CENTRAL UNIVERSITY OF HARYANA

(*Established under the Central Universities Act, 2009*)

(NAAC Accredited 'A' Grade)

CBCS, LOCF and NEP-2020 Based

Curriculum and Syllabi

Of

M.Sc. Statistics

(w.e.f. 2022-2023)

DEPARTMENT OF STATISTICS
SCHOOL OF BASIC SCIENCES

Approved by :	**BOS**	**School Board**	**Academic Council**
Approval Status :	√	√	√
Approval Date :	10-05-2022	12-09-2022	07-10-2022

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Vision and Mission

Vision and Mission of the University

Vision

To develop enlightened citizenship of a knowledge society for peace and prosperity of individuals, nation and the world, through promotion of innovation, creative endeavours, and scholarly inquiry.

Mission

To serve as a beacon of change, through multi-disciplinary learning, for creation of knowledge community, by building a strong character and nurturing a value-based transparent work ethics, promoting creative and critical thinking for holistic development and self-sustenance for the people of India. The University seeks to achieve this objective by cultivating an environment of excellence in teaching, research and innovation in pure and applied areas of learning.

1. Background

i) NEP-2020 and LOCF an integrated Approach

Considering the curricular reforms as instrumental for desired learning outcomes, all the academic departments of Central University of Haryana made a rigorous attempt to revise the curriculum of undergraduate and postgraduate programmes in alignment with National Education Policy-2020 and UGC Quality Mandate for Higher Education Institutions-2021. The process of revising the curriculum could be prompted with the adoption of "Comprehensive Roadmap for Implementation of NEP-2020" in 32nd meeting of the Academic Council of the University held on April 23, 2021. The roadmap identified the key features of the Policy and elucidated the Action Plan with well-defined responsibilities and indicative timeline for major academic reforms.

The process of revamping the curriculum started with the series of webinars and discussions conducted by the University to orient the teachers about the key features of the Policy, enabling them to revise the curriculum in sync with the Policy. Proper orientation of the faculty about the vision and provisions of NEP-2020 made it easier for them to appreciate and incorporate the vital aspects of the Policy in the revised curriculum focused on 'creating holistic, thoughtful, creative and well-rounded individuals equipped with the key 21st century skills' for the 'development of an enlightened, socially conscious, knowledgeable, and skilled nation'.

With NEP-2020 in background, the revised curricula articulate the spirit of the policy by emphasising upon—integrated approach to learning; innovative pedagogies and assessment strategies; multidisciplinary and cross-disciplinary education; creative and critical thinking; ethical and Constitutional values through value-based courses; 21st century capabilities across the range of disciplines through life skills, entrepreneurial and professional skills; community and constructive public engagement; social, moral and environmental awareness; Organic Living and Global Citizenship Education (GCED); holistic, inquiry-based, discovery-based, discussion-based, and analysis-based learning; exposure to Indian knowledge system, cultural traditions and classical literature through relevant courses offering 'Knowledge of India'; fine blend of modern pedagogies with indigenous and traditional ways of learning; flexibility in course choices; student-centric participatory learning; imaginative and flexible curricular structures to enable creative combination of disciplines for study; offering multiple entry and exit points initially in undergraduate programmes; alignment of Vocational courses with the International Standard Classification of Occupations maintained by the International Labour Organization; breaking the silos of disciplines; integration of extra-curricular and curricular aspects; exploring internships with local industry, businesses, artists and crafts persons; closer collaborations between industry and higher education institutions for technical , vocational and science programmes; and formative assessment tools to be aligned with the learning outcomes, capabilities, and dispositions as specified for each course. In case of UG programmes in Engineering and Vocational Studies, it was decided that the departments shall incorporate pertinent NEP recommendations while complying with AICTE, NBA, NSQF, International Standard Classification of Occupations, Sector Skill Council and other relevant agencies/sources. The University has also developed consensus on adoption of Blended Learning with 40% component of online teaching and 60% face to face classes for each programme.

The revised curricula of various programmes could be devised with concerted efforts of the faculty, Heads of the Departments and Deans of Schools of Study. The draft prepared by each department was discussed in series of discussion sessions conducted at Department, School and the University level. The leadership of the University has been a driving force behind the entire exercise of developing the uniform template and structure for the revised curriculum. The Vice Chancellor of the University conducted series of meetings with Heads and Deans to deliberate upon the vital parameters of the revised curriculum to formulate a uniform template featuring Background, Programme Outcomes, Programme Specific Outcomes, Postgraduate Attributes, Structure of Masters Course, Learning Outcome Index, Semester-wise Courses and Credit Distribution, Course-level Learning Outcomes, Teaching-Learning Process, Blended Learning, Assessment and Evaluation, Keywords, References and Appendices. The experts of various Boards of Studies and School Boards contributed to a large extent in giving the final shape to the revised curriculum of each programme.

To ensure the implementation of curricular reforms envisioned in NEP-2020, the University has decided to implement various provisions in a phased manner. Accordingly, the curriculum may be reviewed annually.

ii) About the Statistics

Recent archaeological discovery of two ancient cities of Dravidian civilization (i.e. Mohenzo Daro, Harappa), in the Indus valley revealed that about 6000 BC a people of advanced culture were settled in the region. Among other things a set of dice was found indicating their knowledge of gambling or chance. The kings and rulers even in ancient India required certain facts and figures in order to run the country and accordingly they collected information which is now known as statistical information.

According to ‘Arthasastra’ written by the great Indian economist ‘Kautilya’ (see Shamasastry 1929, Edwards 1961) a civil service existed and there were departments for accounts, revenue, mines, taxation, agriculture, and trade, etc. There was State owned gambling places which used to take five per cent of the winnings in return for a guarantee that there were no loaded dice. This indicates that some development of the probability theory existed during this period.

In 1860, India faced severe famine and the government had to take stringent steps to save the people from starvation, but the government's problem was the lack of information regarding the exact number of people living in the country and the amount of food required. In order to rectify the situation, the government introduced decennial census in 1872 but subsequently established an ad-hoc census organisation in 1881.

In 1868 as a part of statistical development in India, an annual volume of Statistical Abstract of British 1ndia was published for the first time. This annual volume which was published regularly from London was finally transferred to India in 1923. In 1883, the most important development of the statistical set-up in the country took place when, in Calcutta, the All-India Statistical Conference was held, passing numerous resolutions for the future development of statistics in the country.

iii) About the Programme (Nature, extent and aims)

iv) Qualification Descriptors (possible career pathways)

On successful completion of the M.Sc. Statistics Programme, students of the Department are expected to work at different platforms in addition to live productive and meaningful lives. Some of the possible career paths for the postgraduate students may be:

- Indian Statistical Services
- Reserve Bank of India Research Officer
- Statistical Officer in Different Government Agency
- Statistical Quality Control Officer in Industry
- Business analyst in Corporate Sector
- Data Analyst in Corporate Sector

2. PROGRAMME OUTCOMES (POs)

Students enrolled in the Master's Programmes offered by the Departments under the School of Basic Sciences will have the opportunity to learn and master the following components in addition to attain important essential skills and abilities:

PO-No.	Component	Outcomes
PO-1	Basic Knowledge	Capable of delivering basic disciplinary knowledge gained during the programme.
PO-2	In-depth Knowledge	Capable of describing advanced knowledge gained during the programme.
PO-3	Critical thinking and Problem-Solving abilities	Capable of analyzing the results critically and applying acquired knowledge to solve the problems.
PO-4	Creativity and innovation	Capable to identify, formulate, investigate and analyze the scientific problems and innovatively to design and create products and solutions to real life problems.
PO-5	Research aptitude and global competency	Ability to develop a research aptitude and apply knowledge to find the solution of burning research problems in the concerned and associated fields at global level.
PO-6	Holistic and multidisciplinary education	Ability to gain knowledge with the holistic and multidisciplinary approach across the fields.
PO-7	Skills enhancement	Learn specific sets of disciplinary or multidisciplinary skills and advanced techniques and apply them for betterment of mankind.
PO-8	Leadership and Teamwork abilities	Ability to learn and work in a group and capable of leading a team even.
PO-9	Environmental and human health awareness	Learn important aspects associated with environmental and human health. Ability to develop eco-friendly technologies.
PO-10	Ethical thinking and social awareness	Inculcate the professional and ethical attitude and ability to relate with social problems.
PO-11	lifelong learning skills and Entrepreneurship	Ability to learn lifelong learning skills which are important to provide better opportunities and improve quality of life. Capable to establish independent startup/innovation center etc.

3. PROGRAMME SPECIFIC OUTCOMES (PSOs)

The post graduates shall be able to realise the following outcomes by the end of program studies:

Number	Programme Specific Outcomes
PSO-1	Will have a strong foundation in theoretical concepts of Statistics.
PSO-2	Will be able to apply practical concepts of Statistics for solving real life problems.
PSO-3	Will be able to get comprehensive knowledge and understanding of basic concepts in statistics and its linkages with humanities, social sciences and life sciences.
PSO-4	Will have basic and advance knowledge of computational statistical techniques as required for employment in government sector and corporate world.
PSO-5	Will identify interdisciplinary applications of Statistics for enhancing career prospects in different fields and research areas.
PSO-6	Will be able to transform the existing statistical knowledge effectively for the development of new statistical ideas and concepts.
PSO-7	Will be able to analyze, interpret and present the data and bring out the meaning, correlations and interrelationships.
PSO-8	Will be able to use scientific approaches to develop the domain of human knowledge through the use of empirical data expressed in quantitative form.

