DEPARTMENT OF STATISTICS
MANONMANIAM SUNDARANAR UNIVERSITY
TIRUNELVELI - 627012.

Learning Outcome based Curriculum

Vision of the University

To provide quality education to reach the un-reached

Mission of the University

- To conduct research, teaching and outreach progrmmes to improve conditions of human living.
- To create an academic environment that honours women and men of all races, caste, creed, cultures, and an atmosphere that values intellectual curiosity, pursuit of knowledge, academic freedom and integrity.
- To offer a wide variety of off-campus educational and training programs, including the use of information technology, to individuals and groups.
- To develop partnership with industries and government so as to improve the quality of the workplace and to serve as catalyst for economic and cultural development.
- To provide quality / inclusive education, especially for the rural and un-reached segments of economically downtrodden students including women, socially oppressed and differently abled.

Vision and Mission of the Department of Statistics

Vision of the Department

To establish a Centre of Excellence in Data Science and to develop new statistical methodologies according to the changes in the needs of researchers and the organizations

Mission of the University

- To prepare and update databases for the regions under the jurisdiction of the university.
- To develop and update data maps in respect of various phenomena such as education, health, industry etc.
- To conduct Conferences, Workshops and Training programmes on the topics emerging at National and Global level.
- To organize industrial visits periodically in order to understand their statistical needs.
- To conduct field surveys in various localities in the four southern most districts.

Preamble

The M.Sc., Statistics degree programme of Manonmaniam Sundaranar University aims to provide a strong foundation for research and higher studies to teach a wide range of statistical methods for enabling the students to deal with real world situations comprising uncertainty. It augments the ability of students to link statistical concepts and methods with interdisciplinary studies and to develop computer programs for carrying out complex statistical computations. It exposes towards contemporary softwares of global standards and foster interests among students to work as Statistics and Data Analytics professionals. It prepares skilled human resource for the needs of Statistics personnel in public and private sector institutions.

MANONMANIAM SUNDARANAR UNIVERSITY, TIRUNELVELI
(For those candidates who joined 2022-2023 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 / 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) 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	REAL ANALYSIS AND LINEAR ALGEBRA	3L+1T	4
	2	Core	PROBABILITY THEORY	3L+1T+1P	4
	3	Core	DISTRIBUTION THEORY	3L+1T+1P	4
	4	Core	SAMPLING TECHNIQUES	3L+1T+1P	4
	5	Elective	ELECTIVE - I	2L+1T+2P	3
	6	Core	STATISTICAL COMPUTING USING SOFTWARE-I	1L+1T+1P	2
			Subtotal	**27 Hrs.**	**21**
II	7	Supportive	*SUPPORTIVE COURSE-I	3L+1T	3
	8	Core	THEORY OF STATISTICAL ESTIMATION	3L+1T+1P	4
	9	Core	STOCHASTIC PROCESSES	3L+1T	4
	10	Core	STATISTICAL QUALITY CONTROL AND RELIABILITY THEORY	3L+1T+1P	4
	11	Core	OPERATIONS RESEARCH	2L+1T+2P	4
	12	Core	STATISTICAL COMPUTING USING SOFTWARE-II	1L+1T+1	2
	13	Core	MINI PROJECT AND VIVA-VOCE	---	3
			Subtotal	**26 Hrs.**	**24**

III	14	Supportive	*SUPPORTIVE COURSE-II	3L+1T	3
	15	Core	TESTING OF HYPOTHESES	3L+1T+1P	4
	16	Core	MULTIVARIATE ANALYSIS	3L+1T+1P	4
	17	Core	ECONOMETRICS	3L+1T	4
	18	Core	DEMOGRAPHY	3L+1T+1P	4
	19	Core	LINEAR MODELS AND DESIGN OF EXPERIMENTS	3L+1T+1P	4
	20	Core	STATISTICAL COMPUTING USING SOFTWARE-III	1L+1T+1P	2
			Subtotal	**30 Hrs.**	**25**
IV	21	Core	TIME SERIES ANALYSIS	2L+1T+2P	4
	22	Elective	ELECTIVE - II	3L+1T+1P	3
	23	Elective	ELECTIVE - III	2L+1T+2P	3
	24	Elective	ELECTIVE - IV	3L+1T+1P	3
	25	Core	STATISTICAL COMPUTING USING SOFTWARE-IV	1L+1T+1P	2
	26	Core	MAJOR PROJECT AND VIVA-VOCE	---	5
			Subtotal	**23 Hrs.**	**20**
			Total	**106 Hrs.**	**90**

Total number of credits : 90 (Minimum)
Total number of Core Courses : 20
Total number of Elective Courses : 04
Total Hours : 106 Hrs.

NOTE 1:

Practical exercises for the Courses 6, 12, 20 and 25 are from the Core and Elective courses taught in the respective Semesters.

NOTE 2:

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

NOTE 3: L: LECTURE T: TUTORIAL P: PRACTICAL

4. List of Elective Courses (Major):

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

(i) PROGRAMMING IN C++
(ii) PROGRAMMING IN S-PLUS/R
(iii) STATISTICAL DATA MINING

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

(i) APPLIED REGRESSION ANALYSIS
(ii) ACTUARIAL STATISTICS
(iii) FUZZY LOGIC AND ITS APPLICATIONS
(iv) STOCHASTIC MODELLING AND ITS APPLICATIONS

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

(i) CATEGORICAL DATA ANALYSIS
(ii) OFFICIAL STATISTICS

(iii) PROGRAMMING IN PYTHON
(iv) MACHINE LEARNING

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

(i) BIO-STATISTICS AND SURVIVAL ANALYSIS
(ii) STATISTICAL METHODS IN CLINICAL TRIALS
(iii) EVALUATIONARY ALGORITHM AND DEEP LEARNING

5. List of Supportive Courses (Non-Major):

The following supportive courses will be offered by the Department of Statistics to the post- graduate students studying in other Academic Departments in the University.

(i) STATISTICAL METHODS
(ii) ELEMENTS OF BIO-STATISTICS
(iii) PROBABILITY AND STATISTICS (Online Course)
(iv) INTRODUCTION TO R SOFTWARE (Online Course)

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 Minor and Major project works respectively during the second and fourth semesters under the supervision of a faculty member of the University Department of Statistics. Each candidate shall have to prepare and submit the report of Minor and Major project works at the end of the respective semesters. The project reports will be evaluated for a maximum of 80 marks. Each candidate shall appear for a Viva-Voce examination in the respective semester for a maximum of 20 marks.

Each student shall be encouraged to publish a minimum of one research paper from his/her Mini/Major projects in UGC-CARE listed journals.

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 mandatorily 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 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

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

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**	**0**	**1**	**4**
Prerequisites		Basics of Real Analysis and Matrix Theory	**Syllabus Version**		**2022-23**	

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. PROBABILITY THEORY

Course Code	NSTC 12	TITLE OF THE COURSE	L	T	P	C
Core		**Probability Theory**	3	1	1	4
Prerequisites		Basic knowledge of set theory, convergence and random variables	Syllabus Version		2022-23	

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*							

3. 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**		**2022-23**	

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*							

4. 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**		**2022-23**	

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*							

5. ELECTIVE – I (shall be chosen from the list of Elective courses)

6. STATISTICS COMPUTING USING SOFTWARE – I

Probability Theory

Random variable – distribution function – discrete and continuous random variables – Expectation and moments

Chebyshev's, Markov's, Holder's, Jensen's and Minkowski's inequalities

Characteristic function and its properties – inversion theorem and its applications

law of large numbers and its applications
Central limit theorems and applications

Distributions Theory

Fitting the Distributions
Functions of random variables and their distributions
Methods of finding distributions: Cumulative Distribution Function
Jacobian of transformation
Moment Generating Function
Unconditional and conditional expectation
Central-t, Central-F, central chi-square distributions

Sampling Theory

Simple random sampling methods of drawing sample.
Estimation of the population total and variance estimation.
PPSWR Hurwitz -Thompson estimator - Des Raj ordered estimator Murthy's unordered estimator Midzuno scheme.
Linear and circular systematic sampling.
Stratified sampling SRS, PPSWR, PPSWOR
Ratio Estimator (including ratio estimator for stratified sampling – separate and combined)
Regression Estimator (including regression estimator for stratified sampling – separate and combined)
Cluster Sampling (Cluster of Equal sizes)

II SEMESTER

7. SUPPORTIVE COURSE-I
(shall be chosen from the list of Supportive courses for other department students)

8. THEORY OF STATISTICAL ESTIMATION

Course Code	NSTC 21	TITLE OF THE COURSE	L	T	P	C
Core		**Theory of Statistical Estimation**	3	1	1	4
Prerequisites		Knowledge of Real Analysis, Probability Theory and Distribution Theory	Syllabus Version		2022-23	

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).
3. 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. STOCHASTIC PROCESSES

Course Code	**NSTC 22**	**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**		**2022-23**	

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.]

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=34 Paper: P-10. Stochastic Processes and Time Series Analysis - ISI, Kolkata
2. https://nptel.ac.in/courses/111/103/111103022/ Stochastic Processes – IIT Guwahati
3. https://nptel.ac.in/courses/111/102/111102098/ Introduction and Motivation for studying Stochastic Processes – IIT Delhi
4. https://ocw.mit.edu/courses/mathematics/18-445-introduction-to-stochastic-processes-spring2015/lecture-notes/
5. 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*							

10. STATISTICAL QUALITY CONTROL AND RELIABILITY THEORY

Course Code	**NSTC23**	**TITLE OF THE COURSE**	**L**	**T**	**P**	**C**
Core		**Statistical Quality Control and Reliability theory**	**3**	**1**	**1**	**4**
Prerequisites		Basic knowledge of probability theory, Distribution theory and Sampling theory	**Syllabus Version**		**2022-23**	

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
CO 1	Construct variable and attribute control charts for detecting large and smaller shifts in the production process.	**K1, K3**
CO 2	Compute process capability measures for analyzing production process	**K4, K5**
CO 3	Evaluate the performance of sampling plans using OC, ASN, ATI, AOQ functions under various sampling inspection situations	**K2, K3 and K5**
CO 4	Understand the concepts of reliability and censoring schemes for applications in life testing experiments	**K2, K3 and K6**
CO 5	Determine life time distribution for a given life testing experiment and estimate reliability measures.	**K2, K4, K5 and K6**
CO 6	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*							

11. OPERATIONS RESEARCH

Course Code	**NSTC 31**	**TITLE OF THE COURSE**	**L**	**T**	**P**	**C**
Core		**OPERATIONS RESEARCH**	**2**	**1**	**2**	**4**
Prerequisites		Knowledge of Probability Theory, Distribution Theory and Queuing theory	**Syllabus Version**		**2022-23**	

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*							

12. STATISTICAL COMPUTING USING SOFTWARE – II

Estimation Theory:

Sufficiency criterion
Unbiased estimator
UMVUE
Cramer-Rao lower bound, Bhattacharya's lower bound and
Chapman-Robbins lower bound
MLE and Standard error of ML estimators.
MLE through the method of successive approximation.
MLE for truncated distribution.
Method of Moments.
Interval estimation: Confidence interval for mean, difference of means, variance and ratio of variances.

