SYLLABUS
DIBRUGARH UNIVERSITY
FYUGP 2020
(Under NEP 2020)

STATISTICS

(পৰিসংখ্যা)

(Recommended by B.O.S. in Statistics, D.U. in its meeting held on 05.03.2024 and approved by U.G. Board in its meeting held on …….. and passed by the Academic Council meeting held on ……. and effective from the session ……..)

Dibrugarh University **ডিব্রুগড় বিশ্ববিদ্যালয়**

Vision of University: To develop human resource by integrating knowledge and skill, human values and compassion for a better world.

Mission of University: To impart value oriented education and skill based training that foster leadership traits of the learners, thus generating sustainable development, social harmony and peace.

Department of Statistics **পৰিসংখ্যা বিজ্ঞান বিভাগ**

Vision of Department: To empower individuals with statistical expertise that drives home evidence-based decision making, fasters innovation, and promotes societal well-being.

Mission of Department: To impart a rigorous and comprehensive statistical knowledge that cultivates deep understanding of statistical theories, methods and applications, which foster not only skilled statisticians but also ethical leaders committed to making statistically literate individuals who can harness the power of statistics for informed-decision making and innovation.

PREAMBLE

As recommended by the University Grants Commission (UGC) and proposed for implementation by Dibrugarh University, the Department of Statistics works to implement the relevant components of New Education Policy (NEP), 2020 for Four Year Under Graduate Program (FYUGP). The following facts are taken into consideration when designing the basic structure of the Under Graduate (UG) programme:

a) Flexibility to switch between disciplines of study,
b) Opportunity for learners to select the courses of their interest across all disciplines,
c) Flexible entry and exit options with UG certificates, UG diplomas, or Bachelor degrees dependingon the number of credits earned,
d) Flexibility for students to switch between institutions so they can engage in multi- and/or interdisciplinary learning,
e) Flexibility to switch to alternative modes of learning,
f) Knowledge required for self-employment initiatives and entrepreneurship mindset,
g) Ability for complex critical thinking and real-life problem solving,
h) Capability to understand global issues, multicultural competence and digital literacy,
i) Capable on research skills, communication skills, community based engagement, environmentawareness, responsibility and accountability.

INTRODUCTION

The Under Graduate (UG) syllabus of Statistics in light of New Education Policy (NEP), 2020 consists of Major (Core) disciplines, Minor disciplines, Multi-Disciplinary Generic Elective Courses (MDGEC), Ability Enhancement Courses (AEC), Value Added Courses (VAC), Skill Enhancement Courses (SEC), Environmental Education (EE), YOGA, Community Based Engagement (NCC/NSS/Adult Education/Student Mentoring/NGO/Govt. institutions, etc.), Digital and Technological Solutions/Digital Fluency (DTS/DF), Internship, Project, Research Ethics and Methodology, Research Project (Development of Project/Research Proposal, Review of related literature), Dissertation (Collection of Data, Analysis and Preparation of Report) and Discipline Specific Electives (DSE).

The UG degree programme offers certificates, diplomas and degrees as follows:

UG Certificate: Students who opt to exit after completion of the first year (Two Semesters) and have secured 44 credits will be awarded a UG certificate. These students are allowed to re-enter within three years and complete the degree programme within the stipulated maximum period of seven years.

Certificate course consists of two Major disciplines, two Minor disciplines, two MDGEC, two AEC,two VAC, two SEC, YOGA and Environmental Education with emphasis on community-basedactivities.

UG Diploma: Students who opt to exit after completion of the second year (Four Semesters) and have secured 88 credits will be awarded the UG diploma. These students are allowed to re-enter within a periodof three years and complete the degree programme within the maximum period of seven years.

Diploma course consists of six Major disciplines, four Minor disciplines, three MDGEC, three AEC, two VAC, three SEC, YOGA, Environmental Education with emphasis on community-based activities and Digital and Technological Solutions/Digital Fluency and Community engagement.

3-year UG Degree: Students who wish to undergo a 3-year (Six Semesters) UG programme will be awarded UG Degree in the Major discipline after successful completion of three years, securing 132 credits.

3-year UG degree course consists of fourteen Major disciplines, six Minor disciplines, three MDGEC,three AEC, two VAC, three SEC, YOGA, Environmental Education with emphasis on community- based activities, Digital and Technological Solutions/Digital Fluency, Community engagement, Internshipand Project.

4-year UG Degree (Honours with Research): Students who secure 75% marks and above in the first six semesters and wish to undertake research at the undergraduate level can choose a research stream in the fourth year (Two Semesters). They should do a research project or dissertation under the guidance of a faculty member of the University/College. The research project/dissertation will be in the major discipline.The students who secure 176 credits, including

12 credits from a research project/dissertation, are awardedUG Degree (Honours with Research).

4-year UG degree course consists of twenty Major disciplines, eight Minor disciplines, three MDGEC,three AEC, two VAC, three SEC, YOGA, Environmental Education with emphasis on community- based activities, Digital and Technological Solutions/Digital Fluency, Community engagement, Internship,Project, Research Ethics and Methodology, Research Project or one DSE and Dissertation or two DSE.

UG Degree Programmes with Single Major: A student has to secure a minimum of 50% credits from themajor discipline for the 3-year/4-year UG degree to be awarded a single major.

UG Degree Programmes with Double Major: A student has to secure a minimum of 40% credits from the second major discipline for the 3-year/4-year UG degree to be awarded a double major

Interdisciplinary UG Programmes: The credits for core courses shall be distributed among the constituentdisciplines/subjects so as to get core competence in the interdisciplinary programme.

Multidisciplinary UG Programmes: In the case of students pursuing a multidisciplinary programme of study, the credits to core courses will be distributed among the broad disciplines such as Life sciences, Physical Sciences, Mathematical and Computer Sciences, Data Analysis, Social Sciences, Humanities, etc..

The statutory bodies of the Universities and Colleges such as the Board of Studies and Academic Council will decide on the list of courses under major category and credit distribution for double major, interdisciplinary and multidisciplinary programmes.

AIM

The UG Programme in statistics is designed to teach students how to think analytically, critically and logically, which enables them to employ mathematical reasoning in real-world situations. A UG degree in statistics will expose students to a variety of intriguing and practical concepts that will help them in their preparation for data-scientist/statistician/strategic banker/ researcher/biostatistician and other statistics-oriented job profiles in industry, government, public-sector undertaking companies, business, commerce, finance and research.

The program covers a broad range of topics on mathematical and applied statistics. This also covers hands-on sessions in Computer Lab using various software such as C/C++, R, SPSS etc. The comprehensive training on coding and use of software will enable the students to grasp the subject matter better and will make them complete in terms of research and industry perspectives.

The programme aims to increase students' skill in statistics (both mathematical and applied), mathematical analysis and algebra and coding as well as other cross-disciplinary subjects like mathematics, commerce, physics, computer sciences, economics etc. By choosing papers from theMDGEC, AEC, SEC, VAC, YOGA, EE, DTS, DSE, Community based engagement etc., they are able to apply the skills they have learned to situations that happen in the real world. Also aims students' flexibilityto move from one discipline to another, to move one institution to another, to switch alternative modes of learning.

GRADUATE ATTRIBUTES

Disciplinary Knowledge

Being able to demonstrate comprehensive knowledge and coherent understanding of both the mathematical and applied components of statistics as well as chosen interdisciplinary areas of study in a broad multidisciplinary context; ability to connect relevant disciplines, as well as recent innovations, with the learning disciplines of choice.

Communication Skills

Capability to express various statistical ideas clearly through data analysis, graphical methods, examples and counter-examples; ability to use statistical tools and techniques effectively as a precise language of communication in other fields of scientific and social studies; ability to pay close attention, read texts and research papers critically, and communicate complicated information clearly and concisely to policy-makers as well as to the public.

Moral and Ethical Awareness/Reasoning

Ability to recognise ethical issues that are pertinent to one's work and pledge not to engage in unethical behaviour such as plagiarism, copyright and infringement of intellectual property rights; ability to appreciate recent developments in various fields and one’s research with honesty and integrity in all aspects.

Multicultural Competence

Ability to correlate and compare recent developments in various branches of statistics and related fields like data-science in a variety of organisations worldwide; ability to collaborate research with other scientific disciplines; ability to effectively participate in a multicultural group or society and interact politely with diverse groups, and the acquisition of knowledge of the values and beliefs of multiple cultures, and a global viewpoint to honour diversity.

Information/Digital Literacy

Ability to access, asses and utilize Information and Communications Technology (ICT) tools. Ability to understand, read and write programming language/packages/modules (C; C++; R; SPSS) for computation, simulation, graphics and data analytics.

Reflective Thinking

An understanding of how a researcher or an investigator influences and shapes the information one creates; ability to formulate appropriate questions pertaining to the ideas in almost all branches of science dealing with data in order to propose innovative solutions using the analytics tools and statistical thinking; ability to interpret the findings and use them to solve a variety of problems found in numerous fields of science, economy, agriculture, industry and the society.

Cooperation/Team Work

Ability to collaborate with diverse teams in an effective and respectful manner; capacity to cooperate withpeople from varied backgrounds in the interests of a common goal.

Research Related Skills

The ability to formulate appropriate questions, problems, and hypotheses by analyzing the datasets and interpreting the findings; ability to demonstrate the results, techniques and predictive models using the concepts statistics; ability to develop methodology and design research proposals.

Problem Solving

Ability to work independently and do in-depth study to find ways that statistical methods are used in various industries and in daily life to improve job possibilities in a wide range of fields and academic study; ability to use innovative, imaginative, lateral thinking, interpersonal skills, and emotional intelligence; ability to tackle various challenges in both familiar and unfamiliar circumstances, then apply what they've learned to deal with real life problems.

Critical Thinking

Capability to analyse and synthesise theoretical and applied problems, as well as acquire knowledge and skills through logical reasoning, analytical thinking and evaluations; ability to find gaps and logical faults in design of any empirical research; inculcate a healthy attitude to be a lifelong learner.

The Objectives of the Undergraduate Programme in Statistics are listed in the following. Aftercompleting the programme the students will be able to-

1: Apply Statistical tools and techniques to solve problems of other relevant disciplines.

2: Pursue higher studies in the subject to take part in the academic enrichment of the subject and society as a whole.

3: Develop new techniques/methods for solving the unsolved problems of Statistics and other disciplines.

4: Construct Statistical models to mimic real life problems and make prediction and to identify important factors.

Teaching Learning Process:

The outcome-based approach demands a considerable transition from teacher-centric to learner-centric pedagogies and from passive to active/participatory pedagogies, especially in the context of undergraduate study. This course promotes the systematic and sequential acquisition of knowledge and skills. It also focuses on practical abilities, as well as an awareness of the link between methods and practice. Teaching curriculum involve discussions, presentations, use of

required textbooks, e-learning tools, other self-study materials, project, internship, exploring industrial needs and other research activities and so on.

Assessment Methods:

A variety of subject-specific assessment procedures are to be used to determine how well students are progressing. Continuous evaluation will decide the final grade which includes both in-semester evaluation and the final examination. In-semester evaluation will consist of class exams, mid-term exams, assignments etc. as determined by the concerned teacher of the course of study. The following techniques will be used to evaluate how successfully students are meeting their goals: tutorials, timed exams, problem-based assignments, lab reports for practical assignments, observations of practical skills, individual project reports, team project reports, oral presentations, including seminar presentations, viva-voce, quiz and so on.

PROGRAM OUTCOMES (POs)

PO1: Graduates will demonstrate a strong understanding of fundamental statistical concepts, theories, and methodologies.

PO2: Graduates will be proficient in collecting, cleaning, analyzing, and interpreting data using statistical software and techniques.

PO3: Graduates will possess a solid foundation in mathematical concepts and techniques relevant to statistics, including calculus, linear algebra, and probability theory.

PO4: Graduates will be competent in using statistical software packages such as R, Python, or SPSS to conduct data analysis and visualization.

PO5: Graduates will be able to design experiments, surveys, and observational studies to address research questions and hypotheses effectively.

PO6: Graduates will understand and apply inferential statistical methods such as hypothesis testing, confidence intervals, regression analysis, and analysis of variance.

PO7: Graduates will have knowledge of advanced statistical techniques for analyzing complex datasets with multiple variables, including multivariate analysis, factor analysis, and cluster analysis.

PO8: Graduates will be proficient in analyzing time-series data and forecasting future trends using appropriate statistical models and techniques.

PO9: Graduates will be able to communicate statistical findings effectively to diverse audiences through written reports, oral presentations, and data visualization.

PO10: Graduates will demonstrate critical thinking skills and the ability to apply statistical reasoning to solve real-world problems in various domains.

PO11: Graduates will understand the ethical principles and guidelines governing the conduct of statistical research and practice, including issues related to confidentiality, data integrity, and bias.

PO12: Graduates will engage in lifelong learning and professional development activities to stay updated with advancements in the field of statistics and pursue career opportunities in academia, industry, government, or research.

DIBRUGARH UNIVERSITY, RAJABHETA, DIBRUGARH – 786004

FYUGP Structure as per UGC Credit Framework of December, 2022

Year	Semester	Course	Title of the Course	Total Credit
Year 1	1st Semester	C 1	Descriptive Statistics	4
		Minor 1	Basic Statistical Methods	4
		GEC 1	Statistical Methods	3
		AEC 1	Modern Indian Language	4
		VAC 1	Value Added Course 1	2
		SEC 1	Collection of Data and its Presentation	3
			Total	**20**
	2nd Semester	C 2	Probability Theory and Statistical Distributions	4
		Minor 2	Basic Probability Theory and Distributions	4
		GEC 2	Basics of Statistical Distributions and Inference	3
		AEC 2	English Language and Communication Skills	4
		VAC 2	Value Added Course 2	2
		SEC 2	Data Science using MS EXCEL	3
			Total	**20**
The students on exit shall be awarded Undergraduate Certificate (in the Field of Study/Discipline) after securing the requisite 44 Credits in Semester 1 and 2 provided they secure 4 credits in work based vocational courses offered during summer term or internship / Apprenticeship in addition to 6 credits from skill based courses earned during 1st and 2nd Semester.				
Year 2	3rd Semester	C 3	Sampling Distributions	4
		C 4	Mathematics for Statistics	4
		Minor 3	Statistical Inference	4
		GEC 3	Applied Statistics	3
		VAC 3	Value Added Course 3	2
		SEC 3	Data Science Using SPSS Software	3
			Total	**20**
	4th Semester	C 5	Statistical Quality Control	4
		C 6	Statistical Inference-I	4
		C 7	Survey Sampling	4
		C 8	Statistical Computing Using C Programming	4
		Minor 4	Industrial Statistics	4
			Total	**20**
Grand Total (Semester I, II, III and IV)				**80**
The students on exit shall be awarded Undergraduate Diploma (in the Field of Study/Discipline) after securing the requisite 88 Credits on completion of Semester IV provided they secure additional 4 credit in skill based vocational courses offered during First Year or Second Year summer term.				
	5th	C 9	Linear Models and Regression Analysis	4

	Semester	C 10	Operations Research	4
		C 11	Statistical Computing Using R-Programming	4
		Minor 5	Demography and Vital Statistics	4
			Internship and Community Engagement Or Internship/Community Engagement	2+2 4
			Total	**20**
	6th Semester	C 12	Design of Experiments	4
		C 13	Time Series Analysis	4
		C 14	Demography and Vital Statistics-I	4
		C 15	Multivariate Analysis and Non-parametric Methods	4
		Minor 6	Survey Sampling and National Accounts Statistics	4
			Total	**20**
Grand Total (Semester I, II, III, IV, V and VI)				**120**
The students on exit shall be awarded Bachelor's Degree (in the Field of Study/Discipline) (3 years) after securing the requisite 120 Credits on completion of Semester 6.				
Year 4	7th Semester	C 16	Survival Analysis and Bio-statistics	4
		C 17	Stochastic Processes and Queuing Theory	4
		C 18	Advanced Regression Analysis	4
		Minor 7	Linear Models	4
		RM 1	Research Methodology	4
			Total	**20**
	8th Semester	C 19	Statistical Inference-II	4
		C 20	Econometrics	4
		Minor 8	Design of Experiments	4
			A. Dissertation Or B. Any two from the following DSE papers: DSE1: Financial Statistics DSE2: Demography and Vital Statistics-II DSE3: Indian Statistical Heritage and Official Statistics in India	8 4+4
			Total	**20**
Grand Total (Semester I, II, III, IV, V, VI, VII and VIII)				**160**
The students on exit shall be awarded Bachelor's Degree with Honours (in the Field of Study/Discipline) OR (Honours with Research) (4 years) after securing the requisite 160 Credits on completion of Semester 8.				

Abbreviations Used:

- **C : Core / Major**
- **VAC : Value Added Course**
- **AEC : Ability Enhancement Course**

- **SEC : Skill Enhancement Course**
- **GEC : Generic Elective Course**
- **DSC : Discipline Specific Course (Maximum 04 Courses) - 5th Year**
- **DSE : Discipline Specific Elective (Minimum 05 Courses) - 5th Year**

B.Sc. IN STATISTICS PROGRAMME (NEP)
DETAILED SYLLABUS OF 1st SEMESTER

Title of the Course	**:**	**Descriptive Statistics**
Course Code	**:**	**STSC1**
Nature of the Course	**:**	**Major**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**60 (50T + 10P) (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge:

- To understand basic concepts of statistics, statistical data and its types.
- To understand tabular and graphical representation of data.
- To learn different measures of central tendency and dispersion.
- To gain knowledge of correlation and Regression.
- To learn basic concept of index numbers and its methods.

Skills:

- To develop skills in using different scales of measurement.
- To learn to interpret statistical data using techniques of central tendency, dispersion, moments, skewness and kurtosis.
- To develop skills in using different methods of correlation and regression and its coefficient.
- To gain proficiency in Index numbers and its different methods and construction

Attitude:

- To develop a keen interest in different scales of measurement.
- To build up concern in different measures of central tendency and dispersion.
- To accumulate significance of moments, skewness, and kurtosis.
- To develop concern about correlation and regression and its different types.
- To cultivate meticulous approach to index numbers and its different methods.

COURSE OUTCOMES:
After the completion of this course, students will be able to:

CO1: Understand the basic concepts of statistics, statistical data and its types.
- ILO1: Define statistics, statistical data, population and sample.
- ILO2: Describe different types of statistical data.
- ILO3: Understand different scales of measurement.

CO2: Understand tabular and graphical representation of statistical data.
- ILO1: Describe different tabular representation of data.
- ILO2: Discuss different graphical representation of data.
- ILO3: Understand different tabular and graphical representation of data with illustrations.

CO3: Determine different measures of attributes for categorical data.

ILO1: Understand theory of attributes.
ILO2: Discuss independence and association of attributes.
ILO3: Describe different methods of measuring association.

CO4: Evaluate measures of central tendency and dispersion to statistical data.
ILO1: Describe different measures of central tendency with geometry.
ILO2: Discuss different measure of dispersion with geometry.
ILO3: Describe moments, skewness and kurtosis with geometry.

CO5: Evaluate correlation and regression and its types and methods using statistical data.
ILO1: Understand scatter diagram and methods of curve fitting
ILO2: Describe correlation, its types and methods of measuring correlation.
ILO3: Describe regression and its types, lines of regression and regression coefficients.
ILO4: Understand multiple and partial correlation and coefficient of determination.

CO6: Demonstrate Index numbers and its methods and construction for statistical data.
ILO1: Understand different types and construction of Index numbers.
ILO2: Describe methods of constructing Index numbers.
ILO3: Describe test of consistency of Index numbers.
ILO4: Discuss Chain Indices, Inflation and Deflation of Index numbers.
ILO5: Discuss methods of construction of cost of living Index numbers.

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	**Cognitive Process Dimension**					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge						
Conceptual Knowledge		CO1		CO3, CO4, CO5		
Procedural Knowledge		CO2			CO6	
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	M	M	M	M	L	M	M	S	M	S
CO2	S	S	M	M	M	M	L	M	M	S	M	S
CO3	S	S	M	M	M	M	L	M	M	S	M	S
CO4	S	S	M	M	L	M	M	M	M	S	M	S
CO5	S	S	M	M	M	M	M	M	M	S	M	S
CO6	S	S	M	M	M	M	M	M	M	S	M	S

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (10 Marks)	**Basic Statistics:** Definition and scope of Statistics, concepts of statistical population and sample. **Types of Data and its Collection:** quantitative and qualitative, primary and secondary, attributes, variables, scales of measurement nominal, ordinal, interval and ratio. **Presentation of Data:** Tabular and graphical. **Categorical Data:** Attributes and different measures of their association.	09	01	-	10
2 (14 Marks)	**Measures of Central Tendency:** Mathematical and positional measures with their geometry. **Measures of Dispersion:** Range, quartile deviation, mean deviation, standard deviation, coefficient of variation, moments, absolute moments, factorial moments, skewness and kurtosis, Sheppard's corrections with their geometry.	10	02	-	12
3 (14 Marks)	**Bivariate Data:** Definition, scatter diagram, simple correlation, interpretation of r and rank correlation. Simple linear regression, principle of least squares squares and its geometry, fitting of polynomials and exponential curves. **Multivariate Data:** Definition, partial and multiple correlation, interpretation of R, and coefficient of determination.	10	02	-	12
4 (12 Marks)	**Index Numbers:** Definition, construction of index numbers and problems thereof for weighted and unweighted index numbers including Laspeyre's, Paasche's, Edgeworth-Marshall and Fisher's. Chain index numbers, conversion of fixed based to chain based index numbers and vice-versa. Consumer price index numbers.	08	02	-	10
5 (10 Marks)	**List of Practical: (both calculator and computer based)** 1. Graphical representation of data. 2. Problems based on measures of central tendency. 3. Problems based on measures of dispersion. 4. Problems based on combined mean and variance and coefficient of variation. 5. Problems based on moments, skewness and kurtosis. 6. Fitting of polynomials, exponential curves. 7. Karl Pearson correlation coefficient. 8. Correlation coefficient for a bivariate frequency	-	-	08	16

	distribution. 9. Fitting of Lines of regression and angle between them 10. Spearman rank correlation with and without ties. 11. Partial and multiple correlations. 12. Calculation of price and quantity index numbers using simple and weighted average of price relatives. 13. Calculation of Chain Base index numbers. 14. Calculation of Consumer Price Index Number.				
	Total	**37**	**07**	**08**	**60**

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practical***

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READINGS:

1. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edition. The World Press, Kolkata.
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edition), Pearson Education, Asia.
3. Mood, A.M. Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edition, (Reprint), Tata McGraw-Hill Pub. Co. Ltd, Delhi.
4. Barman. M. P., Hazarika. J, Bora. T (2021): Statistical Methods, Mahaveer Pub, Dibrugarh.
5. McColl, J. H. (2004). Multivariate probability. John Wiley and Sons.
6. Elhance, D. N., Elhance, V., & Aggarwal, B. M. (1958). Fundamentals of Statistics, Allahabad. Kitab Mahal.
7. Kakaty, S. C.(2003). Mathematical Statistics: Theory and Applications, Kaustubh Prakashan, Dibrugarh.
8. Rohatgi, V. K., Saleh, A. K. M. E. (2011). An Introduction to Probability and Statistics. Germany: Wiley.

*****

Title of the Course	**:**	**Basic Statistical Methods**
Course Code	**:**	**MINSTS1**
Nature of the Course	**:**	**Minor**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**60 (50T + 10P) (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge:

- To understand basic concepts of statistics, statistical data and its types.
- To understand tabular and graphical representation of data.
- To learn different measures of central tendency and dispersion.
- To gain knowledge of correlation and Regression.
- To learn basic concept of index numbers and its methods.

Skills:

- To develop skills in using different scales of measurement.
- To learn to interpret statistical data using techniques of central tendency, dispersion, moments, skewness and kurtosis.
- To develop skills in using different methods of correlation and regression and its coefficient.
- To gain proficiency in Index numbers and its different methods and construction

Attitude:

- To develop a keen interest in different scales of measurement.
- To build up concern in different measures of central tendency and dispersion.
- To accumulate significance of moments, skewness, and kurtosis.
- To develop concern about correlation and regression and its different types.
- To cultivate meticulous approach to index numbers and its different methods.

COURSE OUTCOMES:

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

CO1: Understand the basic concepts of statistics, statistical data and its types.
- ILO1: Define statistics, statistical data, population and sample.
- ILO2: Describe different types of statistical data.
- ILO3: Understand different scales of measurement.

CO2: Understand tabular and graphical representation of statistical data.
- ILO1: Describe different tabular representation of data.
- ILO2: Discuss different graphical representation of data.
- ILO3: Understand different tabular and graphical representation of data with illustrations.

CO3: Determine different measures of attributes for categorical data.
- ILO1: Understand theory of attributes.

ILO2: Discuss independence and association of attributes.
ILO3: Describe different methods of measuring association.

CO4: Evaluate measures of central tendency and dispersion to statistical data.
ILO1: Describe different measures of central tendency with geometry.
ILO2: Discuss different measure of dispersion with geometry.
ILO3: Describe moments, skewness and kurtosis with geometry.

CO5: Evaluate correlation and regression and its types and methods using statistical data.
ILO1: Understand scatter diagram and methods of curve fitting
ILO2: Describe correlation, its types and methods of measuring correlation.
ILO3: Describe regression and its types, lines of regression and regression coefficients.
ILO4: Understand multiple and partial correlation and coefficient of determination.

CO6: Demonstrate Index numbers and its methods and construction for statistical data.
ILO1: Understand different types and construction of Index numbers.
ILO2: Describe methods of constructing Index numbers.
ILO3: Describe test of consistency of Index numbers.
ILO4: Discuss Chain Indices, Inflation and Deflation of Index numbers.
ILO5: Discuss methods of construction of cost of living Index numbers.

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	**Cognitive Process Dimension**					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge						
Conceptual Knowledge		CO1		CO3, CO4, CO5		
Procedural Knowledge		CO2			CO6	
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	M	M	M	M	L	M	M	S	M	S
CO2	S	S	M	M	M	M	L	M	M	S	M	S
CO3	S	S	M	M	M	M	L	M	M	S	M	S
CO4	S	S	M	M	L	M	M	M	M	S	M	S
CO5	S	S	M	M	M	M	M	M	M	S	M	S
CO6	S	S	M	M	M	M	M	M	M	S	M	S

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (10 Marks)	**Statistical Methods:** Definition and scope of Statistics, concepts of statistical population & sample. **Data:** Quantitative and qualitative, primary and secondary, attributes, variables, scales of measurement nominal, ordinal, interval and ratio. **Presentation:** Tabular and graphical, including histogram and ogives. **Categorical Data:** Attributes and different measures of their association.	08	01	-	09
2 (14 Marks)	**Measures of Central Tendency:** Mathematical and positional measures with their geometry. **Measures of Dispersion:** Range, quartile deviation, mean deviation, standard deviation, coefficient of variation, moments, absolute moments, factorial moments, skewness and kurtosis, Sheppard's corrections with their geometry.	10	02	-	12
3 (14 Marks)	**Bivariate Data:** Definition, scatter diagram, simple correlation, interpretation of r and rank correlation. Simple linear regression, principle of least squares squares and its geometry, fitting of polynomials and exponential curves. **Multivariate Data:** Definition, partial and multiple correlation, interpretation of R, and coefficient of determination.	10	02	-	12
4 (12 Marks)	**Index Numbers:** Definition, Construction of index numbers and problems thereof for weighted and unweighted index numbers including Laspeyre's, Paasche's, Edgeworth-Marshall and Fisher's. Chain index numbers, conversion of fixed based to chain based index numbers and vice-versa. Consumer price index numbers, tests of adequacy of Index Numbers, inflation(Core and Headline).	09	02	-	11
5 (10 Marks)	**List of Practical: (both calculator and computer based)** 1. Graphical representation of data. 2. Problems based on measures of central tendency. 3. Problems based on measures of dispersion. 4. Problems based on combined mean and variance and coefficient of variation. 5. Problems based on moments, skewness and kurtosis. 6. Fitting of polynomials, exponential curves. 7. Karl Pearson correlation coefficient.	-	-	08	16

	8. Correlation coefficient for a bivariate frequency distribution. 9. Lines of regression, angle between lines and estimated values of variables. 10. Spearman rank correlation with and without ties. 11. Partial and multiple correlations. 12. Planes of regression and variances of residuals for given simple correlations. 13. Planes of regression and variances of residuals for raw data. 14. Calculate price and quantity index numbers using simple and weighted average of price relatives. 15. To calculate the chain base index numbers. 16. To calculate consumer price index number.				
	Total	**37**	**07**	**08**	**60**

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practical***

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READINGS:

1. Goon A. M., Gupta M. K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edition. The World Press, Kolkata.
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications. 7th Edition, Pearson Education, Asia.
3. Mood, A. M. Graybill, F. A. and Boes, D. C. (2007): Introduction to the Theory of Statistics, 3rd Edition, (Reprint), Tata McGraw-Hill Pub. Co. Ltd, Delhi.
4. Barman. M. P., Hazarika. J, Bora. T (2021): Statistical Methods, Mahaveer Pub, Dibrugarh.
5. McColl, J. H. (2004). Multivariate probability. John Wiley and Sons.
6. Elhance, D. N., Elhance, V., and Aggarwal, B. M. (1958). Fundamentals of Statistics, Allahabad. Kitab Mahal.
7. Kakaty, S. C. (2003). Mathematical Statistics: Theory and Applications, Kaustubh Prakashan, Dibrugarh.

