MANONMANIAM SUNDARANAR UNIVERSITY, TIRUNELVELI

(For those candidates who joined 2023-2024 and onwards)

M.Sc., STATISTICS

(Choice Based Credit System)

1. Eligibility criteria for admission:

A candidate who has passed (i) B.Sc. Degree with Statistics / Data Science / Data Analytics / Bio-Statistics / Agricultural Statistics / Actuarial Statistics / Medical Statistics as the main subject or (ii) B.Sc., Degree with Mathematics / Computer Science / Information Technology as the main subject and Statistics as a core / allied / ancillary course with 45% Marks (40% in the case of SC/ST) in aggregate in Part III shall be permitted to join the course and to appear in the University examination and to qualify for the award of M.Sc., (STATISTICS) degree after a course of study of two academic years in the University Department of Statistics.

2. Admission Procedure:

Candidates shall be admitted for M.Sc., STATISTICS degree programme giving priority to the candidates of B.Sc., (Statistics / Data Science / Data Analytics) degree programme with 50% reservation in admission and remaining 50% to the eligible candidates of B.Sc., degree programme in Mathematics, Computer Science, Information Technology in view of promoting Statistics education in the jurisdiction of the University. When there arise vacant positions in either of the sections, the same vacant positions shall be filled with the candidates of other section following University Admission Guidelines and the reservation norms of the Government of Tamil Nadu.

3. Scheme of Examination:

Sem. **(1)**	**Cou. No.** **(2)**	**Course Status** **(3)**	**Course Title** **(4)**	**Contact Hrs./Week** **(5)**	**Credits** **(6)**
I	1	Core – 1	REAL ANALYSIS AND LINEAR ALGEBRA	3L+1T+1P	4
	2	Core - 2	SAMPLING METHODS	3L+1T+1P	4
	3	Core - 3	MEASURE AND PROBABILITY THEORY	3L+1T+1P	4
	4	Elective - I	CATEGORICAL DATA ANALYSIS / POPULATION STUDIES	2L+1T+1P	3
	5	Elective - II	STATISTICAL METHODS IN CLINICAL TRAILS / BAYESIAN INFERENCE	2L+1T+1P	3
	6	Practical- I	STATISTICAL COMPUTING WITH R	1L+2P	2
	7	AECC - 1	SOFT SKILLS – I	1L+1T	2
			Sub Total	**28 Hrs.**	**22**
II	8	Core - 4	ESTIMATION THEORY	3L+1T+1P	4
	9	Core - 5	DISTRIBUTION THEORY	3L+1T+1P	4
	10	Core - 6	TIME SERIES ANALYSIS	3L+1T+1P	4
	11	Elective-III	ACTURIAL STATISTICS / Simulation Analysis	2L+1T+1P	3
	12	Elective-IV	ECONOMETRICS / Survival Analysis	2L+1T+1P	3
	13	Practical- II	STATISTICAL COMPUTING WITH R/PYTHON	1L+2P	2
	14	ED - I*	SKILLS Enchantement (NPTEL/Swayam)	1L+1T	3
	15	AECC - 2	Value Added Course *(Certificate Course)*	1L+1T	-
			Sub Total	**30 Hrs.**	**23**

III	16	Core-7	TESTING OF HYPOTHESES	3L+1T+1P	4
	17	Core-8	LINEAR MODELS	3L+1T+1P	4
	18	Core-9	MULTIVARIATE ANALYSIS	3L+1T+1P	4
	19	Elective-V	OPERATIONS RESEARCH/ DBMS	2L+1T+1P	3
	20	CIM	STATISTICAL QUALITY CONTROL AND RELIABILITY THEORY (Core Industry Module)	2L+1T+1P	3
	21	Practical-III	STATISTICAL PRACTICAL USING SOFTWARE-I	1L+2P	2
	22	ED - II*	SKILLS Enchantement (NPTEL/Swayam)	1L+1T	3
	23	Internship	Internship / Industrial Activity (Carried out in Summer Vacation at the end of I year – 30 hours)	-	2
	24	AECC - 3	Value Added Course *(Certificate Course)*	1L+1T	-
Sub Total				**30 Hrs.**	**25**
IV	25	Core-10	DESIGN OF EXPERIMENTS	3L+1T+1P	4
	26	Core-11	STOCHASTIC PROCESSES	3L+1T+1P	4
	27	Core-12	MACHINE LEARNING TECHNIQUES	3L+1T+1P	4
	28	Practical-IV	STATISTICAL PRACTICAL USING SOFTWARE-II	1L+3P	3
	29	Core Project	PROJECT AND VIVA-VOCE	3L+1T	3
	30	PCSEC	Professional Competency Skill Enhancement Course (Training for Competitive Examinations)	2L+1T	2
	31	EA	EXTENSION ACTIVITY	-	1
Sub Total				**26 Hrs.**	**21**
Total				**114 Hrs.**	**91**

Total number of credits : 90 (Minimum)
Total number of Core Courses : 12
Total number of Elective Courses : 05
Total number of AECC : 03 (AECC-Ability Enhancement Compulsory Course)
Total number of ED courses : 02 (ED- Extra Disciplinary Courses)
Total Hours : 114 Hrs.

NOTE 1:

Practical exercises for the Courses 6, 13, 21 and 28 are from the Core and Elective courses taught in the respective Semesters.

NOTE 2:

*Students of M.Sc., (Statistics) should select Extra Disciplinary Courses offered by other Departments of the University.

NOTE 3:

L: LECTURE T: TUTORIAL P: PRACTICAL

NOTE 4:

4. List of Elective Courses (Major):

ELECTIVE – I: (Any one of the following may be opted)

(i) CATEGORICAL DATA ANALYSIS

(ii) POPULATION STUDIES

ELECTIVE – II: (Any one of the following may be opted)

(i) STATISTICAL METHODS IN CLINICAL TRIALS
(ii) BAYESIAN INFERENCE

ELECTIVE – III: (Any one of the following may be opted)

(i) ACTUARIAL STATISTICS

(ii) SIMULATION ANALYSIS

ELECTIVE – IV: (Any one of the following may be opted)

(i) ECONOMETRICS

(ii) SURVIVAL ANALYSIS

ELECTIVE – V: (Any one of the following may be opted)

(i) OPERATION RESEARCH

(ii) DATA BASE MANAGEMENT SYSTEM (DBMS)

5. Extra Disciplinary Courses for other Departments (not for Statistics students)

Students from other Departments may also choose any one of the following as Extra Disciplinary Course.

ED-I: Statistics for Social Sciences
ED-II: Statistics for Life Sciences
ED-III: Financial Mathematics
ED-IV: Optimization Techniques
ED-V: History of Statistics
ED-VI: Computational Statistics using R

6. Examination:

Each candidate admitted to the course will be examined in each course under Continuous Internal Assessment by the Course Teacher and by end semester University Examination. The weightage of marks of continuous Internal Assessment system and end semester University Examination shall be 25:75.

Each admitted candidate shall have to carry out a Major project work during the fourth semester under the supervision of a faculty member of the University Department of Statistics.

Each candidate shall have to prepare and submit the report of Major project work at the end of the fourth semester. The project report will be evaluated for a maximum of 80 marks. Each candidate shall appear for a Viva-Voce examination in the fourth semester for a maximum of 20 marks.

Each student shall be encouraged to publish a minimum of one research paper from his/her Major project in reputed journals/Conference Proceedings.

The question paper for end semester examination should be set as per the University guidelines. Tentative Pattern of question paper for end semester examination is hereunder.

QUESTION PAPER PATTERN FOR UNIVERSITY EXAMINATION

M.Sc., Degree Examination

Branch II – Statistics

Time: 3 Hours Max. Marks: 75

Section - A (10 × 1 =10)

Answer ALL the questions

Multiple choice questions (Each question carries 1 marks)

1. UNIT-I
2. UNIT-I
3. UNIT-II
4. UNIT-II
5. UNIT-III
6. UNIT-III
7. UNIT-IV
8. UNIT-IV
9. UNIT-V
10. UNIT-V

Section - B (5 × 5 = 25 Marks)

Answer ALL the questions

Each question carries 5 marks

11. (a) UNIT-I

(OR)

(b) UNIT-I

12. (a) UNIT-II

(OR)

(b) UNIT-II

13. (a) UNIT-III

(OR)

(b) UNIT-III

14. (a) UNIT-IV

(OR)

(b) UNIT-IV

15. (a) UNIT-V

(OR)

(b) UNIT-V

Section – C (5 × 8 = 40 marks)

Answer ALL the questions

Each question carries 8 marks

16. (a) UNIT-I

(OR)

(b) UNIT-I

17. (a) UNIT-II

(OR)

(b) UNIT-II

18. (a) UNIT-III

(OR)

(b) UNIT-III

19. (a) UNIT-IV

(OR)

(b) UNIT-IV

20. (a) UNIT-V

(OR)

(b) UNIT-V

7. Award of Degree

A candidate who has secured minimum of 50% marks in the end semester University Examination as well as 50% marks comprising both continuous Internal Assessment and end semester University Examination in each course shall be declared to have passed the M.Sc., degree programme in Statistics subject to the following:

- Each student shall earn a minimum of 90 credits from the Scheme of Examination, and shall earn additional 4 credits from any two of the MOOCs, each of at least 2 credits, offered by NPTEL, SWAYAM and e-PG-Pathshala approved by MHRD, Govt. of India. The student shall choose these courses, related to Statistics, Mathematics, Computer Science and other related disciplines for earning additional credits. These additional 4 credits shall be treated as non-scholastic, and shall not be considered for Ranking.

- The certificates for earning additional credits shall be issued by the University, wherever required.

A candidate who has secured minimum of 60% marks comprising both continuous Internal Assessment and end semester University Examination in aggregate shall be declared to have passed M.Sc., degree programme in Statistics with FIRST class.

M.Sc., Statistics Degree Programme

Programme Objectives

The M.Sc., Statistics degree programme offered by Manonmaniam Sundaranar University aims to

- Provide a strong foundation for research and higher studies
- Teach a wide range of statistical methods to enable the students deal with real world situations comprising uncertainty.
- Augment the ability of students to link statistical concepts and methods to interdisciplinary studies.
- Inculcate towards developing computer programs for carrying out complex statistical computations
- Expose towards to contemporary softwares of global standards
- Foster interests among students to work as Statistics and Data Analytics professionals.
- Prepare skilled human resource for the needs of Statistics personnel in public and private sector institutions.

Programme Specific Outcomes (PSOs)

On completion of the M.Sc., Statistics degree programme, the students will be able to

PSO1:	Plan sample surveys and scientific experiments and analyze the outcomes
PSO2:	Handle large and multiple data sets and describe their inherent properties employing acquired knowledge on statistics software
PSO3:	Select and apply appropriate statistical methods for analyzing any type of data
PSO4:	Understand and explain the hidden and intrinsic relationships among the characteristics in the data
PSO5:	Develop procedures for making optimal inferences in decision making situations
PSO6:	Solve mathematical problems applying statistical theory
PSO7:	Develop computer programs for complex scientific computations

Programme Outcomes (POs)

On completion of the M.Sc., Statistics degree programme, the students will be able to

PO1:	Pursue higher studies / research in Statistics
PO2:	Apply knowledge on statistical methods to the real-world problems and interdisciplinary studies
PO3:	Select and apply appropriate statistical methods for analyzing the high dimensional database and to make meaningful interpretations
PO4:	Draw optimal inferences in decision-making problems involving uncertainty
PO5:	Plan and conduct large scale sample surveys
PO6:	Develop computer programs and to use statistical software for carrying out statistical computations and data analysis
PO7:	Achieve success in national level competitive examinations and to work as Statistics personnel in public and private sector institutions

I SEMESTER

1. REAL ANALYSIS AND LINEAR ALGEBRA

Course Code	**NSTC 11**	**TITLE OF THE COURSE**	**L**	**T**	**P**	**C**
Core		**REAL ANALYSIS AND LINEAR ALGEBRA**	**3**	**1**	**1**	**4**
Prerequisites		Basics of Real Analysis and Matrix Theory	**Syllabus Version**		**2023-24**	

L: Lecture T: Tutorial P: Practical C: Credits

Course Objectives:

The main objectives of this course are to

- Impart the understanding of the concepts of real analysis and linear algebra
- Enhance the analytical ability of proving the theorems and solving the problems in real analysis and linear algebra
- Comprehend the concepts which are essential for learning other courses in the curriculum

Course Outcomes (COs):

At the end of this course of study, the student will be able to

CO No.	Course Outcome	Cognitive Levels
CO1	Investigate convergence of sequences and series of real valued functions	**K1, K2, K3**
CO2	Examine the differentiability and conditions for existence of maxima and minima and integrability of real valued functions	**K2, K4**
CO3	Apply the conditions for integrability of real valued functions	**K1, K5**
CO4	Understand finite dimensional vector spaces and to study their properties for real world situations	**K3, K4**
CO5	Analyze the properties of matrices from their eigenvalues and eigenvectors and to categorize quadratic forms and reduce them	**K3, K5**
CO6	Develop computer programs for carrying out computations related to the methods learnt in their course	**K1 –K6**
K1: *Remember* **K2**: *Understand* **K3**: *Apply* **K4**: *Analyze* **K5**: *Evaluate* **K6**: *Create*		

Course Outline:

UNIT I

Basics of open, closed and closure of sets, infimum, supremum and countability of sets, limit of sets – Bolzano-Weirstrass theorem. Convergence of sequences and series of real numbers – absolute and conditional convergence – Point-wise and uniform convergence – Tests for absolute, conditional and uniform convergence – Properties of uniform convergence.

[14 hours]

UNIT II

Real valued functions -Limits and continuity, algebra of continuous functions and uniform continuity – Differentiability and algebra of differentiable functions – Maxima and Minima of functions of one variable – mean value theorems, Taylor's theorem – Maxima and Minima of functions of two variables. [10 hours]

UNIT III

Riemann – Stieltjes sums – Riemann-Stieltjes integral – Properties and Evaluation – algebra of integrable functions - Fundamental theorem – Mean value theorems for integrable functions, integration by parts, Differentiation under integral sign – Leibnitz's rule - Improper integrals - Multiple integrals and their evaluation by repeated integration. [12 hours]

UNIT IV

Vector spaces and subspaces – linear dependence – dimension and basis of a vector space – linear transformation - Orthogonality – Orthonormal basis – Gram-Schmidt orthogonalization process – Inner product space – basic properties and simple problems. [11 hours]

UNIT V

Matrices – Rank, Trace and inverse of matrices – properties – Eigen values and Eigenvectors – Idempotent and partitioned matrices – Generalized inverse and its determination - Reduction of matrices into diagonal, echelon, canonical and triangular forms - Quadratic forms – Reduction and classification of quadratic forms – Sylvester's law of Inertia. [13 hours]

UNIT VI

Contemporary issues: Experts' lectures – online seminars and webinars. [2 hours]

Note 1: Students will be trained to develop appropriate computer programmes in *R* and *Python* related to computations taught in this course.

Total:62 hours

Note 2: Examination shall be conducted on contents of UNIT I through UNIT V only.

Books for Study:

1. Rudin, W. (1985): Principles of Mathematical Analysis (Third Edition). McGraw Hill, New York.
2. Ajith Kumar and Kumaresan. S (2014). A Basic Course in Real Analysis. CRC Press, Taylor & Francis Group, Florida.
3. Ramachandra Rao, A. and Bhimasankaram, P. (2000): Linear Algebra (Second Edition). Hindustan Book Agency, Hyderabad.