Statistical Quality Control and Reliability:

CUSUM Control chart
Modified Control chart
Moving Average Control chart
Sloping Control Chart
Determination of AOQ for CSP–1, CSP–2 plans for given parameter values, OC curve for CSP–1 plan.

Using Dodge–Romig tables to draw OC, AOQ and ASN curve for single and double sampling plans.
Computation of Failure Rates: Mean Time to Failure Rate, Hazard Rate.

Operations Research:

Sensitivity Analysis and parametric Programming.
Variation in cost vector C.
Variation in requirement vector B.
Addition of single variable .
Deletion of single variable.
Parameterization of the cost vector C.
Parameterization of the requirement vector B.
Non-Linear Programming Problem: Kuhn-Tucker conditions.
All Integer Programming using Gomory's constraint.
Inventory Control exercises.

13. MINI PROJECT AND VIVA-VOCE

III SEMESTER

14. SUPPORTIVE COURSE-II
(Shall be chosen from the list of Supportive courses for other department students)

15. 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		2022-23	

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*				

16. 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		2022-23	

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.]

1. STAT 505: Applied Multivariate Statistical Analysis (https://online.stat.psu.edu/stat505/)
2. https://epgp.inflibnet.ac.in/home/viewsubject?catid=+u3y6udbivoj97lfescmhq== P-11. Multivariate analysis
3. 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*							

17. ECONOMETRICS

Course Code	NSTC 33	TITLE OF THE COURSE	L	T	P	C
Core		ECONOMETRICS	3	1	0	4
Prerequisites		Knowledge of Micro Economics, Estimation Theory, Hypotheses testing and Linear models.	Syllabus Version		2022-23	

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* K**6:** *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*				

18. DEMOGRAPHY

Course Code	**NSTC 34**	**TITLE OF THE COURSE**	**L**	**T**	**P**	**C**
Core		**Demography**	**3**	**1**	**1**	**4**
Prerequisites		Basic ideas on demography, vital statistics, population migration and data sources.	**Syllabus Version**		**2022-23**	

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

Course Objectives:

The main objectives of this course are to

- introduce the basic techniques of demographic analysis.
- become familiar with the sources of data available for demographic research.
- identify appropriate sources of data, perform basic demographic analysis using various techniques
- ensure their comparability across populations.
- focus on measures of mortality, Fertility, Migration levels patterns and population projection techniques.

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 concepts and learn the basics in Birth, Death and other vital statistics.	**K1, K2**
CO2	Provide the basic knowledge in Measurements of Population and obtain the various measures.	**K2, K3**
CO3	Describe and explore the importance of life table and its types	**K2, K3**
CO4	Analyse and understand the concepts of Migration and its importance.	**K2, K4**
CO5	Understand the core idea of population projection and their estimation.	**K1-K3**
CO6	Develop computer programme for computation of mortality and fertility measures, construction of population growth model.	**K1-K6**
K1: *Remember* **K2**: *Understand* **K3**: *Apply* **K4**: *Analyze* **K5**: *Evaluate* **K6**: *Create*		

Course Outline:

UNIT I

Development and scope of demography - Demographic data: sources and current status - Chandrashekar-Deming index - Adjustment of age data – use of Whipple – Myer and UN indices - Population size and growth in India - Trends and differentials in world population – Health Surveys and use of hospital statistics – Population transition theory. [12 hours]

UNIT II

Mortality - Basic measurements - Crude, specific, standardized death rates - Life table - construction, use and interpretation-force of mortality - abridged life tables. [12 hours]

UNIT III

Fertility -Basic measurements - Gross and Net Reproduction rate - Cohort fertility analysis - Fertility models -Population regulation programs in India - Demographic transition theory. [12 hours]

UNIT IV

Special distribution of population - basic concepts - measurements and models of migration - concept of international migration - Urban development components of urban and metropolitan growth - Urbanization in developed and developing countries - Stable and quasi populations- Intrinsic growth rate. [12 hours]

UNIT V

Components of population growth and change – Models of population growth and their filling to population data - Methods of projection - Logistic equation - component method of projection - stable population theory – Decennial population census in India – Nuptiality and its measurements. [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, S. C., and Kapoor, V. K. (2016). Fundamentals of Applied Statistics, Sultan Chand & Sons Private Limited, New Delhi.
2. Mukhopadhyay, P. (2011): Applied Statistics, Second Edition, Books and Allied (P) Ltd., India.
3. Misra, B.D. (1982). An Introduction to the Study of Population. South East Asia Publishers, Madras.
4. Spiegelman, M. (1969): Introduction to Demographic Analysis. Harvard University Press.
5. Gun, A.M., Gupta. M.K and Das Gupta. B. (2016): Fundamental of Statistics, Volume. 2, World Press Private Ltd, Kolkata.

Books for Reference:

1. Benjamin, B. (1975): Demographic Analysis. George Allen and Unwin Limited.
2. Bogue, D.J. (1969). Principles of Demography. Digitized 2007
3. Cox, P.R. (1978): Demography (Fifth Edition). Cambridge University Press.
4. Gibbs, J.P. (2012). Urban Research Methods. Literary Licensing, LLC.
5. Keyfliz, N. and Caswell, H. (2006). Applied Mathematical Demography. Springer.
6. Kumar, R. (1986): Technical Demography. John Wiley & Sons, Canada.
7. Wolfenden, H.H. (1954). Population Statistics and their Compilation. American Actuarial Society.

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

1. https://nptel.ac.in/courses/102101056

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*	*High*	*Medium*	*Medium*	*High*	*High*
CO4	*High*	*High*	*High*	*Medium*	*High*	*High*	*High*
CO5	*High*	*Medium*	*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*	*Medium*	*High*	*High*	*Medium*	*High*	*High*
CO2	*Medium*	*High*	*Medium*	*High*	*High*	*High*	*High*
CO3	*Medium*	*Medium*	*High*	*High*	*High*	*High*	*Medium*
CO4	*Medium*	*High*	*High*	*High*	*High*	*High*	*Medium*
CO5	*Medium*	*Medium*	*High*	*Medium*	*Medium*	*High*	*High*
CO6	*High*	*High*	*High*	*High*	*High*	*Low*	*High*
Correlation Level: *Low* *Medium* *High*							

19. LINEAR MODELS AND DESIGN OF EXPERIMENTS

Course Code	**--**	**TITLE OF THE COURSE**	**L**	**T**	**P**	**C**
Core	**--**	**LINEAR MODELS AND DESIGN OF EXPERIMENTS**	**3**	**1**	**1**	**4**
Prerequisites		Basic knowledge of Linear Algebra, Linear regression models, Estimation and Testing of Hypotheses	**Syllabus Version**		**2022-23**	

Course Objectives:

The main objectives of this course are to:

- understand the need and the objective of experimental design.
- Inculcate the need for principles of experimental design.
- plan and conduct designed experiments efficiently and effectively,
- analyze and interpret experimental results,
- Motivate towards construction of experimental designs in research.

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 experimental design	**K2**
CO2	Remember the basic principles of experimental design	**K1,K2**
CO3	Identify the experimental unit and select the layout of the design	**K1,K2,K5**
CO4	Formulate and Analyses the Single Factor to multiple factor experiments	**K4,K6**
CO5	Apply the concept of reduction in block sizes and analyze the results; illustrate the application of Incomplete block design	**K3,K4**
CO6	Develop computer programmes to analyze the outcomes of designed experiments for real world problems.	**K1-K6**
K1: Remember **K2 :** Understand **K3:** Apply **K4:**Analysis **K5:** Evaluate **K6 :** Create		

UNIT I

Linear models – assumptions on error components – Fixed, Random and mixed effects models, models with full rank and less than full rank - least square and maximum likelihood estimators of the parameters and their properties - Gauss-Markov theorem - testing linear hypotheses. [12 hours]

UNIT II

Analysis of variance for one-way, two–way classification with one and more than one (equal) observations per cell with interaction - Multiple comparisons: Fisher's least significance difference (L.S.D.) test, Tukey's Test and Duncan's Multiple Range test (DMRT) - Analysis of covariance (ANCOVA)-description of the method in the case of one and two concomitant variables. [12 hours]

UNIT III

Fundamental principles of design of experiments - Randomization, Replication and Local control - Completely randomized design (CRD) - Randomized complete block design (RCBD) - Latin square design (LSD) and their analyses - Missing plot technique for RBD and LSD - more than one observation per cell in RBD-Graeco-LSD-ANACOVA technique in CRD, RBD and LSD - Transformations. [12 hours]

UNIT IV

Factorial experiments – 2^n and 3^n experiments and their analysis-complete and partial confounding – Concept of Fractional replicated experiments - concept and analysis of asymmetrical factorial experiments - Split-plot and Strip-plot designs. [12 hours]

UNIT V

Incomplete block design - Balanced incomplete block design and partially balanced incomplete block design with two associate classes-parametric relation and analysis - Analysis of Youden square design - Concept of Lattice design - Analysis of non-orthogonal data.

[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. Cochran, W. G and Cox, G. M. (1957): Experimental Designs. John Wiley & sons, New York.
2. Das, M. N. and Giri, N. C. (1986): Design and Analysis of Experiments (2^{nd} Edition). Wiley Eastern Ltd., New Delhi.
3. Dey, A. (2010): Incomplete Block Designs. World Scientific Publishing Company.
4. Fisher, R. A. (1953): Design and Analysis of Experiments. Oliver and Boyd, London.

Books for Reference:

1. Giri, N.C. (1986): Analysis of Variance. South Asian Publisher, New Delhi.

2. John, P.W.M (1998): Statistical Design and Analysis Experiments. Macmillan Company, New York.
3. Joshi, D. D (1987): Linear Estimation and Design of Experiments. New Age International (P) Ltd. New Delhi.
4. Kempthorne, O. (1976): Design and Analysis of Experiments. John Wiley & Sons, New York.
5. Montgomery, D.C. (2012). Design and analysis of Experiments. John Wiley & Sons, New Delhi.
6. Searle, S.R. (2012). Linear Models. John Wiley & Sons, Inc., New York.
7. Shan, S.M. and Kabe. (1983). An Introduction to Construction and Analysis of Statistical Designs (Issue 64). Queen University Publications.

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*							

20. STATISTICAL COMPUTING USING SOFTWARE – III

Testing of Hypotheses:

Critical regions and power curves, Testing hypothesis on the parameters of the following distributions: Binomial distribution. Normal distribution and Exponential Distribution. (i) Simple Hypothesis (ii) One sided and two sided alternatives

Most powerful test - Uniformly most powerful test- Likelihood ratio test- Chi-Square Test, Sequential Probability Ratio Test – OC and ASN function.

