Wiley & Sons, Inc.,

WEB RESOURCES

1. [www.wikipedia.org/agricultural experiment](http://www.wikipedia.org/agricultural_experiment)
2. [www.wikipedia.org/basic designs.html](http://www.wikipedia.org/basic_designs.html)www.khanacademy.org

COURSE OUTCOMES

On successful completion of the course, students will be able to

S. NO.	COURSE OUTCOME	BLOOMS VERB
CO1	Remember and understand the theoretical knowledge of analysis of various and design of experiments	Remember, Understand
CO2	Understand the type of suitable design for the analysis of experiments in various practical situation	Understand, Apply
CO3	Apply various design of experiments and evaluate its results	Apply, Analyze, Evaluate
CO4	Create further analysis which are specific to the scope and objective of any experiments	Analyze. Create
CO5	Create a new experimental design as per the objective of the research problem in various fields	Create

MAPPING WITH PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	S	M	M	S	M	S
CO3	S	S	M	S	S	M	M	S	S	S
CO3	S	S	M	M	S	M	S	S	M	S
CO4	S	S	S	M	S	M	M	S	M	S
CO5	S	S	S	M	M	S	M	M	M	S

S- Strong; M-Medium; L-Low

SEMESTER – I & II

21PSTP1	Core Practical – I : Linear Algebra and Multivariate Analysis
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OBJECTIVE

The main objectives of this course are to:

1. Understanding the concepts of linear algebra by practice
2. Impart knowledge on to classify the quadratic forms
3. Instill knowledge to apply multivariate theory into practice
4. Understand the theory through practical oriented training

SYLLABUS

UNIT - I

1. Problems based on Cayley's Hamilton's theorem.
2. Finding of eigen values and eigen vectors
3. Minimal polynomials
4. Algebraic and Geometric multiplicity of characteristic roots.

UNIT - II

1. Classification of Quadratic forms
2. Triangular reduction of quadratic forms.
3. Rank, index and signature of Quadratic forms.
4. Least square solution of $AX = b$ and minimum residual

UNIT - III

1. Testing about mean vector when Σ is known
2. Testing about mean vector when Σ is unknown
3. Testing for Dispersion matrix
4. Bartlett's Test of equality of variances

UNIT - IV

M.Sc. (Statistics)

2021 – 2022 onwards

1. Test of Hotelling's T^2 - statistic
2. Test of Mahalanobis D^2 - statistic
3. Test for Covariance Matrix.

UNIT - V

1. Discriminant functions
2. Principal component Analysis
3. Classifications problems

Note: Two questions from multivariate Analysis and one question from Linear Algebra with internal choice. Students must answer all the questions.

TEXT BOOKS

1. Datta, K.B (1991), Matrix and Linear Algebra, Prentice Hall of India Pvt Ltd., New Delhi
2. Anderson, T.W (1983), Introduction to Multivariate Statistical Analysis, 2nd edition, John Wiley and Sons, Inc., publications, New Delhi.
3. Johnson and Wichern (1996), Applied multivariate statistical analysis, 3rd edition, PHI, Pvt., Ltd, India.

REFERENCE BOOKS

1. Rao, A.R and P. Bhima Shankaran, (1992), Linear Algebra, Tata McGraw Hill Book Publishing company, New York.
2. Giri, N.C (1977), Multivariate statistical inference, Academic press.
3. Morrison, Donald. F (1978), Multivariate Statistical methods, 2nd edition, Tata McGraw Hill International, New York

WEB RESOURCES

<https://nptel.ac.in/courses/111/102/111102112/>
M.Sc. (Statistics)

<http://www.nptelvideos.in/2012/12/applied-multivariate-analysis.html>

COURSE OUTCOMES

On successful completion of the course, students will be able to

S. NO.	COURSE OUTCOME	BLOOMS VERB
CO1	Understanding of matrix algebra by practice	Understand,Apply
CO2	Classification and nature of quadratic forms	Apply, Analyze, Evaluate
CO3	Inferences about mean vector	Analyze,Evaluate
CO4	Carry out the significance tests based on multivariate data	Analyze,Evaluate
CO5	Perform principal components analysis	Analyze,Evaluate

MAPPING WITH PROGRAM OUTCOMES

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	L	S	S	S	S	S	M	S
CO2	S	S	L	S	S	S	S	S	M	S
CO3	S	S	L	S	S	S	S	S	M	S
CO4	S	S	L	S	S	S	S	S	M	S
CO5	S	S	L	S	S	S	S	S	M	S

S- Strong; M-Medium; L-Low

SEMESTER – I & II

21PSTP2

Core Practical - II: Sampling Techniques and Design of Experiments

OBJECTIVE

The main objectives of this course are to:

1. Impact
knowledge on statistical computation using real data sets
2. Unders
stand the methods of estimating the parameters using various sampling methods
3. Unders
stand the methods of performing Analysis of Variance on various experimental designs

SYLLABUS

UNIT - I

Estimation of population mean, total and its variance in SRS and Comparisons of SRS over Ratio and Regression estimators

UNIT - II

Estimation of population means, total and standard error in Stratified Random Sampling (STRS) – variance–comparisons of different allocations in STRS – Gain due to stratification - Comparisons over systematic, STRS and SRS

UNIT - III

ANOVA for one - way, two-way classified data (Without interaction) - ANOCOVA for one-way, two-way classified data. Estimate missing value: RBD-One and Two missing values – LSD - One and Two missing values, Split plot design and strip plot design

UNIT - IV

Analysis of 2^4 and 3^2 symmetrical Factorial experiments. 2^3 Factorial experiment with 2^2 block size for Partial confounding. 2^4 Factorial experiments in 6 block size for complete confounding.

UNIT - V

Analysis of BIBD, Analysis of PBIBD and Youden Square design

Note: One question from Sampling Techniques and two questions from Design of Experiments With internal choice. Student must answer all the questions

TEXT BOOKS

1. Sampath, S. (2005), Sampling theory and methods 2nd edition, Narosa Publishing House, New Delhi
2. Goon, A. M., Gupta, M. K., and Dasgupta, B. (1989). An Outline of Statistical Theory-Vol.II, World Press, Calcutta

REFERENCE BOOKS

1. Singh D and Choudhary F.S. (1986), Theory and analysis of sample survey designs, Wiley Eastern Ltd, New Delhi
2. Das, M. N., and Giri, N. C. (2011). Design and Analysis of Experiments, Second Edition, New Age International Private Ltd., New Delhi
3. Paneerselvam, R. (2012). Design and Analysis of Experiments, PHI Learning Private Ltd., New Delhi

WEB RESOURCES

1. <https://nptel.ac.in/courses/111/104/111104073/>
2. <https://nptel.ac.in/courses/110/105/110105087/>
3. <https://youtu.be/95ZMKW75zvg>

COURSE OUTCOMES

On successful completion of the course, students will be able to

S. NO.	COURSE OUTCOME	BLOOMS VERB
CO1	Estimate the parameters of the population based on random samples	Remember, Understand, Apply
CO2	Understand the principles underlying sampling as a means of making inference about a population	Remember, Understand, Apply, Analyze
CO3	Analyze data from multi-stage surveys	Analyze, Evaluate
CO4	Analyze the data within the framework of various experimental designs	Analyze, Evaluate, Create
CO5	Create new types of designs as per the requirements and study their behaviour while proceeding to the research	Understand, Create

MAPPING WITH PROGRAM OUTCOMES

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	L	S	S	S	S	S	M	S
CO2	S	S	L	S	S	S	S	S	M	S
CO3	S	S	L	S	S	S	S	S	M	S
CO4	S	S	L	S	S	S	S	S	M	S
CO5	S	S	L	S	S	S	S	S	M	S

S- Strong; M-Medium; L-Low

SEMESTER - II

21PSTM3	Major Based Elective Course – III : Programming in R
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OBJECTIVE

1. Understand the operations and functions of R Programming Unders
2. Perform statistical analysis using built-in functions
3. Understand and write customized program for mathematical and statistical problems Learn

SYLLABUS

UNIT - I

Data type manipulation: Numbers, Strings, Factors, Logical, Vectors, Matrices, Arrays, Lists, Data frame. Reading files in to R, Writing files from R, Appending to a file.

