



UNIVERSITY OF CALICUT

Abstract

General and Academic IV- Faculty of Science- CUFYUGP Regulations 2024-B.Sc Applied Statistics with Data Science Honours Programme-Scheme and Syllabus - Implemented with effect from 2024 Admission - Subject to ratification by the Academic Council - Orders Issued.

G & A - IV - K Section

U.O.No. 11430/2024/Admn

Dated, Calicut University.P.O, 23.07.2024

*Read:-*1.U.O.No. 3103/2024/Admn dated 22.02.2024.

2.Minutes of the meeting of the Board of Studies in Statistics-UG held on 14.06.2024.

3.Remarks of the Dean, Faculty of Science dated 04.07.2024.

4. Orders of the Vice Chancellor in the file of even No and dated 06.07.2024.

ORDER

1. The Regulations of the Calicut University Four Year UG Programmes (CUFYUGP Regulations 2024) for Affiliated Colleges, were implemented with effect from 2024 admission onwards, vide paper read as (1) above.

2. The meeting of the Board of Studies in Statistics(UG) held on 14.06.2024, vide paper read as (2)above, approved the scheme and syllabus of the B.Sc Applied Statistics with Data Science Honours programme in tune with CUFYUGP Regulations 2024 with effect from 2024 Admission onwards.

3. The Dean, Faculty of Science vide paper read as (3) above, approved the minutes of the meeting of the Board of Studies in Statistics(UG) held on 14.06.2024.

4. Considering the urgency, the Vice Chancellor has approved the minutes of the meeting of the Board of Studies in Statistics(UG) held on 14.06.2024 and granted permission to implement the scheme and syllabus of the B.Sc Applied Statistics with Data Science Honours programme in accordance with CUFYUGP Regulations 2024 with effect from 2024 Admission onwards, subject to ratification by the Academic Council.

5. The scheme and syllabus of the B.Sc Applied Statistics with Data Science Honours programme in tune with CUFYUGP Regulations 2024 is implemented with effect from 2024 Admission onwards.

6. Orders are issued accordingly. (Syllabus appended)

Ajayakumar T.K

Assistant Registrar

To

1.The Principals of all Affiliated Colleges,

Copy to: PS to VC/PA to PVC/ PA to R/PA to CE/JCE I/JCE IV/EX IV and EG Sections/GA IF/CHMK Library/Information Centres/SF/DF/FC

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Section Officer



UNIVERSITY OF CALICUT

**B.Sc. APPLIED STATISTICS WITH DATA
SCIENCE HONOURS**

**Scheme & Syllabus
(CUFYUGP Regulations 2024)**

2024 admission onwards

**B.Sc. APPLIED STATISTICS WITH DATA SCIENCE
HONOURS**

SCHEME

PROGRAMME OUTCOMES (PO):

At the end of the graduate programme at Calicut University, a student would:

PO1	Knowledge Acquisition: Demonstrate a profound understanding of knowledge trends and their impact on the chosen discipline of study.
PO2	Communication, Collaboration, Inclusiveness, and Leadership: Become a team player who drives positive change through effective communication, collaborative acumen, transformative leadership, and a dedication to inclusivity.
PO3	Professional Skills: Demonstrate professional skills to navigate diverse career paths with confidence and adaptability.
PO4	Digital Intelligence: Demonstrate proficiency in varied digital and technological tools to understand and interact with the digital world, thus effectively processing complex information.
PO5	Scientific Awareness and Critical Thinking: Emerge as an innovative problem-solver and impactful mediator, applying scientific understanding and critical thinking to address challenges and advance sustainable solutions.
PO6	Human Values, Professional Ethics, and Societal and Environmental Responsibility: Become a responsible leader, characterized by an unwavering commitment to human values, ethical conduct, and a fervent dedication to the well-being of society and the environment.
PO7	Research, Innovation, and Entrepreneurship: Emerge as a researcher and entrepreneurial leader, forging collaborative partnerships with industry, academia, and communities to contribute enduring solutions for local, regional, and global development.

PROGRAMME SPECIFIC OUTCOMES (PSO):

At the end of the BSc Applied Statistics with Data Science (Honours) programme at Calicut University, a student would:

PSO1	Acquire a comprehensive understanding of concepts, principles, theories and applications of Statistics.
PSO2	Apply fundamental concepts of descriptive and inferential Statistics using data science methodology
PSO3	Master skills in using Statistical Software to meet the challenges of Employability, Research and Development.
PSO4	Identify the potential area of applications of Statistical theories.
PSO5	Construct Statistical models for real-world problems and obtain solutions
PSO6	Continue to acquire relevant knowledge and skills appropriate to professional activities and demonstrate the highest standards of ethical issues in Statistical Science
PSO7	Acquire the statistical skills required to work in the data science industry

**MINIMUM CREDIT REQUIREMENTS OF THE DIFFERENT PATHWAYS
IN THE THREE-YEAR PROGRAMME IN CUFYUGP**

Sl. No .	Academic Pathway	Major	Minor/ Other Disciplines	Foundation Courses AEC: 4 MDC: 3 SEC: 3 VAC: 3	Intern -ship	Total Credits	Example
		Each course has 4 credits		Each course has 3 credits			
1	Single Major (A)	68 (17 courses)	24 (6 courses)	39 (13 courses)	2	133	Major: Statistics + six courses in different disciplines in different combinations
2	Major (A) with Multiple Disciplines (B, C)	68 (17 courses)	12 + 12 (3 + 3 = 6 courses)	39 (13 courses)	2	133	Major: Statistics+ Mathematics and Chemistry
3	Major (A) with Minor (B)	68 (17 courses)	24 (6 courses)	39 (13 courses)	2	133	Major: Statistics Minor: Mathematics
Exit with UG Degree / Proceed to Fourth Year with 133 Credits							

**B.Sc. APPLIED STATISTICS WITH DATA SCIENCE HONOURS
PROGRAMME
COURSE STRUCTURE FOR PATHWAYS 1 – 3**

1. Single Major

2. Major with Multiple Disciplines

3. Major with Minor

Semester	Course Code	Course Title	Total Hours	Hours / Week	Credits	Marks		
						Internal	External	Total
1	ASD1CJ101 / ASD1MN100	Core Course 1 in Major Descriptive Statistics	75	5	4	30	70	100
		Minor Course 1	60/75	4/5	4	30	70	100
		Minor Course 2	60/75	4/5	4	30	70	100
		Ability Enhancement Course 1– English	60	4	3	25	50	75
		Ability Enhancement Course 2 – Additional Language	45	3	3	25	50	75
		Multi-Disciplinary Course 1 – Other than Major	45	3	3	25	50	75
		Total			23/25	21		
2	ASD2CJ101 / ASD2MN100	Core Course 2 in Major Probability and Random Variables	75	5	4	30	70	100
		Minor Course 3	60/ 75	4/ 5	4	30	70	100
		Minor Course 4	60/ 75	4/ 5	4	30	70	100
		Ability Enhancement Course 3– English	60	4	3	25	50	75
		Ability Enhancement Course 4 – Additional Language	45	3	3	25	50	75
		Multi-Disciplinary Course 2 – Other than Major	45	3	3	25	50	75
		Total			23/ 25	21		
3	ASD3CJ201/ ASD3MN200	Core Course 3 in Major Probability Distributions	75	5	4	30	70	100
	ASD3CJ202	Core Course 4 in Major Bivariate Random Variables and Limit Theorems	60	4	4	30	70	100
		Minor Course 5	60/ 75	4/ 5	4	30	70	100
		Minor Course 6	60/ 75	4/ 5	4	30	70	100
		Multi-Disciplinary Course 3 – Kerala Knowledge System	45	3	3	25	50	75
		Value-Added Course 1 – English	45	3	3	25	50	75
	Total			23/ 25	22			550

4	ASD4CJ203	Core Course 5 in Major Sampling Methods	75	5	4	30	70	100	
	ASD4CJ204	Core Course 6 in Major Sampling Distributions and Estimation Theory	60	4	4	30	70	100	
	ASD4CJ205	Core Course 7 in Major Testing of Hypothesis	75	5	4	30	70	100	
		Value-Added Course 2 – English	45	3	3	25	50	75	
		Value-Added Course 3 – Additional Language	45	3	3	25	50	75	
		Skill Enhancement Course 1 – English	60	4	3	25	50	75	
		Total		25	21			525	
5	ASD5CJ301	Core Course 8 in Major Design and Analysis of Experiments	75	5	4	30	70	100	
	ASD5CJ302	Core Course 9 in Major Data Mining Techniques	75	5	4	30	70	100	
	ASD5CJ303	Core Course 10 in Major Introduction to Time Series and Index Numbers	60	4	4	30	70	100	
		Elective Course 1 in Major	60	4	4	30	70	100	
		Elective Course 2 in Major	60	4	4	30	70	100	
		Skill Enhancement Course 2	45	3	3	25	50	75	
		Total		25	23			575	
6	ASD6CJ304	Core Course 11 in Major Linear Regression Analysis	75	5	4	30	70	100	
	ASD6CJ305	Core Course 12 in Major Multivariate Analysis	75	5	4	30	70	100	
	ASD6CJ306	Core Course 13 in Major Statistical Machine Learning	75	5	4	30	70	100	
		Elective Course 3 in Major	60	4	4	30	70	100	
		Elective Course 4 in Major	60	4	4	30	70	100	
		STA6FS113	Skill Enhancement Course 3 – Data Analysis in Statistics	45	3	3	25	50	75
		STA6CJ349	Internship in Major (Credit for the internship to be awarded only at the end of Semester 6)	60		2	50	-	50
	Total		25	25			625		
Total Credits for Three Years					133			3325	

7	STA7CJ401	Core Course 14 in Major Advanced Analytical Tools	75	5	4	30	70	100	
	STA7CJ402	Core Course 15 in Major Probability Theory	75	5	4	30	70	100	
	STA7CJ403	Core Course 16 in Major Distribution Theory	75	5	4	30	70	100	
	STA7CJ404	Core Course 17 in Major Advanced Sampling Methods & Design of Experiments	75	5	4	30	70	100	
	STA7CJ405	Core Course 18 in Major Advanced Statistical Inference	75	5	4	30	70	100	
		Total			25	20			500
8	STA8CJ406/ STA8MN406	Core Course 19 in Major Applied Stochastic Processes and Time Series Analysis	75	5	4	30	70	100	
	STA8CJ407/ STA8MN407	Core Course 20 in Major Applied Multivariate Techniques	60	4	4	30	70	100	
	STA8CJ408/ STA8MN408	Core Course 21 in Major Generalized Linear Models	60	4	4	30	70	100	
	OR (instead of Core Courses 19-21 in Major)								
	STA8CJ449	Project (in Honours programme)	360*	13*	12	90	210	300	
	STA8CJ499	Research Project (in Honours with Research programme)	360*	13*	12	90	210	300	
		Elective Course 5 in Major / Minor Course 7	60	4	4	30	70	100	
		Elective Course 6 in Major / Minor Course 8	60	4	4	30	70	100	
		Elective Course 7 in Major / Minor Course 9 / Major Course in any Other Discipline	60	4	4	30	70	100	
	OR (instead of Elective Course 7 in Major, in the case of Honours with Research Programme)								
	STA8CJ489	Research Methodology	60	4	4	30	70	100	
	Total		25	24			600		
Total Credits for Four Years					177			4425	

*The teacher should have 13 hrs/week of engagement (the hours corresponding to the three core courses) in the guidance of the Project(s) in Honours programme and Honours with Research programme, while each student should have 24 hrs/week of engagement in the Project work. Total hours are given based on the student's engagement.

4	ASD4CJ203	Core Course 5 in Major Sampling Methods	5	4
	ASD4CJ204	Core Course 6 in Major Sampling Distributions and Estimation Theory	4	4
	ASD4CJ205	Core Course 7 in Major Testing of Hypothesis	5	4
5	ASD5CJ301	Core Course 8 in Major Design and Analysis of Experiments	5	4
	ASD5CJ302	Core Course 9 in Major Data Mining Techniques	5	4
	ASD5CJ303	Core Course 10 in Major Introduction to Time Series and Index Numbers	4	4
		Elective Course 1 in Major	4	4
		Elective Course 2 in Major	4	4
6	ASD6CJ304	Core Course 11 in Major Linear Regression Analysis	5	4
	ASD6CJ305	Core Course 12 in Major Multivariate Analysis	5	4
	ASD6CJ306	Core Course 13 in Major Statistical Machine Learning	5	4
		Elective Course 3 in Major	4	4
		Elective Course 4 in Major	4	4
	STA6CJ349	Internship in Major	-	2
Total for the Three Years				70
7	STA7CJ401	Core Course 14 in Major Advanced Analytical Tools	5	4
	STA7CJ402	Core Course 15 in Major Probability Theory	5	4
	STA7CJ403	Core Course 16 in Major Distribution Theory	5	4
	STA7CJ404	Core Course 17 in Major Advanced Sampling Methods & Design of Experiments	5	4
	STA7CJ405	Core Course 18 in Major Advanced Statistical Inference	5	4
	STA8CJ406/	Core Course 19 in Major	5	4

8	STA8MN406	Applied Stochastic Processes and Time Series Analysis		
	STA8CJ407/ STA8MN407	Core Course 20 in Major Applied Multivariate Techniques	4	4
	STA8CJ408/ STA8MN408	Core Course 21 in Major Generalized Linear Models	4	4
	OR (instead of Core Courses 19 – 21 in Major)			
	STA8CJ449	Project (in Honours programme)	13	12
	STA8CJ499	Research Project (in Honours with Research programme)	13	12
		Elective Course 5 in Major	4	4
		Elective Course 6 in Major	4	4
		Elective Course 7 in Major	4	4
	OR (instead of Elective course 7 in Major, in Honours with Research programme)			
	STA8CJ489	Research Methodology	4	4
Total for the Four Years				114

*The teacher should have 13 hrs/week of engagement (the hours corresponding to the three core courses) in the guidance of the Project(s) in Honours programme and Honours with Research programme, while each student should have 24 hrs/week of engagement in the Project work. Total hours are given based on the student's engagement.

ELECTIVE COURSES IN STATISTICS

Sl. No.	Course Code	Title	Semester	Total Hrs	Hrs/Week	Credits	Marks		
							Internal	External	Total
1	ASD5EJ301	Official Statistics	5	60	4	4	30	70	100
2	ASD5EJ302	Actuarial Statistics	5	60	4	4	30	70	100
3	ASD5EJ303	Psychometric Theory and Methods	5	60	4	4	30	70	100
4	ASD5EJ304	Survival Analysis	5	60	4	4	30	70	100
5	ASD5EJ305	Population Statistics	5	60	4	4	30	70	100
6	ASD6EJ306	Biostatistics	6	60	4	4	30	70	100
7	ASD6EJ307	Econometrics	6	60	4	4	30	70	100
8	ASD6EJ308	Statistical Quality Control	6	60	4	4	30	70	100
9	ASD6EJ309	Operations Research	6	60	4	4	30	70	100
10	ASD6EJ310	Simulation Techniques	6	60	4	4	30	70	100

11	STA8EJ411	Statistical Methods for Machine Learning	8	60	4	4	30	70	100
12	STA8EJ412	Operations Research	8	60	4	4	30	70	100
13	STA8EJ413	Queueing Models	8	60	4	4	30	70	100
14	STA8EJ414	Statistical Decision Theory	8	60	4	4	30	70	100
15	STA8EJ415	Analysis of Clinical Trials	8	60	4	4	30	70	100
16	STA8EJ416	Applied Algorithms and Big Data Techniques	8	60	4	4	30	70	100
17	STA8EJ417	Advanced Trends in Statistics	8	60	4	4	30	70	100

DISTRIBUTION OF GENERAL FOUNDATION COURSES IN STATISTICS

Semester	Course Code	Course Title	Total Hours	Hours/Week	Credits	Marks		
						Internal	External	Total
1	STA1FM 105(1)	Multi-Disciplinary Course 1 Quality Control	45	3	3	25	50	75
	STA1FM 105(2)	Fundamentals of statistics						
2	STA2FM 106(1)	Multi-Disciplinary Course 2 Managerial Decision Making	45	3	3	25	50	75
	STA2FM 106(2)	Statistical sampling and probability theory						
5	STA5FS 112	Skill Enhancement Course 2 Statistical analysis using Python	45	3	3	25	50	75
6	STA6FS 113	Skill Enhancement Course 2 Basic research methodology	45	3	3	25	50	75

EVALUATION SCHEME

1. The evaluation scheme for each course contains two parts: internal evaluation (about 30%) and external evaluation (about 70%). Each of the Major and Minor courses is of 4-credits. It is evaluated for 100 marks, out of which 30 marks is from internal evaluation and 70 marks, from external evaluation. Each of the General Foundation course is of 3-credits. It is evaluated for 75 marks, out of which 25 marks is from internal evaluation and 50 marks, from external evaluation.
2. The 4-credit courses (Major and Minor courses) are of two types: (i) courses with only theory and (ii) courses with 3-credit theory and 1-credit practical.
 - In 4-credit courses with only theory component, out of the total 5 modules of the syllabus, one open-ended module with 20% content is designed by the faculty member teaching that course, and

it is internally evaluated for 10 marks. The internal evaluation of the remaining 4 theory modules is for 20 marks.