Sign Test, Kolmogorov -Smirnov Test, Median Test, Wald-Wolfowitz Run Test, Mann-Whitney U-Test and Test for Randomness.

Multivariate Analysis:

Maximum likelihood estimators of mean vector and dispersion Matrix.
Test for mean vector when dispersion matrix Σ is known. Hotelling'sT2statistic.
Test for covariance matrix Principal component analysis.
Canonical correlation and canonical variables.
Discrimination and Classification problems. Factor Analysis, Cluster Analysis

Demography:

Mortality - Basic measurements
Crude, specific, standardized death rates
Life table - construction, use and interpretation.

Fertility -Basic measurements
Gross and Net Reproduction rate
Cohort fertility analysis - Fertility models

Design of Experiments:

One way – Two way ANOVA- CRD, RBD, LSD with missing value and Multiple Comparison Tests.
Balanced Incomplete Block Design.
Designs arranged in replications. Design not arranged in replications.
Designs with v = b.
Youden Square Design PBIBD (2)
Intra Block Analysis (Group Divisible type only).
Factorial Experiments: 3^2, 3^3, $1/2^k$ replicate of 2^n

IV SEMESTER

21. TIME SERIES ANALYSIS

Course Code	TITLE OF THE COURSE	L	T	P	C
Core	**TIME SERIES ANALYSIS**	2	1	2	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**		**2022-23**	

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*				

22. ELECTIVE-II (shall be chosen from list of Elective courses)

23. ELECTIVE-III (shall be chosen from list of Elective courses)

24. ELECTIVE-IV (shall be chosen from list of Elective courses)

25. STATISTICS COMPUTING USING SOFTWARE– IV

Course Code	TITLE OF THE COURSE	L	T	P	C
Core	STATISTICS PRACTICAL USING SOFTWARE– IV	1	1	1	2
Prerequisites	Knowledge of Statistical Methods for Data Analysis	Syllabus Version		2022-23	

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

Course Objective:

The main objectives of this course are to:

1. Perform Time Series models using Python.
2. Execute code for Regression models.
3. Write customized program for mathematical and statistical problems

Course outcomes

On completion of the course, students should be able to:

CO No.	Expected Course Outcomes	Cognitive Level
CO1	Create programs using python	K2, K3
CO2	Evaluate the functions which is available in python	K4, K6
CO3	Understand the concept of statistical program using python	K2, K5
CO4	Program with Time Series models	K1, K4
CO5	Program with correlation analysis	K5, K6
CO6	Program with Regression models	K5, K6

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

Course outline

MAPE in Python
SMAPE in Python
RMSE in Python
Mean Squared Error (MSE) in Python
Median Absolute Deviation in Python
Mean Absolute Error in Python
Moving Averages in Python
Cumulative Average in Python
Moving Average by Group in Python
Exponential Moving Average in Python
Autocorrelation in Python
Rolling Correlation in Python
Rolling Mean in Pandas
Rolling Median in Pandas
Resample Time Series Data in Python
Augmented Dickey-Fuller Test in Python

Books for Study:

1. B. V. Vishwas and A. Patel. Hands-on Time Series Analysis with Python: From Basics to Bleeding Edge Techniques. A press, 2020.

References:

1. https://www.statology.org/python-guides/
2. S. Johansen. Estimation and hypothesis testing of cointegration vectors in gaussian vector autoregressive models. Econometrica, 59(6):1551–1580, 1991.

26. MAJOR PROJECT AND VIVA-VOCE

SYLLABUS FOR ELECTIVE COURSES

ELECTIVE – I: PROGRAMMING IN C++

Course Code	TITLE OF THE COURSE	L	T	P	C
Elective	PROGRAMMING IN C++	2	1	2	3
Prerequisites	Knowledge of Programming language like Programming in C; object-oriented language; Coding and Statistical Computation	Syllabus Version		2022-23	

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

Course Objectives:

The main objectives of this course are to:

1. Provide programming skills in C++.
2. enables the students to use statistical applications in these programming languages.
3. Describe the procedure and object-oriented paradigm with concepts of streams, classes, functions, data and objects
4. Understand the operations and functions of C++.
5. Import and export the data outputs in C++
6. Able to write programmes in C++.

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 the various Objects Oriented Programming concepts with the help of programs.	K1-K6
CO2	Write inline functions for efficiency and performance	K1-K6
CO3	Overload functions and operators in C++.	K2-K6
CO4	Design and implement generic classes with C++ templates	K1-K6
CO5	Design C++ classes for code reuse.	K1-K6
CO6	Obtained the output results through programming Language	K2-K6

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

Course Outline:

UNIT I

Principles of Objects Oriented Programming –Software Crisis – Software Evolution – Procedure Oriented Programming – Object Oriented Programming paradigm – Basic concepts and benefits of OOP – Structure of C++ - Manipulators. [11 hours]

UNIT II

Functions in C++ : Functions prototyping – Call by Reference – Return by Reference – In – line function – Default, Const Arguments –Functions Overloading – Friend and Virtual Functions – Classes and Objects - Member functions – Nesting of Member functions – Private member functions – Memory allocation for objects – Static data members – Static member function – Returning Object – Const Member Function – Pointers to members. [14 hours]

UNIT III

Constructors: Parameterized Constructors – Multiple Constructors in C Classes – Constructors with Default Arguments – Dynamic – Initialization of Objects – Copy and Dynamic Constructors – Destructors - Operator Overloading – Unary and Binary Operators – Overloading Binary Operators using Friend Functions. [13 hours]

UNIT – IV

Inheritance, Extending Classes:– Defining Derived classes – Single, Multilevel, Multiple, Hierarchical and Hybrid inheritance – Virtual Base Classes – Abstract Classes-Pointers, Virtual Functions and Polymorphism – Pointers to Derived Classes – Virtual Functions [12 hours]

UNIT – V

Managing Console I/O Operations:–C++ streams – C++ stream Classes – Unformatted I/O Operations - Formatted Console I/O Operations – Managing output with Manipulators- Working with Files:– Classes for File Stream Operations- Opening and Closing a File - File Pointers and their manipulators – sequential I/O Operations. Simple Statistical Problems [10 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. Balagurusamy, E. (2001): Object oriented Programming with C++ (2nd Edition). Tata McGraw Hill Publishing Company Limited.
2. Venugopal, K. R., Rajkumar, B., and Ravi Shankar, T. (1999). Mastering C++, Tata McGraw – Hill, New Delhi.

Books for References:

1. Crawly, M.J. (2012). The R book (Second Edition). John Wiley & Sons.
2. Somashekar, M. T., Guru, D. S., Negendraswamy, H. S., and Manjunatha, K. S. (2012). Object Oriented Programming with C++, Prentice Hall Learning (India) Private Limited.
3. Dalgaard, P. (2008). Introductory Statistics with R. Springer Verlag Inc.,

4. Drăghici, S. (2011). Statistics and Data Analysis for Microarrays Using R and Bioconductor (Second Edition). CRC press.
5. Everitt, B.S. (2001). A Handbook of Statistical Analyses Using S-Plus (Second Edition). CRC Press.
6. Lafore, R. (1995): Object Oriented Programming with C++. Tata McGraw Hill Publishing Company Limited.
7. Logan, M. (2011). Bio statistical Design and Analysis Using R: A Practical Guide. John Wiley & Sons.
8. Stroup, B. (1991): The C++ Programming Language, Addison Wesley.

Mapping of Course Outcomes to Programme Outcomes

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

ELECTIVE - I: PROGRAMMING IN S-PLUS / R

Course Code	**TITLE OF THE COURSE**	**L**	**T**	**P**	**C**
Elective	**PROGRAMMING IN S-PLUS / R**	**2**	**1**	**2**	**3**
Prerequisites	Knowledge of Programming language like Programming in C; object-oriented language; Coding and Statistical Computation	**Syllabus Version**		**2022-23**	

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

Course Objectives:

The main objectives of this course are to:

1. Provide programming skills in R.
2. Understand the operations and functions of R Programming
3. Perform statistical analysis using built-in functions
4. Learn and write customized program for mathematical and statistical 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	Understand the basics of R Language	**K2**
CO2	Apply the logical skills for performing statistical analysis	**K3, K4**
CO3	Use appropriate plots, charts and diagrams for all kinds of data	**K3**
CO4	Perform parametric methods	**K3**
CO5	Write and execute the code for multivariate analysis	**K1-K5**
CO6	Obtained the output results through programming Language	**K2-K6**
K1: *Remember* **K2**: *Understand* **K3**: *Apply* **K4**: *Analyze* **K5**: *Evaluate* **K6**: *Create*		

UNIT I

Introduction to R - Using the help facility. R data types and objects, reading and writing data- import and export. Data structures: vectors, matrices, lists and data frames - Built-in data - Reading data from other sources - Merging data across data sources. Dealing with Missing values - Data Cleaning and Transforming - Exploring and Visualizing - Writing your own functions - Statistical models in R. [12 hours]

UNIT II

Control structures: functions, scoping rules, dates and times - Grouping, loops and conditional execution - Ordered and unordered factors - Arrays and matrices - Classes and methods - Graphical procedures – Packages. [12 hours]

UNIT III

Vector matrix operations – matrix operations – addition, subtraction and multiplication, linear equations and eigen values, matrix decomposition – lu, qr and svd and inverse, the linear model and qr decomposition, determinant, finding rank. [12 hours]

UNIT IV

Descriptive Statistics - Frequency and contingency tables–Correlations-t-tests. Nonparametric tests of group differences: Comparing two groups - Comparing more than two groups. [12 hours]

UNIT V

Statistical Distributions and Fitting – Random number and Simulation - Regression - ANOVA – General linear models – Principal component analysis and factor 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. An Introduction to R. Online manual at the R website at http://cran.r-project.org/manuals.html
2. Peter Dalgaard. Introductory Statistics with R (paperback) 1st Edition Springer-Verlag New York, Inc.
3. Brian Everitt and TorstenHothorn. A Handbook of Statistical Analyses Using R, 2nd Edition Chapman and Hall/CRC, 2009.
4. Robert Kabacoff. R in Action Data Analysis and Graphics with R, Manning Publications. 2011.

Books for References:

1. Crawly, M.J. (2012). The R book (Second Edition). John Wiley & Sons.
2. Dalgaard, P. (2008). Introductory Statistics with R. Springer Verlag Inc.,
3. Drăghici, S. (2011). Statistics and Data Analysis for Microarrays Using R and Bioconductor (Second Edition). CRC press.
4. Logan, M. (2011). Bio statistical Design and Analysis Using R: A Practical Guide. John Wiley & Sons.

