ST JOSEPH'S UNIVERSITY

BENGALURU-27

Conferred the status of a Public-Private-Partnership University by the Ministry of Human Resource Development (now MoE), GoI,
under *Rashtriya Uchchatar Shiksha Abhiyan* (RUSA) 2.0 and established by the
St Joseph's University Act no.24 of 2021

DEPARTMENT OF STATISTICS

SYLLABUS FOR POSTGRADUATE PROGRAMME

Based on Outcome Based Education (OBE)

For Batch 2024-2027

PART – A		
1	Name of the University	St Joseph's University
2	Objectives of the University	1. Academic Excellence 2. Social Concern 3. Character Formation
3	Vision of the University	To form women and men for and with others, who through holistic education, strive for a just, secular, democratic, and ecologically sensitive society which empowers the poor, the oppressed and the marginalized.
4	Mission of the University	In keeping with the Jesuit heritage, the university aims at an integral formation of the staff and the students, to be men and women who will be agents of societal change, by enabling them to attain academic and human excellence in a teaching-learning environment that fosters intellectual curiosity, ceaseless enquiry, personal integrity, social commitment, creativity, critical thinking, and innovation.
5	Name of the Degree	Master of Science (M. Sc.)
6	Title of the Academic Programme	M. Sc. Statistics
7	Programme Code	M. Sc. Statistics
8	Name of the School offering the programme	School of physical sciences
9	Name of the Department offering the programme	Department of statistics
10	Vision of the Department offering the programme	To Enhance the quality of life for individuals and societies through the intelligent and ethical use of statistics
11	Mission of the Department offering the Programme	Department aims to instil scientific temper, analytical skills and intellectual vigour among the students, that they may contribute to the needs of the society. Department aims to provide students with life-oriented education through projects of social relevance.
12	Description of the Programme	The M.Sc. Statistics programme provides strong theoretical and practical training in statistical methods, data analysis, and computational techniques. It equips students with skills in probability, inference, modeling, machine learning, and data science. The curriculum emphasizes hands-on learning through projects, software applications, and real-world problem

		solving. Students develop analytical reasoning, research aptitude, and professional ethics. The programme prepares graduates for careers in industry, research, academia, and advanced studies.		
13	Duration of the Programme	2 Years (Four Semesters)		
14	Total No. of Credits	108		
15	Programme Outcomes (POs)	PO 1	Demonstrate strong knowledge of statistical theories, methods, and applications.	Understand, Apply
		PO 2	Analyze complex problems using appropriate statistical models and techniques.	Analyze, Evaluate
		PO 3	Design and develop statistical solutions using computational and analytical tools	Apply, Create
		PO 4	Apply statistics ethically for societal, environmental, and sustainable development.	Apply, Evaluate
		PO 5	Communicate and collaborate effectively with global and cross-cultural teams.	Apply, Create
		PO 6	Demonstrate research aptitude and pursue continuous statistical learning.	Evaluate, Create
		PO 7	Deepen expertise in specialized areas of statistics and data science.	Understand, Analyze
		PO 8	Develop analytical, computational, and professional skills for employability.	Apply, Analyze, Create

PART-B

SUMMARY OF CREDITS IN STATISTICS

DEPARTMENT OF STATISTICS (PG) (2024-26) SEMESTER I									
	Code Number	**Title**	**No. of Hours of Instructions**	**Number of Hours of teaching per week**	**Number of credits**	**Continuous Internal Assessment (CIA) Marks**	**End Semester Marks**	**Total marks**	**Duration of the Exam (in hrs)**
Theory	ST7121	Probability Theory	52	4	4	50	50	100	2
Theory	ST7221	Theory of Point estimation	52	4	4	50	50	100	2
Theory	ST7323	Sampling theory and Statistics for National Development	52	4	4	50	50	100	2
Theory	ST7421	Mathematical Analysis and Linear Algebra	52	4	4	50	50	100	2
Theory	ST7521	Statistical Computing (Soft Core)	39	3	2	25	25	50	1
Theory	ST 7622	Online course	60		2	-	50	50	-
Practical	ST7P1	Practical – I (Based on ST 7221,ST 7321)	44	4	2	15	35	50	3
Practical	ST7P2	Practical – II (Based on ST 7421, ST 7521)	44	4	2	15	35	50	3
					24				

DEPARTMENT OF STATISTICS (PG) (2024-2026) SEMESTER II									
	Code Number	**Title**	**No. of Hours of Instructions**	**Number of Hours of teaching per week**	**Number of credits**	**Continuous Internal Assessment (CIA) Marks**	**End Semester Marks**	**Total marks**	**Duration of the Exam (in hrs)**
Theory	ST8121	Distribution Theory	52	4	04	50	50	100	2
Theory	ST8221	Testing of Hypothesis and Interval Estimation	52	4	04	50	50	100	2
Theory	ST8321	Multivariate Analysis	52	4	04	50	50	100	2
Theory	ST8421	Linear Models and Regression Analysis	52	4	04	50	50	100	2
Theory	ST8521	Introduction to Data science (Soft Core)	39	3	02	25	25	50	1
Theory	ST 8622	Mini Project			02	15	35	50	
Practical	ST8P1	Practical III (based on ST 8121, ST8221 and ST 8321)	44	4	02	15	35	50	3
Practical	ST8P2	Practical IV (based on ST 8421, ST8521)	44	4	02	15	35	50	3
					24				

DEPARTMENT OF STATISTICS (PG) (2024-2027) SEMESTER III									
	Code Number	**Title**	**No. of Hours of Instructions**	**Number of Hours of teaching per week**	**Number of credits**	**Continuous Internal Assessment (CIA) Marks**	**End Semester Marks**	**Total marks**	**Duration of the Exam (in hrs)**
Theory	ST9120	Stochastic Processes	52	4	04	50	50	100	2
Theory	ST9220	Data Mining and Machine Learning	52	4	04	50	50	100	2
Theory	ST9323	Statistical Quality Control	52	4	04	50	50	100	2
Theory	STDE 9420 STDE 9520	Optimization Techniques (Elective-I) Operations Research (Elective-I)	52	4	04	50	50	100	2
Theory	ST 9623	Reliability Theory	52	4	04	50	50	100	2
Theory	ST9720	Research paper presentation	39	4	02	25	25	-	-
Practical	ST9P1	Practical V (based on ST 9120, and ST 9320)	44	4	02	15	35	50	3
Practical	ST9P2	Practical VI (based on ST9220, STDE 9420/STDE 9520)	44	4	02	15	35	50	3
					26				

DEPARTMENT OF STATISTICS (PG) (2024-2027) SEMESTER IV									
	Code Number	**Title**	**No. of Hours of Instructions**	**Number of Hours of teaching per week**	**Number of credits**	**Continuous Internal Assessment (CIA) Marks**	**End Semester Marks**	**Total marks**	**Duration of the Exam (in hrs)**
Theory	ST 0123	Advanced Statistical Inference	52	4	04	50	50	100	2
Theory	ST0220	Design and Analysis of Experiments	52	4	04	50	50	100	2
Theory	STDE 0323 STDE 0420	Bio Statistics (Elective II) Survival analysis (Elective II)	52	4	04	50	50	100	2
Theory	STDE 0520 STDE 0620	Time series analysis (Elective III) Actuarial Statistics (Elective III)	52	4	04	50	50	100	2
Theory	ST 0720	Project Work	39	4	04	15	35		
Practical	ST0P1	Practical III (based on ST 0120, STDE0320/STDE 0420 and STDE0520/STDE 0620)	44	4	02	15	35	50	3
Practical	ST0P2	Practical VIII (based on ST 0220)	44	4	02	15	35	50	3
					24				

CORE COURSES (CC)	
Course Title	**Code Number**
Probability Theory	ST7121
Theory of Point estimation	ST7221
Sampling theory and Statistics for National Development	ST 7323
Mathematical Analysis and Linear Algebra	ST7421
Distribution Theory	ST8121
Testing of hypothesis Distribution Theory and Interval estimation	ST8221
Multivariate Analysis	ST8321
Linear Models and Regression Analysis	ST8421
Stochastic Processes	ST9120
Data Mining and Machine Learning	ST9220
Statistical Quality Control	ST9323
Reliability Theory	ST 9623
Advanced Statistical Inference	ST0124
Design and Analysis of Experiments	ST0220

DISCIPLINE-SPECIFIC ELECTIVE COURSES (DSE)	
Course Title	Code Number
Optimization Techniques	STDE 9420
Operations Research	STDE 9520
Bio-Statistics	STDE 0323
Survival Analysis	STDE 0420
Time Series Analysis	STDE 0520
Actuarial Statistics	STDE 0620

SKILL ENHANCEMENT COURSE (SEC)	
Course Title	**Code Number**
Statistical Computing (Soft Core)	ST7521
Introduction to Data science (Soft Core)	ST8521

ONLINE COURSES (OLC)	
Course Title	**Code Number**
Online courses related to SAS, MATLAB, etc.. (Swayam, MOOC, NPTEL, etc..)	ST 7622

SUMMARY OF COURSE ARTICULATION MATRICES

Mapping of course outcomes (Cos) to Programme Outcomes (POs 1to 8)
[According to revised Bloom's Taxonomy Level (BLT)]

Couse Code & Title	COs	POs							
		PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
Course Code: ST7121 **Course Title:** Probability Theory	CO1	*						*	
	CO2	*	*						
	CO3	*		*					
	CO4	*			*				
	CO5	*	*	*			*		
	CO6			*					*
		POs							
	COs	**PO-1**	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PO-7**	**PO-8**
Course Code: ST7221 **Course Title:** Theory of Point Estimation	CO1	*						*	
	CO2	*	*						
	CO3	*	*	*					
	CO4	*		*				*	
	CO5	*		*					*
	CO6		*				*		*
		POs							
	COs	**PO-1**	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PO-7**	**PO-8**
Course Code: ST 7323 **Course Title:** Sampling Theory and Statistics for National Development	CO1	*						*	
	CO2	*	*	*					
	CO3	*		*					
	CO4	*		*				*	
	CO5	*	*		*				
	CO6				*		*		*
		POs							
	COs	**PO-1**	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PO-7**	**PO-8**
Course Code: ST7421 **Course Title:** Mathematical Analysis and Linear Algebra	CO1	*		*					
	CO2	*	*						
	CO3		*	*					
	CO4		*	*					
	CO5	*	*						*
	CO6	*		*		*			
		POs							
	COs	**PO-1**	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PO-7**	**PO-8**
Course Code: ST7521 **Course Title:** Statistical Computing	CO1	*	*						
	CO2	*	*	*					
	CO3	*	*	*					*
	CO4	*	*	*					*
	CO5	*	*	*		*	*		
	CO6	*	*	*		*	*	*	*
		POs							
	COs	**PO-1**	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PO-7**	**PO-8**
Course Code: ST8121 **Course Title:** Distribution Theory	CO1	*	*				*		
	CO2	*	*				*		
	CO3	*	*	*			*	*	*
	CO4	*	*				*	*	
	CO5	*	*				*	*	
		POs							
	COs	**PO-1**	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PO-7**	**PO-8**
Course Code: ST8221 **Course Title:** Testing of hypothesis and Interval estimation	CO1	*	*				*	*	
	CO2	*	*					*	
	CO3	*	*	*					*
	CO4		*				*	*	
	CO5	*	*				*	*	*

		POs							
	COs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
Course Code: ST8321 **Course Title:** Multivariate Analysis	CO1	*	*						
	CO2	*	*	*					
	CO3	*	*	*				*	*
	CO4	*	*	*				*	*

		POs							
	COs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
Course Code: ST8421 **Course Title:** Linear Models and Regression Analysis	CO1	*	*	*					*
	CO2	*	*	*			*	*	
	CO3		*	*	*		*	*	*
	CO4	*	*	*	*			*	*
	CO5	*	*		*		*	*	
	CO6		*		*	*	*		*

		POs							
	COs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
Course Code: ST8521 **Course Title:** Introduction to Data science	CO1	*		*					
	CO2			*					
	CO3		*			*			
	CO4		*					*	
	CO5	*		*			*		

		POs							
	COs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
Course Code: ST9120 **Course Title:** Stochastic Processes	CO1	*	*				*	*	*
	CO2		*				*	*	*
	CO3	*	*	*			*	*	*
	CO4	*	*	*			*	*	*
	CO5		*	*	*		*	*	*
	CO6		*				*	*	*

		POs							
	COs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
Course Code: ST9220 **Course Title:** Data Mining and Machine Learning	CO1	*							
	CO2			*					*
	CO3	*	*					*	
	CO4	*	*	*				*	
	CO5		*	*				*	*
	CO6		*		*			*	*

		POs							
	COs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
Course Code: ST9323 **Course Title:** Statistical Quality Control	CO1	*	*	*				*	*
	CO2		*	*			*		*
	CO3	*		*			*	*	*
	CO4	*	*	*				*	*
	CO5	*	*	*			*	*	*

		POs							
	COs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
Course Code: ST9623 **Course Title:** Reliability Theory	CO1	*	*				*	*	*
	CO2	*	*	*			*	*	*
	CO3	*	*	*			*	*	*
	CO4	*	*	*			*	*	*
	CO5	*	*	*			*	*	*
	CO6	*	*	*	*		*	*	*

		POs							
	COs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
Course Code: ST0124 **Course Title:** Advanced Statistical Inference	CO1	*	*			*			*
	CO2	*	*		*		*		*
	CO3	*	*		*	*	*	*	*
	CO4	*	*	*	*			*	*
	CO5		*	*	*				*

	CO6			*	*	*	*	*	*
		POs							
	COs	**PO-1**	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PO-7**	**PO-8**
	CO1	*	*				*	*	*
	CO2	*	*	*			*	*	*
Course Code: ST0220	CO3	*	*	*			*	*	*
Course Title: Design and	CO4	*	*	*			*	*	*
Analysis of Experiments	CO5	*	*	*	*		*	*	*
		POs							
	COs	**PO-1**	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PO-7**	**PO-8**
	CO1	*	*				*	*	
	CO2	*	*	*			*	*	*
	CO3	*	*	*			*	*	*
Course Code: STDE 9420	CO4	*	*	*			*	*	*
Course Title: Optimization	CO5	*	*	*			*	*	*
Techniques	CO6	*	*	*	*	*	*	*	*
		POs							
	COs	**PO-1**	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PO-7**	**PO-8**
	CO1	*	*				*	*	
	CO2	*	*	*			*	*	*
	CO3	*	*	*			*	*	*
Course Code: STDE 9520	CO4	*	*	*			*	*	*
Course Title: Operations	CO5	*	*	*			*	*	*
Research	CO6	*	*	*	*	*	*	*	*
		POs							
	COs	**PO-1**	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PO-7**	**PO-8**
	CO1		*	*					*
	CO2	*	*	*			*		*
	CO3	*	*	*		*	*		*
Course Code: STDE 0323	CO4	*	*	*			*	*	*
Course Title: Bio-Statistics	CO5	*	*	*	*		*		*
		POs							
	COs	**PO-1**	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PO-7**	**PO-8**
	CO1	*						*	*
	CO2		*	*					*
Course Code: STDE 0420	CO3	*	*					*	*
Course Title: Survival	CO4		*	*	*	*	*		*
Analysis	CO5	*	*		*		*	*	*
		POs							
	COs	**PO-1**	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PO-7**	**PO-8**
	CO1	*	*					*	*
	CO2	*	*	*				*	*
Course Code: STDE 0520	CO3	*	*	*			*	*	*
Course Title: Time Series	CO4	*	*	*			*	*	*
Analysis	CO5	*	*	*			*	*	*
		POs							
	COs	**PO-1**	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PO-7**	**PO-8**
	CO1	*	*					*	
Course Code: STDE 0620	CO2	*	*					*	
Course Title: Actuarial	CO3	*		*					*
Statistics	CO4		*	*					*

Course content and Course outcomes

M.Sc. program in Statistics

FIRST SEMESTER

ST 7121: Probability Theory

Semester	First
Paper Code	ST 7121
Paper Title	Probability Theory
Number of teaching hrs per week	4
Total number of teaching hrs per semester	52
Number of credits	4

COURSE OBJECTIVES:
1. To introduce fundamental concepts of measure theory and probability spaces. 2. To develop understanding of random variables, distributions, and modes of convergence. 3. To explain expectations, integration theorems, and key inequalities. 4. To familiarize students with generating functions and their properties for statistical inference.

