LEARNING OUTCOMES BASED

CURRICULUM FRAMEWORK (LOCF)

for M.Sc. STATISTICS (With effect from 2023 Onwards)



POST GRADUATE AND RESEARCH DEPARTMENT OF STATISTICS

GOVERNMENT ARTS COLLEGE (AUTONOMOUS) COIMBATORE 641 018

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1. Preamble:

Statistics is aggregate of facts. Statistical techniques are used to make many decisions that influence our day-to-day life. Statistics is a science of collecting, organizing, presenting, analyzing, and interpreting data to assist in making more effective decisions.

Post Graduate Studies in Statistics is the confluence of application and research in diverse fields of Statistics. The curriculum and syllabi of two year M.Sc. degree course in Statistics isscaffold by the expert committee.

2. Introduction

M.Sc. Statistics programme consists of 90 credits spread over four semesters. This programmeis focused on both theory and applied Statistics with an inculcation of practical and project. It is structured to provide advanced knowledge in Statistics and to develop computing skills. This may lead to employability of students in many fields of industries.

2. Learning Outcomes Based Approach to Curriculum Planning

2.1 Nature and Extent of the M.Sc. Statistics Programme

The M.Sc. Statistics Programme has some unique features such as Theory, practical and independent projects. Students are given practical training on realistic problems and extensive insight into Statistical Analysis using latest computer languages.

Students are given in hand training in Statistical Software such as SPSS, R and Python.

The course has been designed in such a way that besides the core courses, a student can opt for outcome based elective courses from the streams such as *Computer Programming, Database Developmentand Numerical Methods*.

The final semester project work is one of the major components of this programme and the students have liberty in choosing the area of specialization. M.Sc. Statistics programme is of two years duration, with semester pattern and have the following features.

- During the first semester, students will be given advanced knowledge in Probability and distributions.
- During the second semester it is focused on applied statistics and computing skills.
- The third semester, students are exposed Hypothesis Testing, Design of Experimentsand Numerical analysis.
- During the final semesters, Advanced Operations Research, Practical and Project are entertained.

2.2 Aims of Master Degree Programme in Statistics

- To prepare post graduate studentsto fit into interdisciplinary areas such as Information Technology, Agriculture, Government, Business, Telecommunication and medicine. As a result, they can pursue their future career either in the core field or in the applied field of Statistics.
- To coach students with computational techniques and software applications for Statistical Analysis.
- To expose students for competitive examinations.
- To train students in developing Statistical models for solving realistic problems.

3. Attributes in Statistics

- **Disciplinary Knowledge**: The proposed curriculum is expected to provide the students a sound knowledge of Statistics covering various aspects. As a result, they will not only appear appropriate for pursuing higher studies in the subject but also develop skill to apply the statistical knowhow to a variety of real life problems.
- **Critical Thinking**: The proposed course is designed to enrich the students with ability to examine the various statistical issues in a more logical and methodical manner. It is expected that the students will strengthen themselves both computationally and analytically.

- **Problem Solving**: The students will be able to critically examine various hypotheses and research queries, and will be able to identify and consult relevant resources to find their rational answers.
- Analytical Reasoning: The students are expected to develop capability to identify logical flaws and loopholes in the arguments of practicing Statisticians, analyse and synthesise data from a variety of sources and accordingly draw conclusions.
- **Research Related Skills**: The students should be able to develop original thinking for formulating new problems and providing their solutions. As a result, they will be able to develop research related skills for their own subject as well as for those who are practicing Statistics
- **Communication Skills and Team Work:** The students are expected to develop effective and confident Communication skill after completion of the course. They will have an ability to work in a team as well as in isolation.
- Moral and Ethical Awareness: After completion of the course, the students are expected to develop ethical and social responsibility as well. As a result, the students will be able to identify ethical issues, avoid unethical behaviour such as fabrication, falsification or misrepresentation and misinterpretation of data.
- Scientific Reasoning: The students will be able to analyse, interpret and draw appropriate conclusions from both quantitative and qualitative data and critically evaluate ideas, evidence and experiences with an unbiased and consistent approach.
- **Reflective thinking:** The students should be sensitive to real experiences with respect to self, society and nation.
- Information/Digital literacy: The proposed course is expected to develop digital literacy among the students for using ICT in different learning situations. The students should be able to equip themselves with in depth programming and simultaneously use appropriate Statistical software for advanced Statistical computing with high level graphical

interface.

- Self-directed Learning: The students are expected to be familiar with data collection, compilation, analysis and interpretation and writing of project reports independently.
- **Multicultural Competence:** The students are expected to be aware of values and beliefs of different cultures and have a global perspective by examining various forms of primary and secondary data resources.
- Leadership Readiness/Qualities: The students will be capable of mapping out the tasks of a team or an organization, formulating an inspiring vision, building a team for achieving the desired objectives, motivating and inspiring team members accordingly, and using management skills to guide people in the right direction smoothly and efficiently.
- Lifelong Learning: The proposed course is designed to develop independent, coherent and decisive thoughts among the students that will ultimately develop

4. Qualification Descriptors

Qualification descriptors for a Master Degree in Statistics:

The qualification descriptors for a Post Graduate Degree in Statistics will

- demonstrate (i) a systematic, extensive, coherent knowledge of an academic field of study and its applications, links to interdisciplinary areas of study with a critical knowledge of the subject and a number of emerging issues, (ii) procedural knowledge that creates professionals in the field of Statistics including research and development, teaching, government and public services, (iii) skills in areas related to specialization and current developments in Statistics.
- demonstrate skills in collection of relevant quantitative and/or qualitative data, analysis and interpretation of data using appropriate statistical methodologies.
- use knowledge, understanding and skills for critical assessment of a wide range of ideas and complex problems and issues relating to the chosen field of study.
- communicate the results of studies undertaken in statistics in a range of different contexts

using the main concepts, constructs and techniques of the subject.

- address one's learning needs relating to current and emerging areas of study, making use of research, development and professional materials as appropriate, including those related to new frontiers of knowledge.
- apply one's statistical knowledge and skills to new contexts and to identify and analyse problems and issues and seek solutions to real-life problems.
- demonstrate subject-related skills that are relevant to some of the job trades and employment opportunities.

5. Programme Learning Outcomes in M.Sc. Statistics

The student graduating with the Degree M.Sc. Statistics should be able to

1. Demonstrate the ability to use skills in Statistics and its related areas of technology for formulating and tackling Statistical related problems and identifying and applying appropriate principles and methodologies to solve a wide range of problems associated with Statistics.

2. Acquire

(i) a fundamental/systematic or coherent understanding of the academic field of Statistics, its different learning areas and applications in Medical Statistics, Actuarial Statistics, Psychological Statistics, Agricultural Statistics, Industrial Quality control, Econometrics, etc.,

(ii) procedural knowledge that creates different types of professionals related to the disciplinary/subject area of Statistics, including professionals engaged in research and development, teaching and government/public service;

(iii)skills in areas related to one's specialization area within the disciplinary/subject area of Statistics and current and emerging developments in the field of Statistics.

3. Recognize the importance of statistical modelling simulation and computing, and the role of approximation and mathematical approaches to analyze the real world problems.

4. Plan and execute Statistical related experiments or investigations, analyze and interpret data/information collected using appropriate methods, including the use of appropriate software such as programming languages and purpose-written packages, and report accurately the findings

of the experiment/investigations while relating the conclusions/findings to relevant theories of Statistics.

5. Demonstrate relevant generic skills and global competencies such as

(i) problem-solving skills that are required to solve different types of Statistics-related problems with well-defined solutions, and tackle open-ended problems that belong to the disciplinary-area boundaries;

(ii) investigative skills, including skills of independent investigation of Statistics-related issues and problems;

(iii) communication skills involving the ability to listen carefully, to read texts and research papers analytically and to present complex information in a concise manner to different groups/audiences of technical or popular nature;

(iv) analytical skills involving paying attention to detail and ability to construct logical arguments using correct technical language related to Statistics and ability to translate them with popular language when needed;

(v) ICT skills;

(vi) personal skills such as the ability to work both independently and in a group.

6. Demonstrate professional behavior such as

(i) being objective, unbiased and truthful in all aspects of work and avoiding unethical, irrational behavior such as fabricating, falsifying or misrepresenting data or committing plagiarism;

(ii) the ability to identify the potential ethical issues in work-related situations;

(iii) appreciation of intellectual property, environmental and sustainability issues; and

(iv) promoting safe learning and working environment.

GOVERNMENT ARTS COLLEGE

(Autonomous – Affiliated to Bharathiar University, Coimbatore)

PG & RESEARCH DEPARTMENT OF STATISTICS



M.Sc. STATISTICS

SYLLABI

2023-2024 onwards

GOVERNMENT ARTS COLLEGE, COIMBATORE

(An Autonomous Institution Affiliated to Bharathiar University)

PG & RESEARCH DEPARTMENT OF STATISTICS

MISSION

The M.Sc. Statistics course aims to persuade students to acquire advanced knowledge on theoretical and applied Statistics in a wider range. It focuses on advance study of Statistics in various fields and to provide practical training. The mission is on the training of students in present trend such as Data Analytics and Big Data Methods through latest computer programming. The course is well designed to motivate students for mastering in selected fields.

Progra	m Educational Objectives (PEOs)
	U ()
On succ	cessful completion of the M.Sc. Statistics program, the students will be able to:
PEO1	Get employment in Government, Public and Private sectors.
PEO2	Apply Statistical Techniques in diverse field
PEO3	Gain advanced knowledge and to focus on Research activities
PEO4	Develop Computing Skills through latest computer programming
PEO5	Store Data, View Data and to Interpret Data and can Serve as a good academician.
Progra	m Specific Outcomes (PSOs)
On succ	cessful completion of M. Sc. Statistics program, the students are expected to
PSO1	Know the importance of Statistics in diverse fields
PSO2	Identify the advancement in Statistics
PSO3	To improve programming skills for data analysis and interpretation
PSO4	Apply statistical methods in experimental outcomes.
PSO5	Understand the advancements and novel Statistical methods.

Progra	am Outcomes (POs)
On suc	cessful completion of the M. Sc. Statistics program, students will be able to
PO1	Possess adequate knowledge in theory and applications
PO2	Implement conceptual ideas, principles and methods in diversified fields of study
PO3	Utilize analytical skills for basic mathematical computation
PO4	Understand the conditions and limitations of statistical methods in application
PO5	Critically analyze statistical data and make interpretations
PO6	Utilize software skills for statistical computation
PO7	Gain effective skills to perform data analysis using statistical tools
PO8	Recognize the importance and value of statistical principles and approach for problem solving on a diversified disciplines
PO9	Prepare to participate in competitive examinations at the state and national level and job placements.
P10	Gain impetus to move for learning at higher level

Γ

6. Structure of M.Sc. Statistics Course

M.Sc. Degree Course -- STATISTICS

Sub Code	Title ofthePaper	Hrs (wk)	Internal (CA) Marks	External Marks	Total Marks	Ext– Min.	Total Pass Mark	Credits
		Sem	ester -	- I				_
23MST11C	Core I : Real Analysis & Linear Algebra	6	25	75	100	38	50	5
23MST12C	Core II : Probability Theory	6	25	75	100	38	50	5
23MST13C	Core III : Distribution Theory	6	25	75	100	38	50	5
23MST14E	Elective I - Big Data Analytics using Python Programming	6	25	75	100	38	50	3
23MST25P	Core Practical I : Practical - I	3						-
23MST26P	Core Practical II : Practical - II (Using Python)	3						-
		Seme	ester –	· II				
23MST21C	Core IV: Sampling Theory	6	25	75	100	38	50	5
23MST22C	Core V : Statistical Estimation Theory	6	25	75	100	38	50	5
23MST23C	Core VI : Statistical Quality Control & Reliability Estimation	6	25	75	100	38	50	5
23MST24E	Elective -II: Introduction to Data Base Management System	6	25	75	100	38	50	3
23MST25P	Core Practical I : Practical - I	3	25	75	100	38	50	4
23MST26P	Core Practical II : Practical-II (Using Python)	3	25	75	100	38	50	4

PG - SCHEME OF EXAMINATIONS: CBCS PATTERN (For the students admitted during the academic year 2023-2024 and onwards)

Sub Code	Title ofthePaper	Hrs (wk)	Internal (CA) Marks	External Marks	Total Marks	EXT-JVIII Pass Mark	Total Pass Mark	Credits
	S	emester	– III					
23MST31C	Core VII : Testing Statistical Hypothesis	6	25	75	100		38	5
23MST32C	Core VIII: Linear Models & Design of Experiments	6	25	75	100		38	5
23MST33C	Core IX : Multivariate Analysis	6	25	75	100		38	5
23MST34E	Elective III : Numerical Analysis	6	25	75	100		38	3
23MST44P	Core Practical III : Practical - III	2						_
23MST45P	Core Practical IV : Practical–IV (Using SPSS)	2						-
23MST46C	Project / Dissertation	2						-
	S	emester	– IV			•		
23MST41C	Core X : Stochastic Processes	6	25	75	100		38	5
23MST42C	Core XI : Econometrics	6	25	75	100		38	5
23MST43C	Core XII : Advanced Operations Research	6	25	75	100		38	5
23MST44P	Core Practical III : Practical - III	4	25	75	100		38	4
23MST45P	Core Practical IV : Practical–IV (Using SPSS)	4	25	75	100		38	4
23MST46C	Core: Project / Dissertation	4	25	75	100		38	5
	Total Hours 120		_			Total	Credits	90

Cores & Electives -Include theory and practical. Includes 50 continuous Internal Assessment Marks for Theory and Practical papers respectively. Project 50 Marks Continuous Internal Assessment mark. Final Project evaluation done by both Internal (25) and External examiner (25) for a Total of 50 Marks.