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

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=+u3y6UdbIvOJ97LFeSCmHQ== P-15. Basic R programming
2. https://nptel.ac.in/courses /110107095.
3. https://nptel.ac.in/courses /111104120

Mapping of Course Outcomes to Programme Outcomes

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

ELECTIVE- I: STATISTICAL DATA MINING

Course Code	TITLE OF THE COURSE	L	T	P	C
Elective	STATISTICAL DATA MINING	2	1	2	3
Prerequisites	Knowledge of Programming language like Programming in C; object-oriented language; Coding and Statistical Computation	Syllabus Version		2022-23	

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

Course Objectives

1. This course aims at facilitating the student to understand the concepts of data warehousing and data mining.
2. Students to understand the various techniques involved in mining the data from the databases.

COURSE OUTCOMES

On completion of the course, students should be able to:

CO No.	*Expected Course Outcomes*	*Cognitive Level*
CO1	Able to learn the concept of data base technology which has led to the need for data mining and its applications	**K2, K3**
CO2	Examine the types of data to be mined and present a general classification of task to integrate data mining system.	**K4, K6**
CO3	Evaluate and select appropriate data mining algorithms and apply, interpret and report the output appropriately.	**K2, K5**
CO4	Apply statistical methods for any given raw data.	**K1, K4**
CO5	Understand the concept of Neural Networks	**K5, K6**
CO6	Understand the concept of Web mining	**K5, K6**

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

Course Outline:

UNIT I

Introduction: Datamining- Kinds of data – Datamining Functionalities - Classification of Data mining Systems - Major Issues on Datamining - Introduction to OLAP - OLAP technology for Data Mining - Data warehousing - Data warehousing to Datamining - Optimizing Data for mining - Data preprocessing. [12 hours]

UNIT II

Data Mining Primitives:Data mining Querylanguage - Association Rules in large - Data mining - KDD Process - Fuzzy sets and logic - Classification and Prediction**:**Information retrieval - Dimensional Modeling of Data - Pattern Matching - Estimation Error- EM and MLE. [12 hours]

UNIT III

Models based on Summarization: Bayes Theorem - Chi squared Statistics Regression - Decision Tree - Neural Networks - Genetic Algorithms - Cluster Analysis– Outlier - Cluster Vs Classification - Clustering Issues - Impact of Outliers on clustering- Clustering problems - Clustering Approaches. [12 hours]

UNIT IV

Clustering Algorithms:Hierarchical algorithm – Single Link- MST Single Link - Complete Link - Average Link- Dendrogram - Partitional Algorithm – MST - Squared Error - K-Means - Nearest Neighbor – PAM – BEA – GA - Categorical algorithm - Large Database. [12 hours]

UNIT V

Web Mining: Introduction - Webdata - Web Knowledge Mining Taxonomy - Web Content mining - Web Usage Mining Research - Ontology based web mining Research - Web Mining 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. Berry, J.A. and Linoff, G.S. (2011): Data Mining Techniques (Third Edition). John Wiley & Sons.
2. Chattamvelli, R. (2009): Data mining Methods. Alpha Science International.
3. Dunham, M.H. (2006): Data mining: Introductory and Advanced Topics. Pearson Education India.
4. Gorunescu, F. (2010): Data mining Concepts, Models and Techniques. Springer.
5. Han, J. and Kamber, M (2001): Data mining Concepts and Techniques (Seventh Edition). Morgan Kaufmann Publications.
6. Hand, D., Mannila, H. and P. Smyth (2001): Principles of Data mining. MIT press.
7. Larose, D.T. (2005): Discovering Knowledge in Data: An Introduction to Data mining. John Wiley & Sons, Canada.

Books for References:

1. Pujari, A.K. (2001): Data mining Techniques, Universities press.
2. Sivanandam S.N. and S. Sumathi (2006): Data mining Concepts, Tasks and Techniques, Springer.
3. Jiawei Han and Micheline Kamber, "Data Mining concepts and Techniques", Second Edition, Elsevier, Reprinted 2011.
4. G.K. Gupta, "Introduction to Data Mining with case Studies", Easter Economy Edition.

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

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=fBYckQKJvP3a/8Vd3L08tQ==P-04.Database management system

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*							

ELECTIVE – II: APPLIED REGRESSION ANALYSIS

Course Code	**TITLE OF THE COURSE**	**L**	**T**	**P**	**C**
Elective	**APPLIED REGRESSION ANALYSIS**	**3**	**1**	**1**	**3**
Prerequisites	Knowledge of regression Analysis	**Syllabus Version**		**2022-23**	

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

Course Objectives

- This course enables the students to learn how to estimate and control regression parameters,
- choose an appropriate regression model by deleting the unnecessary regressors and compute autocorrelation.
- To carry out Residual analysis
- To understand the problem of Multicollinearity and its Identification.
- Problems related to indicator variables
- To understand the concept of Robust Regression.

COURSE OUTCOMES

On completion of the course, students should be able to:

CO No.	Expected Course Outcomes	PSO	Cognitive Level
CO1	Identify the nature of Regression model	PSO4	**K2, K3**
CO2	Examine the model Assumption	PSO6	**K3**
CO3	Construction of Linear and Non-Linear model	PSO6	**K3,K6**
CO4	Estimate the Parameter and its significance	PSO3	**K4,K5**
CO5	Construction of Logistic Regression and Generalized; understand the concept of Robust Regression.	PSO4	**K3,K6**
CO6	Develop computer programmes for construction and evaluation of Regression models for real world problems.	PSO4	**K1- K6**

Course Outline:

UNIT I

Regression and Model Building – Simple and Multiple Linear Regression Model – Estimation of model parameters, properties of the least-squares estimators, estimation of σ^2 – Hypothesis testing – Model Adequacy Checking - Diagnostics for Leverage and Influence. [12 hours]

UNIT II

Multicollinearity: Sources of multicollinearity, Effects of multicollinearity, Multicollinearity diagnostics, methods for dealing multicollinearity. [12 hours]

UNIT III

Variable selection and model building – The Model-Building problem, Consequence of model misspecification, criteria for evaluating subset regression models. Computational techniques for variable selection – All possible Regressions, Stepwise Regression Methods. [11 hours]

UNIT IV

Generalized Linear Models: Introduction - Analysis of Binary model - Logistic Regression Models - Log linear Models – Link functions and linear predictors – Parameter estimation and Inference in the GLM – Prediction and Estimation with the GLM - Residual Analysis in the GLM and over dispersion. [12 hours]

UNIT V

Regression models with Autocorrelation errors – Sources and Effects of Autocorrelation, detecting the presence of autocorrelation, parameter estimation method- Effect of measurement Errors in the Regressors – Simple Linear Regression, The Berkson Model, Bootstrapping in Regression – Bootstrap Sampling in Regression, Bootstrap Confidence intervals. [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. Barnett, V. and T. Lewis. (1994): Outliers in Statistical Data (Third Edition). John Wiley & Sons, New York. (Digitized 2009).
2. Belsley, D.A., Kuth, E. and Welsch, R.E. (2004): Regression Diagnostics- Identifying Influential Data and Sources of Collinearity. John Wiley & Sons, New York.
3. Chatterjee, S. and Hadi, A.S. (2012): Regression Analysis by Examples. John Wiley & Sons, New York.
4. Cook, R.D. (1979) Influential Observations in Linear Regression. Journal of American Statistical Association, Vol: 74, pp. 169-174.
5. Cunst, R.F., and R.L. Mason. (1980): Regression Analysis and Its Applications - A Data Oriented Approach. Marcel Dekker Inc., New York.

Books for reference:

1. Daniel, C. and F.S. Wood. (1999): Fitting Equations to Data (Second Edition), John Wiley & Sons, New York.
2. Draper, N.R, and H. Smith. (1998): Applied Regression Analysis (Third Edition). John Wiley & Sons, New York.
3. Myers, R.H., Montgomery, D.C., Vining, G.G. and Robinson, T.J. (2012): Generalized Models: with Applications in Engineering and the Sciences (Second Edition). John Wiley & Sons.
4. Michael, H.K, Christopher, J.N, John N, William Li. (2013). Applied Linear Statistical Models. McGraw Hill Education (India)

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

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=+u3y6UdbIvOJ97LFeSCmHQ== P-07.Regression analysis I
2. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=+u3y6UdbIvOJ97LFeSCmHQ== P-08.Regression analysis II

Mapping of Course Outcomes to Programme Outcomes

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

Mapping of Course Outcomes to Programme Specific Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO 6	PSO7
CO1	*Medium*	*Medium*	*High*	*High*	*Medium*	*High*	*High*
CO2	*Medium*	*High*	*Medium*	*Medium*	*High*	*High*	*High*
CO3	*Medium*	*High*	*High*	*High*	*High*	*High*	*Medium*
CO4	*High*	*Medium*	*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*							

ELECTIVE- II: ACTUARIAL STATISTICS

Course Code	**TITLE OF THE COURSE**	**L**	**T**	**P**	**C**
Elective	**ACTUARIAL STATISTICS**	**3**	**1**	**1**	**3**
Prerequisites	Knowledge of Probability theory, Distribution theory and stochastic processess	**Syllabus Version**		**2022-23**	

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*							

ELECTIVE- II: FUZZY LOGIC AND ITS APPLICATIONS

Course Code	**TITLE OF THE COURSE**	**L**	**T**	**P**	**C**
Elective	**FUZZY LOGIC AND ITS APPLICATIONS**	**3**	**1**	**1**	**3**
Prerequisites	Basic Knowledge in set theory, Probability theory and Distribution theory	**Syllabus Version**		**2022-23**	

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

Course Objectives:

The main objectives of this course are to

- To understand the basic knowledge of fuzzy set theory.
- To gain knowledge in fuzzy relations and fuzzy measures
- To learn the basics of pattern recognition and decision making.
- To learn about relations between crisp and fuzzy in applications.