Unit 1	**Total Hrs**
Classes of sets: Field, σ-field, minimal σ — field, Borel σ-field on $\mathbf{R}^n$. Sequences of setsand their limits. Measure of a set and its properties. σ-finite measure. Counting measure. Lebesgue measure and Lebesgue- Stieltjes measure. Probability space and its properties. Probability measure induced by a random variable.	**(12L+2T) hrs**
Unit 2	
Random variable, cumulative distribution function (c.d.f.), decomposition of a c.d.f. into discrete and continuous c.d.f.'s, quantile function, sequences of random variables, Modes of convergence- Convergence in distribution / law, convergence in probability, Convergence in rth mean, almost sure convergence. Limit theorems.	**(10L+2T) hrs**
Unit 3	
Expectation of a random variable. Properties. Monotone convergence theorem. Dominated convergence theorem. Markov, Chebycheff, Jensen, Minkowski, and Holder inequalities.	**(10L+4T) hrs**
Unit 4	
Generating function: Moment generating function, Characteristic function. Properties of MGF and CF. Generating moments. Inversion theorem and its applications. Uniqueness theorem.	**(10L+2T) hrs**

REFERENCES

1. Ash, R.B. and Doleans-Dade, C.A. (2000). *Probability and Measure Theory*, Academic Press, NewYork.
2. Bhat, B.R. (1999). *Modern Probability Theory,* 2/e, New Age International, NewDelhi.
3. Billingsley, P. (1995). *Probability and Measure*, 3/e, John Wiley, NewYork.
4. Burril, C. (1972). *Measure, Integration, and Probability,* McGrawHill International, New York.
5. Chung, K.L.(2001). *A Course in Probability, 3/e,* Academic Press, NewYork.
6. Clarke, L.E. (1975). *Random Variables,* Longman Mathematical Texts, London.
7. Khosnevisan, D. (2013). *Probability*, American Mathematical Society, Indian Edition, Universities Press, Hyderabad.
8. Rao, C.R. (1973). *Linear Statistical Inference and Its Applications,* John Wiley, New York.

BLUEPRINT
Code number: ST7121
Title of the paper: Probability Theory

Total marks for which the questions are to be asked (including bonus questions)	Number of hours	Chapter/Unit number
19	14	I
16	12	II
19	14	III
16	12	IV
70	**52**	**TOTAL**
Maximum marks for the paper (Including bonus question):**70**		

Course Articulation Matrix
Mapping of course outcomes (Cos) To Programme Outcomes (POs 1 to 8)
Code number: ST7121
Title of the paper: Probability Theory

COs	POs								BLT
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	
Course Title: Probability Theory									
CO1: Explain the concepts of fields, σ-fields, and measures including Lebesgue and probability measures.	*						*		Understand
CO2: Describe and analyze random variables,	*	*							Analyze

distributions, and modes of convergence.									
CO3: Apply measure and integration theorems to compute expectations and inequalities.	*		*						Apply
CO4: Interpret and use moment and characteristic functions in studying distributions.	*			*					Analyze
CO5: Relate theoretical concepts to limit theorems and their probabilistic applications.	*	*	*			*			Evaluate
CO6: Demonstrate problem-solving and computational skills in probability measures and convergence.			*					*	Apply

FIRST SEMESTER
ST 7221: Theory of Point Estimation

Semester	First
Paper Code	ST 7221
Paper Title	Theory of Point Estimation
Number of teaching hrs per week	4
Total number of teaching hrs per semester	52
Number of credits	4

COURSE OBJECTIVES

1. To introduce families of probability distributions and the fundamental properties and performance measures of statistical estimators.
2. To develop the ability to identify sufficient and complete statistics using key theorems such as the Fisher–Neyman factorization theorem.
3. To enable students to apply concepts of minimum variance estimation, Fisher information, and UMVU estimation using the Rao–Blackwell and Lehmann–Scheffé theorems.
4. To familiarise learners with methods of estimation, including maximum likelihood and method of moments, along with their computational techniques.
5. To provide a strong foundation for evaluating estimator efficiency and applying advanced inference tools in practical statistical problems.

Unit 1	**Total No. Of Hrs**
Families of distributions: location and scale families, k-parameter exponential, Pitman and Cramer families. Properties of estimators: Unbiasedness, convex combination of unbiased estimators, consistent estimators, sufficient condition for consistent estimators with examples. Mean square error.	**(10L+2T) hrs**
Unit 2	
Sufficiency and completeness: Sufficiency, Fisher-Neymann factorization theorem, minimal sufficiency, likelihood equivalence, completeness, bounded completeness. Statement of the theorem on complete sufficient statistic in the k-parameter exponential family.	**(10L+2T)hrs**
Unit 3	
Minimum variance of estimators. Fisher information function and Fisher information matrix. Cramer-Rao inequality, Rao-Blackwell, and Lehmann-Scheffe theorems. Uniformly minimum variance unbiased (UMVU) estimation. Simultaneous estimation of parameters of multinomial and normal distributions. Ancillary statistics, Basu's theorem, and its application in UMVU estimation. Efficiency of estimators.	**(14L+2T) hrs**
Unit 4	
Methods of estimation: Maximum likelihood (ML) and moment estimation. Properties of ML estimators. Computation of ML estimates using Newton-Raphson, method of scoring, least-square estimators and minimum chi-square estimators.	**(10L+2T) hrs**

REFERENCES

1. Casella, G. and Berger, R.L. (2002). *Statistical Inference, 2/e,* Duxbury Press, Belmont, California, USA.
2. Dudewicz, E.J. and Mishra, S.N. (1980). *Modern Mathematical Statistics,* John Wiley, NewYork.
3. Kale, B.K. and Muralidharan, K. (2015). *Parametric Inference: An Introduction*, Narosa, New Delhi.
4. Lehmann, E.L. and Casella, G. (1998). *Theory of Point Estimation*, Springer, New York.
5. Lehmann, E.L. and Romano, J.P. (2005). *Testing Statistical Hypotheses,* 2/e, John Wiley, NewYork.
6. Rohatgi, V.K.and Saleh, A.K.Md.E. (2002): *An Introduction to Probability and Statistics*, John Wiley, NewYork.
7. Zacks, S. (1981). *Parametric Statistical Inference*, John Wiley, NewYork.

BLUEPRINT

Code number: ST7221

Title of the paper: Theory of Point Estimation

Total marks for which the questions are to be asked (including bonus questions)	Number of hours	Chapter/Unit number
16	12	I
16	12	II
22	16	III
16	12	IV
70	**52**	**TOTAL**

Maximum marks for the paper (Including bonus question):**70**

Course Articulation Matrix

Mapping of course outcomes (Cos) To Programme Outcomes (POs 1 to 8)

Code number: ST7221

Title of the paper: Theory of Point Estimation

COs	POs								BLT
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	
CO1: Explain families of distributions and key properties of estimators.	*						*		Understand
CO2: Apply concepts of sufficiency and completeness in statistical estimation.	*	*							Apply
CO3: Analyze minimum variance estimation using Fisher information and related theorems.	*	*	*						Analyze
CO4: Evaluate and construct UMVU estimators using Rao-Blackwell and Lehmann–Scheffé theorems.	*		*				*		Evaluate
CO5: Use and interpret methods of estimation such as ML, moments, least squares, and chi-square..	*		*					*	Apply
CO6: Demonstrate efficiency and consistency in comparing different estimators.		*				*		*	Evaluate

FIRST SEMESTER

ST 7323: Sampling Theory and Statistics for National Development

Semester	First
Course Code	ST 7323
Course Title	Sampling Theory and Statistics for National Development
Number of teaching hours per week	4
Total number of teaching hours per semester	52
Number of credits	4

COURSE OBJECTIVE:

1. To understand foundational sampling **techniques** such as simple random sampling, stratified sampling, systematic sampling, and to learn advanced sampling techniques.
2. To develop the ability to deal with non-sampling errors and non-response.
3. To enable students to apply different sampling techniques to real life data.
4. To study the various growth models to estimate the population such as exponential and logistic.
5. To provide information about economic measures to income inequality and various measures to national development.

Unit 1	**Total Hrs**
Random sampling methods: Simple random sampling, stratified random sampling, and systematic sampling. Determination of sample size. PPS sampling: Probability proportional to size (PPS) with replacement: Cumulative total method and Lahiri's scheme. Hansen-Hurwitz estimator. PPS without replacement: Des Raj estimator for a general sample size and Murthy's estimator for a sample of size2.Horvitz-Thompson estimator, Midzuno-Sen estimator	**(12L+3T) hrs**
Unit 2	
Cluster sampling with equal and unequal cluster sizes. Two-stage sampling with equal number of second stage units. SRS at both the stages. Non-Sampling errors: Non response: Hansen Hurwitz technique, Deming's technique.Randomized response: Warner's model.	**(11L+2T) hrs**
Unit 3	
Two phase sampling: SRSWOR in both phases. Ratio and regression estimators based on SRSWOR sampling: Bias, mean squared error, and variance estimation. Double sampling for ratio and regression estimation.	**(10L+2T) hrs**
Unit 4	
Population growth models-exponential, logistic. Population projection using Leslie matrix. Statistics for national development: Estimation of national income-product approach, income approach, and expenditure approach. GNP and GDP of India, HPI, CPI, Inflation and unemployment in relation to GDP. Measuring inequality in incomes, Gini coefficient, and Theil's measure. Poverty measurement: measures of incidence and intensity, combined measures, Kakwani and Sen Indices.	**(10L+2T) hrs**

REFERENCES

1. Chaudhuri, A. and Mukherjee, R. (1988). *Randomized Response: Theory and Techniques*, Marcel Dekker, NewYork.
2. Cochran, W. G. (1977). *Sampling Techniques*, 3/e; John Wiley, NewYork.
3. Des Raj and Chandok, P. (1998). *Sample Survey Theory*, Narosa Publishing House, NewDelhi.
4. Mukhupadhyay, P. (2009). *Theory and Methods of Survey Sampling*, 2/e, Prentice Hall, NewDelhi.
5. Murthy, M. N. (1977). *Sampling Theory and Methods*, Statistical Publishing Society, Calcutta.
6. Sampath, S. (2006). *Sampling Theory and Methods*, 2/e, Narosa Publishing House, New Delhi.
7. Singh, D. and Chaudhary, F.S. (1986). *Theory and Analysis of Sample SurveyDesigns*, New Age International Publishers, New Delhi.
8. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, Sand Ashok C. (1984). *Sampling Theory of Surveys with Applications*, Iowa State University Press,USA.

BLUEPRINT

Code number: ST 7323

Title of the paper: Sampling Theory and Statistics for National Development

Total marks for which the questions are to be asked (including bonus questions)	**Number of hours**	**Chapter/Unit number**
20	15	I
12	09	II
16	12	III
22	16	IV
70	**52**	**TOTAL**

Maximum marks for the paper (Including bonus question):**70**

Course Articulation Matrix

Mapping of course outcomes (Cos) To Programme Outcomes (POs 1 to 8)

Code number: ST 7323

Title of the paper: Sampling Theory and Statistics for National Development

COs:	POs								BTL
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PO-7**	**PO-8**	
Course Title: Sampling Theory and Statistics for National Development									
CO1: Understand the fundamentals of sampling techniques.	*	*			*			*	Understand
CO2: Apply advanced sampling techniques	*	*		*		*		*	Apply
CO3: Analyze the structure of different sampling designs	*	*		*	*	*	*	*	Analyze
CO4: Apply population growth models and indicators to measures to national development.	*	*	*	*			*	*	Apply
CO5: Evaluate income inequality and poverty using various measures.		*	*	*				*	Evaluate
CO6 **Design** appropriate sampling strategies and construct statistical solutions for demographic and economic decision-making problems using the learned methods.			*	*	*	*	*	*	Design, construct

FIRST SEMESTER

ST 7421: Mathematical Analysis and Linear Algebra

Semester	First
Paper Code	ST 7421
Paper Title	Mathematical Analysis and Linear Algebra
Number of teaching hrs per week	4
Total number of teaching hrs per semester	52
Number of credits	4

COURSE OBJECTIVE:

1. To introduce the fundamental concepts of random variables, probability distributions, and the properties of standard discrete and continuous models.

2. To develop the ability to derive and analyze probability density functions, distribution functions, moments, and related characteristics of univariate, truncated, and multivariate distributions.

3. To provide an understanding of sampling distributions, order statistics, and their applications in reliability, survival analysis, and statistical inference.

4. To enable students to apply distributional concepts and techniques to model real-life data, solve practical problems, and support decision-making under uncertainty.

Unit 1	**Total Hrs**
Sets, sequence and series of real numbers, Cauchy criteria for convergence, supremum and infimum, their properties, Interior points and limit points of subsets of R. Open and closed subsets of R. Bolzanao- Weierstrass theorem. Sequences and series of functions. Pointwise and uniform convergence. Cauchy criteria for convergence, Weierstrass-M test.	**(12L+2T) hrs**
Unit 2	
Riemann-Stieltjes (R-S) integral of a bounded real valued function. Necessary and sufficient condition for R-S integrability. Properties of R-S integrals. Integration by parts. Change of variables in R-S integrals. Mean value theorems for R-S integrals. Improper Riemann integrals. Convergence and absolute convergence of improper integrals. Cauchy criteria for convergence of improper integrals.	**(12L+2T) hrs**
Unit 3	

Beta and Gamma integrals and their properties. Legendre's duplication formula. Integrals involving parameters. Improper integrals involving parameters and their uniform convergence. Differentiation under the integral sign: Leibnitz rule for integral with constant and variable limits. Maxima and minima of functions of several variables. Lagrangian multipliers. Double integrals.	**(8L+2T) hrs**
Unit 4	
Vector spaces, subspaces, linear dependence and independence, basis and dimension of a vector space, inner product and orthogonality of vectors, Gram-Schmidt orthogonalization process, orthonormal basis and its properties. Partitioned matrices: computation of determinant and inverse. Characteristic roots, characteristic vectors. Diagonalization, Singular value decomposition. Systems of linear equations: consistency, existence of solutions, number of solutions, and solving the system of equations. Generalized inverse of a matrix and its properties.	**(12L+2T) hrs**

REFERENCES

1. Apostol, T.M. (1986). Mathematical Analysis, 2/e, Narosa Publishing House, New Delhi.
2. Bartle, R.G. (1975). The Elements of Real Analysis, 2/e, John Wiley.
3. Bilodeau, G.G., Thie, P.R., and Keough, G.E. (2010). An Introduction to Analysis, 2/e, Jones and Bartlett (Indian Edition), New Delhi.
4. Goldberg, R.R. (1970). Methods of Real Analysis, Oxford and IBH Publishing Company, New Delhi.
5. Malik, S.C. and Arora, S. (1998). Mathematical Analysis, New Age, New Delhi.
6. Rudin, W. (2013). Principles of Mathematical Analysis, 3/e, Indian Print, Tata McGrawhill, New Delhi.
7. Bapat, R.B. (2011). Linear Algebra and Linear Models. Springer and Hindustan Book Agency.