Books for Reference:

1. Apostol, T.M. (1974): Mathematical Analysis (Second Edition). Addison-Wesley, New York. (Twentieth Reprint, 2002).
2. Bartle, R.G. and Sherbert, D.R. (2011): Introduction to Real Analysis (Fourth Edition). John Wiley & Sons, New York.
3. Vasistha, A.R. (2005): Matrices. Krishna Prakashan Mandir, New Delhi.
4. Malik, S.C. and Arora, S. (2009). Mathematical Analysis (Second Edition). New Age Science Limited.
5. Rao, C.R. (1973). Linear Statistical Inference and Its Applications (Second Edition). Wiley Eastern Limited, New Delhi.

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

1. https://nptel.ac.in/courses/111106053
2. https://nptel.ac.in/courses/111105069
3. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=ZLCHeZEhCZ8yCri36nSF3A==_P03. Real analysis and measure theory

Mapping of Course Outcomes to Programme Outcomes

	PO1	*PO2*	*PO3*	*PO4*	*PO5*	*PO6*	*PO7*
CO1	High	Medium	High	High	Low	High	High
CO2	High	Medium	Medium	High	Low	High	High
CO3	High	Medium	Medium	High	Medium	High	High
CO4	High	High	High	Medium	Low	High	High
CO5	High	High	High	Medium	Low	High	High
CO6	High	High	High	High	Low	High	Medium
Correlation Levels:	*Low*	*Medium*	*High*				

Mapping of Course Outcomes to Programme Specific Outcomes (PSOs)

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**
CO1	Medium	High	High	High	Medium	High	High
CO2	Medium	High	Medium	High	Low	High	High
CO3	Medium	High	High	Medium	Medium	High	Medium
CO4	High	High	High	High	Medium	High	High
CO5	Medium	High	High	High	Low	High	High
CO6	High	High	High	High	High	Low	High
Correlation Levels:	*Low*	*Medium*	*High*				

2. SAMPLING TECHNIQUES

Course Code	**MSTC13**	**TITLE OF THE COURSE**	**L**	**T**	**P**	**C**
Core		**SAMPLING TECHNIQUES**	**3**	**1**	**1**	**4**
Prerequisites		Basic notions of sampling methods, Probability computation, Descriptive Statistics	**Syllabus Version**		**2023-24**	

L: Lecture T: Tutorial P: Practical C: Credits

Course Objectives:

The main objectives of this course are to

- introduce sampling techniques, which are used for random samples from finite population.
- develop skill to compute various estimators and their sampling errors and provide knowledge for conducting field surveys.
- study the properties of estimators in PPS, SRS, Cluster, Two-stage and Two-phase sampling.

Course Outcomes (COs):

At the end of this course of study, the student will be able to

CO No.	Course Outcome	Cognitive Level
CO1	understand the principles of sampling as a means of making inferences about a population	**K1 – K3**
CO2	understand the difference between randomization theory and model-based analysis	**K1, K6**
CO3	understand the concepts of bias and sampling variability and strategies for reducing these,	**K3, K5**
CO4	Conduct multi-stage surveys and analyze data,	**K4**
CO5	address the practical issues arising in sampling studies.	**K1, K6**
CO6	Apply various types of sampling methods for data collection through computer simulation and in practice	**K1 – K6**
K1: *Remember* **K2**: *Understand* **K3**: *Apply* **K4**: *Analyze* **K5**: *Evaluate* **K6**: *Create*		

Course Outline:

UNIT I

Population and Sample – Census and sample survey – sampling – sampling unit, sampling frame, sampling distribution, standard error, questionnaire and schedule, sampling design – sampling and non-sampling errors – non response and its effects – sample surveys – principles of sample survey - principal steps in sample survey - limitations of sampling – NSSO/CSO in India. [12 hours]

UNIT II

Simple Random Sampling (with and without replacement): Notations and terminology - Estimates of population total, mean and their variances and standard errors - determination of sample size - pooling of estimates – confidence limits – simple random sampling of attributes – interpenetrating sub-samples. [12 hours]

UNIT III

Stratified random sampling estimates of population total, mean and their variances - Related properties – Allocation of sample sizes – Neyman's proportional and optimum allocations - Comparison of stratified sampling with simple random sampling - Estimation of proportion under stratified random sampling. [12 hours]

UNIT IV

Systematic sampling: Estimates of population total, mean, and their variances and standard errors – systematic sampling with linear trend – comparison of systematic sampling with stratified and simple random sampling – circular systematic sampling -Two stage sampling with equal number of second stage units and cluster sampling. ` [12 hours]

UNIT V

Varying Probability Sampling: PPS sampling (with and without replacement) – gain due to PPS sampling – stratified PPS – selection procedures – ordered and unordered estimates – Desraj, Horwitz – Thompson and Murthy's estimates. Ratio Estimate – Methods of estimation, approximate variance of the Ratio Estimate - Regression Estimators – Difference Estimators, Regression Estimators in Stratified Sampling - Double sampling. [12 hours]

UNIT VI

Contemporary Issues: Expert lectures, online seminars – webinars. [2 hours]

Note 1: Students will be trained to develop appropriate computer programmes in *R* and *Python* related to computations taught in this course.

Total:62 hours

Note 2: Examination shall be conducted on contents of UNIT I through UNIT V only.

Books for Study

1. Ardilly, P and Yves T. (2006): Sampling Methods: Exercise and Solutions. Springer.
2. Cochran, W.G. (2007): Sampling Techniques (Third Edition). John Wiley & Sons, New Delhi.
3. Desraj (1976): Sampling Theory. Tata McGraw Hill, New York. (Reprint 1979)
4. Singh, D and Choudhary, F.S. (1977): Theory and Analysis of Sample Survey Designs. Wiley Eastern Ltd, New Delhi. (Reprint 1986).

Books for Reference:

1. Mukhopadhyay, P. (2007): Survey Sampling. Narosa Publisher, New Delhi.
2. Sukhatme, P.V. and Sukhatme, B.V. (1970): Sampling Theory Surveys with Applications (Second Edition). Iowa State University Press.
3. Thompson, S.K. (2012). Sampling. John Wiley & Sons.

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

1. MTH 432A: Introduction to Sampling Theory (http://home.iitk.ac.in/~shalab/course432.htm)
2. https://nptel.ac.in/courses/111/104/111104073/
3. https://nptel.ac.in/content/storage2/courses/111104073/Module14/Lecture42.pdf
4. https://www.mooc-list.com/tags/sampling-methods

Mapping of Course Outcomes to Programme Outcomes

	PO1	*PO2*	*PO3*	*PO4*	*PO5*	*PO6*	*PO7*
CO1	*High*	*Medium*	*High*	*Low*	*High*	*High*	*High*
CO2	*High*	*Medium*	*High*	*Low*	*High*	*High*	*High*
CO3	*High*	*High*	*Low*	*Medium*	*High*	*High*	*High*
CO4	*High*	*High*	*Medium*	*Medium*	*High*	*High*	*High*
CO5	*High*	*Medium*	*Medium*	*Medium*	*High*	*High*	*High*
CO6	*Medium*	*High*	*High*	*Medium*	*High*	*High*	*Medium*
Correlation Levels: *Low* *Medium* *High*							

Mapping of Course Outcomes to Programme Specific Outcomes

	PSO1	*PSO2*	*PSO3*	*PSO4*	*PSO5*	*PSO6*	*PSO7*
CO1	*Medium*	*Medium*	*High*	*High*	*High*	*High*	*High*
CO2	*Medium*	*High*	*Low*	*High*	*Low*	*High*	*High*
CO3	*Medium*	*High*	*High*	*Medium*	*Medium*	*High*	*Medium*
CO4	*High*	*High*	*High*	*High*	*Medium*	*High*	*High*
CO5	*High*	*High*	*Medium*	*Low*	*High*	*High*	*High*
CO6	*High*	*High*	*High*	*High*	*High*	*Low*	*High*
Correlation Levels: *Low* *Medium* *High*							

3. MEASURE AND PROBABILITY THEORY

Course Code	**NSTC 12**	**TITLE OF THE COURSE**	**L**	**T**	**P**	**C**
Core		**MEASURE AND PROBABILITY THEORY**	**3**	**1**	**1**	**4**
Prerequisites		Basic knowledge of set theory, convergence and random variables	**Syllabus Version**		**2023-24**	

L: Lecture T: Tutorial P: Practical C: Credits

Course Objectives:

The main objectives of this course are to

- inculcate knowledge on probability theory concepts in measure theoretic approach
- explore the concepts of random variable, distribution function, expectation and inequalities
- enhance the ability of proving theorems related to convergence of sequences of random variables and distribution functions
- inculcate the students with the practice of solving problems related to characteristic function and convergence properties of sequences of random variables and distribution functions

Course Outcomes (COs):

At the end of this course of study, the student will be able to

CO No.	Course Outcome	Cognitive Levels
CO1	Understand the concepts of measure theory and its properties	**K1, K2**
CO2	Understand and obtain the CDF, Expectations, Moments and Inequalities.	**K1-K3 and K5**
CO3	Describe the concepts of convergence and their implications.	**K2, K3**
CO4	Understand and analyze the importance of Independence and Law of large numbers	**K2, K4**
CO5	Describe and Derive the Central Limit Theorems and their application	**K1-K3**
CO6	Develop computer programs for determining, numerically, limiting distributions, investigating convergence of sequences of random variables and distribution functions	**K1 –K6**
K1: *Remember* **K2**: *Understand* **K3**: *Apply* **K4**: *Analyze* **K5**: *Evaluate* **K6**: *Create*		

Course Outline:

UNIT I

Classes of sets - ring - field - σ-field - minimal σ-field - Borel field - Measurable space - properties - Lebesgue measure and Lebesgue - Stieltjes measure - measure space, Probability space - probability measure – properties of probability measure- Measurable function. [12 hours]

UNIT II

Random variable – distribution function – discrete and continuous random variables – decomposition of distribution functions - Expectation and moments – properties –- Chebyshev's, Markov's, Holder's, Jensen's and Minkowski's inequalities - Characteristic function and its properties – inversion theorem and its applications – Uniqueness theorem – Khintchine - Bochner's theorem (statement only). [12 hours]

UNIT III

Independence of random variables - Convergence of sequences of random variables – convergence in probability, convergence in distribution, convergence in mean, almost sure convergence and their interrelationships. Weak and complete convergences of distribution functions – Helly-Bray lemma, Helly's first and second limit theorems (statement only) and their applications. [12 hours]

UNIT IV

Borel-Cantelli lemma – Kolmogorov's 0-1 law – three series theorem - Kolmogorov's inequality – Bernoulli's, Khintchine's weak law of large numbers - Kolmogorov's strong law of large numbers – Glivenko-Cantelli theorem (statement only). [12 hours]

UNIT V

Central limit theorems – De Moivre-Laplace central limit theorem, Lindeberg-Levy's central limit theorem, Liapunov's central limit theorem – Lindeberg - Feller's central limit theorem (statement only). Absolute continuity of measures - Radon-Nikodym theorem and derivative (without proof) – Conditional probability and conditional expectation – properties and applications. Product space – Fubini's theorem (statement only) and its applications.

[12 hours]

UNIT VI

Contemporary Issues: Expert lectures, online seminars – webinars. [2 hours]

Note 1: Students will be trained to develop appropriate computer programmes in *R* and *Python* related to computations taught in this course.

Total:62 hours

Note 2: Examination shall be conducted on contents of UNIT I through UNIT V only.

Books for Study:

1. Bhat, B.R. (1999): Modern Probability Theory (Third Edition). New Age International, New Delhi. (Reprint 2004)

2. Rohatgi, V.K. and Saleh, A.K.Md.E. (2011): An Introduction to Probability and Statistics (Second Edition). John Wiley & Sons, New York.

3. Bhuyan, K. C (2010). Probability Distribution Theory and Statistical Inference, New Central Book agency private ltd, Reprint, 2015

Books for Reference:

1. Billingsley, P. (2012): Probability and Measure (Third Edition). John Wiley & Sons, New York.
2. Feller, W. (2008): An Introduction to Probability Theory and Its Applications, Volume I (Third Edition), John Wiley & Sons, New York.
3. Feller, W. (1971): An Introduction to Probability Theory and Its Applications, Volume II, John Wiley & Sons, New York. (Reprint, 2008).
4. Basu, A. K. (2012). Measure Theory and Probability, Prentice Hall India Learning Private Limited, New Delhi.
5. Rana, I.K. (2005): An Introduction to Measure and Integration (Second Edition). Morgan & Claypool.
6. Ross, S.M. (2010): A First Course in Probability (Eighth Edition). Pearson Prentice Hall, New Jersey.
7. Breimann, L. (1992): Probability. SIAM, University of -California, Berkeley.

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

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=+u3y6UdbIvOJ97LFeSCmHQ== P-01.Probability I
2. https://nptel.ac.in/courses/111101004
3. https://nptel.ac.in/courses/111104079

Mapping of Course Outcomes to Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	*High*	*High*	*High*	*High*	*Medium*	*High*	*High*
CO2	*High*	*High*	*High*	*High*	*Medium*	*High*	*High*
CO3	*High*	*High*	*Medium*	*Medium*	*Low*	*High*	*High*
CO4	*High*	*High*	*High*	*Medium*	*Medium*	*High*	*High*
CO5	*High*	*Medium*	*Medium*	*High*	*Low*	*High*	*High*
CO6	*Medium*	*High*	*Medium*	*High*	*Low*	*High*	*High*
Correlation Level: *Low* *Medium* *High*							

Mapping of Course Outcomes to Programme Specific Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	*Medium*	*High*	*High*	*High*	*Medium*	*High*	*High*
CO2	*Medium*	*High*	*High*	*High*	*High*	*High*	*High*
CO3	*Medium*	*High*	*High*	*High*	*High*	*Low*	*Medium*
CO4	*High*	*High*	*High*	*High*	*High*	*High*	*Medium*
CO5	*Medium*	*High*	*High*	*Medium*	*Medium*	*High*	*High*
CO6	*High*	*High*	*High*	*High*	*High*	*Low*	*High*
Correlation Level: *Low* *Medium* *High*							

4. ELECTIVE - I: CATEGORICAL DATA ANALYSIS

Course Code	**TITLE OF THE COURSE**	**L**	**T**	**P**	**C**
Elective	**CATEGORICAL DATA ANALYSIS**	**2**	**1**	**1**	**3**
Prerequisites	Knowledge of Basic statistical analysis, Hypothesis testing, Probability theory, and Distribution theory	**Syllabus Version**		**2023-24**	

L: Lecture T: Tutorial P: Practical C: Credits

Course Objectives:

The main objectives of this course are to

- To study distributions for categorical data.
- To describe and make statistical inference for contingency tables.
- To learn different models for categorical data such as Generalized Linear, logit, logistic, log linear and matched pair models.