*****

Title of the Course	**:**	**Statistical Methods**
Course Code	**:**	**GECSTS1**
Nature of the Course	**:**	**Generic Elective**
Total Credits	**:**	**03**
Distribution of Marks	**:**	**60 (50T + 10P) (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge:

- To understand basic concepts of statistics, statistical data and its types.
- To understand tabular and graphical representation of data.
- To learn different measures of central tendency and dispersion.
- To gain knowledge of correlation and Regression.

Skills:

- To develop skills in using different scales of measurement.
- To learn to interpret statistical data using techniques of central tendency, dispersion, moments, skewness and kurtosis.
- To develop skills in using different methods of correlation and regression and its coefficient.

Attitude:

- To develop a keen interest in different scales of measurement.
- To build up concern in different measures of central tendency and dispersion.
- To accumulate significance of moments, skewness, and kurtosis.
- To develop concern about correlation and regression and its different types.

COURSE OUTCOMES:

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

CO1: Understand the basic concepts of statistics, statistical data and its types.
- ILO1: Define statistics, statistical data, population and sample.
- ILO2: Describe different types of statistical data.
- ILO3: Understand different scales of measurement.

CO2: Understand tabular and graphical representation of statistical data.
- ILO1: Describe different tabular representation of data.
- ILO2: Discuss different graphical representation of data.
- ILO3: Understand different tabular and graphical representation of data with illustrations.

CO3: Evaluate measures of central tendency and dispersion to statistical data.
- ILO1: Describe different measures of central tendency with geometry.
- ILO2: Discuss different measure of dispersion with geometry.
- ILO3: Describe moments, skewness and kurtosis with geometry.

CO4: Evaluate correlation and regression and its types and methods using statistical data.
- ILO1: Understand scatter diagram and methods of curve fitting

ILO2: Describe correlation, its types and methods of measuring correlation.
ILO3: Describe regression and its types, lines of regression and regression coefficients.
ILO4: Understand multiple and partial correlation and coefficient of determination.

CO5: Determine different measures of attributes for categorical data.
ILO1: Understand theory of attributes and consistency of data.
ILO2: Discuss independence and association of attributes.
ILO3: Describe different methods of measuring association.

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	**Cognitive Process Dimension**					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge						
Conceptual Knowledge		CO1				
Procedural Knowledge			CO2		CO3, CO4, CO5	
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	M	M	M	M	L	M	M	S	M	S
CO2	S	S	M	M	M	M	L	M	M	S	M	S
CO3	S	S	M	M	M	M	L	M	M	S	M	S
CO4	S	S	M	M	L	M	M	M	M	S	M	S
CO5	S	S	M	M	M	M	M	M	M	S	M	S

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (11 Marks)	**Introduction:** Definition and scope of Statistics, concepts of statistical population and sample. **Data:** Quantitative and qualitative, primary and secondary, attributes, variables, scales of measurement - nominal, ordinal, interval and ratio. **Presentation:** Tabular and graphic, including histogram and ogives.	07	01	-	08
2 (14 Marks)	**Measures of Central Tendency:** Mathematical and positional measures with their geometry. **Measures of Dispersion:** range, quartile deviation, mean deviation, standard deviation, coefficient of variation, Moments, absolute moments, factorial moments, skewness and kurtosis, Sheppard's corrections with their geometry.	08	02	-	10
3 (15 Marks)	**Bivariate Data:** Definition, scatter diagram, simple correlation, interpretation of r and rank correlation. Simple linear regression, principle of least squares squares and its geometry, fitting of polynomials and exponential curves. **Multivariate Data:** Definition, partial and multiple correlation, interpretation of R, and coefficient of determination.	09	01	-	10
4 (10 Marks)	**Categorical Data:** Attributes and different measures of their association. Contingency table.	06	01	-	07
5 (10 Marks)	**List of Practical: (both calculator and computer based)** 1. Graphical representation of data. 2. Problems based on measures of central tendency. 3. Problems based on measures of dispersion. 4. Problems based on combined mean and variance and coefficient of variation. 5. Problems based on moments, skewness and kurtosis. 6. Karl Pearson correlation coefficient. 7. Spearman rank correlation with and without ties. 8. Correlation coefficient for a bivariate frequency distribution.	-	-	05	10
	Total	**30**	**05**	**05**	**45**

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practical***

MODES OF IN-SEMESTER ASSESSMENT: **(40 Marks)**

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READINGS:

1. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edition. The World Press, Kolkata.
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edition), Pearson Education, Asia.
3. Mood, A.M. Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edition, (Reprint), Tata McGraw-Hill Pub. Co. Ltd.
4. Barman. M. P., Hazarika. J, Bora. T (2021): Statistical Methods, Mahaveer Pub, Dibrugarh.
5. McColl, J. H. (2004). Multivariate probability. John Wiley and Sons.
6. Hogg, R.V., Tanis, E.A. and Rao J.M. (2009): Probability and Statistical Inference, 17th edition, Pearson Education, New Delhi.
7. Ross, S. M. (2014). Introduction to probability models. Academic Press Inc.
8. Johnson, R. A., Miller, I., and Freund, J. E. (2000). Probability and statistics for engineers. 6th Edition, Pearson Education India.
9. Elhance, D. N., Elhance, V., and Aggarwal, B. M. (1958). Fundamentals of Statistics, Allahabad. Kitab Mahal.
10. Kakaty, S. C. (2003). Mathematical Statistics: Theory and Applications, Kaustubh Prakashan, Dibrugarh

*****

Title of the Course	**:**	**Collection of Data and its Presentation**
Course Code	**:**	**SECSTS1**
Nature of the Course	**:**	**Skill Enhancement**
Total Credits	**:**	**03**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge:

- To understand the fundamentals of data collection and presentation
- To differentiate between primary and secondary data
- To grasp the concept of big data
- To familiarize with data collection methods
- To learn sampling techniques and sample size determination
- To comprehend ethical considerations in data collection

Skills:

- To design effective data collection instruments
- To execute data collection methods
- To perform data analysis
- To visualize data effectively
- To edit and code data
- To conduct exploratory data analysis

Attitudes:

- To value the importance of data in decision-making
- To maintain objectivity in data collection
- To adhere to ethical standards
- To encourage critical thinking
- To promote accuracy and precision
- To embrace lifelong learning

COURSE OUTCOMES:

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

CO1: Understand the Fundamentals of Data Collection and Presentation

ILO 1: Explain the importance and uses of scientific data in various fields.
ILO 2: Identify and distinguish between different types of data: qualitative and quantitative.
ILO 3: Describe the processes involved in data collection and presentation.

CO2: Differentiate Between Primary and Secondary Data

ILO 1**:** Define primary and secondary data with examples.
ILO 2: Evaluate the advantages and disadvantages of using primary versus secondary data.
ILO 3: Identify sources of secondary data and discuss their reliability and relevance.

CO3: Grasp the Concept of Big Data

ILO 1**:** Explain what big data is and its significance in contemporary research and business.
ILO 2**:** Identify the challenges associated with big data collection, storage, and analysis.
ILO 3: Discuss real-world applications and case studies involving big data.

CO4: Develop and Execute Data Collection Methods

ILO 1**:** Design effective questionnaires, schedules, and interview protocols.
ILO 2**:** Conduct surveys, interviews, and observations in a structured manner.
ILO 3**:** Demonstrate the ability to collect accurate and reliable data from various sources.

CO5: Analyze and Interpret Data Using Statistical Techniques

ILO 1: Apply descriptive statistics to summarize and describe data.
ILO 2: Use exploratory data analysis techniques to identify patterns and outliers.
ILO 3: Create effective data visualizations, such as charts and graphs, to present findings.

CO6: Adhere to Ethical Standards and Maintain Objectivity in Data Collection

ILO 1: Identify and address ethical issues in data collection and analysis.
ILO 2**:** Maintain objectivity and avoid biases in data collection processes.
ILO 3**:** Understand the importance of confidentiality and data protection.

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	**Cognitive Process Dimension**					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge		CO1, CO3				
Conceptual Knowledge		CO2				
Procedural Knowledge			CO4, CO5, CO6			
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	M	S	M	L	M	M	M	S	M	S
CO2	S	S	M	M	M	M	L	M	M	S	M	S
CO3	S	S	M	S	M	L	M	M	M	S	M	S
CO4	S	S	M	M	S	L	M	M	M	S	M	S
CO5	S	S	M	M	S	S	M	M	M	S	M	S
CO6	S	S	M	M	M	L	M	M	M	S	M	S

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (12 Marks)	**Introduction to Data Collection** and Presentation, Scientific data and its importance, Importance of data in decision-making, The role of data collection and presentation in research, Qualitative and Quantitative data, primary and Secondary data. Idea of Big Data.	06	01	-	07
2 (12 Marks)	**Data Collection Methods:** Primary data collection techniques, Surveys: questionnaires and schedule with respect to different objectives in the field of health sciences, social sciences, Behavioural Sciences, Business etc. Interviews: structured, semi-structured, and unstructured interviews. Observations: participant and non-participant observations. Secondary data collection techniques, Publicly available datasets, Government and organizational reports.	09	02	-	11
3 (12 Marks)	**Data Collection Design and Execution:** Planning and formulating research questions, Idea of Sampling techniques and sample size determination and interview protocols, Conducting observations and maintaining objectivity, Ethical considerations in data collection, Editing and coding.	06	02	-	08
4 (14 Marks)	**Statistical Analysis Techniques:** Descriptive statistics: measures of central tendency and dispersion, Exploratory data analysis: data visualization and graphical techniques Choosing appropriate visualization methods, Creating effective charts, graphs, and info graphics. Data Analysis and Interpretation	9	02	-	11
5 (10 Marks)	**Co-requisites** (with simple numerical examples) 1. Preparation of questionnaires and schedule to solve a particular research question. 2. Conduct of a small sample survey in the institution among the students. 3. Collect of a secondary data set from a local government or private organization. 4. Determination of sample size of a survey. 5. Detection of outliers 6. Graphical representation of data. 7. Problems based on measures of central tendency. 8. Problems based on measures of dispersion.	08	-	-	08
	Total	**38**	**07**	-	**45**

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practical***

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READINGS:

1. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edition. The World Press, Kolkata.
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edition), Pearson Education, Asia.
3. Mood, A.M. Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edition, (Reprint), Tata McGraw-Hill Pub. Co. Ltd.
4. Barman. M. P., Hazarika. J, Bora. T (2021): Statistical Methods, Mahaveer Pub, Dibrugarh
5. Brace, I (2013) Questionnaire Design: How to Plan, Structure and Write Survey Material for Effective Market Research. Kogan Page. UK.

*****

B.Sc. IN STATISTICS PROGRAMME (NEP)
DETAILED SYLLABUS OF 2nd SEMESTER

Title of the Course	**:**	**Probability Theory and Statistical Distributions**
Course Code	**:**	**STSC2**
Nature of the Course	**:**	**Major**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**60 (50T + 10P) (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge:

- To familiarize students with the foundational concepts of probability theory, laws and theorems.
- To provide knowledge on useful probability distributions, their properties and applications of various distributions.

Skills:

- To develop practical skills in fitting statistical distributions to data.
- Gain hands-on experience in fitting distributions using calculators and computer software and enhance practical statistical analysis skills.

Attitude:

- To cultivate an analytical and methodical approach towards statistical problems**,** encourage systematic problem-solving techniques and foster a critical mindset for analyzing and interpreting statistical data.
- To promote confidence in using statistical tools and methodologies, and build competence in applying theoretical knowledge to practical scenarios.

COURSE OUTCOMES:
After successful completion of this course, students will be able to:

CO1: Understand and apply the foundational concepts of probability theory.
- ILO1: Knowledge about the random experiments, sample space, and events and ability to distinguish between random and non-random experiments.
- ILO2: Knowledge to conceptualise the probabilities of events including frequentist and axiomatic approach.
- ILO3: They will be able to solve problems involving conditional probability, laws of addition and multiplication, and independent events.
- ILO4: They will learn the notion of conditional probability including the concept of Bayes' Theorem.

CO2: Identify and utilize different types of random variables and their distributions.
- ILO1: Differentiate between discrete and continuous random variables.
- ILO2: Define and illustrate the probability mass function, probability density function, and cumulative distribution function for various random variables.
- ILO3: Perform univariate transformations of random variables, understand their properties and analyze two-dimensional random variables to determine joint,

marginal, and conditional distributions.

CO3: Calculate and interpret expectations, moments, and generating functions for various distributions.

ILO1: Compute expectations for single and bivariate random variables and understand their significance.

ILO2: Determine moments and cumulants for given distributions and explain their applications. Use moment-generating functions, cumulant-generating functions, and characteristic functions in statistical analysis.

ILO3: Compute expectations for single and bivariate random variables and understand their significance.

CO4: Apply knowledge of standard probability distributions in real-world scenarios.

ILO1: Describe and use properties of standard probability distributions such as Binomial, Poisson, Geometric, Negative Binomial, Hypergeometric, Uniform, Normal, Exponential, Cauchy, Beta, and Gamma distributions.

ILO2: Identify limiting and approximation cases of these distributions and understand their relevance.

ILO3: Utilize these distributions in practical applications and problem-solving, demonstrating their importance in statistical analysis.

CO5: Perform practical fitting of distributions using calculators and computer-based methods.

ILO1: Fit a Binomial and Poisson distribution to a given data set using both calculators and computer software

ILO2: Fit Geometric and Negative Binomial distributions to provided data sets

ILO3: Fit Normal and Exponential distributions to data

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	**Cognitive Process Dimension**					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge			CO1			
Conceptual Knowledge			CO2			
Procedural Knowledge				CO3, CO4	CO5	
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	M	S	M	L	M	M	M	S	M	S
CO2	S	S	M	S	M	L	M	M	M	S	M	S
CO3	S	S	M	S	M	M	M	M	M	S	M	S
CO4	S	S	M	S	M	S	M	M	M	S	M	S
CO5	S	S	M	S	M	M	M	M	M	S	M	S

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (10 Marks)	**Probability:** Introduction, random experiments, sample space, events and algebra of events. Definitions of probability – classical, statistical, and axiomatic. Conditional probability, laws of addition and multiplication, independent events, theorem of total probability, Bayes' theorem and its applications.	08	01	-	09
2 (10 Marks)	**Random variables:** Discrete and continuous random variables, pmf, pdf and cdf, illustrations and properties of random variables, univariate transformations with illustrations. Two dimensional random variables: Discrete and continuous type, joint, marginal and conditional pmf, pdf, and cdf, independence of variables, bivariate transformations with illustrations.	08	01	-	09
3 (16 Marks)	**Mathematical Expectation and Generating Functions:** Expectation of single and bivariate random variables and its properties. Moments and cumulants, moment generating function, cumulant generating function and characteristic function. Uniqueness and inversion theorems (without proof) along with applications. Conditional expectations.	11	03	-	14
4 (14 Marks)	**Standard Probability Distributions:** Binomial, Poisson, geometric, negative binomial, hypergeometric, uniform, normal, exponential, Cauchy, beta and gamma along with their properties and limiting/approximation cases.	10	02		12
5 (10 Marks)	**List of Practical: (both calculator and computer based)** 1. Fitting of binomial distribution. 2. Fitting of Poisson distribution. 3. Fitting of geometric distribution. 4. Fitting of negative binomial distribution. 5. To find the ordinate for a given area for normal distribution. 6. Fitting of normal distribution.	-	-	08	16

	7. Fitting of exponential distribution.				
	Total	**37**	**07**	**08**	**60**

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practical***

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READINGS:

1. Hogg, R. V., Tanis, E. A. and Rao J. M. (2009): Probability and Statistical Inference, 17th edition, Pearson Education, New Delhi.
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th edition), Pearson Education, Asia.
3. Myer, P. L. (1970): Introductory Probability and Statistical Applications, Oxford & IBH Publishing, New Delhi.
4. Kakaty, S. C.(2003). Mathematical Statistics: Theory and Applications, Kaustubh Prakashan, Dibrugarh.
5. Ross, S. M. (2014). Introduction to probability models. Academic Press Inc.
6. Johnson, R. A., Miller, I., and Freund, J. E. (2000). Probability and statistics for engineers. 6th Edition, Pearson Education India.
9. Elhance, D. N., Elhance, V., and Aggarwal, B. M. (1958). Fundamentals of Statistics, Allahabad. Kitab Mahal.
10. Rohatgi, V. K., Saleh, A. K. M. E. (2011). An Introduction to Probability and Statistics. Germany: Wiley.

*****

Title of the Course	**:**	**Basic Probability Theory and Distributions**
Course Code	**:**	**MINSTS2**
Nature of the Course	**:**	**Minor**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**60 (50T + 10P) (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge:

- To familiarize students with the foundational concepts of probability theory, laws and theorems.
- To provide knowledge on useful probability distributions, their properties and applications of various distributions.

Skills:

- To develop practical skills in fitting statistical distributions to data.
- Gain hands-on experience in fitting distributions using calculators and computer software and enhance practical statistical analysis skills.

Attitude:

- To cultivate an analytical and methodical approach towards statistical problems**,** encourage systematic problem-solving techniques and foster a critical mindset for analyzing and interpreting statistical data.
- To promote confidence in using statistical tools and methodologies, build competence in applying theoretical knowledge to practical scenarios.

COURSE OUTCOMES:

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

CO1: Understand and apply the foundational concepts of probability theory.

- ILO1: Knowledge about the random experiments, sample space, and events and ability to distinguish between random and non-random experiments.
- ILO2: Knowledge to conceptualise the probabilities of events including frequentist and axiomatic approach.
- ILO3: They will be able to solve problems involving conditional probability, laws of addition and multiplication, and independent events.
- ILO4: They will learn the notion of conditional probability including the concept of Bayes' Theorem.

CO2: Identify and utilize different types of random variables and their distributions.

- ILO1: Differentiate between discrete and continuous random variables.
- ILO2: Define and illustrate the probability mass function, probability density function, and cumulative distribution function for various random variables.
- ILO3: Perform univariate transformations of random variables, understand their properties and analyze two-dimensional random variables to determine joint, marginal, and conditional distributions.

CO3: Calculate and interpret expectations, moments, and generating functions for various

distributions.

ILO1: Compute expectations for single and bivariate random variables and understand their significance.

ILO2: Determine moments and cumulants for given distributions and explain their applications. Use moment-generating functions, cumulant-generating functions, and characteristic functions in statistical analysis.

ILO3: Compute expectations for single and bivariate random variables and understand their significance.

CO4: Apply knowledge of standard probability distributions in real-world scenarios.

ILO1: Describe and use properties of standard probability distributions such as Binomial, Poisson, Geometric, Negative Binomial, Hypergeometric, Uniform, Normal, Exponential, Cauchy, Beta, and Gamma distributions.

ILO2: Identify limiting and approximation cases of these distributions and understand their relevance.

ILO3: Utilize these distributions in practical applications and problem-solving, demonstrating their importance in statistical analysis.

CO5: Perform practical fitting of distributions using calculators and computer-based methods.

ILO1: Fit a Binomial and Poisson distribution to a given data set using both calculators and computer software

ILO2: Fit Geometric and Negative Binomial distributions to provided data sets

ILO3: Fit Normal and Exponential distributions to data

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	**Cognitive Process Dimension**					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge			CO1			
Conceptual Knowledge			CO2			
Procedural Knowledge				CO3, CO4	CO5	
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	M	S	M	L	M	M	M	S	M	S
CO2	S	S	M	S	M	L	M	M	M	S	M	S
CO3	S	S	M	S	M	M	M	M	M	S	M	S
CO4	S	S	M	S	M	S	M	M	M	S	M	S
CO5	S	S	M	S	M	M	M	M	M	S	M	S

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (11 Marks)	**Probability:** Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability– classical, statistical, and axiomatic. Conditional Probability, laws of addition and multiplication, independent events, theorem of total probability, Bayes' theorem and its applications.	07	01	-	08
2 (13 Marks)	**Random Variables:** Discrete and continuous random variables, pmf, pdf and cdf, illustrations and properties of random variables, univariate transformations with illustrations. **Two Dimensional Random Variables:** Discrete and continuous type, joint, marginal and conditional pmf, pdf, and cdf, independence of variables, bivariate transformations with illustrations.	10	02	-	12
3 (13 Marks)	**Mathematical Expectation and Generating Functions:** Expectation of single and bivariate random variables and its properties. Moments and cumulants, moment generating function, cumulant generating function and characteristic function. Uniqueness and inversion theorems (without proof) along with applications. Conditional expectations.	10	02	-	12
4 (13 Marks)	**Standard Probability Distributions:** Binomial, Poisson, geometric, negative binomial, hypergeometric, uniform, normal, exponential, Cauchy, beta and gamma along with their properties and limiting/approximation cases.	10	02	-	12
5 (10 Marks)	**List of Practical: (both calculator and computer based)** 1. Fitting of binomial distribution. 2. Fitting of Poisson distribution. 3. Fitting of geometric distribution. 4. Fitting of negative binomial distribution. 5. To find the ordinate for a given area for normal distribution. 6. Fitting of normal distribution. 7. Fitting of exponential distribution.	-	-	08	16
	Total	**37**	**07**	**08**	**60**

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practical***

MODES OF IN-SEMESTER ASSESSMENT: **(40 Marks)**

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READINGS:

1. Hogg, R.V., Tanis, E.A. and Rao J.M. (2009): Probability and Statistical Inference, 7th edition, Pearson Education, New Delhi.
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th edition), Pearson Education, Asia.
3. Myer, P.L. (1970): Introductory Probability and Statistical Applications, Oxford & IBH Publishing, New Delhi.
4. Rohatgi, V. K., Saleh, A. K. M. E. (2011). An Introduction to Probability and Statistics. Germany: Wiley.
5. Hogg, R.V., Tanis, E.A. and Rao J.M. (2009): Probability and Statistical Inference, 17th edition, Pearson Education, New Delhi.
6. Ross, S. M. (2014). Introduction to probability models. Academic Press Inc.
7. Johnson, R. A., Miller, I., and Freund, J. E. (2000). Probability and statistics for engineers. 6th Edition, Pearson Education India.
8. Elhance, D. N., Elhance, V., & Aggarwal, B. M. (1958). Fundamentals of Statistics, Allahabad. Kitab Mahal.
9. Kakaty, S. C.(2003). Mathematical Statistics: Theory and Applications, Kaustubh Prakashan, Dibrugarh.

*****

Title of the Course	**:**	**Basics of Statistical Distributions and Inference**
Course Code	**:**	**GECSTS2**
Nature of the Course	**:**	**Generic Elective**
Total Credits	**:**	**03**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge:

- To study useful probability distributions and their properties and applications of these distributions.
- To study useful sampling distributions and their properties, applications to make inferences about populations.

Skills:

- To make informative decisions using statistical tests.
- To make evidence-based decisions based on statistical analysis.

Attitude:

- To develop a critical and analytical mindset towards statistical data. Foster a methodical approach to problem-solving in statistics.
- To promote confidence in applying statistical methods using statistical tools and techniques. Instil the importance of accuracy and reliability in statistical analysis.

COURSE OUTCOMES:

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

CO1: Understand and apply the foundational concepts of probability and random variables
- ILO1: Define and explain random experiments
- ILO2: Solve problems involving conditional probability
- ILO3: Differentiate between discrete and continuous random variables and illustrate their probability mass function (pmf)

CO2: Calculate mathematical expectations and understand generating functions
- ILO1: Define and compute the mathematical expectation for different types of random variables.
- ILO2: Explain and use generating functions in the context of probability distributions.
- ILO3: Illustrate the concepts of moments and cumulants through generating functions.

CO3: Identify and utilize basic statistical and sampling distributions in data analysis.
- ILO1: Describe and use properties of basic statistical distributions such as Binomial
- ILO2: Define and apply basic sampling distributions such as Chi-square
- ILO3: Differentiate between population and sample
- ILO4: Explain the basic idea of significance testing

CO4: Perform and interpret various tests of significance for hypothesis testing.
- ILO1: Conduct tests of hypotheses for the parameters of a normal distribution (one sample and two sample problems) and perform tests for the significance of the

correlation coefficient.

ILO2: Analyze categorical data using Chi-square tests of proportions, association, and goodness-of-fit, including Yates' correction.

ILO3: Conduct analysis of variance (one-way classification) and interpret the results. Check the consistency of data and find associations among attributes using statistical methods.

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	**Cognitive Process Dimension**					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge						
Conceptual Knowledge			CO1	CO4		
Procedural Knowledge				CO2	CO3	
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	M	S	M	L	M	M	M	S	M	S
CO2	S	S	M	S	M	L	M	M	M	S	M	S
CO3	S	S	M	S	M	M	M	M	M	S	M	S
CO4	S	S	M	S	M	M	M	M	M	S	M	S

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (16 Marks)	**Probability:** Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability – classical, statistical, and axiomatic. Conditional Probability, laws of addition and multiplication, independent events, theorem of total probability. Random variables: discrete and continuous random variables, p.m.f., p.d.f. and c.d.f.	09	02	-	11
2 (14 Marks)	**Mathematical Expectation and Generating Functions:** Idea of mathematical expectation and generating functions. **Basic Statistical Distributions:** Binomial, Poisson, Normal. **Basic Sampling Distributions:** Chi-square, t and F (Definition and use only). Idea of population and sample. Idea of parameter and statistic. The basic idea of significance test. Null and alternative hypotheses. Type I & Type II errors, level of significance, concept of p-value.	09	02	-	11
3 (20 Marks)	**Tests of Significance:** Tests of hypotheses for the parameters of a normal distribution (one sample and two sample problems). Tests for the significance of correlation coefficient. **Categorical Data:** Tests of proportions, tests of association and goodness-of-fit using Chi- square test, Yates' correction. Analysis of Variance (one way classification only).	12	03		15
4 (10 Marks)	**Co-requisites** (with simple numerical examples) 1. Tests of hypotheses for the parameters of a normal distribution (one sample and two sample problems). 2. Chi-square test of proportions. 3. Chi-square tests of association. 4. Chi-square test of goodness-of-fit. 5. Test for correlation coefficient. 6. Analysis of Variance of a one way classified data 7. Checking consistency of data and finding association among attributes.	08	-	-	08
	Total	**38**	**07**	**-**	**45**

Where, L: Lectures T: Tutorials P: Practical

MODES OF IN-SEMESTER ASSESSMENT: **(40 Marks)**

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READINGS:

1. Goon, A. M., Gupta M. K. and B. Dasgupta (2005). Fundamentals of statistics, Vol.-I & II.
2. McColl, J. H. (2004). Multivariate probability. John Wiley and Sons.
3. Hogg, R. V., Tanis, E.A. and Rao J. M. (2009): Probability and Statistical Inference, 17th edition, Pearson Education, New Delhi.
4. Ross, S. M. (2014). Introduction to probability models. Academic Press Inc.
5. Johnson, R. A., Miller, I., and Freund, J. E. (2000). Probability and statistics for engineers. 6th Edition, Pearson Education India.
6. Elhance, D. N., Elhance, V., and Aggarwal, B. M. (1958). Fundamentals of Statistics, Allahabad. Kitab Mahal.
7. Kakaty, S. C. (2003). Mathematical Statistics: Theory and Applications, Kaustubh Prakashan, Dibrugarh
8. Rohatgi, V. K., and Saleh, A. K. M. E. (2011). An Introduction to Probability and Statistics. Germany: Wiley.

