KANNUR UNIVERSITY

(Abstract)

M Sc Statistics Programme in the Department of Statistical Sciences, Mangattuparamba Campus - Revised Scheme (Distribution of credits of Four semesters) & Syllabus (1st Semester Only) - Approved- Implemented w.e f 2023 admission- Orders Issued

---

ACADEMIC C SECTION

ACAD C/ACAD C3/22131/2023 Dated: 06.11.2023

Read:-1. UO No ACAD C/ ACAD C3/22373/2019 dated 12/09/2023
2. Circular No dated ACAD C/ ACAD C3/22373/2019 dated 12/09/2023
3. Email dated 05/10/2023 from the Head, Dept of Statistical Sciences, Mangattuparamba Campus
4. Minutes of the meeting of the Department Council dated 18/09/2023

ORDER

1. The revised Regulations for Post Graduate Programmes under Choice Based Credit and Semester System in the University Teaching Departments/ Schools were implemented w.e.f 2023 admissions vide paper read 1 above

2. As per paper read 2 above, Heads of all Teaching Departments were requested to submit the revised Syllabus in accordance with the approved Regulations along with a copy of the Department Council Minutes.

3. As per paper read 3 above, the Head, Department of Statistical Sciences Mangattuparamba Campus submitted the scheme (Distribution of credits of Four Semesters) and the Syllabus (1st Semester Only) of M.Sc Statistics Programme to be implemented in the University Teaching Department w.e.f 2023 admissions.

4. Department Council vide the paper read 4 above approved the aforementioned scheme and syllabus of M.Sc Statistics programme to be implemented in the Dept. of Statistical science of the University w.e.f.2023 admission.

5. The Vice Chancellor, after considering the matter in detail and in exercise of the powers of the Academic Council conferred under section 11(1), Chapter III of Kannur University Act 1996, ***approved the Scheme (Distribution of credits of Four Semesters) & Syllabus (1st Semester Only) of M.Sc Statistics Programme and accorded sanction to implement the same in the Department of Statistical Sciences, Mangattuparamba Campus w.e.f 2023 admissions, subject to reporting to the Academic Council***

6.The Scheme (Credit distribution of Four Semesters) and Syllabus (1st Semester Only) of M.Sc Statistics Programme under CBCSS implemented in the Department of Statistical Sciences, Mangattuparamba Campus with effect from 2023 admission, is appended and uploaded in the University website (www.kannuruniversity.ac.in)

7. Orders are issued accordingly.

Sd/-
Narayanadas K
DEPUTY REGISTRAR (ACAD)
For REGISTRAR

To: 1. Head, Department of Statistical Sciences, Mangattuparamba Campus
2. Convenor, Curriculum Committee

Copy To: 1.PS to VC/ PA to PVC/ PA to R
2. To Examination Branch (through PA to CE)
3. EP IV/ EXC I
4. Computer Programmer
5. Webmanager (to publish in the website)
6. SF/DF/FC

Forwarded / By Order

SECTION OFFICER

KANNUR UNIVERSITY

(Abstract)

M. Sc Statistics Programme in the Dept of Statistical Sciences , Mangattuparamba Campus of Kannur University - Scheme & Syllabus of II, III & IV Semesters - Approved - Implemented w. e. f 2023 admission - Orders Issued.

ACADEMIC C SECTION

ACAD C/ACAD C3/22131/2023 Dated: 27.05.2024

Read:-1. UOs No. ACAD C3/22373/2019 dated 12/09/2023 , 08/11/2023 &016/02/2024

2. U.O of even number dated 06/11/2023

3. Circulars No ACAD C/ACAD C3/22373/2019 dated 01/02/2024 & 12/03/2024

4. Email dated 07/05/2024 from the Head, Dept. of Statistical sciences, Mangattuparamba Campus

5. Minutes of the meeting of the Department Council dated 22/04/2024

ORDER

1. The revised Regulations for PG Programmes under CBCSS in the University Teaching Depts/ Schools were implemented w. e. f 2023 admissions vide paper read (1) above.

2. As per paper read (2) above, Revised Scheme (Credit Distribution of Courses) & Syllabus (I Semester only) of M. Sc Statistics Programme was approved and implemented in the Dept. of Statistical Sciences, Mangattuparamba Campus w. e. f. 2023 admission.

3. As per paper read (3) above, Heads of all Teaching Depts who have not submitted the syllabi in full, were requested to submit the syllabi of the remaining semesters in accordance with the approved Regulations and along with the copy of the Dept. Council Minutes.

4. As per paper read (4) above, the Head, Dept of Statistical Sciences submitted the Scheme & Syllabus (II, III & IV Semesters) of M. Sc Statistics Programme to be implemented in the University Teaching Depts w. e. f 2023 admission.

5. Dept Council vide paper read (5) above, approved the aforementioned syllabus of M. Sc Statistics Programme to be implemented in the Dept of Statistical Sciences w. e. f 2023 admission.

6. The Vice Chancellor, after considering the matter in detail, and in exercise of the powers of the Academic Council conferred under Section 11(1) , Chapter III of Kannur University Act 1996, approved the scheme & syllabus of M. Sc Statistics Programme (II, III & IV Semesters) and accorded sanction to implement the same in the Dept of Statistical Sciences, Mangattuparamba

Campus w. e. f 2023 admission, subject to report to the Academic Council.

7. Scheme & Syllabus (I, II, III & IV Semesters) of M. Sc Statistics Programme under CBCSS, implemented in the Dept of Statistical Sciences, Mangattuparamba Campus w. e. f 2023 admission, is appended and uploaded in the University website (www.kannuruniversity.ac.in).

8. Orders are issued accordingly.

Sd/-

Narayanadas K

DEPUTY REGISTRAR (ACAD)

For REGISTRAR

To: 1. Head, Dept of Statistical Sciences, Mangattuparamba Campus
2. Convenor, Curriculum Committee

Copy To: 1. PS to VC/ PA to R
2. PA to CE (to circulate among the sections of the Examination Branch concerned)
3. EP IV/ EX C 1
4. Computer Programmer
5. Webmanager (to publish in the website)
6. SF/DF/FC

Forwarded / By Order

SECTION OFFICER

KANNUR UNIVERSITY

M.Sc. STATISTICS

SCHEME & SYLLABUS

(*Under Choice Based Credit & Semester System)*

2023 admission onwards

DEPARTMENT OF STATISTICAL SCIENCES

Mangattuparamba Campus

KANNUR UNIVERSITY

Post Graduate Programme in Statistics

M.Sc. Statistics programme is a two-year programme divided into four semesters. A student is required to complete 80 credits for the completion of programme and the award of degree.

DURATION: 2 Years (4 semesters)

INTAKE: **25**

OBJECTIVES OF THE COURSE:

1. To encourage and motivate the experimental scientists to use the modern methods of statistics and computing facilities.
2. To establish advanced facilities and promote research and technology development to solve statistical issues and problems.
3. To promote statistical and probabilistic reasoning and use of sound statistical practice avoiding superstitious beliefs.
4. To establish good networking of academic collaboration with national and international organizations, institutions, industries and exchange of faculty and students.
5. To offer statistical information, education and communication services.
6. The course contents will be abreast with the latest development in the area of study. The students have to do a full time institutional or industrial training/ project work for three months, enabling them to have valuable hands-on experience. The theory, practical, project work and training activities of this program prepare the student to acquire knowledge, skills and expertise on specified subjects along with the integrated knowledge of all relevant disciplines.

ELIGIBILITIES:

Candidates who have studied B.Sc. Statistics with minimum of 50% marks or equivalent grade in core course or B.Sc. Mathematics with Statistics as complementary course with 50% marks or equivalent grade in complementary (Statistics) course. The minimum requirement for admission to a Post Graduate Program shall be Grade C or overall CGPA 1.5 under CCSS /Grade C+ or CGPA 2 in Part III under grading system subject to satisfying other eligibility criteria prescribed for postgraduate program of the Kannur University.

ADMISSION:

- The selection of the candidate is mainly based on the marks secured in the Degree Course/Admission test.
- The admission test will cover statistics and mathematics at the undergraduate level.

Relaxation & Weightage

- SC/ST Category: minimum pass marks in the relevant subjects or part of subjects is required for admission to PG Degree program..
- OEC/OBC Category: a relaxation of 5% of marks in the qualifying examination from the prescribed minimum is allowed.

COURSE DETAILS:

A student must register for the required number of courses at the beginning of each semester. No students shall register for more than 28 credits and less than 16 credits per semester.

A total of 80 credits shall be the minimum for successful completion of the course in which a minimum of 50% of credits have to be earned from Discipline Specific Courses including dissertation for any programme. Those who secure only minimum credit for core/ elective subjects has to supplement the deficiency for obtaining the minimum total credits required for successful completion of the program from the other divisions.

EVALUATION:

The faculty member who teaches the course shall do evaluation of the students for each course on the basis of Continuous Evaluation and End Semester Examination shall be evaluated by

External Examiners. The proportion of the distribution of marks among the continuous evaluation and end semester examination shall be **40:60**.

Continuous Evaluation includes assignments, seminars, written examination and viva voce for each course. Weightage to the components of continuous evaluation shall be given for all theory papers of the course as follows:

Components of CE	**Minimum Number**	**Weightage**	**Grade Points**	**Practical Weightage**	**Grade Points**
Test paper	2	40	16	80	-
Assignments	1	20	08	--	--
Seminar presentation, Viva Voce, Discussion, Debate etc.	1	40	16		--
Record	--	--	--	20	-

Test Paper: For each course there shall be at least two class tests during a semester.

Assignments: Each student shall be required to do one assignment for each course.

Seminar: Students are required to present a seminar on a selected topic in each paper. The evaluation of the seminar shall be done by the concerned teacher handling the course.

Viva Voce – End semester theory Viva Voce examination will be conducted for each paper before the commencement of public examination.

Attendance: Minimum attendance required for each paper shall be 75% of the total number of classes conducted for that semester. Those who secured the minimum requirement of attendance only be allowed to register/appear for End Semester Examination.

Condonation of attendance to a maximum of 10 days in a semester subject to a maximum of two times during the whole period of the PG program may be granted by the university as per university rules.

Conduct of Examination:

The vice chancellor will approve the panel of examiners submitted by the Head of the

Department. All the teachers of the Department will be the members of the Board of examiners with Head of the Department as the Chairperson. There shall be a minimum of two external examiners. The panel approved by the Vice-Chancellor will be entrusted with the setting of question papers, conduct and evaluation of examination.

Research Project:

The students have to complete a research project during IV Semester in collaboration with any of the authorized research institutions located within or outside the state or within their own Department.

KANNUR UNIVERSITY

DEPARTMENT OF STATISTICAL SCIENCES

VISION

Motivated by optimism and responsibility, the vision is to develop an exemplary centre for studies, practice and research in Statistics which will be beneficial to the stakeholders and the society.

MISSION

To develop an excellent centre of quality teaching and research in Statistics

To develop an international centre for advanced statistical computing and data analysis.

PROGRAMME OUTCOMES

PO 1 : **Critical Thinking:** Take informed actions after identifying the assumptions that frame our thinking and actions, checking out the degree to which these assumptions are accurate and valid, and looking at our ideas and decisions (intellectual, organizational, and personal) from different perspectives.

PO2 : **Problem Solving:** Identify, formulate, conduct investigations, and find solutions to problems based on in-depth knowledge of relevant domains.

PO 3 : **Communication:** Speak, read, write and listen clearly in person and through electronic media in English/language of the discipline, and make meaning of the world by connecting people, ideas, books, media and technology.

PO 4 : **Responsible Citizenship:** Demonstrate empathetic social concern, and the ability to act with an informed awareness of issues.

PO 5 : **Ethics**: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them.

PO 6 : **Self-directed and Life-long Learning:** Acquire the ability to engage in independent and life-long learning in the broadest context socio- technological changes.

PROGRAMME SPECIFIC OUTCOME

PSO 1: Expertise in the field of Statistical theory and its practical applications.

PSO 2: Expertise to take up responsibilities as efficient Statisticians/Statistical Officers/Research Officers/ Statistical Analytics.

PSO 3: Expertise on techniques of statistics and in the field of data analysis.

PSO 4: Make Awareness on recent trends in Statistical theory and applications.

PSO 5: Utilize statistical methods and tools to analyze data sets, draw meaningful conclusions, and make informed decisions based on Statistical inferences.

PSO6: Demonstrate proficiency in using statistical software such as R and SPSS, to perform statistical computations, visualize data, and facilitate Statistical analysis.

COURSE OUTCOME

CO1 : Demonstrate an in-depth understanding of advanced mathematical concepts, including advanced calculus, linear algebra, complex analysis, differential equations, and discrete mathematics.

CO 2 : Apply rigorous proof techniques to establish mathematical results, including theorems, lemmas, and propositions, and communicate mathematical arguments effectively.

CO 3 : Formulate mathematical models for real-world problems, analyze their properties, and interpret the results in the context of the original problem.

CO 4 : Apply numerical techniques and algorithms to approximate solutions of mathematical problems, analyze their accuracy, convergence, and stability.

CO 5 : Develop research skills, including literature review, problem formulation, data collection, experimental design, and statistical analysis, to conduct independent mathematical research.

Distribution of Grades for the M.Sc. Statistics Programme with effect from 2023-24 Onwards									
	1	2	3	4	5	6	7	8	Total Credits
	Discipline Specific		Electives						
Semester	Core Courses (DSC)	Electives(DSE)	Interdisciplinary/ Multidisciplinary Elective	AEC 2 Credits	SEC (SEC) 2Credits	VAC /MOOC 2Credits	Internship /Field Visit /Minor Project /Institutional /Industrial Visit 2Credits	Dissertation / Major Project	
1	MSSTA01DSC01 MSSTA01DSC02 MSSTA01DSC03 MSSTA01DSC04	**Pool A** MSSTA01DSE01 to 02 (any 1)							
	4 Credit x 4 =16 Credits	**3 Credits**							**19**
2	MSSTA02DSC05 MSSTA02DSC06 MSSTA02DSC07 MSSTA02DSC08	**Pool B** MSSTA02DSE03 to 04 (any 1)		**Pool C**	**Pool D**				**23**
	4 Credit x 4 =16 Credits	**3 Credits**		**2 Credits**	**2Credits**				
3	MSSTA03DSC09 MSSTA03DSC10	**Pool E** MSSTA03DSE05 to 06 (any 1) **Pool F** MSSTA03DSE07 to 13 (any 2)	**Pool G** To be obtained from other Departments			VAC/MOOC			**23**
	4 Credit x 2 = 8 Credits	**3 Credit x 3= 9 Credits**	**4 Credits Each**			**2* Credits**	**2Credits**		
		Pool H MSSTA04DSE14 to 15(any 1) **Pool I** MSSTA04DSE16 to 20 (any 2)						MSSTA04 DSC11	**20**
		4 Credit x 3 =12 Credits						**8 Credits**	
	Total Credit for M.Sc. Statistics Programme								**85**

*Credits for VAC/MOOC are over and above the credit requirement.

	FIRST SEMESTER								
Sl No	Course Code	Title of Paper	Contact Hours/Week			Marks			
			L	T/S	P	ESE	CE	Total	Credits
DISCIPLINE SPECIFIC CORE COURSES (DCE)									
1.1	MSSTA01DSC01	Measure and Probability	4	1		60	40	100	4
1.2	MSSTA01DSC02	Mathematical Methods for Statistics	4	2		60	40	100	4
1.3	MSSTA01DSC03	Distribution Theory	4	1		60	40	100	4
1.4	MSSTA01DSC04	Sampling Theory	4	2		60	40	100	4
DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE)									
1.5	MSSTA01DSExx	One course has to be chosen from **Pool A**		2	6	60	40	100	3
Total			**16**	**8**	**6**	**300**	**200**	**500**	**19**

L=Lecture, T/S=Tutorials/Seminar, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

Sl No	POOL A:- List of Courses for Elective –I DISCIPLINE SPECIFIC ELECTIVES (DSE)								
1.5.1	MSSTA01DSE01	Statistical Computing Using R (**Practical**)		2	6	60	40	100	3
1.5.2	MSSTA01DSE02	Statistical Computing Using SPSS (**Practical**)		2	6	60	40	100	3

FIRST SEMESTER M.Sc. STATISTICS PROGRAMME

DISCIPLINE SPECIFIC CORE COURSES

Course Code & Title	**MSSTA01DSC01-MEASURE AND PROBABILITY**	
Programme	**M.Sc. Statistics**	**Semester I**
Course Description	This course is intended to provide the foundations necessary for a Statistics student. Mathematical concepts like elementary measure theory and probability are included. The development of modern probability theory through the measure theoretic approach is portrayed in this course.	
Course Objectives	The Course aims • To introduce students the inter-link between measure and probability. • Understand the concepts of measure and probability and properties. • Understand convergence of sequence of sets, sequence of measurable functions and sequence of integrals. • Understand convergence of sequence of random variables. • Understand the inequalities involving moments.	

Modules	Content	Module Outcome
Module I: Measure and Measurable Function **(15 Hours)**	Class of sets, limits of sequence of sets, fields and σ-fields, minimal σ-fields and Borel field, Measurable space, measure, measure space, Lebesgue measure and counting measure, measurable functions and their properties. Limit of a sequence of measurable functions, simple functions, non-negative measurable functions, limit of simple functions.	• Recall the fundamentals of the measure theory. • Understand the characteristics and properties of measurable functions. • Limits of simple functions
Module II: Integral and	Integral of a simple function, integral of a measurable function, integral of real valued	• Understand the integral of simple function and

Convergence of Sequence of Integrals **(15 Hours)**	function, positivity and linearity of integral, Limit of a sequence of integrals of measurable functions, The monotone convergence theorem, Fatou's lemma. Bounded convergence theorem, Lebesgue dominated convergence theorem.	measurable function. • State and prove monotone convergence theorem. • State and prove Fatou's lemma • State and prove Lebesgue dominated convergence theorem.
Module III: Probability Measure and Random Variables **(15 Hours)**	Axiomatic approach to probability, probability space, conditional probability space, independence of events and sigma fields, Bayes theorem. Real and vector valued random variables, distribution function, density function and properties, expectation of a random variable and properties. Sequence of random variables and different modes of convergence: in probability, in distribution, in r^{th} mean and almost sure, their mutual implications.	• Understand axiomatic approach of probability • State and prove Bayes theorem. • Articulate random variables, density function and its properties. • Explain different modes of convergence. • Explain their mutual implications.
Module IV: Expectation and Inequalities **(15 Hours)**	Expectation of a function of random variable as Riemann- Stieltjes integral, moments of a random variable. Inequalities involving moments, Cr-inequality, Jenson's inequality, basic inequality, Markov inequality and their applications.	• Explain moments of random variables. • Articulate inequalities involving moments. • Markov inequality and its applications

References	***Text Books*** 1. Bhat, B.R. (2004). *Modern Probability Theory*, New Age Publishers, New Delhi. 2. Robert G. Bartle (1995). *The Elements of Integration and Lebesgue Measure***.** John Wiley &Sons, New York. **Reference Books** 1. Basu, A. K. (1999). *Measure Theory and Probability*, Prentice-Hall. 2. Billingsley, P. (1986). *Probability and Measure, Second Edition*, John Wiley. 3. Parthasarathy, K. R. (2005). *Introduction to Probability and Measure***,** Hindustan Book Agency. 4. Royden, H. L. (1988). *Real Analysis, Third Edition,* McMillain Publishing Company, New-York.
Course Outcomes	After successful completion of this course, student will be able to: 1. Understand the concepts of measure and probability and properties. 2. Understand convergence of sequence of sets, sequence of measurable functions and sequence of integrals. 3. Understand convergence of sequence of random variables. 4. Understand the inequalities involving moments.

TEACHING LEARNING STRATEGIES

- **Lecturing, Visualization, Team Learning**

MODE OF TRANSACTION

- **Lecture, Seminar, Discussion, Questioning and Answering**

ASSESSMENT RUBRICS

Components	Weightage
End Semester Evaluation	**60**
Continuous Evaluation	
Tests	16
Assignment	08
Seminar/viva	16
Total	**40**

Sample Questions to Test Outcomes:

1. Define limit of sequence of sets. Give an example of a sequence of sets for which limit does not exist.
2. Define a sigma field. Show that the intersection of arbitrary number of sigma fields is a sigma field and union of arbitrary number of sigma fields need not be a sigma field.
3. What do you mean by an indicator or characteristic function of a set? Show that indicator function of a measurable set is measurable.
4. State and prove Cauchy-Schwarz inequality.
5. State and prove dominated convergence theorem.
6. Show that the set of discontinuity points of a distribution function is at most countable.

DISCIPLINE SPECIFIC CORE COURSE

Course Code & Title	**MSSTA01DSC02 – MATHEMATICAL METHODS FOR STATISTICS**	
Programme	**M.Sc. Statistics**	**Semester I**
Course Description	This course is intended to provide the basic mathematical foundations necessary for a Statistics student. Expertise in mathematical analysis and linear algebra are inevitable for a statistics student and this course offer such an avenue. Concepts in advanced calculus and linear algebra are also included.	

Course Objectives	• To get a clear understanding of Metric space, compact set, perfect set. • To learn the mean value theorem and its implications. • Describe the properties of Riemann- Stieltjes integral. • Explain the concept of sequence and series of real numbers. • Explain improper integrals, beta and gamma functions. • State Taylor's theorem with applications. • State and prove Cayley-Hamilton theorem. • Establish the relation between algebraic and geometric multiplicity. • To achieve ideas on quadratic forms and reduction of quadratic forms and gets ability for solving problems in these areas. • Define Moore-Penrose g-inverse and derive its properties.