Course Outcomes (COs):

At the end of this course of study, the student will be able to

CO No.	Course Outcome	Cognitive Level
CO1	Understand models for Binary Response Variables and Fit logistic models and Poisson models to data set	**K2, K3**
CO2	Building and applying Log Linear Models for Binary Response Variables	**K1, K4**
CO3	Modelling repeated measurements and generalized estimating equations	**K1-K5**
CO4	Check model assumptions and analyze residuals and goodness-of-fit, Conduct inference for model parameters	**K2, K4**
CO5	Understand latent-class models and missing data approach	**K3, K5**
CO6	Develop computer programmes for problems related to this course	**K2 – K5**
K1: *Remember K2*: *Understand* **K3**: *Apply K***4**: *Analyze K***5**: *Evaluate* K**6**: *Create*		

Course Outline:

UNIT I

Models for Binary Response Variables, Log Linear Models, Fitting Log linear and Logic Models-Building and applying Log Linear Models, Log- Linear- Logit Models for Ordinal Variables. [12 hours]

UNIT II

Multinomial Reponse Models - Models for Matched Pairs- Analyzing Repeated Categorical Response Data - Asymptotic Theory for Parametric Models - Estimation Theory for Parametric Models. [12 hours]

UNIT III

Classical treatments of 2 and 3-way contingency tables, measures of association and nonparametric methods - Generalized linear models - Logistic regression for binary - multinomial and ordinal data - Log-linear models - Poisson regression- Modelling repeated measurements- generalized estimating equations. [12 hours]

UNIT IV

Introduction to contingency tables: 2 × 2and r × c tables - tests for independence and homogeneity of proportions - Fishers exact test - Odds ratio and Logit, other measures of association - Introduction to 3-way tables – full independence and conditional independence - collapsing and Simpsons paradox. [12 hours]

UNIT V

Polytomous logit models for ordinal and nominal response - Log-linear models (and graphical models) for multi-way tables - Causality, repeated measures, generalized least squares - mixed models, latent-class models, missing data, and algebraic statistics approach. [12 hours]

Note 1: Students will be trained to develop appropriate computer programmes in *R* and *Python* related to computations taught in this course.

Note 2: Examination shall be conducted on contents of UNIT I through UNIT V only.

Books for study:

1. Agresti, Alan (1996). An Introduction to Categorical Data Analysis, Wiley.
2. Bergsma, W., Croon, M.A. and Hagenaars, J.A. (2009). Marginal Models: For Dependent, Clustered, and Longitudinal Categorical Data. Springer.
3. Bishop, Y.M., Fienberg, S.E. and Holland, P.W. (1975). Discrete Multivariate Analysis: Theory and Practice, MIT Press.
4. Edwards, D. (2000). Introduction to Graphical Modeling (Second Edition). Springer.
5. Fienberg, S.E. (1980). The Analysis of Cross-Classified Categorical Data. MIT Press.
6. Wasserman, L. (2004). All of Statistics: A Concise Course in Statistical Inference. Springer.
7. Whittaker, J. (1990). Graphical Models in Applied Multivariate Statistics. Wiley.

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

1. https://archive.nptel.ac.in/noc/courses/noc22/SEM1/noc22-mg02/
2. https://archive.nptel.ac.in/noc/courses/noc22/SEM1/noc22-mg03/
3. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=fBYckQKJvP3a/8Vd3L08tQ==P-16. Data analytics

Mapping of Course Outcomes to Programme Outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	*High*	*Medium*	*Medium*	*Low*	*High*	*High*	*High*
CO2	*High*	*Medium*	*High*	*Low*	*High*	*High*	*High*
CO3	*High*	*High*	*High*	*Medium*	*High*	*High*	*High*
CO4	*High*	*High*	*Medium*	*Medium*	*High*	*High*	*High*
CO5	*High*	*Medium*	*Medium*	*Medium*	*High*	*High*	*High*
CO6	*Medium*	*High*	*High*	*Medium*	*Medium*	*High*	*Medium*
Correlation Levels: *Low* *Medium* *High*							

Mapping of Course Outcomes to Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO 6	PSO7
CO1	*Medium*	*Medium*	*High*	*High*	*High*	*High*	*High*
CO2	*Medium*	*High*	*Medium*	*High*	*High*	*High*	*High*
CO3	*Medium*	*Medium*	*High*	*Medium*	*Medium*	*High*	*Medium*
CO4	*High*	*High*	*High*	*High*	*Medium*	*High*	*High*
CO5	*Medium*	*High*	*Medium*	*Medium*	*Medium*	*High*	*High*
CO6	*High*	*High*	*High*	*High*	*High*	*Low*	*High*
Correlation Levels: *Low* *Medium* *High*							

5. ELECTIVE- II: STATISTICAL METHODS IN CLINICAL TRIALS

Course Code	**TITLE OF THE COURSE**	**L**	**T**	**P**	**C**
Elective	**STATISTICAL METHODS IN CLINICAL TRIALS**	**2**	**1**	**1**	**3**
Prerequisites	Basic knowledge in Descriptive Statistics and Inferential Statistics, Biostatistics and Demography	**Syllabus Version**		**2023-24**	

L: Lecture T: Tutorial P: Practical C: Credits

Course Objectives:

The main objectives of this course are to

- To learn and develop scientific view to study the statistical challenges of clinical trials.
- To learn the Epidemiological concepts of diseases
- To understand the concept of observational studies in Epidemiology.
- To enable to identify Clinical & Community trials in Experimental Epidemiology.

Course Outcomes (COs):

At the end of this course of study, the student will be able to

CO No.	Course Outcome	Cognitive Level
CO1	Understand the disease frequency and Mortality/Morbidity rates in clinical study	**K1, K2**
CO2	Understand the occurrence of diseases and models for transmission of infection.	**K2 - K6**
CO3	Apply various designs of clinical trials to the data	**K1-K5**
CO4	Describe optimal cross-over designs experiment with a continuous normally distributed outcome.	**K3, K5**
CO5	Evaluate the Mathematical Modeling in Epidemiology	**K3, K5**
CO6	Understand geographical spread of the disease and latent, infectious periods Estimation.	**K2 – K5**
K1: *Remember* **K2**: *Understand* **K3**: *Apply* **K4**: *Analyze* **K5**: *Evaluate* **K6**: *Create*		

UNIT I

Measures of disease frequency: Mortality/Morbidity rates- incidence rates- prevalence rates - Source of mortality morbidity statistics-hospital records - vital statistics records- Measures of accuracy or validity: sensitivity index - specificity index- Measure of Reliability. [12 hours]

UNIT II

Epidemiologic concepts of diseases: Factors which determine the occurrence of diseases - models of transmission of infection - incubation period - disease spectrum and herd immunity. [12 hours]

UNIT III

Observational studies in Epidemiology: Retrospective (case control) & prospective (cohort or longitudinal) studies - Measures of association: Relative risk, odds ratio, attributable risk- Statistical techniques used in analysis: Cornfield and Garts method - Mantel-Haenszel method- Conditional and unconditional matching - Analysis of data from matched samples, logistic regression approach. [12 hours]

UNIT IV

Experimental Epidemiology: Clinical & community trials - Statistical Techniques: Methods for comparison of two treatments - Crossover design with Garts and McNemars test - Randomization in a clinical trial - sequential methods in clinical trials - clinical life tables - assessment of survivability in clinical trials. [12 hours]

UNIT V

Mathematical Modeling in Epidemiology:(deterministic & stochastic) simple epidemic model - generalized epidemic model- Reed-Frost and Green-wood models - models for carrier borne and host vector diseases - Estimation of latent and infectious periods - geographical spread of the disease - simulation of an epidemic. [12 hours]

UNIT VI

Contemporary issues: Experts' lectures – online seminars and webinars. [2 hours]

Note 1: Students will be trained to develop appropriate computer programmes in *R* and *Python* related to computations taught in this course. **Total:**62 hours

Note 2: Examination shall be conducted on contents of UNIT I through UNIT V only.

Books for study:

1. Armitage. (1980): Sequential medical trials, Charles C. Thomas
2. Bailey, N.T.J. (1987): The Biomathematics of Malaria. Oxford University Press, Incorporated.
3. Fleiss, J.L. (1981): Statistical Methods for Rates and Proportions. John Wiley& Sons, Incorporated, New York.
4. Franeuthal. (1980): Mathematical Modernization in Epidemiology, Springer Verlag.

Books for Reference:

1. Gross and Clark. (1989): Survival Distributions- Reliability Application in Biomedical Sciences, University Microfilms.
2. Kahn, H.A. and C.T. Sempos. (2007): Statistical Methods in Epidemiology (Second Edition). Oxford University press, N.Y.
3. Kahn, H.A. (1983): An introduction to Epidemiologic methods. Oxford University press, N.Y. (Digitized 2007).
4. Lilienfeld and Lilenfeld. (1994): Foundations of Epidemiology (Third edition). Oxford Univ. Press.
5. Macmahon, B. and Pugh, T.E. (1970): Epidemiology-Principles and methods, Little, Brown and Co. Boston/Massachusetts.
6. Pocock, S.J. (2004): Clinical Trials - A Practical Approach, John Wiley.
7. Fletcher, R. and Fletcher, S.W. (2013). Clinical Epidemiology: The essentials. Lippincott Williams & Wilkins.
8. Rothman, K.J. (1986): Modern Epidemiology. Lippincott Williams & Wilkins.
9. Sackett, D.L (1991): Clinical Epidemiology- A Basic Science for Clinical Medicine. Little Brown.

Mapping of Course Outcomes to Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	High	Medium	Medium	Medium	High	High	High
CO2	High	High	Low	Low	High	High	High
CO3	High	High	Medium	Medium	High	High	High
CO4	High	High	Medium	Medium	High	High	High
CO5	High	Medium	Medium	Medium	High	High	High
CO6	High	High	High	Medium	High	High	Medium
Correlation Levels: *Low* *Medium* *High*							

Mapping of Course Outcomes to Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	Medium	Medium	High	High	Medium	High	High
CO2	Medium	High	Low	High	Medium	High	High
CO3	Medium	Low	High	Medium	Medium	High	Medium
CO4	High	High	High	High	Medium	High	High
CO5	High	High	Medium	Low	Low	High	High
CO6	High	High	High	High	High	Medium	High
Correlation Levels: *Low* *Medium* *High*							

6. PRACTICAL-I : STATISTICAL COMPUTING WITH R

7. SOFT SKILLS – I

II SEMESTER

8. ESTIMATION THEORY

Course Code	NSTC 21	TITLE OF THE COURSE	L	T	P	C
Core		ESTIMATION THEORY	3	1	1	4
Prerequisites		Knowledge of Real Analysis, Probability Theory and Distribution Theory	Syllabus Version		2023-24	

L: Lecture T: Tutorial P: Practical C: Credits

Course Objectives:

The main objectives of this course are to

- facilitate for investigating the properties of point estimators
- impart the application of various methods of finding point estimators
- inculcate construction of confidence intervals.

Course Outcomes (COs):

At the end of this course of study, the student will be able to

CO No.	Course Outcome	Cognitive Level
CO1	Apply data reduction technique in decision making problems and to evaluate the properties of point estimators	K1 & K2
CO2	Compute minimum variance bound, minimum variance unbiased and uniformly minimum variance unbiased estimators	K1 - K3
CO3	Find point estimators employing the frequentist and Bayesian approaches	K1 - K3
CO4	Analyze the asymptotic behavior of point estimators	K3 & K4
CO5	Construct confidence intervals applying various methods and to find shortest length confidence intervals	K1, K3 & K6
CO6	Develop computer programmes for computing point and interval estimates in real world problems	K1 – K6

K1: *Remember* **K2**: *Understand* **K3**: *Apply* **K4**: *Analyze* **K5**: *Evaluate* **K6**: *Create*

Course Outline:

UNIT I

Exponential family of distributions - Statistical decision problems – loss functions – 0-1, and squared error loss functions – risk function – Minimax decision. Amount of concentration, mean squared error and variance. Sufficiency criterion – Neyman-Fisher factorization theorem – minimal sufficiency – completeness – ancillary statistic – Basu's theorem. [12 Hours]

UNIT II

Unbiased estimator – estimable function – Rao-Blackwell theorem - UMVUE – Lehmann - Scheffe theorem - Fisher's Information measure and matrix. Cramer-Rao lower bound, Bhattacharya's lower bound and Chapman-Robbins lower bound - applications of lower bounds to the simultaneous estimation in bivariate normal distribution. [10 Hours]

UNIT III

Methods of estimation – Method of moments - method of minimum variance, minimum χ^2 and modified minimum χ^2 - Likelihood function and its plotting – method of maximum likelihood (excluding asymptotic properties of maximum likelihood estimators) – method of scoring and Newton-Raphson's method - Natural conjugate priors and Jeffreys non-informative prior – Bayes estimators under squared error loss function – Bayes risk. [14 Hours]

UNIT IV

Consistent and consistent asymptotically normal (CAN) estimators – consistency of estimators by the method of moments and the method of percentiles - Asymptotic properties of maximum likelihood estimators - Consistent asymptotically non-normal estimators - Information lower bound for asymptotic variance - Asymptotic relative efficiency. [10 Hours]

UNIT V

Interval estimation – pivotal quantity method - large sample method – applications of Chebyshev's inequality - Shortest length confidence interval - Construction of confidence intervals for population proportion (small and large samples) and difference between two population proportions (large samples) – confidence intervals for mean and variance of a normal population – confidence intervals for difference between means and ratio of variances of two normal populations. [14 Hours]

UNIT VI

Contemporary issues: Experts' lectures – online seminars and webinars. [2 hours]

Note 1: Students will be trained to develop appropriate computer programmes in *R* and *Python* related to computations taught in this course. **Total:**62 hours

Note 2: Examination shall be conducted on contents of UNIT I through UNIT V only.

Books for Study:

1. Mukhopadhyay, P. (2006). Mathematical Statistics (Third Edition). Books and Allied Pvt., Ltd., Kolkatta.
2. Rajagopalan, M. and Dhanavanthan, P. (2012): Statistical Inference. PHI Learning Pvt. Ltd., New Delhi.
3. Rohatgi, V.K. and Saleh, A.K.Md.E. (2011): An Introduction to Probability and Statistics (Second Edition). John Wiley & Sons, New York.

Books for Reference:

1. Berger, J.O. (1985): Statistical Decision Theory and Bayesian Analysis (Second Edition). Springer Verlag, New York.
2. Casella, G., and Berger, R.L. (2002): Statistical Inference (Second Edition). Thompson Learning, New York. (Reprint, 2007).
4. Gun, A.M., Gupta, M.K., and Dasgupta, B (1973): An Outline of Statistical Theory, Vol. II, World Press, Kolkata. (Reprint, 2019).
4. Kale, B.K. and Muralidharan (2005): A First Course in Parametric Inference (Second Edition). Narosa Publishing House, New Delhi. (Reprint, 2007).
5. Lehmann, E.L., and Casella, G. (1998): Theory of Point Estimation (Second Edition). Springer Verlag, New York. (Reprint, 2008).
6. Rao, C.R. (1973): Linear Statistical Inference and Its Applications (Second Edition). Wiley Eastern Ltd., New Delhi.
7. A.M. Mood, F.A. Graybill and D.C. Boes (2017): Introduction to the Theory of Statistics (Third Edition), McGraw Hill Education.