Course Outcomes (COs):

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

CO No.	Course Outcome	Cognitive Level
CO1	It lays foundation for difference between the concepts of crisp and fuzzy set, principle for fuzzy sets in the real-life situations	**K2**
CO2	The ability to use and understand the concept of operations on fuzzy sets- Union, intersection, complement properties of α-cuts.	**K2**
CO3	This course also provides the several relations according to the fuzzy set theory and possibility theory	**K2**
CO4	Knowledge and understanding of the applications such as Fuzzy clustering; Fuzzy image processing, fuzzy decision making and fuzzy ranking methods.	**K4**
CO5	Demonstrate understanding of the Fuzzy Set theory in real applications	**K3, K5**
CO6	Exposure to the applicability of neural networks and fuzzy logic	**K3 – K6**
K1: *Remember* **K2**: *Understand* **K3**: *Apply* **K4**: *Analyze* **K5**: *Evaluate* **K6**: *Create*		

Course Outline:

UNIT I

Uncertainty and Imprecision – Statistics and Random Processes – Uncertainty in Information – Fuzzy Sets and membership – Chance versus Ambiguity - Classical Sets and Fuzzy Sets: Classical Sets – Fuzzy Sets – Sets as Points in Hyper-cubes - Classical Relations and Fuzzy Relations: Cartesian Product – Crisp Relations – Fuzzy Relations – Tolerance and Equivalence Relations – Fuzzy Tolerance and Equivalence Relations - Membership Functions. [12 hours]

UNIT II

Fuzzy-to-Crisp Conversions: Lambda-Cuts for Fuzzy Sets – Lambda-Cuts for Fuzzy Relations – Defuzzification Methods - Fuzzy Arithmetic, Numbers, Vectors and the Extension Principle - Extension Principle – Fuzzy Numbers – Interval Analysis in Arithmetic – Approximate Methods of Extension – Fuzzy Vectors. [12 hours]

UNIT III

Classical Logical and Fuzzy Logic: Classical Predicate Logic – Fuzzy Logic – Approximate Reasoning – Fuzzy Tautologies, Contradictions, Equivalence, and Logical Proofs – Other Forms of the Implication Operation – Other Forms of the Composition Operation - Fuzzy Rule-Based Systems: Natural Language – Linguistic Hedges – Rule-Based Systems – Graphical Techniques of Inference. [12 hours]

UNIT IV

Fuzzy Nonlinear Simulation: Fuzzy Relational Equations – Partitioning – Nonlinear Simulation Using Fuzzy Rule-Based Systems – Fuzzy Associative Memories (FAMs) - Fuzzy Decision Making: Fuzzy Synthetic Evaluation – Fuzzy Ordering – Preference and Consensus – Multi-objective Decision Making – Fuzzy Bayesian Decision Method – Fuzzy Inference System (FIS) - Decision Making under Fuzzy States and Fuzzy Actions. [12 hours]

UNIT V

Fuzzy Classification: Classification by Equivalence Relations – Cluster Analysis – Cluster Validity – Classification Metric – Hardening the Fuzzy- Similarity Relations from Clustering. Fuzzy Pattern Recognition: Feature Analysis – Partitions of the Feature Space – Single Sample Identification – Multi-feature Pattern Recognition – Image Processing – Syntactic Recognition. [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. Dan E. Tamir, Naphtali D. Rishe, and Abraham Kandel (2015) Fifty Years of Fuzzy Logic and Its Applications.
2. George, A. and Anastassiou. (2010). Fuzzy Mathematics: Approximation Theory. Springer.
3. George J. Klir and Tina A. Folge.(1988). Fuzzy Set, Uncertainty, and Information. Prentice-Hall, Inc, USA.
4. Klir, G.J. and B. Yuan.(1995). Fuzzy sets and Fuzzy logic Theory and Applications. Prentice-Hall Inc., (Reprint 2003).
5. Nanda. S and Das .N.R. (2010). Fuzzy Mathematical Concepts. Narosa Publishing House, Pvt, Ltd, New Delhi 110002.

Books for Reference:

1. Nguyen, H.T., Prasad, N.R., Walker, A.L. and Walker, E.A. (2003). A First Course in Fuzzy and Neural Control. Chapman Hall/CRC press.
2. Nguyen, H.T. and Walker, E.A. (2005). A First Course in Fuzzy Logic (Third Edition). CRC Press.
3. Ross, T.J. (2009). Fuzzy Logic with Engineering Applications (Third Edition). John Wiley & Sons.
4. Yen, J. and Langari, R. (1999). Fuzzy logic Intelligence, control and information. Prentice Hall.

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

1. https://archive.nptel.ac.in/noc/courses/noc22/SEM1/noc22-ge04/
2. https://archive.nptel.ac.in/noc/courses/noc22/SEM1/noc22-ee21/

Mapping of Course Outcomes to Programme Outcomes

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

ELECTIVE- II: STOCHASTIC MODELLING AND ITS APPLICATIONS

Course Code	**TITLE OF THE COURSE**	**L**	**T**	**P**	**C**
Elective	**STOCHASTIC MODELLING AND ITS APPLICATIONS**	**3**	**1**	**1**	**3**
Prerequisites	Basic Knowledge in Probability theory, Distribution theory, Stochastic Processess	**Syllabus Version**		**2022-23**	

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 Basic Concepts in Stochastic Queueing models in queue related analysis; apply the concept of Retrial Queues in Queueing Networks	**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 - Markov chains -Classification of states and chains - Higher transition probabilities and its limiting behavior -Chapman Kolmogorov's equations - Stationary distribution - Ergodic theorem - Continuous time Markov processes - Poisson processes. [12 hours]

UNIT-II

Birth and death processes - Kolmogorov Feller differential equations of birth and death processes - 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-III

Introduction to Queueing Theory - Basic characteristics of a Queueing system and Problems in Queueing system-Probability Distributions as Models – Basic Concepts in Stochastic Queueing models - Kendall's notation for Queueing models Little's Formulas - Stochastic process representation of Queueing theory-Steady state solutions for the queueing models. [12 hours]

UNIT-IV

Birth and Death Queueing models-State dependent service pattern-transient behavior of queues-Inventory models as a queueing models - Detailed study of single and multiple server queueing models - Advanced Markovian Queueing Models - Erlangian Bulk Queues - Retrial Queues - Queue with Priority Disciplines -Preemptive priority and Non - Preemptive priority queue - Queueing Networks Vacation Queueing Models- Bernoulli Vacation Queueing Models. [12 hours]

UNIT-V

Higher transition probabilities – higher order Markov chains – Multivariate Markov chain models - Applications to queues and storage problems – Decision Problems in Queueing Theory - Simulation techniques in Queueing Models – Case Studies and Applications in Queueing theory. [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.]

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=34 Paper: P-10. Stochastic Processes and Time Series Analysis - ISI, Kolkata
2. https://nptel.ac.in/courses/111/103/111103022/ Stochastic Processes – IIT Guwahati
3. https://nptel.ac.in/courses/111/102/111102098/ Introduction and Motivation for studying Stochastic Processes – IIT Delhi
4. https://ocw.mit.edu/courses/mathematics/18-445-introduction-to-stochastic-processes-spring2015/lecture-notes/
5. 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*							

ELECTIVE - III: CATEGORICAL DATA ANALYSIS

Course Code	TITLE OF THE COURSE	L	T	P	C
Elective	CATEGORICAL DATA ANALYSIS	2	1	2	3
Prerequisites	Knowledge of Basic statistical analysis, Hypothesis testing, Probability theory, and Distribution theory	Syllabus Version		2022-23	

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* **K4**:*Analyze* **K5**:*Evaluate* **K6**: *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 Response 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]

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. 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	PSO6	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*							

ELECTIVE - III: OFFICIAL STATISTICS

Course Code	**TITLE OF THE COURSE**	**L**	**T**	**P**	**C**
Elective	**OFFICIAL STATISTICS**	**2**	**1**	**2**	**3**
Prerequisites	Knowledge of Health, Social and Economic sectors, CSO and NSSO.	**Syllabus Version**		**2022-23**	

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

Course Objectives:

The main objectives of this course is to

1. Understand the functioning of Central and State statistical organizations.
2. Promote human resource development in the official statistics and encourage research and development in theoretical and applied statistics.
3. Execute the data handling tasks in various government records.
4. Able to analyze the secondary data collected from central and state statistical organizations.

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 fundamentals and students will become familiar with institutional, legal and organizational bases, and principles of functioning in official statistics.	**K1**
CO2	Evaluate the methods for data collection, analysis and interpretation of health, social and economic.	**K5**
CO3	Use appropriate methods for presenting and preparing commentaries on official statistics.	**K2, K3**
CO4	Projection of population growth and measurement of income inequality using different methods are expected.	**K1, K2**
CO5	Learn the methodological bases of measurement in official statistics and execute the tasks in agricultural and economic statistics	**K2, K6**
CO6	Finally, students are expected to know the collection, analysis, forecasting and interpretation of results of data relating to agricultural, industry, educational and other social statistics.	**K2-K6**
K1: *Remember* **K2**: *Understand* **K3**: *Apply* **K4**: *Analyze* **K5**: *Evaluate* **K6**: *Create*		

Course Outline:

UNIT I

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

[12 hours]

UNIT II

Population growth in developed and developing countries - Evaluation of performance of family welfare programmes - Projections of labour force and manpower - Scope and content of population census of India. [12 hours]

UNIT III

System of collection of Agricultural Statistics - Crop forecasting and estimation - Productivity, fragmentation of holdings - Support prices - Buffer stocks - Impact of irrigation projects**.** [11 hours]

UNIT IV

Statistics related to industries - Foreign trade - Balance of payment - Cost of living – Inflation - Educational and other social statistics. [11 hours]

UNIT V

Indian official statistics: Present official statistical system in India - Methods of collection of official statistics, their reliability and limitations - Principal publications containing data on the topics such as population, agriculture, industry, trade, prices, labour and employment, transport and communications - Banking and finance - Various official agencies responsible for data collection and their main functions. [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. Allen R. G. D. (1975). Index Numbers in Theory and Practice, Macmillan.
2. C. S. O. (1990). Basic Statistics Relating to the Indian Economy.
3. C.S.O. (1995). Statistical System in India.
4. C. S. O. (1999). Guide to Official Statistics.
5. Mukhopadhyay, P. (2011). Applied Statistics, Second Edition, Books & Allied Ltd, India.
6. Bhaduri, A. (1990). Macroeconomics: The Dynamics of Commodity Production, Macmillan India Limited, New Delhi
7. Branson, W. H. (1992). Macroeconomic Theory and Policy, Third Edition, Harper Collins Publishers India (P) Ltd., New Delhi.

Books for Reference:

1. Gun A. M., Gupta M. K., and Dasgupta. B. (2001), Fundamentals of Statistics, Vol. 2, World Press, India.
2. Panse, V. G. (1964). Estimation of Crop Yields (FAO), Food and Agriculture Organization of the United Nations.
3. Family Welfare Yearbook. Annual Publication of D/o Family Welfare.

4. Monthly Statistics of Foreign Trade in India, DGCIS, Calcutta and other Govt. Publications.
5. Panse, V. G., Estimation of Crop Yields (FAO).
6. Principles and accommodation of National Population Censuses, UNESCO.

Mapping of Course Outcomes to Programme Outcomes

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

ELECTIVE – III: PROGRAMMING IN PYTHON

Course Code	**TITLE OF THE COURSE**	**L**	**T**	**P**	**C**
Elective	**PROGRAMMING IN PYTHON**	**2**	**1**	**2**	**3**
Prerequisites	Basic knowledge in Programming in c++ and R	**Syllabus Version**		**2022-23**	

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

Course Objectives:

The main objectives of this course is to

- provide to basic python skills and data structures, move on to how to load data from different sources.
- Also covering topics typically found in introductory computer programming (coding) courses and
- students merely need to have typical computer usage skills prior to starting this course.