Modules	Content	Module Outcome
Module I: Limit and Continuity of Functions (**15 hours**)	Metric spaces, compact set, perfect set, connected set. Limit of functions, continuous function, continuity and compactness, continuity and connectedness, discontinuities. Monotone functions, derivative of a real valued function, mean value theorem. Reimann –Stieltjes integral and properties.	• Explain metric space, compact set, and perfect set. • State and prove mean value theorem. • Articulate Reiman-Stieltjes integral and its properties.
Module II: Sequence of	Sequences and series of functions, Uniform convergence. Uniform convergence and continuity, uniform convergence and integration, uniform convergence and differentiation,	• Explain point wise and uniform convergence of functions. • Explain improper integrals, beta and gamma

Functions and Functions of Several variables **(15 hours)**	Weirstrass theorem (statement only), improper integrals, the Beta and Gamma functions. Functions of several variables, limits and continuity. Taylor's theorem and its applications. Conditions for the optima of multivariate functions.	functions. • Find limit and continuity of a sequence of function. • To find local and global optima of functions.
Module III: Vector Spaces and Matrices **(15 hours)**	Vector space, sub spaces, linear dependence and independence, basis and dimensions, direct sum and compliment of a subspace, inner product and orthogonality. Algebra of matrices, linear transformations, different type of matrices. Row and column space of a matrix, inverse of a matrix, rank, factorization of a matrix, elementary operations and reduced forms.	• To be familiar with vector space, subspace and its examples. • Explain linear dependence and independence. • Understand the concept of determinants and its properties. • Solve the system of linear equations.
Module IV: Spectral Decomposition and Quadratic Forms **(15 hours)**	Eigen values and eigen vectors, spectral representation and singular value composition, Cayley-Hamilton theorem, algebraic and geometric multiplicities, Jordan canonical form. Linear equations, generalized inverses and quadratic forms, rank nullity theorem, generalized inverses, Moore-Penrose inverse, computation of g-inverse. Quadratic forms, classification of quadratic forms, rank and signature, positive definite and non-negative	• Determine the Eigen values and Eigen vectors of the given matrix • Obtain the diagonal form and triangular form of a given matrix. • Write down the spectral decomposition of the given matrix • Explain different types of quadratic forms. • Explain generalized

	definite matrices, simultaneous diagonalization of matrices.	inverse and how to find it.
References	***Text Books*** 1. Rudin. W. (2013). *Principles of Real Analysis (3rdEd.),* McGraw Hill. 2. Mathai, A. M. and Haubold, H. J. (2017). *Linear Algebra – A course for Physicists and Engineers*, De Gruyter, Germany. ***Reference Books*** 1. Ramachandra Rao and Bhimasankaran (1992). *Linear Algebra*. Tata McGraw Hill, New-Delhi. 2. Malik, S.C & Arora, S. (2006). *Mathematical Analysis*, *Second Edition,* New-age International Publishers. 3. Apsostol, T. M. (1974). *Mathematical Analysis*, *Second Edition*. Norosa, New Delhi. 4. Lewis, D.W. (1995). *Matrix Theory*, Allied publishers, Bangalore. 5. Rao, C. R. (2002). *Linear Statistical Inference and Its Applications*, *Second Edition*, John Wiley and Sons, New York. 6. Seymour Lipschupz, MarcLipson (2005). *Schaum's Outline Series-Linear Algebra (3rd edition).* Tata McGrawHill.	
Course Outcomes	After successful completion of this course, student will be able to: 1. Understand the concepts of limit and continuity of functions and their properties 2. Understand Reimann–Stieltjes integral and its properties. 3. Understand convergence of sequences and series of functions. 4. Understand the vector space, matrices and its properties 5. Understand the properties of quadratic forms and generalized inverses	

TEACHING LEARNING STRATEGIES

- **Lecturing, Visualization, Team Learning**

MODE OF TRANSACTION

- **Lecture, Seminar, Discussion, Questioning and Answering**

ASSESSMENT RUBRICS

Components	Weightage
End Semester Evaluation	**60**
Continuous Evaluation	
Tests	16
Assignment	08
Seminar/viva	16
Total	**40**

Sample Questions to Test Outcomes:

1. Define compact set. Show that compact subset of a metric space are closed.
2. State and prove mean value theorem.
3. Distinguish between uniform convergence and point-wise convergence.
4. Define improper integrals and discuss the convergence of integrals of unbounded functions with finite limits of integration.
5. Explain the extreme values of functions of several variables.
6. Explain different types of quadratic form. State and prove the necessary and sufficient condition for a quadratic form to be positive definite.

DISCIPLINE SPECIFIC CORE COURSE

Course Code & Title	**MSSTA01DSC03- DISTRIBUTION THEORY**	
Programme	**M.Sc. Statistics**	**Semester I**
Course Description	This course is designed to equip the students with the theory of standard probability distributions and their diverse characterizations. The knowledge about the probability distributions facilitates the understanding	

	of various applications of statistical methods like statistical inference and multivariate analysis.
Course Objectives	This course aims to: • Understand and derive generating functions and its properties. • Define and derive the properties of several distributions. • Define and derive joint, marginal and conditional distributions and functions of random variables using Jacobean transformations. • Define and derive the properties of multivariate distributions. • Define and derive the properties of sampling distributions. • Derive the order statistics.

Modules	Content	Module Outcome
Module I: Univariate Discrete Distributions (**15 hours**)	Discrete probability models, Moments and moment generating functions, probability generating functions, characteristic function. Discrete uniform, binomial, Poisson, geometric, negative binomial, hyper geometric and power series distributions. Properties and fitting of these distributions.	• Understand generating functions and their properties. • Derive generating functions of various distributions. • Derive characterizations of discrete distributions. • Derive the various properties of discrete distribution.
Module II: Univariate Continuous Distributions (**15 hours**)	Continuous probability models, Uniform, exponential, Gamma, Weibull, Pareto, beta, Normal, Laplace, logistic, Cauchy and log-normal distributions. Interconnections among these distributions. Properties and fitting of	• Define various continuous distributions. • Derive the properties of each distribution.

	these distributions.	
Module III: Bivariate and Multivariate Distributions (**15 hours**)	Joint, marginal and conditional distributions, independence, covariance and correlations, functions of random variables and their distributions. Jacobin of transformations, bivariate normal distribution, multinomial distribution and their marginal and conditional distributions.	• Find out join, marginal and conditional distributions. • Find out the distribution of functions of random variables using jacobian transformation.
Module IV: Sampling Distributions (**15 hours**)	Basic concepts of sampling distributions from infinite populations, sampling from normal distributions, properties of sample mean and sample variance. Chi-square, t-distribution and F-distributions, properties and applications. Non-central Chi-square, t and F-distributions. Basic concepts of order statistics and their distributions. Distribution of r^{th} order statistics, distribution of sample median and range (for Uniform(0,1) distribution only).	• Define sampling distributions for central and non-central cases. • Derive the properties of central sampling distributions. • Define and derive density and distribution functions of order statistics and systematic statistics. • Derive joint and marginal distributions of order statistics. • Find out distribution of order statistic for various

		distributions.
References	***Text Books*** 1. Rohatgi, V.K. (2001). *An Introduction to Probability and Statistics*, 2^{nd} *Edition.* John Wiley and Sons. 2. Krishnamurthy, K. (2006). *Handbook of Statistical Distributions with Applications.* Chapman &Hall/CRC, New-York. ***Reference books*** 1. Johnson, N.L., Kotz, S. and Balakrishnan, N. (1995). *Continuous Univariate Distributions, Vol. I &Vol. II,* John Wiley and Sons, New-York. 2. Johnson, N.L., Kotz. S. and Kemp. A.W. (1992). *Univarite Discrete Distributions,* John Wiley and Sons, New York. 3. Stuart, A. Ord, A. (1994). *Kendall's Advanced Theory of Statistics, Distribution Theory, 6th Edition.* Wiley-Blackwell. 4. Gupta, S.C. and Kapoor, V.K. (2000). *Fundamentals of Mathematical Statistics, 10 th Revised Edition.* Sultan Chand & Sons, New Delhi.	
Course Outcomes	After successful completion of this course, student will be able to: 1. Understand the concepts of discrete and continuous distributions. 2. Understand the normal distribution and various non-normal distributions, their properties and applications for scientific research. 3. Understand the concept of multivariate distributions and their marginal and conditional distributions. 4. Understand the idea of sampling and sampling distributions from infinite populations.	

TEACHING LEARNING STRATEGIES

- **Lecturing, Visualization, Team Learning**

MODE OF TRANSACTION

- **Lecture, Seminar, Discussion, Questioning and Answering**

ASSESSMENT RUBRICS

Components	Weightage
End Semester Evaluation	**60**
Continuous Evaluation	
Tests	16
Assignment	08
Seminar/viva	16
Total	**40**

Sample Questions to test Outcomes:

1. Distinguish between characteristic function and moment generating functions. Find the moment generating function and characteristic function of a standard Laplace distribution.
2. Define probability generating function. Can it be used to obtain the expected value of X? Explain how.
3. Derive the probability density function of ratio of two independent standard normal variates.
4. If X_1, X_2, X_3 and X_4 are independent standard normal variates, find the distribution of $Y = X_1X_2 - X_3X_4$
5. Define bivariate normal distribution. Obtain its marginal and conditional distributions.
6. Define order statistics. Obtain the distribution of maximum order statistics based on a random sample of size n from exponential distribution with mean 10.

DISCIPLINE SPECIFIC CORE COURSE

Course Code & Title	**MSSTA01DSC04- SAMPLING THEORY**	
Programme	**M.Sc. Statistics**	**Semester I**
Course Description	This course deals with the survey sampling procedures which is the backbone of applied statistics. Fundamentals of survey sampling methodology are covered by this course. The theory and practice of survey sampling methodology is included in this course.	
Course Objectives	• Distinguish between Probability and Non-Probability Sampling • Apply the sampling methods: simple random sampling, systematic sampling, stratified sampling and cluster sampling. • Estimate the population parameters for variables and attributes under the above procedures. • Estimate the population parameters concerning the study variables under auxiliary information (Ratio and regression methods) • Discuss probability proportional to size (PPS) sampling strategies. • Explain the concepts of ordered and unordered estimators and its properties.	

Modules	Content	Module Outcome
Module I: Simple Random Sampling and Systematic Random Sampling (**15 hours**)	Census and sampling-basic concepts, probability sampling and non-probability sampling, simple random sampling with and without replacement, estimation of population mean and total, estimation of sample size, estimation of proportions. Systematic sampling, linear and circular systematic sampling, estimation of mean and its variance, estimation of mean in populations with linear and periodic trends.	• Recall the basics of sample surveys • Understand the technique of simple random sampling and systematic sampling. • Estimate the parameters under simple random

		sampling and systematic sampling.
Module II: Stratified Random Sampling and Auxiliary Variable Techniques **(15 hours)**	Stratification and stratified random sampling. Optimum allocations, comparisons of variance under various allocations. Auxiliary variable techniques, Ratio method of estimation, estimation of ratio, mean and total. Bias and relative bias of ratio estimator. Mean squared error of ratio estimator. Unbiased ratio type estimator. Regression methods of estimation. Comparison of ratio and regression estimators with simple mean per unit method. Ratio and regression method of estimation in stratified population.	• Explain stratified random sampling. • Explain various allocations and derive variance under various allocations. • Articulate ratio and regression method.
Module III: Varying Probability Sampling **(15 hours)**	Varying probability sampling – pps sampling with and without replacements. Des-Raj ordered estimators, Murthy's unordered estimator, Horwitz –Thompson estimators, Zen-Midzuno scheme of sampling, PPS sampling.	• Explain PPS sampling with and without replacement. • Explain ordered and unordered estimators.

<table>
<tr><td>Module IV:
Cluster, Multi Stage and Multi-Phase Sampling

(15 hours)</td><td>Cluster sampling with equal and unequal clusters. Estimation of mean and variance, relative efficiency, optimum cluster size, varying probability cluster sampling. Multi-stage and multiphase sampling. Non-sampling errors.</td><td>● Articulate cluster sampling with equal and unequal clusters.
● Difference between multi stage and multi phase sampling.
● Explain different non-sampling errors.</td></tr>
<tr><td>References</td><td colspan="2">Text books
1. Singh, D. and Chowdhary, F.S. (1986). Theory and Analysis of Sample Survey Designs, New Age International, New Delhi.
2. Cochran. W.G. (2007). Sampling Techniques, John Wiley & Sons, NewYork.
Reference books
1. Des Raj, D. and Chandhok, P. (1998). Sample Survey Theory, Narosa Publishing House, New Delhi.
2. Gupta and Kapoor(2010). Fundamentals of Applied Statistics. Sulthan Chand & Sons.
3. Murthy, M.N. (1967). Sampling Theory & Methods. Statistical Publishing Society, Calcutta.
4. Parimal Mukopadhyay (2012). Theory & Methods of Survey Sampling, PHI Learning, New Delhi.</td></tr>
<tr><td>Course Outcomes</td><td colspan="2">After successful completion of this course, student will be able to:
1. Understand the concepts of probability and non-probability sampling.
2. Understand the estimation methods for population mean, total and proportion under various sampling schemes.
3. Understand the use of auxiliary information for the estimation of various population parameters.</td></tr>
</table>

TEACHING LEARNING STRATEGIES

- **Lecturing, Visualization, Team Learning**

MODE OF TRANSACTION

- **Lecture, Seminar, Discussion, Questioning and Answering**

ASSESSMENT RUBRICS

Components	**Weightage**
End Semester Evaluation	**60**
Continuous Evaluation	
Tests	16
Assignment	08
Seminar/viva	16
Total	**40**

Sample Questions to test Outcomes:

1. Distinguish between probability sampling and non probability sampling. Give an example in each case.
2. Derive the variance of sample mean in stratified random sampling.
3. Explain circular systematic sampling.
4. What do you mean by pps sampling? Explain briefly Horwitz –Thompson estimator.
5. Distinguish between ratio estimators and regression estimators.
6. Explain the difference between the methods of SRS and varying probability scheme.

POOL A: DISCIPLINE SPECIFIC ELECTIVES (DSE)

Course Code & Title	**MSSTA01DSE01- STATISTICAL COMPUTING USING R (Practical)**	
Programme	**M.Sc. Statistics**	**Semester I**
Course Description	This is a practical course deals with the basic statistical computational techniques and graphics using R. R software is most popular among statisticians and this course gives a cutting edge technology for data analysis using R. Hands on training on statistical methods using R is provided.	
Course Objectives	• Define the basic concepts of R software and R packages • Describe various concepts required for developing the R Language • Build our new functions in R • Illustrate different R-Graphics facilities • Find rank and inverse using R software • Describe different sampling methods using R software. • Apply SPSS software to develop different statistical tools. • Interpretation of results using SPSS software.	

Modules	Content	Module Outcome
Module I: Basic Concepts of R Programming **(25 hours)**	Introduction to R- Objects and their classes, operators, vectors and matrices, list and data frames, indexing and accessing data, importing and exporting data. Common built-in functions. Simple applications – Descriptive statistics. R-Graphics- Histogram, Box-plot, Stem and leaf plot, Scatter plot, Q-Q plot. Looping-For loop, repeat loop, while	• Define basic concepts of statistical software R such as Basic operations in R, Mathematical functions used in R, Assign values to variables etc. • Demonstrate the important data structures such as arrays,

	loop, if command, if else command.	matrix, data frames, Class function etc. • Design an overview of the R Language such as Expressions, Objects, Symbols, Functions, Special Values.
Module II: Matrices and Standard Probability Distributions (**20 hours**)	Topics from linear algebra:- Matrices, rank, determinants and inverse. Eigen values and vectors, power of matrices, g-inverse, system of linear equations, roots of algebraic and transcendental equations. Writing own R functions, installation of new packages, different data sets available in R packages.	• How to find rank and inverse using R software. • How to solve system of linear equations using R software. • .How to install l new packages
Module III: Sampling Methods (**25 hours**)	Plotting of cdf and pdf for different values of the parameters of standard distributions. Generations of random samples from standard distributions, demonstrations of the sampling distributions of the standard statistics and functions of random variables- distribution of sample mean and sample variance, illustration of laws of large numbers, central limit theorems.	• .Plotting pdf and cdf curve of different distributions • Random number generation in R • Understanding the Sampling distributions of v statistics

Module IV: Data Analysis Using R (**20 hours**)	Random sample selections, estimation of mean pro-portion, variance, confidence interval and efficiency under SRS, stratified random sampling, Various kind of allocation, stratification, estimators based on ratio and regression methods pps sampling, two stage cluster sampling, and systematic sampling.	• How to draw random samples using different sampling techniques • PPS sampling techniques using R software. • Ratio and regression methods using R software
References	***Text Books*** 1. Maria D.U., Ana F.M. and Alan T.A. (2008*): Probability and Statistics with R.* CRC Press. 2. Dalgaard, P. (2008): *Introductory Statistics with R, (SecondEdition),* Springer. ***Reference Books*** 1. Purohit, S.G, Ghore, S. D and Deshmukh, S. R. (2004): *Statistics Using R*. Narosa. 2. Maria L. Rizzo (2019). *Statistical Computing with R*, Second Edition, Chapman & Hall, CRC Press.	
Course Outcomes	After successful completion of this course, student will be able to: 1. Understand various built in functions in R programming for statistical data analysis. 2. Understand different functions in R programming for writing compute r programmes and develop compute R programmes for different problems. 3. Understand the usage of packages in R for drawing various diagrams and computing descriptive statistics, the comparison of means, ANOVA, non-parametric tests, simple correlation and regression procedures and apply for real data sets.	

TEACHING LEARNING STRATEGIES

- **Practical sessions through computers, statistical computations, Team Learning**

MODE OF TRANSACTION

- **Lecture, Seminar, Hands on training**

ASSESSMENT RUBRICS

Components	Weightage
End Semester Evaluation	**60**
Continuous Evaluation	
Practical Tests	32
Record	08
Total	**40**

Sample Questions to Test Outcomes:

1. Write an R programme to show that sample mean is unbiased estimate of mean of a normal population. Also show graphically that sample mean follows a normal distribution.
2. Let the population be set of numbers 1,2,…10. Write a R programme to obtain a pps sample of size 20 with probability vector (0.2,0.1,0.05,0.05, 0.3,0.1,0.15,0.5)
3. Let $A = (a_{ij})$ be a 3x5 matrix such that $a_{ij} = i^2 - 2j$. Write R programme to obtain its rank and Moore – Penrose inverse.
4. Write R programme to generate a random sample of size 1000 from a standard normal distribution and to estimate $P(|X| > \sqrt{2})$. Also obtain the bias and standard error of this estimate.
5. Write an R programme to generate a random sample of size 20 from discrete random variable taking values -4,-2,0,1,3 with corresponding probabilities 0.2,0.3, 0.4, 0.1. also obtain the barplot.

POOL A: DISCIPLINE SPECIFIC ELECTIVES (DSE)

Course Code & Title	**MSSTA01DSE02-STATISTICAL COMPUTING USING SPSS**	
Programme	**M.Sc. Statistics**	**Semester I**
Course Description	This practical course covers the topics in statistical computations using the popular social science package SPSS. Knowledge in SPSS caters the required skill enhancement for the MSc students. This course is intended to bridge the theory and applications in a smooth way of demonstrations using the modules of SPSS.	
Course Objectives	This course aims to: • Define the basic concepts of SPSS software • Build our new functions in SPSS • Illustrate different SPSS-Graphics facilities • Describe different sampling methods using SPSS software. • Apply SPSS software to develop different statistical tools. • Interpretation of results using SPSS software.	

Modules	Content	Module Outcome
Module I: SPSS Environment, Basic Concepts of SPSS Programming **(20 Hours)**	Introduction to SPSS- Starting SPSS, Working with data file, SPSS windows, Menus, Dialogue boxes. Preparing the Data file, Creating data file and entering data, Defining the variables, Entering data, modifying data file, import file. Variable types in SPSS and Defining variables – Creating a Codebook in SPSS. Screening and cleaning data, Manipulation of data.	▪ Understand the installation and familiar with toolboxes of SPSS. ▪ Data management and modifications of data.

Module II: Preliminary Analysis in SPSS **(25 Hours)**	Computing Variables- Recoding (Transforming) Variables: Recoding Categorical String Variables using Automatic Recode – Sorting Data – Grouping or Splitting Data. Categorical variables, continuous variables. The Explore procedure – Frequencies Procedure – Descriptive – Compare Means – Frequencies for Categorical Data, different statistical distributions	▪ Working with Data types ▪ Recoding and sorting ▪ Descriptive statistics ▪ Explore procedure, graphics in SPSS
Module III: Inferential Statistics **(25 Hours)**	Pearson Correlation, Chi-square Test of Independence – Inferential Statistics for Comparing Means: One Sample t Test, Paired Samples T Test, Independent Samples T Test, One-Way ANOVA. Two way ANOVA, Multivariate ANOVA.	• Compute and interpret correlation coefficients • Learn how to conduct various statistical tests using SPSS • Preparing ANOVA
Module IV: Non-Parametric statistics **(20 Hours)**	Independent Chi square Test, Mann-Whitney test , Wilcoxon signed rank test, Kruskal- Wallis test. Interpreting the output of tests, p-value computation.	• Learn how to perform non parametric tests • Get p value of various tests • Interpretation of test results

References	***Text Book*** 1. Hinton P. R., Brownlow C, Mc Murray, I. and Cozens, B. (2004): *SPSS Explained,* Routledge, Taylor and Francis group, New York. ***Reference Book*** 1. Field, A. (2011); *Discovering Statistics Using SPSS,* Sage Publications.
Course Outcomes	After successful completion of this course, student will be able to: 1. Understand various built in functions in SPSS for statistical data analysis. 2. Understand different functions in SPSS for analyzing given data set. 3.Understand the usage of menus in SPSS window for drawing various diagrams and computing descriptive statistics, the comparison of means, ANOVA, non-parametric tests, simple correlation and regression procedures and apply for real data sets.

TEACHING LEARNING STRATEGIES

- **Practical sessions through computers, statistical computations, Team Learning**

MODE OF TRANSACTION

- **Lecture, Seminar, Hands on training**

ASSESSMENT RUBRICS

Components	Weightage
End Semester Evaluation	**60**
Continuous Evaluation	
Practical Tests	32
Record	08
Total	**40**

Sample Questions to Test Outcomes:

1. Use the SPSS data set saved in the file name "student_data". Plot the necessary graphs to summarize the data.
2. Conduct t-test and a non parametric analogue for testing whether the average BMI of boys and girls are same.
3. Perform an appropriate ANOVA for the given data (use "student_data").
4. Obtain correlation matrix and scatter plots for the marks of the students .
5. Create a cross tab and check whether the variables are independent.
6. Fit a linear regression equation to predict the degree marks knowing marks in SSLC and Plus Two. Also test the significance of regression coefficients and obtain p-values.

	SECOND SEMESTER								
Sl No	Course Code	Title of Paper	Contact Hours/Week			Marks			
			L	T/S	P	ESE	CE	Total	Credits
DISCIPLINE SPECIFIC CORE COURSES (DCE)									
2.1	MSSTA02DSC05	Advanced Probability Theory	4	1		60	40	100	4
2.2	MSSTA02DSC06	Stochastic Processes	4	2		60	40	100	4
2.3	MSSTA02DSC07	Estimation Theory	4	1		60	40	100	4
2.4	MSSTA02DSC08	Testing of Hypothesis	4	2		60	40	100	4
DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE)									
2.5	MSSTA02DSExx	One course has to be chosen from **Pool B**		2	6	60	40	100	3
ABILITY ENHANCEMENT COURSE(AEC)									
2.6	MSSTA02AECxx	Elective-III-DSE (**Pool C**) (Offered to other departments)							2
	----------	To be obtained from other Departments	2						2
SKILL ENHANCEMENT COURSE(SEC)									
2.7	MSSTA02SECxx	Elective-IV-DSE (**Pool D**) (Offered to other departments)							2
	---------	To be obtained from other Departments	2						2
Total Credits									**23**

L=Lecture, T/S=Tutorials/Seminar, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

Sl No	POOL B DISCIPLINE SPECIFIC ELECTIVE (DSE)								
2.5.1	MSSTA02DSE03	Statistical Computing Using R-II (**Practical**)		2	6	60	40	100	3
2.5.2	MSSTA02DSE04	Statistical Computing Using SPSS - II (**Practical**)		2	6	60	40	100	3
Sl No	**POOL C** **ABILITY ENHANCEMENT COURSE (AEC)**								
2.6.1	MSSTA02AEC01	A foundation course in LaTex for scientific documentation		2	6	60	40	100	2
2.6.2	MSSTA02AEC02	Basic Statistical data analysis using EXCEL		2	6	60	40	100	2
Sl No	**POOL D** **SKILL ENHANCEMENT COURSE (SEC)**								
2.7.1	MSSTA02SEC01	Exploratory Data Analysis Using SPSS		2	6	60	40	100	2
2.7.2	MSSTA02SEC02	Regression Analysis Using SPSS		2	6	60	40	100	2

DISCIPLINE SPECIFIC CORE COURSE

Course Code & Title	**MSSTA02DSC05-ADVANCED PROBABILITY THEORY**		
Programme	**M.Sc. Statistics**	**Semester**	**II**
Course Description	This course is intended to provide strong foundation in basic probability concepts and mathematical statistics. Building upon the fundamental principles established in introductory courses, Advanced Probability Theory delves into more intricate and specialized aspects of probability, offering a deeper understanding of the underlying mathematical structures and applications.		