UNIT - II

Performing basic matrix operations: Sum, Product, inverse and transpose. Graphic Representation: Bar plot, Pie charts, Line charts, Histogram, Dot plot, Box plot and Scatter plot.

Descriptive Statistics – Min, Max, Sum on Quantitative Data, Mean or Arithmetic mean, Geometric mean, Median and Mode, Quartiles, Variance and Standard deviation.(discrete and continuous data)

UNIT - III

Probability distribution – Binomial, Poisson and Normal distribution, Correlation, linear Regression and multiple Regression.

UNIT - IV

Inferential Statistics- p-value- Statistical Hypothesis, Degrees of freedom, Confidence interval, Hypothesis testing, Non-parametric test.

UNIT - V

t, F, Chi-square ANOVA (one way and two way ANOVA)

TEXT BOOKS

1. Purohit, S. G., Gore, S. D., and Deshmukh, S. R. (2009). Statistics Using R, Narosa Publishing House, New Delhi.
2. Dalgaard, P. (2008). Introductory Statistics with R, Second Edition, Springer
3. Crawley, M, J. (2007). The R Book, John Wiley and Sons Private Ltd., NY.

REFERENCE BOOKS

1. De Vries, A., and Meys, J. (2016). R For Dummies, Second Edition, John Wiley & Sons Private Ltd, NY.

WEB RESOURCES

1. https://swayam.gov.in/ndl_noc19_ma33/preview
2. https://swayam.gov.in/nd2_aic20_sp35/preview
3. <https://nptel.ac.in/courses/111/104/111104100>

COURSE OUTCOMES

On successful completion of the course, students will be able to

S. NO.	COURSE OUTCOME	BLOOMS VERB
CO1	Understand the basics of R Language	Understand
CO2	Apply the logical skills for performing statistical analysis	Apply
CO3	Use appropriate plots, charts and diagrams for all kinds of data	Evaluate
CO4	Perform parametric methods	Evaluate
CO5	Perform data analysis for real time problems	Evaluate

MAPPING WITH PROGRAM OUTCOMES

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	L	S	S	S	S	M	M	M
CO2	S	S	L	S	S	S	M	M	M	M
CO3	S	S	L	S	S	S	M	M	M	M
CO4	S	S	L	S	S	S	M	M	M	M
CO5	S	S	L	S	S	S	S	M	M	M

S- Strong; M-Medium; L-Low

SEMESTER –II

21PSTM4	Major Based Elective Course - IV: Reliability Theory and Survival Analysis
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OBJECTIVE

1. Understand the concepts and their interpretation in reliability and survival analysis.
2. Know the Statistical methods used in reliability and life data analysis.
3. Comprehend the importance of reliability theory in industries.
4. Understand the concept of censoring and the various distributions used to analyze survival data

SYLLABUS

UNIT – I

Reliability concepts and measures; components and systems; coherent systems ; cuts and paths; modular decomposition; bounds on system reliability; structural reliability importance of components.

UNIT - II

Life distributions; reliability function; hazard rate; common life distributions exponential, Weibull and Gamma. Estimation of parameters and tests in these models.

UNIT - III

Reliability growth models; probability plotting techniques; Hollander-Proschan and Deshpande tests for exponentiality – Basic idea of accelerated life testing. Concepts of time, Order and random Censoring, likelihood in these cases.

UNIT – IV

Life tables, failure rate, mean residual life and their elementary properties. Ageing classes and their properties. Estimation of survival function, Actuarial Estimator, Kaplan- Meier Estimator. Estimation under the assumption of IFR/DFR.

UNIT - V

Two sample problem-Gehan test, Log rank test. Semi-parametric regression : Cox proportional hazards model with one and several covariates. Rank test for the regression coefficients. Competing risks model, parametric and non-parametric inference for this model.

TEXT BOOKS

1. Barlow R.E. and Proschan F. (1985) Statistical Theory of Reliability and Life Testing, To Begin with, Silver Spring.
2. Miller, R.G. (1981) Survival analysis, Wiley, New York.
3. Cox, D.R. and Oakes. D (1984) Analysis of Survival Data, Chapman & Hall, New York.

REFERENCE BOOKS

1. Lawless J.F. (1982) Statistical Models and Methods of Life Time Data, Wiley, New York.
2. Bain L.J. and Engelhardt, M. (1991) Statistical Analysis of Reliability and Life Testing Models, Marcel Dekker, New York.
3. Nelson, W. (1982) Applied Life Data Analysis, Wiley, New York.
4. Zacks, S. (1995) Reliability Analysis, Springer, New York.
5. Gross, A.J. and Clark, V.A. (1975) Survival distribution: Reliability applications in the Biomedical Sciences, Wiley, New Delhi.
6. Kalbfleisch, J.D. and Prentice, R.L. (1980) The Statistical Analysis of Failure Time Data, Wiley, New York.
7. Lawless, J.F. (1982) Statistical Models and Methods of Life Time Data, Wiley, New York.

WEB RESOURCES

1. <https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.639.9909&rep=rep1&type=pdf>
2. <https://www.mdpi.com/2504-4990/1/3/58/pdf>

3. <https://web.stanford.edu/~lutian/coursepdf/unit1.pdf>

COURSE OUTCOMES

On the successful completion of the course, student will be able to:

S.NO.	COURSE OUTCOME	BLOOMS VERB
CO1	Learn the concept of reliability and its various measures.	Remember, Understand
CO2	Find failure rate, identify failure rate distributions.	Understand, Apply, Evaluate
CO3	Compute reliability of components and systems.	Apply, Evaluate
CO4	Learn the application of statistics in handling survival data.	Understand, Apply, Analyze
CO5	Learn the censoring scheme and likelihood function and its estimation. - Non-parametric estimation in lifetime data.	Understand, Apply, Analyze

MAPPING WITH PROGRAM OUTCOMES

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	M	M	M	M	M	M	S	S
CO2	M	S	M	S	S	M	M	M	S	M
CO3	S	S	M	M	S	M	S	M	S	S
CO4	S	M	S	M	S	M	M	M	S	S
CO5	S	S	S	M	M	S	M	S	M	M

* S-Strong; M-Medium; L-Low

Semester- II

21RAC02	Research Acumen Course II : Research Writing
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OBJECTIVES

1. Introduce students to the discipline of Research Writing and its specific purposes.
2. Educate students in the basics of research writing.
3. Provide students with the critical faculties necessary in an academic environment and in an increasingly complex, interdependent world.