4. Postgraduate Attributes

On completion of the post graduate programme in statistics, students are expected to equip with the skills of creative, critical and rational thinking associated with statistics and its use for human society. The following attributes are expected from the students of M.Sc. Statistics:

No.	P.G. Attributes
PGA-1	Disciplinary Knowledge
PGA-2	Creative and Critical Thinking
PGA-3	Reflective Thinking
PGA-4	Problem Solving
PGA-5	Analytical Reasoning
PGA-6	Communication Skills
PGA-7	Research Skills
PGA-8	Life Skills
PGA-9	Life-long Learning
PGA-10	Global Competency

5. Structure of Masters Course

Types of Courses	Nature	Total Credits	%
Core Courses (CC)	Compulsory	72	75
Elective Courses (EC)	Discipline Centric Elective Courses	16	16.7
	Generic Elective Courses	8	8.3
Skilled-based courses/ Self-study based courses	Skill Enhancement Courses	4	Nil

6. Learning Outcome Index

(Mapping of Courses with POs and PSOs)

6.1 A Mapping of Courses with POs (first year)

Semester	POs ⇨	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
	Course No. ⇩											
I	CC-1	✓	✓	✓	✓		✓		✓		✓	✓
	CC-2	✓	✓	✓	✓	✓	✓		✓		✓	✓
	CC-3	✓	✓	✓	✓	✓	✓		✓		✓	✓
	CC-4	✓	✓	✓	✓	✓	✓		✓		✓	✓
	CC-5	✓		✓	✓			✓	✓		✓	✓
	GEC-1	✓		✓	✓		✓	✓	✓		✓	✓
	GEC-2	✓		✓	✓		✓	✓	✓		✓	✓
II	CC-6	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
	CC-7	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
	CC-8	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
	CC-9	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	DCEC-1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	DCEC-2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	GEC-3	✓		✓	✓		✓	✓	✓	✓	✓	✓
	GEC-4	✓		✓	✓		✓	✓	✓	✓	✓	✓

6.1B Mapping of Courses with POs (second year)

Semester	POs ⇨	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
	Course No. ⇩											
III	CC-10	✓	✓	✓	✓	✓		✓		✓	✓	✓
	CC-11	✓	✓	✓	✓	✓	✓		✓	✓		✓
	CC-12	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
	CC-13	✓	✓	✓			✓	✓	✓	✓	✓	
	CC-14	✓		✓	✓	✓	✓		✓	✓	✓	✓
	DCEC-3	✓	✓	✓	✓	✓		✓	✓		✓	✓
	DCEC-4	✓	✓	✓		✓	✓	✓	✓		✓	✓
IV	CC-15	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
	DCEC-5	✓	✓	✓	✓	✓		✓		✓	✓	
	DCEC-6	✓	✓	✓	✓	✓	✓		✓	✓		✓
	DCEC-7	✓	✓	✓	✓		✓	✓	✓	✓		✓
	DCEC-8	✓	✓	✓	✓	✓		✓	✓		✓	✓

6.2A Mapping of Courses with PSOs (first year)

Semester	PSOs ⇨ / Course No. ⇩	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
I	CC-1	✓	✓		✓	✓	✓		✓
	CC-2	✓	✓	✓	✓	✓	✓	✓	✓
	CC-3	✓	✓	✓	✓	✓	✓	✓	✓
	CC-4	✓	✓	✓	✓	✓	✓	✓	✓
	CC-5		✓	✓	✓	✓	✓	✓	✓
	GEC-1	✓	✓	✓		✓	✓	✓	✓
	GEC-2	✓	✓	✓		✓	✓	✓	✓
II	CC-6	✓	✓	✓	✓	✓	✓	✓	✓
	CC-7	✓	✓	✓	✓	✓	✓	✓	✓
	CC-8	✓	✓	✓	✓	✓	✓	✓	✓
	CC-9		✓	✓	✓	✓	✓	✓	✓
	DCEC-1	✓	✓	✓	✓	✓	✓	✓	✓
	DCEC-2	✓	✓	✓	✓	✓	✓		✓
	GEC-3	✓	✓	✓		✓	✓	✓	✓
	GEC-4	✓	✓	✓		✓	✓	✓	✓

6.2B Mapping of Courses with PSOs (second year)

Semester	PSOs ⇨ / Course No. ⇩	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
III	CC-10	✓	✓	✓	✓	✓	✓	✓	✓
	CC-11	✓	✓	✓	✓	✓	✓	✓	✓
	CC-12	✓	✓	✓	✓	✓	✓	✓	✓
	CC-13	✓	✓	✓	✓	✓	✓	✓	✓
	CC-14		✓	✓		✓	✓	✓	✓
	DCEC-3	✓	✓	✓	✓		✓	✓	✓
	DCEC-4	✓	✓		✓	✓	✓	✓	✓
IV	CC-15	✓	✓	✓	✓	✓	✓	✓	✓
	DCEC-5	✓	✓	✓	✓	✓	✓	✓	✓
	DCEC-6	✓	✓	✓	✓	✓		✓	✓
	DCEC-7	✓	✓	✓	✓	✓	✓	✓	
	DCEC-8	✓	✓	✓	✓	✓	✓		✓

7. Semester-wise Courses and Credit Distribution

SEMESTER-I (24-Credits)							
Sr. No.	**Course Code and Course No**	**Course Title**	**L**	**T**	**P**	**Hrs/ Week**	**Total Credits**
Core Courses (compulsory)							
CC-1	SBS ST 01 101 C 3104	Analysis and Linear Algebra	3	1	0	4	4
CC-2	SBS ST 01 102 C 3104	Probability Theory	3	1	0	4	4
CC-3	SBS ST 01 103 C 3104	Distribution Theory	3	1	0	4	4
CC-4	SBS ST 01 104 C 3104	Sampling Techniques	3	1	0	4	4
CC-5	SBS ST 01 105 C 0044	Practical	0	0	4	8	4
Generic Elective Courses (for students of other Departments**)**							
GEC-1	SBS ST 01 101 GE 3104	Introductory Statistics	3	1	0	4	4
GEC-2	SBS ST 01 102 GE 3104	Operations Research	3	1	0	4	4
SEMESTER-II (24-Credits)							
Sr. No.	**Course Code and Course No**	**Course Title**	**L**	**T**	**P**	**Hrs/ Week**	**Total Credits**
Core Courses (compulsory)							
CC-6	SBS ST 01 201 C 3104	Statistical Inference - I	3	1	0	4	4
CC-7	SBS ST 01 202 C 3104	Regression Analysis	3	1	0	4	4
CC-8	SBS ST 01 203 C 3104	Design of Experiments	3	1	0	4	4
CC-9	SBS ST 01 204 C 0044	Practical	0	0	4	8	4
Discipline Specific Elective Courses (any two depending on interest in specialization)							
DCEC-1	SBS ST 01 201 DCE 3104	Time Series and Statistical Quality Control	3	1	0	4	4
DCEC-2	SBS ST 01 202 DCE 3104	Operations Research	3	1	0	4	4
Generic Elective Courses (for students of other Departments**)**							
GEC-3	SBS ST 01 201 GE 3104	Applied Statistics	3	1	0	4	4

GEC-4	SBS ST 01 202 GE 3104	Biostatistics	3	1	0	4	4
SEMESTER-III (24-Credits)							
Sr. No.	**Course Code and Course No**	**Course Title**	**L**	**T**	**P**	**Hrs/ Week**	**Total Credits**
Core Courses (compulsory)							
CC-10	SBS ST 01 301 C 3104	Multivariate Analysis	3	1	0	4	4
CC-11	SBS ST 01 302 C 3104	Statistical Inference - II	3	1	0	4	4
CC-12	SBS ST 01 303 C 3104	Econometrics	3	1	0	4	4
CC-13	SBS ST 01 304 C 4004	Seminar	4	0	0	4	4
CC-14	SBS ST 01 305 C 0044	Practical	0	0	4	8	4
Discipline Specific Elective Courses (any two depending on interest in specialization)							
DCEC-3	SBS ST 01 301 DCE 3104	Stochastic Processes	3	1	0	4	4
DCEC-4	SBS ST 01 302 DCE 3104	Demography and Vital Statistics	3	1	0	4	4
SEMESTER-IV (24-Credits)							
Sr. No.	**Course Code and Course No**	**Course Title**	**L**	**T**	**P**	**Hrs/ Week**	**Total Credits**
Core Courses (compulsory)							
CC-15	SBS ST 01 401 PROJ 00016	Minor Project/Dissertation	**-**	**-**	**-**	-	16
Discipline Centric Elective Courses (any two depending on interest in specialization)							
DCEC-5	SBS ST 01 401 DCE 3104	Order Statistics	3	1	0	4	4
DCEC-6	SBS ST 01 402 DCE 3104	Survival Analysis	3	1	0	4	4
DCEC-7	SBS ST 01 403 DCE 3104	Decision Theory and Sequential Analysis	3	1	0	4	4
DCEC-8	SBS ST 01 404 DCE 3104	Statistical Computing	3	1	0	4	4
OR							
CC-15	SBS ST 01 401 PROJ 00024	Major Project/Dissertation	-	-	-	-	24

8. Course-Level Learning Outcomes

Course Structure

Course No: CC1	**Course Name:** Analysis and Linear Algebra				**Course Code:** SBS ST 01 101 C 3104		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 4**
2021-2023	M.Sc. Statistics	I	3	1	0	4	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 Hours					
		Pre-requisite of course: Nill					
Course Objective	This course provides help to understand the mathematical concept of convergence and its mathematical formalisms. Students will be able to use some fundamental theorems of real and complex analysis and their properties.						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Understand the convergence of sequence and series of real valued functions. **CO2:** Study the complex regions and contour integrals. **CO3:** Understand of rank of matrix, characteristic roots & vectors and portioning of matrices. **CO4:** Understand the concepts of vector space and subspaces.						