Course Objectives	• Understand the concept of signed measures and their role in measure theory. • Differentiate between singular and absolutely continuous measures. Explore the implications of these measures in probability and measure theory. • Comprehend the Radon-Nikodym theorem and its significance. Apply the theorem to decompose measures and analyze various applications. • Understand the significance and applications of the Hahn Decomposition Theorem. Analyze the decomposition of measures using Hahn-Jordan and Lebesgue theorems. • Comprehend Fubini's theorem and its role in multiple integration. Apply Fubini's theorem to compute integrals in product spaces. • Understand the weak and strong laws of large numbers and their significance. Analyze applications of the laws in probability and statistics. • Define characteristic functions and explore their elementary properties. Apply characteristic functions to analyze moments and distributions. • Understand the central limit theorems and their mutual implications. Explore applications of these theorems in various fields.

Modules	Content	Module Outcome
Module I: Signed Measures and Decompositions **(15 Hours)**	Signed measure space, singular and absolutely continuous measures, Radon-Nikodym theorem (without proof) and its applications. Decomposition of measures, Hahn Decomposition theorem, Hahn-Jordan decomposition, and Lebesgue	• Demonstrate a profound understanding of signed measure spaces • Distinguishing between positive and negative measures. • Able to differentiate between singular and

	decomposition theorem. Product space and product measure. Fubini's theorem(without proof).	absolutely continuous measures, illustrating their distinctive characteristics and practical implications. • Application of the Radon-Nikodym theorem in probability and statistics.
Module II: Characteristic Functions and Properties **(15 Hours)**	Definition of a characteristic function, elementary properties, characteristic functions and moments, Taylor's series expansion of characteristic functions, Bochner's theorem(without proof), inversion theorem, uniqueness theorem, continuity theorem.	• Define characteristic functions, understanding their role in probability theory. • Able to perform Taylor's series expansion on characteristic functions • Grasp the significance of Bochner's theorem, the inversion theorem, uniqueness theorem, and continuity theorem.
Module III: Law of Large Numbers and Independence of the class of events **(15 Hours)**	The Weak laws of large numbers, the strong laws of large numbers and Kolmogorov three series theorem (without proof), applications. Weakconvergenceofdistributions.Helly'sconvergencetheorem,Helly-Braylemma,Scheffetheorem,Independenceofclassofeventsandrandomvariables.Borel0-1criteriaandBorel-CantelliLemma,Kolmogorov0-1 laws.	• Comprehend the weak and strong laws of large numbers, applying them to analyze the convergence of sample averages. • Understand the Kolmogorov Three Series Theorem. • Grasp the concepts of Helly's Convergence Theorem, Helly-Bray Lemma,

		and Scheffe Theorem. • Understand the concept of Borel 0-1 Criteria and Borel-Cantelli Lemma, as well as understand and apply Kolmogorov 0-1 Laws.
Module IV: Central Limit Theorems and Martingales **(15 Hours)**	The central limit theorems – Lindberg Levy, LiapounovandLindberg-Feller(withoutproof)centrallimittheorems,theirmutualimplicationsandapplications.Conditionalexpectation, martingales, simple properties and examples.	• Understand the central limit theorems (Lindberg Levy, Liapounov, and Lindberg-Feller). • Explore the mutual implications of these theorems and apply them to analyze the convergence of sums of independent random variables • Grasp the concepts of conditional expectation and martingales and its properties.
References	***Text Books*** 1. Bhat, B.R.(2004).*Modern Probability Theory.* New Age Publishers, New Delhi. 2. Laha, R.G.and Rohatgi, V.K.(2020).*Probability Theory.* Dover Publications Inc. 3. Robert G.Bartle(1995).*The Elements of Integration and Lebesgue Measure.* John Wiley & Sons, New York. 4. Rohatgi,V.K.(1976).*AnIntroductiontoProbabilityTheoryandMathematicalStatistics.* Wiley Eastern. ***Reference books*** 1. Basu, A.K.(1999).*Measure Theory and Probability.* Prentice-Hall.	

	2. Billingsley, P.(1986).*Probability and Measure.* Second Edition, John Wiley. 3. Parthasarathy,K.R.(2005).*Introduction to Probability and Measure.* Hindustan Book Agency. 4. Royden,H.L.(1988).*Real Analysis*(3rdedition).McMillain Publishing Company, New York.
Course Outcomes	After successful completion of this course, student will be able to: 1. Understand the concepts of decomposition of measures. 2. Understand characteristic function and its properties 3. Understand various laws of large numbers 4. Understand different central limit theorems, their mutual implications and applications and the concept of conditional expectation and martingales.

TEACHING LEARNING STRATEGIES

- **Lecturing, Visualization, Team Learning**

MODE OF TRANSACTION

- **Lecture, Seminar, Discussion, Questioning and Answering**

ASSESSMENT RUBRICS

Components	**Weightage**
End Semester Evaluation(ESE)	**60**
Continuous Evaluation	
Tests	16
Assignment	08
Seminar/viva	16
Total	**40**

Sample Questions to Test Outcomes:

1. Distinguish between measure and signed measure. Show that difference between any two measures defined over the same measurable space is a signed measure.
2. Define positive and negative sets with respect to a signed measure. Give an example in each case.
3. Differentiate between singular measure and absolutely continuous measures. Give an example in each case.
4. State Radon-Nikodym theorem.
5. If $\phi(t)$ is a characteristic function, show that $|\phi(t)|^2$ is a characteristic function.
6. State Tchebchev's WLLN and show that Bernoulli's WLLN is a particular case
7. If $X_1, \ldots, X_n$ are independent random variables, show that the characteristic function of $X_1 + X_2 + \ldots + X_n$ is the product of characteristic functions of X_k's, but the converse need not be true.
8. State and prove Borel 0-1 criterion.
9. State the classical central limit theorem and show that Demoivre CLT is a particular case.
10. Define martingale sequence. Give an example.

DISCIPLINE SPECIFIC CORE COURSE

Course Code & Title	**MSSTA02DSC06-STOCHASTIC PROCESSES**		
Programme	**M.Sc. Statistics**	**Semester**	**II**
Course Description	This course is intended to provide a strong foundation in stochastic processes and their applications, properties of Markov chain, the concept of branching process, stationary distributions, waiting time distributions will be considered in detail.		
Course Objectives	• Gain a comprehensive understanding of stochastic processes, including the conceptual foundation, and be able to provide examples illustrating their applications in various fields. • Able to distinguish between stationary and weakly stationary processes, demonstrating proficiency in analyzing and characterizing their key properties.		

	• Master the Chapman-Kolmogorov equations and classification of states in Markov chains. • Understand branching processes in discrete time, gaining proficiency in their analysis and application to model population growth and extinction scenarios. • Comprehend the properties of exponential distribution and counting processes, including inter-arrival time and waiting time distributions. • Uunderstanding of Poisson processes, exploring their properties and applications. • Analyze birth-death processes in continuous time Markov chains, mastering transition probability functions and limiting probabilities. • Analyzing basic characteristics of queues, exploring Markovian models such as M/M/1, M/M/1/N, M/M/c, and network of queues.

Modules	Content	Module Outcome
Module I: Basics Concepts of Stochastic Processes and Markov Chains **(15 Hours)**	Concept of stochastic processes, examples, stationary and weakly stationary processes. Markov chains- Chapman Kolmogorov equations –classification of states – limiting probabilities; gamblers ruin problem and random walk, Branching processes (discrete time).	• Define, give examples and classify different types of stochastic processes. • Define Markov chains, find out transition probabilities and higher order transition probabilities, and prove related results. • Classify sates and chains of a Markov chain and prove related theorems and results. • Find out limiting probabilities, probability of ultimate win and ruin in gambler's ruin problem, and

		probability of ultimate extinction in branching process
Module II: Poisson Processes and Generalizations **(15 Hours)**	Exponential distribution, counting process, inter arrival time and waiting time distributions. Properties of Poisson processes- Conditional distribution of arrival times. Generalizations of Poisson processes, non-homogenous Poisson process, compound Poisson process.	• Describe exponential distribution and its properties. • Define Poisson process and derive its inter arrival distribution, waiting time distributions, conditional distributions and other related results • Describe compound, homogeneous and non-homogeneous Poisson process
Module III: Continuous time Markov Chains and Renewal Processes **(15 Hours)**	Continuous time Markov Chains- Birth and death processes, transition probability function, limiting probabilities. Renewal processes, limit theorems and their applications. Semi-Markov process.	• Describe birth and death process and derive its related results. • Describe transition probability functions, limiting probabilities and derive Kolmogorov backward and forward equations. • Describe renewal theory and its applications and derive limit theorems.

Module IV: Queuing and Brownian Motion Process **(15 Hours)**	Basic characteristics of queues, analysis of Markovian models (M/M/1, M/M/1/N, M/M/c), network of queues. The M/G/I system and G/M/I model. Brownian motion process	• Analyze different aspects of a queuing system. • Derive steady state and waiting time distributions of Markovian and non-Markovian queuing models.
References	***Text Books*** 1. Ross, S. M. (2010). *Introduction to Probability Models. Xth Edition*, Academic Press. 2. Medhi, J. (2009). *Stochastic Processes. Third Edition*. New Academic Science Limited. UK. ***Reference books*** 1. Basu, A.K.(2002). *Elements of Stochastic Processes*, Narosa Publications. 2. Cinlar, E.(1975). *Introduction to Stochastic Processes*. Prentice Hall. New Jersey. 3. Feller, W. (1965, 1968), *An Introduction to Probability Theory and Its Applications, Volume I and II*, Wiley Eastern. 4. Karlin, S. and Taylor, H.M. (1975). *A First Course in Stochastic Processes*. *Second Edition*, Academic Press. New-York.	
Course Outcomes	After successful completion of this course, student will be able to: 1. Understand the concepts of Stochastic processes. 2. Understand the concepts of Markov chains, classification of its states and limiting probabilities. 3. Understand continuous time Markov chains, Poisson processes and its generalizations. 4. Understand the branching processes, various queueing models and Brownian motion process.	

TEACHING LEARNING STRATEGIES

- **Lecturing, Visualization, Team Learning**

MODE OF TRANSACTION

- **Lecture, Seminar, Discussion, Questioning and Answering**

ASSESSMENT RUBRICS

Components	Weightage
End Semester Evaluation (ESE)	**60**
Continuous Evaluation	
Tests	16
Assignment	08
Seminar/viva	16
Total	**40**

Sample Questions to Test Outcomes:

1. Define Markov chain.
2. Prove that a Markov chain is completely determined by its initial distribution and one step TPM.
3. Define periodic and aperiodic Markov chains.
4. Consider Markov chain whose TPM is

$$\begin{pmatrix} 0 & \frac{1}{3} & \frac{2}{3} \\ \frac{1}{2} & 0 & \frac{1}{2} \\ \frac{1}{2} & \frac{1}{2} & 0 \end{pmatrix}$$

(i)Is the chain is irreducible.

(ii)Is the chain is ergodic? Explain.

(iii)Find the stationary distribution of the chain.

5. Show that in an irreducible Markov chain all the states are of same type.

6. Show that probability of extinction of Galton Watson branching process is the smallest positive root of the equation s = P(s), where P(s) is the PGF of the offspring distribution.
7. Suppose that customers arrive at a bank according to a Poisson process with mean rate of 3 per minute. Find the probability that during a time interval of 2 minutes (i)exactly 4 customers arrive (ii) more than 4 customers arrive and (iii) at least one customer arrive.
8. Describe the relation between Poisson process and binomial distribution.
9. Explain renewal process. Give examples
10. Describe the stationary ehaviour of a birth and death processes and hence obtain the system size distribution of M/M/1 and M/M/c queueing models.

DISCIPLINE SPECIFIC CORE COURSE

Course Code & Title	**MSSTA02DSC07-ESTIMATION THEORY**		
Programme	**M.Sc. Statistics**	**Semester**	**II**
Course Description	In this course, various properties of the estimators will be discussed. A detailed study on various theorems like Cramer-Rao lower bound, Rao-Blackwell theorem and various estimation procedure like method of moments, method of maximum likelihood will be the backbone of this course.		
Course Objectives	• List the important properties of estimators of an unknown parameter of a distribution. • Derive the UMVUE of a parameter or function of a parameter. • Apply the concept of Rao-Blackwell and Lehmann-Scheffe theorems. • Select the best estimators using different properties. • Differentiate between classical and Bayesian inference. • Determine the estimators of unknown parameters using methods like MLE, Method of moments etc. • Outline Bayes estimation of parameters of standard distributions.		

Modules	Content	Module Outcome
Module I: Sufficiency and Completeness **(15 Hours)**	Sufficient statistics and minimum variance unbiased estimators,factorizationtheoremforsufficiency(prooffordiscretedistributionsonly),jointsufficientstatistics,exponential family, minimal sufficient statistics, criteria to find the minimal sufficient statistics, ancillary statistics, complete statistics, Basu's theorem(proof for discrete distributions only).	• Derive the important properties of estimators • Determine the sufficient statistic • Explain minimal sufficiency • Define Basu's Theorem • Use likelihood equivalence to obtain minimal sufficient statistic
Module II: Minimum Variance Unbiased Estimation **(15 Hours)**	Unbiased estimator, Best Linear Unbiased Estimator(BLUE), Minimum Variance Unbiased Estimator (MVUE), Fisher information, Cramer-Rao inequality and its applications, Rao-Blackwell theorem, Lehmann – Scheffe theorem. Consistent estimators and consistent asymptotically normal estimators. Invariance property of estimators and consistent asymptotically normal(CAN)estimators.	• State and prove Cramer-Rao inequality. • Explain Best Linear Unbiased Estimator. • Determine consistent estimators and consistent and asymptotically normally distributed estimators. • Apply Rao-Blackwell and Lehmann-Scheffe theorems to find UMVUE. • Identify efficient estimators.
Module III: Methods of Estimation **(15 Hours)**	Method of moments, Method of maximum likelihood (MLE), properties of MLE, MLE in exponential family, Interval estimation, shortest expected length	• Describe different methods of estimation such as method of moments, MLE. • Derive important asymptotic and non-asymptotic

	confidence interval, large sample confidence intervals.	properties of MLE. • Explain confidence interval estimation, shortest expected length confidence interval, large sample confidence interval.
Module IV: Bayesian Inference **(15 Hours)**	Randomized and non-randomized decision rules, risk and loss function, optimality of decision rules, standard loss functions prior and posterior distributions, estimation, confidence interval and prediction under Bayesian approach.	• Design basic elements of Bayesian Inference. • Understand Bayes Theorem for inference. • Calculate Bayes estimators of parameters of standard distributions. • Differentiate between classical and Bayesian Inference.
References	***Text Books*** 1. Kale,B.K.(2005).*A First Course in Parametric Inference*, Second Edition.Narosa Publishing House, New Delhi. 2. Vijay K. Rohatgi, A. K. Md. Ehsanes Saleh (2015). *An Introduction to Probability and Statistics*,3rdEdition. John Wileyand Sons, New York. ***Reference Books*** 1. Casella,G.and Berger,R.L.(2002).*Statistical Inference*, Second Edition. Duxbury, Australia. 2. Bensal,A.K.(2008).*Bayesian Parametric Inference*. New Age, Delhi. 3. Lehmann, E.L(1983). *Theory of Point Estimation*. John Wiley and Sons, New York. 4. Rohatgi, V.K(2003). *Statistical Inference*. Dover Publications.	

	5. Rao, C. R (2002). *Linear Statistical Inference and Its Applications*, Second Edition. John Wily and Sons, New York.
Course Outcomes	After successful completion of this course, student will be able to: 1. Apply various parametric and Bayesian estimation techniques with real life examples. 2. Understand the concepts of Sufficiency and Completeness 3. Understand the concepts of Minimum Variance Unbiased Estimation. 4. Understand various estimation methods and applications in real life problems. 5. Understand Bayesian inference methods and its application.

TEACHING LEARNING STRATEGIES

- **Lecturing, Visualization, Team Learning**

MODE OF TRANSACTION

- **Lecture, Seminar, Discussion, Questioning and Answering**

ASSESSMENT RUBRICS

Components	**Weightage**
End Semester Evaluation(ESE)	**60**
Continuous Evaluation	
Tests	16
Assignment	08
Seminar/Viva	16
Total	**40**

Sample Questions to Test Outcomes:

1. State factorization theorem for sufficiency.
2. Let $X_1, X_2, ..., X_n$ be a random sample of n observations from Gamma distribution with shape parameter θ. Find sufficient statistic for θ.
3. State and prove Basu's theorem.
4. If T is unbiased estimator for θ, show that $T^2$is a biased estimator for θ^2.
5. Let $X_1, X_2, ..., X_n$ be random sample from a poisson population with parameter λ. Show that the sample mean $\overline{X}$ and the sample variance S^2 is not UMVUE.
6. Let $X_1, X_2, ..., X_n$ be a random sample of size n observations from beta first kind distribution with parameter α and β. Find the estimators of α and β by method of moment.
7. Explain Cramer family. Write down an example of family of distribution which belongs to Cramer family and not belongs to Cramer family.
8. Explain in short the different methods of estimation. How Bayesian estimation method is different from conventional estimation methods?
9. Explain Jeffrey's non-informative prior.
10. Find an unbiased estimator of $e^{-\lambda} = P(X = 0)$ in a Poisson distribution.

DISCIPLINE SPECIFIC CORE COURSE

Course Code & Title	**MSSTA02DSC08-TESTING OF HYPOTHESES**		
Programme	**M.Sc. Statistics**	**Semester**	**II**
Course Description	This course offers a detailed study on Fisher-Neyman method of testing hypothesis, likelihood ratio test, non-parametric testing hypothesis and sequential testing.		
Course Objectives	• Formulate hypothesis for a given problem. • Find critical region and power of the test. • Find most powerful test for testing simple hypothesis against simple alternative. • State and prove Neyman-Pearson lemma. • Find UMP test for testing composite hypothesis.		

	• Obtain LMP and LMPU test. • Derive likelihood ratio test for testing the hypothesis for normal populations. • Obtain sequential probability ratio test for testing the hypothesis. • Construct confidence interval for parameters.

Modules	Content	Module Outcome
Module I: Tests of Hypotheses and Most Powerful Tests **(15 Hours)**	Tests of hypotheses and most powerful Tests–Simple versus simple hypothesis testing problem – Error probabilities, p-value and choice of level of significance –Most powerful tests–Neyman Pearson Lemma, generalized Neyman- Pearson lemma.	• Identify simple and composite hypothesis • Find critical region, size and power of the test . • Distinguish between random and non-randomized test • Apply Neymann-Pearson lemma to find most powerful test
Module II: UMP Tests and Similar Tests **(15 Hours)**	MLR property, One-sided UMP tests, two sided UMP tests and UMP unbiased tests, α –similar tests and similar tests with Neyman structure. Principle of invariance in testing of hypotheses, locally most powerful tests. Likelihood ratio tests, asymptotic distribution of likelihood ratio.	• Check the unbiasedness of a test • Find UMP and UMPU test • Obtain Locally Most Powerful test • Obtain Locally Most Powerful Unbiased test
Module III: Non-parametric Tests **(15 Hours)**	Non-parametric Tests: Single sample tests – testing goodness of fit, chi-square tests- Kolmogorov – Smirnov test – sign test – Wilcoxon signed rank test. Two	• Explain non-parametric test- single sample test. • Explain non-parametric test- two sample test

	sample tests – the chi-square test for homogeneity –Kolmogorov Smirnov test; the median test – Mann- Whitney – Wilcoxon test –Test for independence, Kendall's tau, Spearman's rank correlation coefficient	
Module IV: Sequential Tests **(15 Hours)**	Some fundamental ideas of sequential sampling – Sequential Probability Ratio Test(SPRT) – important properties, termination of SPRT – Operating Characteristic (OC) function and Average Sample Number (ASN) of SPRT-Developing SPRT for different problems.	• Derive SPRT for test the parameters of normal distribution, binomial and Poisson distributions. • Find OC function and Average Sample Number of a SPRT.
References	***Text Books*** 1. Vijay K. Rohatgi, A. K. Md. Ehsanes Saleh (2015). *An Introduction to Probability and Statistics*,3rdEdition. John Wiley and Sons, New York. 2. Casella, G. and Berger, R.L.(2002): *Statistical Inference*, Second Edition. Duxbury, Australia. 3. Wald, A.(2004):*Sequential Analysis*. Dover Publications. ***Reference Books*** 1. Fraser, D.A.S.(1957):*Non-parametric Methods in Statistics*, Wiley, New York. 2. Lehman, E.L.(1986):*Testing of Statistical Hypotheses*. John Wiley, New York. 3. Ferguson, T.S. (1967*): Mathematical Statistics: A Decision – Theoretic Approach.* Academic Press, New York. 4. Srivastava, M. and Srivstava, N. (2009): *Statistical Inference: Testing of Hypothesis, Eastern Economy Edition*, PHI Learning Pvt. Ltd., New Delhi.	
Course	After successful completion of this course, student will be able to:	

Outcomes	1. Apply various parametric, non-parametric and sequential testing procedures to deal with real life problems. 2. Understand Most Powerful Tests for testing simple null hypothesis and developing MP tests for different problems. 3. Understand UMP tests and likelihood ratio tests for testing composite hypothesis and developing UMP and likelihood ratio tests for different problems. 4. Understand various non-parametric tests used for different problems 5. Understand the Sequential Probability Ratio Test and developing SPRT for different situations.

TEACHING LEARNING STRATEGIES

- **Lecturing, Hands on Training, Visualization, Team Learning**

MODE OF TRANSACTION

- **Lecture, Seminar, Discussion, Questioning and Answering**

ASSESSMENT RUBRICS

Components	Weightage
End Semester Evaluation (ESE)	**60**
Continuous Evaluation	
Tests	16
Assignment	08
Seminar/Viva	16
Total	**40**

Sample Questions to Test Outcomes:

1. Define a test function. How do you define a power function in terms of a test function?

2. Let p be the probability that a coin will fall head in a single toss in order to testH_0 : p =1/2against H_1 : p =3/4. The coin is tossed 5 times and H0 is rejected if more than 3 heads are obtained. Find the probability of type-I error and power of the test.
3. Define a most powerful test and explain the utility of Neyman-Pearson lemma.
4. Given the nine sample values 4.5, 6.5, 3.8, 4.2, 7.7, 8.5, 9.4, 5.3, 3.9 from a normal distribution with mean μ and variance 4. Find the best critical region for testingH_0 : μ = 4 versus H_1 : μ = 5 of size 0.05. Also calculate the power of the test.
5. Do UMP test exist always? Discuss with the help of an example.
6. Write a short note on families with monotone likelihood ratio. Check whether U(0, θ) has an MLR.
7. Show that the likelihood ratio test for testing the equality of variances of two normal distributions is the usual F-test.
8. Explain chi-square test of goodness of fit and compare it with K-S test.
9. A quality control engineer has taken 50 samples of size 13 each from a production process. The number of defectives for these samples are recorded below. Test the null hypothesis at 0.05 level.
10. Obtain OC function for testing H_0 : p = p_0 versus H_1 : p = p_1 using SPRT with strength (α, β) based on observations from b(n, p).

POOL B: DISCIPLINE SPECIFIC ELECTIVE – PRACTICAL

Course Code & Title	**MSSTA02DSE03- STATISTICAL COMPUTING USING R- II (Practical)**		
Programme	**M.Sc. Statistics**	**Semester**	**II**
Course Description	This course offers a thorough study to acquire knowledge in statistical computing using R. Practical problems related to the core paper in this semester will be solved using R-Package in addition to the bootstrap method and Monte-Carlo integration.		

