Central University of Tamil Nadu, Thiruvarur
School of Mathematics and Computer Sciences
Department of Statistics and Applied Mathematics

Syllabus for B.Sc. STATISTICS
(Honours / Honours with research)
based on Curriculum
and Credit Framework
for
Undergraduate Programme & NEP 2020
(From 2026 onwards)

A. Vision

Vision Statement of the Department

Vision Statement
To provide quality education to bring out potentialities in the students

B. Mission

Mission Statements of the Department

M1	To produce able Statisticians and Applied Mathematicians
M2	To impart current knowledge on cross cutting issues in the domain
M3	To equip students with knowledge to work in domain specific targeted industries

C. Program Outcomes (PO) - B.Sc. Honours / B.Sc. Honours with Research in Statistics

After four years of successful completion of the program, the student will

PO1	Have a broad background in Statistics , an appreciation of its various sub-disciplines and their inter-relationships; acquire in-depth knowledge about topics chosen from those offered through the department.
PO2	Be familiar with a variety of real-life situations where Statistics help accurately explain the underlying abstract or physical phenomena and able to recognize and appreciate the connections between theory and applications
PO3	Develop the ability to effectively and aptly use techniques from different sub-disciplines in solving a broad range of real-life problems.
PO4	Be Statistically literate. Graduates will recognize the importance and value of discipline.
PO5	Have the versatility to work effectively in a broad range of companies (including R and D sectors of financial, pharmaceutical, market research, software development companies, consultancy etc), or analytic, scientific, government, financial, health, teaching and other positions or continue for higher education.
PO6	Be able to independently read and analyze Statistical literature including survey articles, scholarly books, and online sources.
PO7	Be life-long learner, able to independently expand their expertise when needed, or out of their own interest.
PO8	Be able to exhibit ethical and professional behaviour in teamwork

D. Graduate Attributes for B.Sc Statistics (Honours / Honours with Research) Program

1. In-depth knowledge in sub-disciplines offered in this program
2. Problem Solving in various fields
3. Model Building and Data Analysis
4. Ability to interpret and draw conclusions from qualitative/quantitative data
5. Using Computational Software
6. Selecting and integrating appropriate ICT skills for professional development
7. Life-long learner
8. Ethical and professional behaviour in teamwork

E. PO to Mission Statement Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
M1	3	3	3	3	3	3	3	3
M2	3	3	3	3	3	3	3	3
M3	3	3	3	3	3	3	3	3

F. Program Specific Outcomes (PSO)

On the successful completion of the program, the student will be able to

PSO1	Effectively recall basics and display knowledge of conventions.
PSO2	Develop Statistical models for analysing real-life phenomena in diverse disciplines.
PSO3	Efficiently interpret and translate the outcomes obtained from the analysis of Statistical models to an environment understandable to a layman.
PSO4	Effectively use necessary computational software.
PSO5	Apply statistical techniques to optimize and monitor real-life phenomena related to industry and business analytics at local and global levels.

G. PSO to PO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5
PO1	3	3	3	3	3
PO2	3	2	2	2	3
PO3	3	3	2	3	3
PO4	3	3	2	3	3
PO5	3	3	3	3	3
PO6	3	2	2	1	2
PO7	3	2	2	3	3
PO8	1	3	3	1	3

H. Course Structure

This Four-Year Undergraduate Programme is structured under the Choice-Based Credit System (CBCS) and adheres to NEP 2020 guidelines:

Duration: 4 years (8 semesters);
Total Credits: 173 (B.Sc Honours with Research) & 173(B.Sc Honours)

Curriculum Components:

- Core Statistics Courses (CC, CCP)
- Discipline-Specific Electives (DSE), Allied Courses (Minor)
- Ability Enhancement Courses (AECC), Skill Enhancement Courses (SEC), Value Added Courses (VAC), Interdisciplinary/Open Electives (OE), Internship (INT)
- Research/Project Work in the final year (PROJ)
- Extension Activities (EXT)*

Exit Options (as per NEP):

1. Certificate after 1 year
2. Diploma after 2 years
3. B.Sc. Degree after 3 years
4. B.Sc. (Honours /Honours with Research) after 4 years

*Credit not included

H. Question Paper Template

Part – A

Answer *ALL* the questions **(10 x 1 = 10 Marks)**

Question Numbers: 1 to 10

TEN questions – TWO questions from each unit- only MCQ

Part – B

Answer *Any Five* questions **(5 x 3 = 15 Marks)**

Question Numbers: 11-17

FIVE questions – ONE question from each unit

Part – C

Answer *ALL the* questions **(5 x 7 = 35 Marks)**

Question Numbers: 18-22

FIVE questions – ONE question from each unit with internal choice (either or type).

It can be a question with seven marks or with sub-divisions

I. Evaluation Procedure

Evaluation is based on Internal Assessment and End Semester Examination. The Internal Assessment consists of the following components:

Internal Assessment Tests, Assignments, Practical, Project works, Quiz, seminar, viva voce and online tests via platforms Moodle, MOOCs etc.,

	Internal Marks	End Semester Marks	Total
Theory Courses	40	60	100
Practical Courses	Continuous Internal Assessment		100
Project	40	60	100

Internal Assessment evaluation pattern will differ from course to course for each semester. This will have to be declared to the students at the beginning of each semester.

J. For Practical Courses

Rubrics for core course practical (CCP) evaluation:

The split up for CCPR evaluation is as follows:

Component	Marks
Practical Examination	60
Practical Work Record	20
Practical Viva	10
Observation	10
Total	**100**

K. Passing Minimum

For a pass in each theory course, a student should secure a minimum of 50% marks in the End Semester Examinations (ESE) and a minimum of 50% marks in aggregate (i.e., internal and ESE marks put together). For a pass in lab course, a student should secure 50% marks and for a pass in the Project, a student should secure a minimum of 50% marks in total.

L. Practical

The assessment of practical courses will be done on the basis of Continuous Internal Assessment consists of the students' performance in the laboratory, regular attendance, the number of experiments performed, on-time submission of observation and record notes, and written/viva-voce examinations.

M. Internship

Students should undergo Internship/ Apprenticeship for at least 2-weeks duration in an Industry / Organization / Lab Training with faculty or researchers in their own or other HEIs / research institutions during the summer vacation at the end of 4th semester. The Summer Internship report submitted by the student will be evaluated during the subsequent semester and the credit shall be accounted in the 6th semester. After completing the internship, the student has to submit the report of the internship forwarded/signed by the internship supervisor. External evaluation will be done by the committee consists of three faculty members from the department nominated by DRC. Internship evaluation is done on the basis of External (20% based on the report and 20% based on the presentation given by the student in the Department) and Internal (60% by the supervisor from own or other HEIs).

N. Project

Students will carry out project work in the eighth semester on any one of the topics under the guidance of faculty or researchers in their own or other HEIs / research institutions Sectors. Finding an advisor who is willing to supervise the work of a student is solely the responsibility of the student. Preferably, the student should have identified a supervisor by the first week of the commencement of the final year. Guide allocation for the project will be done by the Department. If the student wants to do project under an external guide from other HEIs/research institutions (external guide to be approved by DRC), the internal evaluation will be done by the committee consists of three faculty members from the department nominated by DRC. The evaluation of the Project work will be based on the dissertation and a Viva-Voce examination by Project Evaluation Committee (PEC) consisting of the (internal) supervisor, an internal examiner (other than the supervisor) and an External/internal Examiner. The internal examiner and the external/internal examiner shall be appointed by the supervisor. The dissertation work is evaluated under two categories

a. Internal Assessment (IA), which is a continuous assessment and will be done by his/her supervisor
b. End semester Assessment, which involves evaluation of dissertation and viva voce, will be done by PEC members during Project viva.

Total marks allotted for Project is 100 marks with the following criteria :

Internal Assessments : 40%
End Semester Assessments : 60%

The students are encouraged to publish their project work in a peer-reviewed journal/ Conference/ Seminar/ Patented.

O. Online Course (MOOC/NPTEL/SWAYAM/e_Pathshala/etc.,)

A student should undergo two online courses one in 5th semester (3 credits) and the other in 7th semester (3 credits). Registration has to be done in the current semester along with other courses. The student has to choose the course from the list of SWAYAM online courses related to the domain and approved by the department. Credits earned from a University, which offers the online course can be directly transferred to the respective programme of the candidate after getting due approval from Department. The student has to submit a copy of the course completion certificate to the department.

P. Eligibility Criteria for the Award of Certificate / Diploma/ Degree

1. A student who wishes to exit the programme with **Under Graduate Certificate** in Statistics after successfully completing all the courses during the First Year of the Programme (42 credits), have to secure 4 additional credits in work based vocational courses during summer term. Total credit requirements for awarding **Under Graduate Certificate** are 46 (42+4=46).
2. A student who wishes to exit the program with **Under Graduate Diploma** in Statistics after successfully completing all the courses during First and Second Years of the Programme (84 credits), have to secure 4 additional credits in work based vocational courses during summer term. Total credit requirements for awarding **Under Graduate Diploma** are 88 (84+4=88).
3. A student who wishes to exit the program with **Under Graduate (B. Sc.) Degree** in Statistics after successfully completing all the courses during First, Second and Third Years of the Programme have to secure 131 credits.
4. Students who have secured ≥75% marks in the first 6 semesters alone are permitted to undertake **4-Year UG Degree (Honours with Research) in Statistics**. Others are permitted to undertake **4-Year UG Degree (Honours) in Statistics**. The total credit requirements for awarding **Under Graduate (Honours) is 173 / Under Graduate Degree (Honours with Research)** is **173.**
5. Students can enroll in B.Sc. Statistics through Lateral Entry in 2nd, 3rd, 4th year.

COURSE-WISE CREDIT DISTRIBUTION

1. Four-Year B.Sc. Honours with Research in Statistics

SEM	CC	DSE	Minor	OE	AECC	SEC	VAC	EXT	INT	PROJ	TOTAL
I	5	-	5	3	3	2	3	-	-	-	21
II	-	-	10	3	3	2	3	-	-	-	21
III	5	-	6	3	3	2	2	-	-	-	21
IV	15	-	-	-	3	3	-	1*	-	-	21
V	20	3	-	-	-	-	-	-	-	-	23
VI	16	6	-	-	-	-	-	-	2	-	24
VII	19	3	-	-	-	-	-	-	-	-	22
VIII	4	4	-	-	-	-	-	-	-	12	20
TOTAL	**84**	**16**	**21**	**9**	**12**	**9**	**8**	**1***	**2**	**12**	**173**

2. Four-Year B.Sc. Honours in Statistics

SEM	CC	DSE	Minor	OE	AECC	SEC	VAC	EXT	INT	PROJ	TOTAL
I	5	-	5	3	3	2	3	-	-	-	21
II	-	-	10	3	3	2	3	-	-	-	21
III	5	-	6	3	3	2	2	-	-	-	21
IV	15	-	-	-	3	3	-	1*	-	-	21
V	20	3	-	-	-	-	-	-	-	-	23
VI	16	6	-	-	-	-	-	-	2	-	24
VII	19	3	-	-	-	-	-	-	-	-	22
VIII	8	4	-	-	-	-	-	-	-	8	20
TOTAL	**88**	**16**	**21**	**9**	**12**	**9**	**8**	**1***	**2**	**8**	**173**

3. Three-Year B.Sc. Statistics

SEM	CC	DSE	Minor	OE	AECC	SEC	VAC	EXT	INT	PROJ	TOTAL
I	5	-	5	3	3	2	3	-	-	-	21
II	-	-	10	3	3	2	3	-	-	-	21
III	5	-	6	3	3	2	2	-	-	-	21
IV	15	-	-	-	3	3	-	1*	-	-	21
V	20	3	-	-	-	-	-	-	-	-	23
VI	16	6	-	-	-	-	-	-	2	-	24
TOTAL	**61**	**9**	**21**	**9**	**12**	**9**	**8**	**1***	**2**	**-**	**131**

4. Two-Year Diploma in Statistics

SEM	CC	DSE	Minor	OE	AECC	SEC	VAC	EXT	INT	VOC	TOTAL
I	5	-	5	3	3	2	3	-	-	-	21
II	-	-	10	3	3	2	3	-	-	-	21
III	5	-	6	3	3	2	2	-	-	-	21
IV	15	-	-	-	3	3	-	1*	-	4	25
TOTAL	**25**	**-**	**21**	**9**	**12**	**9**	**8**	**1***	**-**	**4**	**88**

5. One-Year Certificate in Statistics

SEM	CC	DSE	Minor	OE	AECC	SEC	VAC	EXT	INT	VOC	TOTAL
I	5	-	5	3	3	2	3	-	-	-	21
II	-	-	10	3	3	2	3	-	-	4	25
TOTAL	**5**	**-**	**15**	**6**	**6**	**4**	**6**	**-**	**-**	**4**	**46**

*Credit not included

Multiple Entry and Exit Options

Year of Study	Certificate	Credit Requirement
I Year	Certificate	46
II Year	Diploma	88
III Year	UG Degree (B.Sc. Statistics)	131
IV Year	UG Honours (B.Sc Honours in Statistics / B.Sc Honours with Research in Statistics)	173/173

FIRST YEAR

SEMESTER – I

S. No.	Course Code	Course Title	Course Type	Credit	Hours/ Week		Marks	
					L	P	Internal	External
1	STA5011	Descriptive Statistics	CC	3	3	-	40	60
2	STA5012	Statistical Computing with MS-Excel-I	CCP	2	-	4	100	
3	STA5013	Mathematics for Statistics–I	Minor	3	3	-	40	60
4	STA5014	Introduction to MATLAB	Minor	2	-	4	100	
5	STAOE**	Open Elective	OE	3	3	-	40	60
6	ENGAE1	General English – I	AEC	3	3	-	40	60
7	CYBSEC	Cyber Security	SEC	2	2	-	40	60
8	ENSVAC	Environmental Science	VAC	3	3	-	40	60
			Total	**21**	**25**			

SEMESTER – II

S. No.	Course Code	Course Title	Course Type	Credit	Hours/ Week		Marks	
					L	P	Internal	External
1	STA5021	Mathematics for Statistics –II	Minor	3	3	-	40	60
2	STA5022	Mathematics for Statistics –III	Minor	3	3	-	40	60
3.	STA5023	Scientific Computing using MATLAB	Minor	2	-	4	100	
4.	STA5024	Introduction to R Programming	Minor	2	-	4	100	
5.	STAOE**	Open Elective	OE	3	3	-	40	60
6.	TAMAE1/ HINAE1/ FREAE1	Modern Literature / Hindi Language Learning / Introduction to French Language	AEC	3	3	-	40	60
7.	DRRSEC	Disaster Risk Reduction	SEC	2	2	-	40	60
8.	CONVAC	Constitutional Values	VAC	3	3	-	40	60
		Total		**21**	**25**			
		Cumulative Total		**42**				
For Students exiting after the First year with Certificate in Statistics								
9	STAON**	Skill Development of the Youths and their Livelihood(NPTEL)	VOC	4	4		100	
		Total		**46**				

L:Lecture; P: Practical

SECOND YEAR

SEMESTER – III

S. No.	Course Code	Course Title	Course Type	Credit	Hours/ Week		Marks	
					L	P	Internal	External
1.	STA5031	Elementary Probability Theory-I	CC	3	3	-	40	60
2.	STA5032	Statistical Computing with MS-Excel-II	CCP	2	-	4	100	
3.	STA5033	Mathematics for Statistics-IV	Minor	3	3	-	40	60
4.	CSC5033	Python Programming	Minor	3	3	-	40	60
5.	STAOE**	Open Elective	OE	3	3	-	40	60
6.	TAMAE2/ HINAE2/ FREAE2	Ancient, Epic. Literature & Grammar / Hindi Language: Structure and Literature / French Language and Civilization II	AEC	3	3	-	40	60
7.	STASE01	Introduction to LATEX	SEC	2	2	-	40	60
8.	YOFVAC	Yoga and Fitness	VAC	2	2	-	40	60
		Total		**21**	**23**			

SEMESTER – IV

S. No.	Course Code	Course Title	Course Type	Credit	Hours/ Week		Marks	
					L	P	Internal	External
1	STA5041	Elementary Probability Theory-II	CC	3	3	-	40	60
2	STA5042	Statistical Inference -I	CC	3	3	-	40	60
3	STA5043	Applied Statistics-I	CC	3	3	-	40	60
4	STA5044	Statistics Practical-I	CCP	2	-	4	100	
5	STA5045	Statistics Practical-II	CCP	2	-	4	100	
6	STA5046	Practical on Python programming	CCP	2	-	4	100	
7	ENGAE2	General English - II	AEC	3	3	-	40	60
8	STASE02	Computational tools for Business Analysis	SEC	3	3	-	40	60
9		Extension Activity	EXT	1*				
		Total		**21**	**27**			
		Cumulative Total		**84**				
For students exiting after two years (Diploma in Statistics)								
10		Skill Development of the Youths and their Livelihood(NPTEL)	VOC	4	4		100	
		Total		**88**				

L:Lecture; P: Practical

*Students have to enroll in any one of the following extension activities(NCC/NSS/Red Ribbon) in the first semester and attend the enrolled activity across all fours semesters. The course will be evaluated in the fourth Semester.

THIRD YEAR

SEMESTER – V

S. No.	Course Code	Course Title	Course Type	Credit	Hours/ Week		Marks	
					L	P	Internal	External
1	STA5051	Statistical Inference-II	CC	4	4	-	40	60
2	STA5052	Applied Statistics-II	CC	4	4	-	40	60
3	STA5053	Applied Statistics-III	CC	4	4	-	40	60
4	STA5054	Statistical Models–I	CC	4	4	-	40	60
5	STA5055	Statistics Practical-III	CCP	2	-	4	100	
6	STA5056	Statistics Practical-IV	CCP	2	-	4	100	
7	STAON**	MOOC/NPTEL/ SWAYAM	DSE	3	3	-	-	-
		Total		**23**	**27**			

SEMESTER – VI

S. No.	Course Code	Course Title	Course Type	Credit	Hours/ Week		Marks	
					L	P	Internal	External
1	STA5061	Statistical Models – II	CC	4	4	-	40	60
2	STA5062	Stochastic Processes	CC	4	4		40	60
3	STA5063	Statistics Practical-V	CCP	2	-	4	100	
4	STA5064	Multivariate Analysis	CC	4	4	-	40	60
5	STA5065	Statistical Data Analysis using SPSS	CCP	2	-	4	100	
6	STAEC**	Discipline Specific Elective-I	DSE	3	3	-	40	60
7	STAEC**	Discipline Specific Elective-II	DSE	3	3	-	40	60
8	STAIN01	Internship	INT	2	--	-	40	60
		Total		**24**	**26**			
		Cumulative Total		**131**				

L:Lecture; P: Practical

Students can exit after three years with a B.Sc. Statistics Degree (with 131 credits). Students willing to continue for the fourth year can opt either a B.Sc. Honours/ Honours with Research Degree based on their total CGPA. Students who have secured more than 7.5 CGPA marks in the first 6 semesters are permitted to undertake 4-Year UG Degree (Honours with Research). Others are permitted to undertake 4-Year UG Degree (Honours).

FOURTH YEAR

SEMESTER – VII

S. No.	Course Code	Course Title	Course Type	Credit	Hours / Week		Marks	
					L	P	Internal	External
1	STA5071	Operations Research -I	CC	4	4	-	40	60
2	STA5072	Advanced Probability Theory	CC	4	4	-	40	60
3	STA5073	Advanced Sampling Theory	CC	4	4	-	40	60
4	STA5074	Advanced Statistical Inference	CC	4	4	-	40	60
5	STA5075	Demography	CC	3	3	-	40	60
6	STAON**	MOOC/NPTEL/ SWAYAM	DSE	3	3	-	--	--
		Total		**22**	**22**			

SEMESTER – VIII

S. No.	Course Code	Course Title	Course Type	Credit	Hours/ Week		Marks	
					L	P	Internal	External
For B.Sc., Honours Degree								
1	STA5081	Research Project	PROJ	8	--	16	100	
2	STA5082	Statistical Research Methodology	CC	4	4	-	40	60
3	STA5083	Operations Research – II	CC	4	4	-	40	60
4	STAEC**	Discipline Specific Elective–III	DSE	4	4	-	40	60
		Total		**20**	**28**			
		Overall Total		**173**				
For B.Sc., Honours with Research Degree								
1	STA5081	Research Project	PROJ	12	--	24	100	
2	STA5082	Statistical Research Methodology	CC	4	4	-	40	60
3	STAEC**	Discipline Specific Elective–III	DSE	4	4	-	40	60
		Total		**20**	**32**			
		Overall Total		**173**				

L:Lecture; P: Practical

CC: Core Course; CCP: Core Course Practical; Minor: Allied Courses; DSE: Discipline Specific Elective; OE: Open Elective; AECC: Ability Enhancement Compulsory Course; SEC: Skill Enhancement Course; VAC: Value Added Course; EXT: Extension Activity; VOC: Vocational Course; INT: Internship; PROJ: Research Project Statistics Practical I to V can be done using R/Python.