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

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=+u3y6UdbIvOJ97LFeSCmHQ=P-04. Statistical Inference (38).
2. https://nptel.ac.in/courses/111105043/Statistical Inference-IIT Kharagpur.
3. https://nptel.ac.in/courses/111105124/Statistical Inference-IIT Kharagpur

Mapping of Course Outcomes to Programme Outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	*High*	*Medium*	*Medium*	*High*	*Medium*	*Medium*	*High*
CO2	*High*	*Medium*	*Medium*	*High*	*Low*	*High*	*High*
CO3	*High*	*High*	*High*	*High*	*Medium*	*High*	*High*
CO4	*High*	*Medium*	*Medium*	*Medium*	*High*	*Medium*	*High*
CO5	*High*	*High*	*High*	*Medium*	*High*	*Medium*	*High*
CO6	*High*	*High*	*High*	*High*	*Medium*	*High*	*High*
Correlation Level: *Low* *Medium* *High*							

Mapping of Course Outcomes to Programme Specific Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO 7
CO1	*High*	*High*	*High*	*Medium*	*High*	*High*	*High*
CO2	*Medium*	*Medium*	*High*	*Low*	*High*	*High*	*High*
CO3	*High*	*High*	*High*	*Medium*	*High*	*High*	*High*
CO4	*High*	*High*	*Medium*	*Medium*	*Medium*	*High*	*High*
CO5	*High*	*Medium*	*High*	*High*	*Low*	*Medium*	*High*
CO6	*Medium*	*High*	*High*	*Medium*	*Low*	*High*	*High*
Correlation Level: *Low* *Medium* *High*							

9. DISTRIBUTION THEORY

Course Code	**NSTC 13**	**TITLE OF THE COURSE**	**L**	**T**	**P**	**C**
Core		**DISTRIBUTION THEORY**	**3**	**1**	**1**	**4**
Prerequisites		Knowledge of Probability Theory and Real Analysis	**Syllabus Version**		**2023-24**	

L: Lecture T: Tutorial P: Practical C: Credits

Course Objectives:

The main objectives of this course are to

- facilitate for acquiring knowledge on theoretical aspects of probability distributions
- understand relationships among statistical distributions
- inculcate the ability for carrying out statistical analysis of probability distributions.

Course Outcomes (COs):

At the end of this course of study, the student will be able to

CO No.	Course Outcome	Cognitive Level
CO1	Compute marginal and conditional distributions from joint distributions	**K1 – K3**
CO2	Obtain the distributions of functions of random variables	**K1, K6**
CO3	Describe the properties of univariate discrete and truncated distributions and their asymptotic results	**K3, K5**
CO4	Analyze the properties of univariate continuous distributions, their asymptotic results and bivariate normal distribution	**K4**
CO5	Derive the sampling distributions of Order Statistics; central, non-central sampling distributions and their asymptotic results	**K1, K6**
CO6	Develop computer programs for generating random numbers from various discrete and continuous distributions and determining probability distributions to real world situations	**K1 – K6**
K1: *Remember* **K2**: *Understand* **K3**: *Apply* **K4**: *Analyze* **K5**: *Evaluate* **K6**: *Create*		

Course Outline:

UNIT I

Basic distribution theory – Joint, marginal and conditional probability mass functions and probability density functions. Degenerate distribution. Standard distributions: Binomial, Poisson, multinomial and Normal probability distributions. Bivariate normal distribution – properties - asymptotic results – applications of IID random variables. [12 hours]

UNIT II

Functions of random variables and their distributions – Methods of finding distributions: Cumulative Distribution Function - Jacobian of transformation - Characteristic Function and Moment Generating Function – Unconditional and conditional expectation. [12 hours]

UNIT III

Discrete Uniform, Geometric, Negative binomial, Truncated binomial, Truncated Poisson, Power series and Logarithmic distributions – properties - asymptotic results – applications of IID random variables with real life problems. [10 hours]

UNIT IV

Continuous uniform, Exponential, Weibull, Laplace, logistic, log-normal, beta, gamma, and Cauchy distributions. Central-t, Central-F, central chi-square distributions – properties - asymptotic results – applications of IID random variables. [14 hours]

UNIT V

Non–central t - non–central chi-square - non-central F distributions and their properties – applications of IID random variables. Order statistics: Distribution of r^{th} order statistics – Joint distribution of order statistics - Distribution of sample range and median. [12 hours]

UNIT VI

Contemporary Issues: Expert lectures, online seminars – webinars. [2 hours]

Note 1: Students will be trained to develop appropriate computer programmes in *R* and *Python* related to computations taught in this course.

Total:62 hours

Note 2: Examination shall be conducted on contents of UNIT I through UNIT V only.

Books for Study:

1. Rohatgi, V.K. and Saleh, A.K.Md.E. (2011): An Introduction to Probability and Statistics (Second Edition). John Wiley & Sons, New York.
2. Mukhopadhyay, P. (2006). Mathematical Statistics (Third Edition). Books and Allied Pvt., Ltd., Kolkatta.

Books for Reference:

1. Johnson, N.L., Kemp, A.W. and Kotz, S. (2005): Univariate Discrete Distributions (Third Edition). John Wiley & sons, New York.
2. Johnson, N.L, Kotz, S. and Balakrishnan, N. (1994): Continuous Univariate Distributions. Vol. 1 (Second Edition). John Wiley & Sons (Asia), Singapore.
3. Johnson, N.L, Kotz, S. and Balakrishnan, N. (1995): Continuous Univariate Distributions. Vol. 2 (Second Edition). John Wiley & Sons (Asia), Singapore.
4. Karian, Z.A. and Dudewicz, E.J. (2011). Handbook of Fitting Statistical Distributions with *R*. Chapman & Hall.
5. Rao, C.R. (2009): Linear Statistical Inference and Its Applications (Second Edition). John Wiley & Sons.

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

1. https://swayam.gov.in/nd2_cec20_ma01/preview
2. https://nptel.ac.in/courses/111/104/111104032/

Mapping of Course Outcomes to Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	*Medium*	*High*	*High*	*High*	*Medium*	*High*	*High*
CO2	*High*	*High*	*High*	*High*	*High*	*High*	*High*
CO3	*High*	*High*	*Medium*	*Medium*	*Medium*	*High*	*High*
CO4	*High*	*High*	*High*	*Medium*	*High*	*High*	*High*
CO5	*High*	*High*	*Medium*	*High*	*Low*	*High*	*High*
CO6	*High*	*High*	*High*	*High*	*High*	*High*	*High*
Correlation Level: *Low* *Medium* *High*							

Mapping of Course Outcomes to Programme Specific Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	*Medium*	*High*	*High*	*High*	*Medium*	*High*	*Medium*
CO2	*Medium*	*High*	*High*	*Medium*	*High*	*High*	*High*
CO3	*High*	*High*	*High*	*High*	*High*	*High*	*Medium*
CO4	*High*	*High*	*High*	*High*	*High*	*High*	*Medium*
CO5	*High*	*Medium*	*High*	*Medium*	*Medium*	*High*	*High*
CO6	*High*	*High*	*High*	*High*	*High*	*Low*	*High*
Correlation Level: *Low* *Medium* *High*							

10. TIME SERIES ANALYSIS

Course Code	**TITLE OF THE COURSE**	**L**	**T**	**P**	**C**
Core	**TIME SERIES ANALYSIS**	**3**	**1**	**1**	**4**
Prerequisites	Knowledge of Statistical Methods for Data Analysis (statistical methods for analyzing data from experiments and surveys); linear regression models and their properties	**Syllabus Version**		**2023-24**	

L: Lecture T: Tutorial P: Practical C: Credits

Course Objectives:

The main objectives of this course is to

1. Provide time series models which are applicable in emerging fields such as signal processing, pattern recognition and weather forecasting.
2. Learn the Components of Time Series;
3. Describe the autocorrelation and auto covariance functions with their properties;
4. Impart knowledge on various stationary time series models;
5. Enables the student to forecast future values of the time series using MA, AR, ARMA, ARIMA models;
6. Learn basic concepts of spectral analysis and space-time models;

Course Outcomes (COs):

At the end of this course of study, the student will be able to

CO No.	Course Outcome	Cognitive Level
CO1	Understand and be able to apply the concepts and methods underlying the analysis of univariate time series, and the context for interpretation of results	**K1, K2**
CO2	A broad knowledge of time series analysis relevant for analyzing real time data.	**K1-K5**
CO3	Forecast using various stationary and nonstationary time series techniques.	**K2-K5**
CO4	Determine how and when to apply different methods of time series analysis and how to test for goodness of fit using the statistical software.	**K2, K4**
CO5	Use the Box-Jenkins approach to model and forecast time series data empirically.	**K1-K6**
CO6	Able to analyze the time series data	**K1-K6**
K1: *Remember* **K2**: *Understand* **K3**: *Apply* **K4**: *Analyze* **K5**: *Evaluate* **K6**: *Create*		

Course Outline:

UNIT I

Models of Time Series – Additive and Multiplicative models – Analysis and forecasting – Elimination of trend – growth curve – Modified experimental curve (Method of three selected points only) - Gompertz curve- Logistic curve with examples. [11 hours]

UNIT II

Stationary processes – Auto-covariance and autocorrelation functions and their properties – partial auto correlation function - Estimation of autocorrelation and its standard error–unit root test. [10 hours]

UNIT III

Linear stationary models - stationary and invertability - Autoregressive and Moving average processes and their autocorrelation functions- Autoregressive moving average processes.

Linear non-stationary models - Autoregressive integrated moving average processes – integrated moving average processes and Seasonal Autoregressive integrated moving average processes. [14 hours]

UNIT IV

Box-Jenkins models: Identification techniques - Initial estimates for different processes – AR, MA, ARMA - choice between stationary and non-stationary models – model diagnostic - model multiplicity - Study of residuals and diagnostic checking - Use of computer packages for the above techniques. [12 hours]

UNIT V

Introduction to spectral analysis of weakly stationary processes - periodogram and correlogram analysis including computations based on Fourier transform.

Use of spectral representation to show the existence of autoregressive processes and their representation as one-sided moving average processes. [13 hours]

UNIT VI

Contemporary issues: Experts' lectures – online seminars and webinars. [2 hours]

Note 1: Students will be trained to develop appropriate computer programmes in *R* and *Python* related to computations taught in this course.

Total:62 hours

Note 2: Examination shall be conducted on contents of UNIT I through UNIT V only.

Books for study:

1. Montgomery, D. C. and Johnson, L. A. (1977): Forecasting and Time Series analysis. McGraw Hill.
2. Anderson, T. W. (2011): The Statistical Analysis of Time Series. John Wiley & Sons.
3. Makridakis, Spyros; Wheelwright, Steven; Hyndman, Rob J. (1998) Forecasting: Methods And Applications, 3rd Edition

Books for Reference:

1. Bloomfield, P. (2004): Fourier analysis of Time Series - An introduction (Second Edition). John Wiley & Sons.
2. Box, G. E. P. and Jenkins, G.M. and Reinsel, G.C. (2013): Time Series Analysis - Forecasting and Control (Fourth Edition). Holden- Day, San Francisco.
3. Brockwell, P. J. and Davis, R. A. (2002): Introduction to Time Series and Forecasting. Taylor& Francis.
4. Chatfield, C. (1978): The Analysis of Time Series - Theory and Practice (Third Edition). Chapman and Hall, London.
5. Gupta, S. C. and Kapoor, V.K. (2007): Fundamentals of Applied Statistics (Fourth Edition). Sultan Chand & Sons Company, New Delhi.
6. Kendall, M. G. and Stuart, A. (1976): The advanced theory of Statistics, Vol.3, Charles Griffin, London.
7. Kendall, M. G. (1974): Time Series. Charles Griffin, London.

8. Koopmans, L. H. (1995): The spectral analysis of Time Series. Academic press.
9. Priestley, M. B. (1981): Spectral analysis and Time Series. Griffin, London.

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

1. https://epgp.inflibnet.ac.in/ahl.php?csrno=34, P-10. Stochastic Processes and Time Series Analysis.
2. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=+u3y6UdbIvOJ97LFeSCmHQ==P-10. Statistical processes and time series analysis

Mapping of Course Outcomes to Programme Outcomes

	PO1	*PO2*	*PO3*	*PO4*	*PO5*	*PO6*	*PO7*
CO1	*High*	*High*	*Medium*	*Medium*	*High*	*Medium*	*High*
CO2	*High*	*High*	*High*	*Medium*	*High*	*Medium*	*Medium*
CO3	*High*	*Medium*	*High*	*Low*	*High*	*Medium*	*High*
CO4	*Medium*	*High*	*High*	*Medium*	*High*	*Medium*	*Medium*
CO5	*High*	*High*	*Medium*	*Medium*	*High*	*Medium*	*High*
CO6	*High*	*High*	*Medium*	*Medium*	*High*	*Medium*	*High*
Correlation Level:	*Low*	*Medium*	*High*				

Mapping of Course Outcomes to Programme Specific Outcomes

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**
CO1	*Medium*	*High*	*High*	*High*	*Medium*	*High*	*High*
CO2	*Medium*	*High*	*Medium*	*High*	*High*	*High*	*High*
CO3	*Medium*	*High*	*High*	*High*	*High*	*High*	*Medium*
CO4	*High*	*High*	*High*	*High*	*High*	*High*	*Medium*
CO5	*Medium*	*High*	*High*	*Medium*	*Medium*	*High*	*High*
CO6	*High*	*High*	*High*	*High*	*High*	*Medium*	*High*
Correlation Level:	*Low*	*Medium*	*High*				

11. ELECTIVE- III: ACTUARIAL STATISTICS

Course Code	**TITLE OF THE COURSE**	**L**	**T**	**P**	**C**
Elective	**ACTUARIAL STATISTICS**	**2**	**1**	**1**	**3**
Prerequisites	Knowledge of Probability theory, Distribution theory and stochastic processes	**Syllabus Version**		**2023-24**	

L: Lecture T: Tutorial P: Practical C: Credits

Course Objectives:

The main objectives of this course are to

- To learn the life tables used in insurance products.
- To learn the concept of interest, different life insurance products, life annuities, net premiums.
- To motivate students to prepare for exams required for employment in the actuarial science profession

Course Outcomes (COs):

At the end of this course of study, the student will be able to

CO No.	Course Outcome	Cognitive Level
CO1	Understand the utility theory, insurance products and life tables	**K2, K3**
CO2	Know life annuities, net premium and net premium reserves	**K1, K4**
CO3	Understand the concept of life insurance and the existing insurance products of different insurance company.	**K1-K5**
CO4	Understand the concept of Contingent assurances.	**K2, K4**
CO5	Apply Capital sums on retirement in Pension Funds	**K3, K5**
CO6	Develop computer programmes for problems related to this course.	**K2 – K5**
K1: *Remember* **K2**: *Understand* **K3**: *Apply* **K4**: *Analyze* **K5**: *Evaluate* **K6**: *Create*		

Course Outline:

UNIT I

Mortality: Level, trend and differentials in mortality - forces of mortality - Gompetz and Makeham laws of mortality- Complete and abridged life tables-construction, interpretation - applications -stationary funds. [13 hours]

UNIT II

Annuities: Pure endowments - Annuities – Accumulations – Assurances - Varying annuities and assurances - Continuous annuities - family income benefits. [11 hours]

UNIT III

Policy Values: Nature of reserve - prospective and retrospective reserves - fractional premiums and fractional durations - modified reserves - Continuous reserves - Surrender values and paid up policies - Industrial assurance - Children's deferred assurances - Joint life and last survivorship. [13 hours]

UNIT IV

Contingent Functions: Contingent probabilities - Contingent assurances - reversionary annuities - multiple-decrement table -forces of decrement - construction of multiple decrement tables. [12 hours]

UNIT V

Pension Funds: Capital sums on retirement and death- widow's pensions - Sickness benefits - Benefits dependent on marriage. [11 hours]

UNIT VI

Contemporary issues: Experts' lectures – online seminars and webinars. [2 hours]

Note 1: Students will be trained to develop appropriate computer programmes in *R* and *Python* related to computations taught in this course.