- In 4-credit courses with 3-credit theory and 1-credit practical components, out of the total 5 modules of the syllabus, 4 modules are for theory and the fifth module is for practical. The practical component is internally evaluated for 20 marks. The internal evaluation of the 4 theory modules is for 10 marks.

3. All the 3-credit courses (General Foundational Courses) in Statistics are with only theory component. Out of the total 5 modules of the syllabus, one open-ended module with 20% content is designed by the faculty member teaching that course, and it is internally evaluated for 5 marks. The internal evaluation of the remaining 4 theory modules is for 20 marks.

Sl. No.	Nature of the Course		Internal Evaluation in Marks (about 30% of the total)		External Exam on 4 modules (Marks)	Total Marks
			Open-ended module / Practicum	On the other 4 modules		
1	4-credit course	only theory (5 modules)	10	20	70	100
2	4-credit course	Theory (4 modules) + Practical	20	10	70	100
3	3-credit course	only theory (5 modules)	5	20	50	75

1. MAJOR AND MINOR COURSES

1.1. INTERNAL EVALUATION OF THEORY COMPONENT

Sl. No.	Components of Internal Evaluation of Theory Part of a Major / Minor Course	Internal Marks for the Theory Part of a Major / Minor Course of 4-credits			
		Theory Only		Theory + Practical	
		4 Theory Modules	Open-ended Module	4 Theory Modules	Practical
1	Test paper/ Mid-semester Exam	10	4	5	-
2	Seminar/ Viva/ Quiz	6	4	3	-
3	Assignment	4	2	2	-
Total		20	10	10	20*
		30		30	

* Refer the table in section 1.2 for the evaluation of practical component

1.2. EVALUATION OF PRACTICAUM COMPONENT

The evaluation of practicum component in Major and Minor courses is completely by internal evaluation.

- Continuous evaluation of practicum by the teacher-in-charge shall carry a weightage of 50%.
- The end-semester practicum examination and viva-voce, and the evaluation of practicum records shall be conducted by the teacher in-charge and an internal examiner appointed by the Department Council.
- The process of continuous evaluation of practicum courses shall be completed before 10 days from the commencement of the end-semester examination.
- Those who passed in continuous evaluation alone will be permitted to appear for the end-semester examination and viva-voce.

The scheme of continuous evaluation and the end-semester examination and viva-voce of practicum component shall be as given below:

Sl. No.	Evaluation of Practicum Component of in a Major / Minor Course	Marks for Practical	Weightage
1	Continuous evaluation of practicum/ exercise performed in practicum classes by the students	10	50%
2	End-semester examination and viva-voce to be conducted by teacher-in-charge along with an additional examiner arranged internally by the Department Council	7	35%
3	Evaluation of the Practicum records submitted for the end semester viva-voce examination by the teacher-in-charge and additional examiner	3	15%
Total Marks		20	

1.3. EXTERNAL EVALUATION OF THEORY COMPONENT

External evaluation carries 70% marks. Examinations will be conducted at the end of each semester. Individual questions are evaluated in marks and the total marks are converted into grades by the University based on 10-point grading system (refer section 5).

PATTERN OF QUESTION PAPER FOR MAJOR AND MINOR COURSES

Duration	Type	Total No. of Questions	No. of Questions to be Answered	Marks for Each Question	Ceiling of Marks
2 Hours	Short Answer	10	8 – 10	3	24
	Paragraph/ Problem	8	6 – 8	6	36
	Essay	2	1	10	10
Total Marks					70

2. INTERNSHIP

- All students should undergo Internship of 2-credits during the first six semesters in a firm/industry / organization, or training in labs with faculty and researchers of their own institution or other Higher Educational Institutions (HEIs) or research institutions.
- Internship can be for enhancing the employability of the student or for developing the research aptitude.
- Internship can involve hands-on training on a particular skill/ equipment/software. It can be a short project on a specific problem or area. Attending seminars or workshops related to an area of learning or skill can be a component of Internship.
- A faculty member/ scientist/ instructor of the respective institution, where the student does the Internship, should be the supervisor of the Internship.

2.1. GUIDELINES FOR INTERNSHIP

1. Internship can be in Statistics or allied Disciplines.
2. There should be minimum 60 hrs. of engagement from the student in the Internship.
3. Summer vacations and other holidays can be used for completing the Internship.
BSc. Statistics (Honours) Programme, Institute/ Industry visit or study tour is a requirement for the completion of Internship. Visit to minimum one research institute, research laboratory and place of Statistical data analysis importance should be part of the study tour. A brief report of the study tour has to be submitted with photos and analysis.
4. The students should make regular and detailed entries in to a personal log book through the period of Internship. The log book will be a record of the progress of the Internship and the time spent on the work, and it will be useful in writing the final report. It may contain experimental conditions and results, ideas, mathematical expressions, rough work and calculation, computer file names etc. All entries should be dated. The Internship supervisor should periodically examine and countersign the log book.
5. The log book and the typed report must be submitted at the end of the Internship.

6. The Institution at which the Internship will be carried out should be prior-approved by the Department Council of the College where the student has enrolled for the UG (Honours) Programme.

2.2. EVALUATION OF INTERNSHIP

- The evaluation of Internship shall be done internally through Continuous Assessment mode by a committee internally constituted by the Department Council of the College where the student has enrolled for the UG (Honours) Programme.
- The credits and marks for the Internship will be awarded only at the end of semester 6.
- The scheme of continuous evaluation and the end-semester viva-voce examination based on the submitted report shall be as given below:

Sl. No.	Components of Evaluation of Internship		Marks for Internship 2 Credits	Weightage
1	Continuous evaluation of internship through interim presentations and reports by the committee internally constituted by the Department Council	Acquisition of skill set	10	40%
2		Interim Presentation and Viva-voce	5	
3		Punctuality and Log Book	5	
4	Report of Institute Visit/ Study Tour		5	10%
5	End-semester viva-voce examination to be conducted by the committee internally constituted by the Department Council	Quality of the work	6	35%
6		Presentation of the work	5	
7		Viva-voce	6	
8	Evaluation of the day-to-day records, the report of internship supervisor, and final report submitted for the end semester viva-voce examination before the committee internally constituted by the Department Council		8	15%
Total Marks			50	

3. PROJECT

3.1. PROJECT IN HONOURS PROGRAMME

- In Honours programme, the student has the option to do a Project of 12-credits instead of three Core Courses in Major in semester 8.
- The Project can be done in the same institution/ any other higher educational institution (HEI)/ research Centre/ training Centre.

- The Project in Honours programme can be a short research work or an extended internship or a skill-based training programme.
- A faculty member of the respective institution, where the student does the Project, should be the supervisor of the Project.

3.2. PROJECT IN HONOURS WITH RESEARCH PROGRAMME

- A relaxation of 5% in marks (equivalently, a relaxation of 0.5 grade in CGPA) is allowed for those belonging to SC/ ST/ OBC (non-creamy layer)/ Differently-Abled/ Economically Weaker Section (EWS)/ other categories of candidates as per the decision of the UGC from time to time.
- In Honours with Research programme, the student has to do a mandatory Research Project of 12-credits instead of three Core Courses in Major in semester 8.
- The approved research centres of University of Calicut or any other university/HEI can offer the Honours with Research programme. The departments in the affiliated colleges under University of Calicut, which are not the approved research centres of the University, should get prior approval from the University to offer the Honours with Research programme. Such departments should have minimum two faculty member with Ph.D., and they should also have the necessary infrastructure to offer Honours with Research programme.
- A faculty member of the University/ College with a Ph.D. degree can supervise the research project of the students who have enrolled for Honours with Research. One such faculty member can supervise maximum five students in Honours with Research stream.
- The maximum intake of the department for Honours with Research programme is fixed by the department based on the number of faculty members eligible for project supervision, and other academic, research, and infrastructural facilities available.
- If a greater number of eligible students are opting for the Honours with Research programme than the number of available seats, then the allotment shall be based on the existing rules of reservations and merits.

3.3. GUIDELINES FOR THE PROJECT IN HONOURS PROGRAMME AND HONOURS WITH RESEARCH PROGRAMME

1. Project can be in Statistics or allied disciplines.
2. Project should be done individually.
3. Project work can be of experimental/ theoretical/ computational in nature.
4. There should be minimum 300 hrs. of engagement from the student in the Project work in

Honours programme as well as in Honours with Research programme.

5. There should be minimum 13 hrs./week of engagement (the hours corresponding to the three core courses in Major in semester 8) from the teacher in the guidance of the Project(s) in Honours programme and Honours with Research programme.
6. The various steps in project works are the following:
 - Wide review of a topic.
 - Investigation on a problem in systematic way using appropriate techniques.
 - Systematic recording of the work.
 - Reporting the results with interpretation in a standard documented form.
 - Presenting the results before the examiners.
7. During the Project the students should make regular and detailed entries in to a personal log book through the period of investigation. The log book will be a record of the progress of the Project and the time spent on the work, and it will be useful in writing the final report. It may contain experimental conditions and results, ideas, mathematical expressions, rough work and calculation, computer file names etc. All entries should be dated. The Project supervisor should periodically examine and countersign the log book.
8. The log book and the typed report must be submitted at the end of the Project. A copy of the report should be kept for reference at the department. A soft copy of the report too should be submitted, to be sent to the external examiner in advance.
9. It is desirable, but not mandatory, to publish the results of the Project in a peer reviewed journal.
10. The project report shall have an undertaking from the student and a certificate from the research supervisor for originality of the work, stating that there is no plagiarism, and that the work has not been submitted for the award of any other degree/ diploma in the same institution or any other institution.
11. The project proposal, institution at which the project is being carried out, and the project supervisor should be prior-approved by the Department Council of the college where the student has enrolled for the UG (Honours) programme.

3.4. EVALUATION OF PROJECT

- The evaluation of Project will be conducted at the end of the eighth semester by both internal and external modes.
- The Project in Honours programme as well as that in Honours with Research programme will be evaluated for 300 marks. Out of this, 90 marks is from internal evaluation and 210

marks, from external evaluation.

- The internal evaluation of the Project work shall be done through continuous assessment mode by a committee internally constituted by the Department Council of the college where the student has enrolled for the UG (Honours) programme. 30% of the weightage shall be given through this mode.
- The remaining 70% shall be awarded by the external examiner appointed by the University.
- The scheme of continuous evaluation and the end-semester viva-voce of the Project shall be as given below:

Components of Evaluation of Project	Marks for the Project (Honours/ Honours with Research)	Weightage
Continuous evaluation of project work through interim presentations and reports by the committee internally constituted by the Department Council	90	30%
End-semester viva-voce examination to be conducted by the external examiner appointed by the university	150	50%
Evaluation of the day-to-day records and project report submitted for the end-semester viva-voce examination conducted by the external examiner	60	20%
Total Marks	300	

INTERNAL EVALUATION OF PROJECT

Sl. No	Components of Evaluation of Project	Marks for the Project (Honours / Honours with Research)
1	Skill in doing project work	30
2	Interim Presentation and Viva-Voce	20
3	Punctuality and Log book	20
4	Scheme/ Organization of Project Report	20
	Total Marks	90

EXTERNAL EVALUATION OF PROJECT

Sl. No	Components of Evaluation of Project	Marks for the Project (Honours / Honours with Research) 12 credits
1	Content and relevance of the Project, Methodology, Quality of analysis, and Innovations of Research	50
2	Presentation of the Project	50
3	Project Report (typed copy), Log Book and References	60
4	Viva-Voce	50
Total Marks		210

4. GENERAL FOUNDATION COURSES

- All the General Foundation Courses (3-credits) in Statistics are with only theory component.

4.1. INTERNAL EVALUATION

Sl. No.	Components of Internal Evaluation of a General Foundation Course in Statistics	Internal Marks of a General Foundation Course of 3-credits in Statistics	
		4 Theory Modules	Open-ended Module
1	Test paper/ Mid-semester Exam	10	2
2	Seminar/ Viva/ Quiz	6	2
3	Assignment	4	1
Total		20	5
		25	

4.2. EXTERNAL EVALUATION

External evaluation carries about 70% marks. Examinations will be conducted at the end of each semester. Individual questions are evaluated in marks and the total marks are converted into grades by the University based on 10-point grading system (refer section 5).

PATTERN OF QUESTION PAPER FOR GENERAL FOUNDATION COURSES

Duration	Type	Total No. of Questions	No. of Questions to be Answered	Marks for Each Question	Ceiling of Marks
1.5 Hours	Short Answer	10	8 – 10	2	16
	Paragraph/ Problem	5	4 – 5	6	24
	Essay	2	1	10	10
Total Marks					50

5. LETTER GRADES AND GRADE POINTS

- Mark system is followed for evaluating each question.
- For each course in the semester letter grade and grade point are introduced in 10-point indirect grading system as per guidelines given below.
- The Semester Grade Point Average (SGPA) is computed from the grades as a measure of the student's performance in a given semester.
- The Cumulative GPA (CGPA) is based on the grades in all courses taken after joining the programme of study.
- Only the weighted grade point based on marks obtained shall be displayed on the grade card issued to the students.

LETTER GRADES AND GRADE POINTS

Sl. No.	Percentage of Marks (Internal & External Put Together)	Description	Letter Grade	Grade Point	Range of Grade Points	Class
1	95% and above	Outstanding	O	10	9.50 – 10	First Class with Distinction
2	Above 85% and below 95%	Excellent	A+	9	8.50 – 9.49	
3	75% to below 85%	Very Good	A	8	7.50 – 8.49	
4	65% to below 75%	Good	B+	7	6.50 – 7.49	First Class
5	55% to below 65%	Above Average	B	6	5.50 – 6.49	
6	45% to below 55%	Average	C	5	4.50 – 5.49	Second Class

7	35% to below 45% aggregate (internal and external put together) with a minimum of 30% in external valuation	Pass	P	4	3.50 – 4.49	Third Class
8	Below an aggregate of 35% or below 30% in external evaluation	Fail	F	0	0 – 3.49	Fail
9	Not attending the examination	Absent	Ab	0	0	Fail

- When students take audit courses, they will be given Pass (P) or Fail (F) grade without any credits.
- The successful completion of all the courses and capstone components prescribed for the three-year or four-year programme with 'P' grade shall be the minimum requirement for the award of UG Degree or UG Degree (Honours) or UG Degree (Honours with Research), as the case may be.

5.1. COMPUTATION OF SGPA AND CGPA

- The following method shall be used to compute the Semester Grade Point Average (SGPA):
The SGPA equals the product of the number of credits (Ci) with the grade points (Gi) scored by a student in each course in a semester, summed over all the courses taken by a student in the semester, and then divided by the total number of credits of all the courses taken by the student in the semester,

$$\text{i.e. SGPA (Si)} = \frac{\sum_i (C_i \times G_i)}{\sum_i (C_i)}$$

where Ci is the number of credits of the ith course and Gi is the grade point scored by the student in the ith course in the given semester. Credit Point of a course is the value obtained by multiplying the credit (Ci) of the course by the grade point (Gi) of the course.

$$\text{SGPA} = \frac{\text{Sum of the credit points of all the courses in a semester}}{\text{Total credits in that semester}}$$

ILLUSTRATION – COMPUTATION OF SGPA

Semester	Course	Credit	Letter Grade	Grade point	Credit Point (Credit x Grade)
I	Course 1	3	A	8	3 x 8 = 24
I	Course 2	4	B+	7	4 x 7 = 28
I	Course 3	3	B	6	3 x 6 = 18

I	Course 4	3	O	10	3 x 10 = 30
I	Course 5	3	C	5	3 x 5 = 15
I	Course 6	4	B	6	4 x 6 = 24
	Total	20			139
	SGPA				139/20 = 6.950

- The Cumulative Grade Point Average (CGPA) of the student shall be calculated at the end of a programme. The CGPA of a student determines the overall academic level of the student in a programme and is the criterion for ranking the students.