Course Objectives	• Formulate and evaluate different estimators for unknown parameters using the real life data set using R programming language • Choose an appropriate UMP test for a real life data set using R programming language • Perform the appropriate non-parametric tests for a data set using R programming language. • Use bootstrap method to estimate sampling distributions and confidence intervals. • Evaluate integrals using Monte- Carlo integration method.

Modules	Content	Module Outcome
Module I: Testing of Hypothesis **(15 Hours)**	Power function, parametric and non-parametric tests, single sample tests, two sample tests, test for independence, Sequential Probability Ratio Test.	• Develop different Testing of hypothesis procedures such as Most powerful test, Uniformly most powerful test, Likelihood ratio tests, Sequential probability ratio test using the R software. • Perform different parametric test using R software • Perform different non-parametric test using R software
Module II: Re-sampling Methods **(15 Hours)**	Bootstrap methods, bias and standard errors, bootstrapping for estimation of sampling distribution, confidence intervals.	• Apply bootstrap method to estimate sampling distribution. • Evaluate confidence intervals using bootstrap method.
Module III: Classical Estimation	Maximum likelihood estimation, single parameter and multi-parameter	• Justify different estimation techniques – Maximum likelihood estimation .

(15 Hours)	cases, confidence interval estimation.	• Compute posterior distribution using R software
Module IV: Monte Carlo Methods **(15 Hours)**	The Monte Carlo Method of Computing Integrals.	• Apply Markov Chain Monte Carlo method for drawing random samples. • Evaluate Monte-Carlo integration method to integrate complicated integrals.
References	***Text Books*** 1. Jim Albert (2007). *Bayesian Computation with R*, New York: Springer-Verlag. 2. MariaL. Rizzo (2008): *Statistical Computing with R*, Chapman & Hall/CRC. 3. Maria D.U., Ana F.M. and Alan T.A.(2008). *Probability and Statistics with R*.CRC Press. 4. Peter Dalgard (2008). *Introductory Statistics with R*, Second Edition, Springer. ***Reference Books*** 1. Bensal, A. K. (2008): *Bayesian Parametric Inference*, New Age, Delhi. 2. Draper, N. R. and Smith, H.(1998): *Applied Regression Analysis*, (3rdEdition). John Wiley, New York. 3. Casella, G. and Berger, R.L.(2002). *Statistical Inference*, 2ndEdition, Duxbury, Australia.	
Course Outcomes	After successful completion of this course, student will be able to: 1. Equipped with different theoretical methods to achieve the objectives. 2. Enhanced with the basic concepts of statistical theories besides developing their ability to handle real world problems with large scale data.	

TEACHING LEARNING STRATEGIES

- **Practical sessions through computers, statistical computations, Team Learning**

MODE OF TRANSACTION

- **Lecture, Seminar, Hands on training**

ASSESSMENT RUBRICS

Components	Weightage
End Semester Evaluation	**60**
Continuous Evaluation	
Practical Tests	32
Record	08
Total	**40**

POOL B: DISCIPLINE SPECIFIC ELECTIVE – PRACTICAL

Course Code & Title	**MSSTA02DSE04- STATISTICAL COMPUTING USING SPSS-II (Practical)**		
Programme	**M.Sc. Statistics**	**Semester**	**II**
Course Description	This course offers a thorough study to acquire knowledge in statistical computing using SPSS. Practical problems related to the core paper in this semester will be solved using SPSS.		
Course Objectives	• Formulate and evaluate different estimators for unknown parameters using the real life data set using SPSS. • Choose an appropriate UMP test for a real life data set using SPSS. • Perform the appropriate parametric and non-parametric tests for a data set using SPSS • Use bootstrap method to estimate sampling distributions and confidence intervals.		

Modules	Content	Module Outcome
Module I: Testing of Hypothesis **(15 Hours)**	Power function, parametric and non-parametric tests, single sample tests, two sample tests, test for independence, Sequential Probability Ratio Test.	• Develop different Testing of hypothesis procedures such as Most powerful test, Uniformly most powerful test, Likelihood ratio tests, Sequential probability ratio test using the SPSS software. • Perform different parametric test using SPSS software • Perform different non-parametric test using SPSS software
Module II: Re-sampling Methods **(15 Hours)**	Bootstrap methods, bias and standard errors, bootstrapping for estimation of sampling distribution, confidence intervals.	• Apply bootstrap method to estimate sampling distribution. • Evaluate confidence intervals using bootstrap method.
Module III: Classical Estimation **(15 Hours)**	Maximum likelihood estimation, single parameter and multi-parameter cases, confidence interval estimation.	• Justify different estimation techniques – Maximum likelihood estimation . • Compute posterior distribution using SPSS software
Module IV: Monte Carlo Methods **(15 Hours)**	The Monte Carlo Method of Computing Integrals.	• Apply Markov Chain Monte Carlo method for drawing random samples. • Evaluate Monte-Carlo integration method to integrate complicated

		integrals.
References	***Text Books*** 1. Hinton, P. R., McMurray, I., & Brownlow, C. (2014). *SPSS explained*. Routledge. 2. DeCoster, J., & Claypool, H. (2004). *Data analysis in SPSS*. 3. McCormick, K., & Salcedo, J. (2017). *SPSS statistics for data analysis and visualization*. John Wiley & Sons. ***Reference Books*** 1. Bensal, A.K. (2008): *Bayesian Parametric Inference*, New Age, Delhi. 2. Draper, N.R. and Smith, H.(1998): *Applied Regression Analysis*, (3rdEdition). John Wiley, New York. 3. Casella, G. and Berger, R.L.(2002). *Statistical Inference*, 2ndEdition, Duxbury, Australia.	
Course Outcomes	After successful completion of this course, student will be able to: 1. Equipped with different theoretical methods to achieve the objectives. 2. Enhanced with the basic concepts of statistical theories besides developing their ability to handle real world problems with large scale data.	

TEACHING LEARNING STRATEGIES

- **Practical sessions through computers, statistical computations, Team Learning**

MODE OF TRANSACTION

- **Lecture, Seminar, Hands on training**

ASSESSMENT RUBRICS

Components	Weightage
End Semester Evaluation	**60**
Continuous Evaluation	

Practical Tests	32
Record	08
Total	**40**

POOL C

ABILITY ENHANCEMENT COURSE (AEC)

Course code: **MSSTA02AEC01**

Name of the Course: **A foundation course in *LaTex* for scientific documentation.**

Department Offering the Course: **Department of Statistical Sciences**

Mode of Delivery: **Hybrid**

Credit Distribution, Eligibility and Pre-Requisites of the Course

Credits	Credit distribution			Eligibility Criteria	Pre-requisite (if any)
	Lecture	Tutorial	Practical/ Internship		
2	1	1	2		

Skill Outcomes: To introduce students with a software that is being widely used for scientific typesetting, To make students know importance of this software for publishing research articles, letters, project reports, books and beamer/slide presentation and thereby help them to be comfortable with the software .

Course Contents:

Module 1: Installation of Kile and MikeTeX. Class and packages. Latex programming and commands, sample packages. Error messages, Some sample errors, list of LaTeX error messages.

Module 2: Fonts, symbols, Indenting, paragraphs, line spacing, word spacing, titles and subtitles. Document class, page style, parts of the documents, table of contents. Command names and arguments, environments, declarations. Theorem like declarations, comments within text.

Module 3: Mathematical environments, math mode, mathematical symbols. Graphic package, multivalued functions, drawing matrices. Tables, tables with captions. References to figures and tables in text.

Module 4: Picture environments. Extended pictures, other drawing packages. Preparing book, project report in LaTeX, LaTeX Beamer for Technical Presentations.

Suggested Readings:

1. Kottwitz, S. (2021). *LaTeX Beginner's Guide: Create Visually Appealing Texts, Articles, and Books for Business and Science Using LaTeX*. United Kingdom: Packt Publishing**.**
2. Lamport **(**1994**).** *Latex: A Document Preparation System, 2/E*. India: Pearson Education**.**
3. Kopka, H., Daly, P. W. (2003). *Guide to LaTeX*. United Kingdom: Pearson Education.

.

TEACHING LEARNING STRATEGIES

- **Hands on training, Lecturing, Visualization, Team Learning.**

MODE OF TRANSACTION

- **Lab session, Lecture, Seminar, Discussion, Questioning and Answering**

Assessment Rubrics: Evaluation by Department

Sample Questions to Test Outcomes:

1. How do you install Kile and MiKTeX for LaTeX editing and compilation, and what are their roles in the LaTeX ecosystem?
2. Explain the concept of classes and packages in LaTeX, and how they contribute to document formatting and customization.
3. Discuss LaTeX programming and commands, including sample packages, and common error messages encountered during compilation.

4. What are some sample errors in LaTeX, and how can they be addressed? Provide a list of common LaTeX error messages.
5. Describe the role of fonts and symbols in LaTeX, and how they can be customized for document appearance.
6. How do you manage indentation, paragraphs, line spacing, and word spacing in LaTeX documents?
7. Discuss titles, subtitles, document classes, page styles, and the creation of table of contents in LaTeX.
8. Explain command names and arguments, environments, and declarations in LaTeX, including theorem-like declarations and comments within text.
9. What are mathematical environments and math mode in LaTeX, and how can mathematical symbols be utilized?
10. Describe the usage of the graphic package in LaTeX, including drawing matrices, creating tables with captions, and referencing figures and tables within text.

POOL C

ABILITY ENHANCEMENT COURSE –II

Course code: **MSSTA02AEC02**

Name of the Course: **Basic Statistical data analysis using EXCEL**.

Department Offering the Course: **Department of Statistical Sciences**

Mode of Delivery: **Hybrid**

Credit Distribution, Eligibility and Pre-Requisites of the Course

Credits	Credit distribution			Eligibility Criteria	Pre-requisite (if any)
	Lecture	Tutorial	Practical/ Internship		
2	1	1	2		Basic knowledge of statistics

Skill Outcomes:

To build a strong understanding on the Basics of Microsoft Excel, To understand data crunching, Understand core analytic techniques that work in Excel, Data visualization in Excel.

Course Contents:

Module 1: Excel Introduction, Basic Navigation Tab, Concept of Cell and Cell address , row Column concept, Basic mathematical and statistical functions in Excel.

Module 2: Min, Max, Trim, Lower, Upper, Proper, Left, Right, Mid Exact, Randbetween, Rand, Len (Length of character) Paste special, SQRT, If function with Example of IF, More function like And, OR with their example, Conditional Formatting basic and advance level with OR, AND, Nested IF function, Index, Offset, Match.

Module 3: Graphics in excel-pie chart, bar chart, multiple bar diagram, sub-divided bar diagram, histogram, line chart, scatter diagram, box plot.

Module 4: Median, Mode, Standard Deviation (SD), Correlation, Large, Small, Pivot Table, Pivot Charts, Slicing, Sparkling.

Suggested Readings:

1. Linoff, Gordon S (2015). *Data analysis using SQL and Excel*. John Wiley & Sons.
2. Guerrero, Hector, Rauscher Guerrero, and Rauscher (2019). *Excel data analysis*. Springer International Publishing.

TEACHING LEARNING STRATEGIES

- **Hands on training, Lecturing, Visualization, Team Learning.**

MODE OF TRANSACTION

- **Lab session, Lecture, Seminar, Discussion, Questioning and Answering**

Assessment Rubrics: Evaluation by Department

Sample Questions to Test Outcomes:

1. What is the purpose of Excel and how is it commonly used in data management and analysis?
2. Describe the basic navigation tab in Excel and explain the concept of cells, cell addresses, rows, and columns.
3. Discuss basic mathematical and statistical functions in Excel, including examples of their usage.

4. Explain the functions MIN, MAX, TRIM, LOWER, UPPER, PROPER, LEFT, RIGHT, MID, EXACT, RANDBETWEEN, RAND, and LEN, and how they are used in Excel.
5. How does the Paste Special function work in Excel, and what are its common applications?
6. Walk through the usage of the SQRT function and demonstrate its application in Excel.
7. Provide examples of the IF function in Excel and discuss its importance in conditional logic.
8. Explain the functions AND and OR in Excel with examples, and discuss their usage in conjunction with conditional formatting.
9. What are nested IF functions in Excel, and how are they implemented? Provide examples.
10. Discuss advanced functions such as INDEX, OFFSET, MATCH, and their applications in Excel data analysis and manipulation.

POOL D

SKILL ENHANCEMENT COURSE (SEC)-I

Course code: **MSSTA02SEC01**

Name of the Course: **Exploratory Data Analysis Using SPSS**

Department Offering the Course: **Department of Statistical Sciences**

Mode of Delivery: **Hybrid**

Credit Distribution, Eligibility and Pre-Requisites of the Course

Credits	Credit distribution			Eligibility Criteria	Pre-requisite (if any)
	Lecture	Tutorial	Practical/ Internship		
2	1	1	2		Knowledge of basic statistics

Skill Outcomes: To introduce students with a software that is being widely used for Statistical data analysis. To make students know importance of this software for data analysis in research articles and thereby help them to be comfortable with the software.

Course Contents:

Module 1: What is SPSS?, Opening SPSS, Layout of SPSS,Structure of SPSS Exiting SPSS, inputting data, An overview of SPSS.

Module 2: Exploring data distributions using descriptive statistics, Creating frequency distributions and summary tables, Generating basic visualizations (e.g., histograms, box plots) in SPSS.

Module 3: Understanding correlation and covariance, Performing correlation analysis in SPSS, Introduction to linear regression and its application in SPSS,Understanding hypothesis testing principles, Conducting hypothesis tests in SPSS, Interpreting SPSS output for hypothesis testing.

Module 4: Generating various types of charts and graphs in SPSS, Customizing visualizations for clarity and impact, exploring the SPSS Chart Builder tool.

Suggested Readings:

1. Landau, S., & Everitt, B. S. (2003). *A handbook of statistical analyses using SPSS*. Chapman and Hall/CRC.

2. Tukey, J. W. (1977). *Exploratory data analysis* (Vol. 2).

3. Aldrich, J. O. (2018). *Using IBM SPSS statistics: An interactive hands-on approach*. Sage Publications.

TEACHING LEARNING STRATEGIES

- **Hands on training, Lecturing, Visualization, Team Learning.**

MODE OF TRANSACTION

- **Lab session, Lecture, Seminar, Discussion, Questioning and Answering**

Assessment Rubrics: Evaluation by Department

Sample Questions to Test Outcomes:

1. What is the purpose of SPSS and how does it contribute to statistical analysis?
2. Describe the layout and structure of SPSS interface, including its main components and functions.
3. How do you open and exit SPSS, and what considerations should be taken into account?
4. Explain the process of inputting data into SPSS and discuss common formats accepted.
5. What are descriptive statistics, and how can they be used to explore data distributions in SPSS?

6. Describe the steps involved in creating frequency distributions and summary tables using SPSS.
7. How can basic visualizations such as histograms and box plots be generated in SPSS, and what insights can they provide?
8. What are correlation and covariance, and how are they calculated and interpreted in SPSS?
9. Discuss the principles of hypothesis testing and how it is conducted in SPSS.
10. Explain how to customize visualizations for clarity and impact in SPSS, and explore the functionalities of the SPSS Chart Builder tool.

POOL D: SKILL ENHANCEMENT COURSE (SEC)-II

Course code: **MSSTA02SEC02**

Name of the Course: **Regression Analysis Using SPSS**

Department Offering the Course: **Department of Statistical Sciences**

Mode of Delivery: **Hybrid**

Credit Distribution, Eligibility and Pre-Requisites of the Course

Credits	Credit distribution			Eligibility Criteria	Pre-requisite (if any)
	Lecture	Tutorial	Practical/ Internship		
2	1	1	2		Basic knowledge in regression.

Skill Outcomes: To introduce students with software that is being widely used for regression analysis. To make students know importance of this software for data analysis in research articles and thereby help them to be comfortable with the software.

Course Contents:

Module 1: What is SPSS? Opening SPSS, Layout of SPSS, Structure of SPSS Exiting SPSS, inputting data, an overview of SPSS.

Module 2: Introduction to SPSS regression procedures, Importing and preparing data for regression analysis, Overview of the SPSS regression dialog box, Conducting simple linear

regression in SPSS, Interpreting regression output in SPSS, Assumptions and diagnostics in simple linear regression

Module 3: Understanding and formulating multiple linear regression models, Conducting multiple linear regression analysis in SPSS, Interpreting output and assessing model fit

Module 4 : Assumption testing for multiple regression, Dealing with multicollinearity in SPSS Interpreting diagnostic plots and statistic, Organizing and documenting regression analysis in SPSS, Creating comprehensive reports with SPSS output, Best practices for presenting regression findings to diverse audiences

Suggested Readings:

1. Landau, S., & Everitt, B. S. (2003). *A handbook of statistical analyses using SPSS*. Chapman and Hall/CRC.

2. Aldrich, J. O. (2018). *Using IBM SPSS statistics: An interactive hands-on approach*. Sage Publications.

3. Chatterjee, S., & Hadi, A. S. (2013). *Regression analysis by example*. John Wiley & Sons.

TEACHING LEARNING STRATEGIES

- **Hands on training, Lecturing, Visualization, Team Learning.**

MODE OF TRANSACTION

- **Lab session, Lecture, Seminar, Discussion, Questioning and Answering**

Assessment Rubrics: Evaluation by Department

Sample Questions to Test Outcomes:

1. What are the key components of SPSS and how do they contribute to statistical analysis?
2. How do you input data into SPSS and what are the common formats accepted?
3. Describe the process of exiting SPSS and any considerations to keep in mind.
4. What are the steps involved in importing and preparing data for regression analysis in SPSS?
5. Explain the regression dialog box in SPSS and its various options for analysis

	THIRD SEMESTER								
Sl No	**Course Code**	**Title of Paper**	**Contact Hours/Week**			**Marks**			
			L	**T/S**	**P**	**ESE**	**CE**	**Total**	**Credits**
DISCIPLINE SPECIFIC CORE COURSES (DCE)									
3.1	MSSTA03DSC09	Design of Experiments	4	1		60	40	100	4
3.2	MSSTA03DSC10	Multivariate Analysis	4	1		60	40	100	4
DISCIPLINE SPECIFIC ELECTIVES (DSE)									
3.3	MSSTA03DSExx	Elective –I-DSE (**Pool E**) (Practical)	-	2	4	60	40	100	3
3.4	MSSTA03DSExx	Elective –II-DSE (**Pool F**)	3	1		60	40	100	3
	MSSTA03DSExx	Elective –III-DSE (**Pool F**)	3	1		60	40	100	3
INTERDISCIPLINARY ELECTIVE COURSE (IDC)*-									
3.5	MSSTA03IDCxx	IDC Elective (**Pool G**) (Offered to other Departments)	3	2		60	40	100	4
	----------	To be obtained from other departments	--	--	--	--	--	--	--
*-Compulsory course									
VAC/MOOC COURSE*									
3.6	MOOC	Offered by external agencies							2
3.7	MSSTA03VACxx	VAC	2	2	2	60	40	100	2
*** Credits over and above**.									
INTERNSHIP/FIELD VISIT/ MINOR PROJECT/ INDUSTRIAL VISIT									
			2	-	-	60	40	100	2
Total Credits									**23**

L=Lecture, T/S=Tutorials/Seminar, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

Sl No	POOL E DISCIPLINE SPECIFIC ELECTIVES (DSE)								
3.3.1	MSSTA03DSE05	Statistical Computing Using SAS (**Practical**)	-	2	6	60	40	100	3
3.3.2	MSSTA03DSE06	Statistical Computing Using R-III (**Practical**)	-	2	6	60	40	100	3
POOL F **DISCIPLINE SPECIFIC ELECTIVES (DSE)**									
3.4.1	MSSTA03DSE07	Applied Regression Analysis	4	1	-	60	40	100	3
3.4.2	MSSTA03DSE08	Analysis of Clinical Trials	4	1	-	60	40	100	3
3.4.3	MSSTA03DSE09	Statistical Epidemiology	4	1	-	60	40	100	3
3.4.4	MSSTA03DSE10	Survival Analysis	4	1	-	60	40	100	3
3.4.5	MSSTA03DSE11	Operations Research	4	1	-	60	40	100	3
3.4.6	MSSTA03DSE12	Statistical Machine Learning	4	1	-	60	40	100	3
3.4.7	MSSTA03DSE13	Data Visualisation and analysis using Python	2	1	4	60	40	100	3

Sl No	POOL G:- List of INTERDISCIPLINARY ELECTIVES for other Departments (IDC)								
3.5.1	MSSTA03IDC01	Statistical Data Analysis Using SPSS		2	6	60	40	100	4

3.5.2	MSSTA03IDC02	Statistical Data Analysis Using R		2	6	60	40	100	4

DISCIPLINE SPECIFIC CORE COURSE

Course Code & Title	**MSSTA03DSC09- DESIGN OF EXPERIMENTS**	
Programme	**M.Sc. Statistics**	**Semester III**
Course Description	This course provides a comprehensive exploration of the Multivariate Normal Distribution, covering its properties, and various distributions derived from it. Additionally, the course delves into the properties of the Wishart distribution and its application in testing problems using Mahalanobis D^2 and Hotelling's T^2 statistics, as well as applied multivariate analysis areas like principal component analysis, factor analysis.	
Course Objectives	• Describe multivariate normal distribution and its properties. • Find the marginal and conditional distribution of multivariate normal distribution. • Find the distribution of quadratic forms of multivariate normal vectors. • Describe Wishart distribution and its properties. • Obtain the estimators for parameters of multivariate normal distribution. • Describe multiple and partial correlation coefficients. • Define sample multiple and sample partial correlation coefficients for multivariate normal vector. • Test the hypothesis regarding parameters of multivariate normal distribution. • Use Hotelling's T^2 and Mahalanobis D^2 statistics for testing hypothesis.	

Modules	Content	Module Outcome
Module I: Multivariate Normal Distribution (**15 hours**)	Multivariate Normal Distribution– Definition and properties, conditional distributions, marginal distributions. Independence of a linear form and quadratic form, independence of two quadratic forms, distribution of quadratic form of a multivariate vector, partial and multiple correlation coefficients, partial and multiple regression coefficients.	• Define the multivariate normal density function. • Obtain the characteristic function of multivariate normal density • Find the distribution of linear combination of multivariate normal random vector using characteristic function
Module II: Estimation of Multivariate Normal Distribution and Wishart Distribution (**15 hours**)	Estimation of mean vector and dispersion matrix – Maximum likelihood estimation of the mean vector and dispersion matrix. Distribution of simple, partial and multiple (null-caseonly) correlation coefficients; canonical correlation. Wishart distribution-properties– generalized variance.	• Obtain the MLEs of mean and variance of multivariate normal distribution • Find the characteristic function of Wishart distribution • Show that Wishart distribution possess additive property. • Find the distribution of sample dispersion matrix.
Module III: Hypothesis Tests based on Multivariate Normal Distribution (**20 hours**)	Testing problems based on Mahalanobis D^2 and Hotelling's T^2 statistics, Likelihood ratio tests – Testing the equality of mean vector, equality of dispersion matrices, testing the independence of subvectors, sphericity test.	• Test the mean vector of a multivariate normal distribution. • Test the equality of means of two or more multivariate normal distributions. • Use Hotelling's T^2 and Mahalanobis D^2 statistics in testing hypothesis regarding multivariate normal

		distributions. • Find the relationship between Hotelling's T^2 and Mahalanobis D^2 statistics.
Module IV: Classification Problem and Principal Component Analysis **(15 hours)**	The problem of classification-classification of one of two multivariate normal populations when the parameters are known and unknown and extension to several multivariate normal populations. Population principal components – summarizing sample variation by principal components – iterative procedure to calculate sample principal components, factor analysis, cluster analysis.	• Perform principal component analysis and factor analysis. • Classify individuals/items in to one of k multivariate normal populations. • Identify canonical variables and quantify canonical correlation
References	***Text Books*** 1. Anderson, T. W.(1984): *Multivariate Analysis*. John-Wiley, New York. 2. Johnson, R.A. and Wichern, D.W. (2001): *Applied Multivariate Statistical Analysis,* 3rdEdn., Prentice Hall of India, New Delhi. ***Reference Books*** 1. Rao, C.R.(2002): *Linear Statistical Inference and Its Applications*, Second Edition, John Wiley and Sons, New York. 2. Kshirasagar, A.M.(1972):*Multivariate Analysis.* Marcel Dekker, New-York. 3. Rencher, A.C. (1998): *Multivariate Statistical Analysis*. Jon Wiley, New York. 4. Morrison, D.F.(1976): *Multivariate Statistical Methods*, McGraw Hill. New York.	
	After successful completion of this course, student will be able to:	

Course Outcomes	1. Understand the concepts of Sufficiency and Completeness 2. Understand the concepts of Minimum Variance Unbiased Estimation. 3. Understand various estimation methods and applications in real life problems. 4. Apply various parametric and sequential testing procedures to deal with real life problems. 5. Understand Most Powerful Tests for testing simple null hypothesis and developing MP tests for different problems.