*****

Title of the Course	**:**	**Data Science using MS EXCEL**
Course Code	**:**	**SECSTS2**
Nature of the Course	**:**	**Skill Enhancement**
Total Credits	**:**	**03**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge:

- To Understand Excel Data Types and Structures
- To Learn Cell and Worksheet Operations
- To Grasp Advanced Excel Functions and Tools

Skills:

- To Perform Data Analysis and Visualization
- To Execute Cell and Worksheet Operations
- To Use Advanced Excel Tools for Data Management

Attitudes:

- To Cultivate Attention to Detail
- To Foster a Problem-Solving Mindset
- To Promote Data-Driven Decision Making

COURSE OUTCOMES:

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

CO1: To Understand Excel Data Types and Structures

ILO 1: Identify different data types used in Excel.
ILO 2: Explain the structure of an Excel worksheet.
ILO 3: Describe naming conventions and create named ranges.
ILO 4: Understand the importance of data types in performing calculations and analyses.

CO2: To Learn Cell and Worksheet Operations

ILO 1: Freeze panes and split sheets to manage large datasets effectively.
ILO 2: Hide and unhide rows, columns, and sheets to control the visibility of data.
ILO 3: Apply wrapping, merging, and alignment techniques for better data presentation.
ILO 4: Use conditional formatting to highlight important data points.

CO3: To Grasp Advanced Excel Functions and Tools

ILO 1: Utilize logical functions (IF, AND, OR) to perform conditional operations.
ILO 2: Apply text functions (LEFT, RIGHT, MID, CONCATENATE) for data manipulation.
ILO 3: Use mathematical functions (SUM, AVERAGE, MAX, MIN) for basic calculations.
ILO 4: Implement statistical functions (STDEV, VAR, CORREL) for data analysis.

CO4: To Perform Data Analysis and Visualization

ILO 1: Transform raw data into frequency and cumulative frequency tables.

ILO 2: Create various types of charts (bar, column, line, pie, scatter) to visualize data.
ILO 3: Use the data analysis tool pack for descriptive statistics, histograms, and correlations.
ILO 4: Perform chi-square tests using raw data and Excel formulas

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	Cognitive Process Dimension					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge						
Conceptual Knowledge		CO1	CO2	C04		
Procedural Knowledge		CO3				
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	M	S	M	L	M	M	M	S	M	S
CO2	S	S	M	S	M	L	M	M	M	S	M	S
CO3	S	S	M	S	M	M	M	M	M	S	M	S
CO4	S	S	M	S	M	M	M	M	M	S	M	S

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (12 Marks)	**Layout of Excel Worksheet:** Variable name; data types; freezing panes, splitting data sheets, hiding operations; wrapping, merging, alignments. **Cell Operations:** Conditional formatting; sorting; filtering, custom filtering; insert, delete, format cells; **Data Tools:** Remove duplicates, data validation; data table formatting operations (Table Styles).	-	-	07	14
2 (11 Marks)	**Simple Cell Functions:** SUM, Average, MAX, MIN, Count. **Column/row operations (arithmetic):** adding, subtracting, multiplying, dividing, powering, finding percentage. Transforming raw data to frequency table (discrete, continuous). Cumulative frequency table. Data visualization using charts – bar, column, line, pie, scatter, etc.	-	-	08	16
3 (12 Marks)	**Excel Functions:** LOGICAL functions, TEXT functions, some MATHEMATICAL and STATISTICAL functions. Pivot tables in excel. Introduction to LOOKUP functions in Excel (How, Where and Why) – VLOOKUP, HLOOKUP, INDEX, MATCH)	-	-	10	20
4 (15 Marks)	**Excel Add-Ins:** Data analysis tool pack (descriptive statistics, histogram, correlation, regression, t-test, F-test, z-test, ANOVA), Perform chi-square test using raw data and excel formulas.	-	-	12	24
5 (10 Marks)	**Co-requisites and Problem Solving:** Reporting from Excel Outputs. Project Compilation. Real life Data Analysis.	-	-	08	16
	Total	**-**	**-**	**45**	**90**

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practical***

MODES OF IN-SEMESTER ASSESSMENT: **(40 Marks)**

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READINGS:

1. Berk, K N. (2003): Data analysis with Microsoft Excel. Duxbury Press, London.
2. Nigam, M. (2019): Data analysis with Excel. BPB Publications, New Delhi.

3. Ramirez, A. (2020): Excel Formulas and Functions 2020: The Step by Step Excel Guide with Examples on How to Create Powerful Formulas. Caprioru, India.

*****

B.Sc. IN STATISTICS PROGRAMME (NEP)
DETAILED SYLLABUS OF 3rd SEMESTER

Title of the Course	**:**	**Sampling Distributions**
Course Code	**:**	**STSC3**
Nature of the Course	**:**	**Major**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**60(50T + 10P) (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge:

- To study different sampling distributions and their properties.
- To understand the mathematical foundation necessary for further study in statistical inference.

Skills:

- To develop proficiency in applying the Central Limit Theorem and other limit laws in practical scenarios.
- To gain expertise in conducting tests of significance and constructing confidence intervals using various sampling distributions.

Attitude:

- To cultivate a critical approach towards statistical hypothesis testing and decision-making.
- To encourage a methodical and logical approach to solving statistical problems.

COURSE OUTCOMES:

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

CO1: Understand and apply various convergence concepts and limit laws in statistical analysis.

ILO1: Understand and distinguish between different types of convergence.
ILO2: Apply limit laws such as Chebyshev's inequality, WLLN, and SLLN to solve problems.
ILO3: Utilize the Central Limit Theorem and Liapunov Theorem in practical scenarios.

CO2: Describe and utilize order statistics in practical applications.

ILO1: Define order statistics and describe their distributions.
ILO2: Calculate and interpret the distribution of the smallest and largest order statistics.
ILO3: Understand and use the joint distribution of r^{th} and s^{th} order statistics.

CO3: Understand key sampling distribution concepts and conduct large sample tests.

ILO1: Define key concepts such as random sample, parameter, and statistic.
ILO2: Describe the sampling distribution of sample means, variances, and proportions.
ILO3: Conduct large sample tests for single proportions, differences of proportions, single means, differences of means, standard deviations, and differences of standard deviations using the CLT.

CO4: Utilize χ^2 distribution, Student's t-distribution and Snedecore's F-distribution for significance testing and confidence intervals.

ILO1: Derive the pdf of the $\chi 2$ distribution, Student's t-distribution, and Snedecore's F-distribution and describe their properties.

ILO2: Conduct tests of significance and construct confidence intervals using χ^2, t and F distributions.

CO5: Perform practical statistical tests and construct confidence intervals using both manual and computer-based methods.

ILO1: Perform practical tests of significance and construct confidence intervals for proportions, means, and standard deviations.

ILO2: Conduct exact sample tests based on the $\chi 2$ distribution.

ILO3: Test the goodness of fit and independence of attributes.

ILO4: Use computer-based tools to analyze data and interpret results effectively.

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	**Cognitive Process Dimension**					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge						
Conceptual Knowledge			CO1,CO2			
Procedural Knowledge				CO3, CO4, CO5		
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	M	S	M	L	M	M	M	S	M	S
CO2	S	S	M	S	M	L	M	M	M	S	M	S
CO3	S	S	M	S	M	M	M	M	M	S	M	S
CO4	S	S	M	S	M	S	M	M	M	S	M	S
CO5	S	S	M	S	M	M	M	M	M	S	M	S

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (12 Marks)	**Limit Laws:** convergence in probability, almost sure convergence, convergence in mean square and convergence in distribution and their inter relations, Chebyshev's inequality, WLLN, SLLN and their applications, De-Moivre Laplace theorem, Central Limit Theorem (CLT) for i.i.d. variates, applications of CLT and Liapunov Theorem. **Order Statistics:** Introduction, distribution of the r^{th} order statistic, smallest and largest order statistics. Joint distribution of r^{th} and s^{th} order statistics.	09	02	-	11
2 (14 Marks)	**Sampling Distribution:** Definitions of random sample, parameter and statistic, sampling distribution of a statistic, sampling distribution of sample mean, standard errors of sample mean, sample variance and sample proportion. **Testing of Hypotheses:** Null and alternative hypotheses, level of significance, Type I and Type II errors, their probabilities and critical region. Large sample tests, use of CLT for testing single proportion, difference of two proportions, single mean, difference of two means, standard deviation and difference of standard deviations by classical and p-value approaches.	10	02	-	12
3 (12 Marks)	**Exact Sampling Distribution:** Definition and derivation of pdf of χ^2 with n degrees of freedom (df) using mgf, nature of pdf curve for different degrees of freedom, mean, variance, mgf, cumulant generating function, mode, additive property and limiting form of χ^2 distribution. Tests of significance and confidence intervals based on distribution.	09	01	-	10
4 (12 Marks)	**Student's t-Distributions:** Student's and Fishers t-distribution, Derivation of its pdf, nature of probability curve with different degrees of freedom, mean, variance, moments and limiting form of t distribution. **Snedecore's F-Distribution:** Derivation of pdf, nature of pdf curve with different degrees of freedom, mean, variance and mode. Distribution of $1/F(n_1,n_2)$. Relationship between t, F and χ^2 distributions. Test of significance and confidence Intervals based on t and F distributions.	09	02	-	11
5 (10 Marks)	**List of Practical: (both calculator and computer based)** 1. Testing of significance, and construction of confidence intervals for proportion.	-	-	08	16

	2. Testing of significance, and construction of confidence intervals for single mean and difference of two means and paired tests. 3. Testing of significance, and construction of confidence intervals for difference of two standard deviations. 4. Exact sample tests based on chi-square distribution. 5. Testing of significance when the population variance has a specific value and its confidence intervals. 6. Testing of goodness of fit. 7. Testing of independence of attributes. 8. Testing based on 2 × 2 contingency table without and with Yates' corrections. 9. Testing of significance of an observed sample correlation coefficient . 10. Testing and confidence intervals of equality of two population variances.				
	Total	**37**	**07**	**08**	**60**

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practical***

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READINGS:

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2003): An Outline of Statistical Theory, Vol. I, 4th edition World Press, Kolkata.
2. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2nd edition (Reprint) John Wiley and Sons.
3. Hogg, R.V. and Tanis, E.A. (2009): A Brief Course in Mathematical Statistics. Pearson Education.
4. Johnson, R.A. and Bhattacharya, G.K. (2001): Statistics-Principles and Methods, 4th edition John Wiley and Sons.
5. Mood, A.M., Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd edition (Reprint).Tata McGraw-Hill Pub. Co. Ltd.
6. Kakaty, S. C.(2003). Mathematical Statistics: Theory and Applications, Kaustubh Prakashan, Dibrugarh
7. Rohatgi, V. K., Saleh, A. K. M. E. (2011). An Introduction to Probability and Statistics. Germany: Wiley.

****

Title of the Course	**:**	**Mathematics for Statistics**
Course Code	**:**	**STSC4**
Nature of the Course	**:**	**Major**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**60 (50T + 10P) (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge

- Grasp the definitions and properties of limits, continuity, and differentiability.
- Learn the convergence tests for series, including comparison, ratio, and root tests.
- Understand the calculation and properties of determinants.
- Learn various matrix operations including addition, multiplication, and inversion.
- Understand the definitions and properties of vector spaces and subspaces.
- Learn about basis, dimension, and linear transformations.

Skills

- Solve complex problems in real analysis using the learned theoretical concepts.
- Analyze the convergence and divergence of series through various tests.
- Execute matrix addition, subtraction, multiplication, and inversion accurately.
- Utilize determinants in solving linear equations and understanding matrix properties.

Attitude

- Develop a critical and analytical approach towards mathematical problems.
- Encourage curiosity and questioning to deepen understanding of mathematical concepts.
- Cultivate an appreciation for the beauty and logic inherent in mathematical structures and proofs.
- Develop an attitude of persistence and patience in solving complex mathematical problems.

COURSE OUTCOMES:

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

CO1: Understand the foundational concepts of Real Analysis and Series analysis.

ILO1: Define and explain the principles of limits, continuity, and differentiability.
ILO2: Explain various convergence tests such as comparison, ratio, and root tests.
ILO3: Understand and describe the properties of power series

CO2: Comprehend Determinants and Matrices:

ILO1: Define and calculate determinants and explain their properties.
ILO2: Describe various matrix operations including addition, multiplication, and inversion.
ILO3: Apply determinants in solving linear equations and analyzing matrix properties.

CO3: Explore and Understand Vector Spaces

ILO1: Define vector spaces and subspaces, and explain their properties.
ILO2: Explain the concepts of basis, dimension, and linear transformations.
ILO3: Explore applications of the Cayley-Hamilton theorem in solving matrix equations.

ILO4: Understand the process of diagonalizing quadratic forms and their geometric interpretations.

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	**Cognitive Process Dimension**					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge						
Conceptual Knowledge		CO1				
Procedural Knowledge			CO2, CO3			
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	M	S	M	L	M	M	M	S	M	S
CO2	S	S	M	S	M	L	M	M	M	S	M	S
CO3	S	S	M	S	M	L	M	M	M	S	M	S

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (15 Marks)	**Real Analysis:** Real Numbers. Bounded and unbounded sets, neighborhoods and limit points, Suprimum and infimum, derived sets, open and closed sets, sequences and their convergence, limits of some special sequences. Cauchy's general principle of convergence, Cauchy's first theorem on limits, monotonic sequences.	11	02	-	13
2 (10 Marks)	**Series Analysis:** Infinite series, positive termed series and their convergence, Comparison test, D'Alembert's ratio test, Cauchy's nth root test, Raabe's test. Gauss test, Cauchy's condensation test and integral test (Statements and Examples only). Absolute convergence of series, Leibnitz's test for the convergence of alternating series, Conditional convergence.	07	02	-	09
3 (10 Marks)	**Determinants and Matrices:** Algebra of matrices and determinants. Types of Matrices: triangular, symmetric and skew symmetric matrices, idempotent matrices, orthogonal matrices, singular and non-singular matrices related results and their properties. Trace of a matrix, unitary, involutory and nilpotent matrices.	08	01	-	09
4 (15 Marks)	**Vector Space:** Definition, properties, basis, dimension, span, linear dependency. **Matrix Operations:** Rank of a matrix, row-rank, column-rank, standard theorems on ranks, rank of the sum and the product of two matrices. Generalized inverse (concept with illustrations). Partitioning of matrices and simple properties. Characteristic roots and Characteristic vector, useful Properties of characteristic roots, Cayley-Hamilton theorem, Quadratic forms definition and classifications; Linear orthogonal transformation.	11	02	-	13
5 (10 Marks)	**List of Practical: (both calculator and computer based)** 1. Problems related to linearly independence and dependence. 2. Determination of rank of a matrix of order 4x4. 3. Inverse of a matrix of order 4x4. 4. Solution of system of equations. 5. Problems related to quadratic forms. 6. Determination of eigen values and vectors. 7. Classification of quadratic form with eigen value.	-	-	08	16
	Total	**37**	**07**	**08**	**60**

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practical***

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READINGS:

1. Malik S.C. and Savita Arora, (1994): Mathematical Analysis, Second Edition, Wiley Eastern Limited, New Age International Limited, New Delhi.
2. Somasundram D. and Chaudhary B. (1987): A First Course in Mathematical Analysis, Narosa Publishing House, New Delhi.
3. Gupta S.L. and Nisha Rani, (1995): Principles of Real Analysis, Vikas Publ. House Pvt. Ltd., New Delhi.
4. Appostol T.M. (1987): Mathematical Analysis, 2nd edition, Narosa Publishing House, New Delhi.
5. Shanti Narayan, (1987): A course of Mathematical Analysis, 12th revised edition, S. Chand & Co. (Pvt.) Ltd., New Delhi.
6. Singal M.K. and Singal A.R., (2003): A First Course in Real Analysis, 24th edition, R. Chand & Co., New Delhi.
7. Bartle, R. G. and Sherbert, D. R. (2002): Introduction to Real Analysis (3rd edition), John Wiley and Sons (Asia) Pte. Ltd., Singapore.
8. Ghorpade, Sudhir R. and Limaye, Balmohan V. (2006): A Course in Calculus and Real Analysis, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint.
9. Jain, M. K., Iyengar, S. R. K. and Jain, R. K. (2003): Numerical methods for scientific and engineering computation. New age International Publisher, India.
10. Lay David C.: Linear Algebra and its Applications, Addison Wesley, 2000.
11. Schaum's Outlines: Linear Algebra, Tata McGraw-Hill Edition, 3rd edition, 2006.
12. Krishnamurthy V., Mainra V.P. and Arora J.L.: An Introduction to Linear Algebra (II, III, IV, V).
13. Jain P.K. and Khalil Ahmad: Metric Spaces, Narosa Publishing House, New Delhi, 1973
14. Biswas, S. (1997): A Textbook of Matrix Algebra, New Age International, 1997.
15. Gupta S.C.: An Introduction to Matrices (Reprint). Sultan Chand & Sons, 2008.
16. Artin M.: Algebra. Prentice Hall of India, 1994.
17. Datta K.B.: Matrix and Linear Algebra. Prentice Hall of India Pvt. Ltd., 2002.
18. Hadley G.: Linear Algrbra. Narosa Publishing House (Reprint), 2002.
19. Searle S.R.: Matrix Algebra Useful for Statistics. John Wiley & Sons., 1982.

*****

Title of the Course	**:**	**Statistical Inference**
Course Code	**:**	**MINSTS3**
Nature of the Course	**:**	**Minor**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**60 (50T + 10P) (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge:

- Understand the assumptions, properties, and applications of Chi-square, t, and F distributions in statistical inference.
- Understand the concept of Minimum Variance Unbiased Estimator (MVUE) and its importance in statistical estimation.
- Explore the critical region, level of significance, concepts of best critical region, most powerful test, and uniformly most powerful test.
- Study the Neyman-Pearson lemma, Likelihood Ratio Test (LRT) and Sequential Probability Ratio Test (SPRT).

Skills:

- Develop skills in calculating Maximum Likelihood Estimators (MLE) for exponential and normal distributions.
- Learn to perform Likelihood Ratio Tests (LRT) for single-sample and two-sample testing problems.
- Gain practical experience in using calculators and computers to perform statistical calculations and simulations.

Attitude:

- Emphasize the importance of accurate calculation and interpretation of statistical results.
- Encourage a problem-solving mindset in applying statistical techniques to real-world data.
- Encourage curiosity and exploration of new statistical techniques and their applications.

COURSE OUTCOMES:

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

CO1: Understand and apply sampling distributions such as Chi-square, t, and F distributions.

ILO1: Explain the assumptions and properties of Chi-square, t, and F distributions.
ILO2: Apply Chi-square, t, and F distributions to real-world data and interpret the results.
ILO3: Demonstrate the applications of Chi-square, t, and F distributions in hypothesis testing.

CO2: Grasp the concepts and principles of estimation.

ILO1: Define and explain the concepts of unbiasedness, consistency, efficiency, and sufficiency in estimation.
ILO2: Understand and apply the Factorization theorem (without proof) to identify sufficient statistics.

ILO3: Identify and calculate the Minimum Variance Unbiased Estimator (MVUE).

CO3: Master various methods of estimation.

ILO1: Apply the method of moments for parameter estimation in binomial, Poisson, and normal distributions.

ILO2: Utilize the method of maximum likelihood estimation for parameter estimation in exponential and normal distributions.

ILO3: Compare and contrast the efficiency and applicability of different estimation methods.

CO4: Understand the theory and application of hypothesis testing.

ILO1: Define and explain critical region, level of significance, size, power, best critical region, and most powerful test.

ILO2: Apply Neyman Pearson lemma to construct most powerful tests for specific hypotheses.

ILO3: Understand and perform likelihood ratio tests for single-sample and two-sample problems.

CO5: Grasp the principles and applications of sequential analysis.

ILO1: Explain the Sequential Probability Ratio Test (SPRT) and its fundamental relations among α, β, A, and B.

ILO2: Determine A and B in practical scenarios and understand Wald's fundamental identity (sans proof).

ILO3: Construct and interpret Operating Characteristics (OC) and Average Sample Number (ASN) functions, and draw corresponding curves for sequential testing procedures.

CO6: Apply practical skills using both calculator and computer-based methods.

ILO1: Calculate maximum likelihood estimators for exponential and normal distributions.

ILO2: Perform estimation by the method of moments for binomial, Poisson, and normal distributions.

ILO3: Draw power curves for tests of equality of normal means and conduct likelihood ratio tests for single-sample and two-sample problems.

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	Cognitive Process Dimension					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge						
Conceptual Knowledge		CO1, CO2	CO3, CO4			
Procedural Knowledge			CO5, CO6			
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	M	S	M	L	M	M	M	S	M	S
CO2	S	S	M	M	M	M	L	M	M	S	M	S
CO3	S	S	M	S	M	L	M	M	M	S	M	S
CO4	S	S	M	M	S	L	M	M	M	S	M	S
CO5	S	S	M	M	S	S	M	M	M	S	M	S
CO6	S	S	M	M	M	L	M	M	M	S	M	S

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (12 Marks)	**Sampling Distributions:** Chi-square, t and F (assumption, properties and applications)	09	01	-	10
2 (14 Marks)	**Estimation:** Concepts of estimation, unbiasedness, consistency, efficiency and sufficiency. Factorization theorem(without proof). Minimum variance unbiased estimator (MVUE). **Methods of Estimation:** Method of moments, method of maximum likelihood estimation.	10	02	-	12
3 (12 Marks)	**Testing of Hypothesis:** Critical region, level of significance, size and power, best critical region, most powerful test, uniformly most powerful test, Neyman Pearson lemma (statement and applications to construct most powerful test). Likelihood ratio test, properties of likelihood ratio tests (without proof).	09	02	-	11
4 (12 Marks)	**Sequential Analysis:** Sequential probability ratio test (SPRT). Fundamental relations among α, β, A and B, determination of A and B in practice. Wald's fundamental identity (sans proof) and concept of operating characteristics (OC) and Average Sample Number (ASN) functions, example based on normal distribution.	09	02	-	11
5 (10 Marks)	**List of Practical: (both calculator and computer based)** 1. Maximum likelihood estimators for the exponential, normal distributions. 2. Estimation by method of moments for the binomial, Poisson, normal distributions. 3. Drawing power curves for the tests of equality of normal mean (s). 4. Likelihood ratio test: Single-sample and two-sample testing problems. 5. Sequential testing procedure: Construction of OC, ASN function and drawing of OC, ASN curve.	-	-	08	16

	Total	37	07	08	60

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practical***

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READINGS:

1. Goon A. M., Gupta M. K., and Dasgupta B. (2005). Fundamentals of Statistics, Vol. I, World Press, Calcutta.
2. Rohatgi V. K. and Saleh, A. K. Md. E. (2009). An Introduction to Probability and Statistics. 2nd edition (Reprint) John Wiley and Sons.
3. Miller, I. and Miller, M. (2002): John E. Freund's Mathematical Statistics (6th edition, low price edition), Prentice Hall of India.
4. Dudewicz, E. J., and Mishra, S. N. (1988). Modern Mathematical Statistics. John Wiley & Sons.
5. Mood A.M., Graybill F.A., and Boes D.C. (1974). Introduction to the Theory of Statistics, McGraw Hill.
6. Bhat B. R, Srivenkatramana T., and Rao Madhava K. S. (1997). Statistics: A Beginner's Text, Vol. I, New Age International (P) Ltd.
7. Snedecor G.W., and Cochran W.G. (1967). Statistical Methods. lowa State University Press.
8. McColl, J. H. (2004). Multivariate probability. John Wiley and Sons.
9. Hogg, R. V., Tanis, E. A. and Rao J. M. (2009). Probability and Statistical Inference, 17th edition, Pearson Education, New Delhi.
10. Ross, S. M. (2014). Introduction to probability models. Academic Press Inc.
11. Johnson, R. A., Miller, I., and Freund, J. E. (2000). Probability and statistics for engineers. 6th Edition, Pearson Education India.
12. Elhance, D. N., Elhance, V., and Aggarwal, B. M. (1958). Fundamentals of Statistics, Allahabad. Kitab Mahal.

*****

Title of the Course	**:**	**Applied Statistics**
Course Code	**:**	**GECSTS3**
Nature of the Course	**:**	**Generic Elective**
Total Credits	**:**	**03**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge:

- Understand the construction and application of index numbers in economics.
- Learn the principles and methods of statistical quality control.
- Gain knowledge about demographic methods and their significance.

Skills:

- Develop the ability to compute and interpret various index numbers.
- Acquire skills in constructing and analyzing control charts for variables and attributes.
- Enhance capabilities in calculating and interpreting demographic measures.

Attitude:

- Appreciate the role of statistics in economics, industry, and society.
- Develop a methodical and analytical approach to solving statistical problems.
- Foster a critical mindset towards data interpretation and quality control processes.

COURSE OUTCOMES:

After the completion of this course, students will be able to

CO1: Develop a comprehensive understanding of index numbers.

ILO1: Ability to define and describe various types of index numbers.
ILO2: Competence in constructing price and quantity index numbers using Laspeyre's, Paasche's, Marshall-Edgeworth's, and Fisher's formulas.
ILO3: Skill in interpreting consumer price index numbers and wholesale price index numbers.
ILO4: Understanding the uses and limitations of index numbers.
ILO5: Capability to perform base shifting, splicing, and deflating of index numbers.

CO2: Gain proficiency in statistical quality control techniques.

ILO1: Knowledge of the importance of statistical methods in industrial research and practice.
ILO2: Understanding the causes of variations in quality: chance and assignable.
ILO3: Ability to construct and interpret X-bar and R-charts for variables.
ILO4: Proficiency in creating and analyzing p-charts and c-charts for attributes.
ILO5: Skill in estimating process capability and understanding its implications.

CO3: Acquire in-depth knowledge of demographic methods.

ILO1: Understanding the measurement of population, rates, and ratios of vital events.
ILO2: Ability to compute and interpret measures of mortality, including CDR, SDR, IMR, and standardized death rates.
ILO3: Competence in measuring fertility and reproduction rates, including CBR, GFR,

and TFR.

ILO4: Proficiency in constructing and using life tables and understanding their uses.

ILO5: Skill in measuring population growth using GRR and NRR.

CO4: Develop practical skills in statistical analysis and interpretation.

ILO1: Ability to construct and interpret statistical control charts (X-bar & R-chart, s-chart, np-chart, p-chart, c-chart, u-chart).

ILO2: Skill in constructing and interpreting single sample inspection plans, including OC, AQL, LTPD, ASN, ATI, AOQ, AOQL curves.