LIST OF DISCIPLINE SPECIFIC ELECTIVES:

List of Electives for DSE–I

S. No	Course Code	Course Name	Credit	Hours
1	STAEC01	Official Statistics	3	3
2	STAEC02	Actuarial Statistics	3	3
3	STAEC03	Biostatistics	3	3
4	STAEC04	Econometrics	3	3
5	STAEC05	Artificial Intelligence	3	3

List of Electives for DSE–II

S. No	Course Code	Course Name	Credit	Hours
1	STAEC06	Financial Statistics	3	3
2	STAEC07	Reliability Theory and Survival Analysis	3	3
3	STAEC08	Machine Learning	3	3
4	STAEC09	Fuzzy Set Theory and Fuzzy Logic	3	3

List of Electives for DSE–III

S. No	Course Code	Course Name	Credit	Hours
1	STAEC10	Bayesian Methods	3	3
2	STAEC11	Applied Stochastic Processes	3	3
3	STAEC12	Deep Learning	3	3
4	STAEC13	Statistical Methods in Clinical Trials	3	3

OPEN ELECTIVES
(To be offered for other Department students)

S. No	Course Code	Course Name	Credit	Hours	Type
1	STAOE01	Basic Statistics	3	3	OE
2	STAOE02	Data Analysis using Excel	3	3	OE
3	STAOE03	Exploratory Data Analysis	3	3	OE

Minor Courses
(To be offered for other Department students)

S. No	Course Code	Course Name	Credit	Hours	Type
1	STAOM01	Statistics-I	3	3	Minor
2	STAOM02	Statistics-II	3	3	Minor

CORE COURSES
THEORY AND PRACTICAL

SEMESTER - I

STA5011	DESCRIPTIVE STATISTICS	Credits : 3

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Describe statistical concepts and types of data	Remember
CO 2	Summarize data using central tendency and dispersion measures	Understand
CO 3	Analyze relationships using correlation and curve fitting techniques	Apply
CO 4	Apply the process of hypothesis testing and its significance.	Analyze
CO 5	Understand the test of significance, tests based on normal, t, F and Chi-square distributions	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	2	1
CO2	2	3	2	3	2
CO3	1	3	2	3	3
CO4	2	3	2	2	2
CO5	3	2	3	2	2

c. Syllabus :

UNIT I:

Definition of Statistics: Origin, Scope and limitations of statistics – Concepts of Statistical Population and sample. Primary data-Secondary Data, Types of data -Nominal, Ordinal, Ratio, Interval, Classification and Tabulation of data, Data presentation - Frequency Distribution – One dimensional, two dimensional data Visualization: line diagram, Box plots, stem and Leaf plots, Scatter plots, Histogram. **(9H)**

UNIT II:

Measures of Central Tendency: Arithmetic Mean, Median, Mode, Geometric mean and Harmonic mean. Measures of Dispersion: Range, Quartile Deviation, Mean Deviation and Standard Deviation, Coefficient of Variation, Skewness and Kurtosis. **(9H)**

UNIT III:

Empirical moments about mean and any point. Factorial moments, Absolute moments, Interrelationship. Sheppard's correction for moments. Fitting of Straight line, Second-degree Parabola, Power curve and Exponential curves.

(9H)

UNIT IV:

Introduction to Bi-variate data, Correlation: Meaning, Types of Correlation, Measures of Correlation: Karl Pearson's Coefficient of Correlation, Rank Correlation Coefficient (with and without ties), Coefficient of determination, Concept of Multiple and Partial correlation coefficients, and properties. Intra-class correlation **(9H)**

UNIT V:

Theory of Attributes: Notations, Class, Order of class frequencies, Ultimate class frequencies, Consistency of data, Conditions for consistency of data for 2 and 3 attributes only, Independence of attributes, Association of attributes and its measures, Relationship between association and colligation of attributes, Yule's Coefficient, Contingency table: Square contingency, Mean square contingency, Coefficient of mean square contingency, Tschuprow's coefficient of contingency. **(9H)**

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3. Gupta.S.C. and Kapoor.V.K. (2014), Fundamentals of Mathematical Statistics, 12/e, Sultan Chand and sons.
4. Agarwal.B.L (2013), Basic Statistics, 6/e, New Age International Publishers.
5. Anderson.R, Sweeney.J and Williams.A (2019): Statistics for Business and Economics, 13/e, Cengage Publishers
6. Sheldon M.Ross (2005), Introductory Statistics, 2/e, Elsevier Publications.
7. Murray R. Spiegel and Larry J. Stephens (2005), Schaum's Outline of Theory and Problems of Statistics, 3/e, Tata Mc Graw Hill Publishing Company Ltd, New Delhi.

STA5012	STATISTICAL COMPUTING WITH MS–EXCEL - I	Credits:2

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Perform basic Excel file and data operations	Remember
CO 2	Use logical, statistical and mathematical functions in excel	Understand
CO 3	Create graphical statistical presentation using Excel	Apply
CO 4	Compute Statistical measures using Excel	Analyze
CO 5	Evaluate data variability and relationships	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	2	1
CO2	1	3	2	1	2
CO3	2	3	2	3	3
CO4	3	3	2	1	3
CO5	3	2	3	3	3

c. List of Experiments:

1. Introduction to Excel and File Operations
2. Data Operations
3. Functions in Excel
4. Graphical statistics using Excel
5. One dimensional data representation
6. Two dimensional data presentation
7. Perform Operations with Formulas and Functions
8. Construction of Frequency distribution
9. Visualization of frequency distribution (2D and 3D)
10. Computation of Measures of Central Tendency
11. Computation of Measures of Dispersion
12. Computation of Moments about mean and any point
13. Computation of Factorial Moments
14. Computation of Absolute moments
15. Generating Random numbers
16. Calculation of Karl Pearson coefficient of Correlation
17. Calculation of Rank correlation coefficient.
18. Computation of order of class frequencies and Check for consistency
19. Framing Contingency table
20. Computation of Yule and Tschuprow's coefficient

REFERENCES:

1. Jain R. (2021): A to Z of MS EXCEL: A Book for Learners and Trainers, Amazon Digital Services LLC - KDP Print US

2. Minhas, D.S. (2023): All you wanted to know about: creating worksheets with MS-EXCEL, New Dawn publishing

3. Wayne, W L (2019), Microsoft Excel: Data Analysis & Business Model, PHI

4. Aggarwal, V.B, Sood, A. and Gupta, S. (2000): A Tutorial on MS-Excel, Pitambar Publishing Company Private Limited.

5. Frag Curtis (2013). Step by Step Microsoft Excel 2013, Microsoft Press.

6. Agarwal B. L. (2003). Programmed Statistics, Second Edition, New Age International Publisher, New Delhi.

7. Goon A. M., Gupta M.K. and Dasgupta B. (2002). Fundamentals of Statistics, Vol. I and II, 8th Edition, The World Press Pvt. Ltd. Kolkata.

8. Gupta S. P. (2002): Statistical Methods, Sultan Chand and Sons, New Delhi. 5. Gupta V.K. and Kapoor S.C.: Fundamentals of Mathematical Statistics-Sultan & Chand.

STA5013	MATHEMATICS FOR STATISTICS - I	Credits: 3

a. Course Outcomes (COs):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO1	Demonstrate conceptual understanding of algebraic and functional relationships, and their applications to statistical modelling.	Remember
CO2	Apply vector algebra to compute dot and cross product of vectors, and also determine the projection of vectors with its interpretation in physical and geometrical contexts.	Analyze
CO3	Evaluate the gradient of a scalar function and apply it to determine directional derivatives and rates of change.	Skill
CO4	Apply matrix operations to analyze and solve elementary linear systems arising in statistical and data-oriented contexts.	Apply
CO5	Analyze the existence and uniqueness of solutions to linear systems using concepts of rank and consistency.	Understand

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	1	1	2
CO2	3	2	1	1	1
CO3	2	3	2	1	2
CO4	2	3	2	3	3
CO5	2	3	2	3	3

c. Syllabus:

UNIT I:

Real and complex numbers, intervals and inequalities; Sets and set operations, Cartesian products; Relations and functions; Polynomials, factorization, and algebraic identities; Elementary and classical mathematical functions; Exponential and logarithmic expressions.

(9H)

UNIT II:

Scalars and vectors, types of vectors, Dot product, cross product, scalar triple product, vector triple product, projection of vectors, Applications in geometry—angle between vectors, area of triangle/parallelogram. **(9H)**

UNIT III:

Vector-valued functions of one variable, Derivative and integral of vector functions, Curves, Arc length and curvature, Scalar field and vector field, Gradient of a scalar function, Directional derivative, Divergence and curl of a vector field, Laplacian operator. **(9H)**

UNIT IV:

Matrix types and operations—scalar, Hermitian, skew-Hermitian, triangular, diagonal, unitary, equivalent and similar matrices, Transpose and conjugate of matrix, Inverse of a matrix, determinants and its properties, Rank of a matrix. **(9H)**

UNIT V:

Systems of linear equations, Homogeneous and non-homogeneous systems, Existence and uniqueness of solutions, Reduced row echelon form, Gaussian elimination method, Gauss-Jordan method, Eigenvalue problem, Diagonalization. **(9H)**

REFERENCES:

1. Weir, M. D., and Hass, J. (2014). Thomas' Calculus (Early Transcendental), 13th Edition, Pearson Education, Inc.
2. Serge Lang. (1971). Basic Mathematics, Addison-Wesley Series in Introductory Mathematics, Addison-Wesley Publishing Company, Inc.
3. Serge Lang. (1986). Introduction to Linear Algebra, 2nd Edition, Springer Publishers.
4. B. S. Grewal. Higher Engineering Mathematics (Selected early chapters), Khanna Publishers.
5. Marsden J.E., and Tromba A.J. (1996). Vector Calculus, Fourth Edition., W. H. Freeman and Co., New York.
6. Courant R. and John F. (1989). Introduction to Calculus and Analysis, Vol. 2, Springer-Verlag, New York.

STA5014	INTRODUCTION TO MATLAB	Credits: 2

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO1	Navigate and utilize the MATLAB interface and libraries Effectively and also understand its main features and importance for developing programming-skills.	Remember
CO2	Construct and execute basic MATLAB programs involving variables, arrays, matrices, control structures.	Analyze
CO3	Use MATLAB to provide an interactive environment with various built-in functions for dealing polynomials.	Understand
CO4	Apply MATLAB tools for graphical representations and solve differential equations	Apply
CO5	Work with script files, MATLAB basic built-in functions, handle functions, graphics and animation.	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	3	3	2
CO2	3	2	2	3	2
CO3	3	2	2	3	1
CO4	3	2	2	3	1
CO5	3	2	2	3	2

c. List of Experiments:

1. Fundamental of the MATLAB Environments.
2. Implementation of the basic input and output commands.
3. MATLAB code for basic arithmetic operations.
4. Numerical representations, precision and accuracy.
5. Computation of Exponential and logarithmic functions.
6. Computations for Trigonometry functions.
7. Creations of Vectors, Array, Matrices.
8. Perform arithmetic operations on vectors.
9. Creation of functions and anonymous user defined functions.
10. Creating script and function files.
11. Control Structures: if, elseif
12. Control Structures: Switch case, for loop, while loop.
13. Symbolic math tool box.

14. Derivative and integration of functions.
15. Operations on Polynomials and finding zeros of polynomials.
16. Calculation of Polynomial integration and differentiation.
17. Introduction to Plotting Environment.
18. Visualization -2 D and 3 D graphs.
19. Creation of Sub plots and Multiple plots.
20. Solution of differential equations and Visualization.

References:

1. Pratap, R. (2010). Getting Started with MATLAB (A Quick Introduction for Scientists and Engineers), Oxford University Press, Inc., New York.
2. Chapman, S. J. (2017). Essentials of MATLAB Programming, Cengage Learning-Engineering, 3rd Edition.
3. Wendy L. Martinez and Angel R. Martinez. (2016). Computational Statistics Handbook with MATLAB, 3rd Edition, Chapman and Hall/CRC Press.
4. Amos Gilat. (2016). MATLAB: An Introduction with Applications, 6th Edition, Wiley.
5. Higham, D. J., and Higham, N. J. (2005). MATLAB Guide, 2nd Edition, The Society for Industrial and Applied Mathematics (SIAM), Philadelphia, USA.

SEMESTER - II

STA5021	MATHEMATICS FOR STATISTICS - II	Credits: 3

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Explain the basic concept of integration of function.	Remember
CO 2	Understand the derivative of function of two variables, gamma and beta functions.	Understand
CO 3	Apply Laplace transform of functions, derivative and integrals.	Apply
CO 4	Analyze the properties of special functions, matrices and definite integrals.	Analyze
CO 5	Evaluate real time applications by eigenvalue problem, Laplace transform technique.	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	1	1
CO2	3	3	2	2	2
CO3	3	3	1	3	1
CO4	3	2	2	3	2
CO5	3	3	3	3	3

c. Syllabus:

UNIT I:

Differential Calculus: Concept of derivative, derivatives of Algebraic, Trigonometric, hyperbolic, exponential, and logarithmic functions; Product, quotient, chain rule; Maxima and minima, Error Approximation, Taylor theorem. **(9H)**

UNIT II:

Integral Calculus: Definite integral, Properties of Definite Integrals, Bernoulli's formula, Interpretation of integrals and applications, Leibnitz rule, Indefinite integrals. **(9H)**

UNIT III:

Functions of several variables: Partial differentiation – Maxima and Minima of functions of two variables – Integration – Double Integrals – Jacobian transformation. **(9H)**

UNIT IV:

Gamma and Beta function: Definitions – Recurrence Formula for Gamma Function properties of Beta Function– Applications – Relation between Beta and Gamma Integrals.

(9H)

UNIT V:

Laplace Transform : Introduction – definition – properties – Laplace transforms of standard functions – derivatives and integrals of transforms – transform of derivatives and integrals. **(9H)**

REFERENCES:

1. L. Debnath, D. Bhatta (2015), Integral Transforms and their Application, 3rd Edition, CRC Press.
2. B.S. Grewal (2014), Higher Engineering Mathematics, Khanna Publishers.
3. E. Kresiq (2023), Advanced Engineering Mathematics, 10th Edition J. Wiley and Sons.
4. J Stewart (2016), Calculus: Early Transcendentals, 8th Edition, CENGAGE.

M. K. Venkataraman (1965) : Engineering Mathematics, National Publishing Company

STA5022	MATHEMATICS FOR STATISTICS - III	Credits : 3

a.Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Explain the basic facts on real numbers and functions.	Remember
CO 2	Understand the convergence of sequences and series of real numbers.	Understand
CO 3	Apply the concept of Riemann integration in real time applications.	Apply
CO 4	Analyze the concepts of functions, Derivatives and Integration.	Analyze
CO 5	Evaluate the real time applications by sequence of functions and infinite series.	Skill

b.Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	2	1
CO2	3	3	2	2	2
CO3	3	3	1	3	1
CO4	3	2	2	3	2
CO5	3	3	3	3	3

c.Syllabus:

UNIT I:

Vector spaces, Subspaces, Vector differentiation and matrix differentiation, Linear combinations, Linear dependence and independence, Bases and dimension, Change of bases, Vector spaces with inner products, Gram-Schmidt orthogonalization/orthonormalization process., Linear transformation (LT) and matrix representation of LT. **(9H)**

UNIT II:

Matrix Inverse and rank, G-inverse, Moore-Penrose inverse, Eigen values and eigen vectors of LT, Diagonalization of LT, Cayley-Hamilton theorem, Minimal polynomial for LT, Positive definite matrices. **(9H)**

UNIT III:

Orthogonal transformation, Orthogonal projections and Spectral theorem(without proof), Bilinear forms, Quadratic forms, Reduction of quadratic form into a canonical form; Decomposition of a vector space into the Jordan form, Singular value decomposition, Method of Lagrange multipliers.

(9H)

UNIT IV:

Direct methods-Gaussian elimination with pivoting and scaling, LU decomposition; Iterative methods- Jacobi and Gauss-Seidel method; Root finding methods—Secant, Newton-Raphson method.

(9H)

UNIT V:

Interpolation and curve fitting—Lagrange's interpolation, Newton's divided differences interpolation, Least Squares approximation, Interpolation by splines, Numerical differentiation and integration—Trapezoidal and Simpson rules, Taylor series, Euler's methods. **(9H)**

REFERENCES:

1. Strang, G. (2005). Linear Algebra and its Applications, 4th Edition, Cengage Learning India Pvt Ltd.

2. Ramachandra Rao, A. and Bhimasankaran, P. (2000). Linear Algebra. 2ndEdition, Hindustan Book Agency.

3. Searle, S. R. (2006). Matrix Algebra Useful for Statistics (Wiley Series in Probability and Statistics), John Wiley and Sons, Inc., New York.

4. Harville, D. A. (1977). Matrix Algebra from a Statistician's Perspective, Springer.

5. Lange, K. (2010). Numerical Analysis for Statisticians (Statistics and Computing), 2nd Edition, Springer-Verlag New York Inc.

6. Sastry, S. S. (2012). Introductory Methods of Numerical Analysis, 5th Edition, Prentice Hall India (PHI) Learning Private Limited, New Delhi, India.

STA5023	SCIENTIFIC COMPUTING USING MATLAB	Credits : 2

a. Course Outcomes (COs):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO1	Demonstrate computational understanding of applications of matrix algebra in scientific computing.	Remember
CO2	Study computational techniques in MATALAB to find the numerical solutions of nonlinear algebraic equations and interpret their relevance in engineering and science.	Learn
CO3	Analyze and solve constrained and unconstrained optimization problems in MATALAB using Newton, gradient-based, and built-in methods.	Skill
CO4	Apply regression and curve fitting techniques, including least squares, linear, and polynomial methods, to model and analyze data in MATLAB.	Examine
CO5	Employ numerical methods to approximate derivatives and integrals including partial derivatives and quadrature rules using MATLAB.	Apply

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	2	2
CO2	1	2	3	3	3
CO3	1	2	2	3	2
CO4	2	3	3	3	3
CO5	1	2	3	3	2

c. List of experiments

1. Review of MATLAB environment, Vectors, and Matrices.
2. Indexing and Data Access Techniques.
3. Logical Operations and Vectorization Techniques.
4. Matrix Operations for Linear Algebra Applications.
5. Find a root using Bracketing Methods
6. Open Methods for Root Finding (Fixed Point, Newton, and Secant).
7. Solving Linear Systems Using Direct Methods.
8. Matrix Factorization and Eigenvalue Problems.
9. Approximation of Functions and Data.
10. Approximating Functions Using Taylor Series.
11. Unconstrained Optimization Methods.

12. Constrained Optimization and MATLAB Built-in Functions.
13. Interpolation (Linear, Quadratic and Cubic)
14. Curve Fitting-Linear, Polynomial .
15. Linearization of Nonlinear Data and Interpolation.
16. Numerical Differentiation of Single-Variable Functions.
17. Error Analysis in First-Order Derivative Approximation.
18. Numerical Partial Differentiation.
19. Numerical Integration
20. Quadrature Methods.

REFERENCES:

1. Pratap, R. (2010). Getting Started with MATLAB (A Quick Introduction for Scientists and Engineers), Oxford University Press, Inc., New York.
2. Chapra, S. C. (2012). Applied Numerical Methods with MATLAB for Engineers and Scientists, 3rd Edition, The McGraw-Hill Companies, Inc., New York.
3. Arash Karimpour. (2020). Fundamentals of Data Science with MATLAB: Introduction to Scientific Computing, Data Analysis, and Data Visualization, MATLAB Press.
4. Quarteroni, A., Saleri, F., and Gervasio, P. (2014). Scientific Computing with MATLAB and Octave (Texts in Computational Science and Engineering), 4th Edition, Springer Nature.
5. Yang, W.Y., Cao, W., Chung, T.S., and Morris, J. (2005), Applied Numerical Methods Using MATLAB, Johny Wiley and Sons, Inc., Publication.

STA5024	INTRODUCTION TO R PROGRAMMING	Credits: 2

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to
(Course outcomes are specific for a particular course. CO should be specific, measurable, achievable, realistic, and time-bound)

	Course Outcome	Level
CO 1	Understand the basics of R Language	Understand
CO 2	Perform parametric methods	Analyze
CO 3	Apply the logical skills for creating data frames.	Apply
CO 4	Use appropriate plots, charts and diagrams for all kinds of data	Apply
CO 5	Write and execute the code by loops and conditional statements.	Skill

a. Mapping of Program Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	3	3
CO2	3	3	3	3	2
CO3	3	2	2	3	3
CO4	3	3	3	3	3
CO5	3	2	1	3	2

b. List of Experiments

1. Environment setup and basics in R
2. Objects in R
3. Built-in Functions in R
4. Data types in R
5. Data structures in R (Vectors & List)
6. Data structures in R (Arrays & Matrices)
7. Data structures in R (Data frames)
8. R Factors
9. Importing and exporting data in R
10. Control statements: if…else, Nested If, And Or
11. While Loops
12. For Loop
13. Measures of central tendency and measures of dispersion in R
14. Data visualization in R (Plot, Line, Bar, Pie Charts)
15. Data visualization in R (Box plot & Scatter Plot)
16. Graphics in R

17. Checking Normality using Histogram and Q-Q plot.
18. Correlation coefficient – Pearson's, Spearman and Kendall's Tau.
19. One sample and two sample t test.
20. DPLYR package

REFERENCES:

1. Chambers, J. M. (1998). Programming with data: A guide to the S language. Springer Science and Business Media.
2. Venables, W., and Ripley, B. D. (2000). S programming. Springer Science and Business Media.
3. Everitt, B. S. (2019). A handbook of statistical analyses using S-Plus. CRC Press.
4. Dalgaard, P. (2002).Statistics and computing: Introductory Statistics with R. Springer.
5. Maindonald, J., and Braun, J. (2006). Data analysis and graphics using R: an example-based approach (Vol. 10). Cambridge University Press.
6. https://pll.harvard.edu/subject/r
7. https://nptel.ac.in/courses/111/104/111104100/

SEMESTER - III

STA5031	ELEMENTARY PROBABILITY THEORY-I	Credits: 3

a. Course Outcomes (COs):

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

CO No.	Course Outcome	Cognitive Levels
CO1	Explain the basic concepts of unconditional and conditional probability	Remember, Understand
CO2	Understand and obtain the CDF, Expectations, Moments and Inequalities.	Remember, Apply & Evaluate
CO3	Describe the concepts of convergence and their implications.	Understand, Apply
CO4	Understand and Analyze the importance of Independence and Law of large numbers	Understand, Analyze
CO5	Describe and Derive the Central Limit Theorems and their application.	Remember-Apply

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	2
CO2	3	3	3	3	2
CO3	3	3	2	2	1
CO4	3	3	3	2	2
CO5	3	2	2	3	1

c. Syllabus :

UNIT I:

Probability: Sample space – Events – elementary events, mutually exclusive events - algebraic operations on events- definition of probability – *apriori* probability, *aposteriori* probability, axioms of probability - independent events – conditional probability - Addition and Multiplication theorems of probability – Bayes Theorem. Simple problems-Applications to real time problems. **(9H)**

UNIT II:

Random variables: Discrete and continuous random variables – distribution function - properties – probability mass function and probability density function – discrete and continuous probability distributions. Simple problems- Applications to real time problems. **(9H)**

UNIT III:

Multiple random variables: Joint, Marginal and Conditional distribution functions - independence of random variables – Algebra of random variables and their distribution functions. Simple problems- Applications to real time problems.