CGPA for the three-year programme in CUFYUGP shall be calculated by the following formula.

$$\text{CGPA} = \frac{\text{Sum of the credit points of all the courses in six semesters}}{\text{Total credits in six semesters (133)}}$$

CGPA for the four-year programme in CUFYUGP shall be calculated by the following formula.

$$\text{CGPA} = \frac{\text{Sum of the credit points of all the courses in eight semesters}}{\text{Total credits in eight semesters (177)}}$$

- The SGPA and CGPA shall be rounded off to three decimal points and reported in the transcripts.
- Based on the above letter grades, grade points, SGPA and CGPA, the University shall issue the transcript for each semester and a consolidated transcript indicating the performance in all semesters.



CALICUT UNIVERSITY

FOUR-YEAR UNDERGRADUATE PROGRAMME (CU-FYUGP)

B.Sc. APPLIED STATISTICS WITH DATA SCIENCE HONOURS

**SYLLABUS
MAJOR COURSES (CORE)**

MAJOR COURSES

SEMESTER I

Programme	B. Sc. APPLIED STATISTICS WITH DATA SCIENCE				
Course Code	ASD1CJ101(P)				
Course Title	Descriptive Statistics				
Type of Course	Major				
Semester	I				
Academic Level	100-199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	HSE level Mathematics/Statistics courses				
Course Summary Objective	To make students capable of defining Statistics and explaining the characteristics of Statistics and enable them to collect statistical data, differentiate, visualize, explain, and illustrate descriptive statistics of univariate and bivariate data				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	To understand what Statistics is and what are the uses of Statistics.	U	F	Achievement test /Quiz
CO2	To describe types of data and data collection methods	U	C	Instructor-created Achievement test / Quiz
CO3	To analyze data with the help of concepts form measures of central tendency and variation	An	P	Practical Assignment / Observation of Practical Skills/ Instructor-created exams
CO5	To interpret the relation between more than two variables and to make inferences based on that.	An	P	Instructor-created exams / Home Assignments
CO5	To develop the skills for effectively presenting data using tables and diagrams.	Ap	M	One Minute Reflection Writing assignments/ Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)# - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

DETAILED SYLLABUS

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I	Introduction to Statistics		10	10
	1	Origin and Development of Statistics, Definition of Statistics, Scope and Limitations of Statistics		
	2	Types of data, Nominal, Ordinal, Ratio, Interval scale data		
	3	Primary and Secondary data, Data Source in the digital age		
	4	Tools of Data Collection, framing of questionnaire and schedule		
	5	Data presentation, One-dimensional, two-dimensional data presentation, line Diagram, Histogram, stem and Leaf plots		
Sections from References: 1.1, 1.2 & 1.3 of Gupta and Kapoor 1.1, 1.3, 2.2, 2.3, & 3.5 of J. Medhi				
II	Measures of Central Tendency and Dispersion		15	25
	6	Arithmetic Mean, Simple and Weighted Mean		
	7	Median, and Mode, Geometric Mean, Harmonic Mean (Calculation and Interpretation).		
	8	Comparison of Measures of Central Tendency- Scenarios for Applying Mean, Median, and Mode- Robustness of Measures, Partition values		
	9	Absolute and relative measures of dispersion, Range, Quartile Deviation, Mean Deviation, Standard Deviation, Coefficient of Variation		
	10	Moments- Central and non-central Moments, Measures of Skewness based on Quartiles and Moments, Kurtosis based on Moments, Box plot		
Sections from References: 4.2, 4.3,4.4,4.5,4.6,4.7,4.8,4.9,and 4.10 of J. Medhi				
III	Correlation of Bivariate Data		15	25
	11	Bivariate Data: Definition, Scatter Diagram.		
	12	Curve fitting: Principle of least squares, fitting of a straight line, exponential and power curves using the principle of least squares		
	13	Correlation: Meaning and types		
	14	Karl Pearson's Coefficient of Correlation and its properties.		
	15	Spearman's Rank Correlation, Point bi-serial correlation, Concepts of partial and Multiple correlation		
Sections from References: 10.1, 10.2,10.3,10.4,10.5 and 10.6 of SC Gupta and VK Kapoor				
IV	Introduction to R		5	10
	16	Operators, Printing Values, Basic data structure, functions, Packages		
	17	Reading Data, Text Files, Cleaning Up Data		
	18	Identifying Data Types, data entry error, and missing values		
	19	Basic Visualizations, Scatterplots, Visualizing Aggregate Values with Bar plots and Pie charts		
	20	Layered Visualizations Using ggplot2, Creating Plots Using qplot() , ggplot()		

	Sections from References: 2.1,2.2,2.3 3.1,3.2,3.3,4.1,4.2 and 4.3 of Manas A Pathak		
V	Open Ended Module: Practical Applications, Case Study and Group Assignments	30	
	1 Practical exercises Hands-on using Software R: Graphical Presentation of Data, Measures of Central tendency and dispersion. Correlation Case study using primary data in the form of Group Assignments and Discussions. Prepare a record of at least 10 questions from Module I, II , III using R Package		

Books and References:

Textbooks :

1. S.C. Gupta and V. K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand and Sons
2. J. Medhi, Statistical Methods – An introductory Text, New Age International Publishers (2005)
3. Manas A. Pathak (2014) Beginning Data Science with R, Springer Cham Heidelberg New York Dordrecht London

References

- 1) Goon A. M., Gupta M. K., Das Gupta. B. (1999): *Fundamentals of Statistics*, Vol. I, World Press, Calcutta.
- 2) B L Agrawal (2013): Basic Statistics – New Age International Publishers.
- 3) Chirag Sha (2020) A Hands-On Introduction to Data Science, Cambridge University Press, University Printing House, Cambridge CB2 8BS, United Kingdom
- 4) Roger D. Peng(2015), R Programming for Data Science, Leanpub book

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	3	1	2	-	-	2	-	2	-	-	-
CO 2	3	3	-	2	1	-	3	1	2	3	-	-
CO 3	1	2	-	2	-	-	2	-	2	-	-	-
CO 4	3	2	-	1	-	-	3	-	2	2	-	-
CO 5	3	2	-	-	-	-	3	-	2	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4		✓		✓
CO 5		✓		✓

SEMESTER II

Programme	B. Sc. APPLIED STATISTICS WITH DATA SCIENCE				
Course Code	ASD2CJ101(P)				
Course Title	Probability and Random Variables				
Type of Course	Major				
Semester	II				
Academic Level	100-199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	HSE level Mathematics/Statistics courses				

Course Summary Objective	Enable the students to learn the concept of probability and random variables; and equip them to apply the concept of mathematical expectation in different contexts.
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Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Define and comprehend the fundamental concepts of probability and apply basic probability rules.	U	C	Instructor-created exams / Quiz
CO2	Define random variables, compute their probabilities, and consequently develop probability and cumulative probability distributions.	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Recognize and interpret moments of a distribution through mathematical expectation	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Develop proficiency in handling probability problems using statistical software and analyzing probability distributions.	U	C	Instructor-created exams / Home Assignments
CO5	Communicate the solutions to probability problems effectively and enhance the ability to present information clearly and concisely	Ap	P	One Minute Reflection Writing Assignments
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I	Concept of Probability		10	20
	1	Random experiment, Sample space, Events,		
	2	Classical (Mathematical) definition of probability		
	3	Statistical regularity, Statistical Definition of Probability		
	4	Field, Sigma field, Axiomatic definition of probability and simple properties		
	5	Addition theorem (two and three events)		
	Sections from References:			
II	Conditional probability		10	15

	6	Definition of Conditional probability		
	7	Multiplication theorem		
	8	Independence of events- Pairwise and Mutual		
	9	Bayes theorem		
	10	Applications of Bayes theorem		
	Sections from References:			
III	Random variables		15	20
	11	Discrete and Continuous Random variables		
	12	Probability mass function (pmf) properties and examples		
	13	Probability density function (pdf)-properties and examples		
	14	Cumulative distribution function and its properties		
	15	Change (transformation) of variables		
	Sections from References:			
IV	Mathematical Expectation		10	15
	16	Expected values of Random Variables		
	17	Raw and Central Moments (definition and relationships)		
	18	Moment generation function (MGF) and its properties		
	19	Characteristic function (definition and use only),		
	20	Moment measures of Skewness and kurtosis.		
	Sections from References:			
V	Open Ended Module: Practical Applications Probability and Distributions		30	
	1	Handling problems related to probability, verification of function as pmf/pdf, Evaluation of moments, MGF and characteristic function in R Case Study, Observing a random phenomenon, construction of empirical probability distribution.		
	Sections from References:			
	Text Books and References			
	1. S.C. Gupta and V. K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand and Sons			
	2. Mood, A.M. Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn., (Reprint), Tata McGraw-Hill Pub. Co. Ltd.			
	3. Christian Heumann, Michael Schomaker and Shalabh (2016): Introduction to Statistics and Data Analysis with Exercises, Solutions and Applications in R., Springer International Publishing Switzerland			
	4. John E Freund (2014): Mathematical Statistics, Pearson Edn, New Delhi			
	5. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2ndEdn. (Reprint) John Wiley and Sons.			

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO 4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	3	1	2	-	-	2	-	2	-	-	-
CO 2	3	3	-	2	1	-	3	1	2	3	-	-
CO 3	1	2	-	2	-	-	2	-	2	-	-	-
CO 4	3	2	-	1	-	-	3	-	2	2	-	-
CO 5	3	2	-	-	-	-	3	-	2	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4		✓		✓
CO 5		✓		✓

SEMESTER III

Programme	B. Sc. APPLIED STATISTICS WITH DATA SCIENCE				
Course Code	ASD3CJ201 (P)				
Course Title	Probability Distributions				
Type of Course	Major				
Semester	III				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	HSE level Mathematics/Statistics courses				
Course Summary Objective	<p>To understand random variables, and their probability distributions (discrete and continuous cases separately). To analyze their characterization & properties of the distribution. To gain proficiency in the transformation of random variables. To analyze their characterization & properties of the real data set.</p>				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Apply probability concepts to the model in real-life data.	U	C	Instructor-created exams / Quiz
CO2	Analyze random phenomena and identify the corresponding distribution and its characterization	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Gain idea about the theoretical and practical aspects of the Probability distribution	U	P	Seminar Presentation / Group Tutorial Work
CO4	Apply transformation of random variables to obtain new distributions.	C	C	Instructor-created exams / Home Assignments

CO5	Uses of moments, cumulates, and characteristic functions.	Ap	P	One Minute Reflection Writing assignments
CO6	Analyze the distributional properties of data using moments, skewness, and kurtosis	Ap	P	Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I	Discrete Distributions - I		10	20
	1	Degenerate distribution		
	2	Bernoulli distribution (definition).		
	3	Binomial distribution (definition, properties and application).		
	4	Poisson distribution (definition, properties and application).		
	5	Relationship between Binomial and Poisson Distributions		
Sections from References:				
II	Discrete Distributions -II		10	15
	6	Discrete Uniform distribution (definition and basic properties).		
	7	Geometric distribution (definition and basic properties).		
	8	Lack of memory property of Geometric Distribution		
	9	Negative Binomial distribution (definition and basic properties).		
	10	Hyper-geometric distribution (definition and basic properties).		
Sections from References:				
III	Continuous distributions		15	20
	9	Rectangular (definition, mean, variance and mgf)		
	10	Exponential (definition, mean, variance and mgf)		
	11	Memoryless property of Exponential distribution		
	12	Gamma (definition, mean, variance and mgf)		
	13	Beta (definition, mean, variance and mgf)		
14	Relationship between Gamma, Beta first and second distributions			
Sections from References:				
IV	Normal distribution		10	15
	15	Definition and probability density function		
	16	Derivation of Mean and Variance, Median, Mode, Mean Deviation		
	17	Derivation of MGF and Moments		
	18	Standard Normal Distribution and Area properties		
	19	Additive property of Normal distribution		
20	Lognormal, Pareto, Cauchy, Weibull and Laplace Distributions (definition only).			
Sections from References:				

V	Open Ended Module: Practical Applications			30	
	1	Fitting of standard distributions Random number generation using software			
Sections from References:					
Books and References:					
<ol style="list-style-type: none"> 1. S.C. Gupta and V.K. Kapoor : Fundamentals of Mathematical Statistics, Sultan Chand and sons 2. V.K. Rohatgi: An introduction to Probability theory and Mathematical Statistics, Wiley Eastern. 3. Mood A.M., Graybill. F.A and Boes D.C. : Introduction to Theory of Statistics McGraw Hill 4. Johnson, N.L., Kemp, A.W., and Kotz, S.. (2005): Univariate Discrete Distributions, 5th edition, WileyInterscience, John Wiley & Sons 5. Johnson, N.L., Kotz, S., and Balakrishnan, N. (2002): Continuous Univariate Distributions, Vol. 1, John Wiley 6. Johnson, N.L., Kotz, S., and Balakrishnan, N. (2002): Continuous Univariate Distributions, Vol. 2, John Wiley 7. Hogg, R. V., Craig, A., and Mckean, J.W. (2019): Introduction to Mathematical STATistics, 8th edition , Pearson 8. John E Freund : Mathematical Statistics (Sixth Edition), Pearson Education (India),New Delhi. 					

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO 4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	3	1	2	-	-	2	-	2	-	-	-
CO 2	3	3	-	2	1	-	3	1	2	3	-	-
CO 3	1	2	-	2	-	-	2	-	2	-	-	-
CO 4	3	2	-	1	-	-	3	-	2	2	-	-
CO 5	3	2	-	-	-	-	3	-	2	-	-	-
CO 6	1	1	2	-	3	3	2	2	1	-	3	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4		✓		✓
CO 5		✓		✓
CO 6	✓			

Programme	B. Sc. APPLIED STATISTICS WITH DATA SCIENCE				
Course Code	ASD3CJ202				
Course Title	Bivariate Random Variables and Limit Theorems				
Type of Course	Major				
Semester	III				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	0	60
Pre-requisites	HSE level Mathematics/Statistics courses				
Course Summary Objective	Make students aware of bivariate distributions and understand BVN. Apply LLN for computing asymptotic probability				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Calculate Marginal & Conditional Probability	U	C	Instructor-created exams / Quiz
CO2	Examine Independence of two Random Variables	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Examine properties of Bivariate Normal Distribution	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Compute upper and lower bound of Probability	U	C	Instructor-created exams / Home Assignments
CO5	Discriminate sequences of Random Variables satisfying Law of Large Numbers	Ap	P	One Minute Reflection Writing assignments
CO6	Asymptotic behavior of Random Variables	Ap	P	Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I	Bivariate Random Variable		12	20
	1	Joint probability mass function and density function		
	2	Marginal Probability functions		
	3	Conditional Probability functions		
	4	Joint Probability Distribution function and its properties		
	5	Independence of Random Variables.		
Sections from References:				
II	Bivariate Expectation		12	15
	6	Mathematical expectation of Bivariate Random Variables,		
	7	Addition theorem of Expectation		
	8	Multiplication theorem of Expectation,		
	9	Covariance, Cauchy-Schwartz Inequality		
	10	Conditional Expectation and Conditional Variance		
Sections from References:				
III	Bivariate Normal Distribution (BVN)		12	15
	11	Probability density function of Bivariate Normal		
	12	Properties of Bivariate Normal distribution		
	13	Marginal Probability density function of BVN		
	14	Conditional Probability density function of BVN		
	15	Standard bivariate normal distribution		
Sections from References:				
IV	Limit Theorems		12	20
	16	Convergence in probability and Convergence in distribution		
	17	Chebyshev's Inequality		
	18	Weak Law of Large Numbers (iid case) and Bernoulli's Law of Large Numbers.		
	19	Central Limit Theorem (Lindberg levy-iid case) Applications of CLT		
	20	Computation of sample size using Chebeshev's Inequality and CLT		
Sections from References:				
V	Open Ended Module: Practical Applications		12	
	1	Hands-on in R: joint probability law, marginal and conditional probability functions, conditional expectation and variance, Chebyshev's inequality, WLLN, BVN		
Sections from References:				
Books and References:				
1. S. C. Gupta and V. K. Kapoor. Fundamentals of Mathematical Statistics. Sultan Chand and Sons.				
2. Samuel Kotz, N. Balakrishnan, Norman L. Johnson. Continuous Multivariate Distributions: Models and Applications. Wiley Series in Probability and Statistics				