Total:62 hours

Note 2: Examination shall be conducted on contents of UNIT I through UNIT V only.

Books for study:

1. Deshmukh, S.R., (2009). Actuarial Statistics: An introduction Using R. University Press. India.
2. Borowiak, D.S. and A. F. Shapiro. (2013). Financial and Actuarial Statistics: An Introduction (Second Edition). CRC press.

Books for Reference:

1. Barcley G.W. (1970): Techniques of Population Analysis. John Wiley, New York.
2. Donald, D.W.A. (1970): Compound interest and annuities (Second Edition). The Institute of Actuaries and the Faculty of Actuaries at the University Press.
3. King,G.Institute of Actuaries textbook, Part II, (Second Edition). Institute of Actuaries (Great Britain).
4. Spurgeon, E.T. (2011): Life Contingencies (3rd Edition). Cambridge University Press.

Mapping of Course Outcomes to Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	High	Medium	Low	Low	Low	High	High
CO2	High	Medium	Low	Low	Low	High	High
CO3	High	High	Low	Medium	Low	High	High
CO4	High	High	Medium	Medium	Low	High	High
CO5	High	Medium	Medium	Medium	Low	High	High
CO6	Medium	High	High	Medium	Low	High	Medium
Correlation Levels: *Low* *Medium* *High*							

Mapping of Course Outcomes to Programme Specific Outcomes (PSOs)

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	Medium	Medium	High	High	Low	High	High
CO2	Medium	High	Low	High	Low	High	High
CO3	Medium	Low	High	Medium	Medium	High	Medium
CO4	High	High	High	High	Medium	High	High
CO5	Low	High	Low	Low	Low	High	High
CO6	High	High	High	High	High	Low	High
Correlation Levels: *Low* *Medium* *High*							

12. Elective - IV: ECONOMETRICS

Course Code	**NSTC 33**	TITLE OF THE COURSE	**L**	**T**	**P**	**C**
Core		**ECONOMETRICS**	**2**	**1**	**1**	**3**
Prerequisites		Knowledge of Micro Economics, Estimation Theory, Hypotheses testing and Linear models.	**Syllabus Version**		**2023-24**	

L: Lecture T: Tutorial P: Practical C: Credits

Course Objectives:

The main objectives of this course are to

- provide the students with the basic principles of econometric models.
- enable the students to use economic methods in several areas like engineering sciences, biological sciences, medical sciences, geo-sciences, agriculture sciences etc.
- Inculcate the ideas of applications of econometrics
- Explore prominent estimation methods for linear regression model and simultaneous equation models
- focus on general linear models, generalized least square and various estimators of the parameters

Course Outcomes (COs):

At the end of this course of study, the student will be able to

CO No.	Course Outcome	Cognitive Level
CO1	Understand the basic concepts of Econometrics, methodology and limitations of using Econometric theory	K1 & K2
CO2	Derive Generalized Least square estimators and verifying the validity of essential assumptions.	K2 & K3
CO3	Forecast from Dynamic models and Evaluate order of Autocorrelation.	K3 & K5
CO4	Determine Simultaneous equations models for real world problems.	K3 & K4
CO5	Obtain and evaluate estimators applying Indirect least squares method, two-stage least squares method, K-Class estimators LIML and FIML.	K3 & K5
CO6	Develop computer programmes for construction and evaluation of Econometric models.	K1 – K6
K1: *Remember* **K2:** *Understand* **K3:** *Apply* **K4:** *Analyze* **K5:** *Evaluate* **K6:** *Create*		

Course Outline:

UNIT I

Nature and scope of Econometrics - Illustrative examples - Production and cost analysis - Theory and analysis of consumer demand specification - Estimation of demand function - Price and income elasticity of demand - Price elasticity of supply - Torquivists model of demand for inferior goods, bias in construction of models. [12 hours]

UNIT II

Single equation linear model: static case - Ordinary least square model and generalized least squares model: Introduction - estimation and prediction - Problem of multicollinearity and heteroscedasticity – Causes, consequences and solutions. [12 hours]

UNIT III

Autocorrelation: consequences and testing for auto-correlated disturbances- Autoregressive series of order 1 (AR(1)) - Lagged variables and distributed log methods - Errors in variable models and Instrumental variables - Forecasting. [12 hours]

UNIT IV

Simultaneous equations model- Concept, structure and types - Identification Problem with restrictions on variance and covariance - Rank and order conditions of identifiability –Methods of Estimation-Indirect least squares method, two-stage least squares method of estimation and Estimation of Limited Information Maximum Likelihood (LIML). [12 hours]

UNIT V

K-Class estimators - Full information estimators - Full Information Maximum Likelihood (FIML) - Three stage least squares estimators (3-SLS) and its Properties - Comparison of various estimation methods. [12 hours]

UNIT VI

Contemporary issues: Experts' lectures – online seminars and webinars. [2 hours]

Note 1: Students will be trained to develop appropriate computer programmes in *R* and *Python* related to computations taught in this course.

Total:62 hours

Note 2: Examination shall be conducted on contents of UNIT I through UNIT V only.

Books for Study:

1. Johnston, J. and DiNardo, J. (1997). Econometric Methods, McGraw-Hill.
2. Gujarati, D.N. and Sangeetha (2007). Basic Econometrics (Third Edition). McGraw Hill Publisher, New York.
3. Wooldridge, J. (2012). Introduction Econometrics: A Modern Approach. Cengage Learning.

Books for Reference:

1. Castle, J. and Shephard, N. (2009). The Methodology and Practice of Econometrics. OUP Oxford publications.
2. Goldberger, A.S. (1964): Econometrics theory. John Wiley & Sons, New Delhi.
3. Kelejion, H.H. and Oates, W.E. (1988). Introduction to Econometrics, Principles and Applications. Harper and Row Publishers Inc., New York.
4. Maddala, G.S. and KajalLagari (2009). Introduction to Econometrics. John Wiley & Sons.
5. Madnani, G.M.K. (2008): Introduction to Econometrics: Principles and Applications. Oxford and IBH Publishing.
6. A. Koutsyiannis.(2001) Theory of Econometrics(Second Edition). Palgrave Macmillan Publishing.

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

1. https://epgp.inflibnet.ac.in/home/viewsubject?catid=+u3y6udbivoj97lfescmhq==P-14. Econometrics and financial time series

Mapping of Course Outcomes to Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	*High*	*High*	*Medium*	*High*	*Medium*	*High*	*High*
CO2	*High*	*Medium*	*High*	*High*	*Medium*	*High*	*High*
CO3	*High*	*High*	*Medium*	*High*	*Medium*	*High*	*High*
CO4	*High*	*Medium*	*Medium*	*Medium*	*Medium*	*High*	*High*
CO5	*High*	*High*	*High*	*Medium*	*High*	*Medium*	*High*
CO6	*High*	*Medium*	*High*	*High*	*Medium*	*High*	*High*
Correlation Level:	*Low*	*Medium*	*High*				

Mapping of Course Outcomes to Programme Specific Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	*Medium*	*High*	*High*	*Medium*	*High*	*High*	*High*
CO2	*Medium*	*Medium*	*High*	*Medium*	*Medium*	*Medium*	*High*
CO3	*High*	*High*	*High*	*Medium*	*High*	*High*	*High*
CO4	*Medium*	*High*	*High*	*Medium*	*Medium*	*Medium*	*High*
CO5	*High*	*Medium*	*High*	*High*	*Low*	*Medium*	*High*
CO6	*Medium*	*High*	*High*	*Medium*	*Low*	*High*	*High*
Correlation Level:	*Low*	*Medium*	*High*				

13. Practical-II: STATISTICAL COMPUTING WITH R/PYTHON

14. ED-I: SKILLS Enhancement (NPTEL/Swayam)

15. Value Added Course

III SEMESTER

16. TESTING OF HYPOTHESES

Course Code	NSTC 31	TITLE OF THE COURSE	L	T	P	C
Core		TESTING OF HYPOTHESES	3	1	1	4
Prerequisites		Knowledge of Probability Theory, Distribution Theory and Estimation Theory	Syllabus Version		2023-24	

L: Lecture T: Tutorial P: Practical C: Credits

Course Objectives:

The main objectives of this course are to

- facilitate developing optimal decision-making procedures for testing various parametric hypotheses
- impart theory and applications of nonparametric methods for decision-making
- inculcate sequential testing methods for hypothesis testing problems

Course Outcomes (COs):

At the end of this course of study, the student will be able to

CO No.	Course Outcome	Cognitive Level
CO1	Formulate hypotheses testing problems	K1
CO2	Evaluate and to select appropriate parametric tests	K5
CO3	Develop most powerful, uniformly most powerful and uniformly most powerful unbiased, sequential probability ratio tests	K1 – K4
CO4	Construct a nontrivial test for any hypotheses testing problem	K3 & K6
CO5	Apply nonparametric methods for drawing inferences	K3
CO6	Develop computer programmes for numerical computations on hypotheses testing problems formulated for real-world problems	K1 – K6

K1: *Remember* **K2**: *Understand* **K3**: *Apply* **K4**: *Analyze* **K5**: *Evaluate* **K6**: *Create*

Course Outline:

UNIT I

Testing of hypotheses – fundamentals of hypotheses testing – randomized and nonrandomized tests - Most powerful test – Neyman-Pearson's fundamental lemma - Monotone likelihood ratio property – uniformly most powerful test - Applications to standard statistical distributions. [12 Hours]

UNIT II

Generalization of Neyman-Pearson fundamental lemma (statement only) - Unbiased tests – construction of uniformly most powerful unbiased tests for one-parameter and multi-parameter exponential family of distributions – applications to standard statistical distributions - Similar tests – Neyman structure - Locally most powerful and locally most powerful unbiased tests. [12 Hours]

UNIT III

Invariance – maximal invariant statistic – invariant test - Likelihood ratio test – asymptotic distribution of likelihood ratio test statistic – consistency of likelihood ratio test – construction of likelihood ratio tests for standard distributions - analysis of variance (one-way method) – Bartlett's test for homogeneity of variances. [12 Hours]

UNIT IV

U statistic and its properties. Nonparametric Tests: One-sample tests - tests for goodness of fit – χ^2 and Kolmogorov-Smirnov tests - tests for randomness – runs test - sign test and Wilcoxon's signed rank test. Two-sample tests - Kolmogorov - Smirnov's test - Mann-Whitney U test, median test. K-sample tests – Kruskal-Wallis test and Friedman's test. [12 Hours]

UNIT V

Need for sequential procedures in statistical inferential problems. Sequential probability ratio test – Wald's equation (statement only) - approximation to stopping bounds – Wald's fundamental identity (statement only) – operating characteristic and average sample number functions – applications to standard distributions – Termination property. [12 Hours]

UNIT VI

Contemporary issues: Experts' lectures – online seminars and webinars. [2 hours]

Note 1: Students will be trained to develop appropriate computer programmes in *R* and *Python* related to computations taught in this course. **Total:**62 hours

Note 2: Examination shall be conducted on contents of UNIT I through UNIT V only.

Books for Study:

1. Gibbons, J.D. and S. Chakraborti (2010): Nonparametric Statistical Inference (Fifth Edition). Taylor & Francis, New York.
2. Mukhopadhyay, P. (2006). Mathematical Statistics (Third Edition). Books and Allied Pvt., Ltd., Kolkata.
3. Rajagopalan, M. and P. Dhanavanthan (2012): Statistical Inference. PHI Learning Pvt. Ltd., New Delhi.
4. Rohatgi, V.K. and Saleh, A.K.Md.E.(2001): An Introduction to Probability and Statistics (Second Edition). John Wiley & Sons, New York. (Reprint, 2009).
5. Srinivastava and Srinivastava (2009): Statistical Inference: Testing of Hypotheses. PHI Learning Pvt. Ltd., New Delhi.

Books for Reference:

1. Casella, G. and Berger, R.L. (2002): Statistical Inference (Second Edition). Thompson Learning, New York. (Reprint, 2007).
2. Conover,W.J.(1999): Practical Nonparametric Statistics (Third Edition). John Wiley & Sons, New York. (Reprint, 2007).
3. Ghosh,B.K.(1970): Sequential Tests of Statistical Hypotheses. Addison-Wesley, New York.
4. Goon, A.M., Gupta, M.K. and Dasgupta, B. (1989): An Outline of Statistical Theory, Vol.II. World Press, Kolkata.
5. Lehmann, E.L. and Romano, J.P. (2005): Testing Statistical Hypotheses (Third Edition), Springer - Verlag, New York. (Reprint, 2009).
6. Rao, C.R. (1973): Linear Statistical Inference and Its Applications (Second Edition). Wiley Eastern Ltd., New Delhi.

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

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=+u3y6UdbIvOJ97LFeSCmHQ==P-05. Statistical inference II.
2. https://nptel.ac.in/courses/111105043/Statistical Inference-IIT Kharagpur.
3. https://nptel.ac.in/courses/111105124/Statistical Inference-IIT Kharagpur

Mapping of Course Outcomes to Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	*High*	*Low*	*Medium*	*High*	*Medium*	*Medium*	*Medium*
CO2	*High*	*Medium*	*Medium*	*High*	*Medium*	*High*	*High*
CO3	*High*	*High*	*High*	*High*	*Low*	*High*	*High*
CO4	*High*	*High*	*Medium*	*Medium*	*Low*	*High*	*High*
CO5	*High*	*High*	*High*	*Medium*	*Low*	*High*	*High*
CO6	*High*	*High*	*High*	*High*	*High*	*High*	*High*
Correlation Level:	*Low*	*Medium*	*High*				

Mapping of Course Outcomes to Programme Specific Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	*Medium*	*Medium*	*High*	*High*	*Medium*	*Medium*	*Medium*
CO2	*High*	*High*	*High*	*Medium*	*High*	*High*	*High*
CO3	*High*	*High*	*High*	*Medium*	*High*	*High*	*High*
CO4	*Medium*	*High*	*High*	*Medium*	*High*	*High*	*High*
CO5	*Medium*	*High*	*High*	*Medium*	*Medium*	*Low*	*High*
CO6	*High*	*High*	*High*	*High*	*High*	*Low*	*High*
Correlation Level:	*Low*	*Medium*	*High*				

17. LINEAR MODELS

Course Code	--	TITLE OF THE COURSE	L	T	P	C
Core	--	LINEAR MODELS	3	1	1	4
Prerequisites		Basic knowledge of Linear Algebra, Linear regression models, Estimation and Testing of Hypotheses	Syllabus Version		2023-24	

Course Objectives:

The main objectives of this course are to:

- To model cross sectional data using minimum number of parameters
- To estimate unbiased estimators for model parameters
- To estimate standard errors of estimates to construct the confidence intervals.
- To test the goodness of fit of the models

Course Outcomes (COs):

At the end of this course of study, the student will be able to

CO No.	Course Outcome	Cognitive Level
CO1	Understand the need and basic concepts of statistical modeling	K2
CO2	Remember the basic principles of linear models	K1,K2
CO3	Identify the model for the given cross-sectional data	K1,K2,K5
CO4	Formulate and analyses the given model	K4,K6
CO5	Apply the concept of linear models and interpret the model based on the variables involved	K3,K4
CO6	Develop computer programmes to analyze the outcomes of linear models for real world problems.	K1-K6
K1: Remember K2**:** Understand **K3:** Apply **K4:** Analysis **K5:** Evaluate K**6:** Create		

UNIT I

Linear Models – Classification, Estimability. The General Linear Hypothesis of Full Rank – Point Estimation (Estimation Under Normal Theory) – Gauss–Markov theorem, Tests of Hypothesis – Testing the Hypothesis $\beta = \beta^*$. [12 hours]

UNIT II

Introduction to Generalized Linear Models: Components of Generalized Linear Model, Binomial Logit Model, Poisson Loglinear Model, Deviance, Linear Probability Model, Logistic Regression Model, Probit and Inverse CDF Link Function, GLM for Counts, Inference for GLM, Deviance and Goodness of Fit, Deviance for Poisson and Binomial Models. [12 hours]

UNIT III

Methods of Estimations – ordinary least squares, generalized least square, maximize likelihood, BLUE. [12 hours]

UNIT IV

General Linear Hypothesis – four common hypotheses – reduced models – null model – saturated model. [12 hours]

UNIT V

Regression and dummy variables – grouped variables – unbalanced data - describing linear models- 1-way classification, 2- way classification, 3-way classification – main and interaction effects - Models not of full rank. [12 hours]

UNIT VI

Contemporary issues: Experts' lectures – online seminars and webinars. [2 hours]

Note 1: Students will be trained to develop appropriate computer programmes in *R* and *Python* related to computations taught in this course.