ILO3: Competence in calculating process capability and comparing 3-sigma control limits with specification limits.

ILO4: Proficiency in performing practical calculations related to demographic measures and index numbers.

CO5: Foster a critical and analytical approach towards statistical data and methods.

ILO1: Appreciation for the role of statistics in economics, industry, and society.

ILO2: Development of a methodical and analytical approach to solving statistical problems.

ILO3: Ability to critically analyze data and interpret results in the context of quality control and demographic analysis.

ILO4: Understanding the application of statistical methods in real-world scenarios.

ILO5: Skill in presenting statistical findings effectively through various modes of assessment (assignments, presentations, laboratory work).

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	**Cognitive Process Dimension**					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge						
Conceptual Knowledge			CO1, CO2			
Procedural Knowledge				CO3, CO4	CO5	
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	M	S	M	S	M	M	M	S	M	S
CO2	S	S	M	S	M	M	M	M	M	S	M	S
CO3	S	S	M	S	M	S	M	M	M	S	M	S
CO4	S	S	M	S	M	S	M	M	M	S	M	S
CO5	S	S	M	S	M	M	M	M	M	S	M	S

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (15 Marks)	**Index Numbers:** Definition, Criteria for a good index number, different types of index numbers. Construction of index numbers of prices and quantities, consumer price index number. Uses and limitations of index numbers. Base shifting, Splicing and deflating of Index numbers.	09	02	-	11
2 (17 Marks)	**Statistical Quality Control:** Importance of statistical methods in industrial research and practice. Causes of variations in quality: chance and assignable. General theory of control charts, process & product control. Control charts for variables: X-bar and R-charts. Control charts for attributes: p- and c-charts.	10	02	-	12
3 (18 Marks)	**Demographic Methods:** Introduction, measurement of population, rates and ratios of vital events. Measurement of mortality: CDR, SDR (with respect to Age and sex), IMR, Standardized death rates. Measurement of fertility and reproduction: CBR, GFR, and TFR. Concept of Life table and its uses. Measurement of population growth: GRR, NRR	12	02	-	14
4 (10 Marks)	**Co-requisites** (with simple numerical examples) 1. Construction of price and quantity index numbers by Laspeyre's formula, Paasche's formula, Marshall-Edgeworth's formula, Fisher's Formula. Comparison and interpretation. 2. Construction of wholesale price index number, fixed base index number and consumer price index number with interpretation. 3. Construction and interpretation of X bar & R-chart 4. Construction and interpretation p-chart (fixed sample size) and c-chart. 5. Computation of measures of mortality. 6. Computation of measures of fertility and population growth.	07	01	-	08
	Total	**38**	**07**	**-**	**45**

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practical***

MODES OF IN-SEMESTER ASSESSMENT: **(40 Marks)**

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READINGS:

1. Mukhopadhyay, P. (1999). Applied Statistics, New Central Book Agency, Calcutta.

2. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008). Fundamentals of Statistics, Vol. II, 9th edition World Press, Kolkata.
3. Gupta, S. C. and Kapoor, V. K. (2008). Fundamentals Of Applied Statistics, 4th edition (Reprint), Sultan Chand & Sons
4. Montogomery, D. C. (2009). Introduction to Statistical Quality Control, 6th edition, Wiley India Pvt. Ltd.
5. Hoyle, David: ISO Quality Systems Handbook, Butterworth Heinemann Publication.
6. Pathak, K. B., Ram, F. (2016). Techniques of Demographic Analysis, Himalaya Publishing House.
7. Keyfitz N., Beckman John A.: Demogarphy through Problems S-Verlag New York.

*****

Title of the Course	**:**	**Data Science using SPSS Software**
Course Code	**:**	**SECSTS3**
Nature of the Course	**:**	**Skill Enhancement**
Total Credits	**:**	**03**
Distribution of Marks	**:**	**60 (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge:

- To Understand SPSS Basics and Data Management
- To Explore Data Types and Scale of Measurements in SPSS
- To Master Variable Transformation and Data Manipulation in SPSS
- To Analyze Descriptive Statistics and Statistical Tests in SPSS

Skills:

- To Use the SPSS Interface for Data Entry and File Management
- To Perform Variable Transformation and Recoding in SPSS
- To Conduct Descriptive Statistics and Graphical Analysis in SPSS
- To Apply Advanced Statistical Tests (Correlation, Regression, ANOVA, Non-parametric Tests) in SPSS

Attitudes:

- To Emphasize Accuracy and Attention to Detail in Data Handling
- To Foster Problem-Solving Skills in Data Analysis with SPSS
- To Promote Collaboration and Effective Communication in Statistical Analysis
- To Encourage a Commitment to Ethical Use and Reporting of Statistical Results

COURSE OUTCOMES:

After the completion of this course, students will able to:

CO 1: Demonstrate Proficiency in SPSS Data Management

ILO 1: Import, organize, and manage data files effectively in SPSS.
ILO 2: Define and manipulate variables accurately in SPSS.
ILO 3: Utilize dialog boxes and commands for data transformation and file merging in SPSS.

CO 2: Apply Descriptive Statistics and Graphical Analysis

ILO 1: Generate and interpret graphs and charts for categorical and continuous variables.
ILO 2: Calculate and interpret descriptive statistics (mean, median, mode, variance, standard deviation).
ILO 3: Conduct exploratory data analysis (EDA) and cross-tabulation in SPSS.

CO 3: Perform Advanced Statistical Analyses

ILO 1: Apply Pearson product-moment correlation, Spearman rank correlation, and partial correlation in SPSS.
ILO 2: Conduct simple linear regression and multiple regression analysis using SPSS.
ILO 3: Perform parametric tests (t-tests, ANOVA, ANCOVA) and non-parametric tests (Chi-square, Mann-Whitney, Kruskal-Wallis) in SPSS.

CO 4: Interpret and Communicate Statistical Findings

ILO 1: Interpret the results of statistical tests and analyses in SPSS.

ILO 2: Evaluate assumptions (normality, homogeneity of variance) and check for outliers in SPSS.

ILO 3: Communicate statistical findings effectively through written reports and graphical representations.

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	**Cognitive Process Dimension**					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge		CO1				
Conceptual Knowledge				CO2, CO3		
Procedural Knowledge					CO4	
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	M	S	M	L	M	M	M	S	M	S
CO2	S	S	M	S	M	L	M	M	M	S	M	S
CO3	S	S	M	S	M	M	M	M	M	S	M	S
CO4	S	S	M	S	M	M	M	M	M	S	M	S

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (12 Marks)	**Introduction:** Starting SPSS, working with data file, different data types, scale of measurements, dialogue boxes. Preparing the data file, creating data file, entering data, variable types in SPSS, defining the variables, modifying data file, import data. Screening and cleaning data, manipulation of data.	-	-	08	16
2 (11 Marks)	**Variable transformation/ recoding**, recoding categorical string variables using automatic recode, grouping or splitting data, replacing missing values, computing new variables, selecting cases, sorting cases, merging files, generating random number.			08	16
3 (15 Marks)	**Descriptive Statistics:** Graphs-creating and editing graphs and charts, categorical variables, continuous variables, frequencies, descriptive, explore, cross tabulation, checking normality, outliers checking. Correlation: Pearson product moment correlation, spearman rank correlation, partial correlation, simple linear regression, multiple regression analysis. One sample and two independent sample t test, paired sample t test. One way analysis of variance (ANOVA), two way ANOVA, analysis of covariance (ANCOVA).	-	-	14	28
4 (12 Marks)	**Non-Parametric Test:** Chi square test, Mann-Whitney test, Kruskal- Wallis test, Wilcoxon signed rank test. One sample and two sample Kolmogorov – Smirnov test, Median test.	-	-	09	18
5 (10 Marks)	**Co-requisites and problem solving:** Reporting from SPSS outputs. Project compilation. Real life data analysis.	-	-	06	12
	Total	**-**	**-**	**45**	**90**

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practical***

MODES OF IN-SEMESTER ASSESSMENT: **(40 Marks)**

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READINGS:

1. Performing Data Analysis using IBM SPSS, Lawrence S. Meyers, Glenn C. Gamst, A. J. Guarino, Wiley Publication
2. SPSS for Windows Step by Step A Simple Guide and Reference, Darren George and Paul Malley.
3. SPSS in Simple Steps, Kiran Pandya, Smruti Bulsari, Sanjay Sinha, Dreamtech Press.

B.Sc. IN STATISTICS PROGRAMME (NEP)
DETAILED SYLLABUS OF 4th SEMESTER

Title of the Course	**:**	**Statistical Quality Control**
Course Code	**:**	**STSC5**
Nature of the Course	**:**	**Major**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**60(50T + 10P) (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge:

- To Understanding the Definition and Dimensions of Quality
- To Exploring the Historical Perspective of Quality Control and Improvement
- To Studying the Contributions of Quality Gurus
- To Recognizing the Significance of the Quality Hall of Fame

Skills:

- To Applying Statistical Process Control Techniques
- To Constructing and Interpreting Control Charts
- To Implementing Acceptance Sampling Plans
- To Calculating and Analyzing Process Capability

Attitudes:

- To Emphasizing Continuous Improvement in Quality Management
- To Developing a Problem-Solving Mindset in Quality Assurance
- To Fostering a Commitment to Customer Satisfaction
- To Promoting Team Collaboration in Quality Initiatives

COURSE OUTCOMES:
After the completion of this course, students will be able to:

CO1: Concept of SQC and History.

ILO1: Students will get the basic idea of Statistical control, the history of the development of SQC and will be able to know various persons (gurus) involved in the SQC developments.

ILO2: Students will learn about ISO (International Organization for Standardization), various tools of SQC and constructions of various charts.

CO2: Various Quality control charts

ILO1**:** Gain knowledge of various control charts

ILO2: Analysis pattern of charts, estimation of process capability.

CO3: Will earn knowledge on various sampling inspection plans with graphical interpretation.

ILO1**:** Explain the principles of single and double acceptance sampling plans.

ILO2**:** Graphically interpret operating characteristic (OC) curves, average quality level (AQL), lot tolerance percent defective (LTPD), average outgoing quality (AOQ), and average outgoing quality limit (AOQL).

ILO3: Utilize Dodge and Romig's sampling inspection plan tables for practical applications.

CO4: Six- Sigma Control Charts

ILO1: Will get concepts of Six-Sigma, total management, and selection criteria for Six-Sigma.

ILO2: Will learn to use of Six-Sigma in production

CO5: Will gain practical knowledge for construction of various charts and drawing interpretation on the results.

ILO1: Construct and interpret various statistical control charts.

ILO2: Design and analyze single sample inspection plans, constructing OC, AQL, LTPD, ASN, ATI, AOQ, and AOQL curves.

ILO3: Calculate process capability and compare it with 3-sigma control limits and specification limits.

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	**Cognitive Process Dimension**					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge						
Conceptual Knowledge		CO1				
Procedural Knowledge			CO2,CO3 CO4		CO5	
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	M	L	L	S	M	M	S	M	S	L	S
CO2	S	S	M	M	S	M	M	M	S	S	M	S
CO3	S	S	M	M	S	M	L	M	S	S	M	S
CO4	S	S	M	M	S	M	L	M	S	S	M	S
CO5	S	S	S	S	S	M	L	M	S	S	M	S

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (14 Marks)	**Quality:** Definition, dimensions of quality, historical perspective of quality control and improvements starting from world war II, historical perspective of quality gurus and quality hall of fame. **Quality System and Standards:** Introduction to ISO quality standards, Quality registration. Statistical process control - seven tools of SPC, chance and assignable causes of quality variation. Statistical Control charts- construction and statistical basis of 3-σ control charts, rational sub-grouping.	11	02	-	13
2 (14 Marks)	**Control Charts:** For variables- X-bar and R-chart & s-chart. For attributes- np-chart, p-chart, c-chart and u-chart. Comparison between control charts for variables and control charts for attributes. Analysis of patterns on control chart, estimation of process capability.	10	02	-	12
3 (12 Marks)	**Acceptance Sampling Plan:** Principle of acceptance sampling plans. Single and double sampling plan their OC, AQL, LTPD, AOQ, AOQL, ASN, ATI functions with graphical interpretation, use and interpretation of Dodge and Romig's sampling inspection plan tables.	09	02	-	11
4 (10 Marks)	**Introduction to Six-Sigma:** Overview of six sigma, lean manufacturing and Total Quality Management (TQM). Organizational structure and six sigma training plans- selection criteria for six-sigma roles and training plans. Voice of Customers (VOC): Importance and VOC data collection. Critical to quality (CTQ).	07	01		08
5 (10 Marks)	**List of Practical: (both calculator and computer based)** 1. Construction and interpretation of statistical control charts: Variable charts- X-bar, R-chart & s-chart. Attribute charts- np-chart, p-chart, c-chart, & u-chart. 2. Single sample inspection plan: Construction and interpretation of OC, AQL, LTPD, ASN, ATI, AOQ, AOQL curves. 3. Calculation of process capability and comparison of 3-sigma control limits with specification limits.	-	-	08	16
	Total	**37**	**07**	**08**	**60**

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practical***

MODES OF IN-SEMESTER ASSESSMENT: **(40 Marks)**

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READING:

1. Montogomery, D. C.: Introduction to Statistical Quality Control, Wiley India Pvt. Ltd.
2. Goon A.M., Gupta M.K. and Dasgupta B.: Fundamentals of Statistics, Vol. II, The World Press, Kolkata.
3. Mukhopadhyay, P: Applied Statistics, Books and Allied (P) Ltd.
4. Montogomery, D. C. and Runger, G.C.: Applied Statistics and Probability for Engineers, Wiley India Pvt. Ltd.
5. Ehrlich, B. Harris: Transactional Six Sigma and Lean Servicing, St. Lucie Press.
6. Hoyle, David: ISO Quality Systems Handbook, Butterworth Heinemann Publication.

*****

Title of the Course	**:**	**Statistical Inference- I**
Course Code	**:**	**STSC6**
Nature of the Course	**:**	**Major**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**60 (50T + 10P) (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge

- Understand the basic concepts of estimation, including unbiasedness, sufficiency, consistency, and efficiency.
- Learn about complete statistics, minimum variance unbiased estimators (MVUE), and the theorems of Rao-Blackwell and Lehmann-Scheffé.
- Gain knowledge of various methods of estimation such as the method of moments, maximum likelihood estimation, and the method of minimum Chi-square.
- Learn the Neyman-Pearson Lemma and its applications in constructing most powerful tests.
- Understand the Sequential Probability Ratio Test (SPRT) for simple null versus simple alternative hypotheses.

Skills

- Apply the concepts of unbiasedness, sufficiency, consistency, and efficiency to real-world problems.
- Use the method of moments, maximum likelihood, and minimum Chi-square in various contexts.
- Identify and construct critical regions for hypothesis testing and implement SPRT in real-world testing scenarios.

Attitude

- Encourage curiosity and motivation to explore advanced topics in estimation and hypothesis testing.
- Develop a proactive attitude towards applying statistical methods to solve practical problems.
- Develop a commitment to using statistical skills for improving decision-making processes in various domains.

COURSE OUTCOMES:

After successful completion of the course students will be able to:

CO1: Understanding Basic Concepts of Estimation

ILO1: Explain the concepts of estimation, including unbiasedness, sufficiency, consistency, and efficiency.
ILO2: Apply the factorization theorem to determine sufficient statistics.
ILO3: Understand and utilize complete statistics in estimation problems.

CO2: Mastering Methods of Estimation

ILO1: Implement the method of moments for parameter estimation and assess its properties.

ILO2: Apply the method of maximum likelihood for parameter estimation and evaluate its properties.
ILO3: Utilize the method of minimum Chi-square for parameter estimation and understand its properties.

CO3: Proficiency in Hypothesis Testing
ILO1: Define critical region, level of significance, size, and power of a test.
ILO2: Identify and construct best critical regions and most powerful tests.
ILO3: Apply the Neyman-Pearson Lemma to construct most powerful tests for simple hypotheses.

CO4: Sequential Analysis Techniques
ILO1: Understand the concept of Sequential Probability Ratio Test (SPRT) and its application to simple hypotheses.
ILO2: Derive and interpret fundamental relations among α, β, A, and B in the context of SPRT.
ILO3: Determine appropriate values of A and B in practical SPRT applications.

CO5: Applications and Advanced Topics in Estimation and Testing
ILO1: Apply estimation and hypothesis testing techniques to real-world data sets.
ILO2: Integrate various statistical methods for comprehensive data analysis.
ILO3: Develop proficiency in using statistical software to perform estimation and hypothesis testing.

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	**Cognitive Process Dimension**					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge		CO1				
Conceptual Knowledge			CO2			
Procedural Knowledge				CO3, CO4	CO5	
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	M	M	S	M	S	L	L	S	S	M	M
CO2	S	S	M	S	M	S	L	L	S	S	M	M
CO3	S	M	M	S	S	S	L	M	S	S	M	M
CO4	S	S	M	S	M	S	L	L	S	S	M	M
CO5	S	S	M	S	M	S	L	L	S	S	M	M

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (12 Marks)	**Basic Concepts:** Concepts of estimation, unbiasedness, sufficiency, consistency and efficiency. Factorization theorem. Complete statistic, Minimum variance unbiased estimator (MVUE), Rao-Blackwell and Lehmann-Scheffe theorems and their applications. Cramer-Rao inequality and MVB estimators (statement and applications).	09	02	-	11
2 (10 Marks)	**Methods of Estimation:** Method of moments, method of maximum likelihood, method of minimum Chi-square (properties and examples). Least squares method.	08	01	-	09
3 (15 Marks)	**Testing of Hypothesis:** Critical region, level of significance, size and power, best critical region, most powerful test, uniformly most powerful test, Neyman Pearson Lemma (statement and applications to construct most powerful test). Likelihood ratio test, properties of likelihood ratio tests (without proof).	11	02	-	13
4 (13 Marks)	**Sequential Analysis:** Sequential probability ratio test (SPRT) for simple null vs. simple alternative hypotheses. Fundamental relations among α, β, A and B, determination of A and B in practice. Wald's fundamental identity (sans proof) and the derivation of operating characteristics (OC) and average sample number (ASN) functions, examples based on normal, Poisson, binomial and exponential distributions.	09	02		11
5 (10 Marks)	**List of Practical: (both calculator and computer based)** 1. Maximum likelihood estimators. 2. Estimation by method of moments for the binomial, Poisson, exponential, normal distributions. 3. Comparison of method of moments and maximum likelihood estimators for the continuous uniform distribution. 4. Computation of Type- I and Type-II errors. 5. Application of NP lemma: construction of MP and UMP tests. 6. Drawing power curves for the tests of equality of normal mean (s). 7. Likelihood ratio test: Single-sample and two-sample testing problems. 8. Sequential testing procedure: Construction of OC, ASN function and drawing of OC, ASN curve.	-	-	08	16
	Total	**37**	**07**	**08**	**60**

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practical***

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READING:

1. Goon A.M., Gupta M.K.: Das Gupta. B. (2005), Fundamentals of Statistics, Vol. I, World Press, Calcutta.
2. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2nd edition (Reprint) John Wiley and Sons.
3. Miller, I. and Miller, M. (2002): John E. Freund's Mathematical Statistics (6th edition, low price edition), Prentice Hall of India.
4. Dudewicz, E. J., and Mishra, S. N. (1988): Modern Mathematical Statistics. John Wiley & Sons.
5. Mood A.M, Graybill F.A. and Boes D.C.: Introduction to the Theory of Statistics, McGraw Hill.
6. Bhat B.R, Srivenkatramana T and Rao Madhava K.S. (1997) Statistics: A Beginner's Text, Vol. I, New Age International (P) Ltd.
7. Snedecor G.W and Cochran W.G. (1967) Statistical Methods. lowa State University Press.
8. McColl, J. H. (2004). Multivariate probability. John Wiley and Sons.
9. Hogg, R.V., Tanis, E.A. and Rao J.M. (2009): Probability and Statistical Inference, 17th edition, Pearson Education, New Delhi.
10. Ross, S. M. (2014). Introduction to probability models. Academic Press Inc.
11. Johnson, R. A., Miller, I., and Freund, J. E. (2000). Probability and statistics for engineers. 6th Edition, Pearson Education India.
12. Elhance, D. N., Elhance, V., and Aggarwal, B. M. (1958). Fundamentals of Statistics, Allahabad. Kitab Mahal.

*****

Title of the Course	**:**	**Survey Sampling**
Course Code	**:**	**STSC7**
Nature of the Course	**:**	**Major**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**60 (50T + 10P) (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge

- Gain a thorough understanding of the concepts of population and sample in the context of sample surveys.
- Acquire detailed knowledge of non-probability and probability sampling techniques.
- Understand the concepts and applications of ratio and regression estimators.

Skills

- Develop the ability to select samples using various sampling methods.
- Learn to determine appropriate sample sizes for different survey designs.
- Acquire the skills to compute estimates of population parameters from sample data.
- Gain the ability to compare different sampling techniques, such as SRS, stratified sampling, and systematic sampling.

Attitude

- Cultivate a meticulous and methodical approach to designing and conducting sample surveys.
- Promote an appreciation for the practical difficulties and considerations in applying various sampling techniques.
- Foster an attitude of continuous learning and staying updated with the latest developments in sample survey techniques.

COURSE OUTCOMES:

After successful completion of the course students will be able to:

CO1: Understand the fundamentals of sample surveys and differentiate between complete enumeration and sampling.

ILO1: Explain the concept of population and sample, and distinguish between complete enumeration and sampling.
ILO2: Identify and describe sampling and non-sampling errors.
ILO3: Differentiate between non-probability and probability sampling techniques.

CO2: Apply simple random sampling techniques to estimate population parameters.

ILO1: Define and explain the procedures for selecting a sample using simple random sampling with and without replacement.
ILO2: Estimate population mean, total, and proportion using simple random sampling.
ILO3: Calculate the variances of the estimates and understand their significance.

CO3: Implement stratified random sampling and evaluate its efficiency compared to simple random sampling.

ILO1: Describe the technique of stratified random sampling and its application.

ILO2: Estimate population mean and total using stratified random sampling.
ILO3**:** Discuss practical difficulties in allocation and estimate the gain in precision using stratified sampling.

CO4: Utilize systematic sampling techniques and compare their efficiency with other sampling methods.

ILO1**:** Explain the technique of systematic sampling and its application.
ILO2**:** Estimate population mean and total using systematic sampling.
ILO3**:** Calculate the variances of estimates in systematic sampling and compare them with those in simple random and stratified sampling, especially in the presence of linear trends.

CO5: Apply cluster sampling, ratio, and regression estimators to improve the efficiency of estimates.

ILO1**:** Describe the technique of cluster sampling and estimate the population mean and its variance.
ILO2**:** Explain the concepts of ratio and regression estimators and their first approximation to the population mean and total.
ILO3: Compare the efficiency of ratio and regression estimators with simple random sampling and discuss the impact of the correlation coefficient on regression estimation.

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	**Cognitive Process Dimension**					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge		CO1				
Conceptual Knowledge			CO2	CO4		
Procedural Knowledge			CO5		CO3	
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	M	L	S	L	L	L	S	S	S	S
CO2	S	S	M	S	S	M	M	L	S	S	S	S
CO3	S	S	M	S	S	M	M	L	S	S	S	S
CO4	S	S	M	S	S	L	L	L	S	S	S	S
CO5	S	S	M	S	S	L	L	L	S	S	S	S

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (12 Marks)	**Introduction to Sample Survey:** Concept of population and sample, complete enumeration versus sampling, sampling and non-sampling errors. Types of sampling: non-probability and probability sampling, basic principle of sample survey, simple random sampling with and without replacement, definition and procedure of selecting a sample, estimates of: population mean, total and proportion, variances of these estimates, estimates of their variances and sample size determination.	10	01	-	11
2 (13 Marks)	**Stratified Random Sampling:** Technique, estimates of population mean and total, variances of these estimates, proportional and optimum allocations and their comparison with SRS. Practical difficulties in allocation, estimation of gain in precision.	10	01	-	11
3 (13 Marks)	**Systematic Sampling:** Technique, estimates of population mean and total, variances of these estimates (N=nk). Comparison of systematic sampling with SRS and stratified sampling in the presence of linear trend and corrections. **Cluster Sampling:** Technique, estimation of population mean and its variance.	10	01	-	11
4 (12 Marks)	**Ratio and Regression Estimators**: Concepts, first approximation to the population mean and total (for SRS of large size), variances of these estimators and estimators of these variances, variances in terms of correlation coefficient for regression method of estimation and their comparison with SRS.	10	01	-	11
5 (10 Marks)	**List of Practical: (both calculator and computer based)** 1. Simple random sampling: Drawing of a random numbers by with replacement method (SRSWR) and without replacement method (SRSWOR). 2. Enumeration of all possible samples in SRSWR, SRSWOR and establish properties. 3. Calculations of population mean, mean square and variance. Estimation of mean, standard error. 4. Stratified Sampling: Allocation of sample to strata by proportional and Neyman's methods. Also, compare their efficiencies relative to SRS. 5. Estimation of gain in precision in stratified sampling. 6. Systematic sampling: Comparison of systematic	-	-	08	16

	sampling with stratified sampling and SRS in the presence of a linear trend. 7. Ratio and regression estimation: Calculation of population mean or population total. Calculation of mean squares. Compare the efficiencies of ratio and regression estimators relative to SRS. 8. Cluster sampling: Estimation of mean or total, variance of the estimate.				
	Total	**40**	**04**	**08**	**60**

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practical***

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READINGS:

1. Cochran W. G. (1984): Sampling Techniques (3rd edition), Wiley Eastern.
2. Sukhatme,P. V., Sukhatme,B. V. Sukhatme, S. Asok, C. (1984). Sampling Theories of Survey with Application, IOWA State University Press and Indian Society of AgriculturalStatistics.
3. Murthy M. N. (1977): Sampling Theory & Statistical Methods, Statistical Pub. Society,Calcutta.
4. Des Raj and Chandhok P. (1998): Sample Survey Theory, Narosa PublishingHouse. New Delhi.
5. Goon A. M., Gupta M. K. and Dasgupta B. (2001): Fundamentals of Statistics (Vol.2), World Press.
6. Ladusingh L. (2018): Survey Sampling Methods, PHI Learning Private Limited.

*****

Title of the Course	**:**	**Statistical Computing Using C Programming**
Course Code	**:**	**STSC8**
Nature of the Course	**:**	**Major**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**60 (50T + 10P) (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge:

- To Understand the History and Importance of C Programming
- To Familiarize with Components and Basic Structure of C Programming
- To Gain Knowledge of Data Types, Constants, and Variables in C
- To Master Operators, Expressions, and Input/Output Operations in C

Skills:

- To Write and Execute Basic C Programs
- To Utilize Decision-Making Constructs and Looping Techniques in C
- To Implement Arrays, Strings, and User-Defined Functions in C
- To Apply Pointers and Memory Management Techniques in C

Attitudes:

- To Develop a Systematic Approach to Problem-Solving in C Programming
- To Emphasize Precision and Accuracy in Coding Practices
- To Foster Patience and Perseverance in Debugging and Testing Code
- To Promote Collaboration and Knowledge Sharing in C Programming Communities

COURSE OUTCOMES:

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

CO1: Demonstrate Proficiency in Fundamental C Programming Concepts

ILO1**:** Write and execute basic C programs to solve simple computational problems.
ILO2**:** Explain the historical significance and evolution of C programming language.
ILO3**:** Identify and utilize fundamental components and structure of C programs.

CO2: Apply Advanced Programming Techniques in C

ILO1: Implement decision-making constructs (if-else, switch) and looping techniques (for, while, do-while) effectively in C programs.
ILO2: Create and manipulate arrays and strings for data storage and manipulation.
ILO3: Develop and utilize user-defined functions to modularize code and enhance reusability.