COURSE LEARNING OUTCOMES

1. **Generic:** The learner is required to have a basic understanding of research
2. **Adaptive:** Assist students in the development of intellectual flexibility, creativity, and research ethics so that they may engage in life-long learning.

LEARNING OUTCOME

Students should achieve mastery of the topics listed below.

1. Exposure to varied approaches to research.
2. The student gets a fair understanding of the politics of human interactions and to work for a peaceful co-existence of all living beings in the world.
3. The student gets an analytical skill in taking up research.
4. The student understands the different tools of research.
5. The student gets a clear understanding of the format of research paper.

SYLLABUS

UNIT-I

Basics of Research Writing : Research and its Characteristics -The Purpose of Research - proper placement of elements in a sentence - Structuring the paragraph - breaking up long sentence - word choice - proper use of punctuation - Avoiding Ambiguity, Repetition, and Vague Language.

UNIT-II

Steps Involved in Research : Topic of Research - Data Collection – Primary Source and Secondary Sources - Topic selection – narrowing the topic through (peer discussion, online forum, library, electronic data base, periodicals).

UNIT – III

Research Writing Styles : Basic components of a research paper – Abstract- introduction, body, conclusion and references - Pagination - Margin - Fonts - Spacing – Spelling - Punctuation - Documentation Styles (MLA Style, APA Style and CMS Style)

UNIT-IV

Dissertation Writing : Comparison between term paper and dissertation - Title - Cover Page – Declaration – Certificate – Acknowledgement – Contents - Introduction - Statement of Problem – Methodology - Review of Literature - Main Body - Conclusion - Bibliography -Works Cited – References

UNIT-V

Research Proposal Writing : Types of funding agencies in India – proposal writing (summary of research, background literature, research question, research methodology, anticipatory problems and limitations, significance of research, ethical considerations, resources required, budget cost, references)

Definition of plagiarism – UGC regulation for plagiarism – plagiarism detection programs – plagiarism free writing.

REFERENCEBOOKS

1. Adrian Wallwork, “English for Writing Research Papers”, Second Edition, Italy, Springer(2016).
2. Laurie Rozakis, “Schaum’s Quick Guide to Writing Great Research Papers”, Second Edition, India, McGraw-Hill (2007).
3. James D. Lester • James D. Lester, Jr. “Writing Research Papers-A Complete Guide” Fifteenth edition, New Delhi, Pearson (2015).

4. Jennifer Peat, Elizabeth Elliott, Louise Baur, Victoria Keena, “Scientific Writing Easy when you know how”, BMJ Books, London (2002).
5. Jean-luclebrun, “Scientific Writing; A Reader and writer’s guide”, Singapore, World Scientific Publishing Co. Private Ltd (2007).

6. Brian Paltridge and Sue Starfield , “Thesis and Dissertation Writing in a Second Language”, USA, Routledge (2007).
7. Subhash Chandra Parija, Vikram Kate, “Thesis Writing for Master's and Ph.D. Program”, Singapore, Springer (2018)

ADDITIONAL WEB RESOURCES

1. <https://www.casemine.com/>
2. <http://www.legalservicesindia.com/article/284/Plagiarism.html>
3. R. Saha ,”Plagiarism, research publications and law”, Current Science, VOL. 112, NO. 12, 25 JUNE 2017. <https://www.currentscience.ac.in/Volumes/112/12/2375.pdf>
4. <https://virtualwritingtutor.com/>

SEMESTER- III

21PST07	Core Course- VII : Statistical Estimation Theory
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OBJECTIVE

The main objectives of this course are to:

1. To know the basic concepts of estimation techniques, its types and properties.
2. To apply the concepts in real life problems.
3. To study various methods for Construction of Confidence intervals.

SYLLABUS

UNIT – I

Point Estimation - Criteria of Point Estimation: Consistency estimation of real valued parameters, Invariance of consistent estimator- Unbiasedness - Sufficiency -Neyman Factorizability criterion- Exponential family of distributions-Distribution admitting sufficient statistics.

UNIT – II

Completeness, bounded completeness -Minimal sufficient statistic, Method of constructing minimal sufficient statistics -Uniformly Minimum Variance Unbiased Estimators, Inequality approach to UMVUE, Rao-Blackwell Theorem, Lehman-Scheffe Theorem.

UNIT – III

Fisher measure of Information, Cramer -Rao Inequality, Different forms of Cramer-Rao Inequality, Chapman-Robbin bound, Efficiency of an estimator, Extension of Cramer -Rao Inequality, Bhattacharya Bound.

UNIT – IV

Methods of Point estimation- Method of Maximum Likelihood Estimation, Cramer and Huzur bazar Theorems, Solution of likelihood equations, method of Scoring, method of minimum variance, method of moment, method of minimum Chi-square estimation and method of least square.

UNIT-V

Interval Estimation-confidence level, A general method of constructing confidence intervals, Construction of shortest average width confidence intervals, Construction of confidence intervals with large and small samples, Construction of the most accurate confidence intervals.

TEXT BOOKS

1. Lehman, E.L (1986), Theory of Point Estimation, John Wiley and sons.
2. Rao, C. R (1973), Linear statistical inference and its applications, 2nd Edition, Wiley Eastern, New Delhi.
3. Raja gopalan.M, Dhanavanthan.P(2012), statistical Inference, PHI Learning Pvt Ltd, New Delhi.

REFERENCE BOOKS

1. Kale, B.K (2005), A First course on parametric Inference, Narosa Publishing House, Second edition, New Delhi.
2. Rohatgi, V.K. (1988), An Introduction to Probability and mathematical statistics, Wiley Eastern Ltd, New Delhi.
3. Jean Dickinson Gibbons (1985), Non- Parametric Statistical Inference(2nd), Marcel Dekkar,Inc,New York.

<https://youtu.be/L-dYNx63v54>

<https://youtu.be/k-eh0bnc-j0>

www.statistical estimation theory.com

www.statsoft.com

On successful completion of the course, students will be able to

S. NO.	COURSE OUTCOME	BLOOMS VERB
CO1	Understand the knowledge of MLE, minimum variance, Unbiased estimation etc.	Remember to Apply
CO2	Compare the estimators and find out the properties of estimator such as unbiasedness, efficiency, sufficiency etc.	Remember to Evaluate
CO3	Apply the lower bound such as Cramer Rao bound to probability distributions.	Analyze , Evaluate
CO4	Apply estimation methods to real life problems.	Analyze to Create
CO5	Construct confidence Intervals for population parameters.	Understand, Create

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	S	L	S	S	S	M	S
CO2	S	S	M	S	L	S	S	S	M	S
CO3	S	S	M	S	L	S	S	S	M	S
CO4	S	S	M	S	S	S	S	S	M	S
CO5	S	S	M	S	S	S	S	S	M	S

S- Strong; M-Medium; L-Low

SEMESTER- III

21PST08	Core Course – VIII : Demography
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The main objectives of this course are to:

1. Learn the core idea of Demographic data.
2. Acquire the knowledge of Mortality and Fertility Rate in India.

3.

Unders

tand the components of population growth, projection and Migration.

UNIT I

Development and scope of demography - Demographic data: sources and current status - Chandrashekar-Deming index - Adjustment of age data – use of Whipple – Myer and UN indices - Population size and growth in India - Trends and differentials in world population – Health Surveys and use of hospital statistics.