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	3	1	2	-	-	2	-	2	-	-	-
CO 2	3	3	-	2	1	-	3	1	2	3	-	-
CO 3	1	2	-	2	-	-	2	-	2	-	-	-
CO 4	3	2	-	1	-	-	3	-	2	2	-	-
CO 5	3	2	-	-	-	-	3	-	2	-	-	-
CO 6	1	1	2	-	3	3	2	2	1	-	3	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4		✓		✓
CO 5		✓		✓
CO 6	✓			

SEMESTER IV

Programme	B. Sc. APPLIED STATISTICS WITH DATA SCIENCE				
Course Code	ASD4CJ203(P)				
Course Title	Sampling Methods				
Type of Course	Major				
Semester	IV				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basic knowledge on probability theory				
Course Summary Objective	To enrich the skills of students to get more specialization in various sampling procedures and to adopt the appropriate sampling technique in real-life applications and survey				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Explain need and necessity of sampling	U	C	Instructor-created exams / Quiz
CO2	Distinguish between methods of sampling	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Construct sampling based on nature of population	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Examine the efficiency of estimation	U	C	Instructor-created exams / Home Assignments
CO5	Construct random samples	Ap	P	One Minute Reflection Writing assignments
CO6	Identify the suitable sampling methods in different contexts	Ap	P	Viva Voce

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
 # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P)
 Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I	Statistical Surveys		10	15
	1	Population and Sample, Parameter and Statistic		
	2	Census and Sampling, advantages of Sample survey over Census		
	3	Types of sampling and Principal steps in Sample Survey.		
	4	Sample design,		
	5	Sampling and non-Sampling errors		
<i>Sections from References:</i> Chapter 1 of Daroga Singh & Chaudhary, F.S. (2020). Theory and Analysis of sample survey design.				
II	Simple random sampling		10	20
	6	Simple Random Sampling (SRS) with Replacement. (SRSSWR) and without Replacement (SRSSWOR)		
	7	Merits and demerits of Simple Random Sampling (SRS).		
	8	Methods of selecting SRS (Lottery method and Random Number method).		
	9	Estimation of Parameters Mean and its variance		
	10	Unbiased estimate of Population Mean Square		
<i>Sections from References:</i> Chapter 2 of Daroga Singh & Chaudhary, F.S. (2020). Theory and Analysis of sample survey design.				
III	Stratified random sampling		15	20
	11	Principles and Advantages of Stratification-		
	12	Estimation of Mean and variance of estimated mean		
	13	Allocation of Sample in Different Strata		
	14	Allocation of sample size under Proportional Allocation and optimum allocation and variance of estimated mean		
	15	Determination of optimum number of strata, Comparison of Stratified sampling over SRS		
<i>Sections from References:</i> Chapter 3 of Daroga Singh & Chaudhary, F.S. (2020). Theory and Analysis of sample survey design.				
IV	Systematic Sampling and Cluster Sampling		10	15
	16	Systematic sampling:		
	17	Estimation of mean and variance.		
	18	Comparison of systematic sampling over SRS and stratified sampling.		
	19	Cluster sampling: Clusters with equal sizes, estimation of mean and total		
	20	Estimation of the population mean and total		
<i>Sections from References:</i> Chapter 4 and 5 of Daroga Singh & Chaudhary, F.S. (2020). Theory and Analysis of sample survey design.				
V	Open Ended Module: Practical Applications		30	

1	Selection of sample and determination of sample size. Estimation of mean and variance under SRSWR Estimation of mean and variance under SRSWOR Estimation of mean and variance under Stratified sampling using real-life problems.		
Sections from References:			
Books and References:			
1. Daroga Singh & Chaudhary, F.S. (2020). Theory and Analysis of sample survey design. New Age International Publishers, New Delhi			
2. Murthy M.N (1967): Sampling theory and Methods, Statistical Publisher Society, Calcutta.			
3. Des Raj (2000): sample Survey Theory, Narosa publishing house.			
4. Sampath S. (2000): Sampling theory and Methods. Narosa Publishing House.			
5. S.C Gupta and V.K Kapoor: Fundamentals of Applied Statistics. Sultan Chand & Sons.			

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	3	1	2	-	-	2	-	2	-	-	-
CO 2	3	3	-	2	1	-	3	1	2	3	-	-
CO 3	1	2	-	2	-	-	2	-	2	-	-	-
CO 4	3	2	-	1	-	-	3	-	2	2	-	-
CO 5	3	2	-	-	-	-	3	-	2	-	-	-
CO 6	1	1	2	-	3	3	2	2	1	-	3	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4		✓		✓
CO 5		✓		✓
CO 6	✓			

Programme	B. Sc. APPLIED STATISTICS WITH DATA SCIENCE				
Course Code	ASD4CJ204				
Course Title	Sampling Distributions and Estimation Theory				
Type of Course	Major				
Semester	IV				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	0	60
Pre-requisites	Basic knowledge on probability theory				
Course Summary Objective	Make students to understand standard sampling distr. Calculate point estimate and its properties construction of interval estimates				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	To understand sampling distributions and its applications	U	C	Instructor-created exams / Quiz
CO2	The student can identify various methods of estimation and will be able to apply them in practical cases.	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Estimate parameters using different methods of estimation	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	The students understand the concept of interval estimation and its applications	U	C	Instructor-created exams / Home Assignments
CO5	Able to estimate parameters of real-life data sets using any statistical software	Ap	P	Observation of practical skills
CO6	Interpret the results and express the conclusion of the analysis	Ap	P	Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I	Sampling Distributions		15	20
	1	Definitions of parameter, statistic, and standard error		
	2	Chi-square distribution (Definition, Mean, Variance, mgf).		
	3	Students t distribution (Definition, Mean Variance)		

	4	Snedecor's F distribution: (Definition, Mean and Variance)		
	5	Distribution of sample mean and variance. Relationship between z, t, F and Chi square distributions.		
	Sections from References:			
II	Point Estimation		10	20
	6	Estimator, Estimate Properties of good Estimator Unbiasedness, Sufficiency, Consistency and Efficiency		
	7	Factorization theorem		
	8	Complete Statistic		
	9	Minimum Variance Unbiased Estimator (MVUE) Cramer-Rao inequality(statement only)		
	10	Completeness Rao-Blackwell theorem, Lehman Scheffe theorem (statement only),		
	Sections from References:			
III	Methods of Point Estimation		13	15
	11	Method of Moments		
	12	Method of Least Square		
	13	Method of minimum chi-square		
	14	Method of Maximum Likelihood Estimation		
	15	Properties of Maximum Likelihood Estimators		
	Sections from References:			
IV	Interval Estimation		10	15
	16	Concept of Confidence Interval		
	17	Confidence Intervals for mean of Normal population		
	18	Confidence Intervals for Proportion		
	19	Confidence intervals for Variance of Normal population		
	20	Confidence Interval for the difference of means and proportion		
	Sections from References:			
V	Open Ended Module:		12	
	1	Understanding concepts and properties from modules 1 to 4 using Practical problems of estimation of parameters using statistical software.		
	Sections from References:			

Books and References:

1. Gupta, S.C. and Kapoor, V.K. (2014): Fundamentals of Mathematical Statistics, Sultan Chand & Sons.
2. Goon, A.M. Gupta, M.K., and Das Gupta, B. (1980): An outline of statistical theory, Vol.I, 6th revised ed. World Press limited, Calcutta
3. Rohatgi, V.K. (1984) An introduction to probability theory and mathematical statistics, Wiley Eastern.
4. Wilks, S.S. (1962): Mathematical statistics - John Wiley & Sons.
5. Hogg, R.V. , Mc Kean J W and Craig, A.T.(2005): Introduction to Mathematical Statistics, 6/e Pearson Edition

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	3	1	2	-	-	2	-	2	-	-	-
CO 2	3	3	-	2	1	-	3	1	2	3	-	-
CO 3	1	2	-	2	-	-	2	-	2	-	-	-
CO 4	3	2	-	1	-	-	3	-	2	2	-	-
CO 5	3	2	-	-	-	-	3	-	2	-	-	-
CO 6	1	1	2	-	3	3	2	2	1	-	3	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4		✓		✓
CO 5		✓		✓
CO 6	✓			

Programme	B. Sc. APPLIED STATISTICS WITH DATA SCIENCE				
Course Code	ASD4CJ205(P)				
Course Title	Testing of Hypothesis				
Type of Course	Major				
Semester	IV				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basic knowledge on probability theory				
Course Summary Objective	To make students capable of framing statistical hypotheses to real-life decision-making problems and to apply proper statistical methods to solve the problem.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Describe the basic concepts and terminologies of testing of hypothesis.	R	F	Instructor-created exams / Quiz
CO2	Understand the theory behind the statistical test construction	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Understand some specific statistical tests and their application	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Describe the situations where parametric tests cannot be used.	U	C	Instructor-created exams / Home Assignments
CO5	Understand the non-parametric alternatives of parametric tests.	Ap	P	One Minute Reflection Writing assignments
CO6	Develop computational ability to apply parametric and non-parametric tests	Ap	P	Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I	Statistical Hypothesis		10	15
	1	Statistical Hypothesis definition		
	2	Null and Alternative hypothesis, Simple and Composite hypothesis, Parametric and Non parametric test, Critical Region		
	3	Type I and Type-II errors,		
	4	Level of significance & Size of the test		
	5	Power of the test and p- value.		
Sections from References:				
II	Tests of hypothesis		10	15
	6	Most powerful test, Uniformly Most Powerful test		
	7	Neyman- Pearson Lemma (statement only)		
	8	NP Lemma to construct uniformly most powerful test,		
	9	Unbiased test (definition only)		
	10	Likelihood ratio test, properties of likelihood ratio tests		
Sections from References:				
III	Parametric Tests		15	20
	11	Large sample test for mean and equality of means,		
	12	Large sample test for proportions and equality of proportions		
	13	Small sample tests, Independent t-test, paired t-test,		
	14	Test for the significance of population variance.		
	15	Concept of ANOVA		
Sections from References:				
IV	Non-parametric Tests		10	20
	16	Concept of non-parametric tests		
	17	One Sample Tests: Run test, Kolmogrov –Smirnov test		
	18	Sign test, Signed rank test (Wilcoxon)		
	19	Mann-Whitney U test. Kruskal-Wallis test.		
	20	Chi-square test of goodness of fit and test for independence of attributes		
Sections from References:				
V	Open Ended Module: Practical Applications		30	
	1	All statistical tests should be done to students with simple example using R or Python.		
Sections from References:				

Books and References:

- Gupta, S.C. and Kapoor, V.K. (2014): Fundamentals of Mathematical Statistics, Sultan Chand & Sons.
2. Goon, A.M. Gupta, M.K., and Das Gupta, B. (1980): An outline of statistical theory, Vol.I, 6th revised ed. World Press limited, Calcutta
3. Rohatgi, V.K. (1984) An introduction to probability theory and mathematical statistics, Wiley Eastern.
4. Wilks, S.S. (1962): Mathematical statistics - John Wiley & Sons.
5. Hogg, R.V. , Mc Kean J W and Craig, A.T.(2005): Introduction to Mathematical Statistics, 6/e Pearson Edition

SEMESTER V

Programme	B. Sc. APPLIED STATISTICS WITH DATA SCIENCE				
Course Code	ASD5CJ301(P)				
Course Title	Design and Analysis of Experiments				
Type of Course	Major				
Semester	V				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basic knowledge on probability theory				
Course Summary Objective	Develop the ability to design, plan, and interpret controlled tests and to apply appropriate statistical techniques in such situations.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Identify various causes of variation	U	C	Instructor-created exams / Quiz
CO2	Describe models to express the resulting observation-based effects and errors	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Discuss the fundamental principles of experiments	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Summarize the total variation into sum of fixed and random causes	U	C	Instructor-created exams / Home Assignments

CO5	Develop the ability to apply different designs in a proper way	Ap	P	One Minute Reflection Writing assignments
CO6	To acquire necessary computational skills for analysing data related with design of experiments	Ap	P	Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I	Theory of Linear Estimation		10	15
	1	Estimability of linear parametric functions.		
	2	Method of least squares		
	3	Best Linear Unbiased Estimator (BLUE)		
	4	Gauss -Markov theorem		
	5	Linear hypothesis, Estimation of error variance.		
Sections from References:				
II	Analysis of variance		10	15
	6	Definitions of Fixed effect model and random effect models		
	7	Definition of analysis of Variance,		
	8	Assumptions and Limitations of ANOVA		
	9	One way ANOVA with a single observation per cell		
	10	Two-way ANOVA with a single observation per cell		
Sections from References:				
III	Analysis of Covariance		17	20
	11	Model of Analysis of covariance		
	12	Analysis of covariance with a single observation per cell		
	13	Experimental Designs		
	14	Principles of design of Experiment		
	15	Randomization, Replication and Local control		
Sections from References:				
IV	Basic Designs		8	20
	16	Completely randomized design (CRD)		
	17	Randomized Block Design (RBD)		
	18	Latin Square Design (LSD).		
	19	Missing plot technique,		
	20	Comparison of Efficiency, Model Adequacy Checking		
Sections from References:				
V	Open Ended Module: Practical Applications		30	
	1	Designing Experiments, Hands on Using R, Practical Interpretation of Results. Practical problems of ANOVA		
Sections from References:				

Books and References:

1. S.C. Gupta & V.K. Kapoor: Fundamentals of Applied Statistics, Sultan Chand & Sons
2. M.N. Das & N. Giri: Design of Experiments, New Age International
3. Douglas C. Montgomery: Design and Analysis of Experiments, Wiley and Sons
4. John Lawson: Design, and Analysis of Experiments with R, Chapman and Hall
5. D.D Joshy, linear Estimation and Design of Experiments, Wiley Eastern

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	3	1	2	-	-	2	-	2	-	-	-
CO 2	3	3	-	2	1	-	3	1	2	3	-	-
CO 3	1	2	-	2	-	-	2	-	2	-	-	-
CO 4	3	2	-	1	-	-	3	-	2	2	-	-
CO 5	3	2	-	-	-	-	3	-	2	-	-	-
CO 6	1	1	2	-	3	3	2	2	1	-	3	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4		✓		✓
CO 5		✓		✓
CO 6	✓			

Programme	B. Sc. APPLIED STATISTICS WITH DATA SCIENCE				
Course Code	ASD5CJ302(P)				
Course Title	Data Mining Techniques				
Type of Course	Major				
Semester	V				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	Programming skill using R.				
Course Summary	The main objectives of this course are to : Enable Students to acquire knowledge of data mining and to characterize different types of patterns that can be discovered by association rule mining. And to equip students to evaluate mathematical methods underlying the effective application of data mining.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
1.	Understand the concept of data warehouse and its various forms	U	C	Seminar Presentation /
2.	Define data mining technique and compare it with other database management techniques	E	P	Instructor-created exams
3.	Explain different association rules related with data mining	E	P	Group Tutorial Work
4.	Analyses different clustering algorithms in data mining	An	C	Home Assignments
5.	Analyse statistical data using different data mining procedures	Ap	M	Practical Skill
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45+30)	Marks (70)
I	Data Warehousing		10	15
	1	Definition of data warehouse		
	2	Multidimensional data models		
	3	OLAP operations, Warehouse schema		
	4	Data warehousing architecture, warehouse server		
	5	Metadata, OLAP engine		
<i>Section from reference: 2.3 to 2.10 of Data Mining Techniques, Arun K Pujari, University Press</i>				
II	Data Mining		10	15
	6	Definition of data mining		
	7	KDD vs Data mining		
	8	DBMS vs Data mining		
	9	Datamining techniques		
	10	Issues, challenges and applications of data mining		
<i>Section from reference: 3.3 to 3.10 of Data Mining Techniques, Arun K Pujari, University Press</i>				