(9H)

UNIT IV:

Mathematical expectation: Expectation – properties – Cauchy - Schwartz inequality, conditional expectation and conditional variance. Moment generating function, characteristic function, probability generating function and their properties. Chebyshev's inequality. Simple problems- Applications to real time problems.

(9H)

UNIT V:

Standard Statistical Distributions: Bernoulli, Binomial, Poisson, Normal, distributions. Moments – probability generating function, moment generating function, characteristic function and properties. Simple problems- Applications to real time problems.

(9H)

REFERENCES:

1. Ramachandran, K.M., C.P.Tsokos (2009). Mathematical Statistics with Applications. Academic Press, New York.
2. Ross, S.M. (2010) A First Course in Probability (8th Edn), Pearson Education Ltd., New Jersey.
3. Hoel P.G., Port, S., and C.J.Stone (1971). Introduction to Probability Theory. Houghton Mifflin Co., London.
4. Larson, H.J. (1982). Introduction to Probability and Statistical Inference (3rd Edn.). John Wiley & Sons., New York.
5. Dhanavanthan, P., and K.M.Sakthivel(2025). Probability Distributions – A Comprehensive Approach. Ane Publishers and Distributors, New Delhi.
6. Mukhopadhyay, P. (2006). Mathematical Statistics, 3rd Edition. Books and Allied Publishers, Kolkatta.
7. Goon, A. M., M.K. Gupta, and B. Dasgupta (2002) Fundamentals of Statistics, Vol. I, (Third Edition), World Press Ltd, Kolkata.
8. Alexander, M. Mood, Franklin A. Graybill and Duane C. Boes (2017). Introduction to the Theory of Statistics (Third Edition), Mc Graw Hill Education, New Delhi.
9. Robert, V. Hogg, Joseph W. McKean and Allen T. Craig (2013) Introduction to Mathematical Statistics (Seventh Edition), Pearson Education, New York.
10. https://swayam.gov.in/nd2_cec20_ma01/preview
11. https://nptel.ac.in/courses/111/104/111104032/

STA5032	STATISTICAL COMPUTING WITH MS-EXCEL - II	Credits: 2

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Calculate Probability	Remember
CO 2	Use logical, statistical and mathematical functions in excel	Understand
CO 3	Create graphical statistical presentation using Excel	Apply
CO 4	Calculate PDF,CDF, Marginal and Conditional distributions	Analyze
CO 5	Analyse distributions	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	2	1
CO2	1	3	2	1	2
CO3	2	3	2	3	3
CO4	3	3	2	1	3
CO5	3	2	3	3	3

c. List of Experiments:

1. Basic calculations using Pivot Tables, Pivot charts
2. Matrix Operations – Addition, multiplication, subtraction, inverse and transpose
3. Calculation of probability applying *apriori* probability
4. Calculation of probability applying additive theorem of probability
5. Calculation of conditional probability
6. Calculation of probability applying multiplicative theorem of probability
7. Calculation of probability applying Bayes Theorem
8. Calculation of non-central moments
9. Computation of Mean and Variance for discrete random variable
10. Calculation of co-efficient of Skewness and co-efficient of kurtosis for discrete random variable
11. Calculation of non-central moments for continuous random variable
12. Computation of Mean, Variance for continuous random variable

13. Computation of Co-efficient of Skewness and co-efficient of kurtosis for continuous random variable
14. Computation of Moment generating function and characteristic function
15. Computation of Mean and Standard Deviation for Binomial Distribution
16. Fitting of Binomial distribution
17. Computation of Mean and Standard Deviation for Poisson Distribution
18. Fitting of Poisson distribution
19. Fitting of Normal distribution (area method)
20. Fitting of Normal distribution (ordinate method)

REFERENCES:

1. Ramachandran, K.M., C.P.Tsokos (2009). Mathematical Statistics with Applications. Academic Press, New York.
2. Ross, S.M. (2010) A First Course in Probability (8th Edn), Pearson Education Ltd., New Jersey.
3. Hoel P.G., Port, S., and C.J.Stone (1971). Introduction to Probability Theory. Houghton Mifflin Co., London.
4. Larson, H.J. (1982). Introduction to Probability and Statistical Inference (3rd Edn.). John Wiley & Sons., New York.
5. Dhanavanthan, P., and K.M.Sakthivel(2025). Probability Distributions – A Comprehensive Approach. Ane Publishers and Distributors, New Delhi.
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8. Alexander, M. Mood, Franklin A. Graybill and Duane C. Boes (2017). Introduction to the Theory of Statistics (Third Edition), Mc Graw Hill Education, New Delhi.
9. Robert, V. Hogg, Joseph W. McKean and Allen T. Craig (2013) Introduction to Mathematical Statistics (Seventh Edition), Pearson Education, New York.
10. https://swayam.gov.in/nd2_cec20_ma01/preview
11. https://nptel.ac.in/courses/111/104/111104032/

STA5033	MATHEMATICS FOR STATISTICS-IV	Credits : 3

a. Course Outcomes (COs):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO1	Explain vector-space concepts, including bases, dimension, matrix representations of linear transformations and their properties, and inner products.	Understand
CO2	Determine the G-inverse and pseudo-inverse of a matrices, and compute eigenvalues and eigenvectors of LT with both algebraic and geometric interpretation.	Skill
CO3	Define and analyze bilinear and quadratic forms, and reduce quadratic forms to canonical forms.	Analyze
CO4	Study some direct and iterative methods for solving systems of simultaneous algebraic equations.	Remember
CO5	Understand various types of polynomials and spline interpolation to construct interpolating polynomials for given data	Apply

b.Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	1	2	1
CO2	3	2	2	3	1
CO3	2	1	1	2	1
CO4	1	3	2	3	2
CO5	1	2	2	3	3

c. Syllabus:

UNIT I:

Real numbers – Least upper bound – Greatest lower bound. Sequence of real numbers: Limit of a sequence – Convergent sequences, Divergent sequences – Bounded sequences – Monotone sequences – Cauchy's first and second theorem on limits –Cauchy's general principle of convergence. **(9H)**

UNIT II:

Series of real numbers : Convergence and divergence – Series with non-negative terms – comparison test, D'Alembert's ratio test, Cauchy's Root test – Alternating series – absolute convergence and conditional convergence – Leibnitz test.

(9H)

UNIT III:

Functions: Limit of real valued function in one variable, continuity – types of discontinuities – algebra of continuous functions – Extreme value theorem – Intermediate value theorem. **(9H)**

UNIT IV:

Uniformly Continuous functions – Increasing and Decreasing functions – Differentiability – Rolle's Theorem – Mean value theorem for derivatives – Taylor's Series expansion.

(9H)

UNIT V:

Riemann Integration: Definition and existence of the integral – refinement of partitions – Darboux's theorem – Conditions of Integrability – Integrability of sum and modulus of integrable functions – Integration and Differentiation – Fundamental Theorem of Calculus. **(9H)**

REFERENCES:

1. T. M. Apostol (1985), Mathematical Analysis, Narosa Publishing House.
2. R. R. Goldberg (1970), Methods of Real Analysis, Oxford & IBH.
3. S. C. Malik and S. Arora (2021), Mathematical Analysis, 6^{th} Edition, New Age International Publishers.
4. M.T. Nair (2022), Calculus of one variable, Springer International Publishing.
5. W. Rudin (1976) , Principles of Mathematical Analysis, 3^{rd} Edition, McGrawHill Company.

CSC5033	PYTHON PROGRAMMING	Credits : 3

a. Course Outcomes (COs):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO1	Understand the fundamental concepts of python and its main components	Understand
CO2	Develop (Read and Write) python programs using variables, assignments, and conditional statements using functions	Skill
CO3	Illustrate and implement different data structures	Analyze
CO4	Demonstrate Object-oriented concepts and file handling	Remember
CO5	Analyse and plot data using python visualization libraries	Apply

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	2	3	3
CO3	3	3	2	3	3
CO4	3	3	3	3	3
CO5	3	3	3	2	3

c. Syllabus:

UNIT I : INTRODUCTION

Introduction to python, Variables, Assignment, Keywords, Built-in functions, Indentation, Comments, Basic data types - integers, float, complex, Boolean, strings; Python program development, running python using REPL shell, Python scripts. Operators and Expressions: Operators- arithmetic operators, comparison (relational) operators, assignment operators, logical operators, bitwise operators, membership operators, identity operators; Expressions and order of evaluations. Control Structures: Conditional control structures - if, else if, else; Loop control structures - for while, for... else, while…else, nested loops, break, continue, pass.

(9H)

UNIT II: PYTHON DATA STRUCTURES AND FUNCTIONS

Data Structures: Lists, Tuples, Sets, Strings, Dictionary - creation, accessing, basic operators and methods; List comprehensions. Functions: Defining functions, calling functions, Passing arguments - keyword arguments, default arguments, positional arguments, variable-length arguments; Types of functions- anonymous functions, fruitful function, recursive functions; Scope of the variables- global and local variables, Development of recursive and non-recursive functions.

(9H)

UNIT III: MODULES, PACKAGES AND OOPS

Creating modules, Import Statement, from...Import Statement, Name Spacing, Creating user defined modules. Standard Modules: sys, math, date, time, os, random and itertools modules. Packages: Package Initialization, Importing * From a Package, Sub packages.

(9H)

UNIT IV: OBJECT ORIENTED PROGRAMMING

Classes and Objects, Attributes and Methods, Constructors and Destructors- (init and del methods), Encapsulation - bundling of data and methods within a class, promotes data integrity and prevents unauthorized access, use of access modifiers to control access to attributes and methods; Inheritance, Method Overriding, Polymorphism, Abstraction, Class and Instance Variables - Differentiate between class variables (shared among all instances) and instance variables (unique to each instance), Access Modifiers-access modifiers and their role in controlling access to class members. Operator Overloading: customization of operators for user- defined classes- define methods such as add, sub, mul, etc.

(9H)

UNIT V: ERRORS AND EXCEPTIONS AND FILES

Introduction to Exceptions, Handling Exception, Try Except Else and Finally Block, Raising Exceptions. File Processing: Reading and writing files -creating a new file, writing to a file, reading text files, opening and closing files, reading, writing, tell (), seek (), rename ().

(9H)

REFERENCES:

1. Eric Matthes, Python Crash Course, No Starch Press, Second edition, 2019
2. Martin C. Brown, Python: The Complete Reference, McGraw Hill Education, Fourth edition, 2018
3. Ryan Marvin Mark Ng'Ang'A Amos Omondi, Python Fundamentals, Packet Publishing, Second edition, 2018
4. Zed Shaw, Learn Python 3 the Hard Way: A Very Simple Introduction to the Terrifyingly Beautiful World of Computers and Code, Addison-Wesley Professional, First edition, 2017.

STASE01	INTRODUCTION TO LATEX	Credits : 2

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Explain the Latex document structure and Beamer presentation.	Remember
CO 2	Understand Latex and beamer coding.	Understand
CO 3	Apply coding to create tables, equations and insert figures.	Apply
CO 4	Analyze the suitable coding for mathematical expression.	Analyze
CO 5	Prepare research reports, presentations, and articles.	Skill

b. Mapping of Program Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	2	2	1
CO2	2	1	2	2	1
CO3	2	2	2	3	1
CO4	3	2	2	3	3
CO5	3	3	3	2	2

C. Syllabus:

UNIT I:

Introduction, Installation: Beginning typesetting - LaTeX. Basics for document structure, and preamble preparation. **(6H)**

UNIT II:

Latex commands: font colour, font size, make title, the syntax for beginning document, new page, sectioning **(6H)**

UNIT III:

Tables and Figures: Create Tables, Insert figures, enumeration list, itemized list, font effects, and insert equations. **(6H)**

UNIT IV:

References: Insert - Manual - BibTex, cite reference, Drafting a research manuscript. **(6H)**

UNIT V:

Introduction to Beamer: Introduction, Workflow for creating Beamer presentation, guidelines, creating frames, structuring the presentations. **(6H)**

REFERENCES:

1. Griffiths, D. F., Higham, D. J. (2016). Learning LaTeX. United States: Society for Industrial and Applied Mathematics.

2. Lamport, L. (2001). Latex: A Document Preparation System : User's Guide and Reference Manual. United States: Addison-Wesley.

3. Erickson, M., Bindner, D. (2011). A Student's Guide to the Study, Practice, and Tools of Modern Mathematics. United Kingdom: Taylor and Francis.

4. Kottwitz, S. (2021). LaTex Beginner's Guide - Second Edition: Create Visually Appealing Texts, Articles, and Books for Business and Science Using LaTex. India: Packt Publishing.

5. Tantau, T., Wright, J., Miletic, V. (2016). The BEAMER Class: User Guide for Version 3.49. (n.p.): 12th Media Services.

SEMESTER -IV

STA5041 ELEMENTARY PROBABILITY THEORY - II CREDITS : 3

a. Course Outcomes (COs):

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

CO No.	Course Outcome	Cognitive Level
CO1	Compute marginal and conditional distributions from joint distributions	Remember – Apply
CO2	Obtain the distributions of functions of random variables	Remember, Create
CO3	Describe the properties of univariate discrete and truncated distributions and their asymptotic results	Apply, Evaluate
CO4	Analyze the properties of univariate continuous distributions, their asymptotic results and bivariate normal distribution	Analyze
CO5	Derive the sampling distributions of Order Statistics; central, non-central sampling distributions and their asymptotic results.	Remember, Create

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	3	3	2
CO2	2	3	3	2	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	2	3	2	2

c. Syllabus:

Unit I:

Limit Theorems: convergence in probability, weak law of large numbers – Bernoulli's theorem, Khintchine's theorem (statements only) – convergence in distribution - Central limit theorems – De Moivre-Laplace CLT, Levy-Lindeberg CLT. Applications to real life situations. Simple problems. **(9H)**

UNIT II:

Distributions of functions of one-dimensional and two-dimensional random variables – Distribution function method, Transformations and Moment Generating Function method. Applications to real life situations, Simple problems. **(9H)**

UNIT III:

Standard Discrete distributions: Discrete Uniform, Truncated Poisson, Geometric, Negative binomial and hypergeometric distributions, Moments – probability generating function, moment generating function, characteristic function and properties. Applications to real life situations, Simple problems. **(9H)**

UNIT IV:

Standard continuous distributions: Uniform, beta of the first kind, Beta of the second kind, Gamma, Exponential, Cauchy distributions - concepts, Moments, Moment Generating function, Characteristic function and properties. Applications to real life situations. Simple problems. **(9H)**

UNIT V:

Exact Sampling Distributions: *Student*'s t, χ^2 and F distributions – derivation of Probability Density Function, moments, moment generating function, characteristic function. Interrelationships. Tables of these distributions and their uses.

(9H)

REFERENCES:

1. Ramachandran, K.M., C.P.Tsokos (2009). Mathematical Statistics with Applications. Academic Press, New York.

2. Ross, S.M. (2010) A First Course in Probability (8th Edn), Pearson Education Ltd., New Jersey.

3. Hoel P.G., Port, S., and C.J.Stone (1971). Introduction to Probability Theory. Houghton Mifflin Co., London.

4. Larson, H.J. (1982). Introduction to Probability and Statistical Inference (3rd Edn.). John Wiley & Sons., New York.

5. Dhanavanthan, P., and K.M.Sakthivel(2025). Probability Distributions – A Comprehensive Approach. Ane Publishers and Distributors, New Delhi.

6. Mukhopadhyay, P. (2006). Mathematical Statistics, 3rd Edition. Books and Allied Publishers, Kolkatta.

7. Goon, A. M., M.K. Gupta, and B. Dasgupta (2002) Fundamentals of Statistics, Vol. I, (Third Edition), World Press Ltd, Kolkata.

8. Alexander, M. Mood, Franklin A. Graybill and Duane C. Boes (2017). Introduction to the Theory of Statistics (Third Edition), Mc Graw Hill Education, New Delhi.

9. Robert, V. Hogg, Joseph W. McKean and Allen T. Craig (2013) Introduction to Mathematical Statistics (Seventh Edition), Pearson Education, New York.

10. https://swayam.gov.in/nd2_cec20_ma01/preview

11. https://nptel.ac.in/courses/111/104/111104032/

STA5042	STATISTICAL INFERENCE - I	Credits : 3

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Recall the concept of consistency, CAN & large sample tests.	Remember
CO 2	Derive CAN & BAN estimators for various families .	Understand
CO 3	Compute asymptotic Confidence Interval and interpret.	Apply
CO 4	Implement large sample tests and interpret. Compare tests based on efficiency.	Analyze
CO 5	Derive & compute Bayesian estimator, credible interval & testing of hypothesis.	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	1	1
CO2	2	3	2	1	2
CO3	2	3	2	3	3
CO4	2	3	2	3	3
CO5	1	2	3	1	3

c. Syllabus:

UNIT I:

Statistical Inference: meaning and purpose, Parameter and Statistic. Estimator and estimate. Point Estimation: consistency, unbiasedness, efficiency and sufficient statistic – Neyman-Fisher factorization theorem (without proof). Minimum sufficient statistics, Completeness, Simple problems.

(9H)

UNIT II :

Methods of Point Estimation: Method of moments, Method of maximum likelihood. Properties of estimators obtained by these methods. Asymptotic properties of maximum likelihood estimators (without proof). Method of Minimum χ^2 and Method of Modified Minimum χ^2. Simple problems.

(9H)

UNIT III :

Interval estimation: Interval estimator, confidence coefficient, confidence limits, pivotal quantity. Interval estimation for proportions, mean(s), variance(s) based on *Student*'s t, χ^2 and F normal distributions. Simple problems. **(9H)**

UNIT IV:

Statistical hypotheses, simple and composite hypotheses, null and alternative hypotheses-critical region, two kinds of errors and their probabilities, level of significance, power. Randomized and non-randomized tests. Most powerful test, Neyman-Pearson lemma. Simple problems. **(9H)**

UNIT V:

Significance tests based on Student's t, $\chi 2$ and F distributions and normal distribution concerning means, difference between two means (independent and dependent samples), variance and variance ratio, Tests for correlation, partial and multiple correlation coefficient – Tests of association and independence – Goodness of fit. Simple problems. **(9H)**

REFERENCES:

1. Ramachandran, K.M., C.P.Tsokos (2009). Mathematical Statistics with Applications. Academic Press, New York.

2. Rajagopalan, M., and P. Dhanavanthan (2012). Statistical Inference. PHI Learning, New Delhi.

3. Mukhopadhyay, P. (2006). Mathematical Statistics, 3rd Edition. Books and Allied Publishers, Kolkatta.

4. Casella, G., R.L.Berger(2024). Statistical Inference, 2nd Edition. Chapman and Hall, New York.

5. Goon, A. M., M.K. Gupta, and B. Dasgupta (2002) Fundamentals of Statistics, Vol. I, Vol. II (Third Edition), World press Ltd, Kolkata.

6. Alexander, M. Mood, Franklin A. Graybill and Duane C. Boes (2017). Introduction to the Theory of Statistics (Third Edition), Mc Graw Hill Education, New Delhi.

7. Bhuyan K.C. (2010), Probability Distribution Theory and Statistical Inference, New Central Book Agency (P) Ltd., New Delhi.

8. Robert, V. Hogg, Joseph W. McKean and Allen T. Craig (2013) Introduction to Mathematical Statistics (Seventh Edition), Pearson Education, New York.

9. https://swayam.gov.in/nd2_cec20_ma01/preview

10. https://nptel.ac.in/courses/111/104/111104032/

STA5043	APPLIED STATISTICS - I	Credits : 3

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Recall the principles of the Design of Experiment.	Remember
CO 2	Explain procedure of CRD and RBD.	Apply
CO 3	Explain and apply LSD and BIBD.	Analyze
CO 4	Understand need of Sample survey	Understand
CO 5	Decide appropriate sampling strategy	Apply

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	2	3
CO2	2	3	2	1	2
CO3	2	3	2	3	3
CO4	3	3	2	1	3
CO5	1	3	3	2	3

c. Syllabus:

UNIT I:

Analysis of variance: Definitions of fixed, random and mixed effect models, analysis of variance and covariance in one-way classified data for fixed effect and random effect models, Analysis of variance and covariance in two-way classified data with one observation per cell for fixed effect and random effect models, Analysis of covariance.