UNIT II

Mortality - Measurements of Mortality: Crude Death Rate (CDR), Specific Death Rate (SDR), Infant Mortality Rate (IMR) and Standardized Death Rates - Direct and Indirect method of Standardization. Life table - construction, use and interpretation - force of mortality - abridged life tables.

UNIT III

Fertility -Basic measurements - Gross and Net Reproduction rate - Cohort fertility analysis - Fertility models - Population regulation programs in India - Demographic transition theory.

UNIT IV

Special distribution of population - basic concepts - measurements and models of migration - concept of international migration - Urban development components of urban and metropolitan growth - Urbanization in developed and developing countries - Stable and quasi populations- Intrinsic growth rate.

UNIT - V

Components of population growth and change – Models of population growth and their fitting to population data - Methods of projection - Logistic equation - component method of projection - stable population theory – Decennial population census in India – Nuptiality and its measurements.

1. Goon, A. M., Gupta, M. K., and Dasgupta, B. (2008). *Fundamentals of Statistics, Vol. II*, Ninth Edition, World Press, India.
2. Gupta, S. C., and Kapoor, V. K. (2016). *Fundamentals of Applied Statistics*, Sultan Chand & Sons Private Limited, New Delhi.
3. Kumar, R. (1986) *Technical Demography*. Wiley Eastern, New Delhi.

1. Benjamin, B. (1975) *Demographic Analysis*, George Allen and Unwin, London.
2. Cox, D.R. (1978) *Demography*, Cambridge University Press, Cambridge.
3. Gibbs, J.P. (2012) *Urban Research Methods*. Literary Licensing, LLC, White Fish, USA.
4. Keyfliz, N. and Caswell, H. (2006). *Applied Mathematical Demography*. Springer, New York.
5. Misra, B.D. (1982). *An Introduction to the Study of Population*. South East Asia Publishers, Madras.

1. <https://nptel.ac.in/courses/109/104/109104045/>
2. https://swayam.gov.in/nd1_noc19_hs39/preview
3. <https://nptel.ac.in/courses/109/104/109104150/>

On successful completion of the course, students will be able to

S. NO.	COURSE OUTCOME	BLOOMS VERB
CO1	Learn the basics of demographic data.	Understand, Analyze
CO2	Provide the basic knowledge in Measurements of Population.	Understand, Apply
CO3	Explore the importance of fertility measures	Remember, Analyze
CO4	Analyze the concepts of Migration and its importance.	Apply, Evaluate
CO5	Understand the core idea of population projection and their estimation.	Remember, Understand, Apply, Analyze, Evaluate, Create

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	M	L	S	M	S	M	L	L
CO2	S	M	M	M	S	M	S	M	M	M
CO3	S	M	M	M	S	M	S	M	M	M
CO4	S	M	M	L	S	M	S	M	L	L
CO5	S	M	M	L	S	M	S	M	L	L

S- Strong; M-Medium; L-Low

SEMESTER - III

21PST09	Core Course - IX : Stochastic Processes
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The main objectives of this course are to:

1. To understand the fundamental ideology in the analysis of stochastic process.
2. To understand and apply the concept of Stationary Process.
3. To understand the applications of Markov processes.
4. To understand the applications of Renewal Process.
5. To understand the analysis of Branching process.

UNIT - I :

Markov chains -Classification of states and chains - Higher transition probabilities and its limiting behavior -Chapman Kolmogorov's equations - Stationary distribution .

UNIT - II :

Continuous time Markov processes - Poisson processes - Birth and death processes - Kolmogorov Feller differential equations of birth and death processes - Applications to queueing problems.

UNIT - III :

Stationary processes - Weakly stationary and strongly stationary processes - Properties of auto covariance and auto correlation functions - Autoregressive and Moving average processes - Spectral density function - Spectral representation of moving average processes.

UNIT - IV :

Renewal theory - Renewal equation - Stopping time - Wald's equation - Elementary renewal theorem and its applications - Markov renewal and Semi Markov processes.

UNIT - V :

Branching processes - properties of generating functions of Branching processes - Probability of ultimate extinction - Limit theorems for continuous time branching process - Martingales in discrete time –Super martingales and sub martingales, Martingale convergence theorem and its applications

1. Medhi, J. (2017). Stochastic Processes, Fourth Edition, New Age International (P) Ltd. New Delhi.
2. Karlin, S. and Taylor, H.M. (1975): A First Course in Stochastic Processes, Vol. I. Academic Press, New York.

1. Papoulis, A. and Pillai, U.S. (2006). Probability, Random Variables and Stochastic Processes, 4/e, Tata McGraw-Hill, New Delhi.
2. Bhat, B. R. (2000). Stochastic Models: Analysis and Applications, New Age International Private Ltd.
3. Box, G.E.P., and Jenkins, G.M., (1976). Time Series Analysis - Forecasting and Control. Holden-Day San Francisco.

1. <https://www.youtube.com/watch?v=TuTmC8aOQJE&t=8s>
2. [www.wikipedia.org/markov chain.html](http://www.wikipedia.org/markov_chain.html)
3. [www.wikipedia.org/ergodic theory.html](http://www.wikipedia.org/ergodic_theory.html)
4. [www.wikipedia.org/stochastic process.html](http://www.wikipedia.org/stochastic_process.html)

On successful completion of the course, students will be able to

S. NO.	COURSE OUTCOME	BLOOMS VERB
CO1	Understand and apply Markovian concept in real time decision making.	Apply
CO2	Adopt Birth-Death process to queueing situation.	Apply
CO3	Apply Time series models to real time problems.	Analyze
CO4	Apply the concept of Renewal theory.	Evaluate
CO5	Apply the concepts of Branching process	Evaluate

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	L	S	S	S	S	S	S
CO2	S	S	S	L	S	S	S	S	M	S
CO3	S	S	S	L	S	S	S	S	S	S
CO4	S	S	S	L	S	S	S	S	M	S
CO5	S	S	S	L	S	S	S	S	S	S

S- Strong; M-Medium; L-Low

SEMESTER - III

21PCMST	Interdisciplinary Course : Data Analysis using Excel
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1. Design and format effective spreadsheets.
2. Create and revise formulas, using functions.
3. Know the significance of data in the form of tables and diagrams using spreadsheets.
4. Learn computational aspects of basic statistical measures/methods.

UNIT - I

Worksheet Design: Building worksheets, Formatting worksheets and Enhancing a Worksheet. Moving Data within and between Workbooks, Usage of different views in Workbooks. Importing, Exporting, and Distributing Data. Summarizing and Consolidating Data.

UNIT - II

Sorting, filtering, freeze panes of data. Alignments and formatting cell data. Use of pivot tables with categorical and numerical data.

Financial functions: ACCRINT, DB, DISC, EFFECT and NPV.

UNIT - III

Charting techniques in Excel: Line, bar and pie charts, Scatter plots and Histogram, Labeling the charts.

UNIT - IV

Statistical functions: Count, Min, Max and Rank. Measures of central tendency: Arithmetic mean. Measures of dispersion: Standard Deviation.

UNIT - V

Finding bivariate statistical measures: Correlation and regression. Testing of significance using statistical functions Z-test, Student 't'-test, Chi-square test and F-test.

1. Curtis D. Frye, Microsoft step by step – Excel 2013, Practice files plus book.
2. Stewart Nordell (2019). 'Microsoft Excel 365 Complete: In Practice', McGraw Hill Ltd.