III	Association Rules		10	20
	11	Methods to discover association rules		
	12	A Priori algorithm		
	13	Partition algorithm		
	14	Dynamic itemset counting algorithm		
	15	Incremental algorithm		
	<i>Section from reference:</i> 4.2 to 4.10 of Data Mining Techniques, Arun K Pujari, University Press			
IV	Clustering Techniques		15	20
	16	Clustering paradigms		
	17	Partitioning algorithms		
	18	k-Medoid algorithms, CLARA, CLARANS		
	19	Hierarchical clustering , DBSCAN, BIRCH, CURE		
	20	Categorical Clustering algorithms, STIRR, ROCK		
	<i>Section from reference:</i> 5.1 to 5.11 of Data Mining Techniques, Arun K Pujari, University Press			
V	Open Ended Module: Practical Applications		30	
	Hands-on Using R, Practical problems related to data mining and interpretation of results			
Books for Study /Reference				
<ol style="list-style-type: none"> 1. Arun K Pujari (2008) Data Mining Techniques, , University Press 2. Pang-Ning Tan, Michael Steinbach, Anujkrptne and Vipin Kumar (2019) Introduction to Data Mining (2nd Edition) Pearson Education Ltd. 3. Manas A. Pathak (2014) Beginning Data Science with R, Springer International Publishing 4. Paolo Giudici and Silvia Figini (2009) Applied Data Mining for Business and Industry, Second Edition, John Wiley & Sons Ltd. 5. Daniel T Larose (2005) Discovering Knowledge in Data : An Introduction to Data Mining, John Wiley & Sons, 				

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	3	1	2	-	-	2	-	2	-	-	-
CO 2	3	3	-	2	1	-	3	1	2	3	-	-
CO 3	1	2	-	2	-	-	2	-	2	-	-	-
CO 4	3	2	-	1	-	-	3	-	2	2	-	-
CO 5	3	2	-	-	-	-	3	-	2	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4		✓		✓
CO 5		✓		✓

Programme	B. Sc. APPLIED STATISTICS WITH DATA SCIENCE				
Course Code	ASD5CJ303				
Course Title	Introduction to Time Series and Index Numbers				
Type of Course	Major				
Semester	V				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	0	60
Pre-requisites	Programming skills using R.				
Course Objectives	To develop the ability to predict trends and seasonal variations in time series data and to develop the ability to apply proper index numbers in appropriate situations				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
1.	Understand the concept of Time series data	U	C	Seminar Presentation /
2.	Will get an awareness on various components of time series	E	P	Instructor-created exams
3.	Will develop the ability to fit trend and seasonal pattern from a time series data	E	P	Group Tutorial Work
4.	Get an idea on index number and how it function	An	C	Home Assignments
5.	Develop the ability to compute different index numbers	Ap	M	Practical Skill test
6	Develop ability to apply statistical software for the computation of index numbers	C	P	Practical Skill test
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48+12)	Marks (70)
I	Introduction to Time Series		12	15
	1	Definition and context, Model		
	2	Components of time series, Trend, Seasonal variation, cyclical and irregular changes		
	3	Measurement of Trend, Graphical method		
	4	Semi-average and Moving average methods		
	5	Least square method		
10II	Seasonal and Cyclical Variations		12	15
	6	Measures of Seasonal variation, Simple average, Ratio to trend Methods	8	9
	7	Ratio to moving average, Link relative methods		
	8	Autoregressive time series,		
	9	First-order autoregressive and second-order autoregressive series		
	10	Auto correlation and correlogram		
III	Index Numbers		12	15
	11	Meaning, definition and types of Index Numbers		
	12	Problems in the construction of index numbers		
	13	Simple aggregate and weighted aggregate index numbers		
	14	Laspeyere's, Paasche's, Marshall-Edgeworth's, Fisher's, Dorbish-Bowley's and Kelly's indices.		
	15	Quantity Index Numbers		
IV	Tests for Consistency of Index Numbers		12	15
	16	Unit test , Factor Reversal test, Time Reversal test		
	17	Chain base index Numbers		
	18	Base shifting, Splicing and Dflating of index numbers		
	19	Consumer Price Index numbers		
	20	Limitations of Index numbers		
V	Open End Module:		12	
	Case study using secondary data available from government offices like NSSO, DES Presentation of collected data.			

Books for Study /Reference

1. S.C. Gupta & V.K. Kapoor: Fundamentals of Applied Statistics, Sultan Chand & Sons
2. Parimal Mukhopadhyay (2022): Applied Statistics, Books and Allied (P) Ltd, Kolkata.
3. B L Agarwal (2013): Basic Statistics, New Age International Publishers.
4. Goon.A.M., Gupta.M.K. and Das Gupta .B (2016) : Fundamental of Statistics , Vol. II, World Press , Calcutta

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	3	1	2	-	-	2	-	2	-	-	-
CO 2	3	3	-	2	1	-	3	1	2	3	-	-
CO 3	1	2	-	2	-	-	2	-	2	-	-	-
CO 4	3	2	-	1	-	-	3	-	2	2	-	-
CO 5	3	2	-	-	-	-	3	-	2	-	-	-
CO 6	1	1	2	-	3	3	2	2	1	-	3	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4		✓		✓
CO 5		✓		✓
CO 6	✓			

SEMSTER VI

Programme	B. Sc. APPLIED STATISTICS WITH DATA SCIENCE				
Course Code	ASD6CJ304(P)				
Course Title	Linear Regression Analysis				
Type of Course	Major				
Semester	VI				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites					
3Course Summary Objective	Objective make students to describe and assess the strength of relationships between variables, to explain them using math model, check adequacy of model				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Students will be able to understand the context of regression analysis	U	C	Instructor-created exams / Quiz
CO2	Capable of fitting a linear regression model to the given data	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Able to scrutinize the fitted model using the model adequacy checking	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Capable for forecasting the future values using the fitted model	U	C	Instructor-created exams / Home Assignments
CO5	Able to understand which type of regression model is appropriate	Ap	P	One Minute Reflection Writing assignments
CO6	Develop skills to predict future situations based on available data sets	Ap	M	Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge (F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

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Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I	Simple Regression		10	20
	1	Regression Model building, Regressor, Response, Error, use of Regression.		
	2	Simple Linear Regression model, Assumptions		
	3	Least square and maximum likelihood estimation of the parameters of the model,		
	4	Properties of least square estimators and fitted regression model		
	5	Hypothesis testing on slope and intercept of the model, Coefficient of Determination		
<i>Sections from References:</i> 1.1, 1.3 , 2.1, 2.2 , 2.3,2.4,2.5 and 2.6 of Montgomery, D. C., Peck, E. A., & Vining, G. G. (2012). Introduction to Linear Regression				
II	Multiple Regression		15	20
	6	Multiple Regression model, assumptions		
	7	Least square and maximum likelihood estimation of the parameters of the model,		
	8	Testing significance of regression coefficients, test on individual regression coefficient.		
	9	Confidence interval for multiple regression ,		
	10	R^2 and adjusted R^2 · Multicollinearity		
<i>Sections from References:</i> 3.1, .3.2, 3.3,3.4,3.5, and 3.10 of Montgomery, D. C., Peck, E. A., & Vining, G. G. (2012). Introduction to Linear Regression				
III	Model adequacy checking		10	15
	11	Residuals		
	12	Methods for scaling residuals,.		
	13	Residual plots,		
	14	PRESS statistic.		
	15	Detection and treatment of outliers		
<i>Sections from References:</i> 4.1, 4.2, 4.3, and 4.4 of Montgomery, D. C., Peck, E. A., & Vining, G. G. (2012). Introduction to Linear Regression				
IV	Transformation and weighting		10	15
	16	Transformation and weighting to correct model inadequacy ,		
	17	Variance stabilizing transformations		
	18	Transformations to linearize the model.		
	19	Concept of Box-Cox transformation..		
	20	Sources of multicollinearity, Variance Inflation Factor		
<i>Sections from References:</i> 5.1, 5.2, 5.3, and 5.4 of Montgomery, D. C., Peck, E. A., & Vining, G. G. (2012). Introduction to Linear Regression				

V	Open Ended Module: Practical Applications		30	
	1	Concept of non-linear regression, Practical example of fitting a regression model using statistical software.		
	Sections from References:			
Books and References:				
<ol style="list-style-type: none"> 1. Montgomery, D. C., Peck, E. A., & Vining, G. G. (2012). Introduction to Linear Regression Analysis. Wiley. 2. Seber, G. A. F., & Lee, A. J. (2003). Linear Regression Analysis. Wiley 3. Draper, N and Smith, H (1998): Applied Regression Analysis, 3rd Edition, Wiley-Interscience. 4. Chatterjee, S, Ali S. Hadi (2013): Regression Analysis by Example, 5th Edition, John Wiley and Sons. 5. Weisberg, S. (2014). Applied Linear Regression. Wiley. 				

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	3	1	2	-	-	2	-	2	-	-	-
CO 2	3	3	-	2	1	-	3	1	2	3	-	-
CO 3	1	2	-	2	-	-	2	-	2	-	-	-
CO 4	3	2	-	1	-	-	3	-	2	2	-	-
CO 5	3	2	-	-	-	-	3	-	2	-	-	-
CO 6	1	1	2	-	3	3	2	2	1	-	3	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4		✓		✓
CO 5		✓		✓
CO 6	✓			

Programme	B. Sc. APPLIED STATISTICS WITH DATA SCIENCE				
Course Code	ASD6CJ305(P)				
Course Title	Multivariate Analysis				
Type of Course	Major				
Semester	VI				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites	1. Good knowledge of Multivariate Normal distribution. 2. Programming skill using R.				
Course Summary	Develop the ability to deal with multivariate data sets and the ability to make proper inference from multivariate data sets.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level *	Knowledge Category#	Evaluation Tools used
CO1.	Analysing Multivariate data using reduction techniques like Principal Component Analysis, Factor Analysis and Canonical correlation.	An	P	Seminar Presentation /
CO2.	Formulate multivariate hypothesis tests and drawing appropriate conclusions	C	M	Instructor-created exams
CO3.	Discriminate multivariate normal population.	E	C	Group Tutorial Work
CO4.	Identify data reduction techniques	U	C	Home Assignments
CO5.	Develop the ability to apply multivariate distributions like T^2 and D^2	A	P	Instructor created exams
CO6	Analyse multivariate data using statistical software's.	An	P	Practical Skill
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I	Multivariate Normal Distribution		10	20
	1	Density of Multivariate normal distribution, Properties		
	2	Marginal and conditional distributions, Characteristic function		
	3	Distribution of linear combination of normal vector		
	4	Maximum likelihood estimation (MLE) of the μ and $d \Sigma$		
	5	Inference concerning the mean vector when covariance matrix is known		
II	T^2 and D^2 Distributions		15	20
	1	Hotelling T^2 distribution , derivation and its uses		
	2	Mahalanobis D^2 Distribution, derivation and its uses		
	3	Relation between T^2 and D^2 - Generalized variance		
	4	Wishart distribution (statement only) and its properties		
	5	One-way Multivariate Analysis of Variance (MANOVA)		
III	Classification Models		10	15
	11	Classification problems		
	12	Classification into one of two populations		
	13	Classification into one of several populations		

	14	Sample discriminate function		
	15	Estimation – Fisher’s method for discriminating among several populations.		
IV	Dimensionality Reduction Techniques		10	15
	16	Principal components – Properties		
	17	Extraction of Principal components and their variances		
	18	Canonical correlation – Estimation of canonical correlation and variates.		
	19	Factor analysis – Mathematical model		
	20	Estimation of Factor Loadings – Concept of factor rotation – Varimax criterion		
V	Open –End		30	
	Problems regarding Module I to IV using Statistical software			
	Reference Books			
	<ol style="list-style-type: none"> 1. Anderson, T.W. (2009): An Introduction to Multivariate Statistical Analysis, 3/e, Wiley. 2. Johnson, R. A and. Wichern D.W (2015): Applied Multivariate Statistical Analysis, 6/e, Pearson Education India. 3. Morrison F (2003) : Multivariate Statistical Methods, Brooks/Cole, 4th Revised edn., McGraw Hill Book Company 4. Seber G A (2004) : Multivariate Observations, John Wiley. 5. Denis, D J (2021) : Applied Univariate, Bivariate and Multivariate Statistics : Understanding Statistics for Social and Natural Scientists, With Application in SPSS and R, John Wiley & Sons. 			

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	3	1	2	-	-	2	-	2	-	-	-
CO 2	3	3	-	2	1	-	3	1	2	3	-	-
CO 3	1	2	-	2	-	-	2	-	2	-	-	-
CO 4	3	2	-	1	-	-	3	-	2	2	-	-
CO 5	3	2	-	-	-	-	3	-	2	-	-	-
CO 6	1	1	2	-	3	3	2	2	1	-	3	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4		✓		✓
CO 5		✓		✓
CO 6	✓			

Programme	B. Sc. APPLIED STATISTICS WITH DATA SCIENCE				
Course Code	ASD6CJ306(P)				
Course Title	Statistical Machine Learning				
Type of Course	Major				
Semester	VI				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	3	-	2	75
Pre-requisites					
3Course Summary Objective	Objective make students to describe and assess the strength of relationships between variables, to explain them using math model, check adequacy of model				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Toolsused
CO1	Students will understand what machine learning is	U	C	Instructor-createdexams / Quiz
CO2	Students will recollect some situations where machine learning is applied	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Will be able to recognize the pattern underlying a set of data	Ap	P	Seminar Presentation / Group TutorialWork
CO4	Develop the ability to apply appropriate methods for the classification of data	U	C	Instructor-createdexams / Home Assignments
CO5	Will be able to apply neural network theories for making proper inferences from data	Ap	P	One Minute Reflection Writingassignments
CO6	Will develop the ability to make proper inferences from complex data sets	Ap	P	Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P), Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I	Introduction to Statistical Machine Learning		10	15
	1	Why Machine Learning?		
	2	Some Applications , Image Recognition, Speech Recognition, Medical Diagnosis, Statistical Arbitrage		
	3	Measurements		
	4	Features, and Feature Vectors		
		Supervised Learning		
	<i>Sections from References:</i> 1.2, 1.3, 1.4, 5.2, 5.3, and .6 of Sanjeev Kulkarni and Gilbert Harman , An Elementary Introduction to Statistical Learning Theory			
II	The Pattern Recognition Problem		15	20
	6	Example of Pattern Recognition Problem, Decision Rules		
	7	Success Criterion, The Best Classifier: Bayes Decision Rule		
	8	Bayes Decision Rule, Optimality		
	9	Lack of Knowledge of Distribution, Training Data, Assumptions on the Training Data,		
	10	A Brute Force Approach to Learning, Curse of Dimensionality, Inductive Bias.		
	<i>Sections from References:</i> 4.1, 4.2, 4.3, 4.4, 4.5,5.3, 6.1,6.2,6.3,6.4,6.5 and 6.6 of Sanjeev Kulkarni and Gilbert Harman , An Elementary Introduction to Statistical Learning Theory			
III	The Nearest Neighbor Rule		10	20
	11	The Nearest Neighbor Rule and its performance		
	12	Intuition and Proof Sketch of Performance		
	13	Using more Neighbors		
	14	Kernel Rules		
	15	Universal Consistency of Kernel Rules		
	<i>Sections from References:</i> 7.1,7.2,7.3,7.4, 8.3, 8.4, 8.5 and 8.6 of Sanjeev Kulkarni and Gilbert Harman , An Elementary Introduction to Statistical Learning Theory			
IV	Neural Networks: Perceptrons		10	15
	16	Multilayer Feedforward Networks		
	17	Neural Networks for Learning and Classification		
	18	Perceptrons, Threshold		
	19	Learning Rule for Perceptrons		
	20	Representational Capabilities of Perceptrons		
	<i>Sections from References:</i> 9.1,9.2,9.3,9.4, 9.3, 9.4, and 9.5 of Sanjeev Kulkarni and Gilbert Harman , An Elementary Introduction to Statistical Learning Theory			
	Open Ended Module: Practical Applications		30	

	1	Practical applications from industry		
	Sections from References:			
Books and References:				
<ol style="list-style-type: none"> 1. Sanjeev Kulkarni and Gilbert Harman, An Elementary Introduction to Statistical Learning Theory, John Wiley and Sons. Inc. publication 2. Chirag Sha (2020) A Hands-On Introduction to Data Science, Cambridge University press, University Printing House, Cambridge CB2 8BS, United Kingdom. 3. Trevor Hastie, Robert Tibshirai, Jerome Friedman The Elements of Statistical Learning: Mining, Inference and Prediction, 2nd edition, Springer publication 4. Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani (2013) An Introduction to statistical learning with applications in R, Springer 				