TEACHING LEARNING STRATEGIES

- **Lecturing, Visualization, Team Learning**

MODE OF TRANSACTION

- **Lecture, Seminar, Discussion, Questioning and Answering**

ASSESSMENT RUBRICS

Components	Weightage
End Semester Evaluation (ESE)	**60**
Continuous Evaluation	
Tests	16
Assignment	08
Seminar/Viva	16
Total	**40**

Sample Questions to Test Outcomes:

1. Define a singular multivariate normal distribution. Give an example of a random vector following singular multivariate normal distribution.
2. Write down the density function of a non-singular multivariate normal distribution.
3. Let $X \sim N_2(\mu, \Sigma)$ where $\mu = \begin{bmatrix} -10 \\ 20 \end{bmatrix}$ and $\Sigma = \begin{bmatrix} 2 & -2 \\ -2 & 5 \end{bmatrix}$. Write down the correlation matrix. Also obtain the distribution of $Y = [x_1, -2x_2]$
4. Define partial and multiple correlations and explain how you evaluate it from a non-singular covariance matrix.
5. Compute the multiple correlation $\rho_{4.123}$ from the following covariance matrix

$$\Sigma = \begin{bmatrix} 2 & -1 & 0 & 1 \\ -1 & 4 & 1 & 0 \\ 0 & 1 & 2 & 1 \\ 1 & 0 & 1 & 8 \end{bmatrix}$$

6. Let $X = (x_1, x_2, \ldots, x_p) \sim N_p(\mu, \Sigma), \Sigma > O$, and let $X_1 = (x_1, x_2, \ldots, x_q)'$ $X_2 = (x_{q+1}, x_{q+2}, \ldots, x_p)'$ Derive the conditional distributions of $X_1|X_2$ and $X_2|X_1$
7. Derive the distribution of sample mean of a sample of size n from $N_p(\mu, \Sigma)$
8. Show that sample mean and sample covariance matrix are independently distributed when the sample is from $N_p(\mu, \Sigma), \Sigma > 0$.
9. Derive the characteristic function of a Wishart distribution and use it to prove its additive property.
10. Define Mahalanob's D^2 statistics and explain its role in multivariate analysis.

DISCIPLINE SPECIFIC CORE COURSE

Course Code & Title	**MSSTA03DSC10: MULTIVARIATE ANALYSIS**	
Programme	**M.Sc. Statistics**	**Semester III**
Course Description	This course provides a foundational understanding of key terminologies and concepts in experimental design and analysis. The course explores techniques for handling missing data and delves into the analysis of completely randomized, randomized block, Latin square, and Graeco-Latin square designs. Additionally, students will gain proficiency in fitting models, assessing model adequacy, conducting ANOVA, post hoc analyses, and dealing with incomplete block designs. Factorial experiments, complete and partial confounding, are also discussed extensively.	
Course Objectives	• Understand the basic principles and guidelines of Design of experiments • Design and analyze various designs like CRD RBD, LSD and Greatcoat LSD. • Apply incomplete block designs in designing experiments and analyze them. • Understand and apply the factorial designs and its various versions. • Apply Response surface methodology and understanding various aspects involved in it.	

Modules	Content	Module Outcome
Module I: (**15 hours**) Basics of design of experiments	Basic terminology and definitions, Fixed, mixed and random effect models, Gauss Markov theorem, fundamental principles of design of experiments, Analysis of variance-one way and two way, Analysis of co-variance for completely randomized and randomized block designs. Analysis of experiments with missing observations.	• Learn fixed, mixed and mixed effect models. • Understand one way and two way ANOVA. • Understand how to perform ANCOVA. • Learn estimation of missing data.
Module II: **(15 hours)** Detailed study of randomized designs	Completely randomized design-analysis, randomized block design-analysis, Latin square design-analysis, Graeco-Latin square design, analysis of missing data. Fitting and Model adequacy checking. ANOVA and Post Hoc analysis.	• Learn CRD, LSD, GLSD designs and their analysis. • Understand methods for model adequacy checking
Module III: **(15 hours)** Incomplete designs and their properties	Incomplete block design-Balanced incomplete block design, intra and inter block analysis of BIBD, partially balanced incomplete block design.	• Learn incomplete block design and balanced incomplete block design • Understand partially incomplete design
Module IV: (**15 hours**) Factorial moments	Factorial experiments-2^n and 3^n, concept of complete and partial confounding in symmetrical factorial designs.	• Learn factorial experiments • Understand concept of confounding

References	***Text Books*** 1. Das, M.N. and Giri, N.S. (2002): *Design and Analysis of Experiments, 2nd Edition*, New Age International(P) Ltd., New Delhi. 2. Joshi,D.D.(1987):*Linear Estimation and Design of Experiments*. Wiley Eastern Ltd., New Delhi. 3. Montgomery, D.C. (2001*): Design and Analysis of Experiments. 5th Edition,* John Wiley & Sons-New York. ***Reference Books*** 1. Gupta, S. C and Kapoor, V. K.(2010). *Fundamentals of Applied Statistics.* Sulthan Chand & Co, New Delhi. 2. Dean,A. and Voss, A.(1999):*Design and Analysis of Experiments*. Springer Verlag, New York. 3. Box, G.E .P. Hunter, W. (2005*): Statistics for Experimental Design, Innovations and Discovery, Vol. II*, Wiley.
Course Outcomes	After successful completion of this course, student will be able to: 1. Apply ANOVA for one way and two way classification, fixed effect models with equal and unequal number of observations per cell, Random and Mixed effect models. 2. Design and analyse incomplete block designs, understand the concepts of orthogonality, connectedness and balance. 3. Identify the effects of different factors and their interactions and analyse factorial experiments. 4. Construct complete and partially confounded factorial designs and perform their analysis. 5. Apply Split-plot designs and their analysis in practical situations.

TEACHING LEARNING STRATEGIES

- **Lecturing, Visualization, Team Learning**

MODE OF TRANSACTION

- **Lecture, Seminar, Discussion, Questioning and Answering**

ASSESSMENT RUBRICS

Components	Weightage
End Semester Evaluation (ESE)	**60**
Continuous Evaluation	
Tests	16
Assignment	08
Seminar/Viva	16
Total	**40**

Sample Questions to Test Outcomes:

1. Define the basic terminology used in the design of experiments and differentiate between fixed, mixed, and random effect models.
2. Explain the Gauss Markov theorem and its significance in the context of experimental design.
3. What are the fundamental principles of design of experiments, and how are they applied in practice?
4. Describe the analysis of variance (ANOVA) for one-way and two-way experimental designs, highlighting their differences and similarities.
5. Discuss the analysis of covariance (ANCOVA) and its application in completely randomized block design.
6. How do you analyze experiments with missing observations? Discuss the methods and considerations involved.
7. Provide a detailed explanation of completely randomized design (CRD), including its analysis and interpretation.

8. Explain the concept of randomized block design (RBD) and discuss its analysis methods, including the use of ANOVA and post hoc tests.
9. What is a Latin square design, and how is it analyzed? Discuss the Greatcoat least significant difference (LSD) method and its application
10. Describe incomplete block designs, focusing on balanced incomplete block design (BIBD) and its intra and inter-block analysis. Discuss the properties and applications of BIBD.

POOL E: DISCIPLINE SPECIFIC ELECTIVE COURSE(DSE)

Course Code & Title	**MSSTA03DSE05-STATISTICAL COMPUTING USING SAS (PRACTICAL)**		
Programme	**M.Sc. Statistics**	**Semester**	**III**
Course Objectives	• To introduce some advanced statistical computing techniques in applied statistics to extract information and visualization thereby enabling them to perform data analysis effectively and efficiently in SAS programming. • Illustrate different statistical techniques based on all the elective course in third semester.		

Modules	Content	Module Outcome
	Statistical Computing III is a practical course. The practical is based on all the elective courses in the third semester.	• Describe different statistical technique to solve problems coming under all the elective courses in third semester.
Course Outcomes	After successful completion of this course, student will be able to: 1. Equipped with different theoretical methods in applied statistics to achieve the objectives. 2. Enhanced with the basic concepts of statistical theories besides developing their ability to handle real world problems with large scale data.	

TEACHING LEARNING STRATEGIES

- **Practical sessions through computers, statistical computations, Team Learning**

MODE OF TRANSACTION

- **Lecture, Seminar, Hands on training**

ASSESSMENT RUBRICS

Components	Weightage
End Semester Evaluation	**60**
Continuous Evaluation	
Practical Tests	32
Record	08
Total	**40**

POOL E: DISCIPLINE SPECIFIC ELECTIVE COURSE

Course Code & Title	**MSSTA03DSE06-STATISTICAL COMPUTING USING R – III (PRACTICAL)**		
Programme	**M.Sc. Statistics**	**Semester**	**III**
Course Objectives	• To introduce some advanced statistical computing techniques in applied statistics to extract information and visualization thereby enabling them to perform data analysis effectively and efficiently in R programming. • Illustrate different statistical techniques based on all the elective course in third semester.		

Modules	Content	Module Outcome

	Statistical Computing III is a practical course. The practical is based on all the courses in the third semester.	• Describe different statistical technique to solve problems coming under all the courses in third semester.
Course Outcomes	After successful completion of this course, student will be able to: 1. Equipped with different theoretical methods in applied statistics to achieve the objectives. 2. Enhanced with the basic concepts of statistical theories besides developing their ability to handle real world problems with large scale data.	

TEACHING LEARNING STRATEGIES

- **Practical sessions through computers, statistical computations, Team Learning**

MODE OF TRANSACTION

- **Lecture, Seminar, Hands on training**

ASSESSMENT RUBRICS

Components	**Weightage**
End Semester Evaluation	**60**
Continuous Evaluation	
Practical Tests	32
Record	08
Total	**40**

POOL F: DISCIPLINE SPECIFIC ELECTIVE COURSE

Course Code & Title	**MSSTA03DSE07- APPLIED REGRESSION ANALYSIS**		
Programme	**M.Sc. Statistics**	**Semester**	**III**
Course Description	This course delves into the fundamentals of regression analysis, starting with simple linear regression models and least square estimation techniques. Additionally, students will learn how to interpret error and residual plots to assess model fit and diagnose potential issues. The course also covers advanced topics such as multicollinearity, heteroscedasticity, and autocorrelation, including their nature, consequences, detection methods, and remedial measures.		
Course Objectives	• Describe simple and multiple linear regression models and its properties • Apply principle of least square method to estimate the parameters in simple and multiple linear regression models. • Identify multicollinearity problem, its consequences. • Discuss the problem of estimation of parameters when multicollinearity occurs. • Identify auto correlation and its consequences. • Explain the consequence of the presence of error in variables while estimating the parameters of a structural equation. • Explain polynomial regression. • Explain generalized linear model. • Explain logistic regression.		

Modules	Content	Module Outcome
Module I: Simple Linear Regression Models **(15 Hours)**	The simple linear regression model, least square estimation, statistical assumptions and properties of estimators, standard error of estimates, tests of significance and confidence intervals for the parameters, error and residual plots.	• Explain simple linear regression model • Describe least square estimators. • Articulate to inference regarding regression parameters.
Module II: Multiple Regression, Diagnostics, **(15 Hours)**	Multiple regression models, OLS and ML estimators, testing and prediction. Diagnostic checks and correction. Generalized and Weighted Least Squares Estimation. Multicollinearity, heteroscedasticity and autocorrelation: their nature, consequences, detection, remedial measures and estimation in the presence of them.	• Explain multiple linear regression. • Parameter estimation in multiple linear regression model. • Explain multicollinearity. Discuss detection and remedial measures of multicollinearity. • Explain heteroscedasticity. Discuss detection and remedial measures of heteroscedasticity
Module III: Polynomial and Nonparametric Regression **(15 Hours)**	Diagnostic for Leverage and Influence. Polynomial regression in one and several variables. Linearization transforms, Indicator Variables, Non parametric regression, and concept of spline smoothing.	• Understand influential and leverage points and their impacts on regression model. • Explain polynomial regression and non parametric regression.

Module IV: Non-Linear Regression, GLM **(15 Hours)**	Generalized linear models. Logistic regression. Poisson regression. Variable Selection and Model Building. Estimation of GLM.	• Discuss generalized linear model and its members. • Explain logistic regression and Poisson Regression.
References	***Text Books*** 1. Draper, N. R. and Smith, H.(1998): *Applied Regression Analysis, 3rd Ed.* John Wiley. 2. Gujarati, D.N. (2007): *Basic Econometrics (Fourth Edition)*, McGraw- Hill, New York. 3. Hosmer, D.W. and Lemeshow, S.(1989): *Applied Logistic Regression*, John Wiley. 4. Montgomery, D.C, Peek, E.A. and Vining, G.G.(2006): *Introduction to Linear Regression Analysis*, John Wiley. ***Reference Books*** 1. Seber, G.A. F. and Lee, A. J.(2003): *Linear Regression Analysis*, Wiley 2. Johnston, J.(1984): *Econometric Methods,3rded.,* McGraw Hill, New York. 3. Goon, Gupta, Das Gupta (2001): *An Outline Series in Statistics Vol1I,* World Press.	
Course Outcomes	After successful completion of this course, student will be able to: 1. Understand various regression models including logistic regression models and generalized linear models. 2. Understand consequences of multicollinearity, heteroscedasticity, autocorrelation, their detection and remedial measures. 3. Apply statistical techniques to model relationships between variables and make predictions. 4. Acquire knowledge of various advanced regression	

	models, estimation methods and related econometric theories.

TEACHING LEARNING STRATEGIES

- **Lecturing, Visualization, Team Learning**

MODE OF TRANSACTION

- **Lecture, Seminar, Discussion, Questioning and Answering**

ASSESSMENT RUBRICS

Components	Weightage
End Semester Evaluation (ESE)	**60**
Continuous Evaluation	
Tests	16
Assignment	08
Seminar/Viva	16
Total	**40**

Sample Questions to Test Outcomes:

1. What are simple linear regression models, and how are they estimated using the method of least squares? Discuss the statistical assumptions underlying the least squares estimation.
2. Explain the properties of estimators in simple linear regression. What is the standard error of estimates, and how is it calculated?
3. Describe tests of significance and confidence intervals for the parameters in simple linear regression. How do these tests help in assessing the significance of the relationship between variables?
4. Discuss error and residual plots in the context of simple linear regression. How are these plots used to assess the adequacy of the regression model?

5. Define multicollinearity, heteroscedasticity, and autocorrelation in multiple regression models. What are their consequences, and how can they be detected and remedied?
6. Explain the methods of ordinary least squares (OLS) and maximum likelihood (ML) estimation in multiple regression models. When is each method preferred, and what are their properties?
7. Describe simultaneous equation models, including examples. What issues arise from the inconsistency of OLS estimators, and how can they be addressed through identification rules?
8. Discuss the method of indirect least squares and the method of two-stage least squares for estimation in simultaneous equation models. How do these methods address identification problems?
9. Explain polynomial regression in one and several variables. What are linearization transforms, and how are they used in polynomial regression models?
10. Define generalized linear models, logistic regression, and nonparametric regression. How do these models differ from traditional linear regression models, and what are their applications?

POOL F: DISCIPLINE SPECIFIC ELECTIVE COURSE

Course Code & Title	**MSSTA03DSE08-ANALYSIS OF CLINICAL TRIALS**		
Programme	**M.Sc. Statistics**	**Semester**	**III**
Course Objectives	• Understand the basic concepts, need and ethics of clinical trials. • Have a clear idea on types of forms, clinical practice and clinical data management. • Understand about different types of errors and blinding techniques used in a clinical trial. • Understand about different types of randomization procedures and designs used in a clinical trial. • Determine the sample size for different types of response variables.		

	• Have a clear idea on reporting and interpreting of results in a clinical trial. • Describe multi-centre trials, surrogate endpoints, bioassay, and meta-analysis.

Modules	Content	Module Outcome
Module I: Basics of Clinical Trials, Errors, and Data management **(15 Hours)**	Introduction to clinical trials, Need of clinical trials, Adverse events, Placebo, Study protocol, Case report form (CRF) and E-CRF, Informed consent form (ICF), Phases of clinical trial – overview of phase I to phase IV clinical trials, Ethics of animal experimentation and ethics of clinical trial, bias and random error in clinical studies, Systematic errors- assembly bias, detection bias, measurement bias, recall bias, post entry exclusion bias, bias due to selective loss of data, assessment bias, Standard operating procedure (SOP), Good clinical practice (GCP)- goals and WHO principles, Clinical Data management (CDM)– development of case report forms, database development, data entry, query, and correction, database lock, archive and transfer, data edit check specifications.	• Understand the need and ethics of clinical trial. • Describe different types of forms used in clinical trial. • Understand about different types of errors that occur during the conduct of clinical trial. • Have a clear idea on clinical practice and clinical data management.
Module II: Randomization, Blindness & Design of	Randomization- Adaptive and Non-adaptive randomization- simple, stratified, blocked, baseline adaptive and response adaptive, Randomized and non-randomized	• Understand about different types of randomization procedures used in

Clinical Trials **(15 Hours)**	control trials, Methods of blinding – unblind, single, double, and triple blinded trials, Design of clinical trials-parallel group designs, crossover designs, factorial designs, adaptive designs, group sequential designs, Zelen designs, historical control, hybrid design, Comparative and controlled trials.	clinical trials. • Have an idea on different types of blinding. • Describe different types of designs used in clinical trials.
Module III: Sample Size Determination, interpretation of results, Multi-center trials **(15 Hours)**	Sample size determination for two independent and paired samples-continuous and dichotomous response variable, Sample size determination for time to failure data, Multi-centre trials– reason and conduct of trials, Reporting and interpreting of results in a clinical trial – guidelines for reporting, interpretation and publication bias, Surrogate end points and outcome measure.	• Determine the sample size for different types of response variables. • Describe multi-centre trials. • Have a clear idea on reporting and interpreting of results in a clinical trial. • Describe surrogate endpoints.
Module IV: Bioassay &Meta Analysis **(15 Hours)**	Bioassay– Standard and test preparation, Relative potency, Analytical dilution and comparative dilution assay, Design of bioassays, Direct and indirect assays, Equipotent doses, Dose meta meters, Parallel line and slope ratio assays-analysis and validity test, Quantal assay and probit analysis, Meta analysis- concept and goals, steps, statistical methods –fixed and random effect approaches, concern and conclusion.	• Understand different types of bioassay and their analysis. • Describe meta-analysis.

References	***Text Books*** 1. Friedman, L. M., Furburg, C.D. Demets, L.(1998): *Fundamentals of Clinical Trials*, Springer Verlag. 2. Jennison and B. W. Turnbull (1999*): Group Sequential Methods with Applications to Clinical Trials,* CRC Press. 3. Kulinskaya E, Morgeathaler S, Staudte R G(2008), *Meta-analysis*, Wiley. ***Reference Books*** 1. Das, M. N. and Giri (2008). *Design of Experiments*, New Age, India 2. Fleiss,J.L.(1989): *The Design and Analysis of Clinical Experiments*, Wiley. 3. Piantadosi S. (1997): *Clinical Trials: A Methodological Perspective*. Wiley. 4. Wrosenberger, J M Lachin (2002): *Randomization in Clinical Trials Theory and Practice*, Wiley.
Course Outcomes	After successful completion of this course, student will be able to: 1. Understand Basics of Clinical Trials. 2. Understand design of clinical trials. 3. Understand Sample size determination in clinical trials. 4. Understand the concept of meta-analysis in clinical trials.

TEACHING LEARNING STRATEGIES

- **Lecturing, Visualization, Team Learning**

MODE OF TRANSACTION

- **Lecture, Seminar, Discussion, Questioning and Answering**

ASSESSMENT RUBRICS

Components	Weightage
End Semester	**60**

Evaluation(ESE)	
Continuous Evaluation	
Tests	16
Assignment	08
Seminar/Viva	16
Total	**40**

Sample Questions to Test Outcomes:

1. What is the purpose of conducting clinical trials, and why are they essential in the field of medicine?
2. Explain the concept of adverse events in clinical trials. How are they monitored and reported?
3. Define the term "placebo" and discuss its role in clinical research. How is it used in placebo-controlled trials?
4. Describe the components of a study protocol and their significance in ensuring the integrity and validity of a clinical trial.
5. Differentiate between a Case Report Form (CRF) and an Electronic Case Report Form (e-CRF). What are the advantages of using e-CRFs?
6. Discuss the importance of obtaining informed consent from participants in clinical trials. What information should be included in an informed consent form (ICF)?
7. Provide an overview of the phases of clinical trials (Phase I to Phase IV) and their respective objectives.
8. What are the ethical considerations involved in animal experimentation and clinical trials involving human subjects? Discuss the principles of Good Clinical Practice (GCP) endorsed by the World Health Organization (WHO).
9. Explain the concepts of bias and random error in clinical studies. Provide examples of systematic errors commonly encountered in clinical research.

10. Describe the role of Standard Operating Procedures (SOPs) in ensuring quality and consistency in clinical trial conduct. What are the goals of Good Clinical Practice (GCP), and how do they contribute to the integrity of clinical research?

POOL F: DISCIPLINE SPECIFIC ELECTIVE COURSES

Course Code & Title	**MSSTA03DSE09-STATISTICAL EPIDEMIOLOGY**	
Programme	**M.Sc. Statistics**	**Semester III**
Course Description	This course introduces fundamental concepts in epidemiology, exploring its definition, scope, and notable achievements The course addresses potential errors in epidemiological studies and ethical considerations. Additionally, distribution and summary measures are discussed, encompassing central tendency, variability, and distributions like normal and log normal. Furthermore, the concept of causation, strategies for establishing the cause of disease, levels of prevention, and an introduction to clinical epidemiology are explored.	
Course Objectives	• To understand basic concepts of epidemiology and explain different study designs in epidemiology. • Identifying achievements in epidemiology and measuring health and disease. • To aquire the knowledge of cohort study designs, case control study designs. • Develop the knowledge of various matched case control studies and cross over study designs. • To know about statistical concepts and inference. • Understand relationship between variables. • State Mendal's law and estimation of allele frequency, estimation of allele frequencies, Hardy-Weinberg law. • Introduce the concept of detection and estimation of linkage, inheritance of quantitative traits, stochastic models of carcinogenesis.	