1. Benchmark Series: Microsoft Excel 2016 Levels 1 and 2 with SNAP and eBook.
2. Curtis D. Frye, Microsoft step by step – Excel 2016, Microsoft press.

1. <https://www.microsoft.com/en-us/microsoft-365/excel>
2. <https://docs.microsoft.com/en-us/office365/servicedescriptions/office-online-service-description/excel-online>

On successful completion of the course, students will be able to

S. No.	Course Outcome	Blooms Verb
CO1	Define terminology related to spreadsheet applications.	Remember, Understand
CO2	Find and replace cell data and formats.	Understand , Apply
CO3	Use appropriate plots, Charts and diagrams for all kinds of statistical data.	Understand , Apply, Analyze
CO4	Create and revise formulas, using functions.	Understand , Apply, Analyze
CO5	Analyze the data and interpret the results for statistical methods.	Understand , Apply, Analyze

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	M	M	M	M	M	S	S
CO2	M	S	M	S	S	S	S	S	M	M

CO3	S	S	M	M	S	S	S	M	M	S
CO4	S	M	S	M	S	M	M	S	S	S
CO5	S	S	S	S	M	S	M	M	S	S

*S- Strong; M-Medium; L-Low

SEMESTER –IV

21PST10	Core Course -X : Testing of Hypothesis
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OBJECTIVE:

The main objectives of this course are to:

1. Know the principle and concepts of hypothesis testing.

2. Understand Neyman-Pearson fundamental lemma for testing statistical hypothesis.
3. Understand the MP Test , UMP Test and LR Test.
4. Understand the sequential test procedure and SPRT.
5. Know to apply Non-parametric tests.

SYLLABUS:

UNIT – I

Randomized and non-randomized tests. Neyman – Pearson fundamental lemma, Most Powerful test, Uniformly most powerful test, Uniformly most powerful test for distributions with monotone likelihood ratio, Generalization of fundamental lemma (statement only)

UNIT - II

Unbiasedness for hypothesis testing, Uniformly Most Powerful Unbiased Tests, UMP Unbiased tests for one-parameter exponential family, Similar regions and complete sufficient statistic, Tests with Neyman Structure, Uniformly most powerful similar tests.

UNIT - III

Invariant tests – maximal invariant statistic, uniformly most powerful invariant tests. Likelihood Ratio tests, Consistent tests. Asymptotic properties of likelihood ratio tests.

UNIT - IV

Sequential test –Sequential Probability Ratio Test (SPRT). OC and ASN functions of SPRT and their derivation. Optimum properties of SPRT.

UNIT - V

One sample non-parametric tests – Kolmogorov–Smirnov test, Sign test, Wilcoxon’s Signed Rank test, Test for randomness. Two-sample non-parametric tests – Kolmogorov-Smirnov test, Wald-Wolfowitz runs test, Mann-Whitney U test, Median test. Kruskal-Wallis Test and Friedman’s test.

TEXT BOOKS:

- 1.Srivastava, M. K. and Srivastava,N. (2009) Statistical Inference: Testing of Hypotheses, PHI Learning, New Delhi.
- 2.Rohatgi, V.K. and Saleh, A.K.MD.E. (2011) An Introduction to Probability and Statistics, Wiley, New York.
- 3.Rao, C.R. (1998) Linear Statistical Inference and its applications, Wiley Eastern, New

Delhi.

4. Gibbons, J. D., and Chakraborti, S. (2010). Nonparametric Statistical Inference (Fifth Edition). Taylor & Francis, New York.

BOOKS FOR REFERENCE:

1. Lehmann E.L. and Casella, G. (1998) Testing statistical hypotheses, 2/e, Springer, New York.
2. Casella, G. and Berger, R.L. (2002). Statistical Inference (Second Edition). Thompson Learning, New York. (Reprint, 2007).
3. Rajagopalan, M. and Dhanavanthan, P. (2012). Statistical Inference. PHI Learning Pvt. Ltd., New Delhi.
4. Conover, W. J. (1999). Practical Nonparametric Statistics (Third Edition). John Wiley & Sons, New York. (Reprint, 2007).
5. Goon, A.M., Gupta, M. K., and Dasgupta, B. (1989). An Outline of Statistical Theory, Vol. II, World Press, Kolkata.
6. Kale, B. K. (2005). A First Course in Parametric Inference (Second Edition). Narosa Publishing House, New Delhi. (Reprint, 2007).
7. Mukhopadhyay, P. (2002), Mathematical Statistics, Book and Allied Publishers, New Delhi.
8. Wald, A. (1982). Sequential Analysis, John Wiley & Sons, New York.

WEB RESOURCES:

<https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=34>

<https://nptel.ac.in/courses/103/106/103106120/>

Introduction to Statistical Hypothesis Testing – IIT Madras

www.statsoft.com

www.en.wikipedia.org

COURSE OUTCOMES:

On the successful completion of the course, student will be able to:

S.NO.	COURSE OUTCOME	BLOOMS VERB
CO1	Determine the size of critical region and power of test function.	Apply, Evaluate
CO2	Apply the NP lemma to real life problem solving.	Apply, Evaluate
CO3	Apply a sequential procedure for a specified stopping rule and	Understand,

	the decision rule.	Apply, Evaluate
CO4	Apply the likelihood ratio test to the hypothesis of real life situations.	Apply, Evaluate
CO5	Test statistical hypothesis by selecting suitable test procedure.	Apply, Analyze, Evaluate

MAPPING WITH PROGRAMME OUTCOMES

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	M	S	M	S	S	M	M
CO2	S	S	S	M	S	M	S	S	M	M
CO3	S	M	M	M	S	M	S	S	M	M
CO4	S	S	M	M	S	M	S	S	M	M
CO5	S	S	M	M	S	M	S	S	M	M

* S-Strong; M-Medium; L-Low

SEMESTER - IV

21PST11	Core Course XI : Statistical Quality Control
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1. To understand the meaning of Quality improvement.
2. Understand the application of statistics in industrial environment.
3. To study the methods of finding smaller shifts in the data.

UNIT – I

Quality Improvement in the modern business Environment. The meaning of quality improvement. The

link between quality improvement and productivity. Quality cost: prevention cost, Appraisal cost, Internal failure cost, External failure cost, Methods of quality improvement. Total quality management (Basic concepts only).

UNIT – II

Acceptance sampling - lot formation – sampling inspection by attributes – single sampling plans – OC function – rectifying inspection - Double and multiple sampling plans – OC, ASN, ATI and AOQ functions - Use of Dodge – Roming and other tables of plans. AQL, LTPD, producer's risk and consumer's risk on OC curve - operation and use of single, double and multiple sampling plans.

UNIT – III

Sampling inspection by variables - known and unknown sigma variables sampling plan - merits and demerits of variables sampling plan - derivation of OC curve and the parameters of the plan.

UNIT – IV

Continuous sampling plans by attributes - CSP-1 and its modifications - concept of AOQL in CSPs - Multi-level continuous sampling plans - Operation of multi-level CSP of Lieberman and Solomon - Wald-Wolfowitz continuous sampling plans - Sequential Sampling Plans by attributes - OC and ASN functions.

UNIT - V

Statistical Process Control (SPC): Causes of quality variation - Control charts for variables and attributes - Rational subgroups - Construction and operation of \bar{x} , R, σ , p, np, c and u charts, Exponentially Weighted Moving Average (EWMA). CUSUM control chart - Two sided and one sided procedures - V mask Technique - Tabular CUSUM and decision interval. Process capability analysis, Process capability ratios - use and their interpretations.