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	3	1	2	-	-	2	-	2	-	-	-
CO 2	3	3	-	2	1	-	3	1	2	3	-	-
CO 3	1	2	-	2	-	-	2	-	2	-	-	-
CO 4	3	2	-	1	-	-	3	-	2	2	-	-
CO 5	3	2	-	-	-	-	3	-	2	-	-	-
CO 6	1	1	2	-	3	3	2	2	1	-	3	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4		✓		✓
CO 5		✓		✓
CO 6	✓			

CALICUT UNIVERSITY
FOUR-YEAR UNDERGRADUATE PROGRAMME (CU-FYUGP)

B.Sc. APPLIED STATISTICS WITH DATA SCIENCE
(HONOURS)

SYLLABUS
MAJOR (ELECTIVE COURSES)

B.Sc. Applied Statistics with Data Science
MAJOR ELECTIVE COURSES

ELECTIVE COURSES - SEMESTER V (Any Two from the following list of courses)			
No	Semester	Course Code	Course Title
1	V	ASD5EJ301	Official Statistics
2	V	ASD5EJ302	Actuarial Statistics
3	V	ASD5EJ303	Psychometric Theory and Methods
4	V	ASD5EJ304	Survival Analysis
5	V	ASD5EJ305	Population Statistics
ELECTIVE COURSES- SEMESTER VI (Any Two from the following list of courses)			
6	VI	ASD6EJ306	Biostatistics
7	VI	ASD6EJ307	Econometrics
8	VI	ASD6EJ308	Statistical Quality Control
9	VI	ASD6EJ309	Operations Research
10	VI	ASD6EJ310	Simulation Techniques

SEMESTER V

Programme	B.SC. APPLIED STATISTICS WITH DATA SCIENCE				
Course Code	ASD5EJ301				
Course Title	Official Statistics				
Type of Course	Major (Elective)				
Semester	V				
Academic Level	300-399				
Course Details	Credit	Lecture per Week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites					
Course Objective	Make an awareness among students of the official statistical systems of the country and get an idea of the role of the subject Statistics in National Policy Formulation, Planning, and framing of various policies by the Governments				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Explain the roles and responsibilities of various central and state organizations.	U	C	Instructor- created exams / Quiz
CO2	Explain the methods of data collection and dissemination in the official setup	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Explain the population growth in developed and developing countries	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Explain Statistics related to Industries, foreign trade, balance of payment, cost of living, inflation, educational, and other social statistics	U	C	Instructor- created exams / Home Assignments
CO5	Explain the National income estimation by various approaches.	Ap	P	One Minute Reflection Writing assignments

CO6	Describe Lorenz curve, Gini Coefficient and Theil's measure of income inequality			
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I	Official Statistical Systems		12	20
	1	Introduction to Indian and International Statistical systems.		
	2	Methods of collection of official statistics.		
	3	Role of Ministry of Statistics & Program Implementation (MoSPI)		
	4	Role, function and activities of Central Statistical Office (CSO), National Sample Survey Office (NSSO), and National Statistical Commission		
	5	Government of India's Principal publications containing data on topics such as population, industry, and finance, Scope and Contents of Population Census of India		
Sections from References:				
II	Official Statistical indices		12	15
	6	Population growth in developed and developing countries.		
	7	Evaluation of the performance of family welfare programs.		
	8	Projections of labour force and manpower.		
	9	Statistics related to Industries, foreign trade, balance of payment		
	10	Statistics related to cost of living, inflation, educational and other social Statistics		
Sections from References:				
III	Human Development indices		12	15
	11	Economic development		
	12	Growth in per capita income and distributive justice indices of development,		
	13	Human Development Index.		
	14	SDG indices		
	15	National income estimation- Product approach, Income approach and Expenditure approach		
IV	Measuring inequality in incomes		12	20
	16	Measuring inequality in incomes: Lorenz curve,		
	17	Gini Coefficient,		
	18	Theil's measure.		

	19	Poverty measurements: Different issues,		
	20	measures of incidence and intensity		
	Sections from References:			
V	Open Ended Module:		12	
	1	Discussion of latest governmental and other publications related with above areas		
	Sections from References:			
Books and References:				
1. Guide to Official Statistics (CSO) , Statistical System in India (CSO)				
2. Principles and Accommodation of National Population Census, UNEDCO.				
3. Monthly Statistics of Foreign Trade in India, DGCIS, Calcutta and other Govt. Publications.				
4. Sen, A(1977): Poverty and Inequality.				
5. Chubey, P.K (1995): Poverty Measurement, New Age International				

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	3	1	2	-	-	2	-	2	-	-	-
CO 2	3	3	-	2	1	-	3	1	2	3	-	-
CO 3	1	2	-	2	-	-	2	-	2	-	-	-
CO 4	3	2	-	1	-	-	3	-	2	2	-	-
CO 5	3	2	-	-	-	-	3	-	2	-	-	-
CO 6	1	1	2	-	3	3	2	2	1	-	3	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4		✓		✓
CO 5		✓		✓
CO 6	✓			

Programme	B.SC. APPLIED STATISTICS WITH DATA SCIENCE				
Course Code	ASD5EJ302				
Course Title	Actuarial Statistics				
Type of Course	Major Elective				
Semester	V				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites					
Course Objective	To learn the life tables used in insurance products. To learn the concept of interest, different life insurance products, life annuities, net premiums. To motivate students to prepare for exams required for employment in the actuarial science profession.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Discuss future life time distributions and their probabilities.	U	C	Instructor-created exams / Quiz
CO2	Know the concept of life table.	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Apply different kinds of interest rates expressed in different time periods.	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Understand the basics life assurance and life annuity contracts.	U	C	Instructor-created exams / Home Assignments
CO5	Understand the utility theory, insurance products and life tables. Understand the concept of interest.	Ap	P	One Minute Reflection Writing assignments
CO6	: Understand the concept of life insurance and the existing insurance products of different insurance company. Know life annuities, net premium and net premium reserves	Ap	P	Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P)Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I	Future lifetime distribution		12	15
	1	Future life time random variables,		
	2	Force of mortality, Laws of mortality		
	3	De Moivre's law, Gompertz's Law (Definition only)		
	4	Makeham's Law, Weibull's Law (Definition only)		
	5	Probabilities of survival and death, Curtate Future life time		
	Sections from References:			
II	Life Tables		12	15

	6	Construction of a life table		
	7	Assumptions for fractional ages		
	8	Uniform distribution of deaths		
	9	Balducci assumption,		
	10	Constant force of mortality assumption		
	Sections from References:			
III	Rates of interests and Annuities		12	20
	11	Compound interest and discount factor		
	12	Nominal rate of interest, Force of interest, Accumulated value		
	13	Annuities, Annuities certain- Immediate and due		
	14	Monthly annuity certain		
	15	Continuous annuity certain, Deferred annuity		
	Sections from References:			
IV	Life insurance and annuity contracts		12	20
	16	Continuous Life insurance contracts		
	17	Term life assurance, Endowment		
	18	Whole life, Continuous Life annuities- whole life annuity		
	19	n-year temporary life annuity,		
	20	n- year certain and life annuity		
	Sections from References:			
V	Open Ended Module:		12	
	1	Discussion with real life actuarial problems		
	Sections from References:			
Books and References:				
<ol style="list-style-type: none"> 1. Shailaja R. Deshmukh- Actuarial Statistics-an introduction using R, Universities Press. 2. Rotar, V.I. (2015). Actuarial Models – The mathematics of Insurance – Second Edition. CRC Press New York 3. Promislow, S.D. (2015). Fundamentals of Actuarial Mathematics- Third Edition. John Wiley & Sons , New York 4. Bowers, N.L., Gerber, H.U., Hickman, J.C., Jones, D.A.& Nesbitt, C.J. (1997). Actuarial Mathematics, Society of Actuaries 				

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	3	1	2	-	-	2	-	2	-	-	-
CO 2	3	3	-	2	1	-	3	1	2	3	-	-
CO 3	1	2	-	2	-	-	2	-	2	-	-	-

CO 4	3	2	-	1	-	-	3	-	2	2	-	-
CO 5	3	2	-	-	-	-	3	-	2	-	-	-
CO 6	1	1	2	-	3	3	2	2	1	-	3	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4		✓		✓
CO 5		✓		✓
CO 6	✓			

Programme	B.SC. APPLIED STATISTICS WITH DATA SCIENCE
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Course Code	ASD5EJ303				
Course Title	Psychometric Theory and Methods				
Type of Course	Major Elective				
Semester	V				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites					
Course Objective	To introduce fundamental theories and methodologies used to evaluate the quality of psychological measurements in research and applied settings. It covers broad topics in Psychometrics, classical test theory and item response theory				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the theoretical fundamentals of classical test theory	U	C	Instructor-created exams / Quiz
CO2	Discuss the foundations of testing like reliability, validity and utilize psychometric modeling approaches to evaluate those foundations for specific tests	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Describe item response theory models and their applications in measurement	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Understand the similarities, differences, and links between classical test theory and modern test theory	U	C	Instructor-created exams / Home Assignments
CO5	Understand and apply the basics of factor analysis and principal components analysis for purposes of test construction and validation	Ap	P	Instructor-created exams / Home Assignments
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I		Introduction to Psychometrics	12	15

	1	What Is Psychometrics, Scope of Psychometrics, Challenges to Measurement in Psychology		
	2	Scales of Measurement		
	3	Unidimensional Tests		
	4	Multidimensional Tests with Correlated Dimensions		
	5	Multidimensional Tests with Uncorrelated Dimensions		
	<i>Sections from References:</i> Chapters 1, 2, 3 of Furr, R. M. (2018). Psychometrics: An Introduction (3rd Ed). SAGE Publications, Inc			
II	Classical Test Theory		12	15
	6	Assumptions, Equations, Limitations of Classical Test Theory		
	7	Theory of True and Error Scores		
	8	Item Analysis Within Classical Test Theory		
	9	Difficulty Level		
	10	Discrimination Index , Item-to-Total Correlations, Item-to-Criterion Correlations		
	<i>Sections from References:</i> Chapters 5 of Kline, T. (2005). Psychological Testing: A Practical Approach to Design and Evaluation. Sage Publications			
III	Item Response Theory (IRT)		12	20
	11	Equations, Limitations, and Item Analyses of IRT		
	12	One-Parameter, Two-Parameter, Three-Parameter Logistic Models		
	13	Multiple-Response IRT Models, Nominal Responses, Graded Responses, Partial Credit Responses		
	14	Parameter Estimation, Maximum Likelihood Estimation,		
	15	Bayesian Estimation, Model Fit		
	<i>Sections from References:</i> Chapters 6 of Kline, T. (2005). Psychological Testing: A Practical Approach to Design and Evaluation. Sage Publications			
IV	Reliability and Validity		12	20
	16	Test-retest Reliability, Alternative Forms Reliability, Measures of Internal Consistency, Split-Half , Cronbach's Alpha (α) , Coefficient Theta (θ) , Kuder-Richardson 21 (KR21)		
	17	Reliability of Raters, Interrater Reliability Indices, Observer Agreement Percentage,		
	18	Kendall's Coefficient of Concordance, Cohen's Kappa Coefficient		
	19	Modern Test Theory Approaches to Reliability		
	20	Assessing Validity Using Content and Criterion Methods		
	<i>Sections from References:</i> Chapters 7,8, and 9 of Kline, T. (2005). Psychological Testing: A Practical Approach to Design and Evaluation. Sage Publications			
V	Open Ended Module:		12	
	1	Computation of indices, preparation of tools		
	Sections from References:			

Books and References:

1. Furr, R. M. (2018). Psychometrics: An Introduction (3rd Ed). SAGE Publications, Inc.
2. Kline, T. (2005). Psychological Testing: A Practical Approach to Design and Evaluation. Sage Publications.
3. Allen, M. J. & Yen, W. M. (1979). Introduction to Measurement Theory. Waveland Press. Inc

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	3	1	2	-	-	2	-	2	-	-	-
CO 2	3	3	-	2	1	-	3	1	2	3	-	-
CO 3	1	2	-	2	-	-	2	-	2	-	-	-
CO 4	3	2	-	1	-	-	3	-	2	2	-	-
CO 5	3	2	-	-	-	-	3	-	2	-	-	-
CO 6	1	1	2	-	3	3	2	2	1	-	3	3

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

- Quiz / Assignment/ Quiz/ Discussion / Seminar
- Midterm Exam
- Programming Assignments (20%)
- Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓	✓		✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4		✓		✓
CO 5		✓		✓
CO 6	✓			

Programme	B.SC. APPLIED STATISTICS WITH DATA SCIENCE				
Course Code	ASD5EJ304				
Course Title	Survival Analysis				
Type of Course	Major Elective				
Semester	V				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites					
Course Objective	The student has a thorough knowledge of the basic theory of stochastic modelling and statistical analysis of survival data, including graphical techniques. This includes both parametric and non-parametric analysis of censored survival data and data for recurrent events, as well as related regression models				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the basic concepts and ideas of survival analysis.	U	C	Instructor-created exams / Quiz

CO2	Examine the properties and methods for standard survival time distributions	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Estimate survival functions using parametric and non-parametric methods.	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Apply and interpret semi-parametric and parametric regression models for survival data.	U	C	Instructor-created exams / Home Assignments
CO5	To apply the concepts learned in the previous modules to a real-life data set.	Ap	P	One Minute Reflection Writing assignments
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I	Basic Quantities and Models of Survival Analysis		10	15
	1	Examples of survival data, Basic Quantities, and Models		
	2	Survival Function, Hazard function,		
	3	Mean residual life function		
	4	Common Parametric models for survival data.		
	5	Regression models for survival data		
	<i>Sections from References:</i> Chapter 1, 2.2, 2.3, 2.4, 2.5, and 2.6 of Klein J.P. and Moeschberger M.L. (2003) Survival Analysis - Techniques for censored and truncated data, Second Edition, Springer-Verlag, New York			
II	Censoring and Truncation		10	15
	6	Right censoring		
	7	Left censoring		
	8	Interval censoring		
	9	Truncation		
	10	Likelihood construction for censored and truncated data.		
	<i>Sections from References:</i> Sections from References: Section 3.2, 3.3, 3.4, 3.5, 3.6 of Klein J.P. and Moeschberger M.L. (2003) Survival Analysis - Techniques for censored and truncated data, Second Edition, Springer-Verlag, New York			

III	Nonparametric Estimation of Basic Quantities		18	20
	11	Estimators of the Survival Functions for Right-Censored Data		
	12	Estimators of Cumulative Hazard Functions for Right-Censored Data		
	13	Point-wise Confidence Intervals for the Survival Function		
	14	Life Table, Estimation of Survival in the Cohort Life Table.		
	15	Hypothesis testing- One sample tests, Tests for two or more samples		
	<i>Sections from References:</i> Sections from References: Section 4.2,4.3,4.4,4.5 4.6, 5.3,5.4,7.2,7.3 of Klein J.P. and Moeschberger M.L. (2003) Survival Analysis - Techniques for censored and truncated data, Second Edition, Springer-Verlag , New York			
IV	Semiparametric Proportional Hazards Regression with Fixed Covariates		10	20
	16	Coding Covariates		
	17	Partial likelihood for distinct event time data		
	18	Model Building Using the Proportional Hazards Model		
	19	Additive hazards regression models.		
	20	Regression Diagnostics		
	Sections from References: <i>Sections from References:</i> Sections from References: Sections from chapters 8, 9 10 and 11 of Klein J.P. and Moeschberger M.L. (2003) Survival Analysis - Techniques for censored and truncated data, Second Edition,			
V	Open Ended Module:		12	
	1	Practical exercises on lifetime data using the statistical softwareR: Fitting the Parametric models for survival data.		
	Sections from References:			
Books and References:				
<ol style="list-style-type: none"> 1. Klein J.P. and Moeschberger M.L. (2003) Survival Analysis - Techniques for censored and truncated data, Second Edition, Springer-Verlag , New York. 2. Lawless J.F (2003) Statistical Models and Methods for Lifetime Data, Second Edition, John Wiley & Sons, Relevant Sections of the Chapters 9. 3. Kalbfleisch J.D and Prentice, R.L. (2002) The Statistical Analysis of Failure Time Data, Second Edition, John Wiley & Sons Inc. 4. Deshpande, J .V. and Purohit, S. G. (2006). Lifetime Data: Statistical Models and Methods. World Scientific. 				