BLUEPRINT
Code number: ST7421
Title of the paper: Mathematical Analysis and Linear Algebra

Total marks for which the questions are to be asked (including bonus questions)	Number of hours	Chapter/Unit number
19	14	I
19	14	II
13	10	III
19	14	IV
70	**52**	**TOTAL**

Maximum marks for the paper (Including bonus question):**70**

Course Articulation Matrix

Mapping of course outcomes (Cos) To Programme Outcomes (POs 1 to 8)

Code number: ST7421

Title of the paper: Mathematical Analysis and Linear Algebra

COs:	**POs**								**BTL**
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PO-7**	**PO-8**	
Mathematical Analysis and Linear Algebra									
CO1: Explain limits, sequences and series, pointwise vs. uniform convergence (Understand).	*	*					*	*	Understand
CO2: Solve problems with Riemann / Riemann–Stieltjes and improper integrals (Apply).	*	*	*				*	*	Analyze
CO3: Analyze Beta/Gamma and parameter-dependent integrals via uniform convergence and differentiation under the integral (Analyze).	*	*	*			*	*	*	Apply
CO4: Apply vector-space and matrix concepts (Gram–Schmidt, eigenvalues, SVD, etc.) to linear algebra problems (Apply / Analyze).	*	*				*	*	*	Analyze
CO5: Design and justify solution procedures for systems of linear equations using generalized inverses (Create).	*	*	*		*	*	*	*	Evaluate

FIRST SEMESTER

ST 7521: Statistical Computing

Semester	First
Paper Code	ST 7521
Paper Title	Statistical Computing
Number of teaching hrs per week	2+1
Total number of teaching hrs per semester	39
Number of credits	2

COURSE OBJECTIVES

1. Understand methods for random number and variate generation.
2. Apply numerical search and root-finding techniques.
3. Generate and analyze probability distributions through simulation.
4. Use numerical and Monte Carlo integration for computation.
5. Verify statistical laws and theorems using simulation methods

Unit 1	**Total No. Of Hrs**
a. Theory of inverse transformation method (ITM) for random variate generation-definition of quantile function, its properties. Quantile function as a random variable and its distribution function. ITM based algorithms to generate random variates from standard discrete and continuous distributions. b. Random variate generation from bivariate and conditional distributions. c. Theory of random number generation -linear, multiplicative and mixed random number generators. Selection of a random number generator	**(8L+ 2T) Hrs**
Unit 2	
Numerical algorithms as grid search, interpolation search, gradient search, Bisection and Newton-Raphson methods, Aitkens extrapolation, Simple applications of the above methods.	**(8L+ 3T) Hrs**
Unit 3	
Probability and Distributions: Random sampling and combinatory; obtaining density, cumulative density and quantile values for discrete and continuous distributions; generating samples from discrete and continuous distributions; Plotting density and cumulative density curves; Q-Q plot.	**(6L+ 2T) Hrs**
Unit 4	
Methods to compute integrals- quadrature formula, double integration, Gaussian integration, Monte Carlo Methods: Monte Carlo integration and its application to compute expected values and probabilities. Verification of WLLN, CLT and other approximations through simulation.	**(8L+ 2T) Hrs**

REFERENCES
1. Introductory Statistics with R by Peter Dalgaard, Springer, 2ndedition, 2008. 2. The R Book by Michael J. Crawley, John Wiley and Sons, Ltd., 2007.Lab

BLUEPRINT Code number: ST7521 Title of the paper: Statistical Computing		
Total marks for which the questions are to be asked (including bonus questions)	**Number of hours**	**Chapter/Unit number**
7	10	I
7	11	II
5	08	III
6	10	IV
25	**39**	**TOTAL**
Maximum marks for the paper (Including bonus question): **25**		

Course Articulation Matrix
Mapping of course outcomes (Cos) To Programme Outcomes (POs 1 to 8)
Code number: ST7521
Title of the paper: Statistical Computing

COs	POs								BLT
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PO-7**	**PO-8**	
Course Title: Statistical Computing									
CO1: Explain the theory of random number and variants generation.	*	*							Understand
CO2: Apply algorithms for generating random samples from standard distributions.	*	*	*						Apply
CO3: Implement and evaluate random number generators for simulation accuracy.	*	*	*					*	Analyze
CO4: Use numerical search and root-finding methods to solve	*	*	*					*	Apply

applied problems.									
CO5: Generate and visualize probability distributions to study sampling behaviour.	*	*	*		*	*			Analyze
CO6: Apply Monte Carlo integration to compute expectations and verify statistical theorems.	*	*	*		*	*	*	*	Evaluate

FIRST SEMESTER
ST 7P1: Practical I

Semester	First
Paper Code	ST 7P1
Paper Title	Practical I (Based on ST 7221, ST 7323)
Number of teaching hrs per week	4
Total number of teaching hrs per semester	44
Number of credits	2

LIST OF ASSIGNMENTS

1. Maximum likelihood estimation - 1 (for standard probability models)
2. Maximum likelihood estimation - 2 (Implementing Likelihood functions in R-software and use of optimize () and optim(), Newton Raphson Method , Expectation-Maximization Algorithm)
3. Method of moments.
4. Method of scoring.
5. Least square estimation.
6. Simple, Stratified and Cluster Sampling
7. PPSWR
8. PPSWOR
9. Ratio and regression methods of estimation.
10. Statistics for National Development - 1: Estimation of National Income, Income Inequality
11. Statistics for National Development - 2: Population Growth Models

FIRST SEMESTER
ST 7P2: Practical – II

Semester	First
Paper Code	ST 7P2
Paper Title	Practical - II (Based on ST7421 and ST7521)
Number of teaching hrs per week	4
Total number of teaching hrs per semester	44
Number of credits	2

LIST of ASSIGNMENTS

1. Calculation of determinant and rank of a matrix.
2. Calculation of inverse and Moore-Penrose inverse
3. Calculation of eigen values, eigen vectors and g-inverse
4. Systems of linear equations.
5. Random number generation: Inverse transformation method
6. Random number generation: bivariate and conditional distributions
7. Numerical Algorithms: Applications of Gradient search, Newton-Raphson, Mullers Method
8. Generating samples from standard probability distribution
9. Plotting density and cumulative density curves
10. Monte Carlo integration and its application to compute expected values and probabilities
11. Verification of WLLN, CLT and other approximations through simulation.

SECOND SEMESTER

ST 8121: Distribution Theory

Semester	Second
Course Code	ST 8121
Course Title	Distribution Theory
Number of teaching hours per week	4
Total number of teaching hours per semester	52
Number of credits	4

COURSE OBJECTIVE

1. To introduce the fundamental concepts of random variables, probability distributions, and the properties of standard discrete and continuous models.
2. To develop the ability to derive and analyze probability density functions, distribution functions, moments, and related characteristics of univariate, truncated, and multivariate distributions.
3. To provide an understanding of sampling distributions, order statistics, and their applications in reliability, survival analysis, and statistical inference.
4. To enable students to apply distributional concepts and techniques to model real-life data, solve practical problems, and support decision-making under uncertainty.

Unit 1	**Total Hrs**
Recapitulation of random variables and probability distributions, Mixtures of probability distributions, Functions of random variables, symmetry of distribution, standard discrete and continuous distributions: Binomial, Poisson, Negative Binomial, Normal, Gamma, Pareto, Weibull. Truncated distributions (Binomial, Poisson, Normal). Applications of truncated distribution.	**(12L+2T) hrs**
Unit 2	
Random vectors, distribution function of random vectors and its properties, joint m.g.f., joint c.f., mixed moments, variance-covariance matrix, multinomial distribution, multivariate normal distribution: pdf, mean vector, dispersion matrix, mgf. Bivariate exponential distributions-Gumbel type I, Gumbel type II, Marshall-Olkin. Independence of random variables, convolutions of random variables, Jacobian transformation, conditional expectation and variances.	**(12L+2T) hrs**
Unit 3	
Sampling distributions: central chi-square, t and F distributions: pdf, mgf, moments. Non-central chi-square, non-central t and non-central F distributions: their pdf. Distribution of quadratic forms. Fisher Cochran theorem (Statement only) of statistics from univariate normal random samples, distributions of linear and quadratic forms involving normal variables.	**(10L+2T) hrs**
Unit 4	

Order statistics, Joint distribution of order statistics, distribution of r-th order statistic, joint distribution of r^{th} and s^{th} order statistics ($r < s$). Distribution of sample median and sample range, Illustration of independence of $X_{(r)}$ and $X_{(s)} - X_{(r)}$ for $r < s$ for exponential, distribution of spacings, normalized spacings with illustration to exponential case.	**(10L+2T) hrs**

REFERENCES

1. Berger, R. and Casella, G. (2002). Statistical Inference, Duxbury Resource Center, Second Edition.
2. Dasgupta, A. (2010) Fundamentals of Probability: A First Course, Springer, New York.
3. Rohatgi, V. K & A. K. M. E Saleh (2001). Introduction to Probability and Statistics, Wiley.
4. Hogg, R. V. McKean, J. W. and Craig, T. T. (2005). Introduction to Mathematical Statistics, Sixth Edition, Pearson Prentice Hall, New Jersey.
5. Rao, C. R. (2002). Linear Statistical Inference and Its Applications, Wiley.

BLUEPRINT
Code number: ST 8121
Title of the paper: Distribution Theory

Total marks for which the questions are to be asked (including bonus questions)	**Number of hours**	**Chapter/Unit number**
19	14	I
19	14	II
16	12	III
16	12	IV
70	**52**	**TOTAL**
Maximum marks for the paper (Including bonus question):**70**		

Course Articulation Matrix
Mapping of course outcomes (Cos) To Programme Outcomes (POs 1 to 8)
Code number: ST 8121
Title of the paper: Distribution Theory

COs:	**POs**								**BTL**
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PO-7**	**PO-8**	
Course Title: **Distribution Theory**									
CO1: Understand the fundamental concepts of random variables, probability distributions, and the properties of standard discrete and continuous models.	*	*				*			Understand
CO2: Analyze probability density functions, distribution functions, and moments of major univariate and truncated distributions.	*	*				*			Analyze
CO3: Apply the concepts of joint, marginal, and conditional distributions, moment-generating functions, and transformations in multivariate analysis.	*	*	*			*	*	*	Apply
CO4: Analyze the structure and properties of sampling distributions such as chi-square, t, and F distributions, including central and non-central forms.	*	*				*	*		Analyze

CO5: Evaluate order statistics, their joint distributions, and related measures such as sample median, range, and spacings, with applications in reliability and survival analysis.	*	*				*	*		Evaluate
CO6: Apply appropriate distributional concepts and statistical reasoning to solve real-life problems involving uncertainty and variability.	*	*	*	*	*	*	*	*	Apply

SECOND SEMESTER

ST 8221: Testing of hypothesis & Interval estimation

Semester	II
Course Code	ST 8221
Course Title	Testing of hypothesis & Interval estimation
Number of teaching hours per week	4
Total number of teaching hours per semester	52
Number of credits	4

COURSE OBJECTIVES:

1. To introduce the fundamental concepts of Hypothesis Testing, including the formation of null and alternative hypotheses, one-tail and two-tail tests, critical regions, and the nature of Type I and Type II errors.
2. To provide a theoretical basis for optimal testing by studying the Most Powerful (MP) test for simple hypotheses and proving the Neyman-Pearson Lemma.
3. To enable students to identify and construct Uniformly Most Powerful (UMP) tests for distributions with the Monotone Likelihood Ratio (MLR) property and understand the existence and non-existence conditions for such tests.
4. To provide detailed exposure to general testing procedures such as the Likelihood Ratio Test Procedure and its asymptotic properties, Pearson's chi-square test for goodness of fit, Bartlett's test for homogeneity of variances, and Wald's Sequential Probability Ratio Test.
5. To develop proficiency in the theory of Interval Estimation, including defining confidence level/coefficient, constructing confidence sets, and enabling the construction of optimal interval estimators, such as the Shortest Expected Length confidence interval and the Uniformly Most Accurate confidence interval.

Unit-1	**Total Hrs**
Formation of null hypothesis, simple and composite hypothesis, One tail and two-tail test, critical region, test functions, two types of errors, size and power of a test, level of significance, power function, expressions for size and power of a test, P-value of a test. Randomized and non- randomized test. Most Powerful (MP) test for testing simple hypothesis against simple alternative, Neyman-Pearson Lemma, illustrations.	**(10L+2T)**
Unit-2	
Distributions with Monotone Likelihood Ratio (MLR) property, Uniformly Most Powerful (UMP) test for testing one tailed null hypothesis against one tailed alternative. Existence of UMP test and Illustrations. Extension of these results in Pitman family when only upper or lower end points depend on the parameter. Non-existence of UMP test for testing null hypothesis against two-sided alternative. Unbiased test. Existence of Uniformly Most Powerful Unbiased (UMPU) test for testing null hypothesis against two-sided alternative. Illustrations. Neyman-Pearson generalized lemma.	**10L+2T)**
Unit-3	

Likelihood Ratio Test Procedure (LRTP), Asymptotic properties of LR test statistic, Pearson's chi- square test for goodness of fit, Assumptions for the validity of chi-square test, Bartlett's Test for homogeneity of variances. Wald's Sequential Probability Ratio Test (SPRT), Wald's equation, Score tests. Illustrations.	**(14L+2T)**
Unit-4	
Confidence level and confidence coefficient, Interval estimation-confidence sets, Relation between confidence sets and testing of hypothesis, Shortest expected length confidence interval. Evaluating interval estimators using size and coverage probability and test-related optimality. Uniformly Most Accurate (UMA) confidence interval (One-sided interval) and its relation with UMP test.	**10L+2T)**

REFERENCES

1. Casella G. and Berger R.L. (2002): Statistical Inference, Wadsworth Grou.
2. Gibbons J.D. (1971): Nonparametric Inference, McGraw-Hill.
3. Kale B.K. (1999): A First Course on Parametric Inference, Narosa Publishing House.
4. Kendall M.G. and Stuart A. (1968): The Advanced Theory of Statistics, Vol.II,Charles Griffin and Co.
5. Lehmann E.L. (1986): Testing Statistical Hypotheses, John Wiley.
6. Pratt T.W. and Gibbons, J.D. (1981): Concepts of Nonparametric Theory, Springer.
7. Rao C.R. (1973): Linear Statistical Inference and Its Applications, Wiley Eastern.
8. Silvey S.D. (1970): Statistical Inference, Chapman & Hall.