1. Duncan, A.J (1986), “Quality control and Industrial statistics”, 5th Edition, Mc.Graw, Richard Irwin, Inc.
2. Grant, E.L. and Leavenworth, R.S. (2000) Statistical Quality Control, 7/e, Tata McGraw Hill, New Delhi.
3. Juran, J.M. and De Feo, J.A. (2010) Juran’s Quality control Handbook – The Complete Guide to Performance Excellence, 6/e, Tata McGraw-Hill, New Delhi.
4. Lawless, J.F. (1972) Statistical models and methods of Lifetime Data, Wiley, New York.
5. John T. Burr, (2004) Elementary Statistical Quality Control (Second Edition), Marcel Dekker New York.

1. Mahajan, M. (2002) Statistical Quality Control,3/e, DhanpatRai and Co., Delhi.
2. Montgomery, D.C (2009), Introduction to statistical quality control, John Wiley & Sons.

1. www.iso90002000.com, www.statsoft.com
2. http://bmepedia.weebly.com/uploads/2/6/6/8/26683759/unit_4_quality_control.pdf
3. <https://nptel.ac.in/courses/116/102/116102019/>

On successful completion of the course, students will be able to

S. No.	Course Outcome	Blooms Verb
CO1	Construct control charts for large and smaller shifts in the process Parameters	Remember, Understand
CO2	Effectively interpret the results from the control charts	Understand , Apply
CO3	Carry out process capability analysis	Understand , Apply
CO4	Adopt appropriate sampling inspection plans for given conditions	Remember , Apply
CO5	Compute control charts of components and systems	Understand , Apply, Analyze

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	S	S	M	M	S	S	M
CO2	S	S	M	M	S	M	S	S	M	M
CO3	M	M	S	S	M	S	S	M	M	S
CO4	S	M	M	M	S	M	S	S	S	M
CO5	S	M	S	S	S	S	S	S	M	M

*S- Strong; M-Medium; L-Low

SEMESTER - IV

21PST12	Core Course – XII: Operations Research
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The main objectives of this course are to:

1. To impart the applications of operations research in various fields.
2. To understand the methods of analysing Inventory problems.
3. To acquire knowledge in various techniques of network planning.

UNIT – I

Review of LPP: Simplex algorithm – Artificial variable technique. - Big - M Method and Two-phase method. Duality in LPP – Formulation of Dual LPP – Primal – Dual relationship – Solving LPP using dual concepts – Dual simplex method.

UNIT – II

Integer programming problem (IPP)– Pure and Mixed integer programming problems – Gomory’s Cutting plane algorithm – Branch and Bound techniques. Dynamic Programming Problem (DPP) - Principles of Optimality- Characteristics of DPP-Recursive equation Approach.

UNIT – III

Non-linear programming problem (NLPP) – Constrained optimization problems- Kuhn-Tucker conditions– Quadratic programming: Wolfe’s and Beale’s algorithms.

UNIT – IV

Inventory models – Structure of Inventory system – General deterministic problem for one item, one level – Inventory models with and without shortage – Multi item deterministic problem – one level model with one break.

UNIT – V

Queuing theory – Basic characteristics of queuing models – Arrival and service distribution – Steady state solution of M/M/1 and M/M/C and waiting time distribution of M/M/1 and M/M/C models. Network scheduling by PERT/CPM: Determination of flows and critical path.

1. Gass, S.I. (1985) Linear Programming, Methods and Applications. Courier Dover, New York.
2. Gupta, P.K. and Man Mohan. (1979) Operations Research: Linear Programming and Theory of Games, Sultan Chand & Sons, New Delhi.
3. Hillier, F.S. and Lieberman, G.J. (2005) Introduction to Operations Research, 9/e, McGraw Hill, New York.
4. Sharma, J.K. (2013) Operations Research: Problems and Solutions, Macmillan India, New Delhi.

1. Sharma, S.D. (2010) Operations Research, Kedarnath Ramnath, Meerut.
2. Swarup, K. Mohan, M. and Gupta, P.K. (2001) Operations Research, Sultan Chand & Sons, New Delhi.
3. Taha, H.A. (2011) Operations Research- An Introduction. Prentice Hall, New Delhi.
4. Rao S.S. (1972), Optimization: Theory and Applications, Wiley Eastern (P) Ltd., New Delhi.

2. <https://youtu.be/vUMGvpsb8dc>

3. <https://youtu.be/y7rEGCsymzs>

4. www.iso90002000.com

5. www.statsoft.com

On successful completion of the course, students will be able to

S. NO.	COURSE OUTCOME	BLOOMS VERB
CO1	Understand the knowledge of LPP, Duality in LPP and Dual Simplex method	Understand, Apply
CO2	Apply the concept of IPP and solve the IPP	Remember to Evaluate
CO3	Construct and evaluate the Non- linear programming problem	Evaluate
CO4	Design and develop inventory problem	Create
CO5	Apply PERT and CPM techniques in research and construction projects.	Apply to Create

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
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CO1	S	S	M	S	L	S	S	S	M	S
CO2	S	S	M	S	L	S	S	S	M	S
CO3	S	S	M	S	L	S	S	S	M	S
CO4	S	S	M	S	S	S	S	S	M	S
CO5	S	S	M	S	S	S	S	S	M	S

S- Strong; M-Medium; L-Low

SEMESTER III & IV

21PSTP3	Core Practical – III : Estimation Theory, Testing of Statistical Hypothesis (Calculator Based)
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The main objectives of this course are to:

1. To know principle of Estimation theory, testing of statistical hypothesis, Sequential Probability Ratio Test (SPRT) and Non-parametric test.
2. To understand the method of constructing Multivariate control Charts.
3. To Solve the Integer Programming Problem

ESTIMATION THEORY

UNIT - I

POINT ESTIMATION

1. UMVUE of one parameter exponential family of distributions
2. Method of maximum likelihood estimation
3. Method of moments
4. Method of minimum chi-square

UNIT - II

INTERVAL ESTIMATION

1. Interval estimation based on Normal distribution
2. Interval estimation based on Student 't' distribution
3. Interval estimation based on Chi-square distribution

4. Interval estimation based on F distribution

TESTING OF STATISTICAL HYPOTHESIS

UNIT – III

PARAMETRIC TEST

1. Most Powerful Test
2. Uniformly Most Powerful Test (one sided)
3. Uniformly Most Powerful Test (two sided)

UNIT - IV

SEQUENTIAL PROBABILITY RATIO TEST (SPRT) and NON PARAMETRIC TEST

1. SPRT - Bernoulli distribution
2. SPRT - Normal distribution
3. SPRT - Exponential distribution
4. Kolmogorov Smirnov test
5. Wilcoxon signed - rank test

UNIT - V

(STATISTICAL QUALITY CONTROL AND OPERATIONS RESEARCH)

1. CUSUM Chart
2. EWMA Chart
3. Integer Programming: Cutting Plane Algorithm.
4. Quadratic Programming: Wolfe's Modified Simplex method.

Note: One question from Estimation Theory and two questions from Testing of Statistical Hypothesis, SQC and OR with internal choice. Student must answer all the questions.