COURSE SYLLABUS

NOTE: Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	**Content of Each Unit**	**Hours of Each Unit**
I	Recap of elements of set theory, introduction to real numbers, open and closed intervals (rectangles), compact sets, Bolzano-Weirstrass theorem. Sequences and series, their convergence, real valued functions, continuous functions.	15
II	Uniform continuity, Uniform convergence. Maxima-minima of functions. Complex numbers, analytic function, Cauchy fundamental theorem, Cauchy integral theorem, contour integrations.	15
III	Determinant and trace, rank, ranks of product of two matrices, elementary matrices and Echelon forms. Partitioned matrices: addition, multiplication and inverse. Cayley Hamilton Theorem, diagonalization, generalized inverse: Definition and its computation.	15

IV	Definite and semi definite quadratic forms, index and signatures, simultaneous diagonalization of symmetric matrices (equivalent quadratic forms). Vector spaces, sub-spaces, linearly dependence and independence, orthogonalization process, orthonormal basis.	15

Suggested Readings:

1. Bartle, R.G. & Sherbert, D.R. (2011). Introduction to Real Analysis, 4th Edition. Wiley.
2. Saff, E.B. & Snider, A.D. (2014). Fundamentals of Complex Analysis with Applications to Engineering, Science and Mathematics, 3rd Edition. Pearson.
3. Rudin, W. (2013). Principles of Mathematical Analysis, 3rd Edition. McGraw Hill.
4. Biswas, S. (2012). A Textbook of Matrix Algebra, 3rd Edition. PHI Learning.

Course No: CC-2	Course Name: Probability Theory				Course Code: SBS ST 01 102 C 3104		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 4**
2021-2023	M.Sc. Statistics	I	3	1	0	4	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 hours					
		Pre-requisite of course: NIL					
Course Objective	This course will lay the foundation of probability theory and statistical modelling of outcomes of real-life random experiments through various statistical distributions.						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Understand the concepts of random variables, sigma-fields generated by random variables. **CO2:** Learn probability distributions and independence of random variables related to measurable functions. **CO3:** Gain the ability to understand the concepts of different types of generating function, sequence of random variables, convergence, modes of convergence. **CO4:** Learn the concepts of weak, strong laws of large numbers and central limit theorem.						

COURSE SYLLABUS

NOTE: 1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Classes of sets, field, sigma field, minimal sigma field, Borel field, sequence of sets, limits of a sequence of sets, measure, probability measure, Integration with respect to measure. Random experiment, outcomes, sample space, events, various definitions of probability, laws of total and compound probability. Boole's inequality. Conditional probability, independence of events. Bayes Theorem.	15
II	Random variable, probability mass function, probability density function, cumulative distribution function. Expectation of a random variable, properties of expectation, conditional expectation and its properties. Bivariate distributions and the joint probability distribution. Independence of random variables. Marginal and conditional distributions.	15

III	Moment generating function, probability generating function, cumulant generating function, characteristic function and their properties. Inversion, continuity and uniqueness theorems.	15
IV	Convergence in probability, almost sure convergence, convergence in distribution and their relationships. Chebyshev's inequality, weak law of large numbers (WLLN), strong law of large numbers (SLLN), central limit theorems.	15

Suggested Readings:

1. Rohatgi V.K. & Saleh A.K. Md.E. (2015). An Introduction to Probability and Statistics, 3rd Edition. Wiley.
2. Rao, B.L.S.P. (2010): A First Course in Probability and Statistics. World Scientific.
3. Hogg, R.V., McKean, J. & Craig, A.T. (2013). Introduction to Mathematical Statistics, 7th Edition. Pearson.
4. Mukhopadhyay, P. (2015). Mathematical Statistics. New Central Book Agency.

Course No: CC-3	Course Name: Distribution Theory				Course Code: SBS ST 01 103 C 3104		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 4**
2021-2023	M.Sc. Statistics	I	3	1	0	4	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 hours					
		Pre-requisite of course: NIL					
Course Objective	*The main objective of the course is to provide the detailed knowledge of the characterization of all the useful discrete and continuous distributions.*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Formulate the mathematical and statistical models for real data sets arising in various fields in order to analyze in respect of various useful characteristics of the populations. **CO2:** Understand how to use univariate distributions in real life problems. **CO3:** Understand central and Non-central χ^2, *t* and *F* distributions. **CO4:** Work with bivariate normal and multivariate normal distribution, which is a challenging problem in today's life.						

COURSE SYLLABUS

NOTE: 1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Bernoulli, Binomial, Poisson, Geometric, Negative Binomial, Multinomial, Hypergeometric and discrete uniform distributions; their means, variances, modes, moment generating functions, cumulant generating function, probability generating functions and characteristic functions, important properties with their proofs related to these distributions.	15
II	Continuous uniform, Exponential, Gamma, Normal, Beta, Cauchy, Laplace, Weibull, Pareto and lognormal with their properties including proofs; their means, variances, moment generating functions, cumulant generating function and characteristic functions.	15

III	Compound, truncated and mixture distributions. Central and Non-central Chi-square (χ^2), t and F distributions with their properties including their means, variances, moment generating functions, cumulant generating function and characteristic functions.. Multidimensional random variables, its pdf/pmf and cdf.	15
IV	Bivariate normal distribution with its applications and important properties including their means, variances, moment generating functions, Multivariate normal distribution, its marginal and conditional distributions and related properties.	15

Suggested Readings:

1. Krishnamoorthy, K. (2015). Handbook of Statistical Distributions with Applications, 2nd Edition. CRC Press.
2. Rohatgi V.K. & Saleh A.K. Md.E. (2015). An Introduction to Probability and Statistics, 3rd Edition. Wiley.
3. Goon, A.M., Gupta, M.K. & Dasgupta, B. (2016). Fundamentals of Statistics, Vol. I. World Press.
4. Forbes, C., Evans, M., Hastings, N. & Peacock, B. (2010). Statistical Distributions, 4th Edition. Wiley.

Course No: CC-4	Course Name: Sampling Techniques				Course Code: SBS ST 01 104 C 3104		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 4**
2021-2023	M.Sc. Statistics	I	3	1	0	4	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 hours **Pre-requisite of course:** NIL					
Course Objective	The objective of this course is to acquaint the students about: (i) the need & merits of sampling over census and (ii) the implementation of various sampling schemes along with their merits, demerits and comparisons in appropriate practical situations.						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Learn the basic concepts of population and sample or the basic concepts of survey. **CO2:** Learn the principles of sample survey and the steps involved in selecting a sample. **CO3:** Understand the distinctive features of different sampling techniques and their related estimation problems. **CO4:** Learn the practical applications of the various sampling techniques in real life situations.						

COURSE SYLLABUS

NOTE: 1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Introduction to sampling, concept of population and sample, census and sample surveys, sampling and non-sampling errors. Types of sampling, non-probability sampling, probability sampling, basic principles of sample surveys. Simple random sampling, sampling from finite populations with and without replacement, unbiased estimation and confidence intervals for population mean and total, simple random sampling of attributes.	15
II	Stratified sampling, reasons for stratification, choice of strata, choice of sampling unit, estimation of population mean and its variance, choice of sample sizes in different strata, variances of estimates with different allocation, effects of deviation from optimum allocations, estimation of the gain in precision due to stratification, cost function, construction of strata. Systematic Sampling: merits and demerits of systematic sampling, estimation of sample mean and its variance, comparison of systematic sampling with simple random and stratified sampling.	15
III	Ratio and regression methods of estimation, variances of the estimates,	15

	optimum property of ratio estimates, comparison among ratio, regression and simple random sampling estimates, ratio estimate in stratified sampling, comparison with the ratio and mean per unit. Cluster Sampling, estimates of mean and its variance for equal and unequal clusters, efficiency in terms of intraclass correlation, optimum unit of sampling, sampling with replacement, estimation of mean and its variance.	
IV	Sampling with varying probabilities with and without replacement, sampling with probability proportional to size, Lahiri's method of selection, Horvitz-Thompson estimator, its variance and unbiased estimate of this variance. Introduction of multistage sampling, two stage sampling with equal first stage units, estimation of its mean and variance, introduction of multiphase sampling, double sampling for ratio and regression methods of estimation.	15

Suggested Readings

1. Singh, D. & Chaudhary, F.S. (2016). Theory and Analysis of Sample Survey Designs. New Age International Publishers.
2. Arnab, R. (2017). Survey Sampling Theory and Applications. Academic Press.
3. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. & Ashok, C. (2014). Sampling Theory of Surveys with Applications. New Delhi: Piyush Publications.
4. Cocharn, W.G. (2007). Sampling Techniques, 3rd Edition. Wiley.

Course No: CC-5	**Course Name: PRACTICAL**				**Course Code: SBS ST 01 105 C 0044**		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 8**
2021-2023	M.Sc. Statistics	I	0	0	4	4	**Total Hours: 120**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 hours **Pre-requisite of course:** NIL					
Course Objective	The objective of this course is to acquaint the students about: (i) the need & merits of sampling over census and (ii) the implementation of various sampling schemes along with their merits, demerits and comparisons in appropriate practical situations. (iii) Detailed knowledge of the characterization of all the useful discrete and continuous distributions.						
Course Outcomes:	**CO1:** Learn the basic concepts of population and sample or the basic concepts of survey. **CO2:** Learn the principles of sample survey and the steps involved in selecting a sample. **CO3:** Understand the distinctive features of different sampling techniques and their related estimation problems. **CO4:** Learn the discrete and continuous probability distribution.						