Modules	Content	Module Outcome
Module I: Basic concepts of Epidemiology **(15 Hours)**	Basic concepts of epidemiology: definition and scope of epidemiology, achievements in epidemiology, measuring health and disease, definition of health and disease, measures of disease frequency, comparing disease occurrence.	• Explain the basic concepts of epidemiology. • Understand the difference between measuring health and disease. • Comparing disease occurrence.
Module II: Study designs in epidemiology **(15 Hours)**	Types of study: observations and experiments, observational epidemiology, cohort study designs, case control study designs,randomized, field trials, control trials, potentials errors in epidemiological studies, ethical issues	• Explain different study designs in epidemiology. • Understand various cohort and case control studies in biostatistics.
Module III: Exploratory analysis **(15 Hours)**	Distribution and summary measures: distribution, measures of central tendency, measures of variability, normal and log normal distributions, estimation, testing, CI, ANOVA, relationship between two variables: chi-square test, correlation, regression, logistic regression.	• To understand statistical concepts. • To know about relationship between two variables.
Module IV: Clinical epidemiology **(15 Hours)**	Concept of cause, establishing the cause of disease, scope of prevention, levels of prevention, Introduction to clinical epidemiology	• Understand the concept of Concept of cause. • Identifying the scope of prevention. • Understand the basic concepts of clinical

		epidemiology.
References	***Text Books*** 1. Beaglehole,R.,Bonita,R.andKjellstorm,T.(1993).*BasicEpidemiology*.WorldHealthOrganization,Geneva. 2. Newman,S.C.(2001).*BiostatisticalMethodsinEpidemiology*.JohnWiley &Sons,NewYork 3. Virasakdi, C. (2010). *Analysis of Epidemiological Data Using R and Epicalc*. Epidemiological Unit, Songla University, Thailand ***Reference books*** 1. Rothan, K. J., Greenland, S. and Lash, T.L. (2008). *Modern Epidemiology, 3rd Edition.* Wokers Kluver 2. Clayton, D. and Hills, M. (1993). *Statistical methods in epidemiology.* Oxford University Press	
Course Outcomes	After successful completion of this course, student will be able to: 1. Understand Basics of epidemiology. 2. Understand types of study used in epidemiology 3. Understand the concept of clinical epidemiology. 4. Identify the scope of cause and prevention of disease.	

TEACHING LEARNING STRATEGIES

- **Lecturing, Visualization, Team Learning**

MODE OF TRANSACTION

- **Lecture, Seminar, Discussion, Questioning and Answering**

ASSESSMENT RUBRICS

Components	Weightage
End Semester	**60**

Evaluation(ESE)	
Continuous Evaluation	
Tests	16
Assignment	08
Seminar/Viva	16
Total	**40**

Sample Questions to Test Outcomes:

1. Define epidemiology and explain its scope. How does epidemiology contribute to public health?
2. Discuss some significant achievements in the field of epidemiology and their impact on public health outcomes.
3. Explain the concept of health and disease. How are they defined in epidemiological terms?
4. Describe different measures of disease frequency used in epidemiology. Provide examples to illustrate their applications.
5. Compare and contrast observational and experimental study designs in epidemiology. What are their respective strengths and limitations?
6. Explain the principles and applications of cohort study designs in epidemiological research. Provide an example of a cohort study and discuss its findings.
7. Discuss the design and utility of case-control studies in epidemiology. What are some common challenges associated with case-control studies?
8. Define randomized controlled trials (RCTs) and field trials. How do these study designs contribute to evidence-based medicine?
9. Identify and discuss potential errors that may occur in epidemiological studies. How can researchers minimize these errors?
10. Explore the ethical issues surrounding epidemiological research. What ethical considerations should researchers take into account when conducting studies involving human subjects?

POOL F: DISCIPLINE SPECIFIC ELECTIVE COURSE

Course Code & Title	**MSSTA03DSE10-SURVIVAL ANALYSIS**	
Programme	**M.Sc. Statistics**	**Semester III**
Course Description	This course offers a comprehensive overview of survival analysis, and covering key concepts such as the survival function, hazard rate function, probability density function, and mean residual lifetime. The course addresses censoring mechanisms including Type-I, Type-II, and random censoring, progressive censoring, and truncation, as well as methods for analyzing truncated and interval censored data. Techniques for comparing survival curves, Kaplan-Meier estimation, life tables, the Mantel-Haenszel test, interval estimation of survival probabilities, and an introduction to survival regression and the Cox proportional hazards model are also covered.	
Course Objectives	• Understand the basic notion of survival analysis • Understanding applications of survival function, hazard function, mean residual life functions and other aging concepts . • Understand and examine the properties of standard lifetime distributions. • Develop the concept of nonparametric tests like KS test, sign test, Mann-Whitney and Wilcoxon U tests. • Introduce the concepts of censoring and truncation and its various classifications. • Introduce the notion of Estimating survival rates using large scale data like DHS, NFHS, DLHS, etc. Comparing survival curves. • Modelling and analysis of lifetime data using survival functions and evaluate and apply regression models for survival data. • Introduce the notion of Kaplan-Meier estimation technique, life tables, Mantel-Haenszel test.	

Modules	Content	Module Outcome
Module I Basics of survival analysis **(15 Hours)**	Basics of survival analysis- discrete and continuous time models, survival function, hazard rate function, probability density function, mean residual life time. Aging classes-IFR, IFRA and their duals, Bathtub failure rate.	• Understand the basic concepts and ideas of survival analysis. • Understand the basic concepts ofageing classes.
Module II Life distributions **(15 Hours)**	Life distributions-exponential, Weibull, lognormal and gamma distributions, characterizations. Concepts of censoring Mechanism –Type-I, Type-II and random censoring, Progressive censoring, Truncation, Methods for truncated and interval censored data.	• Examine the properties and methods for standard survival time distributions. • Understand the basic concepts of nonparametric tests.
Module III Censoring and Truncation **(15 Hours)**	Likelihood construction and estimation of Censored and Truncated Data. Estimating survival rates using large scale data like DHS, NFHS, DLHS, etc. Comparing survival curves	• Estimate survival functions using parametric and non-parametric methods. • Understand the basic concepts of censoring and truncations.
Module IV Estimation of Survival function **(15 Hours)**	Kaplan-Meier estimation technique, life tables, Mantel-Haenszel test. Interval estimation of survival probabilities. Introduction to survival regression. Cox proposional hazard model.	• Apply and interpret regression models for survival data . • Understand the concept of Cox-Proportional hazard model.
References	***Text Books*** 1. Lawless, J.F. (2003): *Statistical Methods for Lifetime (Second*	

	Edition) ,John Wiley & Sons Inc., NewJersey. 2. Kalbfleisch, J. D. and Prentice, R.L. (1980): *The Statistical Analysis of Failure Time Data,* John Wiley& Sons Inc. New Jersey. 3. Moore, D.F. (2016): *Applied Survival Analysis Using R*, Springer. ***Reference Books*** 1. Klein J.P. and Moeschberger M.L. (2003) *Survival Analysis – Techniques for Censored and Truncated Data*, *Second Edition*, Springer-Verlag, New York. 2. Miller, R.G.(1981): *Survival Analysis*, John Wiley & Sons Inc. 3. Bain, L.G.(1978*): Statistical Analysis of Reliability and Life testing Models*, Marcel Decker. 4. Cox, D. R and Oakes, D.(1984): *Analysis of Survival Data*. Chapman and Hall. 5. Fraser, D.A.S.(1957): *Nonparametric Method in Statistics*, Wiley, New York.
Course Outcomes	After successful completion of this course, student will be able to: 1. Understand various lifetime probability distributions and their structural properties 2. Understand different methods for the estimation of survival function. 3. Conduct analysis of lifetime data. 4. Apply statistical techniques to model lifetime data and make predictions.

TEACHING LEARNING STRATEGIES

- **Lecturing, Visualization, Team Learning**

MODE OF TRANSACTION

- **Lecture, Seminar, Discussion, Questioning and Answering**

ASSESSMENT RUBRICS

Components	Weightage
End Semester Evaluation(ESE)	**60**
Continuous Evaluation	
Tests	16
Assignment	08
Seminar/Viva	16
Total	**40**

Sample Questions to Test Outcomes:

1. Define survival analysis and explain the difference between discrete and continuous time models. How are these models applied in epidemiological studies?
2. Discuss the concepts of survival function, hazard rate function, and probability density function in survival analysis. Provide examples to illustrate each concept.
3. Explain the concept of mean residual life time in survival analysis. How is it calculated and interpreted?
4. Define aging classes such as IFR (Increasing Failure Rate), IFRA (Increasing Failure Rate Average), and their duals. How do these concepts relate to the bathtub failure rate model?
5. Describe the exponential, Weibull, lognormal, and gamma distributions commonly used in survival analysis. Discuss their characteristics and applications.
6. Compare and contrast discrete and continuous time models in survival analysis. What are the advantages and limitations of each model?
7. Explain the applications of nonparametric tests Kolmogorov-Smirnov test and chi-square test for goodness of fit in survival analysis.
8. Define different censoring mechanisms like Type-I, Type-II, and random censoring. Discuss how these mechanisms affect the interpretation of survival data.

9. Describe methods for analyzing truncated and interval-censored data in survival analysis. How do researchers estimate survival rates using large-scale datasets like DHS, NFHS, DLHS, etc.?

10. Discuss the Kaplan-Meier estimation technique and its application in estimating survival curves. How are life tables constructed, and what information do they provide in survival analysis?

POOL F: DISCIPLINE SPECIFIC ELECTIVE COURSE

Course Code & Title	**MSSTA03DSE11-OPERATIONS RESEARCH**		
Programme	**M.Sc. Statistics**	**Semester**	**III**
Course Description	This course provides an introduction to linear programming problems (LPP), covering graphical solutions and the concepts of feasible, basic feasible, and optimum basic feasible solutions. Students will learn about analytical results in general LPP and the theoretical development of the simplex method, including artificial variables, the Big-M method, and the two-phase simplex method. Network analysis, including Critical Path Method (CPM) and Program Evaluation and Review Technique (PERT), will be discussed, highlighting the distinctions between CPM and PERT. Furthermore, students will be introduced to game theory, exploring pure and mixed strategies and methods for converting two-person zero-sum games into linear programming problems.		
Course Objectives	• Understand the fundamental concepts of linear programming problems (LPP) and their applications in real-world optimization scenarios. • Develop proficiency in graphical solution techniques for visualizing and analyzing LPPs, including identifying feasible regions and optimal solutions. • Demonstrate the ability to determine feasible, basic feasible, and optimum basic feasible solutions to LPPs, both graphically and analytically. • Gain insight into the theoretical foundations of linear		

	programming, including the analytical results and theoretical development of the simplex method. • Master advanced solution techniques such as the use of artificial variables, the Big-M method, and the two-phase simplex method to solve complex LPPs. • Understand the concept of duality in linear programming and its implications, including duality theorems and the application of dual simplex methods. • Explore practical optimization problems such as transportation and assignment problems, and learn to apply appropriate solution methods to address them effectively.

Modules	Content	Module Outcome
Module I: Algebra of linear programming problems **(15 Hours)**	Introduction to linear programming problem (LPP),graphical solution, feasible, basic feasible, and optimum basic feasible solution to an LPP. Analytical results in general LPP, theoretical development of simplex method.	• Define linear programming problems and their significance in optimization. • Explain the concept of feasible solutions and their graphical representation. • Identify basic feasible solutions and optimal basic feasible solutions in LPPs.
Module II: Duality and Dual Simplex Method **(15 Hours)**	Artificial variables, Big-M method, two phase simplex method Duality, duality theorems, dual simplex methods. Transportation problem, assignment problem.	• Derive analytical results for general linear programming problems. • Understand the theoretical development of the simplex method for solving LPPs. • Apply artificial variables, the Big-M method, and the two-

		phase simplex method to handle special cases in LPPs.
Module III: Integer Programming and Network Analysis **(15 Hours)**	Integer programming: Cutting plane methods, branch and bound technique. Network analysis, Critical path analysis, -CPM, PERT, distinction between CPM and PERT.	• Explore the concept of duality in linear programming and understand the duality theorems. • Discuss the application of dual simplex methods in solving LPPs. • Analyze transportation and assignment problems and apply appropriate solution techniques.
Module IV: Game Theory **(15 Hours)**	Game theory, pure and mixed strategies, conversion of two-person zero gain to a linear programming problem. Solution to game through algebraic, graphical and linear programming method.	• Examine integer programming and its solution methods. • Explore network analysis techniques such as Critical Path Method (CPM) and Program Evaluation and Review Technique (PERT). • Introduce game theory concepts, including pure and mixed strategies.
References	**Text Books** 1. K.V. Mital and Mohan, C (1996). *Optimization Methods in Operations Research and Systems Analysis*,*3rd Edition*, New Age International(Pvt.)Ltd. 2. Kanti Swarup, Gupta, P. K. and John, M. M. (1985): *Operations Research,* Sultan Chand & Sons. **Reference Books**	

	1. Hadley, G.(1964). *Linear Programming*, Oxford& IBH Publishing Co, New Delhi. 2. Taha, H.A. (1982): *Operation Research, An Instruction*, Macmillan. 3. Hiller F. S. and Lieberman, G.J. (1995). *Introduction to Operations Research,* McGraw Hill
Course Outcomes	After successful completion of this course, student will be able to: 1. Identify and develop operational research models from the verbal description of the real system. 2. Understand the mathematical tools that are needed to solve optimization problems. 3. Understand various methods in Integer programming and Game theory.

TEACHING LEARNING STRATEGIES

- **Lecturing, Visualization, Team Learning**

MODE OF TRANSACTION

- **Lecture, Seminar, Discussion, Questioning and Answering**

ASSESSMENT RUBRICS

Components	**Weightage**
End Semester Evaluation(ESE)	**60**
Continuous Evaluation	
Tests	16
Assignment	08
Seminar/Viva	16
Total	**40**

Sample Questions to Test Outcomes:

1. Define Linear Programming Problem (LPP) and discuss its significance in optimization. What are the key components of an LPP, and how is it formulated?
2. Explain the graphical solution method for solving LPPs. How is the feasible region identified, and how are optimal solutions determined graphically?
3. Define feasible solutions, basic feasible solutions, and optimum basic feasible solutions to an LPP. What criteria are used to identify these solutions?
4. Discuss the theoretical development of the simplex method for solving LPPs analytically. How does the simplex method iteratively move from one basic feasible solution to another to find the optimal solution?
5. Explain the concept of artificial variables and the Big-M method in the context of solving LPPs. How are artificial variables used to convert an LPP into a form suitable for the simplex method?
6. Describe the two-phase simplex method for solving LPPs. What are the two phases, and how does this method handle special cases such as degeneracy?
7. Discuss duality in linear programming, including duality theorems and the dual simplex method. What is the relationship between the primal and dual problems, and how is duality used in optimization?
8. Define the transportation problem and the assignment problem. How are these types of problems formulated as linear programming problems, and what are their applications?

POOL F: DISCIPLINE SPECIFIC ELECTIVE COURSE

Course Code & Title	**MSSTA03DSE12- STATISTICAL MACHINE LEARNING**		
Programme	**M.Sc. Statistics**	**Semester**	**III**
Course Description	This comprehensive course covers essential concepts in statistical learning and machine learning, exploring variable types, least squares, nearest neighbors, local methods, supervised learning, function approximation, and more. Students delve into structured regression models, kernel methods, basis functions, and model selection techniques, addressing the bias-variance tradeoff. Through theoretical understanding		

	and practical applications, students develop proficiency in data analysis, model inference, and decision-making in diverse real-world scenarios.
Course Objectives	• To classify variables and articulate their roles within statistical modeling, distinguishing between categorical, numerical, and ordinal variables, and understanding their implications for analysis. • Demonstrate competency in applying least squares regression and nearest neighbors algorithms for data analysis, including model fitting, prediction, and interpretation. • Froficient in employing local regression methods in high-dimensional spaces, understanding their advantages and limitations in capturing complex relationships within data. • Master supervised learning techniques and function approximation methods, utilizing them to model relationships between input and output variables effectively. • Describing the joint distribution of input and output vectors, enabling them to apply appropriate models to real-world datasets and interpret results accurately. • Able to implement structured regression models, incorporating domain-specific knowledge and constraints to improve model performance and interpretability.

Modules	Content	Module Outcome
Module I Introduction and overview of supervised learning **(15 Hours)**	Supervised Learning and Function Approximation, A Statistical Model for the Joint Distribution of input and output vectors, Function Approximation, Structured Regression Models, Linear Methods for Regression: Least squares, Subset selection, Shrinkage Methods, Methods using derived input directions,	• Explore structured regression models and classes of restricted estimators, including roughness penalty and Bayesian methods. • Understand the practical

	Multiple outcome shrinkage and selection, Lasso and related path algorithms.	considerations in automatic selection of smoothing parameters and nonparametric logistic regression.
Module II: Linear methods for classification **(15 Hours)**	Linear methods for classification using linear regression of an indicator matrix, linear discriminant analysis, logistic regression and separating hyperplanes. Basis expansions and regularizations: Piecewise polynomials and splines, Automatic Selection of the Smoothing Parameters, Nonparametric Logistic Regression, Multidimensional Splines.	• Explore linear discriminant analysis (LDA) and its role in multi-class classification problems. • Implement piecewise polynomials and splines for capturing complex functional forms in regression and classification tasks.
Module III: Kernal smoothing **(15 Hours)**	One-Dimensional Kernel Smoothers, Selecting the band width of the Kernel, Structured Local Regression Models in R^p, Local Likelihood and Other Models, Kernel Density Estimation and Classification: Kernel Density Estimation, Kernel Density classification and the Naïve Bayes classifier. Mixture Models for Density Estimation and Classification.	• Explore structured local regression models in multidimensional spaces and their advantages in capturing complex data patterns. • Implement kernel density classification methods for classifying data points based on their estimated densities. • Understand the mathematical properties of RBFs and kernels and their role in non-linear transformations of input data.

Module IV: Model assessment, inference and averaging **(15 Hours)**	Bias, Variance and Model Complexity, The Bias–Variance Decomposition, Optimism of the Training Error Rate, Estimates of In-Sample Prediction Error, The Bayesian Approach and BIC, Minimum Description Length, Cross-Validation, Bootstrap Methods, Conditional or Expected Test Error, introducing Model Inference and averaging: Local regression in IR, The EM Algorithm, MCMC for Sampling from the Posterior, Bagging, Model Averaging and Stacking, Stochastic Search: Bumping.	• Gain proficiency in techniques such as cross-validation and bootstrap methods for model evaluation and selection. • Understand the principles behind the Bayesian Information Criterion (BIC) and minimum description length for model selection.
References	***Text Books*** 1. Hastie, T., Tshibirani, R. and Friedman, J. (2017). *The Elements of Statistical Learning : Data Mining, Inference and Prediction*, 2nd edition. Springer, New York. 2. James, G., Witten, D., Hastie, T. and Tibshirani, R. (2013). *An Introduction to Statistical Learning with Applications in R. S*pringer, New York. ***Reference Book*** 1. James, G., Witten, D., Tibshirani, R. and Hastie, T. *Neural Networks and Deep Learning: A Textbook.*	
Course Outcomes	After successful completion of this course, student will be able to: 1. Gain proficiency in applying least squares regression, nearest neighbors, and local methods for high-dimensional data analysis. 2. Master linear methods for regression and classification, including subset selection, shrinkage methods, and linear discriminant analysis. 3. Learn techniques for estimating in-sample prediction error, including cross-validation and bootstrap methods. 4. Explore advanced model inference methods, including maximum likelihood estimation, Bayesian inference, and the EM algorithm.	

TEACHING LEARNING STRATEGIES

- **Lecturing, Visualization, Team Learning**

MODE OF TRANSACTION

- **Lecture, Seminar, Discussion, Questioning and Answering**

ASSESSMENT RUBRICS

Components	Weightage
End Semester Evaluation(ESE)	**60**
Continuous Evaluation	
Tests	16
Assignment	08
Seminar/viva	16
Total	**40**

Sample Questions to Test Outcomes:

1. How do least squares and nearest neighbors differ in their approach to supervised learning, and what are the advantages and limitations of each method in terms of handling high-dimensional data?
2. Can you explain the concept of the bias-variance tradeoff in the context of model selection? How do different methods such as Lasso, subset selection, and shrinkage methods address this tradeoff, and under what conditions would one method be preferred over another?
3. What are the key principles behind kernel methods and local regression in function approximation? How do these methods handle non-linear relationships between variables, and what are some practical considerations when choosing between different kernel functions or regression approaches?
4. How do linear methods for classification, such as logistic regression and linear discriminant analysis, differ in their approach to separating classes? Discuss the advantages and limitations of each method in terms of handling non-linearly separable data and the assumptions underlying their models.

5. What role does feature extraction play in filtering and smoothing techniques, particularly in the context of multidimensional splines and wavelet smoothing?

6. What are the key principles behind one-dimensional kernel smoothers, and how do they differ from other smoothing techniques such as splines or local regression?

7. How do structured local regression models in multidimensional spaces (Rp) extend the concepts of one-dimensional kernel smoothers?

8. Explain the concept of bias, variance, and model complexity in the context of machine learning models. How does the bias-variance decomposition help in understanding the trade-offs involved in model selection?

9. Explain the concept of model averaging and stacking as techniques for improving predictive performance and robustness in machine learning.

10. Introduce the EM (Expectation-Maximization) algorithm and its application in model inference.

POOL F: DISCIPLINE SPECIFIC ELECTIVE COURSE

Course Code & Title	**MSSTA03DSE13- DATA VISUALIZATION AND ANALYSIS USING PYTHON**		
Programme	**M.Sc. Statistics**	**Semester**	**III**
Course Description	This course explores data acquisition processes such as extraction, cleaning, annotation, integration, reduction, and transformation using Python. It covers various visualization techniques and tools, including basic charts, multivariate visualization, and specialized visualization methods for effective data analysis and interpretation.		
Course Objectives	• Gain proficiency in data acquisition and manipulation using Python libraries. • Understand and implement different data visualization techniques for comprehensive data analysis. • Learn the regression model building framework in Python, from problem definition to model validation. • Develop skills in multiple linear regression including handling categorical variables and diagnosing model issues with Python.		

Modules	Content	Module Outcome
Module I Introduction to PYTHON **(15 Hours)**	Data acquisition processes, extraction, cleaning, annotation, integration, reduction, and transformation. Basic charts, multivariate visualization, pixel-oriented, geometric projection, icon-based, and hierarchical visualization.	• Ability to effectively extract, clean, annotate, integrate, reduce, and transform data using Python. • Understanding of data preprocessing techniques to prepare datasets for analysis, including data normalization, missing value imputation, and feature engineering.
Module II Data visualization tools **(15 Hours)**	Data visualization tools, rank analysis, trend analysis, multivariate analysis, distribution analysis, correlation analysis, and geographical analysis.	• Proficiency in utilizing advanced visualization methods such as pixel-oriented, geometric projection, icon-based, and hierarchical visualization. • Ability to communicate insights and findings derived from data visualization effectively.
Module III Regression model building framework **(15 Hours)**	Regression model building framework, covering problem definition, data pre-processing, model building, diagnostics, and validation. Simple linear regression, coefficients of determination, significance tests, residual analysis, and confidence/prediction intervals.	• Understanding of best practices in data visualization design. • Ability to leverage interactive visualization tools and dashboards to engage stakeholders and facilitate exploratory data

		analysis and decision-making processes.
Module IV Multiple linear regression **(15 Hours)**	Multiple linear regression, coefficients of multiple determination, interpretation of regression coefficients, categorical variables, diagnosing issues, heteroscedasticity and multicollinearity, outliers, autoregression, and variable transformation for robust regression model building.	• Understanding of the regression model building framework and evaluation using Python. • Capability to validate regression models using diagnostic techniques, including confidence and prediction intervals, to assess model accuracy and reliability for predictive analysis.
References	***Text Books*** 1. Andy Kirk, (2016). *Data Visualization a Handbook for Data Driven Design*, Sage Publications. 2. Philipp K. Janert (2010). *Gnuplot in Action, Understanding Data with Graphs,* Manning Publications. ***Reference Books*** 1. Alberto Cordoba (2014). *Understanding the Predictive Analytics Lifecycle*, Wiley. 2. Eric Siegel, Thomas H. Davenport (2013*). Predictive Analytics: The Power to Predict Who Will Click, Buy, Lie, or Die*, Wiley. 3. James R Evans (2013). *Business Analytics-Methods, Models and Decisions*, Pearson. 4. R. N. Prasad, Seema Acharya (2015). *Fundamentals of Business Analytics,* Wiley. 5. Perkovie, L. (2011). *Introduction to computing using python: An Application development focus*. Wiley Publishing.	