BLUEPRINT
Code number: ST8221
Title of the paper: Testing of Hypothesis and Interval Estimation

Total marks for which the questions are to be asked (including bonus questions)	Number of hours	Chapter/Unit number
16	12	I
16	12	II
22	16	III
16	12	IV
70	**52**	**TOTAL**
Maximum marks for the paper (Including bonus question):**70**		

Course Articulation Matrix

Mapping of course outcomes (Cos) To Programme Outcomes (POs 1 to 8)

Code number: ST 8221

Title of the paper: Testing of hypothesis & Interval estimation

COs:	POs								BTL
	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	
Course Title: **Testing of hypothesis & Interval estimation**									
CO1: Recall fundamental concepts of hypothesis testing, including null and alternative hypotheses, critical regions, types of errors, power, and p-values.	*	*				*	*		Remember
CO2: Explain the principles behind MP, UMP, and UMPU tests, the Neyman–Pearson Lemma, and monotone likelihood ratio properties with suitable illustrations.	*	*					*		Understand
CO3: Apply classical testing procedures such as LR tests, chi-square tests, Bartlett's test, SPRT, and score tests to real statistical problems.	*	*	*					*	Apply
CO4: Analyze situations to determine the existence or non-existence of UMP/UMPU tests, evaluate test optimality, and		*				*	*		Analyze

interpret asymptotic properties of test statistics.									
CO5: Evaluate interval estimators based on confidence levels, size and coverage probability, expected length, and.construct confidence intervals and confidence sets including UMA confidence intervals by integrating principles of hypothesis testing and interval estimation.	*	*				*	*	*	Evaluate

SECOND SEMESTER

ST 8321: Multivariate Analysis

Semester	Second
Paper Code	ST 8321
Paper Title	Multivariate Analysis
Number of teaching hrs per week	4
Total number of teaching hrs per semester	52
Number of credits	4

COURSE OBJECTIVES:

1. Understand multivariate normal distribution and their real-life applications
2. Understand Wishart distribution, Hotelling T^2 and Mahalanobis D^2 statistic.
3. Implement dimension reduction techniques using software on real life problems.
4. Demonstrate knowledge and understanding of the basic ideas behind discriminant and clustering analysis techniques with applications.

Unit-1	**Total Hrs**
Introduction to Multivariate analysis, need and applications. Multivariate Normal Distribution (MVN). Sampling from MVN distribution – sample mean vector, sample variance covariance matrix. Distribution of the sample mean vector, independence of sample mean vector and sample variance covariance matrix. Assessing multivariate normality. Q-Q and chi-square plots. Multiple and Partial Correlation coefficients and their distributions (statements only).	**(10L+2T)hrs**
Unit-2	
MLE's of the parameters of multivariate normal distribution and their sampling distributions. Likelihood ratio tests: Tests of hypotheses about the mean vectors and covariance matrices for multivariate normal populations. Classification and discriminant analysis: Bayes, minimax, and Fisher's criteria for discrimination between two multivariate normal populations. Sample discriminant function. Tests associated with discriminant functions. Probabilities of misclassification and their estimation. Discrimination for several multivariate normal populations. Canonical discriminant function.	**(10L+2T)hrs**
Unit-3	
Principal component analysis-sample principal components asymptotic properties. Canonical variables and canonical correlations: definition, estimation, computations. Test for significance of canonical correlations. Multivariate regression model: Estimation of parameters, testing of linear hypotheses about regression coefficients. Multivariate analysis of variance (MANOVA) for one-way and two- way classified data.	**(12L+2H) hrs**
Unit-4	
Cluster Analysis: distances and similarity measures, hierarchical clustering methods, K – means method. Multidimensional scaling: nature of the problem, classical solution. Factor analysis: Orthogonal factor model, factor loadings, estimation of factor loadings, factor scores. Applications.	**(12L+2H) hrs**

REFERENCES

1. Anderson, T. W. (2004). *An Introduction to Multivariate Statistical analysis,* 3/e, John Wiley, NewYork.
2. Giri, N. C. (1977). *Multivariate Statistical Inference,* Academic Press, NewYork.
3. Johnson, R. A. and Wichern, D.W. (2003). *An Introduction to Multivariate Statistical Analysis*, 5/e, PearsonEducation
4. Kshirsagar, A. M. (1972). *Multivariate Analysis,* Marcel Dekker, NewYork.
5. Morrison, D. F. (2005). *Multivariate Statistical Methods,* 4/e, McGrawhill, NewYork.
6. Muirhead, R. J. (1982). *Aspects of Multivariate Statistical Theory,* John Wiley, New York.
7. Seber, G. A. F (1984). *Multivariate Observations*, John Wiley, NewYork.
8. Sharma, S. (1996). *Applied Multivariate Techniques*, John Wiley, NewYork.
9. Srivastava, M. S. (1979). *An Introduction to Multivariate Statistics*, NorthHolland.

BLUEPRINT

Code number: ST8321

Title of the paper: Multivariate analysis

Total marks for which the questions are to be asked (including bonus questions)	Number of hours	Chapter/Unit number
16	12	I
16	12	II
19	14	III
19	14	IV
70	**52**	**TOTAL**

Maximum marks for the paper (Including bonus question):**70**

Course Articulation Matrix

Mapping of course outcomes (Cos) To Programme Outcomes (POs 1 to 8)

Code number: ST8321

Title of the paper: Multivariate analysis

Course Outcomes (COs)	PO's								BTL
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	
CO1: Understand basic concepts of multivariate analysis and assess multivariate normality	*	*							Understand, Apply
CO2: Apply estimation and hypothesis testing for mean vectors and covariance matrices	*	*	*						Apply, Analyze
CO3: Perform classification, discriminant analysis, PCA, CCA, multivariate regression, MANOVA	*	*	*				*	*	Analyze, Evaluate
CO4: Use clustering, MDS, and factor analysis for pattern recognition and dimension reduction	*	*	*				*	*	Analyze, Apply

SECOND SEMESTER

ST 8421: Linear Models and Regression Analysis

Semester	Second
Paper code	ST8421
Paper Title	Linear Models and Regression analysis
Number of teaching hrs per week	4
Total number of teaching hrs per semester	52
Number of credits	4

COURSE OBJECTIVES

1. Apply Gauss-Markov principles to obtain and interpret least squares estimates.
2. Construct confidence intervals and test general linear hypotheses in linear models.
3. Implement multiple and generalized linear regression models for data analysis.
4. Evaluate model adequacy using residual diagnostics and goodness-of-fit measures.
5. Detect and address multicollinearity, heteroscedasticity, and autocorrelation problems.
6. Perform variable selection and model improvement using classical selection techniques.

Unit-1	**Total Hrs**
Linear model. Estimability of linear parametric functions in Gauss-Markov model, least squares estimation, BLUE, Gauss-Markov theorem. Distributional properties of least squares estimators, Independence of BLUE's and residual sum of square. Estimation under linear restrictions involving estimable functions. Confidence intervals for BLUE's, General linear hypotheses, testable hypotheses. Likelihood ratio test procedure.	**(10L+4T)hrs**
Unit-2	
Multiple linear regression, estimation, and properties. Prediction of new observations and prediction interval. Hidden extrapolation. Use of dummy variables. Generalized linear models: link function, binary logistic regression, and Poisson regression.	**(10L+2T) hrs**
Unit-3	
Measures of model adequacy, coefficient of determination R^2, lack of fit test, residuals, scaling residuals, and residual analysis: residual plots as tests for departure from assumptions of homoscedasticity, normality (Q-Q plot), non-linearity, and detection of outliers. Detecting influential observations. Transformations: Box-Cox transformation and transforming the predictors. Subset selection of regressors: Mallow's C_p statistic, all possible, stepwise, forward and backward regressions.	**(10L+2T) hrs**
Unit-4	
Heteroscedasticity and autocorrelation: sources, consequences, detection, and remedial procedures. Multicollinearity: sources, consequences, detection, and remedial procedures. Ridge regression and generalized least squares. Validation of regression models. Analysis of model coefficients and predicted values. Collecting fresh data. Data splitting.	**(12L+2T)hrs**

REFERENCES

1. Cook, R. D. and Weisberg, S. (1982). *Residual and Influence in Regression,* Chapman and Hall,London,UK.
2. Draper, N. R. and Smith, H. (1998). *Applied Regression Analysis, 3/e,* John Wiley, NewYork.
3. Gunst, R. F. and Mason, R. L. (1980). *Regression Analysis and Its Applications - A Data Oriented Approach*, Marcel and Dekker, NewYork.
4. Montgomery, D. C. and Peck, E. A., and Vining, G. G. (2012). *Introduction to Linear Regression*, 5/e, John Wiley, NewYork.
5. Ryan, T. P. (1997). *Modern Regression Methods*, John Wiley, NewYork.
6. Searle, S. R. (1971). *Linear Models,* John Wiley, NewYork.
7. Weisberg, S. (1985). *Applied Linear Regression*, John Wiley, NewYork.

BLUEPRINT

Code number: ST8421

Title of the paper: Linear Models and Regression analysis

Total marks for which the questions are to be asked (including bonus questions)	**Number of hours**	**Chapter/Unit number**
19	14	I
16	12	II
16	12	III
19	14	IV
70	**52**	**TOTAL**
Maximum marks for the paper (Including bonus question):**70**		

Course Articulation Matrix
Mapping of course outcomes (Cos) To Programme Outcomes (POs 1 to 8)
Code number: ST8421
Title of the paper: Linear Models and Regression Analysis

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	BTL
CO1: Apply Gauss-Markov principles to obtain and interpret least squares estimates.	*	*	*					*	Apply
CO2: Construct confidence intervals and test general linear hypotheses in linear models.	*	*	*			*	*		Analyse
CO3: Implement multiple and generalised linear regression models for data analysis.		*	*	*		*	*	*	Apply/Create
CO4: Evaluate model adequacy using residual diagnostics and goodness-of-fit measures.	*	*	*	*			*	*	Evaluate
CO5: Detect and address multicollinearity, heteroscedasticity, and autocorrelation problems.	*	*		*		*	*		Evaluate
CO6: Perform variable selection and model improvement using classical selection techniques.		*		*	*	*		*	Apply/Create

SECOND SEMESTER

ST 8521: Introduction to Data Science

Semester	**Second**
Course Code	**ST 8521**
Course Title	**Introduction to Data Science**
Number of teaching hours per week	**2+1**
Total number of teaching hours per semester	**39**
Number of credits	**2**

COURSE OBJECTIVE:

1. To introduce students to data processing and visualization using MS-Excel, R, Python, and Tableau.
2. To develop foundational programming skills, like for data manipulation and file handling in R and Python.
3. To familiarize students with Big Data concepts and essential techniques for data cleaning, missing value imputation, and outlier detection.
4. To train students in performing Exploratory Data Analysis for understanding datasets.
5. To equip students with fundamental model-building skills in regression, classification, and clustering techniques.

Unit 1	**Total Hrs**
a) Data processing using MS-Excel. Graphical and diagrammatic representation, exploring various functions, Data Analysis and Solve add-on packages in MS-Excel b) R language Essentials: Expressions and objects, Assignments, creating vectors, vectorized arithmetic, creating matrices, operations on matrices, lists, data frames – creation, indexing, sorting and conditional selection; examples. c) R Programming: conditional statements -if and if else; loops -for, while, do-while; functions –built-in and user defined; Data entry –reading from text file, data editor; examples. Data and file handling in R. Packages in R, installation, loading, accessing inbuild functions, use of help function. User defined functions- Exercises d) Introduction to Python: Python Essentials; Data Management using dplyr package e) Graphical Representation using R/Python and Tableau	**(10L+ 2T) Hrs**
Unit 2	
Introduction to Big Data, structured and unstructured data, Data Management: Data cleaning; Missing value imputation techniques/methods, Outlier detection techniques: Graphical and analytical methods; Exploratory Data Analysis, Descriptive statistics, importance of EDA through case studies.	**(7L+ 3T) Hrs**
Unit 3	

Model Building: Multiple linear regression, model adequacy-residual analysis, model selection and evaluation. Classification problems: decision trees, support vector machine; Random Forest model. Clustering: k-means	**(12L+ 5T) Hrs**

Note: Above concepts/topics to be covered only through case studies

REFERENCES

1. Jiawei Han, Micheline Kamber (2002), "Data Mining: Concepts and Techniques", Morgan Kaufmann Publishers.
2. Margaret H.Dunham (2003), "Data Mining Introductory and Advanced Topics", Pearson Education.
3. Alex Berson,Stephen J. Smith (2004), "Data Warehousing, Data Mining,& OLAP", Tata McGrawHill.
4. Margaret H.Dunham (2003), "Data Mining Introductory and Advanced Topics", Pearson Education.
5. Alex Berson,Stephen J. Smith (2004), "Data Warehousing, Data Mining,& OLAP", Tata McGrawHill.
6. Ralph Kimball (2007), "The Data Warehouse Life Cycle Toolkit", John Wiley & Sons Inc.
7. O'Neil and Schutt (2013) "Doing Data Science" Shroff Publishers
8. Provost and Fawcett (2013) "Data Science for Business", Shroff Publishers
9. Fung (2013) "Numbersense: how to use big data to your advantage" McGraw-Hill.
10. James, G., Witten, D., Hastie, T., Tibshirani, R. An introduction to statistical learning with applications in R. Springer, 2013.
11. Han, J., Kamber, M., Pei, J. Data mining concepts and techniques. Morgan Kaufmann, 2011.
12. Hastie, T., Tibshirani, R., Friedman, J. The Elements of Statistical Learning, 2nd edition. — Springer, 2009.
13. Practical Data Science with R". Nina Zumel, John Mount. Manning, 2014
14. "Data Science for business", F. Provost, T Fawcett, 2013

BLUEPRINT
Code number: ST8521
Title of the paper: Introduction to Data science

Total marks for which the questions are to be asked (including bonus questions)	Number of hours	Chapter/Unit number
10	12	I
7	10	II
8	17	III
25	**39**	**TOTAL**

Maximum marks for the paper (Including bonus question):**25**

Course Articulation Matrix
Mapping of course outcomes (Cos) To Programme Outcomes (POs 1 to 8)
Code number: ST8521
Title of the paper: Introduction to Data science

COs:	**POs**								**BTL**
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PO-7**	**PO-8**	
Course Title: **Introduction to Data science**									
CO1: Describe Process, manipulate, and visualize data using Excel/R/Python /Tableau	*		*						Understand
CO2 Apply programming constructs in R and Python			*						Apply
CO3: Clean and preprocess datasets using appropriate methods		*			*				Analyze
CO4: Perform EDA and interpret descriptive statistics		*					*		Analyze
CO5: Build and evaluate regression, classification, and clustering models	*		*			*			Evaluate