COURSE SYLLABUS

Content of Each Unit	**Hours**
Practicals based on Distribution Theory (SBS ST 01 103 C 3104) and Sampling Techniques (SBS ST 01 104 C 3104).	120

Course No: GEC-1	Course Name: Introductory Statistics				Course Code: SBS ST 01 101 GE 3104		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 4**
2021-2023	M.Sc. Statistics	I	3	1	0	4	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 hours					
		Pre-requisite of course: NIL					
Course Objective	The objective of this course is to define a variety of basic statistical terms and concepts, solve fundamental statistical problems, understanding of statistical fundamentals to interpret data.						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Study the concept of measures of central tendency, dispersion, skewness and kurtosis. **CO2:** Study the fundamental concept of random variables and its probability distributions. **CO3:** Study discrete and continuous probability distributions along with their applications. **CO4:** Understand applicability of various tests of hypothesis about population parameters using sample statistic and to draw valid conclusions.						

COURSE SYLLABUS

NOTE:

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Introduction to Statistical Analysis, Measures of Central Tendency: Mean, median, mode, geometric mean, harmonic mean. Measures of Dispersion: range, mean deviation, variance, standard deviation. Quartiles. Quartile deviation, coefficient of variation, measures of skewness, measures of kurtosis.	15
II	Random experiment, outcomes, sample space, events, classical definition of probability, random variables, probability mass function, probability density function, cumulative distribution function, mathematical expectation, Variance, Binomial,	15

	Poisson, Geometric, Exponential, Normal distributions.	
III	Null hypothesis, alternative hypothesis, type I error, type II error, level of significance, p-value and power of test. Tests for mean based on normal distribution – one sample t-test, two-sample t-test, paired-sample t-test. Tests for variance based on normal distribution – one sample and two-sample problem. One-way and Two-way analysis of variance (ANOVA) techniques.	15
IV	Karl Pearson's correlation coefficient, Spearman's rank correlation coefficient, principle of least square, lines of regression, simple linear regression, coefficient of determination. Multiple linear regression, coefficient of multiple determination.	15

Suggested Readings:

1. Goon, A.M., Gupta, M.K. & Dasgupta, B. (2016). Fundamentals of Statistics, Vol. I & II. World Press.
2. Das, N.G. (2012). Statistical Methods, Vol I & II. Tata McGraw Hill.
3. Walpole, R.E., Myers, R.H., Myers, S.L. & Ye, K.E (2012). Probability and Statistics for Engineers and Scientists. Pearson.
4. Rao, B.L.S.P. (2010): A First Course in Probability and Statistics. World Scientific.

Course No: GEC-2	Course Name: OPERATIONS RESEARCH				Course Code: SBS ST 01 102 GE 3104		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 4**
2021-2023	M.Sc. Statistics	I	3	1	0	4	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 hours **Pre-requisite of course:** NIL					

Course Objective	To provide the ideas of formulating mathematical modeling and their optimum solution in the context of practical problems belonging to Government/Private Sectors. Also, to give students a firm foundation in the advanced optimization techniques for the solution of the problems covered in course contents.
Course Outcomes:	On completion of this course, students will be able to: **CO1:** Identify and develop operational research models from the verbal description of the real system. **CO2:** Understand the characteristics of different types of decision-making environments and decision-making approaches. **CO3:** Understand the mathematical tools that are needed to solve optimization problems. **CO4:** Analyze the inventory situations.

COURSE SYLLABUS

NOTE:

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.
2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Origin and development of operations research (O.R.), modelling in O.R., applications of O.R., opportunities and shortcomings of O.R. Formulation of linear programming problem (LPP), graphical solution to LPP, properties of a solution to the LPP, generating extreme point solutions.	15
II	The simplex computational procedure, development of minimum feasible solution, a first feasible solution using slack variables, the artificial basis technique.	15
III	Two phase method and Charnes M-method with artificial variables. The	15

	duality problem of linear programming and its economic interpretation, transportation and assignment problems.	
IV	Game theory problem as a linear programming problem, integer programming. Replacement models and sequencing theory. Inventory management: characteristics of inventory systems. Classification of items. Deterministic inventory systems with and without lead-time.	15

Suggested Readings

1. Taha, H.A. (2017). Operations Research: An Introduction, 10th Edition. Pearson.
2. Gass, S.I. (2010). Linear Programming, Methods and Applications, 5th Edition. Dover Books.
3. Gross, D., Shortle, J.F., Thompson, J.M. & Harris, C.M. (2017). Fundamentals of Queueing Theory, 5th Edition. Wiley.
4. Water, D. (2013). Inventory Control and Management, 2nd Edition. Wiley.

Course No: CC-6	Course Name: Statistical Inference - I				Course Code: SBS ST 01 201 C 3104		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 4**
2021-2023	M.Sc. Statistics	II	3	1	0	4	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 hours **Pre-requisite of course:** NIL					

Course Objective	*The objective of estimation theory is to arrive at an estimator that exhibits optimality. To provide a systematic account of Neyman Pearson theory of testing and closely related theory of point estimation and confidence sets, together with their applications.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Understand the various estimation and testing procedures to deal with real life problems. **CO2:** Learn about the Fisher Information, lower bounds to variance of estimators, MVUE. **CO3:** Understand the concept of Neyman-Pearson fundamental lemma, UMP test and interval estimation. **CO4:** Understand the concept of critical regions, likelihood ratio test with its asymptotic distribution.

COURSE SYLLABUS

NOTE:

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.
2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Criteria of a good estimator- unbiasedness, consistency, efficiency, sufficiency. Minimal sufficient statistic. Exponential and Pitman families of distributions. Cramer-Rao lower bound approach to obtain minimum variance unbiased estimator. Uniformly minimum variance unbiased estimator, Complete statistic, Rao-Blackwell theorem, Lehmann-Scheffe theorem.	15
II	Method of moments, minimum chi-square estimation, maximum likelihood estimator and its properties, CAN & BAN estimators. Ancillary statistic and Basu' s theorem.	15

	Simple and composite hypothesis, concept of critical regions, test functions, two types of error, power of the test, level of significance, Neyman-Pearson lemma, uniformly most powerful (UMP) tests.	
III	Types A, A1 critical regions, likelihood ratio test (LRT) with its asymptotic distribution, UMP tests for monotone likelihood ratio family of distributions. Similar tests with Neyman structure, Construction of similar and UMPU tests through Neyman structure.	15
IV	Confidence interval, construction of confidence intervals using pivotal, shortest expected length confidence interval, uniformly most accurate one-sided confidence interval and its relation to UMP test for one sided null against one sided alternative hypothesis.	15

Suggested Readings:

1. Johnson, R.A. and Wichern, D.W. (2015): Applied Multivariate Statistical Analysis, Sixth Edition, Pearson Education India.
2. Hardle, W.K. and Hlavka, Z. (2015): Multivariate Statistics, Springer.
3. Anderson, T.W. (2003): An Introduction to Multivariate Statistical Analysis, Third Edition, Wiley.
4. Härdle, W.K. and Simar, L. (2015): Applied Multivariate Statistical Analysis, Springer.
5. Singh, B.M. (2004): Multivariate statistical analysis, South Asian Publishers.

Course No: CC-7	Course Name: Regression Analysis				Course Code: SBS ST 01 202 C 3104		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 4**
2021-2023	M.Sc. Statistics	II	3	1	0	4	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 hours					
		Pre-requisite of course: NIL					
Course Objective	The objectives of this course are to develop theoretical foundation of regression models and understand fundamental concepts of regression analysis.						
Course Outcomes:	On completion of this course, students will be able to: **CO1:** Understand simple and multiple linear regression models with their applications. **CO2:** Learn the fitting of these models to simulated and real data sets. **CO3:** Learn model adequacy using classical diagnostics, awareness of potential problems (outliers, etc.) and application of remedies to deal with them. **CO4:** Understand the basic concepts of logistic, Poisson and generalized linear models.						

COURSE SYLLABUS

NOTE: 1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Simple Linear Regression: Simple linear regression model. Least-squares estimation of parameters. Hypothesis testing on the slope and intercept. Interval estimation in simple linear regression. Prediction of new observations. Coefficient of determination. Estimation by maximum likelihood. Multiple linear regression: Multiple linear regression models. Estimation of the model parameters. Hypothesis testing in multiple linear regression. Confidence intervals in multiple regression. Coefficient of determination and Adjusted R^2.	15
II	Model Adequacy: Checking of linearity between study and explanatory variable, Residual Analysis, Detection and treatment of outliers, Residual plots. The PRESS statistic. Outlier test based on Studentized Residual (R-student). Test for lack of fit of the regression model. Transformation and Weighting to Correct Model Inadequacies: Variance stabilizing transformations. Transformations to linearize the model. Analytical methods for selecting a transformation on study variable. Diagnostic for	15

	Leverage and Influence: Leverage, measures of influence.	
III	Generalized and weighted least square estimation. Polynomial Regression Models: Polynomial models in one variable. Orthogonal Polynomials. Piecewise polynomial (Splines). Variable Selection and Model Building: Incorrect model specifications. Evaluation of subset regression model. Computational techniques for variable selection.	15
IV	Logistic and Poisson regression models: Introduction, Linear predictor and link functions, logit, probit, odds ratio, maximum likelihood estimation, test of hypothesis. Generalized linear models: Exponential family of distribution, Linear predictors and link functions, Maximum likelihood estimation of GLM. Prediction and confidence interval with GLM.	15

Suggested Readings

1. Montegomery, D.C., Peck, E.A. & Vining, G.G. (2015). Introduction to Linear Regression Analysis, 5th Edition. Wiley.
2. Rao, C.R. (2009). Linear Statistical Inference and its Applications, 2nd Edition. Wiley.
3. Draper, N.R. & Smith, H. (2011). Applied Regression Analysis, 3rd Edition. Wiley.
4. Chatterjee, S. and Hadi, A.S. (2012). Regression Analysis by Example, 5th Edition. Wiley.
5. Fox, J. and Weisberg, S. (2019). An R Companion to Applied Regression, 3rd Edition. Sage Publications.