Total:62 hours

Note 2: Examination shall be conducted on contents of UNIT I through UNIT V only

Books for study:

1. S.R. Searle, Linear Models, John Wiley, 1971.

Books for Reference:

1. Alan Agresti, (2002): Categorical Data Analysis, WileyInterscience, John Wiley& Sons.

2. Radhakrishna Rao, "Linear Statistical Inference and its Applications" Wiley- Interscience, 2ed | 2001 | ISBN: 0471218758

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

1. Https://epgp.inflibnet.ac.in/home/viewsubject?catid=+u3y6udbivoj97lfescmhq== p-03. Design of experiments and sample surveys.
2. https://nptel.ac.in/courses/102106051

Mapping of Course Outcomes to Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	*High*	*Medium*	*High*	*High*	*Medium*	*High*	*High*
CO2	*High*	*High*	*High*	*High*	*High*	*High*	*High*
CO3	*High*	*High*	*Medium*	*Medium*	*Medium*	*High*	*High*
CO4	*High*	*High*	*High*	*Medium*	*High*	*High*	*High*
CO5	*High*	*Medium*	*Medium*	*High*	*Low*	*High*	*High*
CO6	*Medium*	*High*	*High*	*High*	*High*	*High*	*High*
Correlation Level: *Low* *Medium* *High*							

Mapping of Course Outcomes to Programme Specific Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	*Medium*	*Medium*	*High*	*High*	*Medium*	*High*	*High*
CO2	*Medium*	*High*	*High*	*High*	*High*	*High*	*High*
CO3	*Medium*	*High*	*High*	*High*	*High*	*High*	*Medium*
CO4	*High*	*High*	*High*	*High*	*High*	*High*	*Medium*
CO5	*Medium*	*High*	*High*	*Medium*	*Medium*	*High*	*High*
CO6	*High*	*High*	*High*	*High*	*High*	*Low*	*High*
Correlation Level: *Low* *Medium* *High*							

18. MULTIVARIATE ANALYSIS

Course Code	**NSTC 32**	**TITLE OF THE COURSE**	**L**	**T**	**P**	**C**
Core		**MULTIVARIATE ANALYSIS**	**3**	**1**	**1**	**4**
Prerequisites		Pre-requisite: Linear Algebra, Distribution Theory, Estimation Theory and Testing of Hypotheses	**Syllabus Version**		**2023-24**	

L: Lecture T: Tutorial P: Practical C: Credits

Course Objectives:

The main objectives of this course are to

- Acquaint students with the basic ideas, applicability and methods of multivariate data analysis.
- Understand the main features of multivariate data, to use exploratory and confirmatory multivariate statistical methods properly and to carry out multivariate statistical techniques and methods efficiently and effectively.
- Multivariate normal distribution and its characterizations, estimators of the parameters and testing of hypothesis about these parameters, Multivariate linear regression model, classification and discriminate procedures and Principal Component Analysis.

Course Outcomes (COs):

At the end of this course of study, the student will be able to

CO No.	Course Outcome	Cognitive Level
CO1	Identify the need for multivariate statistical techniques and study about the characteristics of Multivariate Distributions	**K1, K2**
CO2	estimation of Parameter to the multivariate normal distribution and necessary and sufficient conditions for a quadratic form.	**K3, K5**
CO3	Recognize the appropriate multivariate method for a problem and relationships between T^2 and D^2 distributions	**K2, K5**
CO4	Idea about Wishart distribution and its properties, Correlation coefficients and discriminant function.	**K1, K4**
CO5	Employ statistical software to conduct the appropriate analysis.	**K5, K6**
CO6	Develop computer programmes for numerical computations and multivariate techniques.	**K1 – K6**
K1: *Remember* **K2**: *Understand* **K3**: *Apply* **K4**: *Analyze* **K5**: *Evaluate* **K6**: *Create*		

Course Outline:

UNIT I

Multivariate normal distribution and its properties - Marginal and conditional distributions - Characteristic function and moments - Distribution of linear combinations of multivariate normal vector - Determination of mean and variance - covariance matrix of multivariate normal distribution. [12 hours]

UNIT II

Random Sampling from multivariate normal distribution - Maximum likelihood estimators of the parameters of multivariate normal distribution - distribution of sample mean vector and sample dispersion mean vector - Necessary and sufficient conditions for a quadratic form to be distributed as chi-square – Cochran's theorem - Inference concerning the sample mean vector when covariance matrix is known. [12 hours]

UNIT III

Generalized T^2 statistic and its distribution - Hotelling's T^2 statistic and its distribution - Two sample problems with unequal covariance matrices likelihood ratio criterion and its applications - Mahalanobis D^2 statistic and its distribution - Applications of Hotelling's T^2 Statistic - Invariance property of T^2 statistic - Relationship between T^2 and D^2 statistics – Behrens – Fisher Problem. [12 hours]

UNIT IV

Wishart distribution (without derivation) - Sampling distribution of sample covariance matrix - Properties of Wishart distribution - Wilk's criterion - Generalized variance (Concept only) - Sampling distribution of simple sample correlation coefficient - Sampling distribution of partial and multiple correlation coefficients in null case (without derivation) - Tests concerning simple, partial and multiple correlation coefficients - Discriminant function (concept only) - Fisher's discriminant function. [13 hours]

UNIT V

Problem of classification - Two populations and k populations - Principal components and their determination - Factor analysis – estimation of factor loadings - Canonical variables and canonical correlations - Derivation of canonical correlation coefficients – Cluster Analysis - Formation of Clusters –Similarity matrix and distance measures - hierarchical clustering Algorithms. [11 hours]

UNIT VI

Contemporary issues: Experts' lectures – online seminars and webinars. [2 hours]

Note 1: Students will be trained to develop appropriate computer programmes in *R* and *Python* related to computations taught in this course.

Total:62 hours

Note 2: Examination shall be conducted on contents of UNIT I through UNIT V only.

Books for Study:

1. Anderson, T.W. (2003): An Introduction to Multivariate Statistical Analysis (Third Edition). Wiley–Inter science, New York.
2. Johnson, R.A. and D.W. Wichern. (2013). Applied Multivariate Statistical Analysis (Sixth Edition), Pearson New International Edition.
3. Rencher, A.C. and W.F. Christensen (2012): Methods of Multivariate Analysis (Second Edition). Wiley-Interscience, New York.
4. N.C. Giri (2003): Multivariate Statistical Analysis (Second Edition). CRC Press, Florida.

Books for References:

1. Kotz, S., Balakrishnan, N. and Johnson, N.L. (2000): Continuous Multivariate Distribution Models and Applications (Second Edition). Vol. 1, Wiley-Inter science, New York.
2. Mardia, K.V., Kent, J.T and Bibby, J.M. (1979): Multivariate Analysis. Academic Press, New York.
3. Morrison, D.F. (2004): Multivariate Statistical Methods (Fourth Edition). Duxbury Press, New York.
4. Rao, C.R. (2001): Linear Statistical Inference and its Applications (Second Edition). Wiley-Inter Science, New York.
5. Kendall, M.G., Stuart, A. and Ord, K.J. (1973): The Advanced Theory of Statistics. (Fourth Edition), Vol. 2, Charles Griffin company Ltd.

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

STAT 505: Applied Multivariate Statistical Analysis (https://online.stat.psu.edu/stat505/)

1. https://epgp.inflibnet.ac.in/home/viewsubject?catid=+u3y6udbivoj97lfescmhq== P-11. Multivariate analysis
2. https://nptel.ac.in/courses/111104024.

Mapping of Course Outcomes to Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	*High*	*Medium*	*Low*	*Low*	*Low*	*High*	*High*
CO2	*High*	*Medium*	*Low*	*Low*	*Low*	*High*	*High*
CO3	*High*	*High*	*Low*	*Medium*	*Low*	*High*	*High*
CO4	*High*	*High*	*Medium*	*Medium*	*Low*	*High*	*High*
CO5	*High*	*Medium*	*Medium*	*Medium*	*Low*	*High*	*High*
CO6	*Medium*	*High*	*High*	*Medium*	*Low*	*High*	*Medium*
Correlation Level: *Low* *Medium* *High*							

Mapping of Course Outcomes to Programme Specific Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	*Medium*	*Medium*	*High*	*High*	*Low*	*High*	*High*
CO2	*Medium*	*High*	*Low*	*High*	*Low*	*High*	*High*
CO3	*Medium*	*Low*	*High*	*Medium*	*Medium*	*High*	*Medium*
CO4	*High*	*High*	*High*	*High*	*Medium*	*High*	*High*
CO5	*Low*	*High*	*Low*	*Low*	*Low*	*High*	*High*
CO6	*High*	*High*	*High*	*High*	*High*	*Low*	*High*
Correlation Level: *Low* *Medium* *High*							

19. Elective-V: OPERATIONS RESEARCH

Course Code	NSTC 31	TITLE OF THE COURSE	L	T	P	C
Core		OPERATIONS RESEARCH	2	1	1	3
Prerequisites		Knowledge of Probability Theory, Distribution Theory and Queuing theory	Syllabus Version		2023-24	

L: Lecture T: Tutorial P: Practical C: Credits

Course Objectives:

The main objectives of this course are to

- enable formulation of optimization problems for various decision making situations
- enhance the ability of identifying suitable method for solving optimization problem
- develop skills for finding optimal solutions through analytical and computational methods
- Train the students towards the needs of R & D in industries and research institutions

Course Outcomes

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

CO No.	Course Outcome	Cognitive Level
CO1	Formulate suitable optimization problems from given requirements	K2, K3
CO2	Identifying suitable method for solving optimization problem	K4, K6
CO3	find optimal solutions through analytical and computational methods for given optimization problem; evaluate and interpret the results to the users	K2, K5
CO4	Visualize the ensuing decision making issues of R & D in industries and to offer optimal solutions	K1, K4
CO5	Solve developed optimization problems analytically; identify new optimization techniques	K5, K6
CO6	Develop computer programmes for finding optimum solution numerically	K1 – K6

K1: *Remember* ***K2:*** *Understand* ***K3:*** *Apply* ***K4:*** *Analyze* ***K5:*** *Evaluate* ***K6:*** *Create*

Course Outline

UNIT I

Linear Programming Problem (LPP) – Properties of LPP - Simplex method – Two-phase method and Big M – Method - Duality in LPP - Dual simplex method - Sensitivity analysis - Post optimality analysis - Discrete changes in the cost vector c and requirement vector b - Integer Programming Problem (IPP) - Need for IPP and types - Gomory's cutting plane algorithm for all IPP. [12 hours]

UNIT II

Non-linear Programming – Maxima and Minima of Functions – Convex and concave functions – Wolfe's method - Transportation Problems - Mathematical formulation, Basic Feasible Solution (BFS) - Loops in a transportation problem and their properties – Methods of BFS and test of optimality - Transportation Algorithm - Degeneracy in transportation problem - Unbalanced transportation problem - Assignment Problem – Introduction and Mathematical Formulation - Hungarian Method - Unbalanced Assignment Problem. [12 hours]

UNIT III

Game Theory - Two-person zero-sum games – Maxmin - Minimax Criterion - Minimax and Saddle Point Theorem – Dominance Principle - Connection between Game problem and LPP - Solution of (m x n) games - Algebraic method and Matrix method - Iterative method for approximate solution – Simulation – Simulation Steps - Monte Carlo Simulation. [12 hours]

UNIT-IV

Project Management by PERT and CPM: Meaning of PERT and CPM - Basic steps involved in PERT/ CPM techniques - Network diagram representation - Fulkerson's rule of drawing a network diagram - Determination of critical path, project duration and crashing of project duration – PERT- time estimates and related results - Determination of critical path, estimate of project duration. [12 hours]

UNIT-V

Queueing models and Classifications – Queueing system - Definition of transient and Steady-states - Kendall's notations and classification of queuing models - Distributions in queuing systems - Solution of queuing models: Model I: (M/M/1:∞/FCFS): Birth and Death Model. Inter-relationship between Lq, Ls, Wq and Ws: Model-II - General Erlangian queuing model (Birth-Death Process) - Model-III: (M/M/1: N/FCFS) and Model IV: (M/M/S/∞/FCFS). [12 hours]

UNIT VI

Contemporary issues: Experts' lectures – online seminars and webinars. [2 hours]

Note 1: Students will be trained to develop appropriate computer programmes in *R* and *Python* related to computations taught in this course.

Total:62 hours

Note 2: Examination shall be conducted on contents of UNIT I through UNIT V only.

Books for study:

1. Gupta, P.K. and Man Mohan. (1979): Operations Research: Linear Programming and Theory of Games (3rdEdition). Sultan Chand and Sons, New Delhi.
2. Sharma, J.K. (2013): Operations Research: Problems and Solutions (Fifth Edition). Macmillan India Limited.
3. Sharma, S.D (2010): Operations Research. KedarNath Ram Nath and Co, Meerut.
4. Swarup, K., Mohan, M. and Gupta P.K. (2001): Operations Research. Sultan Chand and Sons, New Delhi.
5. Taha, H.A (2011): Operations Research: An Introduction (Ninth Edition). Prentice Hall Publishing Company.

6. Nita H. Shah, Ravi M. Gor and HardikSoni (2013): Operations Research. PHI Learning Private Limited, Delhi.

Nooks for References

1. Gass, S.I. (1985): Linear Programming, Methods and Applications. Courier Dover Publications. (Reprint 2003)
2. Gross, D. and Harris, C.M. (1974): Fundamental of Queuing Theory, John Wiley.
3. Hadley, G (1963): Linear Programming. Addison Wesley Publishing Company.
4. Hillier, F.S. and Lieberman, G.J. (2005): Introduction to Operations Research (9th Edition). McGraw – Hill Publishing Company.
5. Saaty, T.L. (1961): Elements of Queuing Theory with Applications, Mc Graw Hill.

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

1. https://nptel.ac.in/courses/110106062
2. https://nptel.ac.in/courses/111107128
3. https://nptel.ac.in/courses/110106059
4. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=ZLCHeZEhCZ8yCri36nSF3A== P-14. Operations Research (35).