SECOND SEMESTER

ST 8P1: Practical – III

Semester	Second
Paper Code	ST8P1
Paper Title	Practical- III (Based on ST 8121, ST 8221 and ST 8321)
Number of teaching hrs per week	4
Total number of teaching hrs per semester	44
Number of credits	2

List of Assignments
ST 8121: Distribution Theory ST 8221: Testing of Hypothesis and Interval Estimation ST 8321: Multivariate Analysis 1. Sampling distribution 2. Order Statistics 3. Formulation of hypothesis, Size of the test, power of the test and plotting power function. 4. Most powerful tests 5. UMP one sided test including plotting of power function 6. UMPU test based on one parameter exponential family. 7. Interval estimation 8. Likelihood ratio test for finite sample based on one and two independent sample from normal distribution and exponential distribution. 9. Bartlett test for homogeneity of variances. 10. Discriminant Analysis 11. Principal component analysis and Factor Analysis

SECOND SEMESTER

ST 8P2: Practical – IV

Semester	Second
Paper Code	ST8P2
Paper Title	Practical- IV (Based on ST 8421 and ST 8521)
Number of teaching hrs per week	4
Total number of teaching hrs per semester	44
Number of credits	2

List of Assignments

ST 8421: Linear Models and Regression Analysis
ST 8521: Introduction to Data Science

1. Computation of mean vector, covariance matrix, partial and multiple correlations. from a multivariate data.
2. Fitting multiple linear regression models – Stepwise regression
3. Multicollinearity diagnostics.
4. Residual analysis.
5. Tests for autocorrelation.
6. Fitting a ridge regression model.
7. Fitting logistic and Poisson regression models
8. Exploratory data analysis
9. Data Modeling
10. Graphic displays
11. Mining Databases

THIRD SEMESTER

ST9120: Stochastic Processes

Semester	Third
Paper Code	ST 9120
Paper Title	Stochastic Processes
Number of teaching hrs per week	4
Total number of teaching hrs per semester	52
Number of credits	4

COURSE OBJECTIVE:
1. Construct and analyse transition probabilities, n-step transitions, and stationary distributions for discrete-time Markov chains. 2. Classify states and evaluate transient, recurrent, and absorbing behaviours with applications to random walks and gambler’s ruin. 3. Apply Chapman-Kolmogorov and Kolmogorov-Feller equations to study discrete and continuous-time Markov processes. 4. Model and interpret Poisson, birth-death, and renewal processes, including computations of renewal functions and related results. 5. Estimate transition probabilities and apply stochastic process models to practical problems such as queuing systems. 6. Analyse branching processes and determine extinction probabilities and long-term population behaviour.

Unit 1	Total Hrs
Introduction to Stochastic Processes, Markov chain, one-step transition probabilities, Chapman- Kolmogorov equations, calculation of n-step transition probability and its limit, first passage probabilities. Stationary distribution.	(12L+3T) hrs
Unit 2	
Classification of states, transient Markov chain, absorption probabilities, absorption and recurrence times, random walk and gambler’s ruin problem. Estimation of transition probabilities of a Markov chain, applications.	(10L+3T) hrs
Unit 3	
Discrete state space continuous time MC: Kolmogorov-Feller differential equations; Poisson process, pure birth process, birth and death process, applications to queuing theory. Renewal process, renewal function. Renewal equation. Elementary renewal theorem and its applications.	(12L+2T) hrs
Unit 4	
Branching process: Galton-Watson branching process, probability of ultimate extinction, distribution of population size, Martingale in discrete time.	(8L+2T) hrs

REFERENCES
1. Karlin, S and Taylor, H. M. (1975). A First Course in Stochastic Processes, Academic Press, New York. 2. Bhat, B. R. (2000). Stochastic Models, New Age International, New Delhi. 3. Medhi, J. (2017). Stochastic Processes, 4/e. New Age International, New Delhi. 4. Ross, S.M. (1996). Stochastic Processes, 2/e, John Wiley, New York. 5. A.K. Basu (2003): Introduction to Stochastic Processes, Narosa Publishers.

6. Cox, D.R. and Miller, H.D. (2001): The theory of Stochastic Processes, Chapman & Hall.

BLUEPRINT
Code number: ST9120
Title of the paper: Stochastic Processes

Total marks for which the questions are to be asked (including bonus questions)	**Number of hours**	**Chapter/Unit number**
20	15	I
18	13	II
19	14	III
13	10	IV
70	**52**	**TOTAL**
Maximum marks for the paper (Including bonus question):**70**		

Course Articulation Matrix
Mapping of course outcomes (Cos) To Programme Outcomes (POs 1 to 8)
Code number: ST9120
Title of the paper: Stochastic Processes

COs:	**POs**								**BTL**
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PO-7**	**PO-8**	
Course Title: **Stochastic Processes**									
CO1: Construct and analyse transition probabilities, n-step transitions, and stationary distributions for discrete-time Markov chains.	*	*				*	*	*	Construct
CO2: Classify states and evaluate transient, recurrent, and absorbing behaviours with applications to random walks and gambler's ruin.		*				*	*	*	Compute
CO3: Apply Chapman-Kolmogorov and Kolmogorov-Feller equations to study discrete and continuous-time Markov processes.	*	*	*			*	*	*	Analyse
CO4: Model and interpret Poisson, birth-death, and renewal processes, including computations of renewal functions and related results.	*	*	*			*	*	*	analyse
CO5: Estimate transition probabilities and apply stochastic process models to practical problems such as queuing systems.		*	*	*		*	*	*	Apply
CO6: Analyse branching processes and determine extinction probabilities and long-term population behaviour.		*				*	*	*	Apply

THIRD SEMESTER

ST 9220: Machine Learning Techniques

Semester	**Third**
Course Code	**ST 9220**
Course Title	**Machine Learning Techniques**
Number of teaching hours per week	**4**
Total number of teaching hours per semester	**52**
Number of credits	**4**

COURSE OBJECTIVE:

1. To introduce the core concepts, paradigms, and challenges of Machine Learning.
2. To develop computational skills in Python and scientific libraries for data preprocessing and analysis.
3. To equip students with the ability to build and evaluate regression, classification, and dimensionality-reduction models.
4. To provide comprehensive understanding of tree-based models, ensemble methods, SVMs, and unsupervised learning techniques.

Unit 1	**Total Hrs**
Introduction to Machine Learning: Definitions of Machine Learning, Paradigms of Machine Learning- Supervised, Unsupervised and Reinforcement Learning with examples, Regression versus Classification Problems with examples, Batch Learning and Online Learning, Instance Based Versus Model Based Learning, Training, Testing and Validation. Challenges of Machine Learning- Prediction Accuracy and Model Interpretability Trade-off, Bias- Variance Trade off (Underfitting and Overfitting), Insufficient Quantity of Training Data, Non- representative Training data, Definition of Feature Engineering.	**(6L+1T) hrs**
Unit 2	
Computational Foundations: Basic Python Using Jupiter Notebooks, Scientific Computing using Numpy, SciPy and Matplotlib, Data Preprocessing techniques- Handle Missing Values, Label Encoding and One-hot Encoding, Standardization etc., Data Wrangling and Preprocessing using Pandas, Machine Learning with Scikit Learn.	**(4L+2T) Hrs**
Unit 3	
Multiple Linear Regression- Interaction, Transformations, Categorical Predictors. **Logistic Regression.** Performance Metrics for Regression and Classification- MSE, Confusion Matrix, ROC Curve, AIC, BIC. Resampling Methods- Cross Validation and Bootstrap. Polynomial Regression, Regression Splines, Generalized Additive Methods	**(16L+4T) hrs**

Dimensionality Reduction- Curse of Dimensionality, Subset Selection and Regularization- Ridge, Lasso, Elastic Net.Principal Component Analysis, Kernel PCA, Considerations in High Dimensions.	
Unit 4	
Tree Based Models: Decision Trees- Regression Trees, Classification Trees, Trees vs Linear Models Ensemble Models- Bagging, Random Forests, Feature Importance, Boosting-Adaboost, Gradient Boosting. Support Vector Machines: Linear SVM Classification, Non-Linear SVM Classification, SVM Regression. Unsupervised learning: Challenge of Unsupervised Learning, K Means, PCA, Hierarchical Clustering, Gaussian Mixture Models.	**(15L + 4T) hrs**

REFERENCES

1. Alpaydin, E. (2014). Introduction to Machine Learning, 3e., MIT Press, USA.
2. Bishop, C. (2007). Pattern Recognition and Machine Learning, Springer, New York
3. Breiman, L., Friedman, J., Stone, C. J., and Olshen, R. A. (1984). Classification and Regression Trees. CRC Press, London.
4. Jiawei Han, Micheline Kamber. (2002). Data Mining-Concepts and Techniques, Morgan Kaufman Publishers, U.S.A
5. Raschka, S., Mirjalili,V. (2019). Python Machine learning, Packt Publishing, UK.
6. Gareth, J., Daniela Witten, Trevor, H., Robert, T. (2013). An Introduction to Statistical Learning: With Applications in R, Springer, New York.
7. Friedman, J., Hastie, T., & Tibshirani, R. (2001). The Elements of Statistical Learning, Springer series in statistic, New York, U.S.A.

BLUEPRINT

Code number: ST 9220

Title of the paper: Machine Learning Techniques

Total marks for which the questions are to be asked (including bonus questions)	Number of hours	Chapter/Unit number
9	07	I
8	06	II
27	20	III
26	19	IV
70	**52**	**TOTAL**

Maximum marks for the paper (Including bonus question):**70**

Course Articulation Matrix
Mapping of course outcomes (Cos) To Programme Outcomes (POs 1 to 8)
Code number: ST 9220
Title of the paper: Machine Learning Techniques

COs:	POs								**BTL**
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PO-7**	**PO-8**	
Course Title: **Machine Learning Techniques**									
CO1: explain fundamental machine learning concepts, paradigms, and challenges.	*								Understand
CO2: apply Python and scientific computing libraries to preprocess, manage, and analyze datasets.			*					*	Apply
CO3: evaluate linear and logistic regression models using appropriate performance metrics.	*	*					*		Analyze
CO4: Implement resampling methods, regularization techniques, and dimensionality-reduction approaches for model improvement.	*	*	*				*		Analyze
CO5: construct and interpret tree-based models, ensemble methods, and support vector machine algorithms.		*	*				*	*	Analyze
CO6: Formulate data patterns by using unsupervised learning techniques and PCA models		*		*			*	*	Create

Third Semester

ST 9323: Statistical Quality Control

Semester	Third
Paper Code	ST 9323
Paper Title	Statistical Quality Control
Number of teaching hrs per Week	4
Total number of hrs per semester	52
Number of Credits	4

COURSE OBJECTIVES

1. Understand quality concepts, process variation, and control chart principles.
2. Construct and interpret CUSUM, EWMA, and multivariate control charts
3. Analyze and design acceptance sampling plans and related performance measures.
4. Apply SPRT and compute OC and ASN for quality inspection problems.
5. Evaluate process capability and implement SPC and Six Sigma programmes.

Unit 1	**Total Hrs**
Concept of quality. Quality function and quality characteristics. Quality assurance - its evolution and modern trends. Chance and assignable causes. Principles of a process control chart and associated decision rules. The seven QC tools. Design quality and conformance quality. Quality costs. Quality and productivity. Analysis of OC, ARL, and other measures. Techniques for improving sensitivity of a chart. Process capability and its measures. Design and implementation of SPC and six-sigma programmes, BIS and ISO certification.	**(14L+2T) Hrs**
Unit 2	
Shewhart control charts for monitoring process level and process dispersion. Rational subgroups. Pre-control and analysis of patterns on a control chart, CUSUM and EWMA charts, Process control with autocorrelated observations. Modifications of Shewhart control chart. Multivariate control charts.	**(10L+2T) Hrs**
Unit 3	
Acceptance sampling plan: Principle of acceptance sampling plans. Single and Double sampling plan their OC, AQL, LTPD, AOQ, AOQL, ASN, ATI functions with graphical interpretation, use and Dodge-Romig and MIL-STD systems- interpretation of Dodge and Romig's sampling inspection plan tables.	**(10L+2T) Hrs**
Unit 4	
Sequential Probability Ratio Test; concept and operational definition. Determination of stopping bounds A and B, OC and ASN functions of SPRT for testing the mean of a normal distribution with known variance. Statement of the optimal property of SPRT.	**(14L+2T) Hrs**

REFERENCES

1. Alwan, L.C. (2000). Statistical Process Analysis, McGraw Hill, New York.
2. Grant, E. L. and Leavenworth, R. S. (1996). Statistical Quality Control. 7th edition, McGrawHill, New York.
3. Mittage, H.J. and Rinne, H. (1993). Statistical Methods of Quality Assurance, Chapman and Hall, London, UK.
4. Montgomery, D.C. (2012). Introduction to Statistical Quality Control, 7/e, John Wiley, New York.
5. Smith, G.M. (1991). Statistical Process Control and Quality Improvement, 3/e, Prentice Hall, New York.
6. Wetherill, G.B. and Brown, D.W. (1991). Statistical Process Control: Theory and Practice, Chapman and Hall, London, UK

BLUEPRINT Code number: ST9323 Title of the paper: Statistical Quality Control		
Total marks for which the questions are to be asked (including bonus questions)	**Number of hours**	**Chapter/Unit number**
22	16	I
19	14	II
16	12	III
13	10	IV
70	**52**	**TOTAL**
Maximum marks for the paper (Including bonus question): **70**		

Course Articulation Matrix
Mapping of course outcomes (Cos) To Programme Outcomes (POs 1 to 8)
Code number: ST 9323
Title of the paper: Statistical Quality Control

Cos	**POs**								**BTL**
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PO-7**	**PO-8**	
Course Title: **Statistical Computing**									
CO1: Understand quality concepts, process variation, and control chart principles.	*	*	*				*		Understand
CO2: Construct and interpret CUSUM, EWMA, and multivariate control charts.		*	*			*		*	Apply
CO3: Analyze and design acceptance sampling plans and related performance measures.	*	*				*		*	Analyze
CO4: Apply SPRT and compute OC and ASN for quality inspection problems.	*	*	*				*	*	Apply/Analyze
CO5: Evaluate process capability and implement SPC and Six Sigma programmes.		*	*	*	*	*	*	*	Evaluate

THIRD SEMESTER

STDE 9420: Optimization Techniques (ELECTIVE- I)

Semester	Third
Course Code	STDE 9420
Course Title	Optimization Techniques
Number of teaching hours per week	4
Total number of teaching hours per semester	52
Number of credits	4

COURSE OBJECTIVE:

1. To understand the basics of linear programming and learn efficient solution methods, including the Ellipsoid and Karmarkar algorithms.
2. To study integer programming techniques such as Gomory cuts, fractional cuts, branch-and-bound, and dynamic programming, along with sensitivity analysis.
3. To formulate and solve transportation, assignment, and related optimization problems using standard algorithms and handle special cases like degeneracy and the travelling salesman problem.
4. To learn the principles of nonlinear programming, including convexity, KKT conditions, and quadratic programming methods like Wolfe and Beale algorithms.
5. To apply network models in solving flow and scheduling problems, and use CPM and PERT for identifying critical paths, floats, slacks, and resource needs.