Course No: CC-8	Course Name: Design of Experiments				Course Code: SBS ST 01 203 C 3104		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 4**
2021-2023	M.Sc. Statistics	II	3	1	0	4	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 hours **Pre-requisite of course:** NIL					

Course Objective	To provide orientation of statistics while designing statistical experiments, particularly in agricultural set-up and in pharmaceutical production processes. Exposure to various statistical designs leading to the analysis of variance, eliminating heterogeneity of the data, construction of designs will be provided.
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Understand the concepts of design of experiments and application of ANOVA, ANCOVA. **CO2:** Construct complete and partially confounded factorial designs and perform their analysis. **CO3:** Design and analyse incomplete block designs, understand the concepts of efficiency of BIBD relative to RBD. **CO4:** Understand the concepts of first order, orthogonal and treatment-control designs.

COURSE SYLLABUS

NOTE:

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.
2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Introduction to design of experiments. Three basic principles of design of experiments: randomisation, replication and local control. Uniformity trials. Analysis of basic design, asymptotic relative efficiency, missing plot techniques, analysis of covariance for CRD and RBD.	15
II	Factorial experiments: 2^k, 3^2 and 3^3 systems only. Complete and partial confounding, factorial replication in 2^k systems. Two-level fractional factorial designs: introduction, the one-	15

	quarter fraction of the 2^k design. Alias structure in fractional factorials and other designs.	
III	Incomplete block design: balanced incomplete block design, simple lattice design, split-plot design, strip-plot design, comparison of two treatments, efficiency of BIBD relative to RBD.	15
IV	Response surface methodology, first order designs, and orthogonal designs, treatment-control designs, model variation and use of transformation.	15

Suggested Readings:

1. Montgomery, D.C. (2013). Design and Analysis of Experiments, 8th Edition. Wiley.
2. Toutenburg, H. & Shalabh (2010). Statistical Analysis of Designed Experiments, 3rd Edition. Springer.
3. Cobb, G.W. (2014). Introduction to Design and Analysis of Experiments. Wiley.
4. Lawson, J. (2014). Design and Analysis of Experiments with R. CRC Press.

Course No: CC-9	Course Name: Practical 102				Course Code: SBS ST 01 204 C 0044		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 8**
2021-2023	M.Sc. Statistics	II	0	0	4	4	**Total Hours: 120**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 hours					
		Pre-requisite of course: NIL					
Course Objective	To provide orientation of statistics while designing statistical experiments, particularly in agricultural set-up and in pharmaceutical production processes. Exposure to various statistical designs leading to the analysis of variance, eliminating heterogeneity of the data, construction of designs will be provided.						
Course Outcomes:	**CO1:** Understand simple and multiple linear regression models with their applications. **CO2:** Understand the various estimation and testing procedures to deal with real life problems. **CO3:** Understand the concepts of design of experiments and application of ANOVA, ANCOVA. **CO4:** Construct complete and partially confounded factorial designs and perform their analysis.						

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours
	Practicals based on Statistical Inference - I (SBS ST 01 201 C 3104), Regression Analysis (SBS ST 01 202 C 3104) and Design of Experiments (SBS ST 01 203 C 3104).	120

Course No: DCEC-1	Course Name: Time Series and Statistical Quality Control				Course Code: SBS ST 01 201 DCE 3104		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 4**
2021-2023	M.Sc. Statistics	II	3	1	0	4	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 hours					
		Pre-requisite of course: NIL					
Course Objective	The objective of this course is to equip the students of M.Sc. Statistics with knowledge of industrial statistics as well as applications of Time series in real life.						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Study the components of time series and its use to forecast the future values. **CO2:** Learn auto covariance and auto-correlation functions. **CO3:** Study the concept and applications of control charts for variables and attributes. **CO4:** Understand different sampling inspection plans and their applications.						

COURSE SYLLABUS

NOTE:

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Time series: objects, decomposition, examples of time series, trend component, polynomial, logistic, Gompertz, log-normal trend functions, smoothing of moving average, Spencer's formulae and effects, variate difference method, Measurement of seasonal and cyclical functions, Peridogram and harmonic analysis.	15
II	Concepts of auto regression, autocorrelation, partial autocorrelation and correlogram analysis. Linear models for stationary time series. First order moving average (MA(1)) process, second order moving average (MA(2)) process. First order autoregressive process (AR(1)), second order	15

	autoregressive process (AR(2)). Autoregressive moving average (ARMA) and autoregressive integrated moving average (ARIMA) models.	
III	Concept of quality and meaning of control, Chance and assignable causes of quality variation, product and process controls. Concept of 3-sigma limits. Modified and specifications limits. Different types of control charts like $\bar{X}$, R, np, p and c with their applications in industry.	15
IV	Sampling inspection v/s 100% inspection. Single, double, multiple and sequential sampling plans for attributes. Operating characteristic (OC), AOQL, ASN and ATI curves. Concept of producer's and consumer's risk, AQL and LTPD. Variable sampling plans.	15

Suggested Readings:

1. Montgomery, D.C., Jennings, C.L. & Kulahci, M. (2015). Introduction to Time Series Analysis and Forecasting, 2nd Edition. Wiley.
2. Brockwell, P.J. & Davis R.A. (2016). Introduction to Time Series and Forecasting, 2nd Edition. Springer.
3. Montgomery, D.C. (2012). Introduction to Statistical Quality Control, 7th Edition. Wiley.
4. Grant, E. & Leavenworth, R. (2012). Statistical Quality Control, 7th Edition. Tata McGraw Hill.

Course No: DCEC-2	Course Name: OPERATIONS RESEARCH				Course Code: SBS ST 01 202 DCE 3104		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 4**
2021-2023	M.Sc. Statistics	II	3	1	0	4	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 hours **Pre-requisite of course:** NIL					

Course Objective	To provide the ideas of formulating mathematical modeling and their optimum solution in the context of practical problems belonging to Government/Private Sectors. Also, to give students a firm foundation in the advanced optimization techniques for the solution of the problems covered in course contents.
Course Outcomes:	On completion of this course, students will be able to: **CO1:** Identify and develop operational research models from the verbal description of the real system. **CO2:** Understand the characteristics of different types of decision-making environments and decision-making approaches. **CO3:** Understand the mathematical tools that are needed to solve optimization problems. **CO4:** Analyze the inventory and queueing models.

COURSE SYLLABUS

NOTE:

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.
2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Origin and development of operations research (O.R.), modelling in O.R., applications of O.R., opportunities and shortcomings of O.R. Formulation of linear programming problem (LPP), graphical solution to LPP, properties of a solution to the LPP, generating extreme point solutions.	15
II	The simplex computational procedure, development of minimum feasible solution, a first feasible solution using slack variables, the artificial basis technique. Two phase method and Charnes M-method with artificial variables. The duality problem of linear programming and its economic	15

	interpretation, transportation and assignment problems.	
III	Inventory management: characteristics of inventory systems. Classification of items. Deterministic inventory systems with and without lead-time. All unit and incremental discounts. Single period stochastic models.	15
IV	Queueing Theory: Introduction of the queuing system, Various components of a queueing system. Pure Birth Process; Pure Death Process, Birth and Death Process, M/M/1 , M/M/1 (Generalized), M/M/1/FCFS/K/∞, M/M/C, Erlang's loss model.	15

Suggested Readings

1. Taha, H.A. (2017). Operations Research: An Introduction, 10th Edition. Pearson.
2. Gass, S.I. (2010). Linear Programming, Methods and Applications, 5th Edition. Dover Books.
3. Gross, D., Shortle, J.F., Thompson, J.M. & Harris, C.M. (2017). Fundamentals of Queueing Theory, 5th Edition. Wiley.
4. Water, D. (2013). Inventory Control and Management, 2nd Edition. Wiley.

Course No: GEC-3	**Course Name:** Applied Statistics				**Course Code:** SBS ST 01 201 GE 3104		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 4**
2021-2023	M.Sc. Statistics	II	3	1	0	4	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 Hours					
		Pre-requisite of course: NIL					
Course Objective	The course aims to study various models and components of time series analysis for forecasting purposes and various methods to control the quality of a product. It also gives the study of distribution of population with respect to birth, migration, aging and death.						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Study the components of time series and their measurement. **CO2:** Study process control and its tools-control chart for variables and attributes. **CO3:** Learn the basic measures of mortality and fertility and their application. **CO4:** Understand life tables and their uses in real life problems.						

COURSE SYLLABUS

NOTE:

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.
2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Time Series: Components of time series, Decomposition of time series- Additive and multiplicative model with their merits and demerits, Illustrations of time series, measurement of trend by method of moving averages, method of semi-averages and method of least squares (linear, quadratic and exponential). Measurement of seasonal variations by method of simple averages, method of ratio to trend.	15
II	Statistical Quality Control: Importance of statistical methods in industrial research and practice, determination of tolerance limits, causes of variations in quality: chance and assignable. General theory of control charts, process and product control, control charts for variables: X- bar and R-charts, control charts for attributes: p and c-charts.	15

III	Demographic Methods: Introduction, measurement of population, rates and ratios of vital events, measurement of mortality: Crude Death Rate, Specific Death Rate (w. r. t. age and sex), Infant Mortality Rate, Standardized death rates.	15
IV	Life (mortality) tables: definition of its main functions and uses, measurement of fertility and reproduction: Crude Birth Rate, General Fertility Rate and Total Fertility Rate. Measurement of population growth: Gross Reproductive Rate, Net Reproductive Rate.	15

Suggested Readings:

1. Mukhopadhyay, P. (2011). Applied Statistics, 2nd Edition. Books and Allied (P.) Ltd.
2. Goon, A.M., Gupta, M.K. & Dasgupta, B. (2016). Fundamentals of Statistics, Vol. II. 9th Edition. World Press.
3. Montegomery, D.C. (2013). Statistical Quality Control: A Modern Introduction, 7th Edition. Wiley.
4. Burr, J.T. (2014). Elementary Statistical Quality Control, 2nd Edition. CRC Press.