Mapping of Course Outcomes to Programme Outcomes (Pos)

	PO1	***PO2***	***PO3***	***PO4***	***PO5***	***PO6***	***PO7***
CO1	*High*	*Medium*	*Low*	*Low*	*Low*	*High*	*High*
CO2	*High*	*Medium*	*Low*	*Low*	*Low*	*High*	*High*
CO3	*High*	*High*	*Low*	*Medium*	*Low*	*High*	*High*
CO4	*High*	*High*	*Medium*	*Medium*	*Low*	*High*	*High*
CO5	*High*	*Medium*	*Medium*	*Medium*	*Low*	*High*	*High*
CO6	*Medium*	*High*	*High*	*Medium*	*Low*	*High*	*Medium*
Correlation Levels: *Low* *Medium* *High*							

Mapping of Course Outcomes to Programme Specific Outcomes (PSOs)

	PSO1	***PSO2***	***PSO3***	***PSO4***	***PSO5***	***PSO6***	***PSO7***
CO1	*Medium*	*Medium*	*High*	*High*	*Low*	*High*	*High*
CO2	*Medium*	*High*	*Low*	*High*	*Low*	*High*	*High*
CO3	*Medium*	*Low*	*High*	*Medium*	*Medium*	*High*	*Medium*
CO4	*High*	*High*	*High*	*High*	*Medium*	*High*	*High*
CO5	*Low*	*High*	*Low*	*Low*	*Low*	*High*	*High*
CO6	*High*	*High*	*High*	*High*	*High*	*Low*	*High*
Correlation Levels: *Low* *Medium* *High*							

20. STATISTICAL QUALITY CONTROL AND RELIABILITY THRORY (CORE INDUSTRIAL MODEL)

Course Code	NSTC23	TITLE OF THE COURSE	L	T	P	C
Core		STATISTICAL QUALITY CONTROL AND RELIABILITY THEORY(CORE INDUSTRIAL MODEL)	2	1	1	3
Prerequisites		Basic knowledge of probability theory, Distribution theory and Sampling theory	Syllabus Version		2023-24	

L: Lecture T: Tutorial P: Practical C: Credits

Course Objectives:

The main objectives of this course are to

- Inculcate the concepts of process control and product control
- Import skill for construction of variable and attribute control charts and to analyze process capability
- Instill the practice of conducting sampling inspection for various conditions
- Train towards developing reliability models and to compute related measures.

Course Outcomes (COs):

At the end of this course of study, the student will be able to

CO No.	Course Outcome	Cognitive Level
CO1	Construct variable and attribute control charts for detecting large and smaller shifts in the production process.	K1, K3
CO2	Compute process capability measures for analyzing production process	K4, K5
CO3	Evaluate the performance of sampling plans using OC, ASN, ATI, AOQ functions under various sampling inspection situations	K2, K3 and K5
CO4	Understand the concepts of reliability and censoring schemes for applications in life testing experiments	K2, K3 and K6
CO5	Determine life time distribution for a given life testing experiment and estimate reliability measures.	K2, K4, K5 and K6
CO6	Develop computer programmes for carrying out numerical computations related to this course	K2, K4, K5 and K6

K1: *Remember* **K2**: *Understand* **K3**: *Apply* **K4**: *Analyze* **K5**: *Evaluate* **K6**: *Create*

Course Outline:

UNIT I

Meaning and scope of statistical quality control - causes of quality variation - Control charts for variables and attributes - rational subgroups - construction and operation of $\bar{x}$, σ, R, np, p, c and u charts - operating characteristic curves of control charts. Modified control charts - basic principles and design of cumulative charts - V-mask. [12 hours]

UNIT II

Moving-average and geometric moving-average control charts - sloping control chart. Process capability analysis using histogram, probability plotting and control chart - Process capability ratios- use and their interpretations. [12 hours]

UNIT III

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

Sampling inspection by variables - known and unknown sigma variables sampling plan - merits and demerits of variables sampling plan - derivation of OC curve and the parameters of the plan. [12 hours]

UNIT IV

Continuous sampling plans by attributes - CSP-1 and its modifications - concept of AOQL in CSPs - Multi-level continuous sampling plans - Operation of multi-level CSP of Lieberman and Solomon – Wald - Wolfowitz continuous sampling plans - Sequential Sampling Plans by attributes - OC and ASN functions. [12 hours]

UNIT V

Concept of reliability, components and systems, series and parallel systems, coherent systems, reliability of coherent systems - reliability of system with independent components. Life distributions, reliability function, hazard rate, hazard function - common life distributions - exponential, Weibull, gamma distributions - Estimation of parameters, reliability function -IFR and DFR distributions - Censoring and life testing (concept only). [12 hours]

UNIT VI

Contemporary issues: Experts' lectures – online seminars and webinars. [2 hours]

Note 1: Students will be trained to develop appropriate computer programmes in *R* and *Python* related to computations taught in this course.

Total:62 hours

Note 2: Examination shall be conducted on contents of UNIT I through UNIT V only.

Books for Study:

1. Montgomery, D.C. (2009): Introduction to Statistical Quality Control (Sixth Edition), Wiley India, New Delhi.
2. Mahajan, M. (2002): Statistical Quality Control (Third Edition), Dhanpat Rai and Co., Delhi.
3. Grant, E.L and Leavenworth, R.S. (2000): Statistical Quality Control (Seventh Edition), Tata McGraw Hill, New Delhi.

Books for Reference:

1. Barlow, R.E. and Proschan, F. (1981): Statistical theory of Reliability and Life testing: Probability Models (Second Edition). To Begin With.
2. Bowker, A.H and Lieberman, G.J. (1982): Engineering Statistics (Second Edition). Prentice Hall, New Delhi,
3. Duncan, A.J. (2003.): Quality Control and Industrial Statistics, Irwin-Illinois.
4. Juran, J.M. and De Feo, J.A. (2010): Juran's Quality control Handbook – The Complete Guide to Performance Excellance (Sixth Edition). Tata McGraw-Hill, New Delhi.
5. Schilling, E. G. and Nuebauer, D.V. (2009): Acceptance Sampling in Quality Control (Second Edition), CRC Press, New York.
6. Wetherill, G.B. (1977): Sampling Inspection and Quality Control (Second Edition), Chapman and Hall, London.
7. Ross S.M. (2014): Introduction to Probability Models (Eleventh Edition), Elsevier.

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

1. https://nptel.ac.in/courses/110101150
2. https://nptel.ac.in/courses/112107259
3. https://nptel.ac.in/courses/116102019

Mapping of Course Outcomes to Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	*High*	*High*	*Low*	*High*	*High*	*High*	*High*
CO2	*High*	*High*	*Medium*	*High*	*High*	*High*	*High*
CO3	*High*	*High*	*Low*	*Medium*	*Medium*	*High*	*High*
CO4	*High*	*High*	*Medium*	*Medium*	*High*	*High*	*High*
CO5	*High*	*Medium*	*Medium*	*High*	*Low*	*High*	*High*
CO6	*Medium*	*High*	*High*	*High*	*High*	*High*	*High*
Correlation Level: *Low* *Medium* *High*							

Mapping of Course Outcomes to Programme Specific Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	*Medium*	*Medium*	*High*	*High*	*Medium*	*High*	*High*
CO2	*Medium*	*High*	*Medium*	*High*	*High*	*High*	*High*
CO3	*High*	*High*	*High*	*High*	*Medium*	*High*	*High*
CO4	*High*	*High*	*High*	*High*	*High*	*High*	*Medium*
CO5	*Medium*	*High*	*High*	*High*	*Medium*	*High*	*High*
CO6	*Medium*	*High*	*High*	*Medium*	*High*	*Low*	*Medium*
Correlation Level: *Low* *Medium* *High*							

21. Practical-III: STATISTICAL PRACTICAL USING SOFTWARE-I

22. ED – II: SKILLS Enhancement (NPTEL/Swayam)

23. Internship / Industrial Activity
(Carried out in Summer Vacation at the end of I year – 30 hours)

24. Value Added Course

IV SEMESTER

25. DESIGN OF EXPERIMENTS

Course Code	TITLE OF THE COURSE	L	T	P	C
Core	**DESIGN OF EXPERIMENTS**	**3**	**1**	**1**	**4**
Prerequisites	Matrix algebra & Linear Models.	**Syllabus Version**		**2023-24**	

L: Lecture T: Tutorial P: Practical C: Credits

Course Objectives:

The main objectives of this course are to

- To get theoretical knowledge in Statistical Design of Experiments and analysis of variance
- To build strong theoretical foundation in Orthogonal Latin squares, Hyper Graeco Latin squares, factorial and fractional factorial experiments, PIBD, inter and intra blocks, split plot, analysis covariance, Response surface methodology
- To develop analytical thinking in problem solving skills

Course Outcomes (COs):

At the end of this course of study, the student will be able to to gain understanding in various observational study designs and experimental study designs and how its applied in reallife.

CO No.	Course Outcome	Cognitive Level
CO1	To understand the process of applied experimental design including advanced concepts.	**K1 & K2**
CO2	To Identify the treatments and response variables and investigate logic of hypothesis.	**K3**
CO3	To Analyze the various experimental design and the detailed analysis of experimental data.	**K4**
CO4	To explain the analysis of variance output and interpret the key factors to influence the response variables and understand the role of response surface methodology.	**K5**
CO5	To Construct and apply suitable experimental designs in Agriculture, Pharmaceutical, Industrial and Biological sciences.	**K6**
CO6	Develop computer programmes for carrying out numerical computations related to this course	**K2, K4, K5 and K6**

K1: *Remember* **K2:** *Understand* **K3:** *Apply* **K4:** *Analyze* **K5:** *Evaluate* **K6:** *Create*

Course Outline:

UNIT I

Review of basic designs; Orthogonal latin squares, Hyper Graeco Latin squares – analysis of variance – multiple comparisons – multiple range tests - Missing plot technique.

[12 hours]

UNIT II

General factorial experiments, study of 2 and 3 factorial experiments in randomized blocks; complete and partial confounding; Fractional designs for symmetric factorials; basic idea of asymmetric factorials. [12 hours]

UNIT III

General block design and its information matrix (C), criteria for connectedness, balanced and orthogonality; BIBD – recovery of interblock information; PBIBD (2).- Association scheme, Intrablock analysis, Lattice Design –analysis; Youden design – intrablock analysis; [12 hours]

UNIT IV

Nested and split plot designs – Two stage nested designs, split plot designs, split plot plot designs, strip-split designs, Analysis of covariance with one, two covariates; clinical trials.

[12 hours]

UNIT V

Response surface methodology - first order and second order rotatable designs, applications: [12 hours]

UNIT VI

Contemporary issues: Experts' lectures – online seminars and webinars. [2 hours]

Note 1: Students will be trained to develop appropriate computer programmes in *R* and *Python* related to computations taught in this course.

Total:62 hours

Note 2: Examination shall be conducted on contents of UNIT I through UNIT V only.

Books for Study:

1. Das, M.N. and Giri, N. (1979): Design and analysis of experiments, Wiley Eastern.
2. John, P.W.M. (1971): Statistical design and analysis of experiments, Macmillan.

Books for Reference:

1. Montgomery, C.D. (2001): Design and analysis of experiments, John Wiley, New York.
2. Robert, O., Kuelhl(2000) : Design of experiments. Statistical principles of researchdesign and analysis, Duxbury.
3. Federer, W.T. (1963) : Experimental design; Theory and application, Oxford & IBH

publishing Co.

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

e-books, online tutorials taken from MOOC/SWAYAM platform for thissubject.

1. Https://epgp.inflibnet.ac.in/home/viewsubject?catid=+u3y6udbivoj97lfescmhq== p-03. Design of experiments and sample surveys.
2. https://nptel.ac.in/courses/102106051

Mapping of Course Outcomes to Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	*High*	*Medium*	*High*	*High*	*Medium*	*High*	*High*
CO2	*High*	*High*	*High*	*High*	*High*	*High*	*High*
CO3	*High*	*High*	*Medium*	*Medium*	*Medium*	*High*	*High*
CO4	*High*	*High*	*High*	*Medium*	*High*	*High*	*High*
CO5	*High*	*Medium*	*Medium*	*High*	*Medium*	*High*	*High*
CO6	*Medium*	*High*	*High*	*High*	*High*	*High*	*High*
Correlation Level: *Low* *Medium* *High*							

Mapping of Course Outcomes to Programme Specific Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	*Medium*	*Medium*	*High*	*High*	*Medium*	*High*	*High*
CO2	*Medium*	*High*	*High*	*High*	*High*	*High*	*High*
CO3	*Medium*	*High*	*High*	*High*	*High*	*High*	*Medium*
CO4	*High*	*High*	*High*	*High*	*High*	*High*	*Medium*
CO5	*Medium*	*High*	*High*	*Medium*	*Medium*	*High*	*High*
CO6	*High*	*High*	*High*	*High*	*High*	*Medium*	*High*

26. STOCHASTIC PROCESSES

Course Code	**TITLE OF THE COURSE**	**L**	**T**	**P**	**C**
Core	**STOCHASTIC PROCESSES**	**3**	**1**	**0**	**4**
Prerequisites	Knowledge of Probability Theory and Distribution Theory	**Syllabus Version**		**2023-24**	

L: Lecture T: Tutorial P: Practical C: Credits

Course Objectives:

The main objectives of this course are to

- explain concept of stochastic process which students need for their experiment and research.
- provide classification and properties of stochastic processes, discrete and continuous Markov chains, Brownian motion, renewal process, stationary processes and branching process.
- focus on theoretical concepts pertaining to handling various stochastic models.
- impart the application of various stochastic models for forecasting and prediction

Course Outcomes (COs):

At the end of this course of study, the student will be able to

CO No.	Course Outcome	Cognitive Level
CO1	Apprehend the concept of stochastic process, its specifications, and analyze the classification of states; construct Markov Chain for real world situations.	**K1, K2 & K4**
CO2	Understand Continuous time Markov processes and obtain the birth and death processes; explore their applications to various practical problems.	**K1 - K3**
CO3	Explore the concept of Stationary processes in univariate and multivariate scenarios; derive the properties of auto-covariance and autocorrelation functions.	**K1 - K3**
CO4	Determine renewal process, renewal function, distribution of arrival and inter arrival times and renewal policy under varied conditions.	**K3 & K4**
CO5	Apply the Martingales concept in finance related analysis; apply the concept of branching process and offspring distribution in different situations including biological studies, population dynamics and circuit theory.	**K1, K3 & K6**
CO6	Develop computer programmes towards construction of stochastic models; evaluate them for prediction and forecasting.	**K1 – K6**
K1: *Remember* **K2:** *Understand* **K3:** *Apply* **K4:** *Analyze* **K5:** *Evaluate* **K6:** *Create*		

Course Outline:

UNIT I

Introduction of stochastic processes - Specifications of a stochastic processes - Classification of stochastic processes - Markov chains -Classification of states and chains - Higher transition probabilities and its limiting behavior -Chapman Kolmogorov's equations - Stationary distribution - Ergodic theorem - One dimensional random walk and Gambler's ruin problems. [12 hours]

UNIT II

Continuous time Markov processes - Poisson processes and related distributions - Birth and death processes – Kolmogorov-Feller differential equations of birth and death processes - Applications to queues and storage problems and Wiener process. [12 hours]

UNIT III

Stationary processes - Weakly stationary and strongly stationary processes - Properties of auto covariance and auto correlation functions - Autoregressive and Moving average processes - Spectral density function - Spectral representation of moving average processes. [12 hours]

UNIT IV

Renewal theory - Renewal equation - Stopping time - Wald's equation - Elementary renewal theorem and its applications - Renewal reward processes - Residual and Excess life times - Markov renewal and Semi Markov processes. [12 hours]

UNIT V

Branching processes - properties of generating functions of Branching processes - Probability of ultimate extinction - Limit theorems for continuous time branching process - Martingales in discrete time – Super martingales and sub martingales, Martingale convergence theorem and its applications. [12 hours]

UNIT VI

Contemporary issues: Experts' lectures – online seminars and webinars. [2 hours]

Note 1: Students will be trained to develop appropriate computer programmes in *R* and *Python* related to computations taught in this course.