(9H)

UNIT II:

Experimental designs: Role, 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). **(9H)**

UNIT III:

Randomized Block Design (RBD), Latin Square Design (LSD)–layout, model and statistical analysis, relative efficiency, Analysis with missing observations. **(9H)**

UNIT IV:

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. **(9H)**

UNIT V:

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, post stratification and its performance. Systematic Sampling: Technique, estimates of population mean and total, variances of these estimates (N=nk). **(9H)**

References:

1. D. C. Montgomery, Design and Analysis of Experiments, fifth edition, John Wiley, 2008.
2. M.N. Das, and N. C. Giri, Design and Analysis of Experiments, second edition, Wiley Eastern, 1991.
3. Hinkelmann, K., & Kempthorne, O. (2007). Design and analysis of experiments, volume 1: Introduction to experimental design (Vol. 1). John Wiley & Sons.
4. Davies, O. L. (1956), Design and Analysis of Industrial Experiments, 2nd edition Hafner Publishing Company, New York.
5. Cochran W.G. (1984). Sampling Techniques, (3rd Ed.), Wiley Eastern.
6. 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
7. Murthy M.N. (1977). Sampling Theory & Statistical Methods, Statistical Pub. Society, Calcutta.

STA5044	STATISTICS PRACTICAL - I	Credits : 2

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Generate random numbers using distributions	Remember
CO 2	Find Point estimators	Apply
CO 3	Find Interval estimators	Analyze
CO 4	Test the significance for small sample problems	Understand
CO 5	Test the significance for large sample problems	Apply

b. Mapping of Program Specific Outcomes with Course Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	2	3
CO2	2	3	2	1	2
CO3	2	3	2	3	3
CO4	3	3	2	1	3
CO5	1	3	3	2	3

C. List of Experiments:

1. Verifying Khintchine's Weak Law of Large Numbers, De Moivre-Laplace Central Limit Theorem and Levy-Lindeberg Central Limit Theorem
2. Drawing of random numbers from Binomial distribution and fitting of distribution.
3. Drawing of random numbers from Poisson distributions and fitting of distribution
4. Drawing of random numbers from Normal distribution and fitting of distribution
5. Drawing of random numbers from Exponential distribution and fitting of distribution

Point Estimation

6. Finding moment estimator and its standard error (ungrouped and grouped data)
7. Finding maximum likelihood estimator and its standard error (ungrouped and grouped data)
8. Finding maximum likelihood estimator and its standard error (method of scoring)
9. Finding minimum χ^2 estimator (grouped data)
10. Finding modified minimum χ^2 estimator (grouped data)

Interval Estimation (Small Sample problems)

11. Confidence interval construction for mean of normal distribution (variance unknown)
12. Confidence interval construction for variance of normal distribution (mean unknown)

13. Confidence interval construction for difference between means of two normal distributions (Variances are common, but unknown)

14. Confidence interval construction for ratio of variances of two normal distributions (means are unknown)

Interval Estimation (Large Sample problems)

15. Confidence interval construction for mean, variance of normal distribution and for difference between means of two normal distributions
16. Confidence interval construction for population proportion and for difference between two population proportions

Tests of Significance (Small Sample problems)

17. Testing hypotheses concerning mean of normal distribution (variance unknown) and variance of normal distribution (mean unknown)

18. Testing hypotheses concerning difference between means of two normal distributions
(Variances are common, but unknown) and ratio of variances of two normal distributions (means are unknown)

Tests of Significance (Large Sample problems)

19. Testing hypotheses concerning mean and variance of normal distribution and difference between means of two normal distributions
20. Testing Goodness-of-fit & Testing independence of Attributes ($m, n \leq 5$)

REFERENCES:

1. Ramachandran, K.M., C.P.Tsokos (2009). Mathematical Statistics with Applications. Academic Press, New York.
2. Rajagopalan, M., and P. Dhanavanthan (2012). Statistical Inference. PHI Learning, New Delhi.
3. Mukhopadhyay, P. (2006). Mathematical Statistics, 3rd Edition. Books and Allied Publishers, Kolkatta.
4. Casella, G., R.L.Berger(2024). Statistical Inference, 2nd Edition. Chapman and Hall, New York.
5. Goon, A. M., M.K. Gupta, and B. Dasgupta (2002) Fundamentals of Statistics, Vol. I, Vol. II (Third Edition), World press Ltd, Kolkata.
6. Alexander, M. Mood, Franklin A. Graybill and Duane C. Boes (2017). Introduction to the Theory of Statistics (Third Edition), Mc Graw Hill Education, New Delhi.
7. Bhuyan K.C. (2010), Probability Distribution Theory and Statistical Inference, New Central Book Agency (P) Ltd., New Delhi.
8. Robert, V. Hogg, Joseph W. McKean and Allen T. Craig (2013) Introduction to Mathematical Statistics (Seventh Edition), Pearson Education, New York.

9. https://swayam.gov.in/nd2_cec20_ma01/preview

STA5045	STATISTICS PRACTICAL - II	Credits: 2

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Recall the principles of the Design of Experiment.	Remember
CO 2	Explain procedure of CRD and RBD.	Apply
CO 3	Explain and apply LSD and BIBD.	Analyze
CO 4	Understand need of Sample survey	Understand
CO 5	Decide appropriate sampling strategy	Apply

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	2	3
CO2	2	3	2	1	2
CO3	2	3	2	3	3
CO4	3	3	2	1	3
CO5	1	3	3	2	3

c. List of Experiments:

1. Analysis of Variance of one-way classified data
2. Analysis of Variance of two-way classified data with one observation
3. Analysis of Covariance of one-way classified data
4. Analysis of Covariance of two-way classified data
5. Analysis of a CRD
6. Analysis of an RBD
7. Analysis of an LSD
8. Analysis of a missing plot for CRD
9. Analysis of an RBD with one missing observation
10. Analysis of an LSD with one missing observation
11. Analysis of a missing plot for RBD
12. Analysis of a missing plot for LSD
13. To select SRS with replacement.
14. To select SRS without replacement.
15. For a population of size 5, estimate population mean, population mean square and population variance. Enumerate all possible samples of size 2 by WR and WOR and establish all properties relative to SRS.
16. For SRSWOR, estimate mean, standard error, the sample size
17. Stratified Sampling: allocation of sample to strata by proportional allocation.
18. Stratified Sampling: allocation of sample to strata by Neyman's methods.

19. Compare the efficiencies of above two allocations of Stratified sampling to SRS.
20. Estimation of gain in precision in stratified sampling.

REFERENCES:

1. Ramachandran, K.M., C.P.Tsokos (2009). Mathematical Statistics with Applications. Academic Press, New York.
2. Ross, S.M. (2010) A First Course in Probability (8^{th} Edn), Pearson Education Ltd., New Jersey.
3. Hoel P.G., Port, S., and C.J.Stone (1971). Introduction to Probability Theory. Houghton Mifflin Co., London.
4. Larson, H.J. (1982). Introduction to Probability and Statistical Inference (3^{rd} Edn.). John Wiley & Sons., New York.
5. Dhanavanthan, P., and K.M.Sakthivel(2025). Probability Distributions – A Comprehensive Approach. Ane Publishers and Distributors, New Delhi.
6. Mukhopadhyay, P. (2006). Mathematical Statistics, 3^{rd} Edition. Books and Allied Publishers, Kolkatta.
7. Goon, A. M., M.K. Gupta, and B. Dasgupta (2002) Fundamentals of Statistics, Vol. I, (Third Edition), World Press Ltd, Kolkata.
8. Alexander, M. Mood, Franklin A. Graybill and Duane C. Boes (2017). Introduction to the Theory of Statistics (Third Edition), Mc Graw Hill Education, New Delhi.
9. Robert, V. Hogg, Joseph W. McKean and Allen T. Craig (2013) Introduction to Mathematical Statistics (Seventh Edition), Pearson Education, New York.
10. https://swayam.gov.in/nd2_cec20_ma01/preview
11. https://nptel.ac.in/courses/111/104/111104032/

STA5046	PRACTICAL ON PYTHON PROGRAMMING	Credits : 2

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Understand and use the essential modules in Python.	Remember
CO 2	Use classes and objects in application programs and visualize data.	Understand
CO 3	Deal with Tuples.	Apply
CO 4	Apply suitable programming constructs and built-in data structures to solve a problem.	Analyze
CO 5	Understand the library functions.	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	2	1
CO2	3	3	2	3	2
CO3	2	2	3	2	3
CO4	3	2	2	1	2
CO5	2	2	3	2	1

c. List of Experiments:

1. Python Environment
2. Algorithm, Flowchart and Pseudocode
3. Variables, Data Types, Operators and Built-in Functions
4. Importing from Packages
5. Control Structures
6. Looping structure
7. Lists , Dictionary & comprehensions
8. Creation of Indices
9. Operations on tuples dictionary
10. Operations on dictionaries sets
11. Statistical computing
12. Strings and Regular expressions
13. Patterns
14. String operations(Comparison, Formatting, Slicing, Splitting, Stripping)
15. Functions
16. Arguments

17. Recursive and lambda functions
18. Files and operations%(Create, Open, Read, Write, Append and Close tell and seek methods)
19. Built – In modules User-Defined modules
20. Numpy and Pandas packages

REFERENCES:

1. Matthes, E. (2023). Python crash course: A hands-on, project-based introduction to programming. no starch press.

2. Brown, M. C. (2001). Python: The complete reference. McGraw-Hill Professional.

3. Guttag, J. V. (2016). Introduction to computation and programming using Python: With application to understanding data. MIT press.

4. Mark Lutz (2007). Learning Python, 3rd Edition.

5. Vamsi Kurama (2017), Python Programming: A Modern Approach, Pearson.

6. Allen Downey,(2017),Think Python, 2nd Edition, Green Tea Press.

7. W.Chun(2016), Core Python Programming, 2016, Pearson.

8. Kenneth A. Lambert (2015). Introduction to Python, Cengage.

STASE02	COMPUTATIONAL TOOLS FOR BUSINESS ANALYSIS	Credits : 3

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	To learn the basics of Tableau.	Remember
CO 2	To understand the advanced tableau technique.	Understand
CO 3	Apply Power BI for data visualization.	Apply
CO 4	Analysis of dashboards using Power BI.	Analyze
CO 5	To build database using SQL.	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	2	1
CO2	2	3	2	3	2
CO3	1	3	2	3	3
CO4	2	3	2	2	2
CO5	3	2	3	2	2

c. Syllabus:

UNIT I :

Introduction to Data Visualization and Tableau, Role of Tableau in Business Analytics, Getting Started with Tableau Desktop and Tableau Server, Connecting Tableau to Data Sources: Connecting to Excel and CSV Files, Connecting to Cloud Services (Google Sheets, AWS, etc.), Live vs Extract Connections. Building Dashboards and Preparing Data, Creating Interactive Dashboards and Visualizations, Data Preparation and Cleaning in Tableau, Exploratory Data Analysis with Tableau. **(9H)**

UNIT II :

Advanced Tableau Techniques: Creating Calculated Fields and Parameters, Advanced Visualization Techniques, Designing Effective Dashboards, Project-Based Learning and Real-World Applications: Business Data Analytics in Practice, Project Planning and Execution, Capstone Project: Integration of Skills. **(9H)**

UNIT III:

Introduction to Power BI, Setting Up Power BI: Installing Power BI Desktop, Navigating the Power BI Interface, Connecting Power BI to Power BI Service. Connecting and Preparing Data: Connecting to Data Sources, Data Transformation in Power BI, Data Modeling in Power BI. **(9H)**

UNIT IV :

Building and Enhancing Reports: Creating Interactive Reports and Dashboards, Advanced Visualizations, Advanced Analytics and Insights. Collaboration and Sharing: Analyzing and Sharing Data, Collaboration and Data Governance. **(9H)**

UNIT V:

Introduction to SQL: Relational Database Fundamentals, SQL Fundamentals, The Components of SQL, Using SQL to Build Databases, Retrieving Data, Controlling Operations , SQL in the Real World: ODBC and JDBC , SQL:2003 and XML. **(9H)**

REFERENCES:

1. Murray, D. (2016). Tableau your data!: Fast and easy visual analysis with Tableau software (2nd ed.). John Wiley & Sons.
2. Jones, M. (2020). Learning Tableau: Tools for business intelligence, data prep, and visual analytics (3rd ed.). O'Reilly Media.
3. Duerr, L. (2022). Tableau for dummies (2nd ed.). John Wiley & Sons.
4. Chandra, D. (2020). Beginning Microsoft Power BI: A practical guide to self-service data analytics with Excel & Power BI. Apress.
5. Judah, J., & Barone, P. (2022). A beginner's guide to Microsoft Power BI: A step-by-step course in data modeling, visualization, and dashboards. Independently Published.

   Allen, W. (2018). SQL all-in-one for dummies. John Wiley & Sons.
6. Viescas, J. L., & Hernandez, M. (2014). SQL queries for mere mortals: A hands-on guide to data manipulation in SQL (3rd ed.). Addison-Wesley.

SEMESTER - V

STA5051	STATISTICAL INFERENCE - II	Credits : 4

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Recall the concept of consistency, CAN & large sample tests.	Remember
CO 2	Derive CAN & BAN estimators for various families .	Understand
CO 3	Compute asymptotic Confidence Interval and interpret.	Apply
CO 4	Implement large sample tests and interpret. Compare tests based on efficiency.	Analyze
CO 5	Derive & compute Bayesian estimator, credible interval & testing of hypothesis.	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	1	1
CO2	2	3	2	1	2
CO3	2	3	2	3	3
CO4	2	3	2	3	3
CO5	1	2	3	1	3

a. Syllabus:

UNIT I:

Unbiased Estimation: Minimum variance bound estimator – Regularity conditions, Cramer's family of distributions, Fisher's information measure - Cramer-Rao Inequality. Uniformly minimum variance unbiased estimator - Rao-Blackwell's theorem and Lehmann- Scheffe's theorem, Ancillary Statistics, Basu Theorem, Applications to real life situations. Simple problems.

(12H)

UNIT II :

Bayes estimation: concepts of prior, posterier and conjugate prior. Loss function: 0-1 loss function and quadratic error loss function. Bayes estimator. Simple problems involving quadratic error loss function. Applications to real life situations. Simple problems.

(12H)

UNIT III :

Consistency, Sufficient conditions for consistency. Consistency of moment and maximum likelihood estimators. Asymptotic properties of maximum likelihood estimators. Confidence Interval: Pivotol Method, shortest length confidence interval, Applications to real life situations. Simple problems. **(12H)**

UNIT IV:

Monotone Likelihood Ratio, UMP Test, Relation between test of hypothesis and CI, UMA, Likelihood ratio test- construction of tests for mean, equality of two means (independent samples), variance and equality of variances of normal populations. Applications to real life situations. Simple problems.

(12H)

UNIT – V:

Non-parametric tests – advantages and disadvantages of nonparametric tests- test for randomness, Kolmogorov -Smirnov test (one-sample), sign test, median test, Mann-Whitney U test, Wilcoxon's signed-rank test , Kruskal-Wallis test. Applications to real life situations. Simple problems.

(12H)

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1. Ramachandran, K.M., C.P.Tsokos (2009). Mathematical Statistics with Applications. Academic Press, New York.
2. Rajagopalan, M., and P. Dhanavanthan (2012). Statistical Inference. PHI Learning, New Delhi.
3. Mukhopadhyay, P. (2006). Mathematical Statistics, 3rd Edition. Books and Allied Publishers, Kolkatta.
4. Casella, G., R.L.Berger(2024). Statistical Inference, 2nd Edition. Chapman and Hall, New York.
5. Goon, A. M., M.K. Gupta, and B. Dasgupta (2002) Fundamentals of Statistics, Vol. I, Vol. II (Third Edition), World press Ltd, Kolkata.
6. Alexander, M. Mood, Franklin A. Graybill and Duane C. Boes (2017). Introduction to the Theory of Statistics (Third Edition), Mc Graw Hill Education, New Delhi.
7. Bhuyan K.C. (2010), Probability Distribution Theory and Statistical Inference, New Central Book Agency (P) Ltd., New Delhi.
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STA5052	APPLIED STATISTICS - II	CREDITS : 4

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Conduct factorial and confounding experiments	Skill
CO 2	Conduct split plot designs	Understand
CO 3	Compute sample size for sample surveys	Analyze
CO 4	Recall sampling strategies	Remember
CO 5	Use ratio and regression methods for estimation	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	2	3
CO2	2	3	2	1	2
CO3	2	3	2	3	3
CO4	3	3	2	1	3
CO5	1	3	3	2	3

c. Syllabus:

UNIT I:

Factorial designs- 2^2, 2^3, 2^k, 3^2, 3^3 & 3^k factorial experiments, confounding in 2^k & 3^k fractional factorial experiments, Partial Confounding. **(12H)**

UNIT II:

Generalised Block Design(GBD), Incomplete block designs, Balanced Incomplete Block Design (BIBD), partially balanced incomplete block design (PBIBD). Split-Plot Designs: Analysis of a Split-Plot Design with Complete Blocks, Whole-Plot Analysis. **(12H)**

UNIT III:

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. **(12H)**

UNIT IV:

Variances in terms of correlation coefficient for regression method of estimation and their comparison with SRS. Comparison of systematic sampling with SRS and stratified sampling in the presence of linear trend and corrections. **(12H)**

UNIT V:

Cluster sampling (equal clusters only) estimation of population mean and its variance, comparison (with and without randomly formed clusters). Relative efficiency of cluster sampling with SRS in terms of intra class correlation. Concept of sub sampling. **(12H)**

REFERENCES:

1. D. C. Montgomery, Design and Analysis of Experiments, fifth edition, John Wiley, 2008.
2. M.N. Das, and N. C. Giri, Design and Analysis of Experiments, second edition, Wiley Eastern, 1991.
3. A. Dey, Incomplete Block Designs, Hindustan Book Agency, 2010.
4. Hinkelmann, K., & Kempthorne, O. (2007). Design and analysis of experiments, volume 1: Introduction to experimental design (Vol. 1). John Wiley & Sons.
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6. Des Raj and Chandhok P. (1998). Sample Survey Theory, Narosa Publishing House. B. Sc. Honours (Statistics) 17
7. Singh D., Chaudhary F.S. (1986). Theory and Analysis of Sample Survey Designs, New Age International (P) Ltd.

STA5053	APPLIED STATISTICS - III	CREDITS : 4

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Know the concepts and scope of Quality control.	Remember
CO 2	Construct variable and attribute control charts for detecting large and smaller shifts in the production process.	Understand
CO 3	Evaluate the performance of sampling plans using OC, ASN, ATI, AOQ functions under various sampling inspection situations.	Apply
CO 4	Understand the concept of time series with its components.	Skill
CO 5	Analyze the data and predict the future values using various methods of time series	Analyze

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	2	1
CO2	2	3	2	3	2
CO3	1	3	2	3	3
CO4	2	3	2	2	2
CO5	3	2	3	2	2

c. Syllabus:

UNIT I:

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. **(12H)**

UNIT II:

Control charts for variables: X-bar & R-chart, X-bar & s-chart. Analysis of patterns on control chart, estimation of process capability. Control charts for attributes: np- chart, p-chart, c-chart and u-chart. Comparison between control charts for variables and control charts for attribute. **(12H)**

UNIT III:

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. **(12H)**

UNIT IV:

Introduction to times series data, application of time series from various fields, Components of a times series, Decomposition of time series. Measurement of Trend: Free-hand curve method, method of semi-averages, method of curve fitting, method of moving average. **(12H)**

UNIT V:

Measurement of Seasonal Variations: Method of simple averages, Ratio to (Linear) Trend method, Ratio to Moving Averages and Link Relative method, De-seasonalization of Data, Measurement of cyclic variations, Methods of Exponential and moving average smoothing. Interventions and Outliers. **(12H)**

References:

1. N. T. Thomopoulos, Applied Forecasting Methods, Prentice Hall, 1980.
2. G. E. P. Box, G. M. Jenkins andG. C. Reinsel, Time Series Analysis–Forecasting and Control, Pearson Education, 2004.
3. P. J. Brockwell and R. A. Davis, Introduction to Time Series and Forecasting, Springer, 2002.
4. D. C. Montgomery and L. A. Johnson, Forecasting and Time Series analysis, McGraw Hill, 1977.
5. Chan, N. H. (2004). Time series: applications to finance. John Wiley & Sons.
6. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I &II,8thEdn. The World Press, Kolkata.
7. Mukhopadhyay,P(2011):Applied Statistics, 2nd edition revised reprint, Books and Allied (P)Ltd.
8. Montogomery, D. C. and Runger, G.C. (2008): Applied Statistics and Probability for Engineers, 3rd Edition reprint, WileyIndia Pvt.Ltd.

STA5054	STATISTICAL MODELS-I	CREDITS : 4

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Recall the basics of linear regression model	Remember
CO 2	Explain parameter estimation, testing of hypothesis and confidence intervals in various regression models.	Understand
CO 3	Test of stationarity and invertibility	Apply
CO 4	Fit time series data using AR, MA, and ARIMA models.	Analyze
CO 5	Compute Periodogram, correlogram and Spectral Analysis.	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	1	1
CO2	2	3	2	1	2
CO3	2	3	2	3	3
CO4	2	3	2	3	3
CO5	1	2	3	1	3

c. Syllabus

Unit I:

Simple linear regression model - least squares estimate (LSE) - Properties of LSE - Hypothesis testing on slope and intercept-test for significance of regression - confidence and prediction intervals, regression through origin, ML estimation, case where regressor is random. **(12H)**

Unit II:

Multiple regression model - least squares estimate (LSE) - Properties of LSE - Hypothesis testing - confidence and prediction intervals - General linear hypothesis testing; Residuals and their properties - residual diagnostics; Transformation of Variables: VST - Box-Cox power transformation; Dummy variables and their use in regression analysis. **(12H)**

Unit III:

Stationary Stochastic models: weak and strong stationarity, Deseasonalising and detrending an observed time series, Auto-covariance, autocorrelation function (ACF), partial autocorrelation function (PACF) and their properties, Conditions for stationarity and invertibility. **(12H)**

Unit IV:

Models for Time Series: Time series data, Trend, seasonality, cycles and residuals, Stationary, White noise processes, Autoregressive (AR), Moving Average (MA), Autoregressive and Moving Average (ARMA). Autoregressive Integrated Moving Average (ARIMA) processes, Choice of AR and MA periods. Seasonal ARIMA model. **(12H)**

Unit V:

Spectral analysis and decomposition: Spectral analysis of weakly stationary process, Periodogram and Correlogram analysis, Spectral decomposition of weakly AR process. Multivariate time series models, State space model, ARCH and GARCH Models. **(12H)**

REFERENCES:

1. Draper, N. R., and Smith, H. (1998). Applied regression analysis (Vol. 326). John Wiley and Sons.
2. Weisberg, S. (2005). Applied linear regression (Vol. 528). John Wiley and Sons.
3. Kutner, M., Nachtsheim, C. J., Neter, J., and Li, W. (2005). Applied linear statistical models. McGraw-Hill. New York, 7.
4. Montgomery, D. C., Peck, E. A., and Vining, G. G. (2021). Introduction to linear regression analysis. John Wiley and SonsMontgomery, D. C. (1985). Introduction to statistical quality control. John Wiley & Sons.
5. Schilling, E. G., & Neubauer, D. V. (2017). Acceptance sampling in quality control. Chapman and Hall/CRC.
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8. Wetherill, G. B. (2013). Sampling inspection and quality control (Vol. 129). Springer.
9. Ramsey, P. (1991). Process Quality Control: Troubleshooting and Interpretation of Data.
10. Halpern, S. (1979). An Introduction to Quality Control and Reliability. Prentice Hall of India.