Course No: GEC-4	Course Name: Biostatistics				Course Code: SBS ST 01 202 GE 3104		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 4**
2021-2023	M.Sc. Statistics	II	3	1	0	4	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 hours **Pre-requisite of course:** NIL					
Course Objective	The objective of this course is to define a variety of data types, representation and interpretation of data, sampling techniques and design of experiments.						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** able to learn about different types of data & scales also tabulated representation of data. **CO2:** understand how to represent data graphically. **CO3:** able to learn how to collect samples and analyze them by using different sampling techniques. **CO4:** understand the concept of design of experiments and their applications.						

COURSE SYLLABUS

NOTE:

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.
2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Statistical Data, Types of Data: attributes and variables, discrete & continuous data, Primary data, Secondary data, Different types of scales- nominal, ordinal, ratio and interval. Presentation of data: Construction of tables with one or more factors of classification.	15
II	Diagrammatic and graphical representation of data: Pictorial representation, Bar chart, Pie Chart, histogram, frequency polygon, frequency curve and ogives. Stem and leaf chart. Box Plot Central tendency and its measures: Mean, Median and Mode	15
III	Concepts of population and sample, census and sample surveys, Basic concepts in sampling and designing of a large scale surveys, steps involved in sample survey, Types of sampling: sample and the	15

	probability sample; simple random sampling with and without replacement; Stratified sampling; Systematic sampling.	
IV	Experimental designs: Terminology, experimental error, basic principles, uniformity trials, fertility contour maps, choice of size and shape of plots and blocks. Basic designs: Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD) – layout, model and statistical analysis, relative efficiency, analysis with missing observations.	15

1. Goon, A.M., Gupta, M.K. & Dasgupta, B. (2016). Fundamentals of Statistics, Vol. I & II. World Press.
2. Das, N.G. (2012). Statistical Methods, Vol I & II. Tata McGraw Hill.
3. Daniel, W.W. & Cross, C.L. (2012). Biostatistics: A Foundation for Analysis in the Health Sciences, 10th Edition. Wiley.
4. Montgomery, D. C. (2008): Design and Analysis of Experiments, John Wiley.

Course No: CC-10	Course Name: Multivariate Analysis				Course Code: SBS ST 01 301 C 3104		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 4**
2021-2023	M.Sc. Statistics	III	3	1	0	4	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 hours **Pre-requisite of course:** NIL					

Course Objective	*The main objective of this course is to introduce students to the analysis of observations on several correlated random variables for a number of individuals. Multivariate analysis is applicable in almost all scientific studies, for example in Anthropology, Life sciences, Agriculture and Economics, when one deals with several variables simultaneously.*
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Account for important theorems and concepts in multivariate analysis. **CO2:** Understand the concept of Wishart and Hotelling's T^2 distribution. **CO3:** Understand the link between multivariate techniques and corresponding univariate techniques. **CO4:** Conduct statistical inference about multivariate means including hypothesis testing, confidence region calculation, etc.

COURSE SYLLABUS

NOTE:

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.
2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Multivariate normal distribution, its properties and characterization. Random sampling from a multivariate normal distribution. Maximum likelihood estimators of parameters. Distribution of sample mean vector. Inference concerning the mean vector when the covariance matrix is known. Matrix normal distribution. Multivariate central limit theorem.	15
II	Wishart matrix, its distribution and properties. Distribution of sample generalized variance. Hotelling's T^2 statistic and its	15

	distribution and properties. Applications in tests on mean vector for one and more multivariate normal populations. Mahalanobis' D^2 .	
III	**[Course Outcome (s) No. : CO3]** Likelihood ratio test criteria for testing of independence of sets of variables, equality of covariance matrices, identity of several multivariate normal populations, equality of a covariance matrix to a given matrix, equality of a mean vector and a covariance matrix to a given vector and a given matrix.	15
IV	**[Course Outcome (s) No. : CO4]** Classification and discrimination procedures for discrimination between two multivariate normal populations, sample discriminant function, tests associated with discriminant functions, classification into more than two multivariate normal populations. Principal components, canonical variables and canonical correlations. Multivariate analysis of variance [MANOVA] of one-way classified data. Wilk's lambda criterion.	15

Suggested Readings:

1. Rohatgi, V.K. & Saleh, A.K. Md.E. (2015). An Introduction to Probability and Statistics, 3rd Edition. Wiley.
2. Lehmann, E.L. & Casella, G. (2014). Theory of Point Estimation, 2nd Edition. Springer.
3. Lehmann, E.L. & Romano, J.P. (2010). Testing Statistical Hypotheses, 3rd Edition. Springer.
4. Casella, G. & Berger, R.L. (2013). Statistical Inference, 2nd Edition. Cengage Learning.

Course No: CC-11	Course Name: Statistical Inference-II				Course Code: SBS ST 01 302 C 3104		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 4**
2021-2023	M.Sc. Statistics	III	3	1	0	4	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 hours					
		Pre-requisite of course: NIL					
Course Objective	The main objective of the course is to provide the detailed knowledge of the characterization of another inferential procedure that is Bayesian and non-parametric Inference.						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Describe the role of the posterior distribution, the likelihood function, prior and the posterior distribution about a parameter in Bayesian framework. **CO2:** Understand inferences for lifetime models in Bayesian framework. **CO3:** Learn the basic concepts of nonparametric techniques. **CO4:** Understand the sequential probability ratio test and its application.						

COURSE SYLLABUS

NOTE:

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Elements of the Bayesian paradigm. Introduction to prior and posterior distributions, loss functions. Bayes risks, Bayesian paradigm versus classical paradigm. Prior distribution, subjective determination of prior distribution, improper priors, non-informative priors, conjugate prior families, construction of conjugate families using sufficient statistic for fixed dimensions.	15
II	Bayesian estimation of parameters of some well-known distributions like binomial, multinomial, Poisson, normal, lognormal, exponential, Rayleigh and Weibull distributions. Credible and highest posterior density (HPD) interval, HPD credible intervals in case of normal, gamma, exponential and Weibull distributions.	15

III	Concept of nonparametric and distribution-free methods, probability integral transformation, empirical distribution function, kernel, one-sample and two-sample *U*-Statistics, test of independence, sign test, rank-order statistics, Wilcoxon signed-Rank test. Wald-Wolfowitz runs test, Kolmogorov-Smirnov two-sample test, median test, Mann-Whitney U test.	15
IV	The sequential probability ratio test (SPRT) and its application to binomial, Poisson, geometric, exponential, normal, operating characteristic (OC) function of SPRT, average sample number (ASN) function and their application, Wald's fundamental identity and its uses.	15

Suggested Readings:

1. Berger, J.O. (2013): Statistical Decision Theory and Bayesian Analysis, Springer.
2. Hollander, M., Wolfe, D. and Chicken, E. (2013): Nonparametric Statistical Methods, 3rd Edition, Wiley.
3. Gibbons, J.D. and Chakraborti, S. (2010): Nonparametric Statistical Inference, 5th Edition, CRC Press.
4. Rohatgi, V.K. & Saleh, A.K. Md.E. (2015). An Introduction to Probability and Statistics, 3rd Edition. Wiley.

Course No: CC-12	Course Name: Econometrics				Course Code: SBS ST 01 303 C 3104		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 4**
2021-2023	M.Sc. Statistics	III	3	1	0	4	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 hours					
		Pre-requisite of course: NIL					
Course Objective	The purpose of this course is to give students a solid foundation in econometric techniques, various functions for economic analysis and future forecasting.						
Course Outcomes:	On completion of this course, students will be able to: **CO1:** Understand the basic concepts of econometric models. **CO1:** Learn knowledge of various econometric models, estimation methods and related econometric theories. **CO1:** Understand the statistical techniques to model relationships between variables and make predictions. **CO1:** Learn how to conduct econometric analysis of data.						

COURSE SYLLABUS

NOTE:

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.
2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Introduction to econometrics. A review of least squares and maximum likelihood estimation methods of parameters in classical linear regression model and their properties. Generalized least squares estimation and prediction, construction of confidence regions and tests of hypotheses. Regression analysis under linear restrictions, restricted least squares estimation method and its properties. Autocorrelation, sources and consequences, Autoregressive process tests for autocorrelation, Durbin Watson test.	15
II	Problem of Multicollinearity, its implications. Source of multicollinearity, tools for handling the problem of multicollinearity. Remedies for multicollinearity. Ridge regression. Heteroskedasticity, consequences and tests for it, estimation procedures under heteroskedastic disturbances, Bartlett's test, Breusch Pagan test and	15

	Goldfelf Quandt test. Dummy Variable Models.	
III	Specification Error Analysis, Tests for Structural Change and Stability, Asymptotic theory and regressors. Stein-Rule Estimation. Instrumental variable estimation. Measurement Error Models.	15
IV	Simultaneous equations model, problem of identification, necessary and sufficient condition for the identifiability of parameters in a structural equation, ordinary least squares, indirect least squares, two-stage least squares and limited information maximum likelihood method.	15

Suggested Readings

1. Gujrati, D.N. & Porter, D.C. (2017). Basic Econometrics, 6th Edition. McGraw Hill.
2. Maddala, G.S. & Lahiri, K. (2010). Introduction to Econometrics, 4th Edition. Wiley.
3. Greene, W.H. (2012). Econometric Analysis, 7th Edition. Pearson.
4. Studenmund, A.H. & Johnson, B.K. (2017). Using Econometrics: A Practical Guide, 7th Edition. Pearson.