CO3: Utilize Pointers and Memory Management in C Programming

ILO1: Declare, initialize, and dereference pointers in C programs.
ILO2: Understand and apply pointer arithmetic and pointer-to-pointer relationships.
ILO3: Implement dynamic memory allocation and deallocation using malloc, calloc, realloc, and free functions.

CO4: Implement Advanced Concepts and Techniques in C Programming

ILO1: Demonstrate knowledge of implicit and explicit type conversions, including typecasting.

ILO2: Utilize advanced operators (increment/decrement, assignment, bitwise) effectively in C programs.

ILO3: Apply input/output operations (formatted and unformatted) to read and print data in C programs.

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	**Cognitive Process Dimension**					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge		CO1				
Conceptual Knowledge			CO2		CO3	
Procedural Knowledge						CO4
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	L	S	M	M	L	L	M	S	M	M
CO2	S	M	L	S	L	M	L	L	M	S	M	M
CO3	S	M	L	S	L	M	L	L	M	S	M	M
CO4	S	S	L	S	M	M	L	L	M	S	M	M

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (15 Marks)	**Introduction to C:** History and importance of C, Components, basic structure programming, character set, C tokens, Keywords and Identifiers and execution of a C program. **Data types:** Basic data types, Enumerated data types, derived data types. Constants and variables: declaration and assignment of variables, **Operators and Expressions:** Arithmetic, relational, logical, assignment, increment/decrement, operators, precedence of operators in arithmetic, relational and logical expression. Implicit and explicit type conversions in expressions, library functions. **Managing input and output operations:** reading and printing formatted and unformatted data.	12	02	-	14
2 (12 Marks)	**Decision Making and Branching**: if…else, nesting of if…else, else if ladder, switch, conditional operator. Looping in C for, nested for, while, do…while, jumps in and out of loops. **Arrays:** Declaration and initialization of one-dim and two-dim arrays. Character arrays and strings:	10	02	-	12
3 (12 Marks)	**User-Defined Functions:** A multi-function program using user-defined functions, definition of functions, return values and their types, function prototypes and calls. **Category of Functions:** no arguments and no return values, arguments but no return values , arguments with return values, no arguments but returns a value, functions that return multiple values. Recursion function. Passing arrays to functions, Storage class of variables.	10	02		12
4 (11 Marks)	**Pointers:** Declaration and initialization of pointer variables, accessing the address of a variable, accessing a variable through its pointer, pointer expressions, pointer increments/decrement and scale factor. Pointers and arrays, arrays of pointers, pointers as function arguments, functions returning pointers.	05	01	-	06
5 (10 Marks)	**List of Practical: (computer based)** 1. Plot of a graph y = f(x). 2. Roots of a quadratic equation (with imaginary roots also). 3. Sorting of an array and hence finding median. 4. Mean, median and mode of a grouped frequency data. 5. Variance and coefficient of variation of a grouped	-	-	08	16

	frequency data. 6. Preparing a frequency table. 7. Value of n! using recursion. 8. Random number generation from uniform, exponential, normal (using CLT) and gamma distribution, calculate sample mean, variance and compare with population parameters. 9. Matrix addition, subtraction, multiplication, transpose and trace. 10. Fitting of Binomial, Poisson distribution and apply Chi-square test for goodness of fit. 11. Chi-square contingency table. 12. t-test for difference of means and paired t-test. 13. Testing equality of two variances (F- test). 14. Multiple and partial correlation. 15. Compute ranks and then calculate rank correlation (without tied ranks). 16. Fitting of linear regression model.				
	Total	**37**	**07**	**08**	**60**

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practical***

MODES OF IN-SEMESTER ASSESSMENT: **(40 Marks)**

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READING:

1. Kernighan, B. W. and Ritchie, D. (1988): C Programming Language, 2nd edition, Prentice Hall.
2. Balagurusamy, E. (2011): Programming in ANSI C, 6th edition, Tata McGraw Hill.
3. Gottfried, B. S. (1998): Schaum's Outlines: Programming with C, 2nd edition, Tata McGraw Hill

*****

Title of the Course	**:**	**Industrial Statistics**
Course Code	**:**	**MINSTS4**
Nature of the Course	**:**	**Minor**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**60 (50T + 10P) (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge:

- Understand the techniques and approaches of Statistical Quality Control (SQC) used in the industry for manufacturing high-quality goods and services at low cost.
- Learn about quality systems and standards, including ISO quality standards and quality registration.
- Comprehend statistical process control, including the seven tools of SPC and the construction and statistical basis of 3-σ control charts.
- Understand the principles of acceptance sampling plans, including single and double sampling plans and their associated concepts (OC, AQL, LTPD, AOQ, AOQL, ASN, ATI).

Skill:

- Develop the ability to construct and interpret statistical control charts, including X-bar, R-chart, s-chart, np-chart, p-chart, c-chart, and u-chart.
- Acquire the skills to analyze patterns on control charts and estimate process capability.
- Learn to construct and interpret acceptance sampling plan curves (OC, AQL, LTPD, ASN, ATI, AOQ, AOQL).
- Enhance the capability to calculate process capability and compare 3-sigma control limits with specification limits

Attitude:

- Cultivate an appreciation for the importance of quality control in manufacturing and service industries.
- Develop a commitment to continuous improvement and excellence in quality management.
- Foster an attitude of diligence and precision in the construction and analysis of control charts and sampling plans.
- Encourage a proactive approach to identifying and addressing quality variations and defects.

COURSE OUTCOMES:

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

CO1: Concept of SQC and History

ILO1: Students will get the basic idea of Statistical control, the history of the development of SQC and will be able to know various persons (gurus) involved in the SQC developments.

ILO2: Students will learn about ISO (International Organization for Standardization), various tools of SQC and constructions of various charts.

CO2: Various Quality control charts

ILO1: Gain knowledge of various control charts

ILO2: Analysis pattern of charts, estimation of process capability.

CO3: Will earn knowledge on various sampling inspection plans with graphical interpretation.

ILO1: Explain the principles of single and double acceptance sampling plans.

ILO2: Graphically interpret operating characteristic (OC) curves, average quality level (AQL), lot tolerance percent defective (LTPD), average outgoing quality (AOQ), and average outgoing quality limit (AOQL).

ILO3: Utilize Dodge and Romig's sampling inspection plan tables for practical applications.

CO4: Six- Sigma Control Charts

ILO1: Will get concepts of Six-Sigma, total management, and selection criteria for Six-Sigma.

ILO2: Will learn to use of Six-Sigma in production

CO5: Will gain practical knowledge for construction of various charts and drawing interpretation on the results.

ILO1: Construct and interpret various statistical control charts.

ILO2: Design and analyze single sample inspection plans, constructing OC, AQL, LTPD, ASN, ATI, AOQ, and AOQL curves.

ILO3: Calculate process capability and compare it with 3-sigma control limits and specification limits.

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	**Cognitive Process Dimension**					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge						
Conceptual Knowledge		CO1				
Procedural Knowledge			CO2, CO3, CO4		CO5	
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	M	L	L	S	M	M	S	M	S	L	S
CO2	S	S	M	M	S	M	M	M	S	S	M	S
CO3	S	S	M	M	S	M	L	M	S	S	M	S
CO4	S	S	M	M	S	M	L	M	S	S	M	S
CO5	S	S	S	S	S	M	L	M	S	S	M	S

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (14 Marks)	**Quality:** Definition, historical perspective of quality control and improvements starting from World War II, historical perspective of quality gurus and quality hall of fame. **Quality System and Standards:** Introduction to ISO quality standards, Quality registration. Statistical Process Control - Seven tools of SPC, chance and assignable Causes of quality variation. Statistical control charts- construction and statistical basis of 3-σ control charts, rational sub-grouping.	12	02	-	14
2 (13 Marks)	**Control Charts:** Variables- X-bar, R-chart, & s-chart. Attributes- np-chart, p-chart, c-chart and u-chart. Comparison between control charts for variables and control charts for attributes. Analysis of patterns on control chart, estimation of process capability.	09	02	-	11
3 (12 Marks)	**Acceptance Sampling Plan:** Principle of acceptance sampling plans. Single and Double sampling plan their OC, AQL, LTPD, AOQ, AOQL, ASN, ATI functions with graphical interpretation, use and interpretation of Dodge and Romig's sampling inspection plan tables.	10	02	-	12
4 (11 Marks)	**Introduction to Six-Sigma:** Overview of six sigma, lean manufacturing and total quality management (TQM). Organizational structure and six sigma training plans- selection criteria for six-sigma roles and training plans.	06	01	-	7
5 (10 Marks)	**List of Practical: (both calculator and computer based)** 4. Construction and interpretation of statistical control charts: Variable charts- X-bar, R-chart & s-chart. Attribute charts- np-chart, p-chart, c-chart, & u-chart. 5. Single sample inspection plan: Construction and interpretation of OC, AQL, LTPD, ASN, ATI, AOQ, AOQL curves. 1. Calculation of process capability and comparison of 3-sigma control limits with specification limits.	-	-	08	16
	Total	**37**	**07**	**08**	**60**

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practical***

MODES OF IN-SEMESTER ASSESSMENT: **(40 Marks)**

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READING:

1. Montogomery, D. C. (2009): Introduction to Statistical Quality Control, 6th edition, Wiley India Pvt. Ltd.
2. Goon A. M., Gupta M. K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th edition. The World Press, Kolkata.
3. Mukhopadhyay, P (2011): Applied Statistics, 2nd edition revised reprint, Books and Allied(P) Ltd.
4. Montogomery, D. C. and Runger, G. C. (2008): Applied Statistics and Probability for Engineers, 3rd edition reprint, Wiley India Pvt. Ltd.
5. Ehrlich, B. Harris (2002): Transactional Six Sigma and Lean Servicing, 2nd edition, St. Lucie Press.
6. Hoyle, David (1995): ISO Quality Systems Handbook, 2nd edition, Butterworth Heinemann Publication.

*****

B.Sc. IN STATISTICS PROGRAMME (NEP)
DETAILED SYLLABUS OF 5th SEMESTER

Title of the Course	**:**	**Linear Models and Regression Analysis**
Course Code	**:**	**STSC9**
Nature of the Course	**:**	**Major**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**60 (50T + 10P) (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge:

- To gain knowledge of analysis of variance and covariance in one-way and two-way classified data for fixed effect models.
- To get an idea about theory of linear estimation, Gauss-Markov theorem.
- To learn about Simple regression analysis, Estimation and hypothesis testing.
- To get an idea about Prediction from a fitted model and Violation of usual assumptions.

Skill:

- To develop skills of computation of the distribution of quadratic forms.
- To develop skills of fitting simple linear regression model.
- To gain proficiency in fitting of orthogonal polynomials.
- To develop skills of performance of Analysis of variance test in case of one way and two way classified data with one observation per cell.
- To develop skills of performance of Analysis of covariance of one way and two way classified data.

Attitude:

- Develop a keen interest in analysis of variance and covariance in one-way and two-way classified data.
- To build up concern in linear estimation and Gauss-Markov theorem.
- To accumulate the concept of Simple regression analysis, Estimation and hypothesis testing.
- To build up concepts related to violation of usual assumptions of regression model.

COURSE OUTCOMES:

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

CO1: Understand the basic concepts of analysis of variance and covariance

ILO1: analysis of variance and covariance in one-way classified data for fixed effect models

ILO2: analysis of variance and covariance in two-way classified data with one observation per cell for fixed effect models.

CO2: Gauss-Markov Set-up

ILO1: Theory of linear estimation, estimability of linear parametric functions.

ILO2: Method of least squares, Gauss-Markov theorem.

CO3: Simple Regression Models

ILO1: Simple regression analysis, Estimation and hypothesis testing in case of simple regression models

ILO2: Orthogonal polynomials.

CO4: Model Adequacy Checking

ILO1: Prediction from a fitted model.

ILO2: Violation of usual assumptions concerning normality.

ILO3: Problem of homoscedasticity, autocorrelation and multi-collinearity.

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	**Cognitive Process Dimension**					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge						
Conceptual Knowledge		CO1	CO2			
Procedural Knowledge				CO3, CO4		
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	L	S	M	S	S	L	M	S	S	M	M
CO2	S	L	S	M	S	S	L	M	M	S	L	M
CO3	S	L	S	S	S	S	M	L	S	S	M	M
CO4	S	L	S	S	S	S	M	L	S	S	L	M

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (14 Marks)	**Analysis of Variance:** Definitions of fixed, random and mixed effect models, analysis of variance and covariance in one-way classified data for fixed effect models, analysis of variance and covariance in two-way classified data with one observation per cell for fixed effect models.	12	02	-	14
2 (10 Marks)	**Gauss-Markov Set-up:** Theory of linear estimation, estimability of linear parametric functions, method of least squares, Gauss-Markov theorem with proof.	05	01	-	06
3 (12 Marks)	**Regression Models:** Simple regression analysis, Estimation and hypothesis testing in case of simple regression models (matrix and scalar versions). Orthogonal polynomials.	09	02	-	11
4 (14 Marks)	**Model Checking:** Prediction from a fitted model, Violation of usual assumptions concerning normality; homoscedasticity, autocorrelation and multi-collinearity.	11	02	-	13
5 (10 Marks)	**List of Practical: (both calculator and computer based)** 1. To compute the distribution of quadratic forms. 2. To fit simple linear regression model. 3. Orthogonal polynomials. 4. Analysis of variance of a one way classified data. 5. Analysis of variance of a two way classified data with one observation per cell. 6. Analysis of covariance of a one way classified data. 7. Analysis of covariance of a two way classified data.	-	-	08	16
	Total	**37**	**07**	**08**	**60**

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practical***

MODES OF IN-SEMESTER ASSESSMENT: **(40 Marks)**

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READING:

1. Weisberg, S. (2005). Applied Linear Regression (3rd edition). Wiley.
2. Wu, C. F. J. and Hamada, M. (2009). Experiments, Analysis, and Parameter Design Optimization (2nd edition), John Wiley.
3. Renchner, A. C. And Schaalje, G. B. (2008). Linear Models in Statistics (2nd edition), John Wiley and Sons.
4. Mukhopadhyay, P.: Mathematical Statistics Central, New Book Agency (P) Ltd.

5. Chatterjee S. price B.: Regression Analysis by Example John Wiley.

*****

Title of the Course	**:**	**Operations Research**
Course Code	**:**	**STSC10**
Nature of the Course	**:**	**Major**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**60 (50T + 10P) (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge

- Understand the fundamental concepts and principles of Operations Research (OR) including linear programming problem(LPP), Transportation Problem, Game Theory and Project Management.
- Understand the fundamental concepts and mathematical formulations of linear programming.
- Study different methods for solving transportation problems, such as the Northwest Corner Rule and Vogel's Approximation Method.
- Grasp the basic principles and terminology of game theory, including players, strategies, and payoffs.
- Understand the role of OR in improving decision-making processes and operational efficiencies.

Skills

- Develop the ability to formulate and solve linear programming problems using appropriate mathematical techniques.
- Develop skills in creating project plans, setting objectives, and defining project scopes.
- Develop the ability to formulate real-world problems into OR models.
- Enhance analytical skills to interpret and analyze the results of OR models.

Attitude

- Foster a systematic and logical approach to problem-solving.
- Encourage a data-driven and quantitative mindset in decision-making.
- Develop a critical and analytical attitude towards complex and uncertain problems.
- Promote the importance of ethical considerations and responsible use of OR methodologies.

COURSE OUTCOMES:

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

CO1: Understand the foundational concepts of LPP.

ILO1: Describe the fundamental concepts and mathematical formulations of linear programming.

ILO2: Explain the simplex method and other algorithms for solving linear programming problems.

ILO3: Interpret the principles of duality theory and its applications in linear programming.

CO2: Able to model, analyze, and apply transportation problem to solve real-world problems in various fields

ILO1: Identify the structure and characteristics of transportation problems.

ILO2: Compare different methods for solving transportation problems, such as the Northwest Corner Rule and Vogel's Approximation Method.

ILO3: Analyze the application of transportation problems in logistics and supply chain management.

CO3: Able to model and analyze real-world scenarios using Game theory

ILO1: Define the basic principles and terminology of game theory, including players, strategies, and payoffs.

ILO2: Distinguish between different types of games, such as zero-sum games, cooperative game.

ILO3: Apply game theory concepts to real-life scenarios in economics, and business decision-making.

CO4: Analyze and model projects using appropriate mathematical techniques.

ILO1: Explain the key concepts and phases of project management.

ILO2: Describe different project management methodologies, including Waterfall and Agile.

ILO3: Evaluate tools and techniques for effective project planning, scheduling, and execution.

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	**Cognitive Process Dimension**					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge						
Conceptual Knowledge		CO1				
Procedural Knowledge				CO2, CO3, CO4		
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	S	M	M	M	M	M	S	S	M	S
CO2	S	M	M	M	L	M	L	M	S	S	M	S
CO3	S	S	S	M	M	L	L	M	S	S	S	S
CO4	S	M	S	M	M	M	M	M	S	S	M	S

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (15 Marks)	**Introduction to Operations Research:** phases of OR, model building, various types of OR problems. Mathematical concepts associated with Programming Problem. **Linear Programming Problem (LPP):** Mathematical formulation of the LPP, graphical solutions of a LPP Simplex method for solving LPP, two-phase technique, Charne's M-technique for solving LPP involving artificial variables. Special cases of LPP. Concept of Duality in LPP	12	03	-	15
2 (12 Marks)	**Transportation Problem:** Initial solution by North West corner rule, Least cost method and Vogel's approximation method (VAM), MODI's method to find the optimal solution, special cases of transportation problem. **Assignment Problem:** Hungarian method to find optimal assignment, special cases of assignment problem.	10	02	-	12
3 (11 Marks)	**Game Theory:** Rectangular game, minimax-maximin principle, solution to rectangular game using graphical method, dominance and modified dominance property to reduce the game matrix and solution of 2×2, $2 \times n$, $m \times 2$ rectangular game with mixed strategy.	07	01	-	08
4 (12 Marks)	**Project Management:** PERT/CPM techniques, applications, time estimates and critical path in network analysis. Updating, network crashing, ideas of resource allocation.	08	01	-	09
5 (10 Marks)	**List of Practical:** (Preferably using TORA/WINQSB/LINGO) 1. Mathematical formulation of L.P.P and solving the problem using graphical method, Simplex technique, two phase method and Charne's Big M method involving artificial variables. 2. Identify the following Special cases by graphical and Simplex method: i. Degenerate solution. ii. Unbounded solution. iii. Alternate solution. iv. Infeasible solution. 3. Allocation problem using transportation model. 4. Allocation problem using assignment model. 5. Problems based on game matrix i. Graphical solution to m×2, 2×n, 2×2 rectangular game.	-	-	08	16

	ii. Mixed strategy. 6. Problems based on PERT/CPM technique.				
	Total	**37**	**07**	**08**	**60**

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practical***

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READINGS:

1. KantiSwarup, Gupta, P. K. and Manmohan (2007): Operations Research, 13th edition, Sultan Chand and Sons.
2. Taha, H. A. (2007): Operations Research: An Introduction, 8th Edition, Prentice Hall of India.
3. Hadley, G: (2002): Linear Programming, Narosa Publications.
4. Hillier, F. A and Lieberman, G. J. (2010): Introduction to Operations Research- Concepts and cases, 9th edition, Tata McGraw Hill.
5. B. C. Punia, K. K. Khandelwal. Project Planning And Control With PERT and CPM, 4th Edition, Kindle Edition
6. Sharma, J. K. (2009). Operations research theory and application. Macmilan Publishers.
7. S. D. Sharma: Operations Research (Theory Methods & Applications), Kedar Nath Ram Nath; 2020th edition

*****

Title of the Course	**:**	**Statistical Computing Using R-Programming**
Course Code	**:**	**STSC11**
Nature of the Course	**:**	**Major**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**60 (50T + 10P) (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge

- To Understand the History, Pros, and Cons of R Programming
- To Master R as a Statistical Software and Language
- To Learn Methods of Data Input, Accessing, and Indexing in R
- To Explore Probability Distributions and Statistical Inference in R

Skills

- To Use R as a Calculator and Implement Basic Operations
- To Perform Descriptive Statistics and Handle Categorical Data in R
- To Visualize Data Using Various Plotting Functions in R
- To Apply Statistical Tests and Linear Models for Inference in R

Attitudes

- To Embrace R as a Tool for Statistical Analysis and Data Visualization
- To Cultivate Attention to Detail in Data Handling and Analysis with R
- To Foster a Problem-Solving Mindset in Statistical Inference and Modeling
- To Promote Collaboration and Knowledge Sharing in R Programming Communities

COURSE OUTCOMES:

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

CO1: Demonstrate Proficiency in R Fundamentals

ILO1: Execute basic R commands and utilize R as a statistical software.
ILO2: Navigate the RStudio environment and manage R workspace effectively.
ILO3: Install R packages, use scripts, and access help resources in R.

CO2: Perform Descriptive Statistics and Data Visualization Using R

ILO1: Calculate measures of central tendency, dispersion, skewness, and kurtosis in R.
ILO2: Generate and interpret various types of plots including scatter plots, bar plots, histograms, and boxplots in R.
ILO3: Handle categorical data and create appropriate visualizations in R.

CO3: Apply Probability Distributions and Statistical Inference in R

ILO1: Estimate parameters of probability distributions using optimization functions in R.
ILO2: Conduct parametric and non-parametric statistical tests for inference in R.
ILO3: Perform simple regression, ANOVA, and ANCOVA analyses in R.

CO4: Develop Proficiency in Flow Control and Function Development in R

ILO1: Implement flow control structures such as for loops, if statements, and while loops in R.

ILO2: Create and develop user-defined functions to modularize R code.
ILO3: Generate random observations from various distributions using built-in R functions.

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	Cognitive Process Dimension					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge			CO1			
Conceptual Knowledge			CO2, CO3			
Procedural Knowledge				CO4		
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	S	M	S	M	S	S	S	M	M	L	S
CO2	S	S	M	S	M	S	S	S	S	S	L	S
CO3	S	S	S	S	M	S	S	S	M	S	L	S
CO4	S	M	L	S	M	S	S	S	M	S	L	S

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (11 Marks)	**Introduction to R:** History of R, pros and cons of R, R-studio, R as a calculator, R as a statistical software and language, downloading and installing R, commands, objects and functions, using scripts, the R workspace, installing packages, getting help. Methods of data input, data accessing and indexing, built-in functions, importing data into R, logical vectors and relational operators, matrix operations in R.	06	01	-	07
2 (13 Marks)	**Descriptive Statistics Using R:** Measures of central tendency, measures of dispersions, measures of skewness and kurtosis, correlation and tabulation of data. Handling categorical data with R. **Visualization of Data:** Standard plot function, arguments, construction of scatter plot, barplot, pie graph, histogram, boxplot, multiple bar diagram etc., visualization of data.	10	02	-	12
3 (14 Marks)	**Probability Distributions:** Probability Distributions (Discrete and Continuous), Estimation of parameters (optim and nlm function). **Statistical Inference:** Different parametric and non-parametric statistical tests. Linear models, simple regression, ANOVA, ANCOVA.	12	02	-	14
4 (12 Marks)	**Flow Control in R:** the for () loop, if () statement, while () loop, repeat loop, break and next statements. Creating/Developing functions. Random observation generation from various univariate distributions using available functions.	09	02	-	11
5 (10 Marks)	**List of Practical:** (Using R-Programming Language) 1. Calculation of summary measures. 2. Statistical graphs and plots with real data. 3. Random number generation from uniform, exponential, normal (using CLT) and gamma distribution. Calculate sample mean and variance and compare with population parameters. 4. Matrix addition, subtraction, multiplication, transpose and trace. 5. Fitting of Binomial, Poisson distribution and apply Chi-square test for goodness of fit. 6. Chi-square contingency table. 7. t-test for difference of means. 8. Paired t-test. 9. Testing equality of two variances (F- Test). 10. Multiple and partial correlation. 11. Compute ranks and then calculate rank correlation	-	-	08	16

	(without tied ranks) 12. Fitting of linear regression model. 13. ANOVA F-test.				
	Total	**37**	**07**	**08**	**60**

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practical***

MODES OF IN-SEMESTER ASSESSMENT: **(40 Marks)**

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READINGS:

1. Purohit S. G., Gore S. D., Deshmukh S. R. (2008), Statistics using R, Narosa Publishing House.
2. Field, A., Miles J., Field Z. (2012), Discovering Statistics Using R, SAGE.
3. Dalgaard P. (2002), Introductory Statistics with R, Springer.
4. Cohen Y. and Cohen J. Y. (2007), Statistics and Data with R, An Applied Approach Through Examples, Wiley.
5. Braun W. J. and Murdoch D. J. (2009), A First Course in Statistical Programming with R, Cambridge.

*****

Title of the Course	**:**	**Demography and Vital Statistics**
Course Code	**:**	**MINSTS5**
Nature of the Course	**:**	**Minor**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**60 (50T + 10P) (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge:

- Understand basic concepts, terms and its importance.
- Learn different population theories
- Know the sources of demographic data and their characteristics.
- Gain knowledge of different fertility and mortality rates and their meaning.
- Understand life table techniques.

Skills:

- Develop skills to qualify errors in age data.
- Develop expertise in computing various fertility and mortality rates and their interpretation.
- Can construct abridged life table and interprete its meaning.
- Develop skills to analyse simple demographic data and prepare scientific reports.

Attitude:

- Develop a keen interest in demography and its multidisciplinary nature.
- Develop interest in various fertility, mortality rates and their role in planning and development of a country.
- Motivated to study life tables of different countries and compare.
- Foster a collaborative mindset for interdisciplinary research work.

COURSE OUTCOMES:

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

CO1: Understand basics of demography.

ILO1: Explain meaning of demography and its interdisciplinary characteristics.
ILO2: Learn demographic transition
ILO3: Define fertility rates, mortality rates, growth rate and life table.

CO2: Know sources of demographic data

ILO1: Collection of data by census, registration and sample surveys.
ILO2: Sources of errors in these data.
ILO3: Methods of evaluating errors in age data

CO3: Apply indices of fertility and mortality

ILO1: Describe fertility levels in a population.
ILO2: Describe mortality rates of a population
ILO3: Explain standardize mortality rate.
ILO4: Explain reproduction rates.

CO4: Apply life table techniques for mortality study.

ILO1: Explain columns of a life table and their meaning, uses.
ILO2: Construct life table for a population
ILO3: Determine expectation of life at different ages.

CO5: Describe a study population using appropriate tools.

ILO1: Demonstrate the levels of fertility and mortality in the study population.
ILO2: Can compute dimension of infant death in the population.
ILO3: Can determine growth of population using simple tools.
ILO4: Can explain life history of a population using life table.