Programme	B.S.C. APPLIED STATISTICS WITH DATA SCIENCE
Course Code	ASD5EJ305
Course Title	Population Statistics
Type of Course	Major Elective
Semester	V

Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites					
Course Objective	Students will understand the basics of population studies and demography and will be able to apply statistical tools and techniques in analysing data related with demography.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand nature, scope and sources of demographic data	U	C	Instructor-created exams / Quiz
CO2	Understand Population theories life tables and their main features	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Calculate and interpret mortality and fertility measures	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Analyze internal migration and its measurement, exploring migration models	U	C	Instructor-created exams / Home Assignments
CO5	Apply demographic concepts and measures practically using data analysis tools like R or Excel.	Ap	P	One Minute Reflection Writing Assignments
CO6		Ap	P	Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I	Nature of Population Studies		12	10
	1	Nature and Scope		
	2	Sources of demographic data		

	3	World population- growth and distribution		
	4	Demographic profiles of the Indian Census.		
	5	Population Growth in India		
	Sections from References: Chapters 1,2,3 and 4 from Asha Bhende and Tara Kanitkar (2015), Principles of Population Studies, Himalaya Publishing			
II	Population Theories		12	20
	6	Early Thinking on Population Issues, Pre- Malthusian Theories		
	7	Malthusian theory, Classical and neo classical theories		
	8	Optimum allocation theory, Sociality view		
	9	Biological theories		
	10	Theory of demographic transition		
	Sections from References: Chapter 5 from Asha Bhende and Tara Kanitkar (2015), Principles of Population Studies, Himalaya Publishing			
III	Vital Statistics		12	20
	11	Rates and ratios of vital events, Measurement of mortality, Crude Death rate		
	12	Specific death rate, Standardized death rates		
	13	Infant Mortality rate, Death rate by cause		
	14	Mortality table or life table, Makehams and Gompertz curves. National life tables. UN model life tables, Abridged life tables		
	15	Stationary population and stable population, Force of mortality		
	Sections from References: Chapter 9 from SC Gupta and VK Kapoor, Fundamentals of Applied Statistics (2010) Sultan Chand and sons,			
IV	Measurement of Fertility		12	20
	16	Crude birth rate, General fertility rate, Age-specific birth rate Total fertility rate,		
	17	Gross reproduction rate, Net reproduction rate		
	18	Concept of international migration and its measurement, migration models		
	19	Net migration. International and postcensal estimates		
	20	Decennial population census in India		
	Sections from References: Chapter 9 from SC Gupta and VK Kapoor, Fundamentals of Applied Statistics (2010) Sultan Chand and sons,			
V	Open Ended Module:		12	
	1	Hands-on in R or Excel: Mortality and fertility and other vital statistics measures.		
	Sections from References:			
Books and References:				
1. Asha Bhende and Tara Kanitkar (2015), Principles of Population Studies, Himalaya Publishing				
2. S. C. Gupta and V. K. Kapoor. Fundamentals of Applied Statistics. Sultan Chand and Sons.				
3. Benjamin B, Health and Vital Statistics, Allen and Unwin				

Programme	B.SC. APPLIED STATISTICS WITH DATA SCIENCE				
Course Code	ASD6EJ306				
Course Title	Biostatistics				
Type of Course	Major Elective				
Semester	VI				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites					
Course Objective	The student will describe the need and ethics of clinical trials and designs for various phases of clinical trials.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	The student will explain Principles of Biostatistical study designs	U	C	Instructor-created exams / Quiz
CO2	The student will explain measures of morbidity.	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	The student will describe the concepts of survival time functions of important parametric models.	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	The student will explain types of censoring and estimation of parameters using censored data.	U	C	Instructor-created exams / Home Assignments
CO5	The student will explain the non-parametric methods for estimating survival function and variance of the estimator using Kaplan –Meier methods.	Ap	P	One Minute Reflection Writing assignments
CO6	The student will describe the basic biological concepts in genetics.	Ap	P	Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I	Introduction		12	20
	1	Examples of Statistical Problems in Biomedical Research		
	2	Types of Biological data		
	3	Principles of Biostatistical design of medical studies		
	4	study designs- observational study, experimental study-comparative experiment, cross over experiment		
	5	prospective and retrospective study		
	6	case-control and longitudinal study		
	7	Measuring the occurrence of disease, Measures of morbidity - prevalence and incidence rate, association between prevalence and incidence, uses of prevalence and incidence.		
Sections from References:				
II	Survival analysis		12	15
	8	Introduction to survival analysis, concepts and definitions		
	9	Survival function		
	10	probability density function		
	11	hazard function		
	12	inter relationships,		
	13	Survival distributions- exponential distribution, Weibull distribution and lognormal distribution.		
Sections from References:				
III	Types of censoring		12	15
	14	Concepts of censoring and truncation		
	15	Type I, Type II and progressive or random censoring with biological examples,		
	16	Estimation of mean survival time and variance of the estimator for type I and type II censored data with numerical examples (for exponential distribution).		
	17	Non-parametric methods for estimating survival function and variance of the estimator- Kaplan –Meier methods.		
Sections from References:				
IV			12	20
	18	Basic biological concepts in genetics Mendel’s law, Hardy- Weinberg equilibrium		
	19	Random mating, natural selection, mutation, genetic drift,		
	20	Detection and estimation of linkage in heredity		
	21	Planning and design of clinical trials, Phase I, II, and III trials.		
	22	Ethics behind randomized studies involving human subjects; randomized dose-response studies (concept only)		
Sections from References:				
V	Open Ended Module:		12	

1	Practical problems based on module I to IV using statistical software.		
Sections from References:			
Books and References:			
1) Lawless, J.F.(2003): Statistical Methods for Lifetime (Second Edition), John Wiley & Sons.			
2) Rosner B. (2006): Fundamentals of Biostatistics, Edition 6			
3) Cox, D.R. and Oakes, D. (1984): Analysis of Survival Data, Chapman and Hall.			
4) Friedman, L.M., Furburg, C. and DeMets, D.L. (1998): Fundamentals of Clinical Trials, Springer			
5) Lee, Elisa, T. (1992): Statistical Methods for Survival Data Analysis, John Wiley & Sons.			
6) Fisher, L.D. and Belle, G.V. (1993): Biostatistics: A Methodology for the Health Science, John Wiley & Sons Inc.			

Programme	B.SC. APPLIED STATISTICS WITH DATA SCIENCE				
Course Code	ASD6EJ307				
Course Title	Econometrics				
Type of Course	Major Elective				
Semester	VI				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites					
Course Objective	Students will be able to interpret regression results as well as to understand the assumptions underlying the ordinary least squares estimator, and judge in an educated manner whether they hold in a given problem.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	will be able to estimate and interpret linear regression models and be able to distinguish between economic and statistical importance.	U	C	Instructor-created exams / Quiz
CO2	They should be able to use a statistical/econometric computer package to estimate an econometric model	Ap	P	Practical Assignment / Observation of Practical Skills

CO3	To understand the scope and application of econometrics to real world problems.	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	To know econometric problems and their solutions	U	C	Instructor- created exams / Home Assignments
CO5	To get an exposure in simple statistical packages and their use in econometric work	Ap	P	One Minute Reflection Writing Assignments
CO6	To understand real life situations where econometric concepts are applied	Ap	P	Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge (F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I	Introduction		12	10
	1	Purpose and scope of econometrics		
	2	Econometric model		
	3	Model building and role of econometrics.		
	4	General linear model (GLM).		
	5	Estimation under linear restrictions and properties of estimators		
Sections from References:				
II	Heteroscedasticity		12	20
	6	Econometric problems		
	7	Heteroscedasticity		
	8	Tests for heteroscedasticity,		
	9	Consequences of heteroscedasticity and solutions		
Sections from References:				
III	Autocorrelation		12	20
	10	Autocorrelation concept		
	11	Consequences of auto correlated disturbances,		
	12	Detection of Autocorrelation		
	13	Tests of autocorrelation.		
	14	Distributed lag models		
	15	Estimation of parameters		
Sections from References:				
IV	Multiple regression		14	20
	16	Concept of Multiple regression		
	17	Multiple regression analysis.		
	18	Multi collinearity: Introduction and concepts,		
	19	Detection of multi collinearity,		

	20	Consequences multi collinearity		
	21	Sources multi collinearity		
	22	Tests and estimation of multi collinearity		
Sections from References:				
V	Open Ended Module:		12	
	1	Practical Problems related to OLS/ CLR using softwares. Introduction to various Economic functions (Demand , Supply, Utility, Cost , Revenue etc.)		
Sections from References:				
Books and References:				
1. Gujarathi, D. and Sangeetha, S.(2007). Basic Econometrics, Mc Graw Hill				
2. Johnston, J.(2009) Econometric Methods, 4th edition, Mc Graw Hill				
3. Judge, G. J, Griffiths, W. E & et al.(1985). Theory and Practice of Econometrics, 2nd edition , John Wiley				
4. Introductory Econometrics, a modern approach, 5th edition,				
5. Jeffrey M. Wooldridg Maddala, G.S. and Lahiri, K. (2009): Introduction to Econometrics, 4th Wiley & Sons				

Programme	B.SC. APPLIED STATISTICS WITH DATA SCIENCE				
Course Code	ASD6EJ308				
Course Title	Statistical Quality Control				
Type of Course	Major Elective				
Semester	VI				
Academic Level	300-399				
Course Details	Credit	Lecture per Week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites					
Course Objective	To make students aware of Various Quality or standards in Industrial Production, Detecting, Controlling and Maintaining Quality and Total Quality Management				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understanding notion of Quality of products	U	C	Instructor-created exams / Quiz

CO2	Assessing various meaning of Quality	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Explain causes of variation and Statistical Control	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Construction of Control Charts and OC curves	U	C	Instructor-created exams / Home Assignments
CO5	Distinguish Process and Product Control	Ap	P	One Minute Reflection Writing Assignments
CO6	Assessing Process and Product Control	Ap	P	Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P)Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I	Control Charts theory		12	15
	1	General theory of Control Charts.		
	2	Setting Control Limits.		
	3	Importance of 3-sigma limits		
	4	Statistical basis of Control Limits		
	5	Need of two control charts for variables		
	6	Assessing Statistical Control using Charts		
	7	Control Charts for Variables and Attributes		
Sections from References:				
II	Control Charts Construction		12	20
	8	Mean Chart Theory and Construction		
	9	Dispersion (Range, Standard Deviation Chart) Chart. Theory and Construction		
	10	Proportion defective Chart Theory and Construction		
	11	Number of Defective Chart Theory and Construction		
	12	Number of Defects Chart Theory and Construction.		
Sections from References:				
III	Product Control		12	20
	13	Sampling Inspection Plans (Acceptance Sampling Plans)		
	14	Single Sampling Plan		

	15	Double Sampling Plan, ,		
	16	Sequential Sampling Plan		
	17	Incoming and Outgoing Quality		
	18	AQL, RQL, LTPD, AOQ, AOQL		
	19	Errors in Sampling Inspection Plans		
	20	Power function and OC function.		
	21	Producer' and Consumers Risk		
	Sections from References:			
IV	Characterising Sampling Plans		10	15
	22	Constructing OC Curve of Single Sampling Plan using Hyper Geometric distribution		
	23	Constructing OC Curve of Single Sampling Plan using Binomial distribution		
	24	Constructing OC Curve of Single Sampling Plan using Poisson distribution		
	25	Constructing OC Curve of Double Sampling Plan		
	26	ASN, ATI		
	Sections from References:			
V	Open Ended Module:		12	
	1	Preliminaries of Quality Control Definition of Quality. Need of total quality Management and its uses. Causes of Variation, assessing within and between sample variation using Statistical Measures. Concept of Statistical Quality Control, Process Control and Product Control		
	Sections from References:			
Books and References:				
<ol style="list-style-type: none"> 1. Douglas C Montgomery, Introduction to Statistical Quality Control, 8th Edition 2. Mahajan Dhanpat Rai Statistical Quality Control 2nd Edition 3. S C Gupta and V K Kapoor Fundamentals of Applied Statistics SultanChand & Sons 				

Programme	B.SC. APPLIED STATISTICS WITH DATA SCIENCE				
Course Code	ASD6EJ309				
Course Title	Operations Research				
Type of Course	Major Elective				
Semester	VI				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites					
Course Objective	Make students to formulate, solve and implement feasible solutions of complex Industrial, Trade, Commercial problems				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understanding Basics of Operations Research.	U	C	Instructor-created exams / Quiz
CO2	Distinguishing Solution, Feasible Solution, Basic Solution and Basic Feasible Solutions	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Mathematical Formulation Real life problems	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Mastering Simplex Algorithm	U	C	Instructor-created exams / Home Assignments
CO5	Apply LPP in Transportation and Assignment Problems	Ap	P	One Minute Reflection Writing assignments
CO6	Analyse decision making under conflict Game theory	Ap	P	Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I	Liner Programming Problem		12	20
	1	Graphical Solution of LPP.		
	2	Feasible Solution, Basic Feasible Solution of LPP		
	3	Simplex Algorithm without Artificial Variables.		
	4	Artificial Variable technique		
	5	Big M method		
	6	Two Phase method		
Sections from References:				
II	Application of LPP		12	20
	7	Duality Primal and Dual LPP		
	8	Economic Interpretation of Dual		
	9	Dual Simplex Method Solution of primal using Dual.		
	10	Transportation and Assignment Problems as special case of LPP.		
	11	Balanced Transportation Problem, Balanced Assignment Problem		
	12	Initial Basic Feasible Solution using NWCR		
13	Initial Basic Feasible Solution using LCCM			
Sections from References:				
III	Solving TP & AP		12	15
	14	Solution of Transportation Problem using Vogel's Approximation Method		
	15	Optimization using MODI Method		
	16	Hungarian Method of Solving Assignment Problem		
Sections from References:				
IV	Game Theory		12	15
	17	Decision making under Conflict		
	18	Pay off Matrix.		
	19	MinMax MaxMin Criteria		
	20	Pure and Mixed Strategy		
	21	Value of Game and Saddle Point		
	22	Principle of Dominance, solving 2x2 games.		
23	Graphical solution of 2xn and nx2 games			
Sections from References:				
V	Open Ended Module:		12	
	1	Origin, Development of OR. Nature & Scope of OR, Uses & Limitations of OR. Linear Programming Problem, Mathematical Formulation, General, Standard form of LPP.		
Sections from References:				
Books and References:				
<ol style="list-style-type: none"> 1. Operations Research, Swaroop, Kanti, P. K. Gupta and Man Mohan. 2007. 13th Edition. New Delhi: Sultan Chand and Sons 2. Operations Research, J K Sharma, Laxmi Publications 3. Operations Research V K Kapoor Sulthan Chand and Sons 				

Programme	B.SC. APPLIED STATISTICS WITH DATA SCIENCE				
Course Code	ASD6EJ310				
Course Title	Simulation Techniques				
Type of Course	Major Elective				
Semester	VI				
Academic Level	300-399				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites					
Course Objective	Statistical Methods to model and analyse a variety of Random Phenomena				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Generate pseudo-random numbers using different methods.	U	C	Instructor-created exams / Quiz
CO2	Use resampling methods on real datasets.	Ap	P	Practical Assignment / Observation of Practical Skills
CO3	Apply Markov Chain Monte Carlo methods and density estimation	Ap	P	Seminar Presentation / Group Tutorial Work
CO4	Develop programs for simulation purposes.	U	C	Instructor-created exams / Home Assignments
CO5	Apply simulation skills in real-world scenarios	Ap	P	One Minute Reflection Writing assignments
CO6		Ap	P	Viva Voce
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I	Introduction		10	10
	1	Introduction to random number generation.		
	2	Methods for generating random variables - Inverse transform Method		
	3	Composition method, Transformation method		
	4	Acceptance-Rejection method.		
	5	Generating from common statistical distributions Discrete and Continuous. (Rizzo (2019) and Rubinstein (2017		
Sections from References:				
II	Simulation		12	20
	6	Simulation for the multivariate normal distribution		
	7	Simple estimation based on simulated data		
	8	Monte Carlo integration and variance reduction techniques		
	9	Use of antithetic and control variables		
	10	Statistical validation of the simulated data by goodness of fit tests. (Rizzo (2019), Rubinstein (2017) and Ross (2022))		
Sections from References:				
III	Re-sampling		12	20
	11	Introduction to resampling,		
	12	Sampling distribution and other features of a statistic		
	13	Permutation and Randomization tests,		
	14	Theory for Jackknife, Variance estimation-consistency,		
	15	Theory for the bootstrap and its consistency, Distribution and variance estimators		
Sections from References:				
IV	MCMC and EM Algorithm		14	20
	16	Markov Chain Monte Carlo methods:		
	17	The Metropolis–Hasting’s algorithm		
	18	Gibbs sampling.		
	19	EM algorithm.		
	20	Smoothing with kernels, density estimation		
Sections from References:				
V	Open Ended Module:		12	
	1	Generate random numbers using statistical software for different distributions with its estimation and model fitting. Apply resampling methods for real life data.		
Sections from References:				
Books and References:				
1. Rizzo, M. L. (2019). Statistical Computing with R, second edition. Boca Raton, FL: Chapman& Hall/CRC Press				
2. McLachlan, G.J. and Krishnan, T. (1997): The EM Algorithms and Extensions, Wiley.				
3. Robert, C.P. & Casella, G. (2004) Monte Carlo Statistical Methods, 2ndEdn., Springer.				
4. Ross, S. M. (2022). Simulation. Academic Press.				
5. Rubinstein, R.Y. (2017). Simulation and the Monte Carlo Methods, Wiley.				
6. Shao, J., & Tu, D. (2012). The jackknife and bootstrap. Springer Science & Business Media.				