Year	Sem	Subject Code	Title of the Paper	
2023-2024 onwards	Ι	23MST11C	CORE I: REAL ANALYSIS AND LINEAR ALGEBRA	6

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

- Explain the fundamental concepts of real and Linear Algebra and their role in modern mathematics
 and applied contexts.
- To estimate certain theorems like Role's theorem, Lagrange's and Cauchy's mean value theorem
 To discuss Riemann Integrability, Algebra of Integrable functions, Fundamental theorem of Integral
- 3. Calculus, First and Second Mean value theorems.
- 4.
 Integral and RS Integral.
- To summarize Matrices, Rank of a matrix , inverse of a matrix , symmetric and orthogonal matrices, 5.
- Characteristic roots of a vector and Cayley-Hamilton theorem
- To discuss the concept of Quadratic form –Canonical reduction and orthogonal reduction of real quadratic forms
- To generalize the Nature of quadratic forms. Sylvester's law of inertia. Simultaneous reduction of a pair of quadratic forms.

Unit - I

Limits - Algebra of limits-Continuity-Theorems on continuity-Differentiability-Progressive and Regressive derivatives - Necessary condition for the existence of finite derivatives - Darbouxproperty-Role's Theorem-Lagrange's Mean Value Theorem-Cauchy's Mean Value theorem.

Unit - II

Riemann Integral - Partitions and Sums –Upper and Lower R – Integrals – Riemann Integrability – Riemann's necessary and sufficient conditions for R – Integrability – Algebra of Integrable functions - Fundamental theorem of Integral Calculus – First and Second Mean value theorems.

Unit - III

Riemann Stieltjes Integral – Partitions – Lower and Upper RS sums and integrals. RS integral as a limit of sums- Algebra of RS integral functions- Relationship between R-Integral and RS Integral.

Unit - IV

Matrices – Rank of a matrix – inverse of a matrix – symmetric and orthogonal matrices – Characteristic roots of a vector – Cayley - Hamilton theorem. Minimum polynomial, similar matrices, algebraic and geometric multiplicities of a characteristic root - Spectral decomposition of a real symmetric matrix.

Unit - V

Quadratic form –Canonical reduction and orthogonal reduction of real quadratic forms - Nature of quadratic forms- Sylvester's law of inertia - Simultaneous reduction of a pair of quadratic forms.

PEDAGOGY STRATEGIES

- Lecturing
- Assignment
- Classroom Discussion
- Questioning
- Seminar
- Class Test
- Quiz & Drill Practice
- Providing feedback

REFERENCES:

- 1 J.N. Sharma and A.R.Vashista. (2014), Real Analysis, Krishna Series.
- Shanti Narayan, Dr.M.D. Raisinghania, (2008), Elements of Real Analysis, S.Chand& company
 limited, New Delhi,.
- 3 K.B.Datta, (2011), Matrix and Linear Algebra, Prentice Hall of India

FURTHER READING:

- 1 A.R. Rao, and P. Bhimasankaran, (2000), Linear Algebra, Hindustan BookAgency, Hyderabad.
- F.A. Graybill, (1983), Matrices and Applications in Statistics, Wadsworth Publishing Company,
 Belmont, California, USA.
- 3 R.R.Goldberg, (1976), Methods of Real Analysis, Oxford& IBH Publishing Company, New Delhi
- 4 T.M. Apostol, (1986), Mathematical Analysis, Addison-Wesley, New York.

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

- 1 <u>https://www.jirka.org/ra/realanal.pdf</u>
- 2 <u>http://synechism.org/primer/primer-real-analysis.pdf</u>
- 3 <u>http://www.astronomia.edu.uy/progs/algebra/Linear Algebra, 4th Edition (2009)Lipschutz-</u> Lipson.pdf
- 4 https://nptel.ac.in/courses/111/101/111101134/
- 5 https://nptel.ac.in/courses/111/106/1111060

Programme Level			Course	Level Outco	omes (CLO)		
Outcomes	1	2	3	4	5	6	7
Disciplinary Knowledge	\checkmark	\checkmark	\checkmark	✓	\checkmark		
Communication Skills	\checkmark	\checkmark	\checkmark				\checkmark
Critical Thinking	~	\checkmark	\checkmark			\checkmark	
Research related Skills		\checkmark	\checkmark	\checkmark		\checkmark	
Analytical Reasoning			\checkmark	✓	\checkmark	\checkmark	
Problem Solving	✓	\checkmark	\checkmark	✓	\checkmark		\checkmark
Team Work	\checkmark	\checkmark	\checkmark				\checkmark
Moral and Ethical Awareness	\checkmark			✓		\checkmark	~
Multicultural competence		\checkmark		✓	\checkmark	\checkmark	

Year	Sem	Subject Code	Title of the Paper	Hours/Week
2023-2024 onwards	Ι	23MST12C	Core II : PROBABILITY THEORY	6

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

Explain the basics of Probability space, Discrete and General probability space,

- 1. Conditional probability space, Functions and Inverse Functions and Induced probability space by the Random variables
- Extrapolate the concept of Independence- Kolmogorov 0-1 law Borel Cantelli lemma Borel 0-1 law.
- 3. Identify the applications of inequalities in probability theory

Summarize the Mathematical Expectation and Conditional Expectation properties,

4. Inequalities based on Expectation, Basic Inequality, Holder's Inequality, Markov Inequality, and Jenson's Inequality.

Study the Concepts of Convergence of sequence of random variables and
Characteristic function, Definition and Properties of Inversion Theorem and Uniqueness Theorem.

6. Explore the application of law of large numbers and central limit theorems.

Discuss the concepts relating to law of large numbers Bernoulli's Weak Law of Large Numbers, Kolmogorov's Strong Law of Large Numbers, Central Limit Theorem,

7. Liaponov's, Lindeberg Levy theorem, Lindeberg and Feller Central Limit Theorem for i.i.d. random variables.

Unit - I

Probability space – Discrete and General probability space- Conditional probability space-Functions and Inverse Functions - Random Variables – Induced probability space by the Random variables.

Unit - II

Distribution Function – properties - Decomposition theorem - Distribution function of vector random variables - Conditional distribution function - Concept of Independence- Kolmogorov 0-1 law - Borel – Cantelli lemma - Borel 0-1 law-Helly-Bray lemma.

Unit – III - Mathematical Expectation – properties - Conditional Expectation – properties - Inequalities based on Expectation - Basic Inequality - Holder's Inequality - Markov Inequality - Jenson's Inequality – Applications of Inequalities-simple problems.

Unit - IV

Convergence of sequence of random variables - mode of convergence and their relationships-Convergence in rth mean - monotone convergence theorem - Characteristic Function – Definition and Properties – Inversion Theorem — Uniqueness Theorem – Simple problems only.

Unit - V

Law of Large Numbers -Weak and Strong Law of Large Numbers – Bernoulli's Weak Law of Large Numbers - Kolmogorov's Strong law of large numbers – Central Limit Theorems - Lindeberg – Levy's central limit theorem - Liaponov's central limit theorem - Lindberg – Feller's central limit theorem (Statement only) – Application of Theorems.

PEDAGOGY STRATEGIES

- Lecturing
- Assignment
- Classroom Discussion
- Questioning
- Seminar
- Class Test
- Quiz & Drill Practice
- Providing feedback

REFERENCES:

- B.R. Bhat(2015): Modern Probability Theory An Introductory Text Book, Fourth
- 1. Edition, New Age international (P) Ltd
- K.N. Kapoor (2011), : A Text Book on Probability Theory, First Edition, International Book House Pvt. Ltd.,
 - V.K. Rohatgi and A.K. Md. EhranesSaleh (2009): An Introduction to Probability and
- 3. Statistics, Second Edition, Wiley Student Edition, India,

FURTHER READING:

- William Feller (2013): An Introduction to Probability Theory and its Applications, Volume II.
- 2. S.M. Ross (2010), A First Course in Probability, 2010, Pearson Prentice Hall.
- Feller, W (2008). An Introduction to Probability Theory and its Applications, Volume
 II, John Wiley & Sons, New York.

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

- 1. <u>https://onlinecourses.nptel.ac.in/noc20_ma18/preview</u>
- 2. <u>https://nptel.ac.in/courses/111/102/111102111/</u>

Programme	Course Level Outcomes (CLO)								
Level Outcomes	1	2	3	4	5	6	7		
Disciplinary Knowledge	\checkmark	\checkmark	~	\checkmark	\checkmark				
Communication Skills	\checkmark	~	~			~	\checkmark		
Critical Thinking	\checkmark	\checkmark	~				\checkmark		
Research related Skills		\checkmark	~	\checkmark		\checkmark	\checkmark		
Analytical Reasoning			~	\checkmark	\checkmark		\checkmark		
Problem Solving	\checkmark	~	~	\checkmark	\checkmark				
Team Work	\checkmark	\checkmark	\checkmark			\checkmark	\checkmark		
Moral and Ethical Awareness				~	~	~	✓		
Multicultural competence	\checkmark	\checkmark		\checkmark		~	✓		

Year	Sem	Subject Code	Title of the Paper	Hours/ Week
2023-2024 onwards	Ι	23MST13C	Core Paper III: DISTRIBUTION THEORY	6

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

- 1. Explain the Random variables and its distributions
- 2. Derive properties of distributions
- 3. To Demonstrate Moments of the distribution
- 4. Analyze Non-Central distributions
- 5. Discuss the concepts of Ordered Statistics and its distributions.
- 6. Derive probability distributions that are applied in real time situation.
- 7. To compute various measures of distribution.

Unit - I

Random Variables and Distributions – Theorems on Random Variables – Distribution Function – Properties of Distribution Function - Probability Mass Function – Probability Density Function – Two Dimensional Random Variables – Joint Distributions – Joint Densities – Marginal Densities – Conditional Densities – Transformation of one dimensional random variable – Fundamental Theorem – Transformation of two dimensional random variables - Distribution of sum, difference, product, quotient of random variables – Simple Problems.

Unit - II

Discrete Distributions – Binomial – Poisson – Geometric - Hyper-geometric - Negative Binomial - Multinomial distributions –Power Series distributions – limiting cases – Moments - Properties.

Unit - III

Continuous Distributions - Normal - Log normal distributions – Uniform distribution - Gamma distribution – Beta distribution of first kind - Beta distribution of second kind - Exponential distribution - Laplace (Single parameter) - Weibull distributions – Cauchy - Logistic Distributions.

Unit - IV

Non-central distributions – Non-central t - Non-central F - Non-central χ^2 distributions - Its Properties - Distribution of Sample correlation co-efficient for null case - Distribution of regression co-efficient.

Unit - V

Order statistics – Distribution of order statistics – Joint distribution of order statistics – Distribution of the smallest and largest order statistics – asymptotic distribution of r^{th} order statistics – Distribution of range - Mid-range - Median – Simple Problems.

PEDAGOGY STRATEGIES

- Lecturing
- Assignment
- Classroom Discussion
- Questioning
- Seminar
- Class Test
- Quiz & Drill Practice
- Providing feedback

REFERENCES:

Mood, A.M., F.A. Greybill& D.C. Boes, (2001), Introduction to the Theory of Statistics, Tata McGraw–Hill Education Pvt Limited, New Delhi.