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	**Cognitive Process Dimension**					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge		CO2				
Conceptual Knowledge		CO1	CO3			
Procedural Knowledge				CO4	CO5	
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	M	L	L	M	M	L	S	S	M	M
CO2	S	M	L	L	M	L	L	M	M	M	L	L
CO3	S	S	M	S	S	M	M	S	S	S	M	M
CO4	S	S	M	S	S	M	M	S	S	S	S	S
CO5	S	S	M	S	S	M	M	S	S	S	S	S

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (12 Marks)	**Introduction to Demography:** Nature and scope of demography. Population theories of Malthus, natural and biological, demographic transition. Demographic data- sources, coverage and content errors. Use of balancing equations and Chandrasekharan-Deming formula to check completeness of registration data. Adjustment of age data- Myer and UN indices. Population composition, dependency ratio.	08	02	-	10
2 (12 Marks)	**Vital Statistics:** Sources of collecting data on vital statistics, errors in census and registration data. Measurement of Population: rate and ratio of vital events. Measurements of Mortality: Crude Death Rate (CDR), Specific Death Rates (SDR), Infant Mortality Rate (IMR) and Standardized Death Rates.	10	02	-	12
3 (12 Marks)	**Life (mortality) Tables:** Stationary and Stable Population, central mortality rates and force of mortality. Assumption, description, construction of life tables and uses of life tables. Abridged life tables: Concept and construction of abridged life tables by Reed-Merrell method, Greville's method and King's Method.	08	02	-	10
4 (14 Marks)	**Measurements of Fertility:** Crude Birth Rate (CBR), General Fertility Rate (GFR), Specific Fertility Rate (SFR) and Total Fertility Rate (TFR). **Measurement of Population Growth:** Crude rates of natural increase, Pearl's Vital Index, Gross Reproduction Rate (GRR) and Net Reproduction Rate (NRR).	10	02	-	12
5 (10 Marks)	**List of Practical: (both calculator and computer based)** 1. To calculate CDR and age specific death rate for a given set of data. 2. To find Standardized death rate by- (i) Direct method (ii) Indirect method. 3. To construct a complete life table. 4. To fill in the missing entries in a life table. 5. To construct abridged life table using (i) Reed-Merrell method, (ii) Greville's method and (iii) King's method. 6. To calculate CBR, GFR, SFR, TFR for a given set of data. 7. To calculate crude rate of natural increase and Pearle's vital Index for a given set of data.	-	-	08	16

	8. Calculate GRR and NRR for a given set of data and compare them.				
	Total	**37**	**07**	**08**	**60**

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practical***

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READINGS:

1. Mukhopadhyay P. (1999): Applied Statistics, Books and Allied (P) Ltd.
2. Gun, A. M., Gupta, M. K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. II, 9th edition, World Press.
3. Biswas, S. (1988): Stochastic Processes in Demography & Application, Wiley Eastern Ltd.
4. Croxton, Fredrick E., Cowden, Dudley J. and Klein, S. (1973): Applied General Statistics, 3rd edition. Prentice Hall of India Pvt. Ltd.
5. Keyfitz N., Beckman John A.: Demogarphy through Problems S-Verlag New York.
6. Pathak, K. B., Ram, F. (2016): Techniques of Demographic Analysis, Himalaya Publishing House.

*****

B.Sc. IN STATISTICS PROGRAMME (NEP)
DETAILED SYLLABUS OF 6th SEMESTER

Title of the Course	**:**	**Design of Experiments**
Course Code	**:**	**STSC12**
Nature of the Course	**:**	**Major**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**60 (50T + 10P) (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge:

- Develop a clear understanding of various designs of experiments in statistical studies.
- Gain knowledge of basic experimental designs such as Completely Randomized Design (CRD), Randomized Block Design (RBD), and Latin Square Design (LSD), including their layout, models, and statistical analysis.
- Understand the concepts of incomplete block designs, including Balanced Incomplete Block Design (BIBD), its parameters, relationships, and properties.
- Learn about factorial experiments, including their advantages, notations, concepts, and design and analysis for 2^2, 2^3, and higher-order factorial experiments.

Skills:

- Develop the ability to analyze CRD, RBD, and LSD, including cases with single missing observations.
- Acquire skills in intra-block analysis of BIBD and analysis of 2^2 and 2^3 factorial experiments in CRD, RBD, and LSD.
- Learn to analyze completely and partially confounded two-level factorial designs in various block arrangements.
- Enhance the capability to design and analyze fractional factorial experiments, including the construction of one-half and smaller fractions of 2^n factorial experiments.

Attitude:

- Cultivate an appreciation for the importance of experimental design in statistical studies.
- Develop a commitment to rigorous and precise analysis in experimental research.
- Foster an attitude of continuous improvement in the application and interpretation of experimental designs.
- Encourage a proactive approach to identifying and addressing errors and variations in experimental setups and analyses.

COURSE OUTCOMES:

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

CO1: Basics of Experimental Design:

ILO1: Students will able to know the history of experimental design

ILO2: Various terminology used and basic principles design of experiments

ILO3: Learn about some basic designs for analysis. Get a concept of relative efficiency, also missing observations that arise in the experimental design.

CO2: Learn about Incomplete Block Design

ILO1: Will get the concept of Incomplete block design(BIBD), the relationship of various parameters involved in this design, and get the idea of the incidence matrix.

CO3: Will learn about the Factorial Experiments and their concepts

ILO1: Will get the concepts of the factorial experiment, Factors and levels involved.

ILO2: Will lean analysis of factorial experiments.

CO4: Get the idea of confounding in factorial experiments.

ILO1: Will learn about confounding factorial design, its advantages and disadvantages.

ILO2: Also will get an idea of fractional experiments and their uses.

C**O5**: Practical knowledge will be earn by doing various practical from various units of courses which will be helpful for future applications.

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	**Cognitive Process Dimension**					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge						
Conceptual Knowledge		CO1,CO2 CO3,CO4				
Procedural Knowledge			CO1,CO2 CO3,CO4		CO5	
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	L	M	M	S	M	M	M	S	S	L	M
CO2	S	S	M	M	S	S	L	M	S	S	L	M
CO3	S	S	M	S	S	S	M	L	M	S	M	S
CO4	S	S	M	S	S	S	M	L	M	S	M	M
CO5	S	S	M	S	S	M	M	L	M	S	M	S

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (15 Marks)	**Experimental Designs:** Historical perspective, 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 single missing observation.	11	02	-	13
2 (11 Marks)	**Incomplete Block Designs:** Balanced Incomplete Block Design (BIBD) – parameters, relationships among its parameters, incidence matrix and its properties.	08	01	-	09
3 (12 Marks)	**Factorial Experiments:** advantages, notations and concepts, 2^2, $2^3 \ldots 2^n$ and 3^2 factorial experiments, design and analysis.	09	02	-	11
4 (12 Marks)	**Confounding:** Total and Partial confounding for 2^n ($n \leq 5$). Factorial experiments in a single replicate. Fractional factorial experiments: Construction of one-half and fractions of 2^n ($n \leq 5$) factorial experiments.	09	02	-	11
5 (10 Marks)	**List of Practical: (both calculator and computer based)** 1. Analysis of a CRD. 2. Analysis of an RBD. 3. Analysis of an LSD. 4. Analysis of an RBD with one missing observation. 5. Analysis of an LSD with one missing observation. 6. Intra Block analysis of a BIBD. 7. Analysis of 2^2 and 2^3 factorial in CRD and RBD. 8. Analysis of 2^2 and 2^3 factorial in LSD. 9. Analysis of a completely confounded two level factorial design in 2 blocks. 10. Analysis of a completely confounded two level factorial design in 4 blocks. 11. Analysis of a partially confounded two level factorial design.	-	-	08	16
	Total	**37**	**07**	**08**	**60**

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practical***

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READINGS:

1. Cochran, W. G. and Cox, G. M. (1959): Experimental Design. Asia Publishing House.
2. Das, M. N. and Giri, N. C. (1986): Design and Analysis of Experiments. Wiley Eastern Ltd.
3. Goon, A. M., Gupta, M. K. and Dasgupta, B. (2005): Fundamentals of Statistics. Vol. II, 8th edition World Press, Kolkata.
4. Kempthorne, O. (1965): The Design and Analysis of Experiments. John Wiley.
5. Montgomery, D. C. (2008): Design and Analysis of Experiments, John Wiley.
6. Rao, C. R., Rao, C. R., Statistiker, M., Rao, C. R., and Rao, C. R. (1973). Linear statistical inference and its applications (Vol. 2, pp. 263-270). New York: Wiley.

*****

Title of the Course	**:**	**Time Series Analysis**
Course Code	**:**	**STSC13**
Nature of the Course	**:**	**Major**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**60 (50T + 10P) (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge:

- To Understand the Definition and Applications of Time Series in Various Fields
- To Identify the Components of a Time Series and Perform Time Series Decomposition
- To Estimate Trend Using Various Methods and Fit Mathematical Curves
- To Explain Seasonal and Cyclic Components in Time Series Analysis

Skills:

- To Apply Methods of Moving Averages and Detrending Techniques in Time Series Analysis
- To Estimate Seasonal Components Using Simple Averages, Ratios, and Deseasonalization Methods
- To Analyze Special Stochastic Processes Such as MA and AR Processes
- To Calculate Autocorrelation Functions and Construct Correlograms for Stationary Time Series

Attitudes:

- To Develop a Systematic Approach to Time Series Analysis and Forecasting
- To Emphasize Accuracy and Attention to Detail in Time Series Decomposition and Component Analysis
- To Foster Patience and Perseverance in Handling Complex Stochastic Processes
- To Promote Ethical Use and Reporting of Forecasting Results

COURSE OUTCOMES:

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

CO1: Demonstrate Understanding of Time Series Fundamentals

ILO1: Define and explain the applications of time series in different fields.

ILO2: Identify and describe the components of a time series.

ILO3: Perform decomposition of time series data into trend, seasonal, cyclic, and random components.

CO2: Analyze and Estimate Time Series Components

ILO1: Estimate trend using methods such as freehand curve, method of semi-averages, and mathematical curve fitting.

ILO2: Estimate seasonal component using methods like simple averages, ratio to trend, and ratio to moving averages.

ILO3: Analyze the effects of detrending on other components of the time series.

CO3: Understand Special Stochastic Processes in Time Series

ILO1: Explain moving-average (MA) and autoregressive (AR) processes of orders one and two.

ILO2: Apply harmonic analysis to understand cyclic components in time series.

ILO3: Describe variate component methods for handling random components in time series.

CO4: Apply Forecasting Techniques in Time Series Analysis

ILO1: Implement exponential smoothing methods for forecasting in time series.

ILO2: Apply the Box-Jenkins method (ARIMA modeling) for time series forecasting.

ILO3: Evaluate and interpret forecasting results using appropriate statistical measures and techniques.

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	**Cognitive Process Dimension**					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge		CO1				
Conceptual Knowledge				CO2, CO4		
Procedural Knowledge				CO3		
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	M	S	S	M	M	S	S	S	M	S
CO2	S	S	M	S	M	M	M	S	M	S	M	M
CO3	S	S	M	S	S	M	M	S	S	S	M	S
CO4	S	S	M	S	S	M	M	S	S	S	M	S

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (13 Marks)	**Introduction to Time Series:** Definition and application of time series in various fields, components of a times series, decomposition of time series. **Trend:** Estimation of trend by free hand curve method, method of semi averages, fitting a various mathematical curve, and growth curves.	10	02	-	12
2 (15 Marks)	**Method of Moving Averages:** Concept, de-trending. Effect of elimination of trend on other components of the time series. **Seasonal Component:** Concept, estimation of seasonal component by method of simple averages, ratio to trend, ratio to moving averages and link relative method, deseasonalization.	11	02	-	13
3 (12 Marks)	**Cyclic Component:** Concept, harmonic Analysis. Some special stochastic processes: Moving- average (MA) process and autoregressive (AR) process of orders one and two.	09	02	-	11
4 (10 Marks)	**Random Component:** Variate component method. Stationary time series: Weak stationarity, autocorrelation function and correlogram. **Forecasting:** Exponential smoothing methods of forecasting; Box-Jenkins method.	07	01	-	08
5 (10 Marks)	**List of Practical: (both calculator and computer based)** 1. Fitting and plotting of modified exponential curve. 2. Fitting and plotting of Gompertz curve. 3. Fitting and plotting of logistic curve. 4. Fitting of trend by moving average method. 5. Measurement of seasonal indices ratio-to-trend method. 6. Measurement of seasonal indices ratio-to-moving average method. 7. Measurement of seasonal indices link relative method. 8. Calculation of variance of random component by variate difference method. 9. Forecasting by exponential smoothing.	-	-	08	16
	Total	**37**	**07**	**08**	**60**

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practical***

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READINGS:

1. Kendall M. G. (1976): Time Series, Charles Griffin.
2. Chatfield C. (1980): The Analysis of Time Series –An Introduction, Chapman & Hall.
3. Mukhopadhyay P. (2011): Applied Statistics, 2nd edition Revised reprint, Books and Allied.
4. Box, G. E. P. and Jenkins, G. M. (1976): Time Series Analysis- Forecasting and Control, Holden-day, San Francisco.
5. Anderson, T. W. (1971): The Analysis of Time Series, Wiley, N.Y.
6. Bloomfield, P. (1976): Fourier Analysis of Time Series- An Introduction, Wiley.
7. Chatfield, Chris (1996): The Analysis of Time Series: An Introduction, 6th Edition.
8. Priestley, M. B. (1981): Spectral Analysis and Time Series, Griffin, London.

*****

Title of the Course	**:**	**Demography and Vital Statistics - I**
Course Code	**:**	**STSC14**
Nature of the Course	**:**	**Major**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**60 (50T + 10P) (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge:

- Equip students with basic concepts, terms of demography and its importance.
- Different sources of demographic data and their characteristics.
- Different formula for computing rates, ratios of vital events.
- Different types of life tables and their construction.

Skills:

- Develop skill to identify appropriate source of quality data for demographic study.
- Skill them to compute different fertility and mortality rates and interpretation of results.
- Gain skills to prepare different life tables.
- Gain skills to extract and present demographic data in tabular form and write reports.

Attitude:

- Develop interest in the subject demography and its importance in population study.
- Motivated to be concerned with issues related to fertility, mortality including problems of ageing, maternal death in a society.
- Foster a collaborative mindset for interdisciplinary research work.

COURSE OUTCOMES:

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

CO1: Understand the basics of demography

ILO1: Explain meaning of demography, its scope and its interdisciplinary nature.
ILO2: Define population, cohort, person-years, rates, ratios.
ILO3: Explain census of India as a major source of demographic data.
ILO4: Evaluation of age data.

CO2: Know about different registration system and sample surveys in India.

ILO1: Civil registration system, sample registration system and their functioning.
ILO2: Explain and interprete National Family Health Survey, Ageing survey and National sample survey reports.
ILO3: Explain role of registration and survey data for National planning.

CO3: Analyse mortality and fertility data

ILO1: Apply different formulae for computation of fertility and mortality rates/ratios.
ILO2: Explain dimension of infant mortality and maternal death using relevant formula.
ILO3: Describe and interprete results of mortality and fertility study including problems of ageing.

CO4: Understand life table and simple uses.

ILO1: Define life table and its components.
ILO2: Able to interprete the meaning of different life table functions.
ILO3: Apply different methods to construct life tables.
ILO4: Discuss model life table and its importance.

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	Cognitive Process Dimension					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge		CO2				
Conceptual Knowledge		CO1		CO3		
Procedural Knowledge				CO4		
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	M	S	M	M	M	M	S	S	M	S
CO2	S	S	M	S	M	M	M	M	S	S	M	S
CO3	S	S	S	S	M	M	S	S	S	S	L	S
CO4	S	S	S	S	M	M	M	M	S	S	S	S

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (12 Marks)	**Introduction to Demography:** Nature and scope of Demography. Sources of Demographic data: Census, Registration, Sample Surveys and their limitations. Evaluation and adjustment of age data – Whipple's Index, Myer Index. Completeness of Vital registration data – Chandrasekharan-Deming formula. Theory of demographic transition.	08	02	-	10
2 (10 Marks)	**Vital Statistics:** Civil registration system in India ans Sample Registration System (SRS). Demographic scenario of India according to latest census. Some major surveys: Nationa Sample Surveys (NSS), Demographic Health Surveys (DHS), National Family Health Surveys (NFHS), Aging Survey. Definition of the terms – population, cohort, person-years, Rates, ratios, proportion, density.	08	01	-	09
3 (16 Marks)	**Different Mortality and Fertility Rates:** Crude Death Rate (CDR), Age-Specific Death rate (ASDR), Infant Mortality Rate (IMR), Under-5 mortality Rate, Neo-natal and post neo-natal mortality rate, Maternal Mortality Rate/Ratio. Crude Birth Rate (CBR), General Fertility rate (GFR) and Total Fertility Rate (TFR). Crude Rate of Natural Increase (CRNI) and Pearl's Vital Index. Measures of Reproduction – Gross Reproduction Rate (GRR) and Net Reproduction rate (NRR)	13	02	-	15
4 (12 Marks)	**Life Tables:** Basic concepts, types and forms of life tables, definition of different life table functions. Idea of model life table. Construction of Abridged life table by Reed-Merrel method, Greville's method. Construction of complete life table. Assumptions in construction of life table. Uses of life table.	08	02	-	10
5 (10 Marks)	**List of Practical: (both calculator and computer based)** 1. To calculate CDR and Age Specific death rate for a given set of data. 2. To find Standardized death rate by:- (i) Direct method (ii) Indirect method. 3. To construct a complete life table. 4. To fill in the missing entries in a life table. 5. To construct abridged life table using (i) Reed-Merrell Method, (ii) Greville's Method and (iii) King's Method. 6. To calculate CBR, GFR, SFR, TFR for a given set	-	-	08	16

	of data. 7. To calculate Crude rate of Natural Increase and Pearle's Vital Index for a given set of data. 8. Calculate GRR and NRR for a given set of data and compare them.				
	Total	**37**	**07**	**08**	**60**

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practical***

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READINGS:

1. Mukhopadhyay P. (1999): Applied Statistics, Books and Allied (P) Ltd.
2. Gun, A. M., Gupta, M. K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. II, 9th Edition, World Press.
3. Biswas, S. (1988): Stochastic Processes in Demography & Application, Wiley Eastern Ltd.
4. Croxton, Fredrick E., Cowden, Dudley J. and Klein, S. (1973): Applied General Statistics, 3rd Edition. Prentice Hall of India Pvt. Ltd.
5. Keyfitz N., Beckman John A.: Demography through Problems S-Verlag New york.
6. J. N. Desai M. L. Jhingan, B. K. Bhatt (2003): Demography, Vrinda Publications (P) Ltd., India

*****

Title of the Course	**:**	**Multivariate Analysis and Non-parametric Methods**
Course Code	**:**	**STSC15**
Nature of the Course	**:**	**Major**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**60 (50T + 10P) (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge

- To develop a comprehensive understanding of the properties, marginal, and conditional distributions of bivariate normal distributions.
- To learn about multivariate data, including random vectors, distribution functions, mean vectors, and dispersion matrices.
- To gain knowledge of nonparametric tests including tests for randomness, empirical distribution functions, and specific tests like Kolmogorov-Smirnov, Sign test, Wilcoxon-Mann-Whitney test, and Kruskal-Wallis test.

Skills

- Learn to use discriminant analysis, principal component analysis, and factor analysis in practical scenarios.
- To develop skills in computing multiple and partial correlation coefficients and understanding their properties.
- Gain hands-on experience in fitting bivariate and multivariate normal distributions.
- To learn about practical applications of nonparametric tests using calculators and computer software.

Attitude

- To encourage a methodical approach to problem-solving in multivariate and nonparametric statistical analysis.
- To instill the importance of accuracy and reliability in statistical testing and data analysis.

COURSE OUTCOMES:

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

CO1: Understand and apply the properties of bivariate and multivariate normal distributions.

ILO1: Comprehend the probability density function (pdf) and properties of the Bivariate Normal Distribution (BVN) and understand the concepts of marginal and conditional distributions in BVN.

ILO2: Apply the knowledge of BVN in practical scenarios involving bivariate data and use statistical software to compute and analyze multivariate data.

ILO3: Develop a systematic approach to studying and analyzing multivariate data.

CO2: Perform and interpret various multivariate analyses, including discriminant analysis, principal component analysis, and factor analysis.

ILO1: Gain an in-depth understanding of the multivariate normal distribution and its properties.

ILO2: Understand the concepts and properties of multiple and partial correlation coefficients.

ILO3: Conduct discriminant analysis to differentiate between groups. Apply principal component analysis for data reduction and understand its properties.
ILO4: Perform factor analysis and interpret the results and develop a critical approach to multivariate data analysis.

CO3: Conduct and analyze results from nonparametric tests such as the Kolmogorov-Smirnov test, Sign test, Wilcoxon-Mann-Whitney test, and Kruskal-Wallis test.

ILO1: Understand the principles and applications of nonparametric tests and learn the concepts of tests for randomness and empirical distribution functions.
ILO2: Study-specific nonparametric tests, including Kolmogorov-Smirnov, Sign test, Wilcoxon-Mann-Whitney, and Kruskal-Wallis tests.
ILO3: Conduct nonparametric tests using appropriate statistical methods, interpret the results of nonparametric tests and apply them to real-world data.

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	**Cognitive Process Dimension**					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge			CO1			
Conceptual Knowledge				CO2, CO3		
Procedural Knowledge						
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	S	S	M	M	S	L	S	S	M	S
CO2	S	S	M	S	M	L	S	L	S	S	M	S
CO3	S	S	M	S	M	M	S	L	S	S	M	S

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (11 Marks)	**Bivariate Normal Distribution (BVN):** pdf of BVN, properties of BVN, marginal and conditional pdf of BVN. **Multivariate Data:** Random vector, probability mass/density functions, distribution function, mean vector & dispersion matrix, marginal & conditional distributions.	08	01	-	09
2 (13 Marks)	**Multivariate normal distribution** and its properties. Sampling distribution for mean vector and variance-covariance matrix (sans deduction). Multiple and partial correlation coefficient and their properties.	09	02	-	11
3 (13 Marks)	**Applications of Multivariate Analysis:** Discriminant analysis: Introduction, properties and assumptions, Principal components analysis: Introduction and properties. Factor Analysis: Concepts.	10	02	-	12
4 (13 Marks)	**Non-Parametric Tests:** Introduction and concept, test for randomness based on total number of runs, empirical distribution function, Kolmogrov Smirnov test for one sample, Sign test and signed Rank test, Wilcoxon-Mann-Whitney test, Kruskal-Wallis test.	10	02	-	12
5 (10 Marks)	**List of Practical: (both calculator and computer based)** 1. To compute multiple correlation. 2. To compute partial correlation. 3. Fitting of bivariate normal distribution. 4. Fitting of multivariate normal distribution. 5. Simple application of discriminant analysis. 6. Data reduction principal components analysis and factor analysis. 7. Test for randomness based on total number of runs. 8. Kolmogrov-Smirnov test for goodness of fit. 9. Sign test: one sample, two samples, large samples. 10. To test the Wilcoxon-Mann-Whitney U-test. 11. To test the Kruskal-Wallis test.	-	-	08	16
	Total	**37**	**07**	**08**	**60**

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practical***

MODES OF IN-SEMESTER ASSESSMENT: **(40 Marks)**

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READINGS:

1. Anderson, T. W. (2003): An Introduction to Multivariate Statistical Analysis, 3rd edition, John Wiley
2. Muirhead, R. J. (1982): Aspects of Multivariate Statistical Theory, John Wiley.
3. Kshirsagar, A. M. (1972): Multivariate Analysis, 1stEdition Marcel Dekker.
4. Johnson, R. A. and Wichern, D. W. (2007): Applied Multivariate Analysis, 6th edition, Pearson & Prentice Hall.
5. Mukhopadhyay, P.: Mathematical Statistics.
6. Gibbons, J. D. and Chakraborty, S (2003): Nonparametric Statistical Inference. 4th edition. Marcel Dekker, CRC.
7. Conover. W. J.: Practical Non parametric methods, John Wiley.
8. Bhuyan, K. C. (2005): Multivariate Analysis & Its Applications, New Central Book Agency (P) Limited.
9. McColl, J. H. (2004). Multivariate probability. John Wiley and Sons.
10. Mardia, K. V., Kent, J. T., Bibby, J. M. (1979): Multivariate Analysis, Academic Press.
11. Hardle, W., Havka, Z. (2007): Multivariate Statistics: Exercise & Solutions, Springer.

*****

Title of the Course	**:**	**Survey Sampling and National Accounts Statistics**
Course Code	**:**	**MINSTS6**
Nature of the Course	**:**	**Minor**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**60 (50T + 10P) (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge

- Understand the concept of population and sample in statistical surveys.
- Differentiate between complete enumeration and sampling methods.
- Identify sources of sampling and non-sampling errors in surveys.
- Describe various types of sampling techniques: non-probability and probability sampling.

Skills

- Demonstrate proficiency in simple random sampling (with and without replacement) and its application.
- Apply procedures for selecting samples in statistical surveys.
- Compute estimates for population mean, total, and proportion based on sample data.
- Calculate variances of estimates and understand their implications for precision.

Attitude

- Appreciate the importance of stratified random sampling for improving estimation accuracy.
- Evaluate proportional and optimum allocations in stratified sampling.
- Analyze practical challenges in allocation and assess gains in precision through stratification.
- Critically compare systematic sampling with simple random sampling and stratified sampling in the presence of linear trends.

COURSE OUTCOMES:

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

CO1: Understand the Foundations of Sample Surveys

ILO1: Define the concepts of population and sample.
ILO2: Differentiate between complete enumeration and sampling methods.
ILO3: Identify sources of sampling and non-sampling errors in surveys.

CO2: Master Estimation Techniques in Sample Surveys

ILO1: Compute estimates for population mean, total, and proportion.
ILO2: Calculate variances of population estimates and determine sample sizes.
ILO3: Understand procedures for estimating variances of sample estimates.

CO3: Analyze Systematic and Cluster Sampling

ILO1: Implement systematic sampling to estimate population mean and total.
ILO2: Compute variances of estimates in systematic sampling (N=nk).

ILO3: Compare systematic sampling with simple random sampling (SRS) and stratified sampling.

CO4: Introduction to Ratio and Regression Methods

ILO1: Utilize ratio and regression methods for estimating population parameters.
ILO2: Approximate population mean and total using initial ratio and regression methods.
ILO3: Calculate variances of estimates and compare with SRS methods.

CO5: Understand Official Statistical Systems in India

ILO1: Describe the present official statistical system in India.
ILO2: Evaluate methods used for collecting official statistics, including their reliability and limitations.
ILO3: Identify the roles of MoSPI, NSO, and National Statistical Commission in statistical governance.

CO6: Examine Government Publications and Statistical Data

ILO1: Analyze key publications from the Government of India containing statistical data.
ILO2: Interpret data related to population, industry, and finance from official publications.
ILO3: Assess the reliability and relevance of statistical data for policy-making and research.