Unit 1	**Total Hrs**
Linear Programming: Review of basic concepts, Computational complexity of LPP, Ellipsoid method, Polynomial time algorithm, Karmarkar's polynomial time algorithm, Convergence and complexity, Integer linear programming problem: pure and mixed integer programming problem, Gomory's all Integer programming method. Fractional cut method- all integer and mixed integer linear programming problem, branch and bound method, Dynamic programming, sensitivity analysis, Bellman's optimality principle.	**(14L+2T) hrs**
Unit 2	
General Transportation problem, Transportation matrix, L.P formulation of a Transportation problem. Finding an initial Basic feasible solution: NWCR, LCM and VAM. Test for optimality: Stepping stone algorithm and modified distribution method. Problem of degeneracy and its resolving degeneracy. Unbalanced and maximization transportation problem, Assignment problem: Mathematical formulation, Hungarian algorithm. Travelling salesman problem.	**(10L+2T) hrs**
Unit 3	
Nonlinear programming: Karush-Kuhn-Tucker conditions, Convexity, Quadratic programming, Wolfes and Beales algorithms for solving quadratic programming problems.	**(10L+2T) hrs**
Unit 4	

Networking models: Network flows, maximal flow in the network, Transportation problems, transhipment problems and assignment problems as networking problems. Network scheduling by CPM and PERT. Critical path. Float and slack. Resource Analysis in network scheduling.	**(10L+2T) hrs**

REFERENCES

1. Bertsekas, D. (1999). Nonlinear Programming, 2nd Edn. Athena Scientific.
2. Chong, E. K. P. and Zak, S. (2004). An Introduction to Optimization, Wiley..
3. Fletcher, R. (2000). Practical Methods of Optimization, Wiley
4. Hadley, G. (1987). Linear Programming. Addison-Wesley.
5. Hiller, F.S. and Lieberman, G.J., (2009). Introduction to Operations Research (9th ed.), McGraw-Hill
6. Kambo, N.S. (1991). Mathematical Programming Techniques. Affiliated East-West press.
7. Panneerselvam, R. (2012). Operations Research, 2nd Edn. Prentice Hall of India.
8. Sinha, S. M. (2006) Mathematical Programming: Theory and Methods, Elsevier's
9. Taha, H. A. (2016) Operations Research: An Introduction, 10th edition, Prentice Hall
10. Winston, W.L., (2003) Introduction to Mathematical Programming (4th ed.), Duxbury Press

BLUEPRINT

Code number: STDE 9420

Title of the paper: Optimization Techniques

Total marks for which the questions are to be asked (including bonus questions)	**Number of hours**	**Chapter/Unit number**
22	16	I
16	12	II
16	12	III
16	12	IV
70	**52**	**TOTAL**
Maximum marks for the paper (Including bonus question):**70**		

Course Articulation Matrix
Mapping of course outcomes (Cos) To Programme Outcomes (POs 1 to 8)
Code number: STDE 9420
Title of the paper: Optimization Techniques

COs:	POs								BTL
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PO-7**	**PO-8**	
Course Title: **Optimization Techniques**									
CO1: Understand linear programming concepts and efficient solution methods like Ellipsoid and Karmarkar algorithms.	*	*				*	*		Understand
CO2: Apply integer programming techniques such as Gomory cuts, branch-and-bound, and dynamic programming.	*	*	*			*	*	*	Analyze
CO3: Formulate and solve transportation, assignment, and travelling salesman problems using standard algorithms.	*	*	*			*	*	*	Apply
CO4: Analyze and solve nonlinear programming and quadratic programming problems using KKT conditions and Wolfe/Beale methods.	*	*	*			*	*	*	Analyze

CO5: Model and solve network flow and scheduling problems using CPM, PERT, and related techniques.	*	*	*			*	*	*	Evaluate
CO6: Apply optimization methods to real-life problems and develop problem-solving skills using analytical and computational tools.	*	*	*	*	*	*	*	*	Apply

THIRD SEMESTER
STDE 9520: Operations Research (ELECTIVE- I)

Semester	Third
Course Code	STDE 9520
Course Title	Operations Research
Number of teaching hours per week	4
Total number of teaching hours per semester	52
Number of credits	4

COURSE OBJECTIVE:

1. To understand the fundamental concepts of linear programming, including the simplex method, duality, and methods for transportation and assignment problems.
2. To learn integer programming techniques such as Gomory's cutting plane methods, branch-and-bound, and zero-one programming.
3. To understand nonlinear programming concepts, including Lagrangian methods, Karush-Kuhn-Tucker conditions, and quadratic programming.
4. To study the basic concepts of queueing theory, different queueing models (M/M/1, M/M/c, M/M/∞), and their waiting time distributions.
5. To understand inventory management systems, including EOQ models, multi-period and stochastic inventory models, and policies like (s, S).

Unit 1	**Total Hrs**
Linear Programming: Review on basics of LPP, Simplex algorithm, Big-M and two-phase method. Primal and dual LPP. Dual simplex method. Transportation problem and test for optimality. Assignment problem.	**(12L+2T) hrs**
Unit 2	
Integer programming: Pure and mixed Integer programming problems. Cutting plane methods – Gomory's algorithms. Branch and bound technique. Zero-one programming. Nonlinear programming: Formulation of nonlinear programs. Unconstrained and constrained optimization problems. The Lagrangian method. Karush-Kuhn-Tucker optimality conditions. Quadratic programming. Wolfe's modified simplex method.m: Mathematical formulation, Hungarian algorithm. Travelling salesman problem.	**(14L+2T) hrs**
Unit 3	
Queueing theory: General description and characteristics of a queueing system. M/M/1 and M/M/c queueing systems and their waiting time distributions. M/M/1/N and M / M / ∞ queues. Transient solution of M / M / ∞ queueing system. Introduction to Non-Markovian queues.	**(10L+2T) hrs**
Unit 4	

Inventory models: Basic characteristics of inventory systems (models). ABC analysis. Deterministic inventory systems EOQ Models with quantity discounts, price breaks, and storage limitations. Multiperiod dynamic inventory models. Continuous review stochastic inventory systems. The (s, S) policy.	**(8L+2T) hrs**

REFERENCES

1. Gross, D and Harris, C. M. (1986). Fundamentals of Queueing Theory, 2/e, John Wiley.
2. Taha, H. A. (2002). Operations Research, 7/e; Macmillan.
3. Medhi. J. (1991). Stochastic models in queueing theory, Academic Press.
4. Bazaara, M. S. and Shetty, C. M. (1979). Nonlinear Programming: Theory and Algorithms, John Wiley, New York.
5. Hillier, F. S. and Liebermann, G. J. (1986). Introduction to Operations Research,Holden Day, New York.
6. Kambo, N. S. (1991). Mathematical Programming Techniques, Affiliated East-West Press, New Delhi.
7. Murthy, K. G. (1995). Operations Research: Deterministic Optimization Models, Prentice Hall, New Delhi.
8. Swarup, K. et. al. (1985). Operations Research, Sultan Chand and Co., New Delhi.

BLUEPRINT

Code number: STDE 9520

Title of the paper: Operations Research

Total marks for which the questions are to be asked (including bonus questions)	Number of hours	Chapter/Unit number
19	14	I
22	16	II
16	12	III
13	10	IV
70	**52**	**TOTAL**
Maximum marks for the paper (Including bonus question):**70**		

Course Articulation Matrix
Mapping of course outcomes (Cos) To Programme Outcomes (POs 1 to 8)
Code number: STDE 9520
Title of the paper: Operations Research

COs:	**POs**								**BTL**
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PO-7**	**PO-8**	
Course Title: **Operations Research**									
CO1: Understand the fundamental concepts of linear programming and apply methods like the simplex algorithm, duality, Big-M, two-phase, and dual simplex methods.	*	*				*	*		Understand
CO2:Formulate and solve transportation and assignment problems using standard optimization techniques.	*	*	*			*	*	*	Analyze
CO3: Apply integer programming methods, including Gomory's cutting plane, branch-and-bound, and zero-one programming, to solve discrete optimization problems.	*	*	*			*	*	*	Apply
CO4: Analyze and solve nonlinear programming problems using Lagrangian methods, Karush-Kuhn-Tucker conditions, and quadratic programming	*	*	*			*	*	*	analyze

techniques.									
CO5:Understand queueing theory, model different queueing systems (M/M/1, M/M/c, M/M/∞), and compute waiting time distributions and performance measures.	*	*	*			*	*	*	Evaluate
CO6: Understand and apply inventory management techniques, including deterministic EOQ models, multi-period dynamic models, stochastic inventory systems, and (s, S) policies.	*	*	*	*	*	*	*	*	Apply

THIRD SEMESTER

ST 9623: Reliability Theory

Semester	Third
Course Code	ST 9623
Course Title	Reliability Theory
Number of teaching hours per week	4
Total number of teaching hours per semester	52
Number of credits	4

COURSE OBJECTIVE
1. To introduce the fundamental concepts of reliability, coherent system structures, and component importance in engineering and industrial systems. 2. To develop understanding of various life distributions, hazard functions, reliability measures, and estimation of parameters in reliability models. 3. To study ageing properties and classes of lifetime distributions, and to analyse reliability of series, parallel and k-out-of-n systems. 4. To impart knowledge of shock models, stress–strength models, proportional hazards model, and classical maintenance policies for improving system performance.

Unit 1	**Total Hrs**
Introduction to Reliability and its needs; Structural properties of coherent system: components and systems, coherent structures, representation of coherent systems in terms of paths and cuts, relevant & irrelevant structure; Reliability of a coherent systems; Reliability importance of components.	**(9L+2T) hrs**
Unit 2	
Life Distributions: Concept of distribution function, hazard function, Reliability function, Mean Time to Failure, Bathtub failure rate; loss of memory property of Exponential distribution - parametric families of some common life distributions - life distributions and its characterization - Reliability estimation of parameters in these models.	**(8L+2T) hrs**
Unit 3	
Classes of lifetime distributions. Concept of ageing, positive and negative ageing, IFR, IFRA, NBU, NBUE, DMRL classes of distributions and their dual classes. Interrelations among the classes of life time distributions. Closures of these classes under formation of coherent systems, convolutions, and mixtures. System Reliability: Series and parallel systems. k-out- of -n system. Structure function and block diagrams of these systems. Bounds on System Reliability. System life as a function of component lives. Expected system lifetime.	**(13L+3T) hrs**
Unit 4	
Reliability modelling: Introduction to shock models- Univariate shock models: cumulative damage model, shock models leading to univariate IFR, Successive shock model, stress-strength models- Concepts and its estimation for some life distribution and proportional hazard model, Maintenance policies: Age replacement and block replacement policies and their characteristics.	**(12L+3T) hrs**

REFERENCES
1. Barlow, R.E. and Proschan F. (1985) Statistical Theory of Reliability and Life Testing; Rinehart and Winston. 2. Lawless, J.F. (2003): Statistical Models and Methods of Life Time Data; John Wiley. 3. Zacks, S (1992): Introduction to Reliability Analysis, Springer Verlag. 4. Deshpande, J. V. and Purohit, S. G. (2005). Life Time Data: Statistical Models and Methods, World Scientific. 5. Ross, S.M. (2010). Introduction to Probability Models, 10/e, Academic Press, New York. 6. Bhat, B. R. (2000). Stochastic Models, New Age International, New Delhi. 7. Sinha, S.K. (1986). Reliability and Life Testing. John Wiley and sons.

BLUEPRINT

Code number: ST 9623

Title of the paper: Reliability Theory

Total marks for which the questions are to be asked (including bonus questions)	Number of hours	Chapter/Unit number
15	11	I
13	10	II
22	16	III
20	15	IV
70	**52**	**TOTAL**
Maximum marks for the paper (Including bonus question):**70**		

Course Articulation Matrix

Mapping of course outcomes (Cos) To Programme Outcomes (POs 1 to 8)

Code number: ST 9623

Title of the paper: Reliability Theory

COs:	**POs**								**BTL**
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PO-7**	**PO-8**	
Course Title: **Distribution Theory**									
CO1: Explain concepts of reliability, coherent systems, paths/cuts and component importance..	*	*				*	*	*	Understand
CO2: Analyse and compute reliability measures such as hazard rate, MTTF, survival function for various life distributions..	*	*	*			*	*	*	Apply/Analyze

CO3: Distinguish ageing classes (IFR, IFRA, NBU, NBUE, DMRL etc.) and examine their interrelationships and closure properties.	*	*	*			*	*	*	Analyze
CO4: Evaluate reliability for series, parallel and k-out-of-n systems using structure functions and bounds..	*	*	*			*	*	*	Apply/Evaluate
CO5: Apply shock models, stress-strength concepts and proportional hazards model for real-life reliability problems.	*	*	*			*	*	*	Apply
CO6: Develop and compare maintenance policies (age replacement, block replacement) and recommend optimal strategies.	*	*	*	*		*	*	*	Evaluate/Create

THIRD SEMESTER

ST 9P1: Practical V (based on ST 9120 and ST 9320)

Semester	Third
Paper Code	ST 9P1
Paper Title	Practical V (based on ST 9120 and ST 9320)
Number of teaching hrs per week	4
Total number of teaching hrs per semester	44
Number of credits	2

LIST OF ASSIGNMENTS

ST 9120: Stochastic Processes
ST 932: Quality Assurance and reliability theory

1. Computing n-step and stationary probabilities
2. Sampling path of a Markov chain
3. Computation of first passage probabilities and time, mean recurrence time.
4. Stationary Probabilities of a Markov chain
5. Poisson Process
6. Branching Process
7. OC and ARL curves of X and R control charts
8. CUSUM and EWMA control Charts
9. Multivariate control charts.
10. Single and double attribute sampling plans.
11. Reliability Estimation.

THIRD SEMESTER

ST 9P2: Practical VI (based on ST 9220 and STDE 9420/STDE 9520)

Semester	Third
Paper Code	ST 9P2
Paper Title	Practical VI (based on ST 9220 and STDE 9420/STDE 9520)
Number of teaching hrs per week	4
Total number of teaching hrs per semester	44
Number of credits	2

LIST OF ASSIGNMENTS

ST 9220: Data mining and Machine Learning.
STDE 9420/STDE 9520: Optimization Techniques/Operations Research.

1. Support vector Machine
2. Bayesian classifier
3. Bootstrap sampling
4. EM algorithm
5. k-NN classifier
6. Decision tree for classification
7. Simplex Method /Integer linear Programming Problem
8. Big M Method/Dynamic programming
9. Integer Programming/Transportation problem
10. Nonlinear optimization/Quadratic program
11. Inventory Models/Assignment Problem.