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² Publishers, New Delhi.

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Rohatgi V.K. and A.K. Md. EhranesSaleh (2009), An Introduction to Probability and Statistics, Wiley Student Edition, India.

2 Hogg R.V., and A.T.Craig (2012), An Introduction to Mathematical Statistics, New York.

Johnson, N. L., Kotz, S., and Balakrishnan, N. (2004). ContinuousUnivariate Distributions. Vol.I,

- 3. John Wiley and Sons (Asia), Singapore.
- Johnson, N. L., Kotz, S., and Balakrishnan, N. (2014). Continuous Univariate Distributions, Vol. II.
 John Wiley and Sons (Asia), Singapore.

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

https://nptel.ac.in/courses/111/104/111104032/

1

1

https://nptel.ac.in/courses/117/104/117104117/

2

Programme	Course Level Outcomes (CLO)									
Level Outcomes	1	2	3	4	5	6	7			
Disciplinary Knowledge	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark					
Communication Skills	\checkmark	\checkmark	\checkmark			\checkmark	\checkmark			
Critical Thinking	✓	\checkmark	\checkmark				\checkmark			
Research related Skills		\checkmark	\checkmark	\checkmark		\checkmark				
Analytical Reasoning			\checkmark	\checkmark	\checkmark	\checkmark				
Problem Solving	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark					
Team Work	✓	\checkmark	\checkmark				\checkmark			
Moral and Ethical Awareness		\checkmark		\checkmark	\checkmark	\checkmark				
Multicultural competence			\checkmark		\checkmark	\checkmark	\checkmark			

Year	Sem	Subject Code	Title of the Paper	Hours/ Week
2023-2024 onwards	Ι	23MST14E	Elective Paper I : BIG DATA ANALYTICS USING PYTHON PROGRAMMING	6

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

- 1 Discuss the Big Data concepts and Structure of Data
- 2 Demonstrate the Visualization of Big Data using pyplot.
- 3 Appraise data, variables and declarations in Python
- 4 Explain Python Operators and Control Structures
- 5 Compute Strings and String Manipulations in Python
- 6 Describe about Lists, Tuples, Sets and Dictionary in Python.
- 7 Design Python Programs for Big Data Analytics.

Unit - I

Big Data Analytics – Big Data Definition – Data Sets in Big Data – Big Data in various fields – Dimensions of Big Data – Volume – Variety - Veracity - Velocity – Analysis - Categories of Big Data – Business Intelligence - Data Mining (Concept only) - Statistical Applications - Predictive analysis and Data Modeling – Categories of Data – Structured – Unstructured - Semi Structured – Sources of Big Data – Big Data Analytics using Python.

Unit - II

Introduction to Python – Key Features – Interactive Mode Programming – Script Mode Programming – Saving Python Script – Executing Python Script – Input and Output Functions – Comments (Documentation Section) – Indentation – Tokens of Python - Operators in Python – Data types – Lists – Tuples – Sets – Dictionary.

Unit - III

Control Structures in Python – Sequential Statement – if Statement – if-else Statement – if-elif Statement – Nested if-else Statement – Nested if-elif Statement. Iteration or looping constructs – While Loop – for Loop – Jump Statements – Break – Continue – Pass.

Unit - IV

Python Functions – Defining Functions – Types of Functions – User defined functions – Built-in functions – Lambda functions – Recursion functions – Block – Nested Block – Advantages of User defined functions – Calling a function – Passing Parameters in functions – Function Arguments – Anonymous Functions – Return Statement –Scope of Variables – Composition in functions – Recursive function.

Strings and Manipulation of Strings – Creating Strings – Accessing Characters in a String – Modifying and Deleting Strings – String Operators – Formatting Operators – Formatting Characters – The format() function – Escape Sequence – String functions.

Unit - V

Python Classes and Objects – Definition of class – Creating Objects – Accessing class members – Class methods – Constructor – Destructor – Public and Private Data members – Data Model – Hierarchical Model – Relational Model – Network Database Model – Object Model.

File operation in Python – open() – Python file modes – close() – reader functions – sorting function – writing functions - Big Data Visualization using Pyplot – Data Visualization Definition – Types of visualization– uses – Big Data Plots using Matplotlib and Clustering using Scikit-learn.

PEDAGOGY STRATEGIES

- Lecturing
- Assignment
- Classroom Discussion
- Questioning
- Seminar
- Class Test
- Quiz & Drill Practice
- Providing feedback

REFERENCES:

1 SeemaAcharyaet.al (2018), Big Data Analytics using Python — McGraw Hill Education,

India.

2 Frank Ohlhorst (2019), Big Data Analytics — Wiley & SAS Series.

FURTHER READING:

Wes McKinney - O-Reilly (2020), Python for Data Analysis - OreillyPublisher.

1

Website: (http://oreilly.com/safari).

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

- 1 <u>https://nptel.ac.in/courses/106/107/106107220/</u>
- 2 https://nptel.ac.in/courses/106/106/106106212/

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES

Progr Outcor	am Level nes (PLO)	CLO-1	CLO-2	CLO-3	CLO-4	CLO-5	CLO-6	CLO-7
]	Disciplinary Knowledge	\checkmark	\checkmark	✓	\checkmark	\checkmark	\checkmark	~
Co	ommunication Skills		~		~		\checkmark	~
	Critical Thinking			~	✓	√	√	~
r	Research related Skills	~	~		~		\checkmark	~
	Analytical Reasoning		~		~	\checkmark	\checkmark	~
	Problem Solving		~	~	~	\checkmark	\checkmark	~
	Team Work	~	~	~	~	~	~	~
	Moral and Ethical Awareness	~			~		~	~
N	Aulticultural competence			\checkmark	\checkmark		\checkmark	\checkmark

Course Level Outcomes

Year	Sem	Subject Code	Title of the Paper	Hours/ Week
2023-2024 onwards	Π	23MST21C	CORE IV: SAMPLING THEORY	6

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

- 1. Associate the theory of Census and Sample surveys.
- 2. Distinguish Simple Random Sampling with and without replacement.
- 3. Generalize Stratified and Systematic Random sampling.
- 4. Predict PPS sampling with& without replacement.
- 5. Summarize Ratio Estimator and Regression Estimator.
- 6. Discuss Cluster Sampling.
- 7. Extrapolate Two and Three stage sampling.

Unit - I

Census and Sample surveys– Concept of Population- Sample- Sampling units – Merits and Limitations of Sampling technique -Principal steps in sample survey - Preparation of Questionnaire and Schedules - Concept of sampling and non-sampling errors.

Simple Random Sampling (with and without replacement) - Unbiased Estimate of Mean and Variance – Simple Random Sampling of Attributes – Estimation of mean and variance - Determination of sample size.

Unit - II

Stratified Random Sampling and systematic random sampling - Principles and Advantages of stratification- allocation of sample size in different strata- Estimation of mean and variance of Stratified Random Sampling and Systematic Random Sampling - Comparison of Simple Random Sampling, Stratified Random Sampling and Systematic Random Sampling.

Unit - III

Varying Probability Sampling- Introduction - Procedures of selecting a sample, Estimation in Probability proportional to size (PPS) sampling with replacement - population total and its variance - Gain due to PPS sampling with replacement - PPS sampling without replacement - Procedures of selection of a PPS sampling without replacement - Estimation in PPS sampling without replacement - Population total and its sampling variance.

Unit - IV

Ratio estimators - Introduction - Definition and notations - Bias of ratio estimators, approximate variance of ratio estimator-Ratio estimators in stratified sampling - comparison of separate and combined ratio estimator.

Regression estimators – Introduction - Difference estimator - regression estimator - Regression estimator in stratified sampling

Unit - V

Cluster sampling-Introduction-Notations-Equal cluster sampling –Estimation of mean and variance – Relative efficiency of cluster sampling – optimum cluster size –Cluster sampling for proportions.

Two stage sampling - with equal and unequal first stage units – Estimation of mean and variance. Three stagesampling - with equal probability - Estimation of mean and variance.

PEDAGOGY STRATEGIES

- Lecturing
- Assignment
- Classroom Discussion
- Questioning
- Seminar
- Class Test
- Quiz & Drill Practice
- Providing feedback

REFERENCES:

- Daroga Singh and F.S.Chowdhary (2002), Theory and analysis of Sampling Survey Design,
- 1. John Wiley & Sons, New Age International (P) Ltd., Publishers, New Delhi.
- 2. Wiiliam G. Cocharan(2011), Sampling Techniques:, John Wiley & Sons.

FURTHER READING:

- 1. Des Raj (1978), Sampling Theory, Tata McGraw Hill, New Delhi
- Murthy, M. N. (1967). Sampling Theory and Methods, Statistical Publishing Society, Calcutta.
- 3. Sampath, S. (2000). Sampling Theory and Methods, Narosa Publishing Company, New Delhi.

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

- 1. https://nptel.ac.in/courses/111/104/111104073/
- 2. https://nptel.ac.in/content/storage2/courses/111104073/Module14/Lecture42.pdf

Programme			Course L	evel Outco	mes (CLC))	
Level Outcomes	1	2	3	4	5	6	7
Disciplinary Knowledge	~	✓	✓	✓	✓		
Communication Skills	\checkmark	\checkmark	\checkmark			\checkmark	\checkmark
Critical Thinking	\checkmark	\checkmark	\checkmark				\checkmark
Research related Skills		\checkmark	\checkmark	\checkmark		✓	
Analytical Reasoning			✓	\checkmark	\checkmark		
Problem Solving	\checkmark	\checkmark	✓	\checkmark	\checkmark		
Team Work	\checkmark	\checkmark	\checkmark				\checkmark
Moral and Ethical Awareness		\checkmark		\checkmark	\checkmark	✓	
Multicultural competence			✓		\checkmark	\checkmark	\checkmark

3. https://www.mooc-list.com/tags/sampling-methods

Year	Sem	Subject Code	Title of the Paper	Hours/ Week
2023-2024 onwards	Π	23MST22C	CORE V : STATISTICAL ESTIMATION THEORY	6

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

- 1 Discuss the concept of Characteristics of estimators and Minimal sufficient statistics.
- ² Explain the procedures and demonstrate Unbiasedness Cramer Rao inequality Minimum variance bound estimator – Bhattacharya bounds
- 3 Illustrate the Methods of Estimation and its properties.
- 4 Construct Interval Estimation and Shortest length confidence intervals.
- ⁵ Derive and estimate the Exponential family location and scale family Location invariant estimator Scale invariant Estimator.
- ⁶ Describe the Concept of Bayesian Inference and Baye's Estimator.
- ⁷ Demonstrate the methods of estimating for different distributions.

Unit - I

Point Estimation – Characteristics of Estimators – Consistency – Sufficient condition for consistency – Sufficient statistics – Factorization theorem – Fisher's information – Minimal sufficient statistics.

Unit - II

Unbiasedness – Cramer – Rao inequality – Minimum variance bound estimator – Bhattacharya bounds – Chapman Robbins Inequality.

Efficient Estimator – UMVUE – Sufficient and Complete statistic – Rao-Blackwell theorem.

Unit – III

Methods of Point Estimation – Method of MLE – Method of Moments, Method of Minimum Chi-square – Method of Modified minimum Chi-square.

Unit IV

Interval Estimation – Confidence level and confidence co-efficient – Shortest length confidence intervals – Construction of Confidence intervals for Population Proportion-– Confidence intervals for mean, variance of a normal population – Confidence intervals for Difference between means-Confidence intervals for ratio of variances.

Unit - V

Exponential family – location and scale family – Location invariant estimator – Scale invariant Estimator – Pitman estimator for location and scale – Simple Problems- Principles of decision theory-Loss and Risk functions-Concept of Bayesian Inference - Baye's Estimator – Posterior Baye's Estimator (Concept Only).

PEDAGOGY STRATEGIES

- Lecturing
- Assignment
- Classroom Discussion
- Questioning
- Seminar
- Class Test
- Quiz & Drill Practice
- Providing feedback

REFERENCES:

- M. Rajagopal and P. Dhanavandan(2012): "Statistical Inference", PHI Learning Private Linited, New Delhi.
- 2. S.C.Gupta and V.K.Kapoor, (2013), "Fundamentals of Mathematical Statistics", Eleventh
 Edition, Sultan Chand & Sons, New Delhi.
- Mood M, A. Greybill, C. Boes, (1974), Introduction to the Theory of Statistics, Tata McGraw – Hill Education Pvt Limited, New Delhi.