STA5055	STATISTICS PRACTICAL - III	Credits : 2

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Analyse 2^2 factorial in CRD, RBD and LSD	Remember
CO 2	Analyse of 2^3 factorial in CRD, RBD and LSD	Analyse
CO 3	Obtain two level factorial design	Skill
CO 4	Analyse split Plot design	Analyze
CO 5	Cluster sampling	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	1	1
CO2	2	3	2	1	2
CO3	2	3	2	3	3
CO4	2	3	2	1	3
CO5	1	2	3	1	3

c. List of Experiments :

1. Analysis of 2^k factorial
2. Analysis of 3^k factorial
3. Analysis of 2^k Single replicate factorial design
4. Analysis of 3^k Single replicate factorial design
5. Analysis of 2^k confounded design
6. Analysis of 3^k confounded design
7. Analysis of partial confounding design
8. Generalised Block Design(GBD)
9. Incomplete Block Design(IBD)
10. Balanced Incomplete Block Design(BIBD)
11. Partially Balanced Incomplete Block Design(PBIBD)
12. Split Plot with Complete Block Design
13. Whole Plot Analysis
14. Analysis of Incomplete block designs, balanced incomplete block design
15. Analysis of Split plot design
16. Comparison of systematic sampling with stratified sampling and SRS in the presence of a linear trend.

17. Ratio estimation: Calculate the population mean or total of the population. Calculate mean squares.
18. Regression estimation: Calculate the population mean or total of the population. Calculate mean squares.
19. Compare the efficiencies of ratio and regression estimators relative to SRS.
20. Cluster sampling: Estimation of mean or total, variance of the estimate.
21. Cluster sampling: variance of the estimate, estimate of intra-class correlation coefficient.
22. Cluster sampling: Efficiency as compared to SRS.

REFERENCES:

1. C. Montgomery, Design and Analysis of Experiments, fifth edition, John Wiley, 2008.
2. M.N. Das, and N. C. Giri, Design and Analysis of Experiments, second edition, Wiley Eastern, 1991.
3. A. Dey, Incomplete Block Designs, Hindustan Book Agency, 2010.
4. Hinkelmann, K., & Kempthorne, O. (2007). Design and analysis of experiments, volume 1: Introduction to experimental design (Vol. 1). John Wiley & Sons.
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6. Des Raj and Chandhok P. (1998). Sample Survey Theory, Narosa Publishing House.
7. Singh D., Chaudhary F.S. (1986). Theory and Analysis of Sample Survey Designs, New Age International (P) Ltd.

STA5056	STATISTICS PRACTICAL - IV	Credits : 2

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Fit and Analyze simple Linear Regression Model	Remember
CO 2	Fit and Analyze Multiple Linear Regression Model	Analyze
CO 3	Forecast longitudinal data	Apply
CO 4	Fitting data using Exponential and moving average smoothing	Analyze
CO 5	Fitting of AR, MA, ARIMA model	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	1	1
CO2	2	3	2	1	2
CO3	3	3	2	2	1
CO4	2	2	2	3	2
CO5	2	2	3	2	3

c. List of Experiments :

1. Parameter estimation using least squares method
2. Hypothesis testing in simple linear regression model
3. Confidence estimation in simple linear regression model
4. Regression through origin
5. Multiple linear regression-Parameter estimation using LSE
6. Hypothesis testing in multiple linear regression model, R-square, Adjusted R-square
7. Residual Diagnostics in multiple linear regression model.
8. Test of Stationarity and Invertibility
9. Construction of Auto-covariance
10. Autocorrelation function (ACF)
11. Partial autocorrelation function (PACF)
12. Fit an AR model and estimate parameters.
13. Fit an MA model and check stationarity.
14. Fit an ARIMA model

15. Fit Seasonal ARIMA model
16. Compute the periodogram and correlogram
17. Compute spectral density estimate
18. Estimates using VAR models
19. Estimates using ARCH
20. Estimates using GARCH Models

REFERENCES:

1. Draper, N. R., and Smith, H. (1998). Applied regression analysis (Vol. 326). John Wiley and Sons.
2. Weisberg, S. (2005). Applied linear regression (Vol. 528). John Wiley and Sons.
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10. Halpern, S. (1979). An Introduction to Quality Control and Reliability. Prentice Hall of India.

SEMESTER – VI

STA5061	STATISTICAL MODELS - II	Credits : 4

a.Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Recall the basics of generalized linear model	Remember
CO 2	Explain parameter estimation, testing of hypothesis and confidence intervals in various regression models.	Understand
CO 3	Perform parameter estimation and testing of hypothesis. Implement variable selection methods.	Apply
CO 4	Detect problems of multicolinearity and outliers in data.	Analyze
CO 5	Compare regression models and interpret the results.	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	1	1
CO2	2	3	2	1	2
CO3	2	3	2	3	3
CO4	2	3	2	3	3
CO5	1	2	3	1	3

c. Syllabus:

UNIT I:

Multiple regression model - Multicollinearity: Consequences - detection and remedies - ridge regression; Autocorrelation: sources – consequences – detection - Durbin-Watson test – remedies - Parameter estimation using Cochrane-Orcutt method. Variable Selection Procedures: R-square - adjusted R-square - Mallows' Cp - forward, backward and stepwise selection methods – AIC - BIC. **(12H)**

UNIT II:

Nonlinear regression models: Nonlinear least squares - Transformation to a linear model - Parameter estimation in a nonlinear system - Statistical inference in nonlinear regression; Polynomial regression model - piecewise polynomial fitting; Nonparametric regression: kernel and locally weighted regression. **(12H)**

UNIT III:

Robust Regression: Influential observations – leverage – outliers - methods of detection of outliers and influential observations; estimation in the presence of outliers - M-estimator - Huber

loss function - breakdown point - influence function – efficiency - Asymptotic distribution of M-estimator (Statement only). **(12H)**

UNIT IV:

Generalized linear models: concept of generalized linear model - Link function - ML estimation - Quasi-likelihood estimation - large sample tests about parameters - goodness of fit - analysis of deviance- Residual analysis - types of residuals: raw, Pearson, deviance, Anscombe, quantile; residual plots. Variable selection: AIC – BIC.

(12H)

UNIT V:

Logistic regression: logit model for dichotomous data with single and multiple explanatory variables - ML estimation - large sample tests about parameters - Hosmer-Lemeshow test - ROC curve. Multilevel logistic regression, Logistic regression for Nominal response: Baseline Category model and ordinal response: Proportional odds model. Poisson regression: ML estimation of parameters - testing significance of coefficients – goodness-of-fit - over dispersion: Types – causes – remedies. **(12H)**

REFERENCES:

1. Draper, N. R., and Smith, H. (1998). Applied regression analysis (Vol. 326). John Wiley and Sons.
2. Weisberg, S. (2005). Applied linear regression (Vol. 528). John Wiley and Sons.
3. Kutner, M., Nachtsheim, C. J., Neter, J., and Li, W. (2005). Applied linear statistical models. McGraw-Hill. New York, 7.
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11. Christensen, R. (2006). Log-linear models and logistic regression. Springer Science and Business Media.
12. McCulloch, C. E., and Searle, S. R. (2004). Generalized, linear, and mixed models. John Wiley and Sons.
13. https://onlinecourses.nptel.ac.in/noc24_ma19/preview
14. https://online.stat.psu.edu/stat504/

STA5062	STOCHASTIC PROCESSES	Credits : 4

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Apprehend the concept of stochastic process, its specifications, and analyze the classification of states; construct Markov Chain for real world situations.	Remember
CO 2	Understand the concepts of Chapman-Kolmogorov equation, periodicity and first passage time distribution	Understand
CO 3	Understand Continuous time Markov processes, Poisson process and obtain the birth and death processes.	Apply
CO 4	Understand the concept of branching processes and determine covariance and spectral density of stationary random processes.	Analyze
CO 5	Determine renewal process, renewal function, distribution of arrival and inter arrival times and renewal policy under varied conditions.	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	2
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	2	2	1	3	2
CO5	1	1	1	1	2

c. Syllabus:

UNIT I:

Stochastic processes and their classification- Markov chain with finite and countable States, Transition Probability Matrices, Limiting behaviour of n step transition probabilities, Absorption probabilities, Classification of States. **(12H)**

UNIT II:

Random walk, Gambler's ruin problem, Stationary distribution, Higher Transition Probabilities, Chapman-Kolmogorov equation, First passage theorem, Simple problems.

(12H)

UNIT III:

Poisson process – postulates and properties – Poisson process and related distributions - Pure birth process, Birth and Death processes, Kolmogorov differential equations, Markov process with discrete state space. **(12H)**

UNIT IV:

Markov process with continuous state space, Brownian Motion, Weiner process, Branching processes – Properties of Generating functions of branching processes– Extinction probabilities – Distribution of total number of progeny - Concept of Age dependent Branching process. **(12H)**

UNIT V:

Renewal processes – Definition and examples –renewal interval- Delayed recurrent event- Renewal process in continuous time – renewal function and renewal density-renewal equation- renewal theorem – Study of residual life time process. **(12H)**

REFERENCES:

1. Karlin, S. (2014). A first course in stochastic processes. Academic press.
2. Medhi, J. (2009). Stochastic Processes, 3rd Edition. New age International.
3. Bhat, B. R. (2004). Stochastic models: analysis and applications. New Age International.
4. Jones, P. W., and Smith, P. (2001). Stochastic Processes: An Introduction. Arnold Texts in Statistics.
5. Cinlar, E. (1975). Introduction to stochastic processes Prentice-Hall. Englewood Cliffs, New Jersey (420p).
6. Cox, D. R., and Miller, H. D. (1983). The theory of stochastic processes (Vol. 134).3rd Edition, Chapman and Hall.
7. Ross, S. M. (1983). Stochastic Process. Wiley.
8. https://nptel.ac.in/courses/111/102/111102111/
9. https://www.stat.auckland.ac.nz/~fewster/325/notes/325book.pdf

STA5063	STATISTICS PRACTICAL - V	Credits : 2

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Diagnose Multicolinearity, Autocorrelation and Influential observations.	Remember
CO 2	Implement Robust Regression, Logistic and Poisson Regression.	Analyze
CO 3	Fit and Analyze non-linear and nonparametric Regression.	Apply
CO 4	Construct transition probability matrix and use of Markov chain.	Analyze
CO 5	Apply multivariate techniques on data.	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	1	1
CO2	2	3	2	1	2
CO3	2	3	2	3	3
CO4	2	2	1	3	2
CO5	2	3	2	3	2

c. List of Experiments :

1. Diagnosing Multicollinearity: correlation matrix, VIF, eigen system analysis
2. Parameter estimation by Ridge Estimator
3. Diagnosing Autocorrelation-Graph of Residuals Vs. Time - Durbin-Watson test
4. Parameter estimation by the Cochrane-Orkutt Method
5. Variable selection using all subset methods and Stepwise procedures
6. Fitting and analysis of Non-linear regression model
7. Fitting and analysis of polynomial and nonparametric regression model
8. Diagnosing influential observations and Parameter estimation by M-Estimator
9. Fitting and analysis of Logistic Regression model
10. Fitting and analysis of Poisson Regression model
11. Simulating Markov Process
12. Construction of Transition Probability Matrix
13. Classification of States of a Markov chain

14. Finding Absorption probabilities
15. Finding stationary distribution
16. Simulation and analysis of Random walk
17. Simulation and analysis of Gambler Ruin's problem
18. Estimation in Poisson process
19. Estimation in Renewal process
20. Estimation in Branching process

REFERENCES:

1. Draper, N. R., and Smith, H. (1998). Applied regression analysis (Vol. 326). John Wiley and Sons.
2. Weisberg, S. (2005). Applied linear regression (Vol. 528). John Wiley and Sons.
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18. Cox, D. R., and Miller, H. D. (1983). The theory of stochastic processes (Vol. 134).3rd Edition, Chapman and Hall.

STA5064	MULTIVARIATE ANALYSIS	Credits : 4

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Select appropriate methods of multivariate data analysis, given multivariate data and study objectives	Remember
CO 2	Understand likelihood based, as well as minimum expected cost based, discriminant analysis.	Understand
CO 3	Know the theories of PCA and factor analysis (FA), and be able to apply these methods to real data.	Apply
CO 4	Interpret results of multivariate data analysis.	Analyze
CO 5	Understand the fundamental difference between univariate and multivariate analysis. Design/perform hypothesis testing -and be able to apply MANOVA and understand multivariate regression.	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	3	2
CO2	3	2	3	2	2
CO3	2	3	3	2	3
CO4	2	1	1	2	3
CO5	1	3	2	3	1

C. Syllabus:

UNIT I:

Singular and non-singular Multivariate normal distributions and their properties - Marginal and conditional distributions - Characteristic function and moments - Distribution of linear combinations of multivariate normal vector - Determination of mean and variance -covariance matrix of multivariate normal distribution.

(12H)

UNIT II:

Random Sampling from multivariate normal distribution - Maximum likelihood estimators of the parameters of multivariate normal distribution - distribution of sample mean vector and sample dispersion mean vector - Necessary and sufficient condition for a quadratic form to be distributed as chi-square - Inference concerning the sample mean vector when covariance matrix is known. **(12H)**

UNIT III:

Generalized T^2 statistic and its distribution - Hotelling's T^2 statistic and its distribution - Two sample problems with unequal covariance matrices likelihood ratio criterion and its applications - Mahalanobis D^2 statistic and its distribution - Applications of Hotelling's T^2 Statistic - Invariance property of T^2 statistic - Relationship between T^2 and D^2 statistics - Behrens–Fisher Problem.

(12H)

UNIT IV:

Wishart distribution - Sampling distribution of sample covariance matrix - Properties of Wishart distribution - Wilk's criterion - Generalized variance - Sampling distribution of simple sample correlation coefficient - Sampling distribution of partial and multiple correlation coefficients in null case (without derivation) - Discriminant function - Fisher's discriminant function.

(12H)

UNIT V:

Problem of classification - Two populations and k populations - Principal components and determination - Factor analysis – estimation of factor loadings - Canonical variables and canonical correlations - Derivation of canonical correlation coefficients.

(12H)

REFERENCES:

1. Anderson, T.W. (2003): An Introduction to Multivariate Statistical Analysis (Third Edition). Wiley–Inter science, New York.

2. Johnson, R.A. and D.W. Wichern. (2013). Applied Multivariate Statistical Analysis (Sixth Edition), Pearson New International Edition.

3. Kendall, M.G., Stuart, A. and Ord, K.J. (1973): The Advanced Theory of Statistics. (Fourth Edition), Vol. 2, Charles Griffin company Ltd.

4. Kotz, S., Balakrishnan, N. and Johnson, N.L. (2000): Continuous Multivariate Distribution Models and Applications (Second Edition). Vol. 1, Wiley-Inter science, New York.

5. Mardia, K.V., Kent, J.T and Bibby, J.M. (1979): Multivariate Analysis. Academic Press, New York.

6. Morrison, D.F. (2004): Multivariate Statistical Methods (Fourth Edition). Duxbury Press, New York.

7. Rao, C.R. (2001): Linear Statistical Inference and its Applications (Second Edition). Wiley-Inter Science, New York.

8. Rencher, A.C. (2002): Methods of Multivariate Analysis (Second Edition). Wiley Interscience, New York.

STA5065	STATISTICAL DATA ANALYSIS USING SPSS	Credits:2

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Understand SPSS software data entry, import, recode, group data	Remember
CO 2	Perform Exploratory data analysis	Understand
CO 3	Use statistical tools for parametric and non-parametric analysis	Apply
CO 4	Explain General linear model and multiple regression analysis	Analyze
CO 5	Work on some Multivariate techniques, Classification and Forecasting	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	1	1
CO2	2	3	2	1	2
CO3	2	3	2	3	3
CO4	2	3	2	1	3
CO5	1	2	3	1	3

c. List of Experiments:

1. SPSS Environment
2. Data Creation and functions
3. Descriptive Statistics
4. Visualization
5. Consistency of Data
6. Validity of Data
7. Random number generation from p Variate Normal Distribution
8. MLE's of Mean vector and Co-variance matrix
9. Testing mean vector (One sample)
10. Testing equality of mean vectors(Two Sample)
11. Testing Co-variance matrix (One sample)
12. Testing equality of Co-variance matrices (Two Sample)
13. Problem of Symmetry-Profile Analysis –Significance of contrasts using Hotelling's T^2
14. Discriminant Analysis
15. Fisher's and Mahalanobis functions
16. Principal Component Analysis
17. Factor Analysis
18. Canonical Correlation
19. Clustering Techniques
20. Structural Equation Modeling

REFERENCES:

1. Huizingh, E. (2007). Applied Statistics with SPSS, SAGE.
2. Carver, R.H. and Nash, J. G. (2011). Doing Data Analysis with SPSS, Cengage.
3. Gray, C. D., Kinnear, P. R. (2011). IBM SPSS Statistics 19 Made Simple, Taylor and Francis.
4. Burns, R. and Burns, R. P., (2008). Business Research Methods and Statistics using SPSS, SAGE.
5. Jeremy J. Foster. (2000). Data analysis using SPSS for windows, SAGE.

SEMESTER - VII

STA5071	OPERATIONS RESEARCH - I	Credits : 4

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Formulate and solve linear programming problems	Remember
CO 2	Solve transportation, assignment and travelling salesman problems	Understand
CO 3	Analyse and Solve game theory models	Apply
CO 4	Develop replacement policies under varying conditions	Analyze
CO 5	Apply CPM and PERT techniques for project management	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	2	1
CO2	1	3	2	1	2
CO3	2	3	2	3	3
CO4	3	3	2	1	3
CO5	3	2	3	3	3

c. Syllabus:

UNIT I :

Introduction to Operations Research – Various Models in O.R. – Scope and limitations of O.R.– Phases of Operations Research study -Formulation of Linear programming models – Graphical solution of LPP – Simplex method – Big M-method and Two Phase method - Concepts of Duality – Conversion of Primal to Dual – Dual Simplex method-Problems. **(12H)**

UNIT II :

Transportation problem(TP) – TP formulation- North-West Corner, Least cost, Vogel's Approximation method – Degeneracy, Maximization- Optimal Solution by Modified Distribution Method (MODI),Assignment algorithm-Maximization-Travelling Salesman problem. **(12H)**

UNIT III:

Theory of Games – Basic definition – Maximin and Minimax criterion – Solution of Games with saddle points – Two–by–Two (2x2) Games without saddle point – principle of dominance – problems based on dominance rule – Graphical method for (2xn) and (mx2) games. **(12H)**

UNIT IV:

Replacement problems – Replacement policy for items whose maintenance cost increases with time and the value of money remains constant – Replacement policy for items whose maintenance cost increases with time and the value of money also changes with time. **(12H)**

UNIT V:

Network analysis by CPM/PERT: Basic Concept – Constraints in Network – Construction of the Network – Time calculations –Concept of slack and float in Network Analysis – Finding optimum project duration and minimum project cost. **(12H)**

REFERENCES:

1. Kanti Swarup, P.K. Gupta and Manmohan (2010): Operation Research, Sultan Chand and Sons.
2. S.D. Sharma (2003): Operations Research, Kedarnath Ramnath and Co.
3. Taha H.A. (2008): Operational Research: An Introduction,8/e, Pearson.
4. Hillier F.S. and Libermann G.J. (2004): Introduction to Operations Research, 7thEdition, McGraw Hill

STA5072	ADVANCED PROBABILITY THEORY	Credits : 4

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Explain the random variable and its expectation.	Remember
CO 2	Understand the concepts related to class of sets such as fields, sigma fields, Borel fields and solve related problems.	Understand
CO 3	Apply the convergence theorems to solve problems related to the sequence of random variables.	Apply
CO 4	Analyze the measure-theoretic definition of a random variable and random vector and solve problems related to their distributions.	Analyze
CO 5	Solve the problems related to the central limit theorem.	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	2	2	2
CO2	3	2	3	2	2
CO3	3	1	3	1	3
CO4	2	1	1	2	3
CO5	3	3	2	3	2

c. Syllabus:

UNIT I:

Classes of sets: Sequence of sets, limit of sequence of sets, field, σ-field, σ-field generated by a class, Borelσ-field. Probability measure, Probability space, properties of probability measure. Lebesgue and Lebesgue – Stieltjes measures on R. **(12H)**

UNIT II:

Measurable function, random variable, the distribution function of a random variable, simple random variable, elementary random variable, limit of the sequence of random variables. Method of obtaining a random variable as a limit of sequence of simple random variables.