FOURTH SEMESTER

ST0124: ADVANCED STATISTICAL INFERENCE

Semester	Fourth
Course Code	ST 0124
Course Title	Advanced Statistical Inference
Number of teaching hours per week	4
Total number of teaching hours per semester	52
Number of credits	4

COURSE OBJECTIVES:

1. To introduce the fundamental concepts of consistency, asymptotic properties, efficiency, and robustness of statistical estimators and develop the ability to compare and evaluate estimators.
2. To provide a thorough understanding of robust estimation techniques and resampling methods for handling real-world data irregularities.
3. To equip students with the principles of decision theory and Bayesian inference, including prior–posterior analysis, conjugate priors, and Bayes estimators under various loss functions.
4. To develop the ability to apply non-parametric statistical methods.
5. To enhance analytical and applied skills necessary to integrate parametric, robust, Bayesian, and non-parametric methodologies for solving complex statistical inference problems.

Unit 1	**Total Hrs**
Consistency: Definition and problems for consistency. Weak and strong consistencies. Marginal and jointly consistent estimators. Invariance property. Comparison of consistent estimators. Consistent asymptotically normal (CAN) property: Definition and methods of obtaining CAN estimators. Example of consistent but not asymptotic normal in Pitman family. Invariance property. CAN property of MLE in Cramer's family. Best asymptotically normal (BAN) estimator. Asymptotic relative efficiency (ARE).	**(15L + 2T) Hrs**
Unit 2	
Robust estimation: The influence curve and empirical influence curve. M-estimation: Median, Trimmed and winsorized mean. Influence curve for M-estimators. Limiting distribution of M estimators. Resampling methods: Quenouille's Jackknife estimation, parametric and nonparametric bootstrap methods.	**(7L + 2T) Hrs**
Unit 3	
Decision Theory and Bayesian Analysis: Elements of a decision problem. Estimation and testing as decision problems. Bayes paradigm. Prior and posterior distributions. Conjugate and non informative priors. Construction of Bayes estimators relative to squared error, weighted squared error, absolute error, Stein and LINEX loss functions. Minimax estimation.	**(10L+2T) hrs**

Unit 4	
Non parametric Tests: One sample test: Test based on total number of runs, the ordinary sign test, the Wilcoxon signed - rank test, the Kolmogorov-Smirnov one sample goodness of fit test. Definition of U-statistic and properties. Hoeffding's one-sample U – statistic theorem. Two sample tests: Sign test, Wilcoxon signed rank test, the median test, the Wilcoxon-Mann-Whetney test, Mood's test for two sample scale problem, the Kolmogorov Smirnov two sample test. Analysis of variance by ranks.	**(12L+2T) hrs**

REFERENCES

1. Casella G. and Berger R.L. (2002): Statistical Inference, 2nd Ed., Thomson- Duxbury, Singapore.
2. Kale B.K. and Muralidharan (2015): Parametric Inference, An Introduction, Alpha Science International Limited.
3. Dudewicz, E. J. and Mishra, S. N. (1980). *Modern Mathematical Statistics*, John Wiley, New York.
4. Lehmann, E. L. and Cassella, G. (1998). *Theory of Point Estimation,* 2/e, Springer Verlag, New York.
5. Rohatgi, V. K. and Saleh, A. K. Md. E. (2002). *An Introduction to Probability and Statistics*, 2/e, John Wiley, New York.
6. Zacks, S. (1981). *Parametric Statistical Inference,* John Wiley, New York.
7. Rohatgi, V.K. (2003). *Statistical Inference*, Dover Publications.
8. Wald, A. (1973). *Sequential Analysis*, Dover Publications.
9. Gibbons, J.D., Chakraborti. (201). *Nonparametric Statistical Inference,* Taylor and Francis.
10. Berger, J. O. (1980). *Decision Theory and Bayesian Analysis*, John Wiley, New York.
11. Sinha, S.K. (1988). *Bayesian Estimation,* New Age International, New Delhi.

BLUEPRINT

Code number: ST 0124

Title of the paper: Advanced Statistical Inference

Total marks for which the questions are to be asked (including bonus questions)	**Number of hours**	**Chapter/Unit number**
23	17	I
12	09	II
16	12	III
19	14	IV
70	**52**	**TOTAL**

Maximum marks for the paper (Including bonus question):**70**

Course Articulation Matrix
Mapping of course outcomes (Cos) To Programme Outcomes (POs 1 to 8)
Code number: ST 7323
Title of the paper: Advanced Statistical Inference

COs:	**POs**								**BTL**
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PO-7**	**PO-8**	
Course Title: **Advanced Statistical Inference**									
CO1: Understand robustness, consistency, asymptotic theory, and estimator comparison	*	*					*		Understand
CO2: Apply robust estimation methods and use resampling methods like jackknife and bootstrap.		*	*					*	Apply
CO3: Formulate and solve decision-theoretic and Bayesian estimation problems under various loss functions.	*	*				*			Apply, Evaluate, Create
CO4: Apply and analyze non-parametric inferential techniques		*					*	*	Apply, Analyze
CO5: Integrate and evaluate statistical inference methods across parametric, robust, Bayesian, and non-parametric frameworks.		*	*			*	*		Evaluate, Create

FOURTH SEMESTER

ST 0220: DESIGN AND ANALYSIS OF EXPERIMENTS

Semester	Fourth
Course Code	ST 0220
Course Title	Design and Analysis of Experiments
Number of teaching hours per week	4
Total number of teaching hours per semester	52
Number of credits	4

COURSE OBJECTIVE

5. To introduce the fundamental principles of design of experiments and the formulation of fixed, random, and mixed effect models.
6. To develop understanding of one-way, two-way, and higher-way ANOVA models, block designs, and their analytical properties including connectedness, orthogonality, variance balance, and C-matrix structure.
7. To impart knowledge of intra-block analysis, estimation techniques, interval estimation, testing of linear hypotheses, and multiple comparison procedures for various ANOVA frameworks.
8. To provide an in-depth understanding of special designs such as BIBD, PBIBD, Latin Square, Youden Square, and mixed-model ANCOVA including methods to handle missing observations.
9. To train students in planning, constructing, and analysing factorial experiments (2^n, 3^n), including confounding, fractional replication, and practical layout preparation.

Unit 1	**Total Hrs**
Introduction to design of experiments. Fixed, random and mixed effects models. One way ANOVA, Completely randomized design. General block design: complete block and incomplete block design. C matrix and its properties, concepts of connectedness, orthogonality, variance balance. Intra block analysis of general block design: Estimability, BLUEs, interval estimates of estimable linear parametric functions and testing of linear hypotheses.	**(12L+3T) hrs**
Unit 2	
Two-way ANOVA, Randomized block design. Balanced incomplete block design (BIBD) - Definition and relations among the parameters, Intra block analysis. PBIBD. Multiple comparison test: Tukey, Scheffe, Duncan and Dunnett's procedures.	**(12L+3T) hrs**
Unit 3	
Three-way ANOVA, LSD, Youden square design (YSD). Intra block Analysis of YSD. Analysis of covariance for CRD and RBD designs. Missing plot techniques for RBD and LSD.	**(10L+2T) hrs**
Unit 4	
Factorial experiments: concepts, symmetric factorial experiments. Analysis of 2^n and 3^n factorial experiments in randomized blocks. Complete and partial confounding, Layout and analysis of confounded 2^n and 3^n factorials. Fractional replication for 2^n factorials.	**(8L+2T) hrs**

REFERENCES
1. Das M.N. and Giri N.C. (1979): Design and Analysis of Experiments, 2nd Ed., Wiley. 2. Giri N.C. (1986): Analysis of Variance. South Asian Publishers. 3. Hinkleman and Kempthrone C. (1994): Design and Analysis of Experiments, Vol.I, John Wiley. 4. Joshi D.D. (1987): Linear Estimation and Design of Experiments, Wiley Eastern. 5. Montgomery D.C. (2001): Design and Analysis of Experiments, John Wiley. 6. Chakrabarti, M.C. (1962). Mathematics of Design and Analysis of Experiments, Asia Publishing House, New Delhi. 7. Kempthorne, O. (1952). Design and Analysis of Experiments, Wiley Eastern, New Delhi. and sons. 8. Cochran, W.G. and Cox, G. M. (1957). Experimental Designs, 2/e, John Wiley, New York.

BLUEPRINT Code number: ST0220 Title of the paper: Design and analysis of experiments		
Total marks for which the questions are to be asked (including bonus questions)	**Number of hours**	**Chapter/Unit number**
21	15	I
20	15	II
16	12	III
13	10	IV
70	**52**	**TOTAL**
Maximum marks for the paper (Including bonus question):**70**		

Course Articulation Matrix

Mapping of course outcomes (Cos) To Programme Outcomes (POs 1 to 8)

Code number: ST0220

Title of the paper: Design and analysis of experiments

COs:	**POs**								**BTL**
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PO-7**	**PO-8**	
Course Title: **Distribution Theory**									
CO1: Understand the principles of design of experiments, fixed/random/ mixed models, CRD, and properties of general block designs including C-matrix, connectedness, orthogonality, and variance balance.	*	*				*	*	*	Understand
CO2: Apply and analyse two-way	*	*	*			*	*	*	Apply/Analyze

ANOVA, RBD, BIBD/PBIBD, and perform intra-block analysis and multiple comparison procedures (Tukey, Scheffé, Duncan, Dunnett).									
CO3: Analyse three-way ANOVA, LSD, Youden Square Designs, ANCOVA (CRD & RBD), and handle missing plot techniques in RBD and LSD.	*	*	*			*	*	*	Analyze
CO4: Apply factorial concepts and analyse 2^n and 3^n factorials with confounding.	*	*	*			*	*	*	Apply/Evaluate
CO5: Evaluate fractional factorial designs and construct confounded layouts.	*	*	*	*		*	*	*	Apply

FOURTH SEMESTER

STDE0323: BIOSTATISTICS (Elective II)

Semester	Fourth
Paper Code	STDE 0323
Paper Title	Biostatistics
Number of teaching hrs per Week	4
Total number of hrs per semester	52
Number of Credits	4

COURSE OBJECTIVES
1. Understand survival models, censoring, and parametric tests for survival data. **2.** Apply life table, Kaplan–Meier, and Nelson–Aalen methods in real life situations. **3.** Analyze epidemiologic and clinical data using study designs and Cox models. **4.** Evaluate sample size needs and diagnostic accuracy measures. **5.** Apply competing risk models and stochastic epidemic models.

Unit -1	**Total Hrs**
Probability density function, survival function, hazard rate function, relationship between three types of functions, Life time distributions - exponential, gamma, Weibull, lognormal, Pareto, Rayleigh. Tests of goodness of fit for survival distributions (WE test for exponential distribution, W-test for lognormal distribution, Chi-square test for uncensored observations). Type I, Type II and progressive or random censoring with biological examples, Estimation of mean survival time and variance of the estimator for type I and type II censored data with numerical examples. Parametric methods for comparing two survival distributions viz. L.R test, Cox's F-test. P-value.	**(13L+2T) Hrs**
Unit-2	
Life tables: Standard methods for uncensored and censored data; Non-parametric methods for estimating survival function and variance of the estimator viz. Actuarial and Kaplan –Meier methods. Properties of Kaplan Meier Estimator- Self consistency, Generalized MLE, Statement of Asymptotic properties of KM estimators, Nelson-Aalen estimator, treatment of ties (Peto's method).	**(10L+3T) Hrs**
Unit-3	
Analysis of Epidemiologic and Clinical Data: Planning and design of clinical trials, Phase I, II, and III trials. Consideration in planning a clinical trial, designs for comparative trials. Sample size determination in fixed sample designs. Studying association between a disease and a characteristic: (a) Types of studies in Epidemiology and Clinical Research (i) Prospective study (ii) Retrospective study (iii) Cross-sectional data, (b) Dichotomous Response and Dichotomous Risk Factor: 2X2 Tables (c) Expressing relationship between a risk factor and a disease (d) Inference for relative risk and odds ratio for 2X2 table, Sensitivity, specificity and predictivities, Cox proportional hazard model.	**(10L+2T) Hrs**
Unit-4	
Competing risk theory, Indices for measurement of probability of death under competing risks and their inter-relations. Estimation of probabilities of death under competing risks by maximum likelihood and modified minimum Chi-square methods. Theory of independent and dependent risks. Bivariate normal dependent risk model. Conditional death density functions. Stochastic epidemic models: Simple and general epidemic models (by use of random variable technique).	**(10L+2T) Hrs**

REFERENCES

1. Biswas, S. (1995). Applied Stochastic Processes. A Biostatistical and Population Oriented Approach, Wiley Eastern Ltd.
2. Collett, D. (2003). Modelling Survival Data in Medical Research, Chapman & Hall/CRC.
3. Cox, D.R. and Oakes, D. (1984). Analysis of Survival Data, Chapman and Hall.
4. Elandt Johnson R.C. (1971). Probability Models and Statistical Methods in Genetics, John Wiley & Sons.
5. Ewens, W. J. (1979). Mathematics of Population Genetics, Springer Verlag.
6. Ewens, W. J. and Grant, G.R. (2001). Statistical methods in Bio informatics: An Introduction, Springer.
7. Friedman, L.M., Furburg, C. and DeMets, D.L. (1998). Fundamentals of Clinical Trials, Springer Verlag.
8. Gross, A. J. And Clark V.A. (1975). Survival Distribution; Reliability Applications in Biomedical Sciences, John Wiley & Sons.
9. Indrayan, A. (2008). Medical Biostatistics, Second Edition, Chapman & Hall/CRC.
10. Lee, Elisa, T. (1992). Statistical Methods for Survival Data Analysis, John Wiley & Sons.
11. Li, C.C. (1976). First Course of Population Genetics, Boxwood Press.
12. Miller, R.G. (1981). Survival Analysis, John Wiley & Sons.
13. Robert F. Woolson (1987). Statistical Methods for the analysis of biomedical data, John Wiley & Sons.

BLUEPRINT
Code number: STDE0323
Title of the paper: Biostatistics

Total marks for which the questions are to be asked (including bonus questions)	Number of hours	Chapter/Unit number
20	15	I
17	13	II
16	12	III
16	12	IV
70	**52**	**TOTAL**

Maximum marks for the paper (Including bonus question): **70**

Course Articulation Matrix
Mapping of course outcomes (Cos) To Programme Outcomes (POs 1 to 8)
Code number: STDE 0323
Title of the paper: Biostatistics

COs:	**POs**								**BTL**
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PO- 7**	**PO- 8**	
Course Title: **Statistical Computing**	*						*		
CO1: Understand survival models, censoring, and parametric tests for survival data.		*	*					*	Understand
CO2: Apply life table, Kaplan–Meier, and Nelson–Aalen methods in real life situations.	*	*	*			*		*	Apply

CO3: Analyze epidemiologic and clinical data using study designs and Cox models.	*	*	*		*	*		*	Analyze
CO4: Evaluate sample size needs and diagnostic accuracy measures.	*	*	*			*	*	*	Evaluate
CO5: Apply competing risk models and stochastic epidemic models.	*	*	*	*		*		*	Analyze

FOURTH SEMESTER

STDE 0420: SURVIVAL ANALYSIS (Elective -II)

Semester	Fourth
Paper Code	STDE 0420
Paper Title	Survival Analysis
Number of teaching hrs per Week	4
Total number of hrs per semester	52
Number of Credits	4

COURSE OBJECTIVES

1. Understand survival models, censoring, and parametric tests for survival data.
2. Apply life table, Kaplan–Meier, and Nelson–Aalen methods in real life situations.
3. Analyze parametric survival models including accelerated life models.
4. Apply and interpret Cox proportional hazards regression with covariates.
5. Evaluate competing risk models and cumulative hazard measures.