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 components of a computer and use Jupyter Notebook	**K2, K3**
CO2	Apply suitable programming constructs and built-in data structures to solve a problem.	**K4, K6**
CO3	Understand the library functions using python programs	**K2, K5**
CO4	Use classes and objects in application programs and visualize data.	**K1, K4**
CO5	Dealing with Date and Time Data Types and Tools	**K5, K6**
CO6	Develop, document, and debug modular python programs.	**K6, K5**
K1: Remember **K2:** Understand **K3:** Apply **K4:** Analyze **K5:** Evaluate **K6:** Create		

Course Outline:

UNIT I

Using the Jupyter notebook – Python basics: variables, conditionals and loops – Data Structures: lists and dictionaries. [12 hours]

UNIT II

Data handling and Strings: Reading data in to memory - Working with strings – Catching exceptions to deal with bad data – NumPy Basics: Arrays and Vectorized Computation. [12 hours]

UNIT – III

Using Pandas, the python and data analysis library – Series and data frames – Data Aggregation and Group Operations – Merging and joining. [12 hours]

UNIT IV

Visualization with matplotlib – figures and subplots – Plotting Functions in pandas - Labeling and arranging figures – Outputting graphics. [12 hours]

UNIT V

Time Series Analysis: Date and Time Data Types and Tools - Time Series Basics - Periods and Period Arithmetic - ARIMA Forecasts - Time Series Plotting - Simple Linear Regression Models. [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. Jake VanderPlas (2016): Python Data Science Handbook: Essential Tools for Working with Data (First edition), O'Reilly Media, Inc., USA.
2. Wes McKinney (2013): Python for Data Analysis (Second edition), O'Reilly Media, Inc., USA.
3. Kulkarni (2017): Problem Solving and Python Programming (First Edition), Yes Dee Publishing Pvt Ltd.

4. Guttag, J.V. (2016). Introduction to computation and programming using Python. 2nd edition. MIT Press.
5. Taneja, S., Kumar, N. (2018). Python Programming- A modular Approach. Pearson Education India.

Books for references:

1. Kamthane, A. N., & Kamthane, A.A. (2017) Programming and Problem Solving with Python, McGraw Hill Education.
2. Liang, Y. D. (2013). Introduction to Programming using Python. Pearson Education.

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

1. https://archive.nptel.ac.in/noc/courses/noc22/SEM1/noc22-cs26/
2. https://archive.nptel.ac.in/noc/courses/noc21/SEM1/noc21-cs21/

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*

ELECTIVE – III: MACHINE LEARNING

Course Code	TITLE OF THE COURSE	L	T	P	C
Core	**MACHINE LEARNING**	2	1	2	3
Prerequisites	Probability theory, Distribution Theory and Basic Statistical Methods	**Syllabus Version**		**2022-23**	

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

Course Objectives:

The main objectives of this course is to

- 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 - Markov Random Fields- Conditional Independence Properties - Parameterization of MRFs - Examples - Learning – Conditional Random Fields (CRFs) - Structural SVMs. [12 hours]

UNIT V

Sampling – Basic sampling methods – Monte Carlo - Reinforcement Learning - K-Armed Bandit Elements - Model-Based Learning - Value Iteration- Policy Iteration - Temporal Difference Learning- Exploration Strategies- Deterministic and Non-deterministic Rewards and Actions Eligibility Traces- Generalization- Partially Observable States- The Setting- Example – Semi Supervised Learning - Computational Learning Theory - Mistake Bound Analysis – Sample Complexity Analysis - VC Dimension - Occam Learning - Accuracy and Confidence Boosting.
[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*							

ELECTIVE – IV: BIO-STATISTICS AND SURVIVAL ANALYSIS

Course Code	**TITLE OF THE COURSE**	**L**	**T**	**P**	**C**
Elective	**BIO-STATISTICS AND SURVIVAL ANALYSIS**	**3**	**1**	**1**	**3**
Prerequisites	Basic knowledge in Descriptive Statistics and Inferential Statistics, Probability Theory and Basic Biostatistics	**Syllabus Version**		**2022-23**	

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 comparison of two or more treatments in human subjects.
- To visualize and communicate time-to event data, to fit and interpret failure time model to learn the reliability theory and analysis of survival data.
- To distinguish censored and uncensored data.

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 Phases of Clinical Trials and epidemiological study designs.	**K1, K2**
CO2	Understand the Disease-Exposure association and Diagnostic Testing in Clinical Studies.	**K2 - K6**
CO3	Check model assumptions for Estimation of Means and Proportions and analyze the clinical data.	**K1-K5**
CO4	Apply Logistic regression for case-control studies and its implementation.	**K3, K5**
CO5	Estimate nonparametric survival function of the data	**K3, K5**
CO6	Understand the concept of censoring, life distributions.	**K2 – K5**
K1: *Remember* **K2**: *Understand* **K3**: *Apply* **K4**: *Analyze* **K5**: *Evaluate* **K6**: *Create*		

UNIT I

Introduction Definition/Phases of Clinical Trials; Study Design: Cohort, case-control and observational studies; Terminology of prospective, retrospective; treatment allocation, randomization and stratification, biases, sample size requirements, patient consent, Various types of clinical data (continuous, categorical, count, and time-to-event outcome data); Basic biological concepts in genetics, Basic concept of Bioassays and different Types of biological assays [13 hours]

UNIT II

Disease-Exposure Association: Risk, odds, odds ratio, relative risk, standard errors; Contingency Tables: Association (Chi-square test), Confounding (Mantel-Haenszel), Interactions (Test of homogeneity); Probability Diagnostic Testing and Screening. [12 hours]

UNIT III

Descriptive Statistics; Estimation for Means; Estimation for Proportions; One Sample Hypothesis Test – Means; One Sample Hypothesis Test – Proportions; Two Sample Hypothesis Test; Non-Parametric Hypothesis Testing; One Way ANOVA. [12 hours]

UNIT IV

Introduction to Linear Regression and Correlation; Logistic Regression: estimation: Logistic regression for case-control studies, estimation and interpretation of logistic parameters, [10 hours]

UNIT V

Introduction to Survival modeling - Survival function - Concepts of Censoring-different types of censoring- right, type I, type II and random censoring. Kaplan-Meier (K-M) estimator; Nonparametric Methods for Comparing Survival Distributions - log rank test. Cox Proportional Hazard regression, parametric survival models – Exponential and Weibull. [13 hours]

UNIT V

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. Fundamentals of Biostatistics: Bernard Rosner Recommended 6th /7th Edition
2. Friedman, Furberg & DeMets: Fundamentals of Clinical Trials, 3rd Edition, 1996. Mosby-Year Book, Inc.
3. Rossi R.J. (2010). Applied Biostatistics for Health Sciences, Wiley.
4. Cox, P.R. (1978): Demography (Fifth Edition). Cambridge University Press.
5. David G. K., and Klein, M. (2008). Survival analysis - A Self-Learning Text, Second edition, Springer.
6. Lee, E. T., and Wang J. Wenyu. (2003). Statistical methods for Survival Data Analysis, Third Edition, John Wiley & Sons.
7. David Collett, Chapman (2003). Modelling Survival data in Medical Research, Second Edition, Hall/CRC.
8. Miller Rupert G. (2011)Survival Analysis (Second Edition), John Wiley & Sons Inc Publisher.

Mapping of Course Outcomes to Programme Outcomes

	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*	*Low*	*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*							

ELECTIVE- IV: STATISTICAL METHODS IN CLINICAL TRIALS

Course Code	TITLE OF THE COURSE	L	T	P	C
Elective	STATISTICAL METHODS IN CLINICAL TRIALS	3	1	1	3
Prerequisites	Basic knowledge in Descriptive Statistics and Inferential Statistics, Biostatistics and Demography	Syllabus Version		2022-23	

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*							

ELECTIVE- IV: EVALUATIONARY ALGORITHM AND DEEP LEARNING

Course Code		**TITLE OF THE COURSE**	**L**	**T**	**P**	**C**
Core		**EVALUATIONARY ALGORITHM AND DEEP LEARNING**	**3**	**1**	**1**	**3**
Prerequisites		**Basics in Machine Learning,** neural networks	**Syllabus Version**		**2022-23**	

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

Course Objectives:

The main objectives of this course is to

1.To introduce the fundamentals of neural networks as well as some advanced topics such as recurrent neural networks, long/short term memory cells and convolutional neural networks.

2. To introduce complex learning models and deep learning models

3 To explore various learning models using different software packages

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 fundamentals of deep learning and build deep learning models	**K1, K2**
CO2	Apply the most appropriate deep learning method in any given situation.	**K2 - K6**
CO3	Develop neural network models in data-intensive real-time problems.	**K1-K5**
CO4	Describe efficient generative models	**K3, K5**
CO5	Learn and apply convolutional and recurrent neural network techniques.	**K3, K5**
CO6	Use techniques, skills and modern engineering tools necessary for deep learning practice	**K1 – K5**
K1: *Remember* **K2**: *Understand* **K3**: *Apply* **K4**: *Analyze* **K5**: *Evaluate* **K6**: *Create*		

UNIT-I

Architectures, Properties of CNN representations: invertibility, stability, invariance, convolution, pooling of layers, CNN and Tensor flow, Difficulty of training deep neural networks, Greedy layer-wise training. Newer optimization methods for neural networks (Adagrad, adadelta, rmsprop, adam, NAG), second order methods for training, Saddle point problem in neural networks, Regularization methods (dropout, drop connect, batch normalization). [12 hours]

UNIT-II

LSTM, GRU, Encoder-decoder architectures, Auto-encoders (standard, de-noising, contractive, etc), Variational Autoencoders, kohonen SOM, **:** Back propagation through time, Long Short Term Memory, Gated Recurrent Units, Bidirectional LSTMs, Bidirectional RNNs. Dynamic memory models. Reinforcement learning, Restrictive Boltzmann Machines (RBMs), Introduction to MCMC and Gibbs Sampling, gradient computations in RBMs, Deep Boltzmann Machine., deep belief networks, convolutional networks, LeNet, AlexNet. [12 hours]

UNIT-III

Introduction to Optimization; Single Objective Optimization (SOP); Deterministic Optimization Methods (Gradient Descent, LP and QP); Stochastic Optimization Methods(random search, Stimulated Annealing, Evolutionary Algorithms); Difficulties in Single Objective Optimization; Difficulties with Classical Optimization Algorithms; Need for Evolutionary Algorithms. [12 hours]

UNIT-IV

Evolutionary Algorithm; EA operators (Selection, Recombination and Mutation operators); Single Objective Optimization (SOP) using EAs; Design and Parameterization for Single Objective Applications; Problem Formulation and representation issues for different real world engineering SOPs; Some competent EAs. [12 hours]

UNIT-V

Constrained SOP; Discovery of innovative knowledge through Optimization; Difficulties in EAs; No free lunch theorem; Enhancing efficiency of EAs through incorporation of domain specific information and hybridization with expressly designed algorithms. Introduction to Multi-Objective Optimization (MOP); Concept of Pareto Optimality; Issues in Multi- Objective Optimization; Multi-objective evolutionary approaches. [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. Bengio, Yoshua, Ian Goodfellow, Aaron Courville(2016). Deep learning, MIT press.
2. A.E. Eiben and J.E. Smith. Introduction to Evolutionary Computing, Springer, Heildeberg, Germany, 2003.