FURTHER READING:

- Hogg .R.V. and A.T. Craig (2019), An Introduction to Mathematical Statistics, Third Edition, Amerind, New York, London.
- V.K. Rohatgi., A.K. Md. EhsanesSaleh (2013)," An Introduction to Probability and Statistics", Wiley Series in Probability and Statistics, Texts and references section.
- Goon A.M., M.K. Gupta and B. Das Gupta (1973) An Outline of Statistical Theory, Volume 3
 - 2, World Press Pvt Ltd., Calcutta.

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- 1 <u>https://nptel.ac.in/courses/111/105/111105043/</u>
- 2 https://nptel.ac.in/content/syllabus pdf/117103018.pdf
- https://nptel.ac.in/content/syllabus_pdf/117103018.pdf

3

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES

		CLO-1	CLO-2	CLO-3	CLO-4	CLO-5	CLO-6	CLO-7
(0)	Disciplinary Knowledge	\checkmark	~	~	\checkmark	~	~	\checkmark
	Communication Skills		~	~			~	√
s (PI	Critical Thinking	√	~	~	√	~	~	\checkmark
come	Research related Skills	√			√	~	~	
Out	Analytical Reasoning	\checkmark		~	~		~	~
,evel	Problem Solving			~		~		
am I	Team Work		~		√	~	~	√
Progr	Moral and Ethical Awareness	~			~		~	~
	Multicultural competence	\checkmark	✓	~	\checkmark	~	~	\checkmark
		~	V	~	~	~	V	✓

PG Syllabus – 2023-24 onwards – Department of Statistics

Year	Sem	Subject Code	Title of the Paper	Hours/Week
2023-2024 onwards	II	23MST23C	CORE PAPER VI : STATISTICAL QUALITY CONTROL AND RELIABILITY ESTIMATION	6

COURSE LEVEL OUTCOMES:

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

- 1 Discuss the concept of Process Control, To Monitor Process, To develop Attribute control charts
- 2 Describe about variable control charts, CUSUM control charts for short run
- 3 Demonstrate attribute sampling plans, to derive various efficiency measures, to construct tables for applications
- Analyze sampling plans for continuous production, Sequential sampling procedure, Selection of Sampling Plans from Mil-Std-105D and Mil-Std- 414.
- 5 Design Sampling Plans for variable quality characteristics, To determine the parameters of the sampling plans.
- 6 Assess Statistical Quality Control on Reliability Models Model development Data through Type 6 I and Type II Censoring – Evaluating Reliability.
- Derive MLE of Reliability and Reliability Estimation, Parallel and Series configuration MTBF &
 MTTR Availability and Maintainability.

Unit - I

Basics of control charts – Shewart control charts for Variable characteristics - \overline{X} & R Control Charts – OC and ARL of control charts - Shewart control charts for Attribute characteristics - p Chart – np Chart - C Chart and their uses – CUSUM Control Chart – concept and use of V-mask procedure - Tabular CUSUM Chart.

Unit - II

Control Charts for Individual Observations – Moving Range and Moving Average Charts - Exponentially Weighted Moving Average Charts – Process Capability Analysis.

Unit - III

Attribute Sampling Plans –Single Sampling Plan –conditions of applications – operation procedure – measures of performance – OC – ASN – AOQ - ATI functions of SSP – Double Sampling Plans - MIL STD 105-D(concept only) - Continuous Sampling Plans – CSP-1 Derivations Of OC Function (For CSP-1 Only)-CSP-2 and CSP-3 Plans(concepts only) – Sequential Sampling Plans By Attributes.

Unit - IV

Variable Sampling Plans –Single Sampling Plan - Operating Procedure – OC Function – Comparison of OC Curve with respective n and k - Determination of the parameters - Known & Unknown Sigma Plans for One Sided Specifications - MIL STD 414 (Concept Only).

Unit - V

Need For Reliability – Definitions of Reliability – Basic Elements of Reliability – Hazard Rate – Measurement Of Reliability – Exponential Model Hazard Rate – Mean Time Between Failure (MTBF)-Mean Time To Repair (MTTR)- Censored Samples – MLE of Reliability Under Type –I Censoring and Type –II Censoring In Exponential Case – Reliability for Series and Parallel Systems – k Out of m System - Maintainability (Concept Only).

REFERENCES:

- 1 DOUGLAS C. MONTGOMARY (2008), Introduction to Statistical Quality Control ,Wiley India(p) 1 Ltd, fourth edition, New Delhi.
- EDWARD G. SCHILLING (1982), Acceptance Sampling In Quality Control , Marcel Dekker, Inc,
 ASQC Quality Press, USA.
- 3 M.MAHAJAN (2009) Statistical Quality Control, DhanpatRai& Co (P)Ltd, Delhi.

FURTHER READING:

- 1 DUNCAN, AJ (1985), Quality Control and Industrial statistics, Irwin Homewood
- GUPTA S.C. and V.K.KAPOOR (2009), Fundamentals of Applied statistics, Fourth revised edition, 2
- Sultan Chand & Sons publishers, New Delhi
- 3 EUGENE L GRANT, RICHARD S LEAVENWORTH (2017), Statistical Quality Control, Tata

McGraw Hill Publication, India.

4 BHISHAM C. GUPTA (2021), Statistical Quality Control: Using MINITAB, R, JMP and Python

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

https://nptel.ac.in/courses/112/107/112107259/

- 1
- 2 <u>https://nptel.ac.in/courses/110/105/110105088/</u>

COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES

		CLO-1	CLO-2	CLO-3	CLO-4	CLO-5	CLO-6	CLO-7
(0)	Disciplinary Knowledge	✓	✓	✓	~	✓	✓	~
	Communication Skills			~			~	~
s (P]	Critical Thinking	~	~	~	~	~	~	~
come	Research related Skills	~			~	✓	~	
Out	Analytical Reasoning	~	~	~	~	~	~	~
level	Problem Solving	~	~	~	~	~	~	~
am I	Team Work	~	~	~	~	~	~	~
Progr:	Moral and Ethical Awareness			~	\checkmark		~	~
	Multicultural competence	\checkmark	✓	✓	~	~	\checkmark	\checkmark

Year	Sem	Subject Code	Title of the Paper	Hours/W eek
2023-2024			CORE PAPER X: INTRODUCTION TO	
onwards	II	23MST24E	DATABASE MANAGEMENT SYSTEM	6

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

- 1. Describe the fundamentals of data models to conceptualize and to depict a database system using ER diagram.
- 2. Summarize the basics of SQL and construct queries using SQL
- 3. Discuss the basic concepts and the applications of database systems
- 4. Paraphrase the relational database design principles
- 5. Demonstrate the internal storage structures which will help in physical DB design.
- 6. Explain the fundamental concepts of transaction processing- concurrency control techniques and recovery procedure.
- 7. Recognize the database storage structures and access techniques

Unit - I

Database Management System - Introduction - Data Processing Vs. Data Management Systems - File Oriented Approach - Database Oriented Approach to Data Management -Characteristics of Database - Advantages and Disadvantages of a DBMS - Instances and Schemas -Database Languages - Database Architecture and Independence.

Unit - II

Data Modeling Using E-R Approach - Introduction to Database Design and Data Modeling -Entity-Relationship (E-R) Model - Entity types - Entity set - Attribute and key – Relationships -Relation types - Roles and structural constraints - Weak entities – Enhanced E-R and object modelling - Sub classes - Super classes – Inheritance.

Unit - III

Building Data Model – Steps - Developing the Basic Schema. Relational Model - Introduction
Concepts - Relational Model Constraints - Relational Languages - Relational Algebra - A
Relational Database Management Systems - ORACLE - Data storage and Querying.

Unit - IV

SQL - Introduction, History and Commands of SQL - Data Definition Language (DDL) - Data Manipulation Language (DML) - Transaction Control Language (TCL) - Constraints – Indexes – Difference between SQL Vs NoSQL Databases, Pros and Cons with examples. Introduction -Query Optimization - Heuristic in Query optimization - Basic Algorithms for Executing Query Operation.

Unit - V

Relational Database Design and Normalization - Introduction - Informal Design Guidelines for Relational Schemas - Functional Dependencies - Multivalued Dependencies - Relational Database - First Normal Form - Second Normal Form - Third Normal Form. Database Recovery Concepts. Current and Future Trends in DBMS – International certifications related to DBMS.

PEDAGOGY STRATEGIES

- Lecturing
- Assignment
- Classroom Discussion
- Questioning
- Seminar
- Class Test
- Quiz & Drill Practice
- Providing feedback

REFERENCES:

RAMEZ ELMASRI & SHAMKANT B. NAVATHE (2003), Fundamentals of Database 1 Systems, Pearson Addison-Wesley, Boston San Francisco, New York, 4th edition.

2 ABRAHAM SILBERSCHATZ & HENRY F. KORTH (2013), Data Base System Concepts, McGraw Hill, 6th Edition.
FURTHER READING:

- 1 RAGHURAMA KRISHNAN & JOHANNES GEHRKE (2008), Data Base Management Systems, Tata McGraw Hill, 3rd Edition.
- 2 ABRAHAM SILBERSCHATZ, HENRY F & KORTH, S. SUDARSHAN, (2011) Database System Concepts, Tata McGraw Hill 6th Edition.
- 3 C.J. DATE, A.KANNAN & S.SWAMI NADHAN, (2004)An Introduction to Database systems, Pearson Addison-Wesley, Boston San Francisco, New York, 8th Edition.

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

- 1 <u>https://www2.cs.sfu.ca/CourseCentral/354/zaiane/material/notes/contents.html</u>
- 2 <u>https://www.oracle.com/in/database/what-is-data-management/</u>
- 3 <u>https://www.guru99.com/introduction-to-database-sql.html</u>
- 4 <u>https://www.ibm.com/cloud/blog/sql-vs-nosql</u>
- 5 <u>https://www.mbmsoftware.com/blog/technology/6-trends-in-database-management-</u> 2985.html
- 6 <u>https://www.quest.com/community/blogs/b/database-management/posts/5-dbms-trends-</u> impacting-database-administration
- 7 https://www.guru99.com/database-interview-questions.html (Question Bank).
- 8 https://www2.cs.sfu.ca/CourseCentral/354/zaiane/material/notes/contents.html
- 9 https://www.oracle.com/in/database/what-is-data-management/

		CLO-1	CLO-2	CLO-3	CLO-4	CLO-5	CLO-6	CLO-7
	Disciplinary Knowledge	~	~	✓	✓	✓	✓	~
PLO	Communication Skills			~				
nes (Critical Thinking		✓	✓	✓			✓
utcor	Research related Skills			✓	✓		\checkmark	✓
el Oı	Analytical Reasoning	~	✓	✓	✓			
Lev	Problem Solving	~	✓	~	✓	✓	\checkmark	~
gram	Team Work	\checkmark	~	~	~	~	✓	✓
Prog	Moral and Ethical Awareness	~	~		~	~		
	Multicultural competence	~	✓	~	~	~	~	\checkmark

Year	Sem	Subject Code	Title of the Paper	Hours/Week
2023-2024 onwards	I & II	23MST25P	CORE PRACTICAL I : PRACTICAL - I	3

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

- 1. Estimate the parameters using methods of estimation.
- 2. Estimate the Probability proportionate sampling with replacement, Probability proportionate sampling without replacement.
- 3. Fitting of the Binomial, Poisson, Normal, lognormal and logistic distributions.
- 4. Constructions of the Single sampling plans, Double sampling plans, Sequential Sampling plans
- 5. Design practical Problems to Sampling plans.
- 6. Estimate the parameters using method of moments and MLE.
- 7. Estimate the Cluster sampling. Ratio Estimation and Regression Estimation.

STATISTICAL ESTIMATION THEORY

- 1. MLE and Standard error of MLE of Poisson.
- 2. MLE and Standard error of MLE of Binomial.
- 3. MLE and Standard error of MLE of Normal.
- 4. Minimum Chi-Square method of estimation.

SAMPLING THEORY

- 5. Probability proportionate sampling with replacement.
- 6. Probability proportionate sampling without replacement
- 7. Cluster sampling.
- 8. Ratio Estimation.
- 9. Regression Estimation.

DISTRIBUTION THEORY

- 10. Fitting Poisson distribution.
- 11. Fitting Binomial distribution.
- 12. Fitting Normal distribution.
- 13. Fitting lognormal distribution.
- 14. Fitting logistic distribution

STATISTICAL QUALITY CONTROL & RELIABILITY

- 15. Single sampling plans.
- 16. Double sampling plans.
- 17. Sequential Sampling plans.
- 18. CUSUM control chart.
- 19. Reliability of Type I censoring.
- 20. Reliability of Type II censoring.