(12H)

UNIT III:

Expectation of a random variable, independence. Characteristic function, simple properties. Inversion theorem and uniqueness property **(12H)**

UNIT IV:

Convergence of sequence of random variables, Convergence in distribution, convergence in r^{th} mean, continuity theorem , Weak and Strong laws of large numbers, Kolmogorov's three series theorem for almost sure convergence, Lyapunov's, Lindeberg-Feller Theorems on CLT

(12H)

Unit V : Monotone convergence theorem, Fatou's Lemma, Dominated Convergence theorem, Borel - Cantelli Lemma, and their applications, character property, Yule-Slutsky results.

(12H)

REFERENCES:

1. Bhat, B. R. (2019). Modern Probability Theory. United Kingdom: New Academic Science.
2. Karr, A. F. (1993). Probability. Germany: Springer New York.
3. Billingsley, P. (2012). Probability and Measure. Italy: Wiley.
4. AthreyaK. B. and Lahiri S. (2006). Probability Theory vol 41, Trim series, (Hindustan Book Agency).
5. Feller, W. (1968). An Introduction to Probability Theory and Its Applications, Volume 1. India: Wiley.
6. Loeve, M. (2012). Probability Theory I. United States: Springer New York.
7. https://nptel.ac.in/courses/111/101/111101005

STA5073	ADVANCED SAMPLING THEORY	Credits: 4

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Apply stratified and systematic sampling methods	Remember
CO 2	Analyze estimation techniques under superpopulation model	Understand
CO 3	Evaluate efficiancy and estimation in cluster sampling	Apply
CO 4	Compare one-stage and two-stage sampling procedures	Analyze
CO 5	Identify and minimize non-sampling errors in surveys	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	2
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	2	2	1	3	2
CO5	3	1	1	1	2

c. Syllabus:

UNIT I :

Stratified and Systematic Sampling : Post Stratification, effect of increasing the number of strata, determination of optimum number of strata, construction of strata (Neyman allocation, Proportional allocation and approximate method by Dalenius and Hodges), method of collapsed strata, Systematic Sampling: Circular systematic sampling, Yates' and Cochran method of estimation of sampling variance.

(12H)

UNIT II:

Super population Model: Introduction to Super population model, Ratio method of estimation under super population model, regression method of estimation under super population model.

(12H)

UNIT III:

Cluster Sampling: Estimation of population mean and its variance, efficiency of cluster sampling, the effect of formation of clusters randomly, efficiency of cluster sampling in terms of intra-class correlation, estimation of efficiency, optimum size of cluster.

(12H)

UNIT IV:

Two-Stage Sampling Errors: Two-stage sampling/sub-sampling (Equal first stage units): Estimation of population mean and its variance, Estimator of variance of the sample mean, allocation of sample to two-stages, comparison of two-stage with one-stage sampling.

(12H)

UNIT V:

Non-Sampling Errors: Classification of non-sampling errors, types of non-sampling errors, bias due to non-response, Hansen and Hurwitz technique, comparison of Hansen and Hurwitz technique with SRS under a cost constraint. **(12H)**

REFERENCES:

1. Cochran, W.G. (2011): Sampling Techniques (3rd Ed.), Wiley Eastern John Wiley and Sons.
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. Gupta, S.C. and Kapoor, V.K. (2007): Fundamentals of Applied Statistics, Sultan Chand and Sons.
4. Singh, D. and Chaudhary, F. S. (2015): Theory and Analysis of Sample Survey Designs.
5. Murthy M.N. (1977): Sampling Theory & Statistical Methods, Statistical Pub. Society, Calcutta.
6. Des Raj and Chandhok P. (1998): Sample Survey Theory, Narosa Publishing House.
7. Goon, A. M., Gupta, M. K. and Dasgupta, B. (2001): Fundamentals of Statistics (Vol.2), World Press.

STA5074	ADVANCED STATISTICAL INFERENCE	Credits : 4

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Recall the concept of consistency, CAN & large sample tests.	Remember
CO 2	Derive CAN & BAN estimators for various families .	Understand
CO 3	Compute asymptotic Confidence Interval and interpret.	Apply
CO 4	Implement large sample tests and interpret. Compare tests based on efficiency.	Analyze
CO 5	Derive & compute Bayesian estimator, credible interval & testing of hypothesis.	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	1	1
CO2	2	3	2	1	2
CO3	2	3	2	3	3
CO4	2	3	2	3	3
CO5	1	2	3	1	3

c. Syllabus:

UNIT I:

Consistency of an estimator, weak and strong consistency, joint and marginal consistency, invariance property under continuous transformations, methods of constructing consistent estimators, asymptotic relative efficiency. Consistent and Asymptotic Normal (CAN) Estimators: Definition of CAN estimator for real and vector valued parameters, invariance of CAN property under non-vanishing differentiable transformation. Methods of constructing CAN estimators: Method of Moments, method of percentiles, comparison of CAN estimators.

(12H)

UNIT II:

CAN and BAN estimators in one parameter and multi-parameter exponential family of distributions, BAN estimators, super efficient estimators, Cramer regularity conditions, Cramer – Huzurbazaar results. **(12H)**

UNIT III:

Variance stabilizing transformations; their existence; their applications in obtaining large sample tests and estimators. Asymptotic Confidence Intervals based on CAN estimators and based on VST, Asymptotic Confidence regions in multi-parameter families.

(12H)

UNIT IV:

Likelihood ratio test and its asymptotic distribution, Wald test, Rao's Score test, Pearson Chi-square test for goodness of fit, Bartlett's test for homogeneity of variances. Consistent test, comparison of tests: asymptotic relative efficiency of tests (Pitman and Bahadur efficiency), LRT based confidence intervals. **(12H)**

UNIT V:

Point estimation-Prior, types of prior, posterior, Bayes estimators under various loss functions-generalization to convex loss function. Evaluation of the estimate in terms of posterior risk-comparison with frequency methods. Bayesian hypothesis testing. Interval estimation-credible interval, highest posterior density region, Bayesian hypotheses testing. **(12H)**

REFERENCES:

1. Kale, B. K., & Muralidharan, K. (2015). Parametric Inference: An Introduction. Alpha Science International Limited.
2. Rohatagi V.K. and Saleh A. K. Md. E.(2001) : Introduction to Probability Theory and Mathematical Statistics- John Wiley and sons Inc.
3. Ferguson, T.S. (1996): A Course in Large Sample Theory. Chapman and Hall.
4. Lehmann E L (1999): Elements of Large Sample Theory, Springer
5. Berger, J.O(1985): Statistical Decision Theory and Bayesian Analysis(Second Edition),Springer Verlag, New York
6. Bernardo J M and A.F.M.Smith (2000) : Bayesian Theory, John Wiley & Sons, New York

STA5075	DEMOGRAPHY	CREDITS : 3

a. Course Outcomes (COs):

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

	Course Outcome	Cognitive Level
CO1	Understand the concepts and Learn the basics in Birth, Death and other vital statistics.	Remember, Understand
CO2	Provide the basic knowledge in Measurements of Population and obtain the various measures.	Understand, Apply
CO3	Describe and Explore the importance of life table and its types	Understand, Apply
CO4	Analyse and understand the concepts of Migration and its importance.	Understand, Analyze
CO5	Understand the core idea of population projection and their estimation.	Remember-Apply

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	3	3	2
CO2	2	3	2	3	3
CO3	2	2	3	3	3
CO4	2	3	3	3	3
CO5	3	3	3	3	3

c. Syllabus:

UNIT I:

Demography Data: Demography – definition-sources of demographic data - population census-demographic surveys - Registration method: vital registration - population register and other administrative records, registration of population in India.

(9H)

UNIT II:

Fertility: Fertility measurements – crude birth rates - general, specific and total fertility rates - gross and net reproduction rates and their interpretation.

(9H)

UNIT III:

Mortality: Mortality measurements: crude death rate - specific death rate -standardized death rate - infant mortality rate – maternal mortality rate – case fertility rate -comparative mortality index.

(9H)

UNIT IV:

Life Table and Migration: Description and construction of various columns of a life table and their relationships - uses of life table – migration-factors effecting migration - gross and net migration rates. **(9H)**

UNIT V:

Population Growth: Population projection – population estimates and projection –arithmetic, geometric and exponential growth rates - logistic curve and its suitability for graduating population data - Basic ideas of stationary and stable population.

(9H)

REFERENCES:

1. Mukhopadhyay, P. (2011). Applied Statistics. 2nd Edition. Books and Allied Publishers, Kolkatta.
2. Goon, A. M., M.K. Gupta, and B. Dasgupta (2002) Fundamentals of Statistics, Vol. I, Vol. II (Third Edition), World press Ltd, Kolkata.
3. V.C.Sinha E.Zacharia (2012) Elements of Demography, Allied Publishers, New Delhi.
4. Agarwala, S.N. (1991) Indian Population Problems, Tata Mc Graw Hill Publishing House, New Delhi.
5. Mishra, D.E. (1982) An introduction to the Study of Population, South India Publishers, Madras.
6. Hansraj, D.R. (1981) Fundamentals of Demography, Surjeet publications, New Delhi
7. Asha A. Bhende and Tara Karitkar (1994) Principles of Population Studies, Himalaya Publishing House Pvt Ltd., Mumbai.
8. Suddhendu Biswas and G. L. Sriwatav (2006), Stochastic Processes in Demography and Applications, New Central Book Agency, London.Bogue, D. J. (2007). Principles of Demography, Wiley, New York.
9. Gibbs, J.P. (2012). Urban Research Methods.Literary Licensing, LLC.77
10. Keyfitz, N. and Caswell, H. (2006). Applied Mathematical Demography. Springer lag, New York.
11. Kumar, R. (1986). Technical Demography. John Wiley & Sons, Canada.
12. Spiegelman, M. (1969). Introduction to Demographic Analysis.Harvard University Press.

SEMESTER - VIII

STA5081	RESEARCH PROJECT	Credits : 8/12

The student shall pursue a research project for the whole semester under the allotted guide. The project report shall be submitted in the form of a dissertation, and the evaluation will be based on the performance and the final presentation of the research work done.

a. Course Outcome (CO):

On the successful completion of the Project the student will be able to

	Course Outcome	Level
CO 1	Formulate a research problem based on the literature review and identify appropriate objectives and methodology	Evaluate
CO 2	Applying statistical theory and methods to real-world data	Analyze
CO 3	Demonstrating proficiency in data analysis and modeling, communicating findings effectively	Understand
CO 4	Developing professional skills like independent research and problem-solving	Apply
CO 5	Data Analysis, Modeling and Interpretation of results	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	3	3
CO2	2	3	2	2	3
CO3	2	3	2	2	3
CO4	2	2	1	3	2
CO5	2	3	2	3	2

c. SPECIFICATIONS FOR PROJECT REPORT:

1. Cover page – Content in color on white background
2. Main Heading font size – 16 points.
3. Sub Heading – 14 points.
4. Content – 12 points.
5. Line Spacing – 1.5 points
6. Font – Time New Roman
7. Page Size – A4
8. Binding – Soft binding
9. No. of copies to be submitted – 3 (one copy will be returned to the candidate after evaluation).

STA5082	STATISTICAL RESEARCH METHODOLOGY	Credits : 4

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Identify reliable scientific sources and use databases and citation metrics effectively. Level Apply	Apply
CO 2	Design reproducible experiments and present data using appropriate formats and tools.	Analyze
CO 3	Explain research ethics and distinguish between ethical and unethical practices.	Understand
CO 4	Evaluate publication ethics, authorship, and misconduct issues.	Apply
CO 5	Prepare scientific documents and presentations, and understand intellectual property rights.	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	3	3
CO2	2	3	2	2	3
CO3	2	3	2	2	3
CO4	2	2	1	3	2
CO5	2	3	2	3	2

c. Syllabus:

UNIT I:

Introduction to Research Methodology: Definition, Characteristics, Objectives, Concepts of Research in Statistics and Scientific method, Literature review, types of research, process of scientific research, Research design. Criteria of Good Research, Defining Research Problem-Applications in Statistics.

(12H)

UNIT II:

Statistical Studies – Significance – Data Measurement Scales – Sources of error in Measurement – Tests of Measurement– Technique of Developing Measurement Tools – Scaling Techniques – Likert type Scaling – Cumulative Scaling-Solving Research Problems: concepts, constructs, definition, research questions, objectives and methodologies – Statistical Modelling-Intellectual property rights (IPR) and Plagiarism; publications/patents/startups and its e-filing procedures, norms and policies

(12H)

UNIT III:

Simulation: Concept and Advantages of Simulation, Event type,- Simulation Algorithms-Art of writing: Research paper, Structure and component of research paper, research report, survey article, thesis - Presenting the research paper/thesis- Applications in Statistics.

(12H)

UNIT IV :

Scientific Tools: Journal impact factor, Citation index, References and bibliography, Journal Communication, publishing a paper.

(12H)

UNIT V:

Technical Writing Tool: Introduction to PSTricks and MathJaX. Advanced Type setting using Latex and Beamer. **(12H)**

REFERENCES:

1. C. R. Kothari, Research Methodology (Methods and Techniques), New Age International Publishers, 2004.
2. R. Pratap, Getting Started with MATLAB (A Quick Introduction for Scientists and Engineers), Oxford University Press, Indian Edition, 2010.
3. N. J. Higham, Handbook of Writing for the Mathematical Sciences, 2nd Edition, SIAM, 1998.
4. D. E. Knuth, T. L. Larrabee, and P. M. Roberts, Mathematical Writing, Mathematical Association of America, Washington, D.C., 1989.
5. L. Lamport, LaTeX: A Document Preparation System, 2nd Edition(Addison-Wesley Series on Tools and Techniques for Computer T), 1994.
6. Thomas, C.G., 2021. Research methodology and scientific writing. Thrissur: Springer
7. Jonathan, Anderson et al. (1977), Thesis and Assignment Writing, Wiley Eastern Ltd.
8. Gupta.S.C. and Kapoor.V.K. (2014), Fundamentals of Mathematical Statistics, 12/e, Sultan Chand and sons.
9. Goon A. M., Gupta M.K. and Dasgupta B. (2002). Fundamentals of Statistics, Vol. I and II, 8th Edition, The World Press Pvt. Ltd. Kolkata.
10. Gupta S. P. (2002): Statistical Methods, Sultan Chand and Sons, New Delhi. 5. Gupta V.K. and Kapoor S.C.: Fundamentals of Mathematical Statistics-Sultan & Chand.

STA5083	OPERATIONS RESEARCH - II	Credits: 4

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	To take decision at uncertain environment.	Remember
CO 2	Understanding the application of Simulation to solve critical problems.	Understand
CO 3	Applying Sequencing problem to determine optimum sequence.	Apply
CO 4	Determination of ideal time period for waiting in a queue.	Analyze
CO 5	To learn robust inventory level in production unit.	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	2	1
CO2	2	3	2	3	2
CO3	1	3	2	3	3
CO4	2	3	2	2	2
CO5	3	2	3	2	2

c. Syllabus:

UNIT I :

Introduction to Decision Analysis, Decision-making Problem, Decision-making Process, Decision-making Environment, Decisions under Uncertainty, Decisions Under Risk, Decision-Tree Analysis, Decision-making with Utilities. **(12H)**

UNIT II :

Introduction to Simulation, Process of Simulation, Simulation Models, Event-Type Simulation, Generation of Random Numbers, Monte-Carlo Simulation, Simulation of Inventory Problems, Simulation of a Queueing System, Simulation of Maintenance Problems, Simulation in Investment and Budgeting, Simulation of Job Sequencing, Simulation of Networks, Advantages and Limitations of Simulation. **(12H)**

UNIT III:

Introduction to Sequencing Problem, Problem of Sequencing, Basics terms used in Sequencing, Processing n Jobs through Two machines, Processing n Jobs through k machines, Maintenance Crew Scheduling, Problems on Complex Scheduling. **(12H)**

UNIT IV :

Introduction to Queueing Theory, Queueing System, Elements of a Queueing System, Operating Characteristics of a Queueing System, Deterministic Queueing System, Probability Distribution in Queueing System, Classification of Queueing Model, Transient and Steady States, Steady state analysis of M / M / 1 and M / M / S models with finite and infinite capacities. Poisson Queueing System, Non- Poisson Queueing System, Cost Models in Queueing and Queueing Control.

(12H)

UNIT V:

Inventory Management: ABC inventory system, characteristics of inventory system. EOQ Model and its variations, with and without shortages, Quantity Discount Model with price breaks.

(12H)

REFERENCES:

1 Kanti Swarup, P.K. Gupta and Manmohan (2010): Operation Research, Sultan Chand and Sons.

2 S.D. Sharma (2003): Operations Research, Kedarnath Ramnath and Co.

3 Taha H.A. (2008): Operational Research: An Introduction,8/e, Pearson.

4. Hillier F.S. and Libermann G.J. (2004): Introduction to Operations Research, 7thEdition, McGraw Hill.

DISCIPLINE SPECIFIC ELECTIVES

STAEC01	OFFICIAL STATISTICS	Credits : 3

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Have knowledge on CSO and NSSO.	Remember
CO 2	Know different method of collection of official statistics.	Understand
CO 3	Analyze the impact of Agricultural and Industrial statistics.	Apply
CO 4	Study about Index numbers.	Analyze
CO 5	Examine the financial Statistics	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	2	3
CO2	2	3	3	2	2
CO3	2	2	2	3	2
CO4	3	3	2	1	2
CO5	3	3	3	2	3

C. SYLLABUS:

UNIT I:

Statistical System in India: Central and State Government Organizations, Functions of Central Statistical Organization (CSO), National Sample Survey Organization (NSSO) - Sampling fundamentals – sampling and non-sampling errors - large scale sample surveys.

(9H)

UNIT II:

Official statistics: Meaning, methods of collection, limitations and reliability. Principal publications containing data on the topics such as population, agriculture, industry, trade, prices, labour and employment, transport and communications - Banking and finance.

(9H)

UNIT III:

System of Collection of Agricultural Statistics - Crop forecasting and estimation - Productivity, fragmentation of holdings - Support prices - Buffer stocks - Impact of irrigation projects – Industrial statistics.

(9H)

UNIT IV:

Index Numbers - Price, Quantity and Value indices. Price Index Numbers: Construction, Uses, Limitations, Tests for index numbers - Consumer Price Index, Wholesale Price Index and Index of Industrial Production – Construction of index numbers and uses.

(9H)

UNIT V:

National Income – Measures of national income - Income, expenditure and production approaches – Applications in various sectors in India - Wage Statistics – Trade Statistics – Financial Statistics.

(9H)

REFERENCES:

1. Saluja, M.R (1972): Indian official statistical systems: Statistical publishing society, Calcutta and The Indian Econometric Society, Hyderabad.

2. Central Statistical Organisation (1995), Statistical System in India, Ministry of Statistics and Programme Implementation, India

3. Central Statistical Organisation (1999), Guide to Official Statistics, Ministry of Statistics and Programme Implementation, India.

4. Goon A. M., Gupta M. K., and Dasgupta. B. (2001), Fundamentals of Statistics, Vol. 2, World Press, India.

5. Bhaduri, A. (1990). Macroeconomics: The Dynamics of Commodity Production, Macmillan India Limited, New Delhi.

STAEC02	ACTUARIAL STATISTICS	Credits : 3

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Understand the risk models for insurance.	Remember
CO 2	Use different types of life table.	Understand
CO 3	Find annuity, future value, present value, and compound interest.	Apply
CO 4	Calculate premium for different cases.	Analyze
CO 5	Find policy expenses, claim amount distributions, stop-loss Insurance	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	1	1
CO2	2	3	3	1	2
CO3	2	3	2	3	2
CO4	2	3	2	1	3
CO5	3	2	1	1	3

c. Syllabus:

UNIT I:

Introduction to Insurance Business, Insurance and utility theory, Risk models for Insurance: Individual and aggregate Risk models for short term, aggregate claims distribution, compound Poisson distribution and its applications. Survival function and Life tables: Survival function, Distribution function, Density functions and Force of mortality. Time-until-death random variable and Curtate-future lifetime random variable. **(9H)**

UNIT II:

Life tables, Select and ultimate life tables. Assumptions for fractional ages and some analytical laws of mortality. Life Insurance: Principles of compound interest: Nominal and effective interest rates and force of interest and discount, compound interest, accumulation factor, continuous compounding. Insurance payable at the moment of death and at the end of the year of death, level benefit insurance, Whole life insurance, endowment insurance, deferred insurance and varying benefit insurance. Recursion equations and commutation functions. **(9H)**

UNIT III:

Compound Interest, Interest compounded continuously, Annuities: Annuities certain, Annuity contingent, Annuity perpetual, ordinary annuity, Annuity deferred, Annuity due paid immediately, Continuous and Discrete life annuities, Life annuities with monthly payments and apportion able annuities. Recursion equations, Sinking fund, Amortization of principal, net premium: Fully continuous and discrete premiums, True monthly payment premiums, apportion able premiums and accumulation type benefits. Insurance model including expenses. **(9H)**

UNIT IV:

Net premium reserves: Continuous and discrete net premium reserves, reserves on a semi continuous basis, reserves based on true monthly premiums, reserves on an apportion able or discounted continuous basis, reserves at fractional durations, allocations of loss to policy years, recursive formulas and differential equations for reserves, commutation functions. **(9H)**

UNIT V:

Some practical considerations: Premiums that include expenses-general expenses Type's of expenses, per policy expenses. Claim amount distributions, approximating the individual model,stop-loss Insurance. **(9H)**

REFERENCES:

1. Robin Cunningham, Thomas N. Herzog, Richard L. Models for Quantifying Risk, 4th Edition, ACTEX Publications, 2011.
2. Browers, Newton L et al., Actuarial Mathematics 2nd. Society of Actuaries, 1997.
3. Dickson, David C. M., Hardy, Mary R. and Waters, Howard R., Actuarial Mathematics for Life Contingent Risks, International Series on Actuarial Science, Cambridge, 2009.
4. Deshmukh S. R., An Introduction to Actuarial Statistics, University Press, 2009
5. Narang, Uma, Insurance Industry in India: Features, Reforms and Outlook, New Century Publications
6. Borowiak, D.S. and A. F. Shapiro. (2013). Financial and Actuarial Statistics: An Introduction (Second Edition). CRC Press.