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	**Cognitive Process Dimension**					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge						
Conceptual Knowledge		CO1, CO5	CO2, CO4		CO6	
Procedural Knowledge				CO3		
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	M	M	M	S	L	L	L	M	M	M	S
CO2	S	S	M	S	M	M	L	L	S	M	L	M
CO3	S	S	M	S	M	M	L	L	S	S	L	M
CO4	S	M	S	M	M	M	L	L	M	S	L	M
CO5	S	S	M	S	L	L	L	L	S	M	M	S
CO6	S	S	M	S	M	M	L	L	S	S	S	S

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (13 Marks)	**Introduction to Sample Survey:** Concept of population and sample, complete enumeration versus sampling, sampling and non-sampling errors. Types of sampling: non-probability and probability sampling, basic principle of sample survey, simple random sampling with and without replacement, definition and procedure of selecting a sample, estimates of: population mean, total and proportion, variances of these estimates, estimates of their variances and sample size determination.	10	02	-	12
2 (14 Marks)	**Stratified Random Sampling:** Technique, estimates of population mean and total, variances of these estimates, proportional and optimum allocations and their comparison with SRS. Practical difficulties in allocation, estimation of gain in precision. **Systematic Sampling:** Technique, estimates of population mean and total, variances of these estimates (N=nk). Comparison of systematic sampling with SRS and stratified sampling in the presence of linear trend and corrections.	12	02	-	14
3 (12 Marks)	**Introduction to Ratio and regression methods of estimation**, first approximation to the population mean and total (for SRS of large size), variances of these estimates and estimates of these variances, variances in terms of correlation coefficient for regression method of estimation and their comparison with SRS. Cluster sampling (equal clusters only) estimation of population mean and its variance.	10	02	-	12
4 (11 Marks)	**Present official statistical system in India**, Methods of collection of official statistics, their reliability and limitations. Role of Ministry of Statistics & Program Implementation (MoSPI), National Statistical Office (NSO) and National Statistical Commission. Government of India's Principal publications containing data on the topics such as population, industry and finance.	05	01	-	06
5 (10 Marks)	**List of Practical: (both calculator and computer based)** 1. Simple random sampling: Drawing of a random numbers by with replacement method (SRSWR) and without replacement method (SRSWOR). 2. Enumeration of all possible samples in SRSWR, SRSWOR and establish properties. 3. Calculations of population mean, mean square	-	-	08	16

	and variance. Estimation of mean, standard error. 4. Stratified Sampling: Allocation of sample to strata by proportional and Neyman's methods. Also, compare their efficiencies relative to SRS. 5. Estimation of gain in precision in stratified sampling. 6. Systematic sampling: Comparison of systematic sampling with stratified sampling and SRS in the presence of a linear trend. 7. Ratio and regression estimation: Calculation of population mean or population total. Calculation of mean squares. Compare the efficiencies of ratio and regression estimators relative to SRS. 8. Cluster sampling: Estimation of mean or total, variance of the estimate.				
	Total	**37**	**07**	**08**	**60**

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practical***

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READINGS:

1. Cochran W. G. (1984): Sampling Techniques (3rd edition), Wiley Eastern.
2. Sukhatme, P. V., Sukhatme,B.V. Sukhatme,S. Asok, C. (1984): Sampling Theories of Survey With Application, IOWA State University Press and Indian Society of Agricultural Statistics.
3. Murthy M. N. (1977): Sampling Theory & Statistical Methods, Statistical Pub. Society, Calcutta.
4. Des Raj and Chandhok P. (1998): Sample Survey Theory, Narosa Publishing House. New Delhi.
5. Goon A. M., Gupta M. K. and Dasgupta B. (2001): Fundamentals of Statistics (Vol.2), World Press.
6. Guide to current Indian Official Statistics, Central Statistical Office, GOI, New Delhi. http://mospi.nic.in/

*****

B.Sc. IN STATISTICS PROGRAMME (NEP)
DETAILED SYLLABUS OF 7th SEMESTER

Title of the Course	**:**	**Survival Analysis and Biostatistics**
Course Code	**:**	**STSC16**
Nature of the Course	**:**	**Major**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**60 (50T + 10P) (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge:

- Understand the basics of Biostatistics
- Understand censored data, schemes of censoring and survival analysis technique.
- Learn clinical trials (CT) and its places.
- Learn epidemic models and study design of epidemiology.

Skills:

- Develop skills to randle censored data with statistical methods.
- Learn to draw ROC curve and use it for screening test.
- Gain skills to identify appropriate parametric and non- parametric methods for survival data analysis.
- Develop skills to draw Kaplan-Meier(KM) survival curve and its interpretation.

Attitude:

- Develop interest in Biostatistics and its application in different fields.
- Motivated to study K-M curve and ROC curve more rigorously.
- Foster a collaborative mindset for medical and epidemiological research.

COURSE OUTCOMES:
After the completion of this course, students will be able to:

CO1: Understand fundamentals of Biostatistics.
ILO1: Define Biostatistics survival data, Survival Analysis(SA), censoring schemes and completing risks
ILO2: Learn different parametric and non parametric methods for Survival Analysis.
ILO3: Understand Clinical Trial(CT) and making, blinding, phases in CT.
ILO4: Define Epidemiology and different study designs used in epidemiological study.

CO2: Analysis survival data effectively.
ILO1: Identify appropriate censoring scheme for a study.
ILO2: Demonstrate parametric and non- parametric methods for data analysis.
ILO3: Draw K-M curve and interprete
ILO4: Gain skills to collaborate with simple clinical Trials.

CO3: Explain competing Risks Theory in SA.
ILO1: Explain probabilities of death under different competing risk set up.
ILO2: Demonstrate inter-relations between different probabilities of death.

ILO3: Learn to estimate the probabilities using suitable estimation method.

CO4: Understand and explain epidemiology.

ILO1: Compare and contrast different types of study design in epidemiology.
ILO2: Discuss epidemic models, duration of epidemic.
ILO3: Compute threshold point for screening test using ROC curve.
ILO4: Conduct simple epidemiological study.

.

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	**Cognitive Process Dimension**					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge						
Conceptual Knowledge		CO1	CO3	CO2		
Procedural Knowledge			CO4			
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	M	M	L	L	L	L	L	L	L	L	M
CO2	S	L	M	M	L	L	L	L	L	L	L	L
CO3	S	L	M	M	L	M	L	L	L	L	L	L
CO4	S	L	S	L	L	L	L	L	L	L	L	M

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (16 Marks)	**Survival Analysis:** Survival distributions and their applications exponential, gamma, Weibull, Rayleigh, lognormal, density functions for a distribution having bath-tub shaped hazard function. **Censoring Schemes:** Type I, Type II and progressive or random censoring with biological examples. Estimation of mean survival time and variance of the estimator for type I and type II censored data with numerical examples. **Non-Parametric Methods:** Kaplan-Meier methods for estimating survival function and variance of the estimator.	12	02	-	14
2 (14 Marks)	**Competing Risk Theory:** Indices for measurement of probability of death under competing risks and their inter-relations. Estimation of probabilities of death using maximum likelihood principle and modified minimum Chi-square methods.	10	02	-	12
3 (10 Marks)	**Epidemiology:** Basic concepts of Epidemiology and idea of epidemiological study designs Stochastic epidemic models: Simple epidemic models, general epidemic model definition and concept (without derivation). Duration of an epidemic.	07	01	-	08
4 (10 Marks)	**Clinical Trials:** Definition, ethics, masking and blinding, phases, Randomized control trial. Screening test and its uses. Definition of specificity and sensitivity. ROC curve (specificity-sensitivity based).	08	02	-	10
5 (10 Marks)	**List of Practical: (both calculator and computer based)** 1. To estimate survival function. 2. To determine death density function and hazard function. 3. To identify type of censoring and to estimate survival time for type I censored data. 4. To identify type of censoring and to estimate survival time for type II censored data. 5. To identify type of censoring and to estimate survival time for progressively type I censored data. 6. Estimation of mean survival time and variance of the estimator for type I censored data. 7. Estimation of mean survival time and variance of the estimator for type II censored data. 8. Estimation of mean survival time and variance of the estimator for progressively type I censored	-	-	08	16

	data. 9. To estimate the survival function and variance of the estimator using Non-parametric methods with actuarial methods. 10. To estimate the survival function and variance of the estimator using non-parametric methods with Kaplan-Meier method.				
	Total	**37**	**07**	**08**	**60**

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practical***

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READINGS:

1. Lee, E. T. and Wang, J. W. (2003): Statistical Methods for Survival data Analysis, 3rd edition, John Wiley and Sons.
2. Biswas, S. (2007): Applied Stochastic Processes: A Biostatistical and Population Oriented Approach, Reprinted 2nd Central Edition, New Central Book Agency.
3. Kleinbaum, D. G. (1996): Survival Analysis, Springer.
4. Chiang, C. L. (1968): Introduction to Stochastic Processes in Bio Statistics, John Wiley and Sons.
5. Indrayan, A. (2008): Medical Biostatistics, 2nd edition Chapman and Hall/CRC.
6. Friedman, L. M., Furberg, C. D., Demers, D. L.: Fundamentals of Clinical Trials, Springer Verlag.

*****

Title of the Course	**:**	**Stochastic Processes and Queuing Theory**
Course Code	**:**	**STSC17**
Nature of the Course	**:**	**Major**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**60 (50T + 10P) (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge

- Understand the fundamental concepts of stochastic processes including Poisson processes and Markov chains.
- Gain familiarity with different types of queueing models such as M/M/1, M/M/1/K.
- Comprehend the key theorems and properties of stochastic processes and their applications in real-world scenarios.
- Recognize the relationship between stochastic processes and statistical inference.

Skills

- Develop the ability to model real-world problems using appropriate stochastic processes.
- Acquire proficiency in using analytical techniques to solve queueing theory problems.
- Enhance problem-solving skills by applying theoretical concepts to practical situations.
- Interpret and analyze data from stochastic processes to make informed decisions.

Attitude

- Foster a critical and analytical mindset when approaching complex problems involving uncertainty and variability.
- Encourage perseverance and creativity in tackling challenging mathematical problems.
- Cultivate an appreciation for the practical applications of stochastic processes and queueing theory in various fields such as telecommunications, manufacturing, and service industries.
- Promote the importance of precision and accuracy in mathematical modeling and data analysis.

COURSE OUTCOMES:

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

CO1: Understand the foundational concepts of stochastic processes.

ILO1: Describe the basic principles of probability theory and their application to stochastic processes.

ILO2: Explain the basic properties of stochastic processes such as stationarity, independence, and memoryless.

ILO3: Illustrate examples of stochastic processes in real-world applications.

CO2: Able to model, analyze, and apply Markov chains to solve real-world problems in various fields

ILO1: Explain the fundamental properties of Markov chains, including the concepts of states, transitions, and stationary distributions.

ILO2: Describe the differences between discrete-time and continuous-time Markov chains and their respective applications.

ILO3: Apply Markov chain models to real-world problems and interpret the results in a meaningful context.

CO3: Able to model and analyze real-world scenarios using Poisson processes

ILO1: Explain the fundamental properties and characteristics of Poisson processes.

ILO2: Derive and solve differential equations related to Poisson processes.

ILO3: Analyze and compute probabilities associated with Poisson processes, including calculating the distribution of the number of events in a given time interval.

CO4: Analyze and model queueing systems using appropriate mathematical techniques.

ILO1: Identify and formulate the characteristics of various queueing models such as M/M/1, M/M/1/K

ILO2: Derive key performance measures (e.g., average queue length, waiting time, system utilization) for different queueing models.

ILO3: Apply probability theory and stochastic processes to model and analyze queueing systems.

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	**Cognitive Process Dimension**					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge		CO1				
Conceptual Knowledge			CO2	CO3, CO4		
Procedural Knowledge						
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	L	S	L	M	S	L	L	L	L	L	L
CO2	S	L	S	S	L	S	L	L	L	M	L	L
CO3	S	L	S	L	L	L	L	L	L	S	L	S
CO4	S	L	S	L	L	L	L	L	L	S	L	S

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (10 Marks)	**Basic Concept:** Power series, generating function, probability generating function, conditional probability. **Stochastic Processes**: Introduction, its essence and examples, stationary process, Gambler's ruin problem, and martingales and properties.	05	01	-	06
2 (16 Marks)	**Markov Chains:** Definition of Markov chain, transition probability matrix, order of Markov chain, Markov chain expressed in graphs, higher transition probabilities, Chapmann-Kolmogorov theorem. Generalization of independent Bernoulli trials, classification of states and chains, stability of Markov system, graph theoretic approach.	11	02	-	13
3 (12 Marks)	**Poisson Process:** postulates of Poisson process, properties of Poisson process, inter-arrival time, pure birth process, Yule Furry process, birth and death process, emigration-immigration process, pure death process.	11	02	-	13
4 (12 Marks)	**Queuing System:** General concept, steady state distribution, queuing model, M/M/1 with finite and infinite system capacity, waiting time distribution in stationary cases.	10	02	-	12
5 (10 Marks)	**List of Practical: (both calculator and computer based)** 1. Calculation of transition probability matrix. 2. Identification of characteristics of reducible and irreducible chains. 3. Identification of types of classes. 4. Identification of ergodic transition probability matrix. 5. Stationarity of Markov chain and graphical representation of Markov chain. 6. Calculation of probabilities for given birth and death rates and vice versa. 7. Calculation of probabilities for Birth and Death Process. 8. Computation of inter-arrival time for a Poisson process. 9. Calculation of Probability and parameters for (M/M/1) model and change in behaviour of queue as N tends to infinity.	-	-	08	16
	Total	**37**	**07**	**08**	**60**

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practical***

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READINGS:

1. Medhi, J. (2009): Stochastic Processes, New Age International Publishers.
2. Basu, A. K. (2005): Introduction to Stochastic Processes, Narosa Publishing.
3. Bhat,B. R.(2000): Stochastic Models: Analysis and Applications, New Age International Publishers.
4. Taha, H. (1995): Operations Research: An Introduction, Prentice- Hall India.
5. Feller, William (1968): Introduction to probability Theory and Its Applications, Vol I, 3rd Edition, Wiley International.

*****

Title of the Course	**:**	**Advanced Regression Analysis**
Course Code	**:**	**STSC18**
Nature of the Course	**:**	**Major**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**60 (50T + 10P) (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge:

- To gain knowledge of multiple linear regression model, its estimation.
- To get an idea about the residual analysis and its importance in model diagnostic checking.
- To learn about the variable selection and model building in case of multiple linear regression model.
- To get an idea about the Regression model with dummy variable.
- To gain some knowledge about generalized linear model.

Skill:

- To develop skills of fitting of real life data with the help of multiple linear regression model, parameter estimation and testing of its significance.
- To develop skills of model diagnostic checking through residual analysis.
- To gain proficiency in performance of lack of fit test.
- To develop skills of fitting of linear probability model and logit model through the application of weighted least squares method.
- To gain proficiency in performance of chow test.

Attitude:

- Develop a keen interest in multiple linear regression models and their applications.
- To build up concern in different types of model summary statistic.
- To accumulate the importance of residual analysis in Regression analysis.
- To build up concepts related to different types generalized linear models and their fitting.

COURSE OUTCOMES:

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

CO1: Understand the basic concepts of multiple linear regression model and the assumptions associated with the model.

ILO1: Estimation of model parameters and testing its significance.
ILO2: Regression model with and without intercept.
ILO3: Standardised regression coefficients and some model summary statistic like R^2 and Adjusted R^2 etc.

CO2: Residual Analysis of fitted regression models.

ILO1: Residual plots, normal probability plots etc.
ILO2: Method of scaling residuals standardized and studentized residual.
ILO3: Concepts of Lack of fit test.

CO3: Variable selection and model building.

ILO1: Criteria for evaluating sub-set regression model: R^2 and Adjusted R^2etc.
ILO2: Computational technique for variable selection, all possible regression, stepwise regression etc.

CO4: Regression on dummy variables
ILO1: Dummy as explanatory variable.
ILO2: Chow test vs. Dummy variable Approach.

CO5: Generalized linear models
ILO1: Linear Probability model and its estimation.
ILO2: Logistic regression model and its estimation.

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	**Cognitive Process Dimension**					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge						
Conceptual Knowledge		CO1				
Procedural Knowledge			CO2, CO3, CO4, CO5			
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	L	S	S	L	S	M	L	L	L	L	M
CO2	S	L	S	S	L	S	M	L	L	L	L	M
CO3	S	L	S	S	L	S	M	L	L	M	L	M
CO4	S	L	S	S	L	S	M	L	L	M	L	M
CO5	S	L	S	S	L	S	M	L	L	M	L	M

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (18 Marks)	**Multiple Regression Models:** Estimation of model parameters. Hypothesis testing in multiple linear regressions, Regression with and without intercept. Standardized regression coefficients and interpretations; R^2 and Adjusted R^2.	11	03	-	14
2 (14 Marks)	**Residual Analysis:** Definition; Residual Plots, Normal probability plots; Methods of scaling residuals-standardized and studentized residual (emphasis to be given on case studies/examples). Lack of fit test in regression model.	09	02	-	11
3 (15 Marks)	**Variable selection and model building:** Model building problem, Model misspecification criteria for evaluating sub-set regressions. **Computational technique for variable selection**– All possible regressions, stepwise regression, R^2, Adjusted R^2, MSE and Mellow's C_p, statistic (without derivation).	10	01	-	11
4 (13 Marks)	**Regression on dummy variables**– Dummy as explanatory variable. Chow test vs Dummy variable Approach. **Generalized linear models**– LPM, Logistic regression for dichotomous data with single and multiple explanatory variables estimation, goodness of fit.	07	01	-	08
5 (10 Marks)	**List of Practical: (both calculator and computer based)** 1. Fitting of multiple regression models by least squares method and testing of hypothesis for the regression coefficients. 2. Fitting of multiple regression model by least squares method and calculation of residual analysis. 3. Lack of fit test. 4. Fitting of linear probability model by weighted least squares method. 5. Fitting of logit model by weighted least squares method. 6. Testing of general linear model by chow test.	-	-	08	16
	Total	**37**	**07**	**08**	**60**

Where, L: Lectures T: Tutorials P: Practical

MODES OF IN-SEMESTER ASSESSMENT: **(40 Marks)**

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READINGS:

1. Montgomery D. C. Peck, E. A., Vinning G. G.: Introduction to Linear Regression Analysis, Wiley series in Probability and Statistics.
2. NetorJ, Wasserman, W.: Applied Linear Statistical Model, Richard D. Irwin Inc.]
3. Drpper N. R., Smith H: Applied Regression Analysis Wiley Series in Probability and Stats.
4. Mukhopadhyay, P.: Mathematical Statistics Central, New Book Agency (P) Ltd.
5. Chatterjee S. price B.: Regression Analysis by Example John Wiley

*****

Title of the Course	**:**	**Linear Models**
Course Code	**:**	**MINSTS7**
Nature of the Course	**:**	**Minor**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**60 (50T + 10P) (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge:

- To gain knowledge of analysis of variance and covariance in one-way and two-way classified data for fixed effect models.
- To get an idea about theory of linear estimation, Gauss-Markov theorem.
- To learn about Simple and multiple regression analysis, Estimation and hypothesis testing.
- To get an idea about Prediction from a fitted model and Violation of usual assumptions.

Skill:

- To develop skills of computation of the distribution of quadratic forms.
- To develop skills of fitting simple linear regression model.
- To develop skills of fitting multiple linear regression model.
- To gain proficiency in fitting of orthogonal polynomials.
- To develop skills of performance of Analysis of variance test in case of one way and two way classified data with one observation per cell.
- To develop skills of performance of Analysis of covariance of one way and two way classified data.

Attitude:

- Develop a keen interest in analysis of variance and covariance in one-way and two-way classified data.
- To build up concern in linear estimation and Gauss-Markov theorem.
- To accumulate the concept of Simple regression analysis, Estimation and hypothesis testing.
- To build up concepts related to violation of usual assumptions of regression model.

COURSE OUTCOMES:

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

CO1: Understand the basic concepts of analysis of variance and covariance

ILO1: analysis of variance and covariance in one-way classified data for fixed effect models

ILO2: analysis of variance and covariance in two-way classified data with one observation per cell for fixed effect models.

CO2: Gauss-Markov Set-up

ILO1: Theory of linear estimation, estimation of linear parametric functions.

ILO2: Method of least squares, Gauss-Markov theorem.

CO3: Simple and Multiple Regression Models

ILO1: Simple and multiple regression analysis, Estimation and hypothesis testing.
ILO2: Orthogonal polynomials.

CO4: Model Adequacy Checking
ILO1: Prediction from a fitted model.
ILO2: Violation of usual assumptions concerning normality.
ILO3: Problem of homoscedasticity, autocorrelation and Multicollinearity.
ILO4: Diagnostics using quantile-quantile plots.

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	**Cognitive Process Dimension**					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge						
Conceptual Knowledge		CO1	CO2, CO3, CO4			
Procedural Knowledge						
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	L	S	S	L	M	S	L	L	L	L	L
CO2	S	L	S	S	L	M	S	L	L	L	L	L
CO3	S	L	S	S	L	M	S	L	L	L	L	L
CO4	S	L	S	S	L	M	S	L	L	L	L	L

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (14 Marks)	**Analysis of Variance:** Definitions of fixed, random and mixed effect models, analysis of variance and covariance in one-way classified data for fixed effect models, analysis of variance and covariance in two-way classified data with one observation per cell for fixed effect models.	10	02	-	12
2 (10 Marks)	**Gauss-Markov Set-up:** Theory of linear estimation, Estimability of linear parametric functions, Method of least squares, Gauss-Markov theorem with proof.	07	01	-	08
3 (12 Marks)	**Regression Analysis:** Simple and Multiple regression analysis, Estimation and testing of hypothesis for the regression coefficients. Orthogonal Polynomials.	10	02	-	12
4 (14 Marks)	**Model Checking:** Prediction from a fitted model, Violation of usual assumptions concerning normality, Homoscedasticity and collinearity, Diagnostics using quantile-quantile plots.	10	02	-	12
5 (10 Marks)	**List of Practical: (both calculator and computer based)** 1. Computation of the distribution of Quadratic forms 2. Fitting of simple Linear Regression model 3. Fitting of multiple regression model by least squares method and testing of hypothesis for the regression coefficients. 4. Orthogonal Polynomials 5. Analysis of Variance of a one way classified data 6. Analysis of Variance of a two way classified data with one observation per cell 7. Analysis of Covariance of a one way classified data 8. Analysis of Covariance of a two way classified data	-	-	08	16
	Total	**37**	**07**	**08**	**60**

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practical***

MODES OF IN-SEMESTER ASSESSMENT: **(40 Marks)**

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READING:

1. Weisberg, S. (2005). Applied Linear Regression (Third edition). Wiley.
2. Wu, C. F. J. And Hamada, M. (2009). Experiments, Analysis, and Parameter Design Optimization (Second edition), John Wiley.
3. Renchner, A. C. And Schaalje, G. B. (2008). Linear Models in Statistics (Second edition), John Wiley and Sons.

*****

B.Sc. IN STATISTICS PROGRAMME (NEP)
DETAILED SYLLABUS OF 8th SEMESTER

Title of the Course	**:**	**Statistical Inference-II**
Course Code	**:**	**STSC19**
Nature of the Course	**:**	**Major**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**60(50T + 10P) (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge

- Gain comprehensive knowledge of sufficiency, completeness, Basu's theorem, and minimal sufficiency.
- Understand the construction and application of uniformly minimum variance unbiased estimators (UMVUE), information matrix, and asymptotic properties of maximum likelihood estimators (MLE).
- Understand the Neyman-Pearson lemma, large sample tests, and Bayesian inference.

Skills

- Apply Basu's theorem, minimal sufficiency, and exponential family concepts to practical problems.
- Construct and evaluate UMVUE and understand the role of the information matrix in statistical inference.
- Perform hypothesis testing using Neyman-Pearson lemma, large sample tests such as LR test, Rao's score test, and Wald's test, and construct tests for MLR family distributions.
- Apply Bayesian inference techniques, including prior selection, posterior computation, and Bayes' estimation under different loss functions.

Attitude

- Encourage a thorough and methodical approach to constructing and validating statistical models.
- Emphasize the importance of using accurate and reliable statistical methods in data analysis.
- Develop an appreciation for the role of statistical methods in informed decision-making in various fields

COURSE OUTCOMES:

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

CO1: Understand the fundamental concepts of estimation and properties of estimators.

ILO1: Define and explain the concepts of unbiasedness, sufficiency, consistency, and efficiency.

ILO2: Apply the Factorization theorem to identify sufficient statistics.

ILO3: Explain and utilize the Rao-Blackwell and Lehmann-Scheffe theorems for constructing minimum variance unbiased estimators (MVUE).

ILO4: Understand and apply the Cramer-Rao inequality to determine MVB estimators.

CO2: Master various methods of estimation and their properties.

ILO1: Implement the method of moments for parameter estimation.

ILO2: Apply the method of maximum likelihood for different statistical models.

ILO3: Use the method of minimum Chi-square for parameter estimation with relevant examples.

CO3: Perform hypothesis testing using different statistical tests.

ILO1: Define critical region, level of significance, size, and power of a test.

ILO2: Apply the Neyman-Pearson Lemma to construct most powerful tests.

ILO3: Understand and conduct Likelihood Ratio Tests and explain their properties.

CO4: Conduct sequential analysis for hypothesis testing.

ILO1: Understand the concept and application of Sequential Probability Ratio Test (SPRT) for simple hypotheses.

ILO2: Explain the fundamental relations among α, β, A, and B in SPRT.

ILO3: Determine A and B in practical scenarios for SPRT.

CO5: Apply advanced concepts in estimation, testing, and Bayesian inference.

ILO1: Construct UMVUE and understand the concept of an information matrix.

ILO2: Construct and interpret exact and asymptotic confidence intervals using various methods.

ILO3: Explain Bayesian inference, priors, posteriors, loss functions, and perform Bayes' estimation under different loss functions.

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	**Cognitive Process Dimension**					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge						
Conceptual Knowledge			CO1			
Procedural Knowledge			CO3, CO4, CO5	CO2		
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	L	S	S	L	M	S	L	L	L	L	S
CO2	S	L	S	S	L	M	S	S	L	L	L	S
CO3	S	L	S	S	L	S	S	S	L	L	L	S
CO4	S	L	S	S	L	S	S	S	M	M	L	S

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (13 Marks)	**Sufficiency and Completeness:** Basu's theorem. Minimal sufficiency. Exponential family of distributions and other distributions possessing sufficient, minimal sufficient and complete sufficient statistics. Construction of UMVUE. Information matrix. Asymptotic properties of MLE. MLE under restricted parameter space. Consistent estimation of population moments, median and correlation coefficient. Jackknife estimate of standard error.	10	02	-	12
2 (12 Marks)	**Interval Estimation:** Basic concepts, Methods of constructing exact confidence intervals. Shortest length confidence interval. Construction of asymptotic confidence intervals based on MLE with illustrative examples. Bootstrap confidence intervals.	08	01	-	09
3 (11 Marks)	**Neyman-Pearson lemma:** Proof of Neyman-Pearson lemma. Construction of MP, UMP and UMPU tests. **Large Sample Tests:** LR test. Rao's score test and Wald's test with illustrative examples. Concept of monotone likelihood ratio (MLR) and construction of tests for MLR family of distributions.	09	01	-	10
4 (14 Marks)	**Bayesian Inference:** Priors, conjugate prior, semi-conjugate prior, flat prior, non-informative prior, posteriors, loss functions, Bayes' estimation under different loss functions: Binomial, Poisson, Exponential, Gamma, Beta, Normal with unknown mean and variance etc. Credible interval. Bayes' factor. Bayesian linear regression.	11	02	-	13
5 (10 Marks)	**List of Practical: (both calculator and computer based)** 1. Maximum likelihood estimators under restricted parameter space 2. Computation of exact and asymptotic confidence intervals. 3. Construction of bootstrap confidence intervals. 4. Application of NP lemma: construction of MP, UMP and UMPU tests. 5. Construction of likelihood ratio, score and Wald's tests. 6. Jackknife estimates. 7. Posterior distributions: binomial, Poisson, exponential and normal. 8. Construction of credible intervals. 9. Computation of Bayes' factor.	-	-	08	16
	Total	**38**	**06**	**08**	**60**

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practical***

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READINGS:

1. Goon A. M., Gupta M. K.: Das Gupta. B. (2005): Fundamentals of Statistics, Vol. I, World Press, Calcutta.
2. Rohatgi V. K. and Saleh, A. K. Md. E. (2009): An Introduction to Probability and Statistics. 2nd edition (Reprint) John Wiley and Sons.
3. Miller, I. and Miller, M. (2002): John E. Freund's Mathematical Statistics (6th edition, low price edition), Prentice Hall of India.
4. Dudewicz, E. J., and Mishra, S. N. (1988): Modern Mathematical Statistics. John Wiley & Sons.
5. Mood A. M, Graybill F. A. and Boes D. C.: Introduction to the Theory of Statistics, McGraw Hill.
6. Bhat B. R, Srivenkatramana T and Rao Madhava K. S. (1997): Statistics: A Beginner's Text, Vol. I, New Age International (P) Ltd.
7. Snedecor G. W and Cochran W. G. (1967): Statistical Methods. Lowa State University Press.
8. Robert C. P (2007): The Bayesian Choice. Springer Texts in Statistics.
9. Casella G. and Berger R. L (2007): Statistical Inference. Cengage India Private Limited.