1. Datta, K.B (1991), Matrix and Linear Algebra, Prentice Hall of India Pvt Ltd., New Delhi
2. Anderson, T.W (1983), Introduction to Multivariate Statistical Analysis, 2nd edition, John Wiley and sons, Inc., publications, New Delhi.
3. Johnson and Wichern (1996), Applied multivariate statistical analysis, 3rd edition, PHI, Pvt., Ltd, India.

1. Rao, A,R and P. Bhima Shankaran,(1992), Linear Algebra, Tata McGraw Hill Book Publishing company, New York.

2. Giri, N.C (1977), Multivariate statistical inference, Academic press.
3. Morrison, Donald. F (1978), Multivariate Statistical methods, 2nd edition, Tata McGraw Hill International, New York

1. <https://nptel.ac.in/courses/111/102/111102112/>
2. [.http://www.nptelvideos.in/2012/12/applied-multivariate-analysis.html](http://www.nptelvideos.in/2012/12/applied-multivariate-analysis.html)

On successful completion of the course, students will be able to

S. NO.	COURSE OUTCOME	BLOOMS VERB
CO1	Solve the Problems based on Point Estimation	Understand,Apply
CO2	Solve the Problems based on Interval Estimation	Apply, Analyze, Evaluate
CO3	Draw Power Curve and ASN Curve with the help of SPRT	Analyze,Evaluate
CO4	Draw CUSUM Chart and EWMA Chart	Analyze,Evaluate
CO5	To solve IPP and QPP	Analyze,Evaluate

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
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CO1	S	S	L	S	S	S	S	S	M	S
CO2	S	S	L	S	S	S	S	S	M	S
CO3	S	S	L	S	S	S	S	S	M	S
CO4	S	S	L	S	S	S	S	S	M	S
CO5	S	S	L	S	S	S	S	S	M	S

S- Strong; M-Medium; L-Low S

SEMESTER-III & IV

21PSTP4	Core Practical - IV: Statistical Software Practical using R (Computer Based)
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1. Perform basic operations and functions in R Programming
2. Execute code for statistical methods using build-in functions
3. Write customized program for mathematical and statistical problems

UNIT – I

Operations on vectors and matrices, Creating and manipulating data frames. Charts, Plots, Diagrams and Graphs, Descriptive Statistics, Correlation coefficient – Pearson’s, Spearman and Kendall’s Tau. Fitting simple linear regression.

UNIT – II

Student ‘t’ test, Paired t- test and independent t- test, F- test, Chi- Square test, One way and two way ANOVA.

UNIT – III

Mann Whitney ‘u’ test, Kruskal wallis test, Kolmogorov Smirnov test, Spearman’s rank Correlation and Chi square test.

UNIT – IV

X-bar chart and R – chart, X-bar chart and S – Chart, c Chart, p Chart, np Chart, u chart, Drawing OC curves for Single and Double Sampling Plans for Attributes.

UNIT - V

Principal component Analysis, Factor Analysis, Cluster Analysis and Discriminant Analysis.

1. Purohit, S. G., Gore, S. D., and Deshmukh, S. R. (2009). Statistics Using R, Narosa Publishing House, New Delhi.
 2. Dalgaard, P. (2008). Introductory Statistics with R, Second Edition, Springer
 3. Crawley, M, J. (2007). The R Book, John Wiley and Sons Private Ltd., NY.
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1. De Vries, A., and Meys, J. (2016). R For Dummies, Second Edition, John Wiley & Sons Private Ltd, NY.
 2. Quick, J. M. (2010). Statistical Analysis with R, Packt Publishing Ltd., UK.
 3. Everitt, B. S., and Hothorn, T. (2010). A Handbook of Statistical Analyses Using R, Second Edition, Chapman and Hall/CRC Press.
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1. https://swayam.gov.in/nd1_noc19_ma33/preview
 2. https://swayam.gov.in/nd2_aic20_sp35/preview
 3. <https://nptel.ac.in/courses/111/104/111104100/>

On successful completion of the course, students will be able to

S. No.	Course Outcome	Blooms Verb
CO1	Use appropriate plots, Charts and diagrams for all kinds of statistical data.	Remember, Understand
CO2	Define terminology related to R language.	Understand , Apply
CO3	Create and revise formulas, using functions.	Understand , Apply, Analyze

CO4	Analyze the data and interpret the results for statistical methods.	Understand , Apply, Analyze
CO5	Find and revise multivariate functions in R language.	Understand , Apply, Analyze

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	M	M	M	S	M	S	M
CO2	S	M	M	S	S	S	S	S	M	M
CO3	S	S	S	S	M	S	M	S	S	S
CO4	S	M	S	M	M	S	S	S	S	S
CO5	S	M	S	S	M	S	M	M	M	M

*S- Strong; M-Medium; L-Low

Semester- IV

21RAC03	Research Acumen Course III : Research and Publication Ethics
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1. To provide the students with the fundamental knowledge of basics of philosophy of science and ethics, research integrity, publication ethics.
2. To expose the students to Indexing and citation databases, open access publications, research metrics (citations, h-index, Impact Factor).
3. To create awareness about plagiarism, and plagiarism tools for a valid and ethical research report.

Students will be able to:

1. Understand the scientific philosophy and publication ethics.
2. Know plagiarism and misconduct.
3. Learn about publication of research findings and publication sources.
4. Aware about various scientific databases and altmetrics.

UNIT-I

Philosophy and ethics

Introduction to philosophy: definition, nature and scope, concept, branches. Ethics: definition, moral philosophy, nature of moral judgements and relations.

UNIT-II

Research conduct

Ethics with respect to science and research - Intellectual honest and research integrity - Scientific misconducts: falsification, fabrication, and plagiarism. Redundant publications: duplicate and overlapping publications.

UNIT – III

Publication ethics and misconduct

Publication ethics: Definition, introduction and importance - UGC-CARE - Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types - Violation of publication ethics, authorship and contributorship - Identification of publication misconduct, complaints and appeals.

UNIT-IV

Open access publishing and search tools

Open access publications and initiatives - SHERPA/RoMEO online resources to check publisher copyright and self-archiving policies. Journal finder/ journal suggestion tools - Tools/software for plagiarism detection - Turnitin, Urkund and other open source software tools.

UNIT-V

Databases and research metrics

Databases - Indexing databases; Citation databases - Research Metrics - Impact Factor of journal as per journal citation report (JCR), SNIP, SJR, IPP, Cite Score. Metrics: *h*-index, *g*-index, *i10*-index, altmetrics.

1. Bird, A. (2006). *Philosophy of Science*. Routledge Imprint.
2. Chaddah, P. (2018). *Ethics in Competitive Research: Do not get scooped; do not get plagiarized*. ISBN: 9787-9387480865.
3. Cvetkovic, V. B. and Anderson, K. E. (2010). *Stop Plagiarism: New Resources for Understanding and Prevention*. Neal-Schuman Publishers Inc.
4. Darr, T. (2019). *Combating Plagiarism: A Hands-On Guide for Librarians, Teachers, and Student*. Libraries Unlimited Inc.
5. Lipson, C. (2004). *Doing Honest Work in College – How to Prepare Citations, Avoid Plagiarism and Achieve Real Academic Success (Chicago Guides to Writing, Editing, and Publishing)*. University of Chicago Press.
6. Lipson, C. (2018). *Cite Right, Third Edition – A Quick Guide to Citation Styles--MLA, APA, Chicago, the Sciences, Professions, and More (Chicago Guides to Writing, Editing, and Publishing)*. University of Chicago Press.