STAEC03	BIOSTATISTICS	Credits : 3

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Understand the functions survival distributions	Remember
CO 2	Analyze epidemiologic and clinical data	Apply
CO 3	Understand the concept of censoring	Understand
CO 4	Derive simple and general epidemic models.	Analyze
CO 5	Learn natural selection, mutation and estimation of linkage in heredity	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	1	1
CO2	2	3	2	1	2
CO3	2	3	2	3	3
CO4	2	3	2	1	3
CO5	1	2	3	1	3

c. Syllabus:

UNIT I:

Functions of survival time - survival distributions and their applications viz. exponential, gamma, Weibull, Rayleigh, lognormal, death density function for a distribution having bath-tub shape hazard function; Tests of goodness of fit for survival distributions. **(9H)**

UNIT II:

Analysis of epidemiologic and clinical data - studying association between a disease and a characteristic: types of studies in epidemiology and clinical research - prospective study - retrospective study - cross-sectional data; dichotomous response and dichotomous risk factor - 2x2 tables; expressing relationship between a risk factor and a disease; inference for relative risk and odds ratio for 2x2 table - sensitivity - specificity and predictivity; Cox proportional hazard model. **(9H)**

UNIT III:

Type I and type II censoring schemes with biological examples - estimation of mean survival time and variance of the estimator for type I and type II censored data - numerical examples. Nonparametric methods for estimating survival function and variance of the estimator. **(9H)**

UNIT IV:

Competing risk theory - indices for measurement of probability of death under competing risks and their interrelations; Estimation of probabilities of death under competing risks by maximum likelihood; Theory of independent and dependent risks. **(9H)**

UNIT V:

Simple and general epidemic models-random variable technique-Basic biological concepts in genetics - Mendels law, Hardy-Weinberg equilibrium - random mating, distribution of allele frequency - approach to equilibrium for X-linked genes, natural selection, mutation, genetic drift, equilibrium - natural selection and mutation, detection and estimation of linkage in heredity. **(9H)**

REFERENCES:

1. Collett, D. (2023). Modelling survival data in medical research. CRC press.
2. Friedman, L. M., Furberg, C. D., DeMets, D. L., Reboussin, D. M., and Granger, C. B. (2015). Fundamentals of clinical trials. springer.
3. Indrayan, A., and Malhotra, R. K. (2017). Medical biostatistics. CRC Press.
4. Lee, E. T., and Wang, J. (2003). Statistical methods for survival data analysis (Vol. 476). John Wiley and Sons.
5. Deshpande, J. V., and Purohit, S. G. (2015). Lifetime Data: Statistical Models and Methods (Vol. 16). World Scientific Publishing Company.
6. Daniel, W. W., and Cross, C. L. (2018). Biostatistics: a foundation for analysis in the health sciences. Wiley.

STAEC04	ECONOMETRICS	Credits : 3

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Understand the basic concepts of Econometrics, methodology in Econometric theory	Remember
CO 2	Derive Generalized Least square estimators and verifying the validity of essential assumptions.	Understand
CO 3	Forecast from Dynamic models and Evaluate order of Auto correlation. Determine Simultaneous equations models for real world problems	Apply
CO 4	Obtain and evaluate estimators applying Indirect least squares method, two-stage least squares method, K-Class estimators LIML and FIML.	Analyze
CO 5	Develop computer programmes for construction and evaluation of Econometric models	Apply

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	2
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	2	2	1	3	2
CO5	3	1	1	1	2

c. Syllabus:

UNIT I:

Nature and scope of Econometrics - Illustrative examples Production and cost analysis - Theory and analysis of consumer demand specification - Estimation of demand function - Price and income elasticity of demand - Price elasticity's of supply - Torquivists model of demand for inferior goods models building bias in construction of models.

(9H)

UNIT II:

Single equation linear model static case - Ordinary least square model and generalized least squares model: Introduction - estimation and prediction - Problem of heteroscedasticity – Causes, consequences and solutions of and estimation.

(9H)

UNIT III:

Autocorrelation: Causes, consequences and testing for auto-correlated disturbances - Autoregressive series of order 1 (AR(1)) - Lagged variables and distributed log methods - Errors in variable models and Instrumental variables. Economical Forecasting – long term and short term.

(9H)

UNIT IV:

Simultaneous equations model- Concept, structure and types - Identification Problem with restrictions on variance and covariance - Rank and order conditions of identifiability –Methods of estimation- Indirect least square method, two-stage least squares method of estimation and Estimation of Limited Information Maximum Likelihood (LIMH).

(9H)

UNIT V:

K-Class estimators - Full information estimators - Full Information Maximum Likelihood (FIMH) - Three stage least squares estimators (3-SLS) and its Properties - Comparison of various estimation methods.

(9H)

REFERENCES:

1. Castle, J. and Shephard, N. (2009). The Methodology and Practice of Econometrics. OUP Oxford publications.
2. Gujarati, D.N. and Sangeetha (2007). Basic Econometrics (Third Edition). McGraw Hill Publisher, New York.
3. Goldberger, A.S. (1964): Econometrics theory. John Wiley & Sons, New Delhi. 16
4. Kelejion, H. H. and Oates, W.E. (1988). Introduction to Econometrics, Principles and Applications. Harper and Row Publishers Inc., New York.
5. Maddala, G.S. and Kajal Lagari (2009). Introduction to Econometrics. John Wiley & Sons.
6. Madnani, G.M.K. (2008): Introduction to Econometrics: Principles and Applications. Oxford and IBH Publishing.
7. Wooldridge, J. (2012). Introduction Econometrics: A Modern Approach. Cengage Learning. 3.4 DEMOGRAPHY

STAEC05	ARTIFICIAL INTELLIGENCE	Credits:3

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Demonstrate fundamental understanding of the history of artificial intelligence (AI) and its foundations.	Remember
CO 2	Apply basic principles of AI in solutions that require problem solving, inference, perception, knowledge representation, and learning.	Understand
CO 3	Demonstrate awareness and a fundamental understanding of various applications of AI	Apply
CO 4	Demonstrate proficiency developing applications in an 'AI language', expert system shell, or data mining tool.	Analyze
CO 5	Demonstrate an ability to share in discussions of AI, its current scope and limitations, and societal implications.	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	3	3
CO2	2	3	2	3	2
CO3	3	2	2	2	3
CO4	2	1	3	1	1
CO5	3	2	1	1	3

c. Syllabus:

UNIT I:

The foundations of AI - The History of AI- Intelligent agents- Agent based system. Searching for solution- Uninformed/Blind search - Informed/Heuristic search - A* search - Hill-climbing search -Constraint satisfaction problem. **(9H)**

UNIT II:

Knowledge-based agents – propositional logic – propositional theorem proving – propositional model checking – agents based on propositional logic. First-order logic – syntax and semantics – knowledge representation and engineering – inferences in first-order logic – forward chaining – backward chaining – resolution. **(9H)**

UNIT III:

The planning problem - Planning with state space search - Partial order search - Planning with proportional logic - Planning and acting in the real world, Adversarial planning. **(9H)**

UNIT IV:

Uncertainty-Probabilistic reasoning - Semantics of Bayesian network -Approximate inference in Bayesian network, Exact inference in Bayesian network -Probabilistic reasoning over time. **(9H)**

UNIT V:

Learning from observation - Knowledge in learning - Statistical learning methods - Reinforcement learning. Game Playing and CSP - Game theory – optimal decisions in games – alpha-beta search – monte-carlo tree search – stochastic games – partially observable games. Constraint satisfaction problems – constraint propagation –backtracking search for CSP – local search for CSP – structure of CSP. **(9H)**

REFERENCES:

1. Russell, S. J., andNorvig, P. (2021), "Artificial Intelligence – A Modern Approach", Fourth Edition, Pearson Education.
2. Pool, D. and Mackworth, A. (2011). Artificial Intelligence: Foundations of Computational agents. Cambridge University.
3. Dan W. Patterson(20027), "Introduction to AI and ES", Pearson Education.
4. Kevin Night, Elaine Rich, and Nair B.(2008), "Artificial Intelligence", McGraw Hill.
5. Patrick H. Winston(2006), "Artificial Intelligence", Third Edition, Pearson Education.
6. Deepak Khemani(2013), "Artificial Intelligence", Tata McGraw Hill Education.

STAEC06	FINANCIAL STATISTICS	Credits : 3

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Recall concepts of portfolio and financial market instruments.	Remember
CO 2	Use of financial market instruments	Understand
CO 3	Apply stochastic models for financial data	Apply
CO 4	Analyze the market behaviour	Analyze
CO 5	Provide support for making decisions related to transactions in financial market.	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	2	2	2
CO2	3	2	3	2	2
CO3	3	1	3	1	3
CO4	2	1	1	2	3
CO5	3	3	2	3	2

c. Syllabus:

UNIT I:

Probability review: Real valued random variables, expectation and variance, skewness and kurtosis, conditional probabilities and expectations. Discrete Stochastic Processes, Binomial processes, General random walks, Geometric random walks, **(9H)**

UNIT II:

Review and Extensions- Assets, Portfolios and Arbitrage, Derivatives, Pricing, Hedging, Greeks, Continuous Time Models, Wiener Process, Binomial models with state-dependent increments. **(9H)**

UNIT III:

Elements of Stochastic Calculus, Stochastic Differential Equations, Partial Differential Equations, Black- Scholes' PDE, Applications of Martingales in Pricing of Assets, Estimation of Volatility, CRR Model. **(9H)**

UNIT IV:

Financial Markets Instruments- Exotic Options, Reflection Principle, Asian Options, Change of Numeraire, Pricing of Exchange Options, Forward Rates Modelling, Forward Vesicek Rates, Interest Rates Derivatives and their Pricing, Default Risk in Bond Markets, Credit Default Swaps **(9H)**

UNIT V:

Jump Processes- Poisson Process, Compound Poisson Processes, Stochastic Integrals with Jumps, Itô- Integral with Jumps, Stochastic Differential Equations with Jumps, Girsanov Theorem for Jumps Processes, Lèvy Processes, Pricing and Hedging in Jump Processes. **(9H)**

REFERENCES:

1. Lamberton, D. and Lepeyre, B. (2008). Introduction to Stochastic Calculus Applied to Finance, 2nd ed., Chapman and Hall/CRC Press.
2. Privault, N. (2014). Stochastic Finance –An Introduction with Market Examples, Chapma and Hall/CRC. Financial Mathematics Series, CRC Press, Boca Raton,2014.
3. Tankov, P. (2010). Financial Modeling with Levy Processes, e-Book.

STAEC07	RELIABILITY THEORY AND SURVIVAL ANALYSIS	Credits: 3

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Know about the concepts of Reliability	Remember
CO 2	Get idea about some life time distributions.	Understand
CO 3	Analyze IFR, IFRA, NBU, DMRL and NBUE classes and their duals	Analyze
CO 4	Know about survival Analysis and Models	Understand
CO 5	Analyze Kaplan-Meier method and Cox PH model	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	3	2	2
CO2	3	2	2	3	3
CO3	3	2	2	3	3
CO4	1	3	3	2	2
CO5	2	1	1	2	1

C. SYLLABUS :

UNIT I:

Reliability concepts and measures – components and systems – Coherent systems and their reliability – cuts and paths – modular decomposition – bounds on system reliability – structural reliability importance of components. (9H)

UNIT II:

Life time distributions – reliability function – hazard rate - common life time distributions–exponential, gamma, normal, Weibull, Rayleigh– estimation of parameters, Concept of Type-I (time), Type-II (order) and random censoring. (9H)

UNIT III:

Notions of ageing – IFR, DFR, IFRA, NBU, DMRL and NBUE classes and their duals – implications – closures of these classes under formation of coherent systems. (9H)

UNIT IV:

Introduction to Survival analysis-terminology and functions of survival analysis-goals-basic data layout-censoring-different types of censoring-parametric survival models based on basic life time distributions-Exponential, Weibull, Gamma, Gompertz-Makeham-General method for incorporating covariates in parametric models. (9H)

UNIT V:

Kaplan-Meier's method-general features and assumptions-Log rank test for two groups, several groups-alternatives to log rank test: Wilcoxon, Tarone-Ware, Peto-Prentice and Fleming-Harrington tests-Cox PH model and its features-ML estimation of the Cox PH Model-Hazard Ratio- Adjusted survival curves-Cox likelihood. **(9H)**

REFERENCES:

1. Bain, L.J. and Engelhardt. (1991): Statistical Analysis of Reliability and Life Testing Models. CRC Press.
2. Barlow, R.E., and Proschan, F. (1981): Statistical Theory of Reliability and Life Testing (Second Edition). Holt, Rinehart and Winston, New York.
3. Blischke, W.R. and Murthy, D.N.P. (2000): Reliability–Modeling, Prediction and Optimization. John Wiley and Sons, New York.
4. Lawless, J.F. (2011): Statistical Models and Methods for Lifetime Data (Second Edition). John Wiley and Sons,
5. Nelson, W.B. (2005): Applied Life Data Analysis. John Wiley and Sons, New York.
6. Singpurwalla, N.D. (2006): Reliability and Risk – A Bayesian Perspective. John Wiley and Sons, New York.
7. Zacks, S. (2011): Introduction to Reliability Analysis. Springer London, Limited.
8. Kleinbaum, D. G., and Klein M. (2012): Survival Analysis: A Se

STAEC08	MACHINE LEARNING	Credits: 3

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Have a good understanding of the fundamental issues and challenges of machine learning: data, model selection, model complexity, etc.	Remember
CO 2	Have an understanding Network protocols, analysis of Web traffic, Computer security, Bioinformatics and Machine Learning	Understand
CO 3	Appreciate the underlying mathematical relationships within and across Machine Learning algorithms and the paradigms of supervised and un-supervised learning.	Apply
CO 4	Be able to design and implement various machine learning algorithms in a range of real-world applications.	Analyze
CO 5	Get exposure to a wide variety of mathematical concepts used in computer science discipline like probability, Graph Theory for solving problems, sampling and estimation.	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	3	2
CO2	3	2	3	2	2
CO3	2	3	3	2	3
CO4	2	1	1	2	3
CO5	1	3	2	3	1

C. Syllabus:

UNIT I:

Introduction to Machine Learning, Different Forms of Learning, Linear Regression, Ridge Regression, Lasso, Bayesian Regression, Regression with Basis Functions. **(9H)**

UNIT II:

Instance-Based Classification, Linear Discriminant Analysis, Logistic Regression, Large Margin Classification, Kernel Methods, Support Vector Machines, Multi-class Classification, Classification and Regression Trees. **(9H)**

UNIT III:

Neural Networks: Multi-layer Networks, Back-propagation, Multi-class Discrimination, Training Procedures, Localized Network Structure, Deep Learning. Graphical Models: Hidden Markov Models, Bayesian Networks, Markov Random Fields, Conditional Random Fields. **(9H)**

UNIT IV:

Ensemble Methods: Boosting - Adaboost, Gradient Boosting, Bagging -Simple Methods, Random Forest, Clustering: K-Medoids, CLARA, DENCLUE, DBCSAN. **(9H)**

UNIT V:

Learning Associative rules -Mining Frequent Patterns - basic concepts -Apriori algorithm, FP- Growth algorithm, Associationbased Decision Trees- Simple problems. **(9H)**

REFERENCES:

1. C. Bishop, Pattern Recognition and Machine Learning, Springer - Verlag,2006.
2. T. Mitchell, Machine Learning, McGraw Hill Education, 2017.
3. R. O. Duda, P. E. Hart and D. G. Stork, Pattern Classification, Wiley-Blackwell;2nd edition, 2000.
4. T. Hastie, R. Tibshirani and J. Friedman, Elements of Statistical Learning, 2nd Edition, Springer, 2009.
5. Han, Jiawei, Jian Pei, and Micheline Kamber. Data mining: concepts andtechniques. Elsevier, 2011.

STAEC09	FUZZY SET THEORY and FUZZY LOGIC	Credits: 3

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Have knowledge on Fuzzy sets and Membership Functions.	Remember
CO 2	Decide the difference between crips set and fuzzy set theory.	Understand
CO 3	Make applications on Fuzzy logic membership function and fuzzy inference systems.	Apply
CO 4	Able to make decision under Fuzzy States and Fuzzy Actions.	Analyze
CO 5	Apply Fuzzy pattern recognition, Image processing and Syntactic Recognition.	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	2	2	3
CO2	1	2	1	3	3
CO3	3	2	1	2	2
CO4	2	3	3	3	3
CO5	2	3	2	2	1

C. Syllabus:

UNIT I:

Uncertainty and Imprecision – Statistics and Random Processes – Uncertainty in Information – Fuzzy Sets and membership – Chance versus Ambiguity - Classical Sets – Fuzzy Sets – Sets as Points in Hyper-cubes - Classical Relations and Fuzzy Relations: Cartesian Product – Crisp Relations – Fuzzy Relations – Fuzzy Tolerance and Equivalence Relations - Membership Functions. **(9H)**

UNIT II:

Fuzzy-to-Crisp Conversions: Lambda-Cuts for Fuzzy Sets – Lambda-Cuts for Fuzzy Relations – Defuzzification Methods - Fuzzy Arithmetic, Numbers, Vectors and the Extension Principle - Extension Principle – Fuzzy Numbers – Interval Analysis in Arithmetic – Approximate Methods of Extension – Fuzzy Vectors. **(9H)**

UNIT III:

Classical Logical and Fuzzy Logic: Classical Predicate Logic – Fuzzy Logic – Approximate Reasoning – Fuzzy Tautologies, Contradictions, Equivalence, and Logical Proofs – Other Forms of the Implication Operation – Other Forms of the Composition Operation - Fuzzy Rule-Based Systems: Natural Language – Linguistic Hedges – Rule-Based Systems – Graphical Techniques ofInference. **(9H)**

UNIT IV:

Fuzzy Nonlinear Simulation: Fuzzy Relational Equations – Partitioning – Nonlinear Simulation Using Fuzzy Rule-Based Systems – Fuzzy Associative Memories (FAMs) – Fuzzy Decision Making: Fuzzy Synthetic Evaluation – Fuzzy Ordering – Preference and Consensus –Multi-objective Decision Making – Fuzzy Bayesian Decision Method – Decision Making under Fuzzy States and Fuzzy Actions. **(9H)**

UNIT V:

Fuzzy Classification: Classification by Equivalence Relations – Cluster Analysis – Cluster Validity – Classification Metric – Hardening the Fuzzy- Similarity Relations from Clustering. Fuzzy Pattern Recognition: Feature Analysis – Partitions of the Feature Space – Single Sample Identification –Fuzzy Statistics- Multi-feature Pattern Recognition – Image Processing – Syntactic Recognition. **(9H)**

REFERENCES:

1. George, A. and Anastassiou. (2010). Fuzzy Mathematics: Approximation Theory. Springer.

2. George J. Klir and Tina A. Folge.(1988). Fuzzy Set, Uncertainty, and Information. PrenticeHall, Inc, USA.

3. Klir, G.J. and B. Yuan. (1995). Fuzzy sets and Fuzzy logic Theory and Applications.Prentice-Hall Inc., (Reprint 2003).

4. Nanda. S and Das. N.R. (2010). Fuzzy Mathematical Concepts. Narosa Publishing House,Pvt, Ltd, New Delhi 110002.

5. Nguyen, H.T., Prasad, N.R., Walker, A.L. and Walker, E.A. (2003). A First Course inFuzzy and Neural Control. Chapman Hall/CRC press.

6. Nguyen, H.T. and Walker, E.A. (2005). A First Course in Fuzzy Logic (Third Edition).CRC Press.

7. Ross, T.J. (2009). Fuzzy Logic with Engineering Applications (Third Edition). John Wileyand Sons.

STAEC10	BAYESIAN METHODS	Credits: 3

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO1	Learn various priors and their determination	Remember
CO2	Find posterior distributions for given decision making problem	Understand
CO3	Draw inferences appying Bayesian estimation and hypotheses testing procedures	Analyze
CO4	Carry out computations appying Gibbs sampling and Metropolis-Hasting sampling	Apply
CO5	Determine linear models applying Bayesian methods	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	2	3	1
CO2	3	2	2	3	2
CO3	3	3	3	3	3
CO4	3	3	1	3	3
CO5	3	3	3	3	3

c. Syllabus:

UNIT I:

Subjective probability, its existence and interpretation. Prior distribution, subjective determination of prior distribution. Improper priors, non-informative (default) priors, invariant priors. Conjugate prior families, construction of conjugate families using sufficient statistics of fixed dimension, hierarchical priors and partial exchangeability. Parametric Empirical Bayes. **(9H)**

UNIT II:

Bayesian inference: Bayes sufficiency, summary through posterior, predictive inference. (9H)
UNIT III: Bayesian decision theory: Bayes solutions for practical decision problems. Point estimation, credible sets. **(9H)**

UNIT IV:

Bayesian testing of hypotheses. Comparison with classical procedures. **(9H)**

UNIT V:

Bayesian computation - Monte-Carlo Integration and Markov chain Monte Carlo techniques (without proof) – Gibbs Sampler - Asymptotic expansion for the posterior density. **(9H)**

REFERENCES:

1. Berger, J.O. : Statistical Decision Theory and Bayesian Analysis, Springer Verlag.

2. Ghosh,J.K., Delampady, M., and T.Samanta (2006). An Intriduction to Bayesian Analysis – Theory and Methods. Springer Verlag, New Delhi.