	6. McKinney, W. (2012). *Python for data analysis: Data wrangling with Pandas, NumPy, and IPython.* O Reilly Media, Inc.
Course Outcomes	After successful completion of this course, student will be able to: 1. Apply Python libraries for data acquisition to extract, clean, integrate, and transform datasets efficiently. 2. Utilize Python libraries for various visualization methods to interpret and communicate complex data effectively. 3. Construct regression models using Python libraries, including appropriate pre-processing techniques and diagnostic tools. 4. Analyze simple linear regression results, including coefficients of determination and significance tests, using Python. 5. Implement multiple linear regression models in Python, addressing issues like multicollinearity and heteroscedasticity for robust predictions.

TEACHING LEARNING STRATEGIES

- **Lecturing, Visualization, Team Learning**

MODE OF TRANSACTION

- **Lecture, Seminar, Discussion, Questioning and Answering**

ASSESSMENT RUBRICS

Components	**Weightage**
End Semester Evaluation(ESE)	**60**
Continuous Evaluation	
Tests	16
Assignment	08
Seminar/viva	16
Total	**40**

Sample Questions to Test Outcomes:

1. How would you describe the process of data acquisition and what are its key components?
2. Can you explain the difference between data cleaning and data transformation?
3. What are some common techniques used for reducing the dimensionality of datasets during data preprocessing?
4. Describe a situation where you might encounter missing data during the data acquisition process and how would you handle it?
5. How do you decide which visualization technique to use for a given dataset and analysis objective?
6. Explain the purpose of rank analysis tools in data visualization and provide an example of when you would use them.
7. What is the significance of residual analysis in regression model building and how is it performed?
8. Describe the steps involved in conducting a simple linear regression analysis and interpreting its results.
9. How do you diagnose multicollinearity in a multiple linear regression model and what are its potential consequences?
10. Can you provide an example of how you would use autoregression in a regression model building process and explain its importance?

POOL G: INTERDISCIPLINARY ELECTIVE COURSE (IDC)

Course Code & Title	**MSSTA03IDC01-STATISTICAL DATA ANALYSIS USING SPSS**		
Programme Offered	**Department of Statistical Sciences**	**Semester**	**III**
Course Description	This SPSS course covers navigation of the Data Editor and Output windows, data manipulation via drop-down menus, and variable creation/modification. Topics include descriptive statistics, frequencies, cross tabs, and statistical analyses like t-tests, ANOVA, correlation, regression, alongside generating various plots and graphs for data visualization.		

Course Objectives	• Demonstrate proficiency in navigating SPSS interface components including the Data Editor window, SPSS Output window, and various drop-down menus. • Able to create, modify, import, and transform datasets using SPSS, including tasks such as computing variables, recoding data, and selecting cases. • Gain an understanding of different types of variables and how to assign appropriate labels to them within SPSS, ensuring accurate analysis and interpretation. • Learn to create a variety of plots and graphs in SPSS including bar diagrams, pie diagrams, histograms, box plots, P-P plots, Q-Q plots, and scatter diagrams to effectively communicate insights from their data. • Acquire the skills to perform descriptive statistics analysis using SPSS, including measures such as mean, median, mode, standard deviation, and variance.

Modules	Content	Module Outcome
Module I Introduction to SPSS and its interface **(15 Hours)**	SPSS windows, Data editor window, Types of variables and labels, SPSS output window, Drop down menus of SPSS, Creating and modifying data files	• Proficiency in navigate various SPSS windows, including the Data Editor window and SPSS Output window. • Able to differentiate between categorical and continuous variables and understand their significance in data analysis. • Creating and modifying data files in SPSS.
Module II Data	Import of data files, Transform drop down menu, computing	• Skills to transform variables using the Transform drop-down menu in

management in SPSS **(15 Hours)**	variables, Recode option, Data drop down menu, Split files, Weight cases, Select cases.	SPSS. • They will be able to perform and applying mathematical transformations to enhance data analysis capabilities. • Able to utilize advanced data manipulation features of SPSS to account for sample biases, and selecting cases for focused analysis.
Module III Graphics in SPSS **(15 Hours)**	SPSS plots and graphs, Bar diagram, Pie diagram, Multiple bar diagram, Histogram, Box plot, P-P plot, Q-Q plot, Scatter diagram.	• Demonstrate proficiency in creating various plots and graphs in SPSS. • Develop the skills to interpret and analyze graphical representations generated in SPSS.
Module IV Basic statistical analysis **(15 Hours)**	Analyze drop down menu, Descriptive statistics, Frequencies, Cross tabs, Compare means-independent sample t test, paired sample t test, ANOVA, Correlation, Regression, Confidence intervals, Non-parametric test.	• Demonstrate proficiency in conducting various statistical analyses using the Analyze drop-down menu in SPSS. • Gain proficiency in conducting inferential statistics tests such as frequencies, cross tabs, independent sample t-tests, paired sample t-tests, ANOVA, correlation, regression. • Develop the skills to interpret and report the results of statistical analyses conducted in SPSS accurately.

References	***Text Book*** 1. Hinton P. R, Brownlow C. ,McMurray, I. and Cozens, B. (2004): *SPSS Explained,* Routledge, Taylor and Francis group, New York. **Reference Book** 1. Sabine Landau, Brian S. Everitt (2003): *A Handbook of Statistical Analyses Using SPSS*, New York.
Course Outcomes	After successful completion of this course, student will be able to: 1. Understand the usage of menus in SPSS window for drawing various diagrams. 2. Computing descriptive statistics, the comparison of means, ANOVA, non-parametric tests, simple correlation and regression procedures and apply for real data sets. 3. Acquirte the skills of plotting different graphs using SPSS.

TEACHING LEARNING STRATEGIES

- **Lecturing, Visualization, Team Learning**

MODE OF TRANSACTION

- **Lecture, Seminar, Discussion, Questioning and Answering**

ASSESSMENT RUBRICS

Components	Weightage
End Semester Evaluation(ESE)	**60**
Continuous Evaluation	
Tests	16
Assignment	08
Seminar/viva	16
Total	**40**

Sample Questions to Test Outcomes:

1. Explain the purpose of SPSS windows, including the Data Editor window and the SPSS Output window.
2. Describe the different types of variables in SPSS and how labels are used to annotate them.
3. Discuss the significance of drop-down menus in SPSS and how they facilitate various data manipulation tasks.
4. Demonstrate the process of creating and modifying data files in SPSS, including importing data files from external sources.
5. Explore the Transform drop-down menu in SPSS and its functions for computing variables and recoding data.
6. Illustrate the use of SPSS plots and graphs, including bar diagrams, pie diagrams, histograms, box plots, P-P plots, Q-Q plots, and scatter diagrams.
7. Navigate the Analyze drop-down menu in SPSS and demonstrate how to conduct descriptive statistics, frequencies, cross tabs, and other analyses.
8. Explain the purpose and methodology behind common statistical tests available in SPSS, such as independent sample t-tests, paired sample t-tests, ANOVA, correlation, regression, and non-parametric tests.
9. Discuss the interpretation of results obtained from SPSS analyses, including confidence intervals and significance testing.
10. Provide practical examples of using SPSS to analyze data sets, interpret results, and generate reports for research or decision-making purposes.

POOL G: INTERDISCIPLINARY ELECTIVE COURSE (IDC)

Course Code & Title	**MSSTA03IDC02-STATISTICAL DATA ANALYSIS USING R**		
Programme Offered	**Department of Statistical Sciences**	**Semester**	**III**
Course Description	This introductory R course covers objects, operators, vectors, matrices, lists, and data frames. Students learn data indexing, importing/exporting, and basic functions for descriptive statistics. It includes probability		

	concepts, distributions, random sample generation, and statistical procedures like comparing means, ANOVA, non-parametric tests, and correlation/regression analyses. Graphics include histograms, box plots, and scatter plots.
Course Objectives	• Demonstrate a solid understanding of the fundamental concepts in R programming, including objects and their classes, operators, vectors, matrices, lists, and data frames. • Gain proficiency in indexing and accessing data within R, as well as importing and exporting data from various file formats. • Learn to create various graphical representations of data using R, including histograms, box plots, stem and leaf plots, scatterplots, and Q-Q plots. • Learn to generate random samples from standard probability distributions in R.

Modules	Content	Module Outcome
Module I Introduction to R **(15 Hours)**	Introduction to R- Objects and their classes, operators, vectors and matrices, list and data frames, indexing and accessing data, importing and exporting data. Common built-in functions. Simple applications – Descriptive statistics.	• Demonstrate a solid understanding of the fundamental concepts of R programming, including objects and their classes, • Acquire proficiency in indexing and accessing data within R, enabling them to effectively manipulate datasets for analysis. • Able to apply basic descriptive statistics techniques in R to analyze datasets effectively.
Module II R-Graphics	R-Graphics- Histogram, Box-plot, Stem and leaf plot, Scatter plot, Q-	• Demonstrate proficiency in creating various types of

(15 Hours)	Q plot. Looping- for loop, repeat loop, while loop, if command, if else command.	graphical representations using R. • Mastered various programming control structures in R. • Able to apply their knowledge of R graphics and looping.
Module III Basic probability and distribution **(15 Hours)**	Basicconceptsofprobabilityandrandomvariables,Probabilitydistributions (Binomial, Poisson, Geometric, Uniform, Normal, Gamma, Beta), Plotting of cdf and pdf for different values of the parameters of standard distributions. Generations of random samples from standard distributions.	• Understanding of basic concepts of probability theory and random variables. • Understanding different probability distributions commonly used in statistical analysis, including the binomial, Poisson, etc. • Demonstrate the ability to plot cumulative distribution functions (CDFs) and probability density functions (PDFs) for different parameter values of standard distributions using R.
Module IV Descriptive statistics **(15 Hours)**	The Descriptive statistics, the comparison of means, ANOVA, non-parametric tests, correlation and regression procedures.	• Demonstrate mastery in descriptive statistics, including measures of central tendency, dispersion, and distributional shape. • Understand the principles and applications of comparing means across different groups. • Able to conduct and interpret

		various tests for comparing means, including independent samples t-tests, paired samples t-tests, etc.
References	***Text Books*** 1. Purohit, S. G, Ghore, S.D and Deshmukh, S. R.(2004): *Statistics Using R*. Narosa. ***Reference Books*** 1. Dalgaard, P.(2008): *Introductory Statistics with R, (Second Edition),* Springer.	
Course Outcomes	After successful completion of this course, student will be able to: 1. Understand various built-in functions in R programming for statistical data analysis. 2. Understand different functions in R programming for writing computer programmes and develop computer programmes for different problems. 3. Understand different statistical test using R software	

TEACHING LEARNING STRATEGIES

- **Lecturing, Visualization, Team Learning**

MODE OF TRANSACTION

- **Lecture, Seminar, Discussion, Questioning and Answering**

ASSESSMENT RUBRICS

Components	Weightage
End Semester Evaluation(ESE)	**60**

Continuous Evaluation	
Tests	16
Assignment	08
Seminar/viva	16
Total	**40**

Sample Questions to Test Outcomes:

1. Explain the concept of objects and their classes in R, including how operators are used to manipulate them.
2. Discuss the properties and uses of vectors, matrices, lists, and data frames in R, as well as techniques for indexing and accessing data within them.
3. Demonstrate techniques for importing and exporting data in R, including common file formats such as CSV and Excel.
4. Explore common built-in functions in R and their applications, with a focus on simple applications such as descriptive statistics.
5. Provide practical examples of using R graphics to create histograms, box plots, stem and leaf plots, scatter plots, and Q-Q plots for data visualization.
6. Explain looping constructs in R, including for loops, repeat loops, while loops, and conditional statements like if and if-else commands.
7. Introduce basic concepts of probability and random variables, including common probability distributions such as binomial, Poisson, geometric, uniform, normal, gamma, and beta distributions.
8. Illustrate techniques for plotting cumulative distribution functions (CDF) and probability density functions (PDF) for standard distributions in R.
9. Demonstrate methods for generating random samples from standard distributions in R for simulation and modeling purposes.
10. Discuss the application of descriptive statistics, mean comparison tests, ANOVA, non-parametric tests, correlation, and regression procedures in R for data analysis and hypothesis testing.

	FOURTH SEMESTER								
Sl No	**Course Code**	**Title of Paper**	**Contact Hours/Week**			**Marks**			
			L	**T/S**	**P**	**ESE**	**CE**	**Total**	**Credits**
DISCIPLINE SPECIFIC CORE COURSES (DCE)									
4.1	MSSTA04DSC11	Project/Dissertation Subject Viva							8
DISCIPLINE SPECIFIC ELECTIVES (DSE)									
3.3	MSSTA04DSExx	Elective –I-DSE (Practical) (**Pool H**)	--	2	6	60	40	100	4
3.4	MSSTA04DSExx	Elective –II-DSE (**Pool I**)	3	1	--	60	40	100	4
	MSSTA04DSExx	Elective –II-DSE (**Pool I**)	3	1	--	60	40	100	4
Total Credits									**20**

L=Lecture, T/S=Tutorials/Seminar, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

Sl No	**POOL H:- List of Courses for Elective DISCIPLINE SPECIFIC ELECTIVES (DSE)**								
3.4.1	MSSTA04DSE14	Statistical Computing Using R-IV (**Practical**)		2	6	60	40	100	4
3.4.2	MSSTA04DSE15	Statistical Computing Using PYTHON (**Practical**)		2	6	60	40	100	4
POOL I:- List of Courses for Elective DISCIPLINE SPECIFIC ELECTIVES (DSE)									
3.5.1	MSSTA04DSE16	Advanced Queuing Theory	3	1		60	40	100	4
3.5.2	MSSTA04DSE17	Time Series Analysis	3	1		60	40	100	4
3.5.3	MSSTA04DSE18	Actuarial Statistics	3	1		60	40	100	4

3.5.4	MSSTA04DSE19	Statistical Quality Control	3	1		60	40	100	4
3.5.5	MSSTA04DSE20	Advanced Bayesian Computing with R	3	1		60	40	100	4

POOL H: DISCIPLINE SPECIFIC ELECTIVE COURSE

Course Code & Title	**MSSTA04DSE14-STATISTICAL COMPUTING USING R -IV (PRACTICAL)**		
Programme	**M.Sc. Statistics**	**Semester**	**IV**
Course Objectives	• To introduce some advanced statistical computing techniques in applied statistics to extract information and visualization thereby enabling them to perform data analysis effectively and efficiently in R programming. • Illustrate different statistical techniques based on all the elective course in fourth semester.		

Modules	**Content**	**Module Outcome**
	Statistical Computing IV is a practical course. The practical is based on all the elective courses in the fourth semester.	• Describe different statistical technique to solve problems coming under all the elective courses in fourth semester.
Course Outcomes	After successful completion of this course, student will be able to: 1. Equipped with different theoretical methods in applied statistics to achieve the objectives. 2. Enhanced with the basic concepts of statistical theories besides developing their ability to handle real world problems with large scale data.	

TEACHING LEARNING STRATEGIES

- **Practical sessions through computers, statistical computations, Team Learning**

MODE OF TRANSACTION

- **Lecture, Seminar, Hands on training**

ASSESSMENT RUBRICS

Components	Weightage
End Semester Evaluation	**60**
Continuous Evaluation	
Practical Tests	32
Record	08
Total	**40**

POOL H: DISCIPLINE SPECIFIC ELECTIVE COURSE

Course Code & Title	**MSSTA04DSE15-STATISTICAL COMPUTING USING PYTHON (PRACTICAL)**		
Programme	**M.Sc. Statistics**	**Semester**	**IV**
Course Objectives	• To introduce some advanced statistical computing techniques in applied statistics to extract information and visualization thereby enabling them to perform data analysis effectively and efficiently in PYTHON programming. • Illustrate different statistical techniques based on all the elective course in fourth semester.		

Modules	Content	Module Outcome
	Statistical Computing IV is a practical course. The practical is based on all the elective courses in the fourth semester.	• Describe different statistical technique to solve problems coming under all the elective courses in fourth semester.
Course Outcomes	After successful completion of this course, student will be able to: 1. Equipped with different theoretical methods in applied statistics to achieve the objectives. 2. Enhanced with the basic concepts of statistical theories besides developing their ability to handle real world problems with large scale data.	

TEACHING LEARNING STRATEGIES

- **Practical sessions through computers, statistical computations, Team Learning**

MODE OF TRANSACTION

- **Lecture, Seminar, Hands on training**

ASSESSMENT RUBRICS

Components	Weightage
End Semester Evaluation	**60**
Continuous Evaluation	
Practical Tests	32
Record	08
Total	**40**

POOL I: DISCIPLINE SPECIFIC ELECTIVE COURSE

Course Code & Title	**MSSTA04DSE16- ADVANCED QUEUEING THEORY**		
Programme	**M.Sc. Statistics**	**Semester**	**IV**
Course Description	This course provides an introduction to queueing theory, covering the characteristics of queueing processes and measures of effectiveness. Students will learn about Markovian queueing models, including steady-state solutions for the M/M/1 model, waiting-time distributions, and Little's formula. The course explores queues with unlimited service and finite source queues, as well as the transient behavior of M/M/1 queues and busy period analysis for M/M/c models		
Course Objectives	• Understand the fundamental concepts of queueing theory and its applications in various fields such as telecommunications, manufacturing, and service industries. • Explore the characteristics of queueing processes including arrival rates, service rates, queue lengths, and waiting times, and learn how to measure the effectiveness of queueing systems. • Gain insight into Markovian queueing models and their steady-state solutions, focusing on the M/M/I model and its waiting-time distributions, as well as Little's formula. • Analyze transient behavior in queueing systems, particularly for M/M/1 and M/M/c models, and conduct busy period analysis to assess system performance. • Study models with general service patterns, including the M/G/1 queueing model and the Pollaczek-Khintchine formula, and analyze departure point steady-state system size probabilities. • Discuss special cases such as M/Ek/1 and M/D/1 queues, and explore waiting times, busy period analysis, and general input and exponential service models.		

Modules	Content	Module Outcome
Module I: Markovian Queueing Models **(15 Hours)**	Introductiontoqueueingtheory,Characteristicsofqueueingprocesses,Measures of effectiveness, Markovian queueing models, steady state solutions of the M/M/I model, waiting-time distributions, Little's formula, queues with unlimited service, finite source queues	• Define the key concepts of queueing theory and its relevance in various applications. • Describe the characteristics of queueing processes and the measures used to assess their effectiveness. • Identify different types of Markovian queueing models and their applications.
Module II: Advanced Markovian Models **(15 Hours)**	Transient behavior of M/M/1 queues, transient behavior of M/M/1.Busy period analysis for M/M/1 and M/M/c models. Advanced Markovian models. Bulk input M[X] /M/1model, Bulk service M/M[Y]/1 model, Erlangian models, M/Ek/1and Ek/M/1.A brief discussion of priority queues.	• Analyze steady-state solutions for the M/M/I model and determine waiting-time distributions. • Apply Little's formula to compute system performance metrics. • Evaluate queueing systems with unlimited service and finite sources.
Module III: Queueing Networks **(15 Hours)**	Series queues, open Jackson networks, closed Jackson network, Cyclic queues, Extension of Jackson networks. Non-Jackson networks.	• Analyze the transient behavior of M/M/1 queues and their steady-state characteristics. • Conduct busy period analysis for both M/M/1 and M/M/c models.

Module IV: Non Markovian Queueing Models **(15 Hours)**	Models with general service pattern, The M/G/1 queueing model, The Pollaczek- Khintchine formula, Departure point steady state systems size probabilities, ergodic theory, Special cases M/Ek/1 and M/D/1, waiting times, busy period analysis, general input and exponential service models, arrival point steady state system size probabilities.	• Examine series queues, open and closed Jackson networks, cyclic queues, and their extensions. • Analyze non-Jackson networks and models with general service patterns. • Explore special cases such as M/Ek/1 and M/D/1 queues, considering waiting times and arrival point steady-state system size probabilities.
References	**Text Books** 1. Gross, D. and Harris, C.M. (1985): *Fundamentals of Queueing Theory,* 2ndEdition, John Wiley and Sons, New York. **Reference Books** 1. Ross, S. M.(2010). *Introduction to Probability Models*. 10thEdition, Academic Press, New York. 2. Bose, S.K.(2002).*An Introduction to Queueing Systems*, Kluwer Academic/Plenum Publishers, New York.	
Course Outcomes	After successful completion of this course, student will be able to: 1. Understand various Markovian queueing models and their analysis. 2. Understand transient behaviour of queueing models and analysis of advanced Markovian models with bulk arrival and bulk service. 3. Understand various queueing networks and their extensions. 4. Understand various non Markovian queueing models and their analysis.	

TEACHING LEARNING STRATEGIES

- **Lecturing, Visualization, Team Learning**

MODE OF TRANSACTION

- **Lecture, Seminar, Discussion, Questioning and Answering**

ASSESSMENT RUBRICS

Components	Weightage
End Semester Evaluation(ESE)	**60**
Continuous Evaluation	
Tests	16
Assignment	08
Seminar/Viva	16
Total	**40**

Sample Questions to Test Outcomes:

1. What is queueing theory, and what are the characteristics of queueing processes? How is queueing theory applied in various real-world scenarios?
2. Discuss the measures of effectiveness used in queueing theory to evaluate system performance. How are these measures calculated and interpreted?
3. Explain the concept of Markovian queueing models. What are the key assumptions of Markovian models, and how do they differ from non-Markovian models?
4. Describe the steady-state solutions of the M/M/1 queueing model. How is the waiting-time distribution calculated in this model?
5. What is Little's formula, and how is it used in queueing theory? Discuss its significance in analyzing queueing systems.
6. Explain queues with unlimited service and finite source queues. What are the main characteristics of these types of queues, and how are they modeled?
7. Discuss the transient behavior of M/M/1 queues. How does the system behavior evolve over time in transient state, and what factors influence it?

8. Describe the busy period analysis for M/M/1 and M/M/c models. How are busy periods defined, and how are they analyzed in queueing theory?
9. Explore advanced Markovian models such as bulk input M[X]/M/1 and bulk service M/M[Y]/1 models. What are the key features of these models, and how are they different from basic Markovian models?
10. Discuss series queues, open Jackson networks, closed Jackson networks, and cyclic queues. How do these network structures affect queueing system behavior, and what are their applications in real-world systems?