7. MacIntyre, A. (1998). *A Short History of Ethics: A History of Moral Philosophy from the Homeric Age to the Twentieth Century*, Second Edition. 1998. University of Notre-Dame Publication.
8. Muralidhar, K., AmitGhosh, and Singhvi, A. K. (Eds.) (2019). *Ethics in Science Education, Research and Governance*. Indian National Science Academy, New Delhi, India. https://www.insaindia.res.in/pdf/Ethics_Book.pdf
9. National Academy of Sciences; National Academy of Engineering (2009). *A Guide to Responsible Conduct in Research: Third Edition*. ISBN: 978-0-309-11970-2; Ebook: 978-0-309-14135-2
10. Parsons, H. L. (1980). *Self, Global Issues, and Ethics: 4 (Praxis: Philosophical and Scientific Publications.)*. B.R. Gruner Publishing Co.
11. Williams, K. and Davis, M. (2017). *Referencing and Understanding Plagiarism*. Red Globe Press.
12. Yadav, S. K. (2020). *Research and Publications Ethics*. Ane Books Pvt. Ltd., Chennai.

1. The top list of academic research databases. <https://paperpile.com/g/academic-research-databases/>
2. Publication ethics. <http://www.lnit.org/index.php?m=content&c=index&a=lists&catid=41>
3. Ethics in Research & Publication. https://www.elsevier.com/__data/assets/pdf_file/0008/653885/Ethics-in-research-and-publication-brochure.pdf
4. COPE and Publication Ethics. http://publicationethics.org/files/Overview_publication_ethics.pdf
5. Understanding Academic Integrity, Research, and Classroom Ethics. <https://pitt.libguides.com/academicintegrity>

M. Com Degree

SEMESTER – I

21PCEM1	Major Based Elective Course - I: Statistical Analysis
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The main objectives of this course are to:

1. To understand the methods of sampling.
2. To apply the probability distributions to real life problems.
3. To test the hypothesis based on large and small samples.
4. To perform the Analysis of Variance.

UNIT - I

Statistical Analysis: Concept – Univariate and Bivariate frequency distributions.

Univariate Analysis: Measures of Central Tendency – Dispersion. Applications in commerce and business.

UNIT - II

Bivariate Analysis: Correlation: Definition - types of correlation - Karl Pearson's and Spearman's Rank Correlations (simple problems). Applications in commerce and business.

Regression Analysis: Definition - regression lines - regression between two variables - Applications in commerce and business.

UNIT - III

Random Variable (R.V): Discrete and Continuous R.V – Probability Function – Probability Mass Function and Probability Density Function.

Probability distributions: Binomial and Poisson Distributions – Characteristics and Applications (simple problems only).

UNIT - IV

Testing of Hypothesis: Hypothesis, simple and composite, Null and Alternative Hypothesis, Type I and Type II errors, Critical region, Standard Error.

Tests of Significance: Procedures - Test of Significance for single mean and Difference of means, Single proportion and difference of proportions (Large Sample).

UNIT - V

Testing of significance (small samples): Student 't' test: Single mean and difference of means, F test: Equality of two population variances, Analysis of Variance - One way and Two way classifications, χ^2 test: Conditions for the validity of χ^2 test, Goodness of fit and Independence of attributes.

1. Gupta, S.P (2003), Statistical Methods, Sultan Chand & Sons, New Delhi.

1. Elhance, D.N., Veena Elhance, B.M. Aggarwal (1997), Fundamentals of Statistics, Kitab Mahal Agencies, Allahabad.

2. Sancheti, D.C., V.K. Kapoor (1981), Statistics, Theory methods and applications, Sultan Chand and Sons, New Delhi.

www.booksc.org www.statsoft.com www.easy-excel.com

On successful completion of the course, students will be able to

S.NO.	COURSE OUTCOME	BLOOMS VERB
CO1	Characterise the data using statistical constants	Understand, Analyse

CO2	Apply sampling techniques to real life problems	Apply
CO3	Perform small sample tests	Apply
CO4	Perform large sample tests	Apply
CO5	Perform the Analysis of Variance	Apply

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	M	M	M	S	M	M	M	S	S
CO2	M	S	M	S	S	M	M	M	S	M
CO3	S	S	M	M	S	M	S	M	S	S
CO4	M	M	S	M	S	M	M	M	S	S
CO5	S	S	S	M	S	S	M	S	M	M

S- Strong; M-Medium; L-Low

SEMESTER –II

21PCEM3	Major Based Elective Course - III: Quantitative Techniques for Business Decisions
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1. To understand the time series analysis.
2. To understand the methods of forming and solving a LPP.
3. To solve the Transportation problem.
4. To perform the Network analysis.

UNIT – I

Statistical Analysis of forecasting – Time series: components of time series – Secular trend: Moving average method – Method of least squares – Seasonal indices: Method of simple average – Ratio to Moving average method.

UNIT – II

Statistical Decision theory – Applications in Business – Decision under risk: EMV, EOL, EVPI, Decision under uncertainty: Maxmin, Maxmax, Minimax regret, Hurwitz, Laplace criterions.

UNIT – III

Linear Programming Problem (L.P.P) – Assumptions – Formulation of L.P.P. – Solutions – Graphical method, Simplex method (simple problems only).

UNIT – IV

Transportation Problem: Mathematical formulation – various methods for finding initial basic feasible solution – Balanced and unbalanced problem. Optimum solution - MODI method (Without Looping). Assignment Problem: Mathematical formulation – Hungarian method - Balanced and Unbalanced – Minimization case.

UNIT – V

Network Analysis: CPM and PERT Techniques – Rules of Network – Construction of Network Diagram - Critical Path analysis – Float of an activity – Three time estimates for PERT (simple problems only).

1. KantiSwarup, P.K.Gupta, Manmohan (2002), Operations Research, Sultan Chand & sons, New Delhi.

1 . Sharma, S.D (2003), Operations Research, 14th Edition, Kedarnath Ram Nath and Co, Publishers, Meerut.

2. Kapoor, V. K. (2002), Operations Research Techniques for management, Sultan Chand & Sons, New Delhi.

3. Prem Kumar Gupta and D. S. Hira (2002), Operations Research, S. Chand & company Ltd, New Delhi.

4. Ravindran, A, Don.T. Phillips, James J. Solberg (2000), Operations Research Principles and Practice,2nd Edition, John Wiley and Sons.

5. Sharma, S.D (2003), Operations Research, 14th Edition, Kedarnath Ram Nath and Co, Publishers,Meerut.

1.www.statsoft.com

2.www.easy-excel.com

On successful completion of the course, students will be able to

S.NO.	COURSE OUTCOME	BLOOMS VERB
CO1	Compute the seasonal indices using time series	Understand, Apply
CO2	Use various criteria of decision making to solve real life problems	Understand, Evaluate
CO3	Obtain optimum solution to the LPP	Evaluate, Apply
CO4	Solve the Transportation Problem	Understand, Evaluate
CO5	Find the critical path of a network in certain and uncertain situations.	Apply

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	S	M	S	M	M	M	S	S
CO2	M	M	M	S	M	M	M	M	S	M
CO3	S	S	M	M	M	M	S	M	S	M
CO4	M	S	M	M	S	M	M	M	S	M
CO5	M	S	M	M	S	M	M	S	M	M

S- Strong; M-Medium; L-Low