PEDAGOGY STRATERGIES:

- 1. Lecturing
- 2. Assignment
- 3. Classroom Discussion
- 4. Questioning
- 5. Seminar
- 6. Class Test
- 7. Quiz

REFERENCES:

- 1 Myer, P.L. (1970): Introductory Probability and Statistical Applications, Oxford &IBH Publishing, New Delhi
- 2 Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
- 3 Johnson, R.A. and Bhattacharya, G.K. (2001): *Statistics-Principles and Methods*, 4th Edn. John Wiley and Sons.
- 4 Mood, A.M., Graybill, F.A. and Boes, D.C. (2007): *Introduction to the Theory of Statistics*, 3rd Edn. (Reprint).Tata McGraw-Hill Pub. Co. Ltd.
- 5 Gupta, S.C & Kapoor, V.K. (2013): Fundamentals of Applied Statistics, Sultan & Sons, Delhi.

FURTHER READING:

- 1 Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edn. The World Press, Kolkata
- 2 Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
- 3 Hogg, R.V. and Tanis, E.A. (2009): *A Brief Course in Mathematical Statistics*. Pearson Education.
- 4 Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2ndEdn. (Reprint) John Wiley and Sons
- 5 Montogomery, D. C. (2009): Introduction to Statistical Quality Control, 6th Edition, Wiley India Pvt. Ltd.

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

- 1 <u>http://www.stats.ox.ac.uk/~dlunn/b8_02/b8pdf_8.pdf</u>
- 2 https://nptel.ac.in/content/storage2/courses/103106120/LectureNotes/Lec3 3.pdf
- 3 https://nptel.ac.in/content/storage2/courses/103106120/LectureNotes/Lec5 3.pdf
- 4 https://nptel.ac.in/content/syllabus pdf/111102112.pdf

		CLO-1	CLO-2	CLO-3	CLO-4	CLO-5	CLO-6	CLO-7
	Disciplinary Knowledge	~	~	~	~	~	~	~
(0)	Communication Skills			~			✓	~
s (Pl	Critical Thinking	✓	✓	✓		✓	✓	
come	Research related Skills	✓			✓	✓	✓	
Outo	Analytical Reasoning	~			~		~	√
'evel	Problem Solving			✓		✓		
am I	Team Work		~		~		~	✓
Progr:	Moral and Ethical Awareness				✓	~	✓	~
	Multicultural competence	\checkmark	\checkmark		\checkmark	\checkmark	\checkmark	\checkmark

Year	Sem	Subject Code	Title of the Paper	Hours/ Week
2023-2024 onwards	I & II	23MST26P	CORE PRACTICAL II - PRACTICAL II -USING PYTHON PROGRAMMING	3

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

- 1 Apply the theory through practical oriented training.
- 2 Perform the Visualization of Big data.
- 3 Design Python Programming Scripts for Descriptive Statistics.
- 4 Write Python Programs to fit Probability Distributions.
- 5 Compute Model fitting by developing python programs.
- 6 Perform Computations for Correlation and Regression Equations
- 7 Develop computing skills for Big Data Analytics.

LIST OF EXPERIMENTS

- 1. Visualization of Big Data.
- 2. Program to find total and average marks using class and methods.
- 3. Program using tuples, list, dictionary & sets.
- 4. Program using function to find area of geometry.
- 5. Program to use arithmetic, relational, logical and conditional operators
- 6. Program to Grade the students according to the average marks using nested if.
- 7. Fitting Binomial Distribution and Poisson Distributions.
- 8. Fitting Normal and Gamma Distributions.
- 9. Calculation of Probabilities under Normal Distribution & drawing cumulative curve.
- 10. Partial and Multiple Correlation Coefficients
- 11. Simple and Multiple Regression Coefficients
- 12. Fitting Linear Trend by Least Square method and Forecasting
- 13. Finding mean vector and covariance matrix
- 14. Construction of control charts for Mean and Range
- 15. Probability of Acceptance & drawing OC Curve using Poisson distribution
- 16. Finding Expected values of Random Variables.
- 17. t-test for single and two means.
- 18. Chi-square test for independence of attributes and goodness of fit
- 19. One way and two way ANOVA.
- 20. Factorial Experiments with two factors 2^2 and 3^2 .

REFERENCES:

- SeemaAcharyaet.al (2018), Big Data Analytics using Python McGraw Hill Education, I India.
- 2 Frank Ohlhorst (2019), Big Data Analytics Wiley & SAS Series.

FURTHER READING:

Wes McKinney – O-Reilly (2020), Python for Data Analysis – Oreilly Publisher.

Free Website: (http://oreilly.com/safari).

relatedOnline Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1 <u>https://nptel.ac.in/courses/106/107/106107220/</u>

		CLO-1	CLO-2	CLO-3	CLO-4	CLO-5	CLO-6	CLO-7
	Disciplinary Knowledge	\checkmark	~			~	~	
(O)	Communication Skills		✓	~		✓	√	
ss (P]	Critical Thinking	✓	✓		✓	✓		
come	Research related Skills			✓	✓	✓	√	✓
Out	Analytical Reasoning	\checkmark	~	~	~	~	√	√
'evel	Problem Solving	\checkmark	~	~	~	√	√	√
am L	Team Work	\checkmark	~	~	~	~	\checkmark	√
Progr	Moral and Ethical Awareness	~	~			~	~	
	Multicultural competence	✓	✓	~	~	~	~	✓

Year	Sem Subject Code		Title of the Paper	Hours/ Week
2023-2024 onwards	III	23MST31C	CORE VII : TESTING STATISTICAL HYPOTHESIS	6

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

- Demonstrate testing of statistical hypothesis, basic terms of testing of statistical hypothesis and Monotone Likelihood Property.
- 2 Explain the procedures for Uniformly Most Powerful Unbiased Test and Similar test. AnalyzeLikelihood Ratio Test based on some important distributions. That should be
- 3 followed in statistical inference.
- 4 Describe how to establishment and interpreted to Non-Parametric Tests based on one Sample and Two Sample Problems
- 5 Derive Monotone Likely Ratio Property and established Sequential Probability Ratio Test. 5 Discuss the concept of Hypothesis Testing for Bayesian Approach.
- 6 ApplyMann-Whitney 'U' Test (One Sample and Two Sample Problems) Kolmogorov's Smirnov One Sample Test- Kruskal Wallis Test.
- 7 Design test on the analysis of OC and ASN functions in Sequential Probability Ratio test.

Unit - I

Test of hypothesis - Simple and Composite hypothesis – Types of Errors – Critical Regions – Randomized and Non-Randomized tests – Generalized Neyman – Pearson Lemma Power function – Most powerful test – Uniformly Most Powerful Test- Neyman – Pearson Lemma – Monotone Likelihood Ratio property.

Unit - II

Unbiased test - Uniformly Most Powerful Unbiased Test – Similar test – UMP similar test – Unbiased test for one parameter exponential family – Test with Neyman Structure.

Invariant test – Uniformly Most powerful invariant tests- Maximal Invariant Test.

Unit – III

Likelihood Ratio test – Construction- LR test for Standard Distributions (Binomial, Poisson, Normal and Exponential distributions) – Asymptotic distribution of LRT – Consistency of LRT-Bartlett test for homogeneity of variances.

Unit – IV

Non-parametric tests - Definition - Advantages and Disadvantages – One sample tests – Kolmogorov – Smirnov test – test for randomness – Sign test- Wilcoxon's signed rank test – Two sample tests – Run test, Median test, K-S test and Mann -Whitney U tests- More than two Sample test - Kruskal-Wallis H test.

Unit - V

SPRT - Basic structure – Determination of the constants A and B – Derivation of OC function– ASN function – Derivations based on Binomial, Poisson, Normal and Exponential distributions -Power function. Hypothesis Testing for Bayesian Approach (Concept only).

PEDAGOGY STRATEGIES

- Lecturing
- Assignment
- Classroom Discussion
- Questioning
- Seminar
- Class Test
- Quiz & Drill Practice
- Providing feedback

REFERENCES:

- 1 M. Rajagopalan & P. Dhanavandan (2012), Statistical Inference, Prentice Hall.
- Goon A.M, Gupta M.K and Das Gupta B (2013)., An Outline of Statistical Theory, Volume 2, 2
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- Hogg R.V. and Craig A.T., (1978) An introduction to Mathematical Statistics, Third Edition,
 Amerind, New York, London.
- Rohatgi V.K., (1976), Introduction to Probability theory and Mathematical Statistics, Wiley
 Eastern Limited, New Delhi.
- 3 Lehmann E.L., (2005), Testing Statistical Hypothesis, 2nd Edition, Springer.

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- 1 https://nptel.ac.in/content/storage2/courses/103106120/LectureNotes/Lec3_1.pdf
- 2 https://nptel.ac.in/content/storage2/courses/103106120/LectureNotes/Lec1 3.pdf
- 3 <u>https://freevideolectures.com/course/3499/statistical-inference</u>
- 4 <u>http://www.stats.ox.ac.uk/~dlunn/b8_02/b8pdf_8.pdf</u>

		CLO-1	CLO-2	CLO-3	CLO-4	CLO-5	CLO-6	CLO-7
	Disciplinary Knowledge	\checkmark	~	~	~	~	√	~
$\mathbf{\hat{o}}$	Communication Skills		~	~			√	~
s (Pl	Critical Thinking	✓	~	~	✓	~	√	✓
come	Research related Skills	✓			✓	~	✓	
Out	Analytical Reasoning	✓		~	✓		√	✓
'evel	Problem Solving		~	~		~		✓
am I	Team Work		~		~	~	√	✓
Progr	Moral and Ethical Awareness		~		~		~	~
	Multicultural competence	\checkmark	~	~	~	~	\checkmark	✓

Year	SemSubjectCodeTitle of the Paper		Title of the Paper	Hours/ Week
2023-2024 onwards	III	23MST32C	CORE PAPER VIII – LINEAR MODELS AND DESIGN OF EXPERIMENTS	6

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

- Describe the theoretical underpinning of the linear model, analysis of variance and design of experiments.
- 2 Identify the type of any given experiment and the type of design apt for its analysis.
- 3 Explain the structure and applications of Randomized designs
- 4 Reproduce the advanced models in various designs
- 5 Apply various designs of experiments in several practical situations and evaluate its results.
- 6 Make further analyses which are specific to the objectives of any experiment.
- Create new types of designs as per the requirements and study their behavior while
 proceeding to the research.

Unit - I

Linear Models - Assumptions on Error Components - Fixed/Mixed and Random effect Models – Generalized linear model - Gauss-Markov setup – Estimation of parameters – Least square method – MLE method - Gauss-Markov theorem-BLUE – Linear parametric function and the condition for its estimability -Test for Linear Hypothesis.

Unit - II

Experimental Design - Basic Principles of Experimentation – Experimental Error – Review of CRD & RBD - LSD – Applications – Layout of LSD – Advantages and Disadvantages of LSD – Statistical Analysis of LSD – Least Square Estimates of parameters – Multiple comparison methods – Least Significant Difference method – DMRT and Tukey's Test.

Unit - III

Factorial Experiments – Introduction –Advantages and limitations – Main effects and interaction effects– Statistical Analysis of 2^2 and 2^3 Factorial Experiments – Yates method of computing 2^2 and 2^3 factorial totals. Analysis of 2^n Factorial Experiment - 3^2 Factorial Experiment - Confounding – Partial confounding and complete Confounding.

Unit - IV

Split Plot Design – Introduction – model description – Statistical Analysis – Advantages and Disadvantages. - Analysis of Covariance with one Concomitant variable – model – Least Square Estimates for parameters – Estimation of variance – Statistical analysis in CRD & RBD.

Unit - V

Incomplete Block Designs – Introduction – Balanced Incomplete Block Designs – Parametric Relationships – Symmetric BIBD – Statistical Analysis of Balanced Incomplete Block Designs (Intra Block only) - Partial BIBD.

PEDAGOGY STRATEGIES

- Lecturing
- Assignment
- Classroom Discussion
- Questioning
- Seminar
- Class Test
- Quiz & Drill Practice
- Providing feedback

REFERENCES:

S.C. Gupta and V.K. Kapoor (2015) : Fundamental of Applied Statistics – Sultan Chand & Sons.