Books for Reference:

1. Raúl Rojas, Neural Networks: A Systematic Introduction, 1996, 2nd edition
2. Bishop C., neural networks for pattern recognition, 2015, Oxford university press
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar
3.J.R. Koza et al., Genetic Programming, Kluwer, Norwell, MA, 2003.
5. C.A. Caello, D.A. Van Veldhuitzen and G. Lamont, Evolutionary Algorithms for Solving Multi-Objective Problems, New York, 2002.
6. M.V. Butz, Anticipatory Learning Classifier Systems, Kluwer, Norwell, MA, 2002.
7. T. Back, D.B. Fogel and Z. Michalewicz(Eds); Evolutionary Computation: Basic Algorithms and Operators, Vol.1 and Vol.2, Institute of Physics Publishing Philadelphia, PA, 2000.
8. Y.C.Jin(Ed), Knowledge incorporation in evolutionary computation, Springer, New York, 2005.
9. R. Riolo and B. Worzel (Eds), Genetic programming theory and practice, Norwell, MA, 2003.
10. R. Sarker and M. Mohammadian, and X. Yao(Eds), Evolutionary Optimization, Kluwer, Norwell, MA, 2002.

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

1. https://nptel.ac.in/courses/106106184.
2. https://nptel.ac.in/courses/106106201
3. https://nptel.ac.in/courses/106106224

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*	*Medium*	*Medium*	*Medium*	*High*	*High*
CO3	*High*	*Medium*	*Medium*	*Medium*	*High*	*High*	*High*
CO4	*High*	*High*	*Medium*	*Medium*	*Medium*	*High*	*High*
CO5	*High*	*Medium*	*Medium*	*Medium*	*High*	*High*	*High*
CO6	*High*	*High*	*Medium*	*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*	*High*	*High*	*High*
CO2	*High*	*High*	*Low*	*High*	*High*	*High*	*High*
CO3	*Medium*	*Medium*	*High*	*High*	*High*	*High*	*Medium*
CO4	*High*	*High*	*High*	*High*	*High*	*High*	*High*
CO5	*Medium*	*High*	*Medium*	*Medium*	*High*	*High*	*High*
CO6	*High*	*High*	*High*	*High*	*High*	*Medium*	*High*
Correlation Levels: *Low* *Medium* *High*							

SYLLABUS FOR SUPPORTIVE COURSES

1.STATISTICAL METHODS

Course Code	**TITLE OF THE COURSE**	**L**	**T**	**P**	**C**
Supportive	**Statistical Methods**	**3**	**1**	**-**	**3**
Prerequisites	Knowledge of Basics notions of descriptive statistics	**Syllabus Version**		**2022-23**	

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

Course Objectives:

The main objectives of this course are to:

1. Describe statistical measures used in descriptive statistics
2. Help us to explain the distribution of data in terms of measures location and variability.
3. Be able to compute and interpret the expected value, variance, and standard deviation for a discrete random variable
4. Study the properties of discrete and continuous random variable.
5. Measure the relationship between the variables using correlation and regression 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	Understand the theory and applications of Descriptive Statistics	K1, K2
CO2	Analyze statistical data graphically using frequency distributions and cumulative frequency distributions.	K2, K3
CO3	Analyze statistical data using measures of central tendency and dispersion.	K4, K5
CO4	Solve simple problems under basic probability theory	K1-K3
CO5	Describe the concept of Random variables and its types	K1-K6
CO6	Analyze the data using correlation and regression.	K1-K4
K1: *Remember* **K2**: *Understand* **K3**: *Apply* **K4**: *Analyze* **K5**: *Evaluate* **K6**: *Create*		

Course Outline:

UNIT I

Origin - Scope – Functions, limitations, uses and misuses of statistics - Data collection methods, Classification and Tabulation of data - Diagrammatic and Graphical representation of data.

[12 hours]

UNIT II

Measure of Central tendency - Measures of Dispersion - Relative measures of dispersion - skewness and kurtosis - Lorenz curve. [12 hours]

UNIT III

Elementary probability space - Sample space - discrete probability, independent events - Mathematical and Statistical probability -Axiomatic approach to probability - Addition and multiplication theorems - conditional probability – Bayes' theorem - Simple problems.

[12 hours]

UNIT IV

Random variables - Discrete and continuous random variables - Distribution function – probability mass function and probability density function of a random variable – Addition and product theorems- Expectation of a random variable - evaluation of standard measures of location, dispersion, skewness and kurtosis. [12 hours]

UNIT V

Simple linear correlation and regression - Scatter diagram - Karl Pearson's correlation co-efficient and its properties- Regression equations- their properties - Spearman's correlation co-efficient. Regression equations– fitting of regression equations - regression coefficients and its properties. [12 hours]

(Total: 60L)

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. Goyal, J. K., and Sharma, J. N. (2014), Mathematical Statistics, Krishna Prakashan Private Limited, Meerut.
2. Gupta, S. P. (2012). Statistical Methods, Sultan Chand & Sons, New Delhi.
3. Gupta, S C., and Kapoor, V. K. (2018). Fundamentals of Mathematical Statistics, Eleventh Edition, Sultan Chand & Sons, New Delhi.
4. Hogg, R.V., McKean, J.W. and Craig, A.T. (2013). Introduction to Mathematical Statistics (Seventh Edition). Pearson Education Ltd.
5. Spiegel, M.R., Schiller, J. and Srinivasan, R.A. (2012): Probability and Statistics, Schaum's Outline Series (Fourth Edition). McGraw- Hill Publishing Company, New Delhi.

Books for Reference:

1. Goon, A. M., Gupta, M. K., and Das Gupta, B. (2013). Fundamentals of Statistics, Vol.1, World Press Private Ltd, Calcutta.

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

1. https://nptel.ac.in/courses/ 110107114
2. https://nptel.ac.in/courses/ 111105041
3. https://nptel.ac.in/courses /111104120

Mapping of Course Outcomes to Programme Outcomes

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

2. ELEMENTS OF BIO-STATISTICS

Course Code		**TITLE OF THE COURSE**	**L**		**P**	**C**
Supportive		**Elements of Bio-Statistics**	**3**		**0**	**3**
Prerequisites		Basic knowledge of Probability theory, Distribution theory and Sampling theory	**Syllabus Version**		**2022-23**	

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

Course Objectives:

The main objectives of this course are to

- To know about some statistical concepts related to biological, health related
- Initiate the awareness of Biostatistics and its essential need
- Make the students have a clear understanding of special kinds of various statistical tools used in biostatistics.
- Be knowledgeable about the potential applications of these tools
- Explore the basic and advance concepts available in the probability theory
- Apply the theoretical concepts in their applications

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 concepts of measures of central tendency and measures of Dispersion theory and its properties	**K1, K2**
CO2	Understand basics in probability and derive the addition and multiplication theorems on Probability and Obtain the mean and variance of standard distributions	**K1-K3 and K5**
CO3	Describe the concept of correlation and regression analysis with simple problems	**K2, K3, K5**
CO4	Understand and Analyze the importance of small sample test and large sample test; and Chi-square test	**K2,K4**
CO5	Describe and apply Analysis of Variance: One way and Two way and some nonparametric tests	**K1-K3**
CO6	Analyze the data using Non parametric test	**K1-K4**
K1: *Remember* **K2**: *Understand* **K3**: *Apply* **K4**: *Analyze* **K5**: *Evaluate* **K6**: *Create*		

Course Outline:

UNIT I

Measures of Central tendency: Arithmetic Mean, Median, Mode. Measures of Dispersion: Range, Inter-Quartile Range, Standard Deviation and Coefficient of Variation. [12 hours]

UNIT II

Basic concepts of Probability - Set theoretic definition of probability - Addition and Multiplication Theorems of probability (statements only) - Binomial distribution - Poisson distribution - Normal distribution - their properties and importance in biology. [12 hours]

UNIT III

Simple Correlation- Regression – Bi-serial correlation coefficient - Kendall's coefficient of correlation - Tetrochoric correlation coefficient - Partial and Multiple correlation coefficients (Three variables). Simple problems with application in biology. [12 hours]

UNIT IV

Small sample and Large sample tests: Test for the significance of population mean when population variance is (i) known and (ii) unknown - Tests of significance for testing the equality of means of two normal populations when population variances (i) known and (ii) unknown - Chi-square test -test for independence of the attributes - test for goodness of fit - Coefficient of contingency. [12 hours]

UNIT V

Analysis of Variance: One way classification - Two way classification - Kruskal-Wallis one way analysis of variance by ranks, Friedman two-way analysis of variance by ranks. [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. Campbell, R.C. (1989): Statistics for Biologists. Cambridge University Press, London.
2. Daniel, W.W. (2008): Bio-Statistics: A Foundation for Analysis in the Health Science. John Wiley & Sons, Incorporated.

Books for Reference:

1. Rossi, R. J. (2010). Applied Biostatistics for Health Sciences, John Wiley & Sons, Inc., NY
2. Glantz, S.A. (2012): Primer of Bio-Statistics (Seventh Edition). McGraw-Hill Professional Publishing, USA.
3. Sokal, R.R. and Rohlf, F.J. (1969). Biometry: The Principles and Practice of Statistics in Biological Research (Third Edition). San Francisco, California, Freeman and Company.

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

1. https://swayam.gov.in/nd1_noc20_bt28/preview.
2. https://swayam.gov.in/nd2_cec20_ma05/preview.
3. www.healthknowledge.org.uk.

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*	*Low*	*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*	*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*	*Low*	*High*
Correlation Level: *Low* *Medium* *High*							

3. PROBABILITY AND STATISTICS

(Online Course)

Course Code		**TITLE OF THE COURSE**	**L**	**T**	**P**	**C**
Supportive		**Probability and Statistics**	**3**	**1**	**0**	**3**
Prerequisites		Basic knowledge of Probability theory, Distribution theory and Sampling theory	**Syllabus Version**		**2022-23**	

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

Course Objectives:

The main objectives of this course are to

- Understand the concept of basics of Probability and statistical tools
- Introduce axiomatic approach to probability theory, conditional probability, characteristic function, Distributions and Joint distributions, Theory of estimation and testing of hypothesis
- Explore the basic and advance concepts available in the probability theory and statistics
- Apply all the theoretical concepts in their day-to-day life applications

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 concepts of set theory and its properties	**K1, K2**
CO2	Understand and Obtain the probability, random variable with examples	**K1-K3 and K5**
CO3	Describe the concept of moments, distributions and its properties	**K2, K3**
CO4	Understand and Analyze the importance of Estimation theory and | Unbiased, Consistent Estimators	**K2,K4**
CO5	Describe and Derive the Neyman-Pearson Fundamental Lemma | Applications of N-P Lemma.	**K1-K3**
CO6	Apply the Testing for Normal Mean and Testing for Normal Variance for the analyze of the data.	**K1-K4**
K1: *Remember* **K2**: *Understand* **K3**: *Apply* **K4**: *Analyze* **K5**: *Evaluate* **K6**: *Create*		

Course Outline:

UNIT I

Week 01: Sets, Classes, Collections | Sequence of Sets | Ring, Field (Algebra) | Sigma-Ring, Sigma-Field, Monotone Class | Random Experiment, Events | Definitions of Probability.