3. Robert, C.P. and Casella, G. : Monte Carlo Statistical Methods, Springer Verlag.

4. Leonard, T. and Hsu, J.S.J. : Bayesian Methods, Cambridge University Press.

5. Bernando, J.M. and Smith, A.F.M. : Bayesian Theory, John Wiley and Sons.

6. Robert, C.P. : The Bayesian Choice: A Decision Theoretic Motivation, Springer.

7. Gemerman, D. : Markov Chain Monte Carlo: Stochastic Simulation for Bayesian Inference, Chapman Hall.

8. Box, G.E.P. and Tiao, G.C.: Bayesian Inference in Statistical Analysis, Addison-Wesley.

STAEC11	APPLIED STOCHASTIC PROCESSES	Credits : 3

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Understand Continuous time Markov processes, Q-Matrix and equilibrium distribution	Understand
CO 2	Understand diffusion processes and Brownian motion	Understand
CO 3	Application of different Poisson processes	Apply
CO 4	Understand the concept of MCMC and queueing theory	Analyze
CO 5	Apply epidemic models and perform simulations	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	2
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	2	2	1	3	2
CO5	1	1	1	1	2

c. Syllabus:

UNIT I:

Continuous-time Markov chains: Markov property, transition probability function, standing assumptions, Chapman-Kolmogorov equations, Q-matrix, Kolmogorov forward and backward differential equations, equilibrium distribution. **(9H)**

UNIT II:

Diffusion processes, Weiner processes, Brownian motion with drift, Geometric and Integrated Brownian motion, white noise, First-passage problems. **(9H)**

UNIT III:

Poisson processes, Non-homogeneous Poisson processes, Compound Poisson processes, Doubly stochastic Poisson processes, Filtered Poisson Processes, Renewal processes, Regenerative Processes. **(9H)**

UNIT IV:

Introduction to MCMC, The Markov single-server (M/M/1) queue, Multiserver (M/M/cl/c2) queues, Erlang's formula, Little's formula, Pollaczek-Khintchine formula. **(9H)**

UNIT V:

Stopping times, Strong Markov property, Holding theorem, Deterministic Epidemic model, Stochastic model without removals, Stochastic model with removals, Simulations in Markov Chain. **(9H)**

REFERENCES:

1. Karlin, S. (2014). A first course in stochastic processes. Academic press.
2. Medhi, J. (2009). Stochastic Processes, 3rd Edition. New age International.
3. Bhat, B. R. (2004). Stochastic models: analysis and applications. New Age International.
4. Cox, D. R., and Miller, H. D. (1983). The theory of stochastic processes (Vol. 134).3rd Edition, Chapman and Hall.
5. Ross, S. M. (1995). Stochastic Process. John Wiley & Sons.
6. Ross, S. M. (2023). Introduction to probability models, Elsevier.
7. Gallager, R. G. (2013). Stochastic Processes: Theory for applications. Cambridge University Press.
8. Gangopadhyay, S. and Chandra, T. K. (2018). Introduction to Stochastic Processes. Narosa Publishing House.

STAEC12	DEEP LEARNING	Credits : 3

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Able to understand the mathematics behind functioning of artificial neural networks	Remember
CO 2	Able to analyze the given dataset for designing a neural network based solution	Understand
CO 3	Able to carry out design and implementation of deep learning models for signal/image processing applications	Apply
CO 4	Able to design Auto Encoders.	Analyze
CO 5	Learn about Deep Generative models.	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	2	3
CO2	2	3	2	3	3
CO3	3	3	3	2	2
CO4	1	2	2	1	3
CO5	2	1	3	3	1

c. Syllabus:

UNIT I:

Learning algorithms, Maximum likelihood estimation, Building machine learning algorithm, Neural Networks Multilayer Perceptron, Back-propagation algorithm and its variants Stochastic gradient decent, Curse of Dimensionality. **(9H)**

UNIT II:

Introduction to Deep Learning and Architectures, Machine Learning Vs. Deep Learning, Representation Learning, Width Vs. Depth of Neural Networks, Activation Functions: RELU, LRELU, ERELU, Unsupervised Training of Neural Networks, Restricted Boltzmann Machines, Auto Encoders. **(9H)**

UNIT III:

Architectural Overview – Motivation - Layers – Filters – Parameter sharing – Regularization, Popular CNN Architectures: Res Net, Alex Net, Transfer Learning - Transfer learning Techniques, Variants of CNN: Dense Net, PixelNet. Sequence Modeling – Recurrent and Recursive Nets, Recurrent Neural Networks, Bidirectional RNNs – Encoder-decoder sequence to sequence architectures - BPTT for training RNN, LongShort Term Memory Networks.

(9H)

UNIT IV:

Auto Encoders - Under complete Auto encoders – Regularized Auto encoders – stochastic Encoders and Decoders – Contractive Encoders. **(9H)**

UNIT V:

Deep Generative Models-Deep Belief networks – Boltzmann Machines – Deep Boltzmann Machine - Generative Adversial Networks, Applications of DL. **(9H)**

REFERENCES:

1. Heaton, J. (2018). Ian Good fellow, Yoshua Bengio, and Aaron Courville: Deep learning: The MIT Press, 2016, 800 pp, ISBN: 0262035618. Genetic programming and evolvable machines, 19(1-2), 305-307.
2. Patterson, J., and Gibson, A. (2017). Deep learning: A practitioner's approach. " O'Reilly Media, Inc.".
3. Michelucci, U. (2018). Applied deep learning. A Case-Based Approach to Understanding Deep Neural Networks.
4. Murphy, K. P. (2012). Machine learning: a probabilistic perspective. MIT press.
5. Alpaydın, E. (2014). Introduction to Machine Learning, (Adaptive Computation and Machine Learning)almohreraladbi.
6. Zaccone, G., and Karim, M. R. (2018). Deep Learning with TensorFlow: Explore neural networks and build intelligent systems with Python. Packt Publishing Ltd.
7. Gulli, A., and Pal, S. (2017). Deep learning with Keras. Packt Publishing Ltd.
8. Chollet, F. (2021). Deep learning with Python. Simon and Schuster.

STAEC13	STATISTICAL METHODS IN CLINICAL TRIALS	Credits : 3

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Know the phases of clinical trials and epidemiological designs.	Remember
CO 2	Understand the Disease-Exposure association and diagnostic testing in clinical studies.	Understand
CO 3	Check model assumptions for Estimation of Means and proportions to analyze the clinical data.	Apply
CO 4	Design the different phases of clinical trials	Analyze
CO 5	Estimate survival function of the data	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	3	3	3
CO2	2	3	1	3	2
CO3	2	1	2	3	2
CO4	3	3	3	3	3
CO5	2	3	3	2	3

c. Syllabus:

UNIT I:

Introduction to clinical trials: the need and ethics of clinical trials - bias and random error in clinical studies - conduct of clinical trials - overview of Phase I-IV trials - multi- Center trials. **(9H)**

UNIT II:

Data management: data definitions - case report forms - database design - data collection systems for good clinical practice - concept of blinding/masking in clinical trials; Bioavailability – pharmacokinetics - pharmaco-dynamics - two compartment model. **(9H)**

UNIT III:

Design of clinical trials: parallel vs. cross-over designs - cross-sectional vs. longitudinal designs - review of factorial designs - objectives and endpoints of clinical trials. **(9H)**

UNIT IV:

Design of Phase I trials - design of single-stage and multi-stage Phase II trials - design and monitoring of Phase III trials with sequential stopping. **(9H)**

UNIT V:

Design of bio-equivalence trials - Inference for 2x2 crossover designs: Classical methods of interval hypothesis testing for bioequivalence - Bayesian methods - nonparametric methods; Reporting and analysis: analysis of categorical outcomes from Phase I - III trials - analysis of survival data from clinical trials. **(9H)**

REFERENCES:

1. Jennison, C., and Turnbull, B. W. (1999). Group sequential methods with applications to clinical trials. CRC Press.
2. Chow, S. C., and Liu, J. P. (2008). Design and analysis of clinical trials: concepts and methodologies (Vol. 507). John Wiley and Sons.
3. Chow, S. C., and Liu, J. P. (2008). Design and analysis of bioavailability and bioequivalence studies. CRC press.
4. Clayton, D., and Hills, M. (2013). Statistical models in epidemiology. OUP Oxford.
5. Daniel, W. W., and Cross, C. L. (2018). Biostatistics: a foundation for analysis in the health sciences. Wiley.
6. Fleiss, J. L. (2011). Design and analysis of clinical experiments. John Wiley and Sons.
7. Friedman, L. M., Furberg, C. D., DeMets, D. L., Reboussin, D. M., and Granger, C. B. (2015). Fundamentals of clinical trials. Springer.
8. Marubini, E., and Valsecchi, M. G. (2004). Analysing survival data from clinical trials and observational studies (Vol. 15). John Wiley and Sons.
9. Piantadosi, S. (2017). Clinical trials: a methodologic perspective. John Wiley and Sons.

Open Electives
(To be offered for other Department students)

S. No.	Course Code	Course Name	Credit	Hours	Type
1	STAOE01	Basic Statistics	3	3	OE
2	STAOE02	Data Analysis using Excel	3	3	OE
3	STAOE03	Exploratory Data Analysis	3	3	OE

STAOE01	BASIC STATISTICS	Credits : 3

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Recall data representation, central tendency and dispersion.	Remember
CO 2	Explain bi-variate data, correlation and regression analysis.	Understand
CO 3	Do testing of hypothesis for parameters.	Apply
CO 4	Learn to calculate the probability of an event.	Skill
CO 5	Decide appropriate sample survey design.	Analyze

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	2	1
CO2	1	3	2	1	2
CO3	2	3	2	3	3
CO4	3	3	2	1	3
CO5	3	2	3	3	3

c. Syllabus:

UNIT I:

Definition and scope of Statistics, representation data. Measures of Central Tendency: Mean, Median, Mode; Measures of Dispersion: Range, Mean deviation, Standard deviation, Coefficient of variation. Skewness, and Kurtosis. **(9H)**

UNIT II:

Bivariate data, Scatter diagram, Karl-Pearson Correlation Coefficient, Coefficient of Determination, Spearman's Rank Correlation. linear regression, Principle of least squares. **(9H)**

UNIT III:

Testing of Hypothesis, Null and alternative hypotheses, level of significance, Type I and Type II errors, their probabilities and critical region, Power of the Test, z-test, t-test, F-test, Chi-square test for independence of attributes and Goodness-of-Fit. **(9H)**

UNIT IV:

Probability: Definitions, random experiments, sample space, events. Conditional Probability, laws of addition and multiplication, independent events, theorem of total probability, Bayes' theorem and its applications. **(9H)**

UNIT V:

Complete enumeration versus sampling, Sampling and Non-Sampling errors. Types Of Sampling: Non-Probability and Probability Sampling, Simple Random Sampling with and without replacement. **(9H)**

REFERENCES:

1. S. C. Gupta, Fundamentals of Statistics, 7th Edition, Himalaya Publishing House, 2018.
2. R. V. Hogg, A. Craig and J. W. McKean, 6th Edition, Introduction to Mathematical Statistics, 2006.
3. A. M. Gun, M. K. Gupta and B. Dasgupta, Fundamentals of Statistics (Vol-I and II), World Press, 2016.
4. Gupta, S. C., and Kapoor, V. K. (2020). Fundamentals of mathematical statistics. Sultan Chand and Sons.
5. Kelley, T. L. (1947). Fundamentals of statistics (No. 2). Harvard University Press.
6. https://online.stat.psu.edu/statprogram/reviews/statistical-concepts
7. S. C. Gupta, Fundamentals of Statistics, 7th Edition, Himalaya Publishing House, 2018.
8. R. V. Hogg, A. Craig and J. W. McKean, 6th Edition, Introduction to Mathematical, Statistics, 2006.
9. A. M. Gun, M. K. Gupta and B. Dasgupta, Fundamentals of Statistics (Vol-I andamp; II), World Press, 2016.
10. Gupta, S. C., andamp; Kapoor, V. K. (2020). Fundamentals of mathematical statistics, Sultan Chand andamp; Sons.
11. Kelley, T. L. (1947). Fundamentals of statistics (No. 2). Harvard University Press.

STAOE02	DATA ANALYSIS USING EXCEL	Credits: 3

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	To use different functions of MS Excel with regard to data analysis.	Remember
CO 2	To understand the principles behind data mining, importing data and organizing data.	Understand
CO 3	To apply statistical analysis and technologies on data to find trends, high level visual summaries and solve problems.	Apply
CO 4	Obtain and evaluate estimators applying Indirect least squares method, two-stage least squares method, K-Class estimators LIML and FIML.	Analyze
CO 5	To start data analysis and modeling.	Apply

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	2
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	2	2	1	3	2
CO5	3	1	1	1	2

c. Syllabus:

UNIT I:

Understanding the Excel- ribbon- Ribbon components- Understanding worksheet & workbook-Customization-Important Excel shortcuts. Arithmetic Operations in Excel: Creating Excel sheet & entering data-Format Data (column name bold, align data, enclose data in boxes, and set the print area, print preview & page layout) Data validation in Excel: Filtering, Grouping and Sorting.

(9H)

UNIT II:

Arithmetic Operations in Excel: Creating Excel sheet & entering data-Format Data (column name bold, align data, enclose data in boxes, and set the print area, print preview & page layout) Data validation in Excel: Filtering, Grouping and Sorting.

(9H)

UNIT III:

Basic Formulas & Functions: Formulas-Numeric functions-string functions-date time functions-VLOOKUP functions Logical Functions: IF, AND, OR Nested IF & NOT.

(9H)

UNIT IV:

Charts: Pie, bar, column, Line, Combo charts (plotting charts). Budget: Income sheet preparation, Expenditure sheet, Actual Annual saving & expected actual savings. **(9H)**

UNIT V:

Importing & Entering Data: Importing xml & csv files, Entering and arranging data. Creating Pivot Tables: Creating one dimensional pivot table with column names and 2 dimensional pivot tables (Practical). Basic data analysis: Descriptive statistics, Correlation, Regression & its interpretation. **(9H)**

REFERENCES:

1. Data Analysis with Excel by Manisha Nigam, BPB Publications. ISBN:9789388176675
2. Data Analysis using Excel Tutorial by edureka.

STAOE03	EXPLORATORY DATA ANALYSIS	Credits : 3

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Know about missing data handling and MLE.	Remember
CO 2	Get knowledge on Bayesian Estimation.	Understand
CO 3	Perform Outlier Detections.	Apply
CO 4	Analyze Feature selection Algorithms.	Analyze
CO 5	Examine PCA, Canonical Correlation and Factor Analysis.	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	2	3	1
CO2	3	2	3	2	3
CO3	2	3	1	2	2
CO4	1	2	3	3	2
CO5	3	1	2	3	3

c. Syllabus:

UNIT I:

Introduction To Exploratory Data Analysis: Data Analytics lifecycle, Exploratory Data Analysis (EDA)– Definition, Motivation, Steps in data exploration, The basic data types Data Type Portability, Preprocessing-Traditional Methods and Maximum Likelihood Estimation 4 hours Introduction to Missing data, Traditional methods for dealing with missing data, Maximum Likelihood Estimation – Basics, Missing data handling, Improving the accuracy of analysis.

(9H)

UNIT II:

Preprocessing Bayesian Estimation - Introduction to Bayesian Estimation, Multiple Imputation-Imputation Phase, Analysis and Pooling Phase, Practical Issues in Multiple Imputation, Models for Missing Notation Random Data Summarization and Visualization - Statistical data elaboration, 1-D Statistical data analysis, 2-D Statistical data Analysis, N- D Statistical data analysis. **(9H)**

UNIT III:

Outlier Analysis Introduction, Extreme Value Analysis, Clustering based, Distance Based and Density Based outlier analysis, Outlier Detection in Categorical Data- Feature Subset Selection.

(9H)

UNIT IV:

Feature selection algorithms: filter methods, wrapper methods and embedded methods, Forward selection backward elimination, Relief, greedy selection, genetic algorithms for features selection.

(9H)

UNIT V:

Dimensionality Reduction - Introduction, Principal Component Analysis(PCA), Kernel PCA, Canonical Correlation Analysis, Factor Analysis, Multi-dimensional scaling, Correspondence Analysis. **(9H)**

REFERENCES:

1. Aggarwal, C. C. (2015). Data mining: the textbook (Vol. 1). New York: springer.
2. Koch, I. (2013). Analysis of multivariate and high-dimensional data (Vol. 32). Cambridge University Press.
3. Michael Jambu. (2014). Exploratory and multivariate data analysis. Academic Press Inc. 1990. Cambridge University Press.
4. Charu Aggarwal, C. (2015). Data Classification Algorithms and Applications. CRC press.

Minor Courses
Offered to other Departments by the Department of Statistics and Applied Mathematics

S. No.	Course Code	Course Name	Credit	Hours	Type
1	STAOM01	Statistics-I	3	3	Minor
2	STAOM02	Statistics-II	3	3	Minor

STAOM01	STATISTICS-I	Credits : 3

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Describe statistical concepts and types of data	Remember
CO 2	Summarize data using central tendency and dispersion measures	Understand
CO 3	Apply statistical measures to interpret real life datasets	Apply
CO 4	Analyze relationships using correlation and curve fitting techniques	Analyze
CO 5	Perform data classification and evaluate association of attributes	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	2	1
CO2	2	3	2	3	2
CO3	1	3	2	3	3
CO4	2	3	2	2	2
CO5	3	2	3	2	2

c. Syllabus:

UNIT I:

Definition of statistics: Origin, Scope and limitations of statistics – Concepts of Statistical Population and sample. Primary data-Secondary Data, Types of data -Nominal, Ordinal, Ratio, Interval, Classification and Tabulation of data, Data presentation - Frequency Distribution – One dimensional, two dimensional data Visualization: line diagram, Box plots, stem and Leaf plots, Scatter plots, Histogram.

(9H)

UNIT II:

Measures of Central Tendency: Arithmetic Mean, Median, Mode, Geometric mean and Harmonic mean. Measures of Dispersion: Range, Quartile Deviation, Mean Deviation and Standard Deviation, Coefficient of Variation. Skewness and kurtosis.

(9H)

UNIT III:

Correlation: Meaning, Types of Correlation, Measures of Correlation: Karl Pearson's Coefficient of Correlation, Rank Correlation Coefficient (with and without ties), Simple Linear Regression Model: Fitting of linear regression and related results, regression coefficient.

(9H)

UNIT IV:

Probability: sample space – Events - algebraic operations on events- definition of probability - independent events – conditional probability - addition and multiplication theorems of probability. Random variables: Discrete and continuous random variables – distribution function -properties – probability mass function and probability density function – discrete and continuous probability distributions. **(9H)**

UNIT V:

Some discrete and continuous distributions: Bernoulli, Binomial, Poisson, Uniform, Normal, Exponential. **(9H)**

REFERENCES:

1. Gupta.S.C. and Kapoor.V.K. (2014), Fundamentals of Mathematical Statistics, 12/e, Sultan Chand and sons.
2. Goon A. M., Gupta M.K. and Dasgupta B. (2002). Fundamentals of Statistics, Vol. I and II, 8th Edition, The World Press Pvt. Ltd. Kolkata.
3. Gupta S. P. (2002): Statistical Methods, Sultan Chand and Sons, New Delhi. 5. Gupta V.K. and Kapoor S.C.: Fundamentals of Mathematical Statistics-Sultan & Chand.

STAOM02	STATISTICS-II	Credits : 3

a. Course Outcome (CO):

On the successful completion of the course, the student will be able to

	Course Outcome	Level
CO 1	Describe statistical concepts and types of data	Remember
CO 2	Summarize data using central tendency and dispersion measures	Understand
CO 3	Apply statistical measures ti interpret real life datasets	Apply
CO 4	Analyze relationships using correlation and curve fitting techniques	Analyze
CO 5	Perform data classification and evaluate association of attributes	Skill

b. Mapping of Program Specific Outcomes with Course Outcomes:

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	2	1
CO2	2	3	2	3	2
CO3	1	3	2	3	3
CO4	2	3	2	2	2
CO5	3	2	3	2	2

c. Syllabus:

UNIT I:

Definitions of random sample, parameter and statistics, sampling distribution of a statistics, sampling distribution of sample mean, standard errors of sample mean, sample variance and sample proportion. Null and alternative hypotheses, critical region, level of significance, Type I and Type II errors, concept of p-value.

(9H)

UNIT II:

Sampling distributions: t, F, Chisquare distributions. Testing of hypothesis: Parametric- one sample, two sample, comparing means, Analysis of Variance: one way and Two way ANOVA. Confidence Intervals based on t and F distributions.

(9H)

UNIT III:

Large sample tests 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. **(9H)**

UNIT IV:

Non parametric: Mann- Whitney U test, Wilcoxon signed rank test, Kruskal Wallis test, Friedman test, Chi-square test. **(9H)**

UNIT V:

Multivariate data analysis: Principal Component Analysis, Factor analysis, Classification, Clustering, Discriminant analysis.

(9H)

REFERENCES:

1. Gupta.S.C. and Kapoor.V.K. (2014), Fundamentals of Mathematical Statistics, 12/e, Sultan Chand and sons.
2. Goon A. M., Gupta M.K. and Dasgupta B. (2002). Fundamentals of Statistics, Vol. I and II, 8th Edition, The World Press Pvt. Ltd. Kolkata.
3. Gupta S. P. (2002): Statistical Methods, Sultan Chand and Sons, New Delhi. 5. Gupta V.K. and Kapoor S.C.: Fundamentals of Mathematical Statistics-Sultan & Chand.