Paneerselvam, R. (2012). Design and Analysis of Experiments, PHI Learning Private Ltd.,
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3 M.N. Das and N.P. Giri (2008) : Design and Analysis of Experiments, New Age International.

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- Graybill, F.A. (1961): An Introduction to Linear Statistical Models, McGraw Hill Co., London.
- Montgomery (2009) : Design and Analysis of Experiments, John Wiley & Sons (p) Ltd.
 Das, M. N., and Giri, N. C. (2011). Design and Analysis of Experiments, Second Edition,
- 3 New Age International Private Ltd., New Delhi

ELATED ONLINE CONTENTS [MOOC, SWAYAM, NPTEL, Websites etc.]

1 <u>https://nptel.ac.in/courses/110/105/110105087/</u>

					Course L	evel Outco	omes (CL	0)	
			1	2	3	4	5	6	7
	1	Disciplinary Knowledge	~	~	✓	~	\checkmark		
PLO)	2	Communication Skills	\checkmark	\checkmark	\checkmark		\checkmark	\checkmark	\checkmark
mes (3	Critical Thinking	\checkmark	\checkmark	\checkmark		~		
Jutcol	4	Research related Skills		\checkmark	\checkmark	\checkmark		\checkmark	
evel (5	Analytical Reasoning			\checkmark	\checkmark	\checkmark	\checkmark	\checkmark
ram I	6	Problem Solving	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark		
Prog	7	Team Work	\checkmark	\checkmark	\checkmark				\checkmark
	8	Moral and Ethical Awareness			\checkmark	✓		\checkmark	\checkmark
	9	Multicultural competence	\checkmark	\checkmark			~	\checkmark	
(

Year	Sem.	Subject Code	Title of the Paper	Hours/ Week
2023-2024 onwards	III	23MST33C	CORE IX: MULTIVARIATE ANALYSIS	6

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

- 1 Derive the Bi-variate and Multivariate normal distribution and estimate the mean vector and Covariance matrix.
- 2 Expertise on linear combination of random variables and Maximum Likelihood estimation of parameters of the multivariate normal distribution.
- 3 Discuss the Characteristic function and properties of Wishart distribution and know the derivation of generalized T-square distribution.
- ⁴ Assess Multiple Regression Analysis and its expansion.
- 5 Familiarize the multivariate statistical methods that include Factor Analysis and its application in diversified fields.
- 6 Describe the objectives and assumption on discriminant analysis and the problem of classification.
- 7 Possess through knowledge on Cluster analysis and its applications.

Unit - I

Multivariate Analysis: Introduction - Application of Multivariate techniques – Organisation of Multivariate data –Derivation of Bi-variate and multivariate normal distributions and its properties - Determination of mean vector and covariance matrix of Multivariate Normal Distribution - The mean vector and covariance matrix for Linear combinations of Random Variables – The maximum likelihood estimators of the mean vector and covariance matrix of Multivariate Normal Distribution.

Unit - II

Wishart Distribution: Introduction - Characteristic function and properties of Wishart Distribution. Generalized T-Square Statistic: Introduction – Derivation of the Generalized T-Square Statistic (Hotelling T Square) distribution – uses – applications. Hotelling T Square and Likelihood Ratio Tests.

Unit - III

Multiple Linear Regression: Introduction –Classical Linear Regression Model – Least Square Estimators - Inferences about the Regression Model – Inferences from the Estimated Regression Function – Model Checking and Other Aspects of Regression – Multivariate Multiple Regression.

Unit - IV

Principal Components: Objectives – Population Principal Components – Extraction of Principal Components.

Factor Analysis: Introduction – Model Description (The Orthogonal Factor Model) – Methods of estimation – Factor rotation - Factor Scores – Perspectives and a strategy for Factor Analysis.

Unit - V

Discriminant Analysis: Objectives and assumptions - Fisher's Discriminant Function - Problem of Classification with Two or More Populations.

Cluster Analysis: Objectives – Assumptions - Research design – Formation of clusters – Clustering algorithm.

PEDAGOGY STRATEGIES

- Lecturing
- Assignment
- Classroom Discussion
- Questioning
- Seminar
- Class Test
- Quiz & Drill Practice
- Providing feedback

REFERENCES:

Richard A. Johnson & Dean W. Wichern, (2012) Applied Multivariate Statistical Analysis:
 PHI Learning Private Limited, New Delhi (Sixth Edition).

Lawrence S. Meyers & Glenn Gamst&Guarino A.J, (2005), Applied Multivariate Research

2 Design and interpretation: Sage Publications, New Delhi.

FURTHER READING:

- Anderson T.W, (2011), An Introduction to Multivariate Statistical Analysis: Wiley India Pvt.Ltd, New Delhi (Third Edition).
- Hair, Black, Babin& Anderson &Tatham, (2005), Multivariate Data Analysis: Pearson
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RELATED ONLINE CONTENTS

- 1 https://nptel.ac.in/courses/111/104/111104024/
- 2 https://nptel.ac.in/courses/111/105/111105091/
- 3 https://nptel.ac.in/courses/106/106/106106139/
- 4 <u>https://www.udemy.com/topic/Multivariate-Analysis</u>

		CLO-1	CLO-	CLO-3	CLO-4	CLO-5	CLO-6	CLO-7
			2					
	Disciplinary Knowledge	\checkmark	✓		~	~	✓	✓
0	Communication Skills	✓	✓	\checkmark		✓		~
e (PL	Critical Thinking	✓			~	~	~	
tcom	Research related Skills		~	✓	~	~		
l Ou	Analytical Reasoning	\checkmark	✓	\checkmark		✓		
Leve	Problem Solving	√	~		~		~	~
ram	Team Work	√	~	~		~		
Prog	Moral and Ethical Awareness		~	~	√	√		✓
	Multicultural competence	√	~			~	~	

Year	Sem Subject Code		Title of the Paper	Hours/ Week
2023-2024 onwards	III	23MST34E	ELECTIVE III: NUMERICAL ANALYSIS	6

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

- 1 Discuss the types of errors in computation
- 2 Compute the various types of errors
- 3 Solve the Algebraic and Transcendental equations
- 4 Compute System of linear equations
- 5 Determine the numerical solution of initial value problems and boundary value problems.
- 6 Solve partial differential equations.
- 7 Know the applications of numerical Analysis

Unit - I

Errors in computation - Introduction –rules for estimating errors – Error propagation – Error and their Computations - Errors in the approximation of a function – Error in series approximation – order of approximation – growth of error. Application of numerical analysis in real life situations.

Unit - II

Solution of Algebraic and Transcendental equations – Bisection Method – Method of False position – Iteration method – Newton-Raphson method – Horner's method.

Unit - III

Solution of Linear system of equations – Gauss - elimination method – Gauss-Jordon method – Iterative methods – Gauss - Jacobi and Gauss – Seidal methods – Inverse of a matrix by Gauss – Elimination method

Unit - IV

Initial value problems for Ordinary Differential Equations – Introduction – Taylor series method – Euler's method – Modified Euler's method – Runge-Kutta methods – Predictor – Corrector methods – Adam's and Milne's method.

Unit - V

Numerical solution for Partial Differential Equations – Introduction – Finite Difference approximations to derivatives – Laplace's equation – Parabolic equations

PEDAGOGY STRATEGIES

- Lecturing
- Assignment
- Classroom Discussion
- Questioning
- Seminar
- Class Test
- Quiz & Drill Practice
- Providing feedback

REFERENCES:

Dr. B.S. Grewal (2000) - Numerical Methods in Engineering & Science, Fifth Edition, ,

1 Khanna Publishers, New Delhi.

S.S. Sastry(2013)- Introductory methods of Numerical Analysis, Fifth Edition, PHI Learning

2 Pvt Ltd, New Delhi.

FURTHER READING:

Dr.M.K. Venkataraman (2001) - Numerical Methods in Science and Engineering, Fifth Edition, The National Publishing Company, Chennai.

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https://www.ukessays.com/essays/computer-science/study-on-the-applications-of-

- 1 <u>numerical-analysis-computer-science-essay.php</u>
- 2 <u>https://nptel.ac.in/courses/111/107/111107063/</u>

		CLO-1	CLO-2	CLO-3	CLO-4	CLO-5	CLO-6	CLO-7
	Disciplinary Knowledge	✓	✓	✓	✓	✓	 ✓ 	✓
	Communication Skills	✓	\checkmark	✓	\checkmark	~	~	~
come (PLO)	Critical Thinking		\checkmark			✓	✓	~
	Research related Skills		~	~		~	✓	~
Out	Analytical Reasoning	~	~	~	\checkmark	✓	 ✓ 	✓
Level	Problem Solving		\checkmark	√			✓	×
Program	Team Work		\checkmark	~		~	✓	
	Moral and Ethical Awareness	~		~	~		~	
	Multicultural competence	\checkmark	\checkmark	~	~	\checkmark	\checkmark	 ✓

Year	Sem	Subject Code	Title of the Paper	Hours/ Week
2023-2024 onwards	IV	23MST41C	CORE PAPER X : STOCHASTIC PROCESSES	6

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

- 1. Compute n-step transition probability matrix and its long run probabilities.
- 2. Distinguish the states of a Markov chain.
- 3. Discuss the concept of branching process and to compute extinction probabilities.
- 4. Describe the concept of renewal process and its applications.
- 5. Forecast using various stationary time series techniques.
- 6. Identify the real-life situations where to apply the random processes.
- 7. Interpret the results of the random process studied.

Unit - I

Introduction to Stochastic Processes – Definition – Classification of Stochastic Processes According to State Space and Time Domain – Markov Process – Markov Chain – Countable State Markov Chain – Transition Probability Matrix – Chapman- Kolmogrov Equations – Calculation of 'n' Step Transition Probability Matrix.

Unit - II

Classification of States of a Markov Chain – Recurrent and Transient states – Criteria for Classification of the States – Random Walk with Absorbing and Reflecting Barriers – Probability of Absorption – Duration of Random Walk – Gambler's Ruin Problem.

Unit - III

Continuous Time Markov Chain- Kolmogrov's Differential Equations – Poisson Process – Pure Birth process - Birth and Death Process – Queuing Systems – Birth and Death Processes in Queuing Theory.

Unit - IV

Branching Process (one dimension only) – Definition – Generating Functions – Properties of Generating Functions of Branching Process. Brownian Motion - Concept of Weiner Process – Weiner Process as a Limit of Random Walk – Differential equations for a Weiner Process.

Unit - V

Renewal Process – Renewal Function and its Properties – Elementary Renewal Theorem – Strict and Wide Sense Stationary Processes with Examples – Basic Ideas of Time Series – Auto-Regressive and Moving Average Processes - Autoregressive Integrated Moving Average Processes.

PEDAGOGY STRATEGIES

- Lecturing
- Assignment
- Classroom Discussion
- Questioning
- Seminar
- Class Test
- Quiz & Drill Practice
- Providing feedback

REFERENCES:

- MEDHI. J (1994), Stochastic Processes, Wiley Eastern limited, New Delhi, Second Edition.
 KARLIN & TAYLOR (1975), A first course in Stochastic Processes, Vol. No.1, Second
- Edition, Academic Press, New York.
- HANKE, J.E & WICHERN, D.W. (2009), Business Forecasting, PHI Learning Pvt Limited,
 8th edition, New Delhi.

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 HYDE SHELDON M. ROSS (1995), Stochastic Processes, Wiley Series in Probability and Statistics, Second Edition. BHAT. B. R. (2004), Stochastic Models - Analysis and Applications: New Age international
 (P) Limited, New Delhi.

Adke, S. R., and Manjunath, S. A. (1984): An Introduction to Finite Markov Processes, Wiley Eastern, New Delhi.