Week 02: Conditional Probability | Independence of Events | Problems in Probability | Random Variables | Probability Distribution of a Random Variable.

Week 03: Moments | Characteristics of Distributions | Special Discrete Distributions.

UNIT II

Week 04: Poisson Process | Special Continuous Distributions.

Week 05: Normal Distribution | Problems on Normal Distribution | Function of a Random Variable.

Week 06: Joint Distributions | Independence, Product Moments | Linearity Property of Correlation and Examples | Bivariate Normal Distribution.

UNIT III

Week 07: Additive Properties of Distributions | Transformation of Random Variables | Distribution of Order Statistics | Basic Concepts | Chi-Square Distribution.

Week 08: t-Distribution | F-Distribution | Descriptive Statistics.

UNIT IV

Week 09: Introduction to Estimation | Unbiased and Consistent Estimators | LSE, MME | Examples on MME, MLE.

Week 10: UMVUE, Sufficiency, Completeness | Rao-Blackwell Theorem and its Applications Confidence Intervals.

UNIT V

Week 11: Basic Definitions | Two Types of Errors | Neyman-Pearson Fundamental Lemma | Applications of N-P Lemma.

Week 12: Testing for Normal Mean | Testing for Normal Variance | Large Sample Test for Variance and Two Sample Problem | Paired t-Test | Testing Equality of Proportions | Chi-Square Test for Goodness Fit | Testing for Independence in Contingency Table.

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UNIT VI

Contemporary Issues: Expert lectures, online seminars – webinars

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. Gupta, S.C and Kapoor, V.K. (2000): Fundamental of Mathematical Statistics (10^{th} Edition), Sultan Chand and Sons, New Delhi.
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. Ross, S.M. (2014). Introduction to Probability Models. Academic press.
2. Spiegel, M.R., Schiller, J. and Srinivasan, R.A. (2012): Probability and Statistics, Schaum's Outline Series (Fourth Edition). McGraw- Hill Publishing Company.
3. Walpole, R.E., Myers, R.H., Myers, S.L and Ye, K.E. (2011): Probability and Statistics for Engineering and Scientist (Ninth Edition). Pearson Education.

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

1. https://nptel.ac.in/courses/ 111105041
2. https://nptel.ac.in/courses/ 111106112
3. https://nptel.ac.in/courses/ 111105090

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*	*Low*	*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	PSO 6	PSO7
CO1	*Medium*	*Medium*	*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*	*Low*	*High*
Correlation Level: *Low* *Medium* *High*							

4. INTRODUCTION TO R SOFTWARE

(Online Course)

Course Code	TITLE OF THE COURSE	L	T	P	C
Elective	INTRODUCTION TO R SOFTWARE	3	1	0	3
Prerequisites	Knowledge of Programming language like Programming in C; object-oriented language; Coding and Statistical Computation	Syllabus Version		2022-23	

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

Course Objectives:

The main objectives of this course are to:

2. Provide programming skills in R.
2. Understand the operations and functions of R Programming
3. Perform statistical analysis using built-in functions
4. Learn and write customized program for mathematical and statistical 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	Understand the basics of R Language	K2
CO2	Apply the logical skills for performing statistical analysis	K3, K4
CO3	Use appropriate plots, charts and diagrams for all kinds of data	K3
CO4	Perform parametric methods	K3
CO5	Write and execute the code for multivariate analysis	K1-K5
CO6	Obtained the output results through programming Language	K2-K6

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

UNIT I

Week 01: Basic fundamentals, installation and use of software, data editing, use of R as a calculator, functions and assignments.

Week 02: Use of R as a calculator, functions and matrix operations, missing data and logical operators.

UNIT II

Week 03: Conditional executions and loops, data management with sequences.

Week 04: Data management with repeats, sorting, ordering, lists

UNIT III

Week 05: Vector indexing, factors, Data management with strings, display and formatting.

Week 06: Data management with display paste, split, find and replacement, manipulations with alphabets, evaluation of strings, data frames.

UNIT IV

Week 07: Data frames, import of external data in various file formats, statistical functions, compilation of data.

UNIT V

Week 08: Graphics and plots, statistical functions for central tendency, variation, skewness and kurtosis, handling of bivarite data through graphics, correlations, programming and illustration with examples.

UNIT VI

Contemporary Issues: Expert lectures, online seminars – webinars

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. An Introduction to R. Online manual at the R website at http://cran.r-project.org/manuals.html
2. Peter Dalgaard. Introductory Statistics with R (paperback) 1st Edition Springer-Verlag New York, Inc.
3. Brian Everitt and TorstenHothorn. A Handbook of Statistical Analyses Using R, 2nd Edition Chapman and Hall/CRC, 2009.
4. Robert Kabacoff. R in Action Data Analysis and Graphics with R, Manning Publications. 2011.

BOOKS FOR REFERENCES:

1. Crawly, M.J. (2012). The R book (Second Edition). John Wiley & Sons.
2. Dalgaard, P. (2008). Introductory Statistics with R. Springer Verlag Inc.,
3. Drăghici, S. (2011). Statistics and Data Analysis for Microarrays Using R and Bioconductor (Second Edition). CRC press.
4. Logan, M. (2011). Bio statistical Design and Analysis Using R: A Practical Guide. John Wiley & Sons.

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

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=+u3y6UdbIvOJ97LFeSCmHQ==P-15. Basic R programming
2. https://nptel.ac.in/courses /110107095.
3. https://nptel.ac.in/courses /111104120

Mapping of Course Outcomes to Programme Outcomes

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

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Annexure – II (A)

MANONMANIAM SUNDARANAR UNIVERSITY, TIRUNELVELI – 12.
CERTIFICATE PROGRAMMES
(*To be offered from the year 2022-2023 and onwards*)

The Board also resolved to offer the following new academic programmes by the Department of Statistics

- Certificate in Machine Learning
- Certificate in Introduction to *MATLAB*
- Certificate in Optimization Algorithms with *MATLAB*
- Certificate in Simulation Techniques with *MATLAB*
- Certificate in *R* Programming
- Certificate in *Python* Programming

Eligibility for Admission:

Candidates who have passed undergraduate programme in any branch of Science / Engineering / Technology shall be permitted to join the programme and to appear and qualify for the above Certificate programme examinations.

Duration of the Programme:

The duration of the programme is six months. Examinations will be conducted at the end of the programme in respective subjects. Candidates shall complete the programme as per UGC regulations.

Examination

The regulations for examination, passing minimum in each course and classification of successful candidates are at par with the regulations for other certificate programmes offered by the University.

SCHEME OF EXAMINATION

	Title of the Course	No. of Hours/week	Credits	Maximum Marks		
				CIA	UE	Total
1	Course - I	5	4	25	75	100
2	Course - II	5	4	25	75	100
3	Practical - I	5	6	50	50	100
4	Practical - II	5	6	50	50	100
	Total	20	20			400

Note 1: CIA: Continuous Internal Assessment UE: University Examination

Note 2: Candidates admitted to this programme shall do the practical exercises using the respective Software.

Note 3: Continuous Internal Assessment shall be made by giving Assignments and Tests in each course as per the University norms. Pattern of question paper will be as prescribed by University.

QUESTION PAPER PATTERN

(For Theory Courses)

Certificate Programme Examinations

Time: Three Hours Maximum: 75 marks

SECTION – A (10 × 1 = 10 Marks)

*Answer **ALL** the questions. All questions carry equal marks.*

***Choose the correct answer: (Multiple Choice question*s)**

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)

All questions carry equal 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)

All questions carry equal 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

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QUESTION PAPER PATTERN

Certificate Programme Examinations

Practical – I/II

Time: Three Hours Maximum: 50 marks

Answer any 5 Questions out of 10 Questions
Each question carries 10 marks

(5 × 10 = 50 Marks)

Practical Exercises based on

All the Units of Course -1 for Practical I using respective Programming Language/Software
All the Units of Course -2 for Practical II using respective Programming Language/Software

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Annexure – II (B)

MANONMANIAM SUNDARANAR UNIVERSITY, TIRUNELVELI – 12.
CERTIFICATE PROGRAMMEMES
(*To be offered from the year 2022-2023 and onwards*)

The Board further resolved to offer the following new academic programmes by the Department of Statistics

- Certificate in *LaTex*
- Certificate in Data Analysis with *SPSS*
- Certificate in Research Methods

Eligibility for Admission:

Candidates who have passed undergraduate Programme in any discipline shall be permitted to join the programme and to appear and qualify for the above Certificate programme examinations.

Duration of the Programme:

The duration of the programme is six months. Examinations will be conducted at the end of the programme in respective subjects. Candidates shall complete the programme as per UGC regulations.

Examination

The regulations for examination, passing minimum in each course and classification of successful candidates are at par with the regulations for other certificate programmes offered by the University.

SCHEME OF EXAMINATION

	Title of the Course	No. of Hours/week	Credits	Maximum Marks		
				CIA	UE	Total
1	Course - I	5	4	25	75	100
2	Course - II	5	4	25	75	100
3	Practical - I	5	6	50	50	100
4	Practical - II	5	6	50	50	100
	Total	20	20			400

Note 1: CIA: Continuous Internal Assessment UE: University Examination

Note 2: Candidates admitted to this programme shall do the practical exercises using the respective Software.

Note 3: Continuous Internal Assessment shall be made by giving Assignments and Tests in each course as per the University norms. Pattern of question paper will be as prescribed by University.

QUESTION PAPER PATTERN

(For Theory Courses)

Certificate Programme Examinations

Time: Three Hours Maximum: 75 marks

SECTION – A (10 × 1 = 10 Marks)

*Answer **ALL** the questions. All questions carry equal marks.*

***Choose the correct answer: (Multiple Choice question*s)**

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)

All questions carry equal 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)

All questions carry equal 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

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QUESTION PAPER PATTERN

Certificate Programme Examinations

Practical – I/II

Time: Three Hours Maximum: 50 marks

Answer any 5 Questions out of 10 Questions
Each question carries 10 marks

(5 × 10 = 50 Marks)

Practical Exercises based on

All the Units of Course -1 for Practical I using respective Programming Language/Software
All the Units of Course -2 for Practical II using respective Programming Language/Software

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