Course No: CC-13	Course Name: Seminar				Course Code: SBS ST 01 304 C 4004		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 4**
2021-2023	M.Sc. Statistics	III	4	0	0	4	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 Hours **Pre-requisite of course:** NIL					
Course Objective	The purpose of this course is to give students a solid foundation in communication skill of statistical techniques						
Course Outcomes:	**CO1:** Understand the basic concepts of econometric models. **CO2:** Understand inferences for lifetime models in Bayesian framework. **CO3:** Understand the concept of multivariate normal distribution.						

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours
	Each student must present at least one seminar which will be followed by discussion session with participation from other students and the concerned faculty members present. The student must also submit the slides/write-up of the presentation content to the Student Advisor (Faculty). The seminar, participation in discussions, the submitted slides and overall attendance (as per ordinance) will form the basis of the evaluation. There will be no separate final exam for this course.	60

Course No: CC-14	Course Name: Practical 103				Course Code: SBS ST 01 305 C 0044		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 8**
2021-2023	M.Sc. Statistics	III	0	0	4	4	**Total Hours: 120**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 hours **Pre-requisite of course:** NIL					
Course Objective	The purpose of this course is to give students a solid foundation in multivariate techniques, problems of estimation and analysis econometric models.						
Course Outcomes:	**CO1:** Understand the concepts of multivariate normal distribution with help of R software **CO2:** Understand the concepts analysis econometric models with help of R software **CO3:** Understand the concepts point and interval estimator estimation, with help of R software						

COURSE SYLLABUS

Unit No.	Content of Each Unit	Hours
	Practicals based on Multivariate Analysis (SBS ST 01 301 C 3104), Statistical Inference – II (SBS ST 01 302 C 3104) and Econometrics (SBS ST 01 302 CC 4004).	120

Course No: DCEC-3	**Course Name:** Stochastic Processes				**Course Code:** SBS ST 01 301 DCE 3104		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 4**
2021-2023	M.Sc. Statistics	III	3	1	0	4	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 Hours					
		Pre-requisite of course: NIL					
Course Objective	The objective of this course is to apprise the students with the basic concepts of the theory of stochastic processes in continuous time, also to make them able to use various analytical and computational techniques to study stochastic models that appears in applications.						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Study the fundamental concept of stochastic processes and its applications. **CO2:** Understand Markov processes and Markov chains and their applications in real world. **CO3:** Study the branching process and its properties. **CO4:** Understand Poisson processes and its variations.						

COURSE SYLLABUS

NOTE:

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.
2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Stochastic Processes: Introduction, classification according to state space and time domain. Countable state Markov chains, transition probability matrix, Chapman-Kolmogorov equations, calculation of n-step transition probabilities and their limits, stationary distribution.	15
II	Branching Processes: Properties of generating function of branching processes, probability of ultimate extinction, distribution of the total number of progeny, generalization of the classical Galton-Watson branching process, general branching processes, random walk and gambler's ruin problem.	15
III	Continuous-time Markov Processes: Poisson process and related distributions, generalizations of Poisson process, simple birth-process, simple death-process, simple birth-death process, linear birth-death process. First passage time distribution.	15

IV	Renewal Theory: Elementary renewal theorem and applications. Statement and uses of key renewal theorem, central limit theorem for renewals, study of residual and excess lifetime's process. Renewal reward Process, Markov renewal and semi-Markov processes, Markov renewal equations.	15

Suggested Readings:

1. Medhi, J. (2012). Stochastic Processes, 3rd Edition. New Age International.
2. Ross, S.M. (2016). Stochastic Processes, 2nd Edition. Wiley India.
3. Karlin, S. & Taylor, H.M. (2012). A First Course in Stochastic Processes, 2nd Edition. Academic Press.
4. Prabhu, N.U. (2010). Stochastic Processes: Basic Theory and its Applications. World Scientific.

Course No: DCEC-4	Course Name: Demography and Vital Statistics				Course Code: SBS ST 01 302 DCE 3104		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 4**
2021-2023	M.Sc. Statistics	III	3	1	0	4	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 Hours **Pre-requisite of course:** NIL					
Course Objective	The objective of the course is to make the students conversant with various techniques used in summarization and analysis of data related to demographic and vital events.						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Understand the basic concepts of demography and vital statistics. **CO2:** Understand the trends of mortality and compare and contrast among different age and sex group. **CO3:** Identify the components of population change, including the effects of changing birth, death and migration rates, and demonstrate their influences on age structure. **CO4:** Do population projection by different methods.						

COURSE SYLLABUS

NOTE:

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Coverage and content errors in demographic data, use of balancing equations and Chandrasekharan-Deming formula to check completeness of registration data, adjustment of age data. Use of Whipple, Myer and UN indices, population composition, dependency ratio, population transition theory.	15
II	Measures of Fertility: Stochastic models for reproduction, distribution of time to first birth, inter-live birth intervals and of number of births. Estimation of parameters, estimation of parity progression ratio from open birth interval data.	15

III	Measures of Mortality: Construction of abridged life tables, distribution of life table functions and their estimation. Stable and quasi-stable populations, intrinsic growth rate models for population growth and their fitting to population data. Stochastic models for population growth.	15
IV	Stochastic models for migration and for social and occupational mobility based on Markov chains. Estimation of measures of mobility. Methods for population projection. Use of Leslie matrix. Nuptuality and its measurements.	15

Suggested Readings:

1. Kumar, R. (2006): Technical Demography, New age International (P) Ltd, New Delhi.
2. Samuel, P., Patrick, H. and Michel, G. (2000): Demography: Measuring and Modeling Population Processes, Wiley-Blackwell.
3. Rowland, D.T. (2003): Demographic Methods and Concepts, Oxford university press, Inc., New York.
4. Pathak, K. B. and Ram, F. (2013): Techniques of Demographic Analysis, Himalaya Publishing House.
5. Keyfitz, N. and Caswell, H. (2005): Applied Mathematical Demography, Springer.

Course No: CC-15	Course Name: Minor Project/Dissertation				Course Code: SBS ST 01 401 PROJ 00016		
Batch: 2021-2023	**Programme:** M.Sc. Statistics	**Semester:** IV	**L** -	**T** -	**P** -	**Credits** 16	**Contact Hrs per Week: -** **Total Hours: -**

Total Evaluation Marks: 400
CIE: **120** Marks
TEE: **280** Marks

COURSE SYLLABUS

Content

The aim of the dissertation or project work is to familiarize the students with advanced research. The topic for the project work is to be decided by the supervisor/guide concerned. The project report/ dissertation is to be evaluated by a committee constituted by the Head of Department of Statistics having at least one external expert.

Course No: DCEC-5	Course Name: Order Statistics				Course Code: SBS ST 01 401 DCE 3104		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per**

							Week: 4
2021-2023	M.Sc. Statistics	IV	3	1	0	4	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks			**Examination Duration:** 3 Hours **Pre-requisite of course:** NIL				
Course Objective	*The objective of the course is to learn general strategies for problems about order statistics and how to learn to find the median (or k^{th} largest) in linear average-case number of comparisons (and time).*						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Understand the basic concepts of order statistics, joint, marginal and conditional probabili distributions of order statistics. **CO2:** Learn about distribution-free confidence intervals for population quantile and distributio free tolerance intervals for population distributions. **CO3:** Construct the recurrence relations and identities for moments of order statistics. **CO4:** Enhanced with the concepts of distributions of order statistics for independently and n identically distributed variates and also for dependent variates.						

COURSE SYLLABUS

NOTE:

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.
2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Introduction to order statistics, joint, marginal and conditional distributions of order statistics (discrete and continuous cases). Distribution of the range and other systematic statistics, order statistics as a Markov chain. Examples based on discrete and continuous distributions.	15
II	Distribution-free confidence intervals for population quantiles and distribution-free tolerance intervals. Distribution-free bounds for moments of order statistics and of the range. Approximations to moments in terms of the quantile function and its derivatives. lemma, uniformly most powerful (UMP) tests.	15

III	Moments of order statistics, recurrence relations and identities for moments of order statistics. Large sample approximations to mean and variance of order statistics. Asymptotic distributions of order statistics.	15
IV	Order statistics for independently and not identically distributed (i.ni.d.) variates, Concomitants of order statistics. Random division of an interval and its applications. Order statistics from a sample containing a single outlier. Concepts of record values and generalized order statistics.	15

Suggested Readings:

1. Shahbaz, M.Q., Ahsanullah, M., Shahbaz, S.H. & Al-Zahrani, B.M. (2016). Ordered Random Variables: Theory and Applications. Springer.
2. David, H.A. & Nagaraja, H.N. (2005). Order Statistics, 3rd Edition. Wiley.
3. Ahsanullah, M., Nevzorov, V.B. & Shakil, M. (2013). An Introduction to Order Statistics, Atlantis Studies in Probability and Statistics, Vol. III. Atlantis Press.
4. Arnold, B.C., Balakrishnan, N. & Nagaraja, H.N. (2008). A First Course in Order Statistics. SIAM Publishers.

Course	**Course Name: Survival Analysis**	**Course Code: SBS ST 01 402 DCE**

No: DCEC-6					3104		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 4**
2021-2023	M.Sc. Statistics	IV	3	1	0	4	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 Hours					
		Pre-requisite of course: NIL					
Course Objective	The objective of this course is to provide the applications of statistics in handling survival data. This course introduces the concept of censoring and various life time distributions used to analyse such data.						
Course Outcomes:	On completion of this course, students will be able to: • Understand basic concepts of survival data and lifetime models. • Learn how to handle censored data under different scenarios. • Learn non-parametric estimation of survival function. • Learn the Log-Rank test for testing differences between survival curves and Cox' regression model for estimating and testing effects of covariates.						