*****

Title of the Course	**:**	**Econometrics**
Course Code	**:**	**STSC20**
Nature of the Course	**:**	**Major**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**60 (50T + 10P) (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge:

- To gain knowledge of classical linear regression model, its estimation and the circumstances occurred in case of violation of the assumptions of the model.
- To get an idea about generalised least squares estimation.
- To learn about the simultaneous Linear Equations model, its identification.
- To gain some knowledge about Dynamic Econometric models.

Skill:

- To develop skills of fitting of real life data with the help of classical linear regression model, parameter estimation and testing of its significance.
- To develop knowledge of handling data having the problem of Multicollinearity, Heteroscedasticity and autocorrelation.
- To gain proficiency in fitting of dynamic econometric models.

Attitude:

- Develop a keen interest in econometric models and their applications.
- To build up concern in different types of problems in linear regression analysis like Multicollinearity, Heteroscedasticity and Autocorrelation etc.
- To accumulate the significance of alternative estimation techniques in presence of Multicollinearity, Heteroscedasticity and Autocorrelation etc.

COURSE OUTCOMES:

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

CO1: Understand the basic concepts of classical linear regression model and the assumptions associated with the model.

ILO1: Estimation of the parameters of the CLRM and testing its significance.
ILO2: violation of the assumptions of the CLRM.
ILO3: Heteroscedasticity: consequence, detection and Remedies.
ILO4: Autocorrelation: consequence, detection and Remedies.
ILO5: Multicollinearity: implications and tools for handling the problem.

CO2: Generalised least squares estimation.

ILO1: GLS Method of estimation in case of Autocorrelation
ILO2: GLS Method of estimation in case of Heteroscedasticity
ILO3: Concepts of Ridge Regression.

CO3: Simultaneous Equations model.

ILO1: Examples of simultaneous equations model.

ILO2: Identification problem of simultaneous equations model: Rank and order condition.

CO4: Estimation of simultaneous equations models.
ILO1: Indirect Least Squares and 2 stage Least Squares Estimation.
ILO2: Full information Maximum likelihood method.
ILO3: Dynamic Econometric Models: Distributive lag and Auto Regressive model.

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	**Cognitive Process Dimension**					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge						
Conceptual Knowledge		CO1				
Procedural Knowledge			CO2, CO3	CO4		
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	L	S	S	L	M	S	L	L	L	L	L
CO2	S	L	S	S	L	M	S	L	L	L	L	L
CO3	S	L	S	S	L	M	S	L	L	L	L	L
CO4	S	L	S	S	L	M	S	L	L	L	L	L

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (16 Marks)	**The Classical Linear Normal Regression Model (CLNRM) (Matrix Approach):** Estimation, Test and their properties. Heterosedaticity: consequences, detection and Remedies. Autocorrelation: consequences, detection and Remedies. Multicollinearity: implications and tools for handling the problem. Ridge Regression	12	02	-	14
2 (10 Marks)	**Generealised Least Squares (GLS) estimation:** Heterosedaticity and autocorrelated structure. Zelner"s SURE Method.	08	01	-	09
3 (12 Marks)	**Simultaneous Linear Equations Model.** Examples. Simultaneity bias. Identification problem Rank and order conditions. Examples.	09	01	-	10
4 (12 Marks)	**Estimation in simultaneous equations Model**, ILS and 2 SLS Estimators, Full Information Maximum likelihood method. **Dynamic Econometric Models:** Distributed lag Model and auto regressive model.	10	01	-	11
5 (10 Marks)	**List of Practical: (both calculator and computer based):** 1. Problems based on estimation of General linear model. 2. Testing of parameters of general linear model. 3. Forecasting of general linear model. 4. Problems concerning specification errors 5. Problems related to consequences of multicollinearity. 6. Problems based on Diagnostics of multicollinearity. 7. Problems related to consequences of autocorrelation (AR (I)). 8. Problems based on diagnostics of autocorrelation. 9. Estimation of problems of general linear model under autocorrelation. 10. Problems related to consequences heteroscedasticity. 11. Diagnostics of heteroscedasticity. 12. Estimation of problems of general linear model under heteroscedastic distance terms 13. Problems related to general linear model under (Aitken Estimation).	-	-	08	16

	14. Problems on autoregressive and lag models.				
	Total	**39**	**05**	**08**	**60**

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practical***

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READINGS:

1. Gujarati, D. and Sangeetha, S. (2007): Basic Econometrics, 4th edition, McGraw Hill Companies.
2. Johnston, J. (1972): Econometric Methods, 2nd edition, McGraw Hill International.
3. Koutsoyiannis, A. (2004): Theory of Econometrics, 2nd edition, Palgrave Macmillan Limited,
4. Maddala, G. S. and Lahiri, K. (2009): Introduction to Econometrics, 4th edition, John Wiley & Sons.
5. Parashar Anil K. and Singh H. P., Singh S. P. (1991): Econometrics and Mathematical Economics, S.Chand & Company, New Delhi.
6. Frank, C. R., Jr.: Statistics and Econometrics, Holt, Rinehart and Winston, New York, 1971.
7. Klein, Lawrence R.: An Introduction to Econometrics, Prentice Hall, Engle-wood Cliffs, N. J., 1962.
8. Chow, Gregory C.: Econometric Methods, Mc Graw-Hill, New York,1983.

*****

Title of the Course	**:**	**Design of Experiments**
Course Code	**:**	**MINSTS8**
Nature of the Course	**:**	**Minor**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**60 (50T + 10P) (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge:

- Gain familiarity with basic experimental designs such as Completely Randomized Design (CRD), Randomized Block Design (RBD), and Latin Square Design (LSD), including their layout, models, and statistical analysis.
- Understand the concepts of incomplete block designs, specifically Balanced Incomplete Block Design (BIBD), its parameters, relationships among parameters, and properties.
- Learn the concepts, terminologies, and analysis of factorial experiments, including 2^2, 2^3, and higher-order factorial experiments.
- Study the principles of confounding, including total and partial confounding for factorial experiments and the concepts of fractional factorial experiments.

Skill:

- Develop the ability to construct and interpret statistical control charts for CRD, RBD, and LSD, including cases with single missing observations.
- Acquire skills in intra-block analysis of BIBD and analysis of 2^2 and 2^3 factorial experiments in CRD, RBD, and LSD.
- Learn to analyze completely and partially confounded two-level factorial designs in various block arrangements.
- Enhance the capability to design and analyze fractional factorial experiments, including the construction of one-half and smaller fractions of 2^n factorial experiments.

Attitude:

- Cultivate an appreciation for the importance of experimental design in statistical studies.
- Develop a commitment to rigorous and precise analysis in experimental research.
- Foster an attitude of continuous improvement in the application and interpretation of experimental designs.

COURSE OUTCOMES:

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

CO1: Basics of Experimental Design:

ILO1: Students will able to know the history of experimental design

ILO2: Various terminology used and basic principles of design of experiments

ILO3: Learn about some basic designs for analysis. Get a concept of relative efficiency, also missing observations that arise in the experimental design.

CO2: Learn about Incomplete Block Design

ILO1: Will get the idea of Incomplete block design (BIBD), relationship of various parameter involved in this design, get the idea of the incidence matrix. Properties of BIBD.

CO3: Will learn Factorial Experiments and their concepts

ILO1: Will get the concepts of factorial experiment, Factors and levels.

ILO2: Will lean analysis of factorial experiments.

CO4: Get the idea of confounding in factorial experiments.

ILO1: Will learn about confounding factorial design, its advantages and disadvantages.

ILO2: Also will get the idea of fractional experiments and their uses.

CO5: Practical knowledge will be earned by doing various practicals from various units of courses which will be helpful for future applications.

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	**Cognitive Process Dimension**					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge						
Conceptual Knowledge						
Procedural Knowledge			CO1, CO2 CO3, CO4		CO5	
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	L	M	L	L	L	L	L	L	L	L	L
CO2	S	L	S	S	L	M	S	S	L	L	L	M
CO3	S	L	S	S	L	M	S	L	L	L	L	M
CO4	S	L	S	S	L	M	S	L	L	L	L	M
CO5	S	S	S	S	L	M	S	L	L	M	L	M

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (15 Marks)	**Experimental Designs:** Historical perspective, 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 single missing observation.	11`	02	-	13
2 (11 Marks)	**Incomplete Block Designs:** Balanced Incomplete Block Design (BIBD) – parameters, relationships among its parameters, incidence matrix and its properties.	07	01	-	08
3 (12 Marks)	**Factorial Experiments:** Concepts, terminologies and analysis of 2^2, 2^3,…,2^n factorial experiments.	10	02	-	12
4 (12 Marks)	**Confounding:** Total and partial confounding for 2^n ($n \leq 5$). Factorial experiments in a single replicate. Fractional factorial experiments: Concepts of one-half and fractions of 2^n ($n \leq 5$) factorial experiments.	10	01	-	11
5 (10 Marks)	**List of Practical: (both calculator and computer based):** 1. Analysis of a CRD. 2. Analysis of an RBD. 3. Analysis of an LSD. 4. Analysis of an RBD with one missing observation. 5. Analysis of an LSD with one missing observation. 6. Intra block analysis of a BIBD. 7. Analysis of 2^2 and 2^3 factorial in CRD and RBD. 8. Analysis of 2^2 and 2^3 factorial in LSD. 9. Analysis of a completely confounded two level factorial design in 2 blocks. 10. Analysis of a completely confounded two level factorial design in 4 blocks. 11. Analysis of a partially confounded two level factorial design.	-	-	08	16
	Total	**38**	**06**	**08**	**60**

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practical***

MODES OF IN-SEMESTER ASSESSMENT: **(40 Marks)**

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READINGS:

1. Cochran, W. G. and Cox, G. M. (1959): Experimental Design. Asia Publishing House.
2. Das, M. N. and Giri, N. C. (1986): Design and Analysis of Experiments. Wiley Eastern Ltd.
3. Goon, A. M., Gupta, M. K. and Dasgupta, B. (2005): Fundamentals of Statistics. Vol. II, 8thEdition World Press, Kolkata.
4. Kempthorne, O. (1965): The Design and Analysis of Experiments. John Wiley.
5. Montgomery, D. C. (2008): Design and Analysis of Experiments, John Wiley.
6. Rao, C. R., Rao, C. R., Statistiker, M., Rao, C. R., and Rao, C. R. (1973). Linear statistical inference and its applications (Vol. 2, pp. 263-270). New York: Wiley.

*****

Title of the Course	**:**	**Financial Statistics**
Course Code	**:**	**DSE1**
Nature of the Course	**:**	**Major**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**60 (50T + 10P) (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge:

- Gain a comprehensive understanding of what financial statistics is and its significance in the economic landscape.
- Learn the essentials and components of financial statistics, including key roles and functions of institutions like the RBI, Economics Survey Department, CSO, and Govt. of India.
- Analyze the growth and stagnancy of major products and services of India Apply various time-series and regression modeling techniques such as logistic, Gompertz, exponential, reciprocal, and logarithmic curves for growth analysis.

Skills:

- Develop skills in statistical analysis and modeling of financial data and national income statistics.
- Enhance skills in analyzing economic growth indicators and understanding their implications for the economy.
- Learn and apply time-series modeling and advanced regression techniques for analyzing growth patterns of Indian products and services.

Attitude:

- Develop a critical approach to analyzing financial and economic data.
- Pay close attention to data validation and accuracy in statistical interpretations.
- Promote a mindset of continuous learning and staying updated with the latest developments in financial statistics and economic modeling.

COURSE OUTCOMES:

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

CO1: Understand the Fundamentals of Financial Statistics

ILO1: Define financial statistics and explain its importance in economic analysis.
ILO2: Identify and describe the essential components of financial statistics.
ILO3: Explain the roles and functions of key institutions such as the RBI, Economic Survey Department, and CSO.

CO2: Model National Income and Stock Exchange Outcomes

ILO1: Understand and apply Pareto's Law in the context of national income modeling.
ILO2: Utilize Weibull distribution and appropriate Pearsonian curves to model national income.
ILO3: Explain the concept of stock exchanges and analyze related statistics.

CO3: Analyze Indicators of Economic Growth

ILO1: Identify and describe key indicators of economic growth, including GDP, balance of payment, and foreign exchange reserves.
ILO2: Analyze the components of the trade balance and the exchange rates of the Indian rupee.
ILO3: Evaluate government receipts (tax and non-tax revenue) and expenditures.

CO4: Conduct Statistical Analysis of Export Input Potential
ILO1: Perform statistical analysis on the export of major products and services in India.
ILO2: Identify and analyze key industrial and engineering products contributing to India's exports.
ILO3: Develop time-series models to analyze the export-import scenario of the Indian economy.

CO5: Growth and Stagnancy Analysis of Major Products and Services
ILO1: Conduct growth and stagnancy analysis of major products and services in India.
ILO2: Apply logistic, Gompertz, exponential, reciprocal, and logarithmic regression models to analyze growth trends.
ILO3: Validate the developed growth models using statistical techniques.

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	**Cognitive Process Dimension**					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge						
Conceptual Knowledge		CO1				
Procedural Knowledge			CO2, CO3	CO4, CO5		
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	L	M	L	L	L	S	M	L	L	L	S
CO2	S	L	S	S	L	S	S	S	L	L	L	S
CO3	S	L	S	S	L	S	S	S	L	L	L	S
CO4	S	L	S	S	L	S	S	S	L	L	L	S
CO5	S	L	S	S	L	S	S	S	L	L	L	S

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (15 Marks)	**Introduction of financial statistics** - What financial statistics is, why financial statistics is; Essentials/ Components of financial statistics; Role and functions of RBI, Economics Survey Department, CSO, Govt. of India; National Income Statistics. **Modeling of National Income** – Pareto's Law; Weibul distribution, Appropriate Pearsonian Curve, Idea of Stock Exchange, Statistics related to stock exchange, Time- Series modeling of stock exchange outcome.	13	02	-	15
2 (15 Marks)	**Indicators of Economics Growth** : Brief Resume of Indicators – Gross Domestic Product (GDP), Balance of payment, Foreign exchange reservoir, Foreign Exchange Earnings, Trade Balance, Exchange rates of Indian rupee, Govt's Receipts (tax and non-tax revenue) and Govt. Expenditure, Gross Domestic Saving, Gross Domestic Capital Formation, Foreign Capital Inflow / Outflow.	13	02	-	15
3 (15 Marks)	**Export Input Potential** – Statistical Analysis of Export of Major Products and services of India. Industrial and Engineering Product, Time Series Modeling of Export Import Scenario of Indian Economy.	13	02	-	15
4 (15 Marks)	**Growth and Stagnancy Analysis** of Major Products and services of India (mentioned in above paragraph) **Time Series / Regression modeling of Growth of Indian products** – Logistic, Gompertz, Exponential, Reciprocal curves and Logarithmic curves and Validation of the Modeling .	12	03	-	15
	Total	**51**	**09**		**60**

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practical***

MODES OF IN-SEMESTER ASSESSMENT: **(40 Marks)**

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READINGS:

1. Basic Statistics related of Indian Economy (Yearly publication)
2. EMI Volumes (Yearly publications)
3. CSO Publication (Yearly publications)
4. Productivity News : National Productivity Council, A bi-monthly magazine
5. Southern Economist : Asian New Age Publisher, A monthly magazine
6. Economic and Political Weekly : A Sameeksha Publication

7. Monthly Commentary on Indian Economic Conditions : Indian Institute of Public Opinion, A - monthly journal
8. Indian Journal of Economics : Published by Dept. of Economics & Commerce, University of Allahabad
9. The Economic Times : A daily published National Daily
10. D. Ruppert : Statistics and Finance An Introductions, Cornell Univ. USA, SPRINGER
11. J. M. Steele : Stochastic Calculus, University of Pensylvania, USA, SPRINGER
12. Peta Rossi : Quantitative Marketing and Economics, SPRINGER
13. Hebden, J.(1986), Statistics for Economists, Heritage Publisher, New Delhi

*****

Title of the Course	**:**	**Demography and Vital Statistics - II**
Course Code	**:**	**DSE2**
Nature of the Course	**:**	**Major**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**60 (50T + 10P) (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge:

- Understand the models of population growth, projection and migration.
- Gain knowledge of morbidity study including maternal mortality, abortion and reproductive health.
- Learn distribution of life table functions.
- Understand the concepts of stable, quasi stable and stationary population and stochastic models of fertility.

Skills:

- Gain skills to project and estimate population.
- Develop skills for standardizing fertility and mortality rates.
- Can construct life tables from census data.
- Gain skills to compute incidence and prevalence of disease, Maternal Mortality Ratio (MMR).
- Learn methods for estimating migration.
- Use of Leslie matrix (including algebra of Leslie matrix) for population projection.

Attitude:

- Develop interest to use the knowledge for development of an area.
- Motivated to compare status of fertility, mortality and public health of different regions/countries.
- Develop interest for doing research of multidisciplinary nature.

COURSE OUTCOMES:

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

CO1: Understand basics of population projection, migration and morbidity.

ILO1: Define population estimation and projection
ILO2: Explain different models of population estimation and projection.
ILO3: Explain properties of logistic curve and leslie matrix.
ILO4: Define types of migration.
ILO5: Learn stochastic models of fertility.

CO2: Discuss life table and its applications

ILO1: Can find sampling distributions of life table functions l_x and d_x.
ILO2: Learn estimation of life table parameters p_x, q_x by method of maximum likelihood.
ILO3: Be able to construct abridged life table with census data.
ILO4: Explain multiple uses of life tables for demographic analysis.

CO3: Apply techniques of population estimation and population projection.

ILO1: Project population with arithmetic, Geometric and exponential model.
ILO2: Explain fitting of logistic curve for population projection.
ILO3: Discuss Leslie model for population projection.

CO4: Analyse and interprete migration data.
ILO1: Compare and contrast internal and international migration.
ILO2: Compute rates of internal and international migration and interprete the result.

CO5: Analyse Morbidity and Health data.
ILO1: Distinguish between health and morbidity.
ILO2: Learn international classification of disease.
ILO3: Discuss maternal mortality and abortion; RTI and STD.
ILO4: Compute incidence and prevalence rate of disease in a population.

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	**Cognitive Process Dimension**					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge						
Conceptual Knowledge		CO1				
Procedural Knowledge			CO3	CO2, CO4, CO5		
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	L	S	M	L	M	L	L	M	L	M	M
CO2	S	L	S	S	S	L	M	L	L	L	L	S
CO3	S	S	S	S	L	M	S	L	L	L	L	S
CO4	S	M	S	S	S	M	S	L	S	S	S	S
CO5	S	L	S	M	L	L	L	L	M	L	L	S

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (13 Marks)	**Rates Of Population Growth:** Arithmetic, Geometric and Exponential. Population projection and population estimation. Inter-censal and post-censal estimate of population. Population Projection by mathematical method using logistic model. Properties of logistic curve. Concept of stable, quasi-stable and stationary population. Population projection with Leslie matrix. Properties of Leslie matrix.	09	02	-	11
2 (13 Marks)	**Life Tables:** Abridged life tables and their uses in demographic analysis. Construction of Abridged life tables using census data (conventional method only). Sampling distribution of life table functions l_x and d_x. Estimation of life table parameter p_x using method of maximum likelihood. Necessity of standardizing birth rates and death rates. Direct and Indirect method of standardizing Crude Death rate, Crude Birth rate and General Fertility rate.	10	01	-	11
3 (11 Marks)	**Migration:** Basic concepts, internal and international migration- its causes and consequences. Estimation of internal and international migration by direct method. Idea of stochastic models on fertility and reproduction- Shepps and Perrin model, William Brass model.	08	02	-	10
4 (13 Marks)	**Morbidity:** concepts and definitions of health and morbidity. Sources of data on morbidity and measures of morbidity. Incidence and prevalence rate. Cause of death statistics and its importance. Adult mortality rate. International Classification of Diseases (ICD-X, 1990). Reproductive health, Reproductive Tract Infection (RTI), Sexually Transmitted diseases and related problems. Maternal mortality and abortion.	10	02	-	12
5 (10 Marks)	**List of Practical: (both calculator and computer based):** 1. To find inter-censal estimate of population using arithmetic, geometric and exponential model. 2. To project population using logistic model- Pearl-Reed method and Rhodes method. 3. To calculate standardized crude Birth Rate and Standardised General Fertility Rate. 4. To calculate Standardised Crude Death rate. 5. To find yearly incidence rate from a 5-year data set. 6. To find point prevalence and period prevalence rate from a 5-year data set.	-	-	08	16

	Total	37	07	08	60

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practical***

MODES OF IN-SEMESTER ASSESSMENT: (40 Marks)

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READINGS:

1. Bhende, A. A. and Kanitkar T. : Principles of Population studies , Himalays Publishing House
2. Biswas, S.: Stochastic Processes in demography and applications, Wiley Eastern Ltd
3. Mukhopadhyay, P. : Applied Statistics, Central Book Agency.
4. Pathak, K. B. Pandey, A. : Stochastic models for human reproduction, Himalaya Pub-House
5. Pathak, K. B. and Ram, F: Techniques of Demographic analysis, Himalaya Pub. House.
6. Ramkumar, R.: Technical Demography Wiley Eastern.
7. Park, K.: Preventive and Social Medicine, Bhanot Publisher, Jabalpur, India.
8. Henry S. Shryock, Jacob S. Siegel, Edward G. Stockwell (1976). The Methods and Materials of Demography, Elsevier Science.
9. M. Spiegelman (1969). Introduction to Demography. Revised Edition. Cambridge, Mass., Harvard University Press, xxi p. 514 p., 515.00.

*****

Title of the Course	**:**	**Indian Statistical Heritage & Official Statistics**
Course Code	**:**	**DSE3**
Nature of the Course	**:**	**Major**
Total Credits	**:**	**04**
Distribution of Marks	**:**	**60 (50T + 10P) (End Sem) + 40 (In-Sem)**

COURSE OBJECTIVES:

Knowledge:

- Understand the historical development and significance of official statistics in India, including contributions of prominent Indian statisticians.
- Gain comprehensive knowledge about the current official statistical system in India, including the roles and functions of various governmental agencies.
- Develop a critical understanding of the methodologies and limitations of official statistics collection and dissemination in India.
- Learn to identify and describe key recommendations of important commissions like the Rangarajan Commission.

Skills:

- Develop skills to analyze and interpret official statistical data published by governmental agencies.
- Evaluate the quality and reliability of data published by governmental agencies.
- Critically assess the accuracy and completeness of various statistical methods used by Indian agencies.
- Illustrate the structure and functioning of the present official statistical system in India, including the roles and functions of agencies like MOSPI, CSO, NSSO, and the Registrar General's Office.

Attitudes:

- Cultivate an appreciation for the historical evolution of official statistics in India, both pre- and post-independence.
- Foster an attitude of critical evaluation regarding the methods of collecting official statistics and the challenges associated with them.
- Encourage a proactive approach to understanding the significance of official statistics in public administration, research, and policy planning.
- Develop a commitment to rigorously analyzing and interpreting statistical data for informed decision-making and policy formulation.

COURSE OUTCOMES:

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

CO1: Understand the historical development and significance of official statistics in India, including the contributions of prominent Indian statisticians. By the end of this course, students will be able to:

ILO1: Explain the historical evolution of official statistics in India, both pre- and post-independence.

ILO2: Discuss the fundamental principles of official statistics as they have developed over time.

ILO3: Identify and describe the key recommendations of the Rangarajan Commission.
ILO4: Recognize the significant contributions of Indian statisticians such as P. C. Mahalanobis, C. R. Rao, D. Basu, and others.

CO2: Gain comprehensive knowledge about the current official statistical system in India, including the roles and functions of various governmental agencies. Analyze and interpret data published by governmental agencies. By the end of this course, students will be able to:

ILO1: Illustrate the structure and functioning of the present official statistical system in India. Such as the roles and functions of the Ministry of Statistics & Program Implementation (MOSPI). And the Central Statistical Office (CSO).
ILO2: Discuss the roles of the National Sample Survey Office (NSSO) and the Registered General Office and understand the special data dissemination systems used by these agencies.
ILO3: Develop skills to analyse and interpret official statistical data.
ILO4: Evaluate the quality and reliability of data published by governmental agencies.

CO3: Develop a critical understanding of the methodologies and limitations of official statistics collection and dissemination in India. By the end of this course, students will be able to:

ILO1: Evaluate the methods of collecting official statistics in India.
ILO2: Discuss the limitations and challenges associated with collecting and disseminating official statistics.
ILO3: Critically assess the accuracy and completeness of various statistical methods used by Indian agencies.

Table: Learning Outcome Representation (CO): Bloom's Taxonomy Table

Cognitive Knowledge Dimensions	**Cognitive Process Dimension**					
	Remember	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge		CO1				
Conceptual Knowledge		CO2				
Procedural Knowledge					CO3	
Metacognitive Knowledge						

Table: Course Outcome (CO) and Program Outcome (PO) mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	L	L	L	L	L	L	L	L	L	L	M
CO2	S	S	S	S	S	M	S	S	S	S	S	M
CO3	S	S	M	S	L	L	L	L	L	S	S	S

(S= Strong, M= Medium, L= Low)

UNITS	CONTENTS	L	T	P	Total Hours
1 (12 Marks)	**Historical perspective** (pre and post independence) of official statistics in India, fundamental principles of official statistics, recommendations of Rangarajan Commission, an outline of the present official statistical system, Contribution of Indian Statisticians in the field of statistics – P. C. Mahalanobis, C. R. Rao, D. Basu, D. B. Lahiri, R. R. Bahadur, P. V. Sukhatme, V. S. Huzurbazar, J. Medhi, C. Chandrasekaran. Methods of collecting official statistics and limitations.	12	-	-	12
2 (16 Marks)	**National Statistical Commission**: Need, constitution, its role, functions, etc. Role, functions and activities of the Ministry of Statistics & Program Implementation (MOSPI), Central Statistical Office (CSO), National Sample Survey Office (NSSO), Registered General Office and special data dissemination systems.	16	-	-	16
3 (16 Marks)	**Industrial Statistics**: Annual survey of industries, index of industrial production, small scale industries sector. **Index Numbers**: Consumer price index for industrial workers, agricultural and rural labourers, urban non-manual employees, Wholesale price index number, inflation, deflation with Indian perspective.	16	-	-	16
4 (16 Marks)	**Agricultural Statistics**- introduction, area statistics, yield estimates, sampling design. **Economic Surveys**-Salient features of NSS Socio-Economic Surveys, Sample design. **Other sector wise Statistics**: Health, Education, Women, and Child, etc. Important Surveys & Census, Indicators, Agencies, and Usages, etc.	16	-	-	17
	Total	**52**	**08**		**60**

Where, ***L: Lectures*** ***T: Tutorials*** ***P: Practical***

MODES OF IN-SEMESTER ASSESSMENT: **(40 Marks)**

- Sessional test(s)
- Objective test, Assignments (Class, Home), Paper Presentation, Laboratory Works, Concept note writing.

SUGGESTED READINGS:

1. Ghosh, J. K., Mitra, S. K., and Parthasarathy, K. R. (1992). Glimpses of India's statistical heritage.
2. Goon, A. M., Gupta, M. K. and Dasgupta, B. Das (1991): Fundamentals of Statistics, Volume II, The World Press Pvt Ltd, Calcutta
3. Guide to Current Indian Official Statistics, Central Statistical Office, GOI, New Delhi.

4. Srivastava, S. S. and Asthana, B. N. (1965): Applied Statistics of India, Chaitnya Publishing House.
5. Basic Statistics Relating to the Indian Economy (CSO), 1990.
6. Guide to Official Statistics (CSO) 1999.
7. Family Welfare Yearbook, Annual Publication of D/o Family Welfare.
8. Bhattacharya, P. (2023). India's Statistical System: Past, Present, Future. CEIP: Carnegie Endowment for International Peace. United States of America.

*****