**SEMESTER VII
MAJOR COURSES**

Programme	B. Sc. STATISTICS				
Course Code	STA 7 CJ 401 (P)				
Course Title	ADVANCED ANALYTICAL TOOLS				
Type of Course	Major				
Semester	VII				
Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practicum per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basic knowledge of Real analysis and Matrix theory.				
Course Summary	The main objective of this course to understand Reimann-Stieltjes integral, Uniform convergence, vector space Eigen values and Eigen vectors.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Evaluate the Riemann-Stieltjes integral and verify the conditions for the existence of the integrals.	An	C	Instructor-created exams
CO2	Demonstrate an understanding of limits and continuity of various functions	U	F	Practical Assignment
CO3	Develop skills in generalizing the concepts in univariate calculus to multivariate setup	Ap	C	Seminar Presentation
CO4	Demonstrate proficiency in understanding and applying vector space concepts	U	F	Instructor-created exams / Home Assignments
CO5	Demonstrate proficiency in applying vector space and matrix concepts	U	F	Writing assignments

* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)
- Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P)
Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I	Riemann – Stieltjes Integral		10	15
	1	Definition, Linear properties- Integration by parts - Change of variable		
	2	Reduction to a Riemann integral		
	3	Step functions as integrators-Reduction to a finite sum		
	4	Monotonically increasing integrators- Riemanns conditions- Comparison theorems- Functions of bounded variations (concepts only)		
	5	Necessary & Sufficient conditions for the existence of Riemann Stieltjes integral		
	6	Mean-value theorems		
II	Sequences and Series of Functions		13	20
	7	Point wise convergence of sequence of functions - Examples of sequences of real valued functions		
	8	Definition of Uniform convergence - Uniform convergence and continuity		
	9	Cauchy condition for uniform convergence - Uniform convergence of infinite series of functions		
	10	Uniform convergence and Riemann-Stieltjes Integration - Uniform convergence and differentiation		
	11	Multivariable Functions- Limits and continuity of multivariable functions – Derivatives - directional derivatives		
	12	Total derivative in terms of partial derivatives		
	13	Taylor’s theorem-Inverse and implicit functions.		
III	Algebra of Vectors		10	15
	14	Vector spaces - definition and examples		
	15	Subspaces - Linear independence - Basis and dimension- Linear equations		
	16	Vector spaces with an inner product: Properties		
	17	Gram-Schmidt orthogonalization.		
IV	Algebra of matrices		12	20
	18	Theory of matrices and determinants - Matrix operations-Elementary matrices and diagonal reduction of a matrix- Determinants- Transformations		
	19	Generalized inverse of a matrix		
	20	Matrix representations of vector spaces, bases, etc.		
	21	Idempotent matrices. Special products of matrices		
	22	Eigene values and reduction of matrices: Classification and transformations of quadratic forms. Roots of determinant equations. Canonical reduction of matrices.		
V	Open Ended Module:		30	
		Hands-on-activities using Python/R. Open book problem solving exercises		

Text Books

1. **Khuri, A.T. (1993).** Advanced Calculus with Applications in Statistics. John Wiley & Sons, New York. (Chapter7).
2. **Apostol, T.M. (1974).** Mathematical Analysis- Second Edition. Narosa Publications, New Delhi.
3. **Rao, C.R. (2002).** Linear Statistical Inference & Its Applications- Second Edition. John Wiley & Sons, New York.
4. **Rao, A.R. & Bhimasankaram, P. (1992).** Linear Algebra. Hindustan Book Agency, New Delhi.
5. **Rao, A.R. and Bhimsankaram, P. (1992).** Linear Algebra. Tata McGraw Hill, New Delhi.
6. **Lewis, D.W. (1996).** Matrix Theory. Allied Publishers, Bangalore.
7. **Graybill, F. A. (1983).** Matrices with Applications in Statistics. John Wiley & Sons, New York.

References:

1. **Widder, D.A. (1996).** Advanced Calculus, Second Edition, Prentice Hall, Inc., New Delhi.
2. **Malik, S.C. & Arora, S. (2006).** Mathematical Analysis- Second Edition. New Age International International, New Delhi.
3. **Rudin, W. (1976).** Principles of Mathematical Analysis- Third Edition. McGraw Hill, New York
4. **Biswas, S. (1997).** A text book of Linear Algebra. New Age International, New Delhi.
5. **Rao, C.R. (2002).** Linear Statistical Inference and Its Applications- Second Edition. John Wiley & Sons, New York.

Programme	B. Sc. STATISTICS				
Course Code	STA 7 CJ 402 (P)				
Course Title	PROBABILITY THEORY				
Type of Course	Major				
Semester	VII				
Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practicum per week	Total Hours
	4	3	-	3	75
Pre-requisites	Basic Probability theory, Concept of convergence				

Course Summary	Understanding expectation and various celebrated theorems in classical probability theory.
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Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Recall sequence of sets and its convergence.	R	F	Instructor-created exams
CO2	Explain the concept of field, sigma field, Borel sigma field and monotone class.	U	C	Practical Assignment
CO3	Describe various types of measures and explain its properties.	R	C	Seminar Presentation
CO4	Explain decomposition of distribution function, characteristic function and its properties.	Ap	P	Instructor-created exams / Home Assignments
CO5	Explain the monotone convergence Theorem, Fatou's Theorem and Lebesgue dominated convergence Theorem.	Ap	P	Writing assignments
CO6	Explain the concept of convergence in probability, Convergence almost surely, Convergence in distribution, Convergence in r^{th} mean and their inter-relations.	U	F	Group Tutorial Work
CO7	Illustrate the convergence of distribution functions, Helly-Bray Lemma and Helly – Bray theorem, and Levy continuity theorem.	An	P	Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I			10	20
	1	Definition of minimal sigma field, generated sigma field and induced sigma field		
	2	Random variables, Sigma fields induced by random variables, Vector random variables, limits of sequence of random variables.		
	3	Concept of measure space, finite measure, sigma finite measure, complete measure, counting measure and signed measure (Definition and examples only).		

	4	Probability space, General Probability space.		
	5	Induced probability space.		
II			12	15
	6	Decomposition of distribution functions, Distribution function of vector random variables, Correspondence theorem.		
	7	Expectation and moments, Properties of expectations.		
	8	Moments and inequalities		
	9	Characteristic functions, Properties, Inversion theorem		
	10	Characteristic functions and moments, Bochner's theorem (No proof required)		
	11	Independence of classes of events; Independence of random variables		
	12	Kolmogorov 0-1 law; Borel 0-1 law		
III			12	20
	13	Monotone convergence Theorem.		
	14	Fatou's Theorem		
	15	Lebesgue dominated convergence Theorem		
	16	Lebesgue-Stieltjes integral and its reduction to Riemann-Stieltjes integral and Riemann integral.		
	17	Statement and applications of Lebesgue decomposition and Radon-Nykodym theorem.		
IV			11	15
	18	Convergence in probability, Convergence almost surely		
	19	Convergence in distribution, Convergence in rth mean – their inter-relations- examples and counter examples.		
	20	Weak convergence		
	21	Helly-Bray Lemma and Helly – Bray theorem		
	22	Levy continuity theorem.		
V		Open Ended	30	
		Sequences of sets, limit supremum, limit infimum and limit of sets. Monotone sequence of sets. Fields, Sigma fields, Borel sigma field and monotone class. Hands-on-activities using Python/R. Open book problem solving exercises		

Text Books

1. B.R Bhat (1999). Modern Probability Theory, Wiley Eastern
2. Laha & Rohatgi (1979). Probability theory, Wiley New York
3. De Barra, G. (2000). Measure Theory and Integration, New Age International (P) Ltd, New Delhi.

References

1. **Ash R. B (2000)**. Probability and Measure Theory, Second edition. Academic Press.
2. **Billingsley P (1985)**. Probability and Measure, Second edition, John Wiley and Sons, NewYork.

Programme	B. Sc. STATISTICS				
Course Code	STA7 CJ 403 (P)				
Course Title	DISTRIBUTION THOERY				
Type of Course	Major				
Semester	VII				
Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practicaum per week	Total Hours
	4	3	-	2	75
Pre-requisites	1. Basic knowledge of various univariate and bivariate distributions. 2. Matrix theory – Eigen Values & Eigen vectors.				
Course Summary	The main objective of this course are to understand the concepts of multivariate probability distributions. Study essential properties of multivariate distributions and apply customized probability distributions in the relevant context.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
1.	Distinguish different distributions and illustrate their role in modelling count data.	U	F	Seminar Presentation / Group Tutorial Work
2.	Describe the properties and applications of multivariate normal distribution.	U	C	Instructor-created exams
3.	Estimate the ML Estimates of the mean vector and dispersion matrix of multivariate normal.	An	P	Instructor-created exams
4.	Evaluate marginal and conditional distribution from multivariate normal distribution	An	P	Instructor-created exams / Home Assignments
5.	Describe the genesis of Wishart distribution with its properties.	U	C	Home Assignment
6.	Explain distribution function	Ap	C	Instructor-created

	of random vectors, order statistics and their distributions.			exams / Home Assignments
7.	Compare Hotelling T^2 and Mahalanobis D^2 statistic and able to apply them in testing problems.	U	F	Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45+30)	Marks (70)
I	Open-End		30	20
	1	Overview of univariate & bivariate distributions and their properties. Sampling Distributions- Central and non-central (t, F and χ^2) Order statistics – their distributions and properties- Joint, marginal and conditional distribution of order statistics The distribution of sample range and sample median. Problems using R/Python		
II	Multivariate Normal Distribution		12	20
	1	Definition and properties of multivariate normal density function		
	2	Distribution of a linear combination of the components of a normal random vector.		
	3	Maximum Likelihood estimation of the mean vector and dispersion matrix.		
	4	The distribution of sample mean vector inference concerning the mean vector when the dispersion matrix is known for single and two populations.		
III	Generalized Variance		9	15
	5	Wishart Distribution		
	6	Properties of Wishart distribution		
	7	Test for covariance matrix		
	8	Test for equality of covariance matrices		
	9	Test for independence of sets of variables.		
IV	Quadratic forms and their distributions		14	15
	10	Jacobian of matrix transformation of $Y=AXB$; $Y=AXA'$; $X=TT'$		
	11	Independence of a linear form and quadratic form		
	12	Distributions of quadratic form of a multivariate vector		
	13	Cochran's theorem		
	14	Partial and multiple correlation coefficients		
	15	Partial regression coefficients		
V	T^2 and D^2 distributions		10	
	16	Hotelling T^2 distribution and its applications		

17	Generalized T^2 statistic and its distribution		
18	Uses of T^2 statistic		
19	Optimum properties of T^2 statistic		
20	Mahalanobis D^2 statistic and its distribution		
21	Relation between T^2 and D^2		
22	Test based on T^2 statistic		

Text Book

1. **Anderson T W (2010)** : An Introduction to Multivariate Statistical Analysis, Wiley Eastern Ltd.
2. **Johnson, R A and Wichern D W (2003)** : Applied Multivariate Statistical Analysis, Prentice-Hall of India Private Ltd., New Delhi.

Reference

1. **Jhonson, Kotz and Balakrishna (1991)** : Continuous univariate distributions, Vol-1 2nd Ed., John Wiley and Sons
2. **Johnson, Kemp and Kotz (1992)** : Univariate Discrete distributions, 2nd Ed, John Wiley and Sons
3. **Kotz, Balakrishnan, Johnson (2004)** : Continuous Multivariate Distributions, Vol 1, 2nd Ed. John Wiley & Sons
4. **Mukhopadhyay P (1996)** : Mathematical Statistics, New Central Book Agency (P) Ltd. Calcutta.
5. **Srivastava, M, C G Khatri (1979)** : Introduction to Multivariate Statistics, Elsevier Science Ltd.

Programme	B. Sc. STATISTICS
Course Code	STA 7 CJ 404 (P)
Course Title	ADVANCED SAMPLING METHODS AND DESIGN OF EXPERIMENTS
Type of Course	Major
Semester	VII
Academic Level	400-499

Course Details	Credit	Lecture per week	Tutorial per week	Practicum per week	Total Hours
	4	3	-	2	75
Pre-requisites	Knowledge about sampling procedures and various sampling methods, linear estimation and analysis of variance				
Course Summary	Understand PPS sampling, ratio and regression sampling methods. Identify various factorial design experiments.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Estimate the population parameters concerning the study variables under auxiliary information (Ratio and regression methods).	An	C	Instructor-created exams
CO2	Discuss probability proportional to size (PPS) sampling strategies.	U	F	Home Assignments
CO3	Explain the concepts of ordered and unordered estimators and its properties.	Ap	C	Instructor-created exams
CO4	Discuss the multi stage and multiphase sampling.	U	F	Seminar Presentation
CO5	Apply incomplete block designs and balanced incomplete block designs.	Ap	C	Practical Assignment
CO6	Explain factorial experiments, total confounding and partial confounding.	Ap	C	Group Tutorial Work
CO7	Differentiate between strip plot and split plot designs.	An	P	Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		Open-Ended	30	
		Census and Sampling-Basic concepts, probability sampling and non-probability sampling, simple random sampling with and without replacement, Systematic sampling- linear and circular systematic sampling, Stratification and stratified random sampling, Complete Block Designs. Problems using R/Python		

II	Cluster , Ratio and Regression Sampling		12	20
	1	Cluster sampling with equal and unequal clusters		
	2	Estimation of mean and variance, relative efficiency, optimum cluster size, varying probability cluster sampling		
	3	Ratio method of estimation-estimation of ratio, mean and total.		
	4	Bias and relative bias of ratio estimator. Mean square error of ratio estimator. Unbiased ratio type estimator		
	5	Regression methods of estimation		
III	Varying probability sampling		10	15
	7	pps sampling with and without replacements		
	8	Des- Raj ordered estimators-Murthy's unordered estimator		
	9	Horvitz-Thompson estimators, Yates and Grundy forms of variance and its estimators		
	10	Zen-Midzuno scheme of sampling, π PS sampling		
IV	Incomplete Block Designs		11	20
	12	Balanced Incomplete Block designs		
	13	Construction of BIB Designs, Analysis with recovery of inter-block information and intra-block information		
	14	Partially balanced incomplete block designs		
	15	Analysis of partially balanced incomplete block designs with two associate classes		
	16	Youden square design		
V	Factorial Designs		12	15
	18	Basic definitions and principles - Analysis of 2^n factorial experiments		
	19	Total confounding of 2^n designs in 2^n blocks. Partial confounding in 2^n blocks		
	20	3^n factorial designs		
	21	Fractional factorial designs		
	22	Concepts of Split plot design and strip plot design		

Text Books

1. Cochran W.G. (1992): Sampling Techniques, Wiley