Unit-1	**Total Hrs**
Complete and censored samples, Type I, Type II, and random censoring, Survival function, Failure rate, mean residual life and their elementary properties. Life time distributions - Exponential, Gamma, Weibull, Lognormal, Pareto, Proportional Hazards family. Estimation of parameters of exponential and gamma distributions under various censoring situations.	**(13L+3T) Hrs**
Unit-2	
Life tables: Standard methods for uncensored and censored data; Estimation of survival function – Actuarial Estimator, Kaplan Meier Estimator, Greenwood's formula. Properties of Kaplan Meier Estimator- Self consistency, Generalized MLE, Statement of Asymptotic properties of KM estimators, Nelson-Aalen estimator, treatment of ties (Peto's method)	**(10L + 3T) Hrs**
Unit-3	
Fully parametric analysis of dependency – accelerated life model – simple form, log logistic accelerated life model, proportional hazards model – relation with accelerated life model.	**(8L+2T) Hrs**
Unit-4	
Semi-parametric regression for failure rate – Cox's proportional hazards model with one and several covariates, log likelihood function, log linear hazards, test for regression coefficients, Discrete failure time: ties. Competing risk models-Estimation of cumulative hazard function.	**(10L+3T) Hrs**

REFERENCES

1. Cox D.R. and Oakes D. (1984). Analysis of Survival Data, Chapman and Hall, New York.
2. Kalbfeisch J.D. and Prentice R.L. (2002). The Statistical Analysis of Failure Time Data, John Wiley& Sons, Inc. 2nd Edition.
3. Lawless J.F. (2002). Statistical Models and Methods for Lifetime Data, John Wiley & Sons, Inc.
4. Miller R.G. (1981). Survival Analysis, John Wiley& Sons, Inc.
5. Nelson. B. (2003). Applied life Data Analysis, Wiley Series.

6. Deshpande, J.V., Purohit, S.G. (2006). Life time data: Statistical Models and Methods, World Scientific.

BLUEPRINT
Code number: STDE0420
Title of the paper: Survival Analysis

Total marks for which the questions are to be asked (including bonus questions)	Number of hours	Chapter/Unit number
22	16	I
17	13	II
13	10	III
18	13	IV
70	**52**	**TOTAL**

Maximum marks for the paper (Including bonus question): **70**

Course Articulation Matrix
Mapping of course outcomes (Cos) To Programme Outcomes (POs 1 to 8)
Code number: STDE 0420
Title of the paper: Survival Analysis

COs: At the end of the Course, the student will be able to	**POs**								**BTL**
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO- 6**	**PO-7**	**PO-8**	
Course Title: **Survival Analysis**									
CO1: Understand survival models, censoring, and parametric tests for survival data.	*						*	*	Understand
CO2: Apply life table, Kaplan–Meier, and Nelson–Aalen methods in real life situations.		*	*					*	Apply
CO3: Analyze parametric survival models including accelerated life models.	*	*					*	*	Analyze
CO4: Apply and interpret Cox proportional hazards regression with covariates.		*	*	*	*	*		*	Apply
CO5: Evaluate competing risk models and cumulative hazard measures.	*	*		*		*	*	*	Evaluate

FOURTH SEMESTER

STDE 0520: Time Series Analysis (ELECTIVE – III)

Semester	Fourth
Paper Code	STDE 0520
Paper Title	Time Series Analysis
Number of teaching hrs per week	4
Total number of teaching hrs per semester	52
Number of credits	4

COURSE OBJECTIVES

1. To Understand the concept of time series and its components.
2. To Understand the bases of different models of time series analysis including decomposition.
3. To learn proper model identification and its estimation.
4. To learn and apply different forecasting methods with the least forecasting error.

Unit 1	Total Hrs
Exploratory Time Series Analysis, test for randomness, Tests for trend and seasonality. Estimation of trend by moving average, estimation of seasonal effect for additive and multiplicative models, de-seasonalising and detrending an observed time series.	(6L+1T) hrs
Unit 2	
Time-series (t.s) as discrete parameter stochastic process, definition of strict and weak stationarity of a t.s., Gaussian t.s., ergodicity, autocovariance and autocorrelation functions (ACF) and their properties, partial autocorrelation function (PACF). General linear processes (G.L.P), autocovariance generating function, stationarity and invertibility conditions of a G.L.P; autoregressive processes (AR(p)), stationarity condition, ACF, PACF, Yule-Walker equations, Moving average (MA(q)) processes, Invertibility condition, ACF, PACF, duality between AR(p) and MA(q) processes; ARMA(p,q) processes, stationarity, invertibility, ACF, PACF, particular cases of these processes.	(16L+3T) hrs
Unit 3	
Linear Non-stationary time Series models: ARIMA(p,d,q) processes, general form, three explicit forms, IMA(0,1,1) process, seasonal ARIMA processes. Forecasting: minimum mean square error forecast, BLUP, three basic forms for the forecast, forecast error and its properties, examples; forecasting through exponential and Holt-Winter smoothing.	(11L+2T) hrs
Unit 4	
Estimation: sample ACF, sample PACF, fitting AR(p), MA(q), ARMA(p,q) models; model identification: determination of p, d, q: method of differencing, unit root test, using sampleACF, sample PACF, Bartlett and Anderson bounds; diagnostics: residual analysis, Box-Pierce portmanteau statistic, Ljung-Box test; AIC and BIC criteria.	(11L+2T) hrs

REFERENCES

1. Anderson, T. W. (1971). *The Statistical Analysis of Time Series,* Wiley, New York.
2. Box, G. E. P, Jenkins, G. M, Reinsel, G. C. and Ljung, G. M. (2015). *Time Series Analysis - Forecasting and Control*, 5/e, Wiley.
3. Brockwell, P. J. and Davis, R. A. (2002). *Introduction to Time Series and Forecasting*, 2/e, Indian Print, Springer, New Delhi.
4. Brockwell, P. J. and Davis, R. A. (1991). *Time Series: Theory and Methods*, 2/e, Springer, New York
5. Chatfield, C. (1996). *The Analysis of Time Series: Theory and Practice*, 5/e, Chapman and Hall, London.
6. Chatfield, C. (2003). *Analysis of Time Series: An Introduction*, CRC Press, New Delhi.
7. Montgemory, D. C. and Johnson, L. A. (1977). *Forecasting and Time Series Analysis*, McGrawHill, New York.

BLUEPRINT
Code number: STDE 0520
Title of the paper: Time Series Analysis

Total marks for which the questions are to be asked (including bonus questions)	Number of hours	Chapter/Unit number
9	07	I
26	19	II
18	13	III
17	13	IV
70	**52**	**TOTAL**
Maximum marks for the paper (Including bonus question):**70**		

Course Articulation Matrix
Mapping of course outcomes (Cos) To Programme Outcomes (POs 1 to 8)
Code number: STDE 0520
Title of the paper: Time Series Analysis

COs:	POs								BTL
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	
Time series Analysis									
CO1: the fundamental concepts, components, and models of time series, including stationarity, autocorrelation, and seasonal adjustment methods.	*	*					*	*	Understand

(Understand).									
CO2: Apply exploratory and diagnostic techniques to identify trends, seasonality, and stationarity in time series data, and perform transformations such as differencing and smoothing. (Apply).	*	*	*				*	*	Analyze
CO3: compare* different time series models (AR, MA, ARMA, ARIMA, GARCH) based on their properties, stationarity conditions, and suitability for given datasets. (Analyze).	*	*	*			*	*	*	Apply
CO4: Evaluate model adequacy using diagnostic tools such as residual analysis, Ljung-Box test, AIC, BIC, and forecast accuracy measures. (Apply / Analyze).	*	*	*			*	*	*	Analyze
CO5: Design and construct appropriate time series models for forecasting and analysis, incorporating advanced concepts such as seasonal ARIMA and volatility modeling (ARCH/GARCH). (Create).	*	*	*		*	*	*	*	Evaluate

FOURTH SEMESTER

STDE 0620: Actuarial Statistics (ELECTIVE – III)

Semester	Fourth
Paper Code	STDE 0620
Paper Title	Actuarial Statistics
Number of teaching hrs per week	4
Total number of teaching hrs per semester	52
Number of credits	4

COURSE OBJECTIVES

1. To understand how actuarial science is used in finance, investments, banking and insurance.
2. To understand the statistical behaviour of actuarial indicators.
3. To solve the problems related to the benefit amounts in insurance, annuities, premiums and reserves.
4. To apply mathematical and statistical methods to assess risk in insurance, finance and other industries and professions.

Unit 1	**Total Hrs**
Utility theory, insurance and utility theory, models for individual claims and their sums, survival function, curtate future lifetime, force of mortality. Life table and its relation with survival function, examples, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables.	**(10L+2T) hrs**
Unit 2	
Multiple life functions, joint life and last survivor status, insurance and annuity benefits through multiple life functions evaluation for special mortality laws. Multiple decrement models, deterministic and random survivorship groups, associated single decrement tables, central rates of multiple decrements, net single premiums and their numerical evaluations. Distribution of aggregate claims, compound Poisson distribution and its applications.	**(10L+2T) hrs**
Unit 3	
Principles of compound interest. Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding. Life insurance: Insurance payable at the moment of death and at the end of the year of death-level benefit insurance, endowment insurance, deferred insurance and varying benefit insurance, recursions, commutation functions. Life annuities: Single payment, continuous life annuities, discrete life annuities, life annuities with monthly payments, commutation functions, varying annuities, recursions, complete annuities-immediate and apportionable annuities-due.	**(12L+2T) hrs**
Unit 4	

Net premiums: Continuous and discrete premiums, true monthly payment premiums, apportionable premiums, commutation functions, accumulation type benefits. Payment premiums, apportionable premiums, commutation functions, accumulation type benefits. Net premium reserves: Continuous and discrete net premium reserve, reserves on a semicontinuous basis, reserves based on true monthly premiums, reserves on an apportionable or discounted continuous basis, reserves at fractional durations, allocations of loss to policy years, recursive formulas and differential equations for reserves, commutation functions. Some practical considerations: Premiums that include expenses-general expenses types of expenses, per policy expenses. Claim amount distributions, approximating the individual model, stop-loss insurance.	**(12L+2T) hrs**

REFERENCES

1. Atkinson, M.E. and Dickson, D.C.M. (2000). An Introduction to Actuarial Studies, Elgar Publishing.
2. Bedford, T. and Cooke, R. (2001). Probabilistic risk analysis, Cambridge.
3. Bowers, N. L., Gerber, H. U., Hickman, J. C., Jones D.A. and Nesbitt, C. J. (1986). 'Actuarial Mathematics', Society of Actuaries, Ithaca, Illinois, U.S.A., Second Edition (1997).
4. Medina, P. K. and Merino, S. (2003). A discrete introduction: Mathematical finance and Probability, Birkhauser.
5. Philip, M. et. al (1999). Modern Actuarial Theory and Practice, Chapman and Hall.
6. Rolski, T., Schmidli, H., Schmidt, V. and Teugels, J. (1998). Stochastic Processes for Insurance and Finance, Wiley.
7. Spurgeon, E.T. (1972). Life Contingencies, Cambridge University Press.

BLUEPRINT

Code number: STDE 0620

Title of the paper: Actuarial Statistics

Total marks for which the questions are to be asked (including bonus questions)	**Number of hours**	**Chapter/Unit number**
16	12	I
16	12	II
19	14	III
19	14	IV
70	**52**	**TOTAL**

Maximum marks for the paper (Including bonus question):**70**

Course Articulation Matrix

Mapping of course outcomes (Cos) To Programme Outcomes (POs 1 to 8)

Code number: STDE 0620
Title of the paper: Actuarial Statistics (ELECTIVE - III)

COs:	POs								BTL
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	
Actuarial Statistics									
CO1: Understand the principles of utility theory and apply probability models to individual and aggregate claims, incorporating survival functions and life tables. (Understand).	*	*					*		Understand
CO2: Evaluate insurance and annuity benefits for multiple life statuses and multiple decrement models using associated single decrement tables and central rates. (Apply).		*	*				*		Analyze
CO3: Apply the mathematical principles of compound interest and commutation functions to calculate present and accumulated values for various life insurance and annuity contracts. (Analyze).	*		*					*	Apply
CO4: Calculate net premiums and net premium reserves for various models, utilizing recursive formulas and commutation functions. (Apply / Analyze).		*	*					*	Analyze
CO5: Synthesize practical considerations such as expense-loaded premiums, claim distributions, and stop-loss insurance into actuarial models for policy pricing and reserving. (Create).			*	*		*		*	Evaluate

FOURTH SEMESTER

ST 0P1: Practical V II (based on ST 0120, STDE 0320/STDE 0420 and STDE 0520/STDE 0620)

Semester	Fourth
Paper Code	ST 0P1
Paper Title	Practical VII (based on ST 0123, STDE 0320/STDE 0420 and STDE 0520/STDE 0620)
Number of teaching hrs per week	4
Total number of teaching hrs per semester	44
Number of credits	2

List of Assignments

ST 0123: Advanced Statistical Inference
STDE 0320/STDE0420: Biostatistics/Survival analysis
STDE 0520/STDE 0620: Time series analysis/Actuarial Statistics

1. CAN estimators
2. Quenouille's and Jackknife estimation
3. Bayes estimators.
4. Minimax rule.
5. One and Paired sample tests: Wilcoxon signed - rank test and KS one sample goodness of fit test.
6. Two sample tests: Two sample run: Kolmogorov Smirnov two sample, Wilcoxon Mann Whitney
7. Life time distributions
8. Actuarial and Kaplan Meier Estimator
9. Estimation and elimination of trend and seasonal components /Future lifetime random variable and related measures
10. Examining Stationarity using sample ACF and PACF/ Computation of various measures using Gompertz and Makeham's Model.
11. Fitting MA and AR model/Cox proportional Hazard models

FOURTH SEMESTER

ST 0P2: Practical VIII (based on ST0220)

Semester	Fourth
Paper Code	ST 0P2
Paper Title	Practical VIII (based on ST0220)
Number of teaching hrs per week	4
Total number of teaching hrs per semester	44
Number of credits	2

List of Assignments

ST 0220: Design and Analysis of Experiments

1. Two -way ANOVA
2. Analysis of BIBD
3. Analysis of PBIBD
4. Analysis of Youden square design
5. Missing Plot Techniques for RBD and LSD
6. Analysis of Covariance for CRD
7. Analysis of Covariance for RBD
8. Analysis of 2^3 factorial experiments
9. Analysis of 3^2 factorial experiments
10. Confounding in 2^3 factorial experiments
11. Confounding in 3^2 factorial experiments