COURSE SYLLABUS

NOTE: 1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Concepts of survival function, failure rate or hazard function, mean residual life and their properties. Ageing classes- IFR, DFR, IFRA, DFRA, NBU, NBUE, BT and UBT, scaled TTT transform and characterization of ageing classes.	15
II	Life testing plans or censoring methods, right and left censoring, concepts of Type-I (time) and Type-II (failure), random censoring schemes. Life distributions-exponential, Weibull, log-logistic, gamma, log-normal distributions. Parametric inference- estimation of parameters associated with various life time distributions and life testing plans.	15
III	Nonparametric methods of estimation of survival function - actuarial estimator, Kaplan-Meier estimator. Tests of exponentiality against non-parametric classes-Total time on Test, Deshpande Test.	15
IV	Two sample problem - Gehan test, log-rank test, Mantel-Haenzel test. Cox proportional hazards model, competing risks model.	15

Suggested Readings

1. Deshpande, J.V. & Purohit, S.G. (2016). Life Time Data: Statistical Models and Methods, 2nd Edition. Word Scientific.

2. Lee, E.T. & Wang, J.W. (2015). Statistical Methods for Survival Data Analysis, 4th Edition. Wiley.
3. Miller, R.G. (2011). Survival Analysis, 2nd Edition. Wiley.
4. Moore, D.F. (2016). Applied Survival Analysis using R. Springer.

Course No:	**Course Name:** Decision theory and sequential analysis	**Course Code: SBS ST 01 403 DCE 3104**

DCEC-7							
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 4**
2021-2023	M.Sc. Statistics	IV	3	1	0	4	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 Hours **Pre-requisite of course:** NIL					
Course Objective	The main objective of this course is to provide the detailed knowledge of the decision theory and sequential analysis.						
Course Outcomes:	After completing this course, student is expected to learn the following: **CO1:** Understand the concept of decision theory and sequential analysis. **CO2:** Learn how to perform posterior decision analysis and hypothesis testing. **CO3:** Understand the decision rule and fundamental identity in sequential analysis. **CO4:** Learn the wider applications of decision principles of Bayesian and frequentist approaches.						

COURSE SYLLABUS

NOTE:

1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.
2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Elements of decision theory: Expected loss, decision rules and risks - Bayesian expected loss, frequentist risks, randomized and nonrandomized decision rules, admissible decision rule, complete, essential complete and minimal complete classes of decision rules and their relationship, minimax and Bayes decision rule, estimation testing viewed as decision rule problem, Bayes and minimax estimators. Minimax and Bayes tests in simple cases.	15
II	Decision principles: the conditional Bayes decision principle and frequentist decision principles. Misuse of classical Inference procedures, the frequentist perspective, the conditional perspective, the likelihood principle, choosing a paradigm or decision principle. Utility theory: introduction,	15

	the utility of money.	
III	Bayesian decision theory: Posterior decision analysis, estimation, finite action problems and hypothesis testing. Minimax Analysis: Introduction, game theory, basic elements, general techniques for solving games, finite games, the minimax theorem.	15
IV	Sequential Decision rule: Stopping rule, terminal decision rule. Bayes and minimax sequential decision Rules. Invariant sequential decision problems, sequential test of a simple hypothesis. The sequential probability ratio test, the fundamental identity of sequential analysis.	15

Suggested Readings:

1. Robert, C.P. (2013): The Bayesian Choice: A Decision Theoretic Motivation, Springer.
2. Berger J.O. (2013): Statistical Decision Theory and Bayesian Analysis, Springer.
3. Wald, A. (2013): Sequential Analysis, Dover Publications.
4. Mukhopadhyay, N. and de Silva, B.M. (2008): Sequential Methods and Their Applications, CRC Press.

Course No: DCEC-8	Course Name: Statistical Computing				Course Code: SBS ST 01 404 DCE 3104		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: 4**
2021-2023	M.Sc. Statistics	IV	3	1	0	4	**Total Hours: 60**
Total Evaluation Marks: 100 **CIE:** 30 Marks **TEE:** 70 Marks		**Examination Duration:** 3 Hours					
		Pre-requisite of course: NIL					
Course Objective	The students will study the statistical simulation using Computers. It contains introduction to System, Models, Simulation, Random Number Generation and Variance Reduction Techniques.						
Course Outcomes:	On completion of this course, students will be able to: **CO1:** Understand the basic ideas of random number generation using different techniques. **CO2:** Learn theoretical methods and practicable techniques of statistical simulations. **CO3:** Understand how to apply Monte Carlo simulations and the EM algorithm. **CO4:** Learn how to handle real world problems with large scale data.						

COURSE SYLLABUS

NOTE: 1. Question no. 1 has seven parts and students need to answer any four. Each part carries three and half Marks.

2. Question no. 2 to 5 have three parts and student need to answer any two parts of each question. Each part carries seven marks

Unit No.	Content of Each Unit	Hours of Each Unit
I	Introduction and need of statistical simulation. Random number generation, requisites of a good random number, methods of random number generation such as linear congruential and mixed congruential, statistical tests for pseudo random numbers. Methods of generating random variables such as inverse transforms, composition and acceptance-rejection methods.	15
II	Monte Carlo integration and variance reduction techniques: Hit or miss Monte Carlo method, sample mean Monte Carlo method, importance sampling, correlated sampling control variates, stratified sampling, antithetic variates, partition of region.	15
III	EM algorithm: applications to missing and incomplete data problems, mixture models. Smoothing with kernels, density estimation, simple non-parametric regression. Smoothing with kernels: density estimation, choice of kernels.	15

IV	Simulation based testing: simulating test statistics and power functions, permutation tests. Bootstrap methods: resampling paradigms, bias and standard errors, confidence intervals, bootstrapping in regression. Jackknife and cross validation: Jacknife in sample surveys, cross-validation for tuning parameters.	15

Suggesting Readings

1. Rubinstein, R.Y. and Kroese, D.P. (2008): Simulation and the Monte Carlo Method, Second Edition, Wiley.
2. Voss, J. (2014): An Introduction to Statistical Computing: A Simulation Approach, Wiley.
3. Ross, S.M. (2012): Simulation, Fifth Edition, Academic Press.
4. Thomopoulos, N.T. (2013): Essentials of Monte Carlo Simulation, Springer.

Course No: CC-15	Course Name: Major Project/Dissertation				Course Code: SBS ST 01 401 PROJ 00024		
Batch:	**Programme:**	**Semester:**	**L**	**T**	**P**	**Credits**	**Contact Hrs per Week: -**
2021-2023	M.Sc. Statistics	IV	-	-	-	24	**Total Hours: -**

Total Evaluation Marks: 600

CIE: **180** Marks

TEE: **420** Marks

Course Outcomes

1. Identifying appropriate research question and applying suitable research designs
2. Execution of independent research experiments
3. Application of knowledge and skills previously gained for selected research problem
4. Establishing links between theory and methods in selected area of research
5. Understand and apply ethical standards of conduct in the collection and evaluation of data and other resources

COURSE SYLLABUS

Content

The aim of the dissertation or project work is to familiarize the students with advanced research. A departmental committee will distribute the topics according to the skill and merit of the students. The project report/dissertation will be evaluated by a committee constituted by the Head of Department of Statistics having at least one external expert.

9. Teaching-Learning Process

- Lectures
- Discussions
- Simulations
- Role Playing
- Participative Learning
- Interactive Sessions
- Seminars
- Research-based Learning/Dissertation or Project Work
- Technology-embedded Learning

10. Implementation of Blended Learning

Blended Learning is a pedagogical approach that combines face to-face classroom methods with computer-mediated activities in the process of teaching and learning. It implies nice blend of face-to-face and online activities to make the learning processes more interesting and engaging. It focuses on integration of traditional classroom activities and innovative ICT-enabled strategies. It emphasizes student-centric learning environment where the teacher is the facilitator for productive and measurable learning outcomes. It optimizes and compliments the face-to-face learning, giving ample freedom and flexibility to the students and teachers to access and explore the wide range of open-access sources such as video lectures, podcasts, recordings and articles through digital platforms. It gives freedom and autonomy to the teachers in selection of appropriate digital platforms, resources and time-slots to complement and supplement face to face learning. The Blended Learning doesn't undermine the role of the teacher, rather it gives him/her an opportunity to explore the unexplored in accordance with the requirements of the curriculum.

Key features of Blended Learning

- Student-centric pedagogical approach focusing on flexibility in timing, quality content, needs and interests of students and freedom to study through the mode of his/her choice;
- Freedom to Select variety of mediums and techniques;
- Increased student engagement in learning;
- Enhanced teacher and student interaction;
- Improved student learning outcomes;
- More flexible teaching and learning environment;
- More responsive for self and continuous learning;
- Better opportunities for experiential learning;
- Increased learning skills;
- Greater access to information, improved satisfaction and learning outcomes.

11. Assessment and Evaluation

- Continuous Comprehensive Evaluation at regular after achievement of each Course-level learning outcome
- Formative Assessment on the basis of activities of a learner throughout the programme instead of one-time assessment
- Oral Examinations to test presentation and communication skills
- Open Book Examination for better understanding and application of the knowledge acquired
- Group Examinations on Problem solving exercises
- Seminar Presentations
- Review of Literature
- Collaborative Assignments

12. Keywords

- LOCF
- NEP-2020
- Blended Learning
- Face to face (F to F) Learning
- Programme Outcomes
- Programme Specific Outcomes
- Course-level Learning Outcomes
- Postgraduate Attributes
- Learning Outcome Index
- Formative Assessment and Evaluation
- Comprehensive and Continuous Evaluation

13. References

- National Education Policy-2020.
- https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pdf
- The draft subject specific LOCF templates available on UGC website.
- https://www.ugc.ac.in/ugc_notices.aspx?id=MjY5OQ==
- Draft Blended Mode of Teaching and Learning: Concept Note available on UGC website. https://www.ugc.ac.in/pdfnews/6100340_Concept-Note-Blended-Mode-of-Teaching-and-Learning.pdf

14. Appendices