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- 1 https://nptel.ac.in/courses/111/103/111103022/ Stochastic Processes-IIT Guwahati
- 2 <u>https://ocw.mit.edu/courses/mathematics/18-445-introduction-to-stochastic-processes-spring-2015/lecture-notes/</u>
- 3 https://www.stat.auckland.ac.nz/~fewster/325/notes/325book.pd

			Co	ourse Le	vel Out	comes (CLO)	
		1	2	3	4	5	6	7
	Disciplinary Knowledge	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark		
Level Outcomes (PLO	Multicultural Competence	\checkmark		\checkmark			\checkmark	~
	Self-directed learning	~	✓			~		~
	Reflective thinking		\checkmark	\checkmark	\checkmark		\checkmark	
	Analytical Reasoning				\checkmark	\checkmark	\checkmark	~
gram	Problem Solving	\checkmark	\checkmark	\checkmark	\checkmark	✓		~
Pro	Cooperation / Team work		√	\checkmark		✓	\checkmark	
	Moral and ethical awareness		✓	~		~	~	✓
	Multicultural competence	\checkmark	\checkmark	\checkmark		~	\checkmark	~

Year	Sem	Subject Code	Title of the Paper	Hours/ Week
2023-2024 onwards	IV	23MST42C	CORE XI – ECONOMETRICS	6

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

- 1 Describe the concepts of Econometrics, methodology and scope of Econometrics
- ² Derive Generalized Least Square estimators and its properties.
- ³ Address the problem of basic assumptions of GLS.
- ⁴ Focus on the problem of Identification and its conditions.
- ⁵ Find the solution for structural and reduced form models.
- ⁶ Obtain reliable and optimal solution under simultaneous equation models.
- ⁷ Classify and explore the econometric models in planning.

Unit - I

Preliminaries on Econometrics - Definition and Scope of Econometrics - Goals and Division of Econometrics - Specification and Estimation of the model - Evaluation of the parameter estimates - Forecasting power of the model - Desirable properties of an econometric model.

Unit – II - Ordinary Least Squares and Its Properties - Simple Linear Regression Model: OLS method of estimating the parameters - properties of OLS estimators. Multiple Regression: Model with two explanatory variables.

Unit – III - Auto correlation and Multicollinearity - Auto correlation - Assumptions of serial independence - Sources and Consequences of Auto correlation – Tests for Auto correlation. Multi-collinearity: Meaning - Consequences of Multi-collinearity - Tools for handling Multi-collinearity – Heteroscedasticity.

Unit - IV

Simultaneous Linear Equation Models - Identification - The problem of identification - Formal rules for identification - Identifying restrictions - Single and Simultaneous Equation methods -

Estimation of parameters – Indirect Least Squares - Two - Stage Least Squares.

Unit - V

Econometric Models in Planning - Asymptotic properties of Two - Stage Least Square Estimator - Limited Information Maximum Likelihood - Econometric Models in Planning - Harrod's growth model - Assumptions - Domar's model - Assumptions - Mathematical or equational form – Similarities and dissimilarities between Harrod and Domar Models.

PEDAGOGY STRATEGIES

- Lecturing
- Assignment
- Classroom Discussion
- Questioning
- Seminar
- Class Test
- Quiz & Drill Practice
- Providing feedback

REFERENCES:

- A. Koutsoyiannis, (1977) Theory of Econometrics, Second Edition, PALGRAVE, Replica
 Press Pvt. Ltd, India.
- 2 Johnson, J (1997)Econometric Methods, Fourth Edition, McGraw Hill.

FURTHER READING:

- 1 DamodarN.Gujarati and Sangeetha (2015) -Basic Econometrics, Fourth Edition, Tata 1 McGraw Hill Private Limited, New Delhi.
- S.P.Singh, Anil K. Parashar&H.P.Singh (1997) Econometrics and Mathematical Economics, 2
- Seventh Edition, S. Chand & Company Ltd, Ramnagar, New Delhi 110 055.
- 3 Wooldridge (2008) Introductory Econometrics, Fourth Edition, Cengage Learning, India

ELATED ONLINE CONTENTS [MOOC, SWAYAM, NPTEL, Websites etc.]

- 1 https://swayam.gov.in/nd2 cec20 ma10/preview
- 2 https://swayam.gov.in/nd1 noc19 ma29/preview
- 3 <u>https://nptel.ac.in/courses/112/106/112106131/</u>
- 4 https://nptel.ac.in/courses/112/106/112106134/

			Co	ourse Lev	el Outco	mes (CL	0)	
		CLO-1	CLO-2	CLO-3	CLO-4	CLO-5	CLO-6	CLO-7
	Disciplinary Knowledge	\checkmark	~	~	~	~	~	~
(0)	Communication Skills	~		~	~	~	~	~
comes (PI	Critical Thinking		~	~			~	
	Research related Skills	~		~		~	~	
l Out	Analytical Reasoning	~	~		~			~
Leve	Problem Solving		~	✓		✓	~	
Program	Team Work	~	~	~	~	~	~	~
	Moral and Ethical Awareness	~			~		~	~
	Multicultural competence		~		~	~	~	

PG Syllabus – 2023-24 onwards – Department of Statistics

Year	Sem	Subject Code	Title of the Paper	Hours/ Week
2023-2024 onwards	IV	23MST43C	CORE PAPER XII – ADVANCED OPERATIONS RESEARCH	6

COURSE LEVEL OUTCOMES:

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

- 1 Formulate a LPP for a given resources and able to solve it.
- 2 Compute the optimal solution for the industrial situations.
- 3 Apply the Non linear programming problem and arrive the optimal solution.
- 4 Solve the Queueing problems raised in various situations
- 5 Simulate the current events and predict the future behavior of the events
- 6 Identify the events and activities and solve it by Network analysis
- 7 Discuss the different decision making environment and make optimal decisions

Unit - I

Linear Programming Problem - Artificial variable techniques – Big M method - Two phase method – Concept of Duality – Primal and Dual relationships - Duality and Dual solution – Dual Simplex algorithm – Concept and Simple problems

Unit - II

Non-linear Programming - Introduction – General NLPP – Constrained optimization with equality constraints – Necessary and Sufficient conditions for a General NLPP - Constrained optimization with inequality constraints - Kuhn-Tucker Necessary and Sufficient conditions for General NLPP with m (< n) constraints – Graphical solution

Unit - III

Queuing Theory - Introduction – Queuing system – Elements and Operating characteristics of Queuing system – Pure Birth process – Pure Death process – Classification of Queuing models -Problems from Single Server: Infinite Population Model (M/M/1): (FCFS/ ∞/∞) and Finite Population Model (M/M/1): (FCFS/N/ ∞) - Problems from Multi Server: Infinite Population Model (M/M/C): (FCFS/ ∞/∞) and Finite Population Model (M/M/C): (FCFS/N/ ∞)

Unit - IV

Network Analysis - Network and Basic components – Logical Sequencing – Rules of Network construction – Fulkerson's rule – Critical Path Method – Total Float, Free Float and Independent Float - PERT algorithm – Differences between PERT and CPM – Cost considerations in PERT and CPM - Crashing.

Unit - V

Decision Analysis - Decision making environment – Decisions under uncertainty – Decisions under Risk – EMV, EOL and EVPI approach – Decision-Tree analysis.

Simulation - Introduction - Advantages and Disadvantages – Monte-Carlo method – Algorithm – Application of Simulation in Inventory and Queuing problems – Simple problems.

PEDAGOGY STRATEGIES

- Lecturing
- Assignment
- Classroom Discussion
- Questioning
- Seminar
- Class Test
- Quiz & Drill Practice
- Providing feedback

REFERENCES:

KantiSwarup, P.K. Gupta and Manmohan (2009)- Operations Research Sultan Chand & Sons, New Delhi,

V. Sundaresan, K.S. Ganapathy Subramanian, K. Ganesan(2000)- Resource Management
 Techniques, A.R. Publications, Tamil Nadu, New Revised Edition.

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1 Taha, H. A. (1982). Operations Research: An Introduction, 3rd Edition, McMillan Publishing

Co., Inc., London

- Sharma, S. D. (2017). Operations Research: Theory, Methods and Applications, KedarNath,
- 2 Ram Nath and Co, Meerut.
- 3 J.K. Sharma (2007) Operations Research Theory & Applications Macmillan India Ltd.

ELATED ONLINE CONTENTS [MOOC, SWAYAM, NPTEL, Websites etc.]

- <u>1</u> <u>https://nptel.ac.in/courses/111/107/111107128/</u>
- 2 https://nptel.ac.in/courses/112/106/112106134/
- 3 <u>https://onlinecourses.swayam2.ac.in/cec20_ma10/preview</u> COURSE LEVEL MAPPING OF PROGRAM LEVEL OUTCOMES

			(Course Le	vel Outco	mes (CL	0)	
		1	2	3	4	5	6	7
	Disciplinary Knowledge	\checkmark	✓	\checkmark	\checkmark	\checkmark		
(PLO)	Communication Skills	✓	~	~				\checkmark
omes	Critical Thinking	✓	✓	✓			\checkmark	\checkmark
Outc	Research related Skills		✓	✓	~		\checkmark	
Level	Analytical Reasoning			\checkmark	\checkmark	\checkmark		
gram	Problem Solving	\checkmark	✓	✓	~	✓		
Pro	Team Work	✓	✓	✓		✓	\checkmark	\checkmark
	Moral and Ethical Awareness	\checkmark	\checkmark		~	\checkmark		
	Multicultural competence	\checkmark	✓		\checkmark	✓		

Year	Sem	Subject Code	Title of the Paper	Hours/ Week
2023-2024 onwards	III& IV	23MST44P	CORE PRACTICAL – III : PRACTICAL – III	3

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

- 1 Apply the logical skills for performing statistical analysis
- 2 Solve numerical problems using different methods
- 3 Analyze and interpret the various design of experiments
- 4 Perform various tests of significance using multivariate data
- 5 Analyze the appropriate tests of significance.
- 6 Evaluate the critical region and power curves
- 7 Solve network and queuing problems
- 8 Simulate using monte-carlo technique

DESIGN OF EXPERIMENTS

- 1. Latin Square Design
- 2. 2^3 Factorial experiments
- **3.** 3^2 Confounding factorial experiments
- 4. Balanced Incomplete Block Design

NUMERICAL ANALYSIS

- 5. Newton Raphson Method
- 6. Gauss Elimination Method
- 7. Gauss Jacobi Method
- 8. Taylor Series
- 9. Runge-Kutta Method

MULTIVARIATE ANALYSIS

- 10. Estimation of Mean Vector and Covariance matrices
- 11. Hotelling's T^2 statistic testing for mean vector

- 12. Hotelling's T^2 statistic Testing for equality of means
- 13. Fisher's discriminant function
- 14. Principal component analysis

STATISTICAL INFERENCE – II (Testing of Hypothesis)

- 15. Critical regions and power curves concerning testing of hypothesis of the Normal distribution
- 16. Critical regions and power curves concerning testing of hypothesis of
- 17. Exponential distribution
- 18. Median test
- 19. Run test
- 20. Non-parametric test: Kolmogorov-Smirnov test one and two samples
- 21. Mann-Whitney U test

ADVANCED OPERATIONS RESEARCH

- 22. Critical Path Method
- 23. Program Evaluation and Review Technique
- 24. Queuing model: (M/M/1): $(FCFS/N/\infty)$
- 25. Monte Carlo Simulation
- 26. Critical Path Method

REFERENCES:

- S.C. Gupta and V.K. Kapoor (2015)- Fundamental of Applied Statistics, Fourth Edition, Sultan Chand &Sons ,New Delhi.
- Anderson T.W, (2011), An Introduction to Multivariate Statistical Analysis, Third Edition, Wiley India
 Pvt. Ltd, New Delhi.
- 3 P. Kandasamy, V. Thilagavathy, K. Gunavathi(2016)- Numerical Methods, S.Chand& Company Ltd, New Delhi.
- S.P. Gupta (2011) Statistical Methods, fortieth Revised Edition, Sultan Chand & Sons, New Delhi.
- 5 KantiSwarup, Gupta, P. K., and Man Mohan (2017) Operations Research, Nineteenth Edition, Sultan Chand & Sons, New Delhi.