Total:62 hours

Note 2: Examination shall be conducted on contents of UNIT I through UNIT V only.

Books for Study:

1. Medhi, J. (1984): Stochastic Processes, New Age International Publishing Limited, New Delhi. (Reprint 2002).
2. Karlin, S. and Taylor, H.M (1975): A First Course in Stochastic Processes – Vol. I. Academic Press, New York.

Books for Reference:

1. Cinlar, E. (2013): Introduction to Stochastic Processes, Courier Dover Publications.
2. Cox, D.R. and A.D. Miller (1984): The Theory of Stochastic Processes, Chapman & Hall.
3. Harris, T.E. (1963):Theory of Branching Processes, Courier Dover Publications.
4. Linda J.S. Allen (2011). An Introduction to Stochastic Processes with Applications to Biology, Second Edition, Chapman & Hall/CRC
5. Papoulis, A. and Pillai, U.S. (2006). Probability, Variables and Stochastic Processes (Fourth Edition). Tata McGraw-Hill.
6. Resnick, S. (1992): Adventures in Stochastic Processes, Birkhauser, Boston. (Reprint 2005).
7. Ross, S.M (1996): Stochastic Processes, 2nd Edition, John Wiley & Sons, New Delhi
8. Tjims, H.C. (2003): A First course in Stochastic Models, John Wiley & Sons, New Delhi.

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

4. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=34 Paper: P-10. Stochastic Processes and Time Series Analysis - ISI, Kolkata
5. https://nptel.ac.in/courses/111/103/111103022/ Stochastic Processes – IIT Guwahati

6. https://nptel.ac.in/courses/111/102/111102098/ Introduction and Motivation for studying Stochastic Processes – IIT Delhi
7. https://ocw.mit.edu/courses/mathematics/18-445-introduction-to-stochastic-processes-spring2015/lecture-notes/
8. https://www.stat.auckland.ac.nz/~fewster/325/notes/325book.pdf

Mapping of Course Outcomes to Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	*High*	*High*	*High*	*High*	*High*	*High*	*High*
CO2	*High*	*Medium*	*High*	*Medium*	*Low*	*High*	*High*
CO3	*High*	*High*	*High*	*High*	*Medium*	*High*	*High*
CO4	*High*	*Medium*	*Medium*	*Medium*	*Medium*	*Medium*	*High*
CO5	*High*	*High*	*High*	*Medium*	*Medium*	*Medium*	*High*
CO6	*High*	*High*	*High*	*High*	*Medium*	*High*	*High*
Correlation Level:	*Low*	*Medium*	*High*				

Mapping of Course Outcomes to Programme Specific Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	*High*	*High*	*High*	*Medium*	*High*	*High*	*High*
CO2	*Medium*	*High*	*High*	*Low*	*High*	*High*	*High*
CO3	*High*	*High*	*High*	*Medium*	*High*	*High*	*High*
CO4	*High*	*High*	*High*	*Medium*	*Medium*	*High*	*High*
CO5	*High*	*Medium*	*High*	*High*	*Low*	*Medium*	*High*
CO6	*Medium*	*High*	*High*	*Medium*	*Low*	*High*	*High*
Correlation Level:	*Low*	*Medium*	*High*				

27. MACHINE LEARNING TECHNIQUES

Course Code	**TITLE OF THE COURSE**	**L**	**T**	**P**	**C**
Core	**MACHINE LEARNING TECHNIQUES**	**3**	**1**	**1**	**4**
Prerequisites	Probability theory, Distribution Theory and Basic Statistical Methods	**Syllabus Version**		**2023-24**	

L: Lecture T: Tutorial P: Practical C: Credits

Course Objectives:

- To understand the concepts of machine learning.
- To appreciate supervised and unsupervised learning and their applications.
- To understand the theoretical and practical aspects of Probabilistic Graphical Models.
- To appreciate the concepts and algorithms of reinforcement learning.
- To learn aspects of computational learning theory.

Course Learning Outcomes

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

CO No.	Expected Course Outcomes	Cognitive Level
CO1	Describe the Types of Machine Learning - Basic Concepts and Examples in Machine Learning	**K2, K3**
CO2	Apply suitable Linear Models for Classification and Bayesian Logistic Regression to solve a problem.	**K4, K6**
CO3	Understand the Clustering- K-means and The EM Algorithm in General	**K2, K5**
CO4	Use Directed Graphical Models - Bayesian Networks	**K1, K4**
CO5	Dealing with Markov Models – Hidden Markov Models	**K5, K6**
CO6	Develop, document, and debug High-Dimensional Spaces -- The Curse of Dimensionality - Dimensionality Reduction	**K6, K5**
K1: Remember **K2:** Understand **K3:** Apply **K4:** Analyze **K5:** Evaluate **K6:** Create		

Course Outline:

UNIT I

Introduction to Machine Learning - Types of Machine Learning - Basic Concepts and Examples in Machine Learning - Linear Models for Regression - Linear Basis Function Models - The Bias-Variance Decomposition - Bayesian Linear Regression - Bayesian Model Comparison. [12 hours]

UNIT II

Linear Models for Classification - Discriminant Functions - Probabilistic Generative Models - Probabilistic Discriminative Models - Bayesian Logistic Regression - Decision Trees - Classification Trees - Regression Trees – Pruning - Neural Networks - Feed-Forward Network Functions - Error Back-Propagation - Regularization - Mixture Density and Bayesian Neural Networks - Kernel Methods - Dual Representations - Radial Basis Function Networks - Ensemble methods - Bagging - Boosting. [12 hours]

UNIT III

Clustering- K-means - EM - Mixtures of Gaussians - The EM Algorithm in General - Model Selection for Latent Variable Models - High-Dimensional Spaces -- The Curse of Dimensionality - Dimensionality Reduction - Factor Analysis - Principal Component Analysis - Probabilistic PCA Independent Components Analysis. [12 hours]

UNIT IV

Directed Graphical Models - Bayesian Networks - Exploiting Independence Properties – From Distributions to Graphs - Examples - Markov Random Fields - Inference in Graphical Models - Learning –Naive Bayes Classifiers - Markov Models – Hidden Markov Models – Inference – Learning- Generalization – Undirected graphical models [12 hours]

UNIT V

Sampling – Basic sampling methods –Model-Based Learning - Value Iteration- Policy Iteration - Temporal Difference Learning- Exploration Strategies- Deterministic and Non-deterministic Rewards and Actions Eligibility Traces- Semi Supervised Learning - Computational Learning Theory - Mistake Bound Analysis – Sample Complexity Analysis [12 hours]

UNIT VI

Contemporary issues: Experts' lectures – online seminars and webinars. [2 hours]

Note 1: Students will be trained to develop appropriate computer programmes in *R* and *Python* related to computations taught in this course.

Total: 62 hours

Note 2: Examination shall be conducted on contents of UNIT I through UNIT V only.

Books for Study:

1. Christopher Bishop (2006). "Pattern Recognition and Machine Learning" Springer.
2. Kevin P. Murphy (2012). "Machine Learning: A Probabilistic Perspective", MIT Press.

Books for Reference:

1. Ethem Alpaydin (2005). "Introduction to Machine Learning", Prentice Hall of India.
2. Tom Mitchell (1997). "Machine Learning", McGraw-Hill.
3. Hastie, Tibshirani and Friedman (2008). "The Elements of Statistical Learning" (2nd ed), Springer.
4. Stephen (2009). "Machine Learning –An Algorithmic Perspective", CRC Press.

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

1. https://archive.nptel.ac.in/noc/courses/noc22/SEM1/noc22-cs29/
2. https://archive.nptel.ac.in/noc/courses/noc22/SEM1/noc22-cs58/
3. https://archive.nptel.ac.in/noc/courses/noc22/SEM1/noc22-cs24/

Mapping of Course Outcomes to Programme Outcomes (POs)

	PO1	***PO2***	***PO3***	***PO4***	***PO5***	***PO6***	***PO7***
CO1	*High*	*Medium*	*Medium*	*Medium*	*Medium*	*High*	*High*
CO2	*High*	*Medium*	*Medium*	*Medium*	*Medium*	*High*	*High*
CO3	*High*	*High*	*Medium*	*Medium*	*Medium*	*High*	*High*
CO4	*High*	*High*	*Medium*	*Medium*	*Medium*	*High*	*High*
CO5	*High*	*Medium*	*Medium*	*Medium*	*Medium*	*High*	*High*
CO6	*Medium*	*High*	*High*	*Medium*	*Medium*	*High*	*Medium*

Correlation Levels: *Low* *Medium* *High*

Mapping of Course Outcomes to Programme Specific Outcomes (PSOs)

	PSO1	*PSO2*	*PSO3*	*PSO4*	*PSO5*	*PSO6*	*PSO7*
CO1	*Medium*	*Medium*	*High*	*High*	*Medium*	*High*	*High*
CO2	*Medium*	*High*	*Low*	*High*	*Medium*	*High*	*High*
CO3	*Medium*	*Medium*	*High*	*Medium*	*Medium*	*High*	*Medium*
CO4	*High*	*High*	*High*	*High*	*Medium*	*High*	*High*
CO5	*Medium*	*High*	*Medium*	*Medium*	*Medium*	*High*	*High*
CO6	*High*	*High*	*High*	*High*	*High*	*Low*	*High*
Correlation Levels: *Low* *Medium* *High*							

28. Practical-IV: STATISTICS PRACTICAL USING SOFTWARE-II

29. PROJECT AND VIVA-VOCE

30. Professional Competency Skill Enhancement Course (Training for Competitive Examinations)

Course Code	TITLE OF THE COURSE	L	T	P	C
Core	Professional Competency Skill Enhancement Course (Training for Competitive Examinations)	**2**	**1**	**0**	**2**

L: Lecture T: Tutorial P: Practical C: Credit

Course Outline:

UNIT I Descriptive Statistics

Origin, Uses, Scope and limitations of Statistics – Collection, Classification and Tabulation of data – Diagrammatic and Graphical representations – Measures of location, dispersion, skewness and kurtosis – Correlation and regression – Curve fitting – Linear and quadratic equations by the method of least squares. [8 Hours]

UNIT II Probability and Distribution Theory

Random variables and Distribution function, Distribution function of a random vector – Mathematical expectation and conditional expectation Chebychev's inequality – Convergence in probability – Convergence in distributions – Weak and Strong laws of large numbers – Central limit theorems (Lindeberg-Levy, Liapunov's).

Introduction to distributions - Discrete distributions: Negative binomial and Hyper geometric distributions - Continuous distributions: Cauchy, Beta, Gamma, Weibull and Log-Normal - Sampling distributions: Non central t, F and Chi-square distributions and their properties – Bivariate Binomial, Poisson Normal and their properties. [8 Hours]

UNIT III Estimation Theory and Testing of Hypothesis

Introduction to estimation theory and properties of estimators. Theorems and inequalities: Cramer – Rao inequality, Batacharya inequality, Rao – Blackwell, Neyman – Fisher factorization theorems with examples. Methods of estimation: Method of moments, Maximum likelihood, Minimum Chi-Square and method of least squares, Bayesian estimation – Introduction - Point and interval estimation and Bayes estimator under squared error loss function.

Introduction to testing of hypotheses: Basic concepts – More powerful Test - Neyman – Pearson lemma: UMP and unbiased tests – MLR property and its uses for construction of UMP tests - Non-Parametric tests: Run test, Median test, Mann-Whitney test, Wilcoxon test, Kolmogorov-Smirnov test (one and two sample test procedures), Kruskal-Wallis test and SPRT test [8 Hours]

UNIT IV Sampling Theory and Design of Experiments

Simple random sampling – Stratified, systematic, cluster (Single stage) – Estimation of mean and variance in SRS - Ratio and Regression estimators, estimation under double sampling – Cluster sampling – Two stage sampling – Sample Survey Organisation – CSO and NSO – Sampling and non-sampling errors.

Analysis of Variance: Principles of design of experiments – CRD, RBD and LSD – 2^2 and 2^3 Factorial experiments. [8 Hours]

UNIT V Time Series and Vital Statistics

Time series – Components of time series – Trend and Seasonal Variations – Determination and elimination.

Vital Statistics – Importance – Collection – Mortality and its measurements – Life table construction and uses – Fertility and its measurements. [8 Hours]

Total: 40 hours

Books for Study:

1. Gupta, S. C., and Kapoor, V. K. (2016). Fundamentals of Applied Statistics, Sultan Chand & Sons Private Limited, New Delhi.
2. Ardilly, P and Yves T. (2006): Sampling Methods: Exercise and Solutions. Springer. Cochran, W.G. (2007): Sampling Techniques (Third Edition). John Wiley & Sons, New Delhi.
3. Rohatgi, V.K. and Saleh, A.K.Md.E. (2011): An Introduction to Probability and Statistics (Second Edition). John Wiley & Sons, New York.
4. Mukhopadhyay, P. (2006). Mathematical Statistics (Third Edition). Books and Allied Pvt., Ltd., Kolkatta.
5. Montgomery, D. C. and Johnson, L. A. (1977): Forecasting and Time Series analysis. McGraw Hill.
6. Mukhopadhyay, P. (1999): Applied Statistics, New Central Book Agency, Calcutta.

Books for Reference:

1. Holcomb, Z. C. (2017). Fundamentals of Descriptive Statistics, Routledge, New York.
2. Rohatgi, V. K. and A. K. Md. E. Saleh (2009). An Introduction to Probability Theory and Mathematical Statistics (Second Edition). John Wiley & Sons, New York.
3. Bhuyan K.C. (2010), Probability Distribution Theory and Statistical Inference, New Central Book Agency (P) Ltd., New Delhi.
4. Mukhopadhyay, P. (2007): Survey Sampling. Narosa Publisher, New Delhi.
5. Brockwell, P. J. and Davis, R. A. (2002): Introduction to Time Series and Forecasting. Taylor& Francis.
6. Goon, A. M., Gupta, M. K., and Dasgupta, B. (2008). Fundamentals of Statistics, Vol. II, Ninth Edition, World Press, India.

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

1. https://nptel.ac.in/courses/111/104/111104120.
2. https://www.iiserpune.ac.in/~bhasbapat/phy221_files/curvefitting.pdf.
3. https://nptel.ac.in/courses/111/104/111104098.
4. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=+u3y6UdbIvOJ97LFeSCmHQ== P-01. Probability I
5. MTH 432A: Introduction to Sampling Theory (http://home.iitk.ac.in/~shalab/course432.htm)
6. https://nptel.ac.in/courses/111/104/111104073/

30. EXTENSION ACTIVITY

******