POOL I: DISCIPLINE SPECIFIC ELECTIVE COURSE

Course Code & Title	**MSSTA04DSE17-TIME SERIES ANALYSIS**		
Programme	**M.Sc. Statistics**	**Semester**	IV
Course Description	This course offers a comprehensive exploration of stochastic processes underlying temporal data, covering auto-covariance, auto-correlation, and spectral density properties. Students delve into exploratory analysis techniques, including trend and seasonality tests, and learn forecasting methods such as exponential and Holt-Winter smoothing. The course extensively examines stationary processes, encompassing Autoregressive (AR), Moving Average (MA), and ARIMA models, with emphasis on model selection criteria. Estimation methods like Yule-Walker and maximum likelihood are discussed, along with diagnostic checks for model validation. Spectral analysis and basic concepts of seasonal ARIMA, ARCH, and GARCH models are introduced, enriching students' analytical toolkit for time series data interpretation and forecasting.		
Course Objectives	• Understand the fundamental concepts of stochastic processes and their applications in modeling time series data, providing a solid foundation for further analysis. • Learn to analyze auto-covariance, auto-correlation, and spectral density properties of time series data, enabling students to characterize and interpret temporal patterns effectively.		

	• Acquire proficiency in forecasting methods such as exponential smoothing, moving average smoothing, and Holt-Winter smoothing, empowering students to make accurate predictions based on historical data. • Gain in-depth knowledge of autoregressive (AR), moving average (MA), autoregressive moving average (ARMA), and autoregressive integrated moving average (ARIMA) models, enabling students to select and apply appropriate models for different time series data sets. • Explore spectral analysis, periodgrams, correlograms, and diagnostic checks for model validation, equipping students with advanced analytical tools for interpreting and analyzing time series data effectively.

Modules	Content	Module Outcome
Module I: Time Series Basic Concepts **(15 Hours)**	Motivation, Time series as a discrete parameter stochastic process, Auto-Covariance, Auto-Correlation and spectral density and their properties. Exploratory time series analysis, Exponential and moving average smoothing, Holt-Winter smoothing, forecasting based on smoothing, Adaptive smoothing.	• Understanding Stochastic Processes. • Applying Stochastic Processes to Time Series Analysis. • Interpreting Stochastic Process Properties. • Applying Stochastic Processes in Forecasting:
Module II: Autoregressive Models **(15 Hours)**	Detailed study of the stationary process: Autoregressive, Moving Average, Autoregressive Moving Average and Autoregressive Integrated Moving Average Models. Choice of AR/MA periods.	• Understanding exploratory Analysis Techniques. • Understanding Smoothing Methods. • Characterizing Stationary Processes.

		• Interpreting Time Series Properties.
Module III: Estimation of ARMA and ARIMA Models **(15 Hours)**	Estimation of ARMA models: Yule-Walker estimation for AR Processes, Maximum likelihood and least square estimation for ARMA Processes, Discussion (without proof) of estimation of mean, Auto-covariance and autocorrelation function under large samples theory, Residual analysis and diagnostic checking. Forecasting using ARIMA models.	• Understanding forecasting Techniques. • Identifying model Selection and Estimation. • Validation and Diagnostic Checks. • Utilize advanced analytical tools such as spectral analysis, periodograms, and correlograms.
Module IV: Non-Linear Time Series Models **(15 Hours)**	Spectral analysis of weakly stationary process. Periodogram and correlogram analysis. Seasonal ARIMA models (Basic concepts only), ARCH and GARCH models (Basic concepts only)	• Understand seasonal and non-seasonal models such as seasonal ARIMA, ARCH, and GARCH models. • Apply advanced analytical techniques including spectral analysis, periodograms, and correlograms.
References	**Text Books** 1. Box G.E.P and Jenkins G.M.(1970). *Time Series Analysis, Forecasting and Control.* Holden -Day. 2. Brockwell P.J .and Davis R.A. (1987). *Time Series: Theory and Methods,* Springer Verlag. **Reference Books** 1. Abraham B and Ledolter J.C. (1983). *Statistical Methods for Forecasting,* Wiely	

	2. Anderson T.W.(1971). *Statistical Analysis of Time Series*, Wiely. 3. Shumway, R., & Stoffer, D. (2019). *Time series: a data analysis approach using R*. Chapman and Hall/CRC. 4. Hyndman, R. J., & Athanasopoulos, G. (2018). *Forecasting: principles and practice*. OTexts.
Course Outcomes	After successful completion of this course, student will be able to: 1. Understand exploratory time series analysis and its real data application. 2. Understand autoregressive models and their estimation methods. 3. Understand non-linear time series models and their estimation methods. 4. Apply statistical techniques to time series data and make predictions.

TEACHING LEARNING STRATEGIES

- **Lecturing, Visualization, Team Learning**

MODE OF TRANSACTION

- **Lecture, Seminar, Discussion, Questioning and Answering**

ASSESSMENT RUBRICS

Components	**Weightage**
End Semester Evaluation(ESE)	**60**
Continuous Evaluation	
Tests	16
Assignment	08
Seminar/Viva	16
Total	**40**

Sample Questions to Test Outcomes:

1. What is the significance of time series analysis in understanding data trends and making predictions? Discuss the motivation behind studying time series data.
2. Define a discrete parameter stochastic process and explain how time series can be viewed as such a process. How does this perspective help in analyzing time series data?
3. Explain the concepts of auto-covariance, auto-correlation, and spectral density in the context of time series analysis. Discuss their properties and their roles in characterizing time series behavior.
4. Describe the techniques involved in exploratory time series analysis. How do tests for trend and seasonality contribute to understanding time series patterns?
5. Compare and contrast exponential smoothing, moving average smoothing, and Holt-Winter smoothing methods for time series forecasting. Provide examples illustrating their application.
6. Provide a detailed study of stationary processes, including autoregressive (AR), moving average (MA), autoregressive moving average (ARMA), and autoregressive integrated moving average (ARIMA) models. Discuss the choice of AR/MA periods in model selection.
7. Discuss different estimation methods for ARMA models, including Yule-Walker estimation for AR processes and maximum likelihood/least square estimation for ARMA processes. Explain the concept of residual analysis and diagnostic checking.
8. Explain the concept of spectral analysis for weakly stationary processes. Discuss the use of periodograms and correlograms in analyzing spectral density and autocorrelation functions.
9. Introduce the basic concepts of seasonal ARIMA models, ARCH models, and GARCH models in time series analysis. Discuss their relevance and applications in modeling time series data.

POOL I: DISCIPLINE SPECIFIC ELECTIVE COURSE

Course Code & Title	**MSSTA04DSE18- ACTUARIAL STATISTICS**		
Programme	**M.Sc. Statistics**	**Semester**	**IV**
Course Description	This course explores the intersection of insurance and utility theory, beginning with models for individual claims and their aggregate sums. Students will learn about survival functions, curtate future lifetime, and the force of mortality, laying the foundation for understanding life tables and their relationship with survival functions. The course also delves into compound Poisson distribution and its applications, as well as the principles of compound interest, including nominal and effective rates, force of interest, and continuous compounding. Recursions, commutation functions, and the nuances of different types of annuities will also be explored, including complete and apportionable annuities.		
Course Objectives	• Develop a greater understanding of statistical principles and their application in actuarial statistics. • Describe the core areas of actuarial practice and relate to those areas actuarial principles, theories and models. • Describe estimation procedures for lifetime distributions. • Explain the concept of survival models. • Understand the application of knowledge of the life insurance environment. • Describe Net premiums and its various types. • Expand their applied knowledge in various specialized areas of actuarial studies and statistics.		

Modules	Content	Module Outcome
Module I: Utility theory **(15 Hours)**	Insurance and utility theory, models for individual claims and their sums, survival function, curtate future lifetime, force of mortality. Life tables and its relation with survival function, examples, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables.	• Explains the utility theory and insurance. • Explain survival function and application. • Examine the properties of force of mortality. • Define Life tables and its relation with survival function, examples.
Module II: Life functions **(15 Hours)**	Multiple life functions, joint life and last survivor status, insurance and annuity benefits through multiple life functions evaluation for special mortality laws. Multiple decrement tables, central rates of multiples decrement, net single premiums and their numerical evaluations.	• Explain Multiple life functions and its properties. • Articulate the insurance and annuity benefits through multiple life functions evaluation for special mortality laws. • Explains the Multiple decrement tables. • Describe net single premiums and their numerical evaluations.
Module III: Distribution of aggregate claims **(15 Hours)**	Compound Poisson distribution and its applications. Principles of compound interest: Nominal and effective rates of interest and discount, force of interest and discount, compound interest,	• Define Distribution of aggregate claims. • Derive the compound Poisson distribution and explain its applications. • Explain Principles of

	accumulation factor, continuous compounding.	compound interest and its attributes.
Module IV: Life insurance **(15 Hours)**	Insurance payable at the moment of death and at the end of the year of death-level benefit insurance, endowment insurance, differed 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 apportion able annuities-due.	• Explain the Life insurance and its types. • Describe Insurance payable at the moment of death and at the end of the year of death-level benefit insurance • Explain the Life annuities and its types.
References	***Text Books*** 1. Beard, R.E., Penlikainen, T. and Pesonnen, E (1984): *Risk Theory: The Stochastic Basis of Insurance*, 3rd Edition, Chapman and Hall, London. ***Reference Books*** 1. Bowers, N.L., Gerber, H.U., Hickman, J.E., Jones, D.A. and Nesbitt, C.J. (1997): *Actuarial Mathematics', Society of Actuarias*, Ithaca, Illiois, U.S.A., second Edition. 2. Neill, A. (1977): *Life Contingencies*, Heineman.	
Course Outcomes	After successful completion of this course, student will be able to: 1. Understand the principles of insurance and utility theory, and apply them to analyze individual claims and their aggregate sums. 2. Analyze the relationship between life tables and survival functions, and apply this knowledge to evaluate insurance and annuity	

	benefits. 3. Demonstrate proficiency in using multiple decrement tables to assess insurance risks. 4. Apply the Compound Poisson distribution and principles of compound interest to model insurance-related phenomena. 5. Develop skills in evaluating and designing life annuities, including single payment, continuous, discrete, and monthly payment annuities.

TEACHING LEARNING STRATEGIES

- **Lecturing, Visualization, Team Learning**

MODE OF TRANSACTION

- **Lecture, Seminar, Discussion, Questioning and Answering**

ASSESSMENT RUBRICS

Components	Weightage
End Semester Evaluation(ESE)	**60**
Continuous Evaluation	
Tests	16
Assignment	08
Seminar/Viva	16
Total	**40**

Sample Questions to Test Outcomes:

1. Define insurance and utility theory. How does utility theory influence decision-making in insurance?
2. Discuss models for individual claims and their sums in the context of insurance. How are these models used to assess risk and determine premiums?

3. Explain the concepts of survival function, curtate future lifetime, and force of mortality in the context of life insurance. How are these concepts related?
4. Describe life tables and their relationship with the survival function. Provide examples to illustrate the use of life tables in actuarial calculations.
5. What assumptions are made for fractional ages in life tables? How do these assumptions impact the accuracy of actuarial calculations?
6. Discuss some analytical laws of mortality commonly used in actuarial science. What are select and ultimate tables, and how are they applied?
7. Explain multiple life functions and their significance in joint life and last survivor status insurance policies. How are insurance and annuity benefits evaluated using multiple life functions?
8. Define multiple decrement tables and central rates of multiple decrements. How are net single premiums calculated using multiple decrement tables?
9. Describe the compound Poisson distribution and its applications in insurance. How is it used to model the frequency and severity of insurance claims?
10. Discuss the principles of compound interest, including nominal and effective rates of interest, force of interest and discount, and continuous compounding. How are these principles applied in actuarial calculations for insurance products like endowment and annuity policies?

POOL I: DISCIPLINE SPECIFIC ELECTIVE COURSE

Course Code & Title	**MSSTA04O19-STATISTICAL QUALITY CONTROL**		
Programme	**M.Sc. Statistics**	**Semester**	**IV**
Course Description	This course covers the theory and application of statistical process control (SPC), beginning with the fundamentals of control charts. Students will learn about Shewhart control charts for variables, including R, s, p, np, c, and u charts, as well as modified control charts. Additionally, students will explore various sampling plans, including single, double, multiple, and sequential sampling plans. The course will also cover sampling plans		

	for single and double specification limits, as well as continuous sampling plans I, II, and III, and comparisons between sampling plans based on variables and attributes.
Course Objectives	• Understand the principles and theory behind statistical process control (SPC) and the significance of control charts in quality management. • Develop proficiency in constructing and interpreting Shewhart control charts for variables (R, s charts) and attributes (p, np, c, u charts), as well as modified control charts. • Gain insight into the performance of control charts through operating characteristic (OC) and average run length (ARL) curves. • Learn about advanced control chart techniques, including moving average control charts, exponentially weighted moving average (EWMA) charts, and cumulative sum (CUSUM) charts. • Explore process capability analysis and understand process capability indices to assess and improve process performance. • Master various sampling plans such as single sampling, double sampling, multiple sampling, and sequential sampling plans, including rectifying inspection plans. • Compare sampling plans based on variables and attributes and explore continuous sampling plans (I, II, and III) for continuous quality control processes.

Modules	Content	Module Outcome
Module I: Control Charts **(15 Hours)**	Statistical process control, theory of control charts, Shewhart control charts for variables, R,s charts, p, np, c, u charts, modified control charts.	• Understand the theory behind control charts and their role in SPC. • Demonstrate proficiency in constructing and interpreting Shewhart control charts for variables (R, s charts) and attributes (p, np, c, u charts). • Explore modified control charts and their applications in various industries.
Module II: Process Capability Analysis **(15 Hours)**	O.C and ARL curves of control charts, moving average control charts, EWMA charts, CUSUM charts, process capability analysis, process capability indices.	• Analyze operating characteristic (OC) and average run length (ARL) curves of control charts. • Apply moving average control charts, exponentially weighted moving average (EWMA) charts, and cumulative sum (CUSUM) charts to monitor process variability. • Conduct process capability analysis and calculate process capability indices to assess the performance of a process.
Module III: Acceptance Sampling for	Single sampling, double sampling, multiple sampling and sequential sampling plans, rectifying	• Differentiate between single sampling, double sampling, multiple sampling, and

Attributes **(15 Hours)**	inspection plans, measuring performance of the sampling plans - OC,AOQ,ASN, ATI curves.	sequential sampling plans. • Develop rectifying inspection plans to improve quality control processes. • Measure the performance of sampling plans using metrics such as OC, average outgoing quality (AOQ), average sample number (ASN), and average total inspection (ATI) curves.
Module IV: Acceptance Sampling by Variables **(15 Hours)**	Sampling plans for single specification limit with known and unknown and unknown variance. Sampling plans with double specification limits., comparison of sampling plans by variables and attributes, Continuous sampling plans I, II and III.	• Design sampling plans for single specification limits with known and unknown variance. • Implement sampling plans with double specification limits and compare them based on variables and attributes. • Explore continuous sampling plans (I, II, and III) and understand their applications in industries with continuous production processes.
References	***Text Books*** 1. Montgomory, D. C. (2005), *Introduction to Statistical Quality Control.* 5thEdition.Wiley,New-York. 2. Gerant, E. L. and Leaven Worth, R.S. (1980). *Statistical Quality Control.* McGraw Hill. ***Reference Books*** 1. Duncan, A.J.(1986).*Quality Control and Industrial Statistics*. 2. Mittage, H.J. and Rinne, H. (1993). *Statistical Methods for Quality Assurance.* Chapman and Hall.	

	3. Oakland, J. S. and Follorwel, R. F.(1990). *Statistical Process Control.* East-West Press. 4. Schilling, E.G. (1982). *Acceptance Sampling in Quality Control.* Marcel Dekker.
Course Outcomes	After successful completion of this course, student will be able to: 1. Understand the construction various control charts and their real data applications. 2. Understand various process capability indices and their applications. 3. Understand various different acceptance sampling plans for attributes and variables.

TEACHING LEARNING STRATEGIES

- **Lecturing, Visualization, Team Learning**

MODE OF TRANSACTION

- **Lecture, Seminar, Discussion, Questioning and Answering**

ASSESSMENT RUBRICS

Components	**Weightage**
End Semester Evaluation(ESE)	**60**
Continuous Evaluation	
Tests	16
Assignment	08
Seminar/Viva	16
Total	**40**

Sample Questions to Test Outcomes:

1. Define Statistical Process Control (SPC) and discuss its importance in quality management. What are the key objectives of implementing SPC in manufacturing processes?
2. Explain the theory of control charts in SPC. What are the fundamental principles behind control charts, and how do they help in monitoring and controlling process variability?
3. Describe Shewhart control charts for variables, including R charts and s charts. How are these charts constructed, and what do they indicate about process stability and variation?
4. Discuss p, np, c, and u charts in SPC. What types of processes are these charts suitable for, and how are they interpreted in terms of process control?
5. Explain modified control charts and their applications in SPC. What modifications can be made to traditional control charts, and under what circumstances are these modifications necessary?
6. Define Operating Characteristic (OC) and Average Run Length (ARL) curves of control charts. How are these curves used to evaluate the performance of control charts?
7. Describe moving average control charts, exponentially weighted moving average (EWMA) charts, and cumulative sum (CUSUM) charts. What advantages do these charts offer over traditional control charts?
8. Explain process capability analysis and process capability indices. How are these measures used to assess the ability of a process to meet specified quality requirements?
9. Discuss single sampling, double sampling, multiple sampling, and sequential sampling plans. What are the differences between these sampling plans, and how are they applied in quality inspection?
10. Describe sampling plans for single specification limits and double specification limits. How do these sampling plans vary based on known and unknown variance, and how are they evaluated using OC, AOQ, ASN, and ATI curves?

POOL I: DISCIPLINE SPECIFIC ELECTIVE COURSE

Course Code & Title	**MSSTA04DSE20- ADVANCED BAYESIAN COMPUTING WITH R**		
Programme	**M.Sc. Statistics**	**Semester**	**IV**
Course Description	This course provides a comprehensive overview of statistical decision-making, covering randomized decision rules, standard loss functions, and decision principles. Students explore the incorporation of prior information through subjective determination of prior density, non-informative priors, maximum entropy priors, and conjugate priors. Computational methods include Monte Carlo simulation, Markov Chain Monte Carlo methods like the Metropolis-Hastings algorithm, and introduction to software packages like Learn Bayes and Win-BUGS for practical implementation and examples.		
Course Objectives	• Understand the fundamental principles of statistical decision-making, including randomized decision rules and standard loss functions. • Explore the concept of prior information and its incorporation into decision-making. • Master the application of Bayes' theorem for inference, including the estimation of prior and posterior densities, and gain proficiency in analyzing parametric families and likelihoods, such as the exponential family. • Apply learned concepts and techniques to practical examples and real-world problems, using software packages such as Learn Bayes and Win-BUGS.		

Modules	Content	Module Outcome
Module I: Bayesian Inference **(15 Hours)**	Statistical decision problem, randomized decision rule, decision principle, standard loss functions, Prior information, subjective determination of prior density, non-informative priors,maximumentropypriors,conjugatepriors,discreteprior.Parametricfamily andlikelihood,exponentialfamily,Baye s'theoremforinference, prior and posterior densities.	• Understand and explain the concept of statistical decision-making. • Apply decision principles effectively in various decision-making scenarios. • Evaluate and compare different decision strategies based on their performance in minimizing expected loss and achieving desired outcomes.
Module II: Single and multi-parameter models **(15 Hours)**	single parameter models, normal distribution with known variance and unknown mean, normal with known mean and unknown variance, Poisson model, normaldistributionwithbothparameters unknown,multinomialmodel,Dirichletprior,Bioassayexperiment,comparing two proportions, predictive distribution, beta-binomial distribution, multivariate normal distribution, Introduction to Learn Bayes package, Examples using Learn Bayes package.	• Demonstrate proficiency in formulating and specifying prior. • Apply Bayes' theorem for inference tasks and analyze the impact of prior specification on posterior inference. • Evaluate the suitability of different prior distributions for specific modeling scenarios.
Module III: Bayesian	Computing integrals using Monte-Carlo simulation, approximation based	• Implement computational methods such as Monte Carlo

Computation **(15 Hours)**	on posterior mode, importance sampling, Markov Chain Monte Carlo methods, Metropolis-Hastings algorithm, random walk, Gibbs sampling.	simulation, importance sampling, and Markov Chain Monte Carlo (MCMC). • Evaluate the performance and efficiency of different computational techniques in generating posterior samples and estimating posterior distributions.
Module IV: Model Comparison and Regression models **(15 Hours)**	Hierarchical models, shrinkage estimators, posterior predictive model checking, comparison of hypotheses, Bayes factor, one sided test for normal mean, two-sided test for normal mean,normallinearregressionmodel,predictionoffutureobservations,examplesandRcodes, introduction to Win-BUGS package.	• Understand the concept of hierarchical models and their application in modeling complex data. • Perform posterior predictive model checking to assess the adequacy of hierarchical models and identify potential model misspecifications.
References	***Text Books*** 1. Jim Albert (2007). *Bayesian Computation with R*, New York: Springer Verlag. 2. Berger,O.J.(1985). *Statistical decision Theory and Bayesian Analysis,* Second Edition, Springer Verlag. 3. Bensal, A. K .(2008). *Bayesian Parametric Inference*, New Age, Delhi. ***Reference Books*** 1. Ferguson,T.S.(1967). *Mathematical Statistics: A Decision Theoretic Approach,* Academic Press, New-York. 2. Bolstad, W.(2004*). Introduction to Bayesian Statistics*, Hoboken, NJ: John Wiley.	

	3. Gelman, A., Carlin, J., Stern, H. and Rubin, D.(2003). *Bayesian Data Analysis,* New York: Chapman and Hall. 4. Gilks, W. R., Richardson, S and Spiegelhalter, D.J.(1996). *Markov Chain Monte Carlo in Practice.* Chapman & Hall/ CRC, New York. 5. Robert, C. and Casella, G.(2004).*Monte Carlo Statistical Methods*, New York: Springer 6. Spiegelhalter, D., Thomas, A., Best, N. and Lunn, D. (2003),Win-BUGS1.4Manual.
Course Outcomes	After successful completion of this course, student will be able to: 1. Understand the advantageous Bayes estimation over that based on frequentist approach. 2. Understand the LearnBayes package for various Bayesian computations 3. Understand MCMC methods in various situations in which the exact computation is difficult. 4. Understand Gibbs sampling to generate random samples from a multivariate distribution.

TEACHING LEARNING STRATEGIES

- **Lecturing, Visualization, Team Learning**

MODE OF TRANSACTION

- **Lecture, Seminar, Discussion, Questioning and Answering**

ASSESSMENT RUBRICS

Components	Weightage
End Semester Evaluation(ESE)	**60**
Continuous Evaluation	

Tests	16
Assignment	08
Seminar/Viva	16
Total	**40**

Sample Questions to Test Outcomes:

1. Define a randomized decision rule and explain its significance in statistical decision-making.
2. Discuss the role of prior information in Bayesian inference and explain how it is incorporated into the decision-making process.
3. Describe the concept of maximum entropy priors and explain when they are useful in Bayesian analysis.
4. Compare and contrast Monte Carlo simulation and importance sampling methods for estimating posterior distributions.
5. Explain the Metropolis-Hastings algorithm and discuss its advantages and limitations in Markov Chain Monte Carlo (MCMC) sampling.
6. Provide an example of a hierarchical model and explain how it can be used to analyze data with nested levels of variability.
7. Discuss the concept of shrinkage estimators and explain how they address overfitting in hierarchical modeling.
8. Explain the process of posterior predictive model checking and discuss its importance in assessing model adequacy.
9. Compute the Bayes factor for two competing hypotheses and interpret the results in the context of model comparison.
10. Implement the Win-BUGS software package to perform Bayesian analysis on a given dataset, and interpret the results obtained.