FURTHER READING

- 1 Taha, H. A. (1982). Operations Research: An Introduction, Third Edition, McMillan Publishing Co., Inc., London.
- 2 R. PanneerSelvam(2012)- Design And Analysis of Experiments, Prentice Hall.
- 3 Richard A. Johnson & Dean W. Wichern(2012) Applied Multivariate Statistical Analysis, Sixth Edition, PHI Learning Private Limited, New Delhi

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

https://nptel.ac.in/courses/110/105/110105087/

https://nptel.ac.in/courses/111/107/111107063/

https://www.udemy.com/topic/Multivariate-Analysis

https://freevideolectures.com/course/3499/statistical-inference

		CLO-	CLO-	CLO-	CLO-	CLO-	CLO-	CLO-	CLO-
		1	2	3	4	5	6	7	8
	Disciplinary Knowledge	\checkmark	\checkmark	\checkmark	~	~	\checkmark	\checkmark	✓
(Communication Skills	\checkmark	\checkmark	~	~	~	✓	~	~
(PLC	Critical Thinking		~	✓	~	✓	~	~	~
come (Research related Skills		~	~	~	✓	~	~	~
Out	Analytical Reasoning	\checkmark	~	~	~	~	~	~	~
Level	Problem Solving	✓	~	~	~	~	~	~	~
Program I	Team Work	~	\checkmark		~	✓			
	Moral and Ethical Awareness	√	✓	✓	~		~	✓	
	Multicultural competence	\checkmark	\checkmark	\checkmark	\checkmark	 ✓ 	\checkmark	~	\checkmark

Year	Sem	Subject Code	Title of the Paper	Hours/ Week
2023-2024 onwards	III & IV	23MST45P	Core Practical – IV : PRACTICAL – IV (Using SPSS)	3

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

- 1. Apply the theory through practical oriented training.
- 2. Perform the basic operations of SPSS Package.
- 3. Utilize the SPSS package for Data Analytics.
- 4. Compute Parametric and Non-parametric Tests.
- 5. Fit the important probability distributions.
- 6. Analyse the given data using Correlation, Regression measures.
- 7. Perform analyses for various designs of experiment.

Using SPSS the students have to draw / analyze the given data using the following statistical techniques

- 1. Diagrammatic Representation (Multiple Bar, Pie-chart)
- 2. Descriptive Measures: Mean, Median, Mode, SD and Correlation Coefficient
- 3. Construction of Regression Equations SPSS
- 4. Chi-square test for independence of attributes
- 5. Factor Analysis
- 6. One-way ANOVA
- 7. Two-way ANOVA
- 8. 2³-Factorial Design
- 9. t-test for means
- 10. F-test for two variances
- 11. χ^2 test for Independence of Attributes
- 12. Fitting Binomial Distribution
- 13. Fitting Poison Distribution
- 14. Fitting Normal Distribution
- 15. Partial and Multiple Correlation Coefficients
- 16. Construction of Multiple Regression Equation
- 17. Fitting Linear Trend by Least Square method
- 18. Finding mean vector and covariance matrix
- 19. Construction of control charts for Mean and Range
- 20. Probability of Acceptance & drawing OC Curve using Poisson distribution
- 21. Kolmogorov Smirnov's one sample test
- 22. Kruskal-Wallis Test Independent samples.
- 23. Wilcoxon's signed rank test
- 24. Sign Test for Two Samples
- 25. Freedman's test 2-way ANOVA

Books for Further study:

- Landau, S., and Everitt, B.S. (2004). A Handbook of Statistical Analyses using SPSS, Chapman & Hall/CRC Press, New York
- Almquist, Y. B., Ashir, S., and Brännström, L. A Guide to SPSS: The Basics, Version 1.0.1, Stockholm University, Sweden.

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

- 1. <u>https://nptel.ac.in/courses/110/107/110107113/</u>
- 2. NPTEL :: Mathematics NOC: Non-parametric Statistical Inference

			Co	ourse Le	evel Out	comes (CLO)	
		1	2	3	4	5	6	7
	Disciplinary Knowledge	\checkmark	\checkmark	\checkmark		✓		
(PLC	Multicultural Competence	\checkmark		\checkmark			~	~
omes	Self-directed learning	~	✓					~
Level Outc	Reflective thinking		✓		~		~	
	Analytical Reasoning				✓		~	
gram	Problem Solving	~	✓	~	~	~	~	~
\Pr	Cooperation / Team work	~	✓	~	✓	~	~	~
	Moral and ethical awareness		✓	~		~		~
	Multicultural competence		√	\checkmark		~		~

M.C.A. Degree Course

		8						
Sub Code	Title of the Paper	Hrs (wk)	Internal (CA) Marks	External Marks	Total Marks	Ext- Min.	Total Pass Mark	Credits
	S	emester	– I					
23MCA25C	CORE PAPER V – PROBABILITY AND STATISTICS	4	50	50	100	25	50	5

(For the students admitted during the academic year 2023-2024 and onwards)

Year	Sem.	Subject Code	Title of the Paper	Hou rs/Week
2023-2024 onwards	II	23MCA25C	CORE PAPER V – PROBABILITY AND STATISTICS	4

COURSE LEVEL OUTCOMES:

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

- 1 Distinguish between different types of probability concepts.
- 2 Demonstrate an understanding of the basic concepts of random variables.
- 3 Discuss the concept of expectation and joint probability distribution of random variables.
- 4 Describe the main properties of probability distributions and its applications.
- 5 Exhibit different types of probability distributions with real life problems.
- 6 Apply the test of significance concept for large and small sample theories.
- 7 Identify the applications of z-test, t-test and Chi-Square test with appropriate examples.

UNIT - I

Probability - Basic Definitions - Mathematical Probability - Statistical Probability - Axiomatic Approach to Probability - Addition Theorem - Multiplication Theorem - Independent Events - Conditional Probability - Baye's Theorem - Simple Problems.

UNIT - II

Random Variables - Discrete Random Variable - Probability Mass Function - Continuous Random Variable - Probability Density Function - Simple Problems.

UNIT-III

Mathematical Expectation of a Random Variable – Properties of Expectation - Moment Generating Function - Joint Probability Distribution of Two-Dimensional Random Variables - Marginal and Conditional Distributions - Simple Problems.

UNIT-IV

Discrete Distributions - Binominal and Poison Distributions - Results and it's Applications - ContinuousDistributions - Rectangular (Uniform) and Normal Distributions - Results and it's Applications - Simple Problems. (No derivations).

UNIT- V

Tests of Significance for Large Samples - Basic Definitions - Normal Test of Single Mean and Difference of Means - Tests of Significance for Small Samples - t-Test for Single Mean and Difference of Means - Chi-Square Test for Independence of Attributes.

PEDAGOGY STRATEGIES

- Lecturing
- Classroom Discussion
- Questioning
- Seminar
- Assignment
- Class Test
- Quiz & Drill Practice
- Providing feedback

REFERENCES:

Gupta,S.C.andKapoor, V.K. (2018)-

1 FundamentalsofMathematicalStatistics,SultanChand&Sons, New Delhi, 11threvisedEdition.

Kapoor J. N. and Sexena H. C. (2011) – Mathematical Statistics - Sultan Chand & Sons.

FURTHER READING:

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HoggR.V and craig A.H. (2012) – Introduction to Mathematical Statistics, SeventhEdition, PearsonEducation.
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1

Gupta, S.P.(2014)-StatisticalMethods,SultanChand&Sons,NewDelhi,44th Thoroughly RevisedEdition.e

2

Rohatgi. V.K. – An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern, New Delhi.

3

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

- 1 https://nptel.ac.in/courses/111/105/111105041/
- 2 https://nptel.ac.in/courses/111/106/111106112/

https://www.dcpehvpm.org/E-

Content/Stat/FUNDAMENTAL%200F%20MATHEMATICAL%20STATISTICS-

³ S%20C%20GUPTA%20&%20V%20K%20KAPOOR.pdf

		CLO-1	CLO-2	CLO-3	CLO-4	CLO-5	CLO-6	CLO-7
Program Level Outcomes (PLO)	Disciplinary Knowledge	~	~	~	~	~	~	~
	Communication Skills			~	~	~		~
	Critical Thinking			✓	~	✓	~	
	Research related Skills		✓	~		~		✓
	Analytical Reasoning		✓	~		✓	~	
	Problem Solving	✓	~	~	✓	~	✓	~
	Team Work	✓	~	✓	~		~	~
	Moral and Ethical Awareness		~	~		~		~
	Multicultural competence		✓		✓	~		✓
Teaching Learning Processes

The teaching learning processes play the most important role in achieving the desired aims and objectives of the postgraduate programs in Statistics as elaborated in detail in the Learning Based Curriculum Framework (LOCF). Statistics is the science which deals with data collection, analysis and interpretation of numerical data. While such ideas and concepts originate in the minds of the genius, anywhere and anytime in the universe, their verifications and confirmations have to be done in the data analysis. To achieve this goal, the appropriate training of young individuals to become competent statisticians in future has to be accomplished. For this purpose, a competitive postgraduate program in Statistics is focused.

We have:

- Necessary and sufficient infrastructural facilities for the class rooms, laboratories and libraries, equipped with adequate modern and modular furniture and other requirements.
- Modern and updated computer laboratory equipment are needed for the undergraduate programme.
- Recent reference and text books for the libraries are to be updated
- Sufficient infrastructure for ICT and other facilities needed for technology-enabled learning like computer facilities, PCs, laptops, Wi-Fi and internet facilities with all the necessary software.
- Sufficient number of teachers in permanent position to do all the class room teaching and perform and supervise the computer laboratory experiments to be done by the students.
- All the teachers should be qualified as per the UGC norms and should have good communication skills.
- Sufficient number of technical and other support staff to run the laboratories, libraries, equipment and maintain the infrastructural facilities like buildings, electricity, sanitation, cleanliness etc.
- Teachers should make use of all the approaches for an efficient teaching-learning process i.e.,

(i) Class room teachings with lectures using traditional as well as electronic boards,

ii) Use of smart class rooms for simulation and demonstration for conveying the difficult concepts and tools of Statistics in class room teaching and laboratories,

(iii) Tutorials must be an integral part of all the theory and laboratory courses. Theory courses

should have 1-2 tutorials every week depending upon the nature of the course,

(iv) Teaching should be complimented with student's seminar to be organized very frequently,

(v) Guest lectures and seminars/workshops should be arranged by eminent teachers to be invited by the concerned college/university/HEI,

vi) Open-ended project work should be given to all students individually or in group to 2-3 students depending upon the nature of the course,

(vii) Special attempts should be made by the institution to develop problem-solving skills and design of Statistics projects for demonstration at the UG level. For this purpose, a mentor system may be evolved where 3-4 students may be assigned to each faculty member,

(viii) Teaching load should be managed such that the teacher has enough time to interact with the students to encourage an interactive/participative learning.

8. Assessment Methods

In the PG education of Statistics leading to the M.Sc. Statistics degree, the assessment and evaluation methods focus on testing the conceptual understanding of the Advanced Techniques, development of Statistical skills and experimental techniques retention and ability to apply the knowledge acquired to explain with analysis and reason what has been learnt and to solve new problems and communicate the results and findings effectively. Since the learning objectives are defined clearly for each course in detail, it is easier to design methods to monitor the progress in achieving the learning objectives during the course and test the level of achievement at the end of the course.

- The courses offered in the M.Sc. Statistics are the advanced courses at the college/ University level, the priority is given to Formative Assessment for monitoring the progress towards achieving the Learning Objectives while keeping its weightages lower than Summative Assessments. This is to assure that the students know their strengths and weaknesses periodically through the results of Formative Assessments and make amends for the gaps in their knowledge without affecting their final grades in any significant way.
- In this context it is suggested that 25-30% weightage be given to Formative Assessments in case of theory components while 30-40% weightage be given to the Laboratory/Field work/Projects/Case Study/Dissertation components of the various courses.
- Some of the methods suggested for Theory Component with regard to Formative

Assessment are i) Regular Tutorial assignments ii) Seminar presentations

iii) Performance in group discussions iv) Problem based longer assignments (other than tutorials) v) True/False Tests vi) Multiple Choice Tests vii) Short Answer Tests viii) viva-voce tests ix) Any other innovative tests in the context of the course.

- In the case of substantive Summative Assessment for the theory papers, can be a combination of the following i) Mid-Semester test ii) Seminar Report iii) Individual /Team Project report iv) Oral Presentations of Seminar/Projects v) Viva -Voce Examination on the above reports.
- End Semester closed book examination in the pattern of a) Multiple Choice b) Short Answer c) Long Answer. End Semester Open Book Examination in the form of a) Peer review by a group of experts by written and oral examinations, b) Any other innovative method depending upon the nature of the course.
- Laboratory Experiments / Field work / Projects / Case Study / Dissertation can be assessed for Formative Assessment through i) Regular evaluation of Lab. experiments regarding written report of each experiment and Viva-Voce on each experiment, ii) Mid semester examination.

9. Key Words

- Applied Statistics
- Analytical Reasoning
- Course Learning Outcomes
- Design of Experiments
- Disciplinary Knowledge
- Distribution Theory
- Econometrics
- Estimation Theory
- Graduate outcomes

- Operations Research
- Probability and Random Variables
- Program Learning Outcomes
- Qualification Descriptors
- Research-related Skills
- Sampling Theory
- Scientific Reasoning
- Skill Development
- Statistical Inference
- Statistical Quality Control
- Testing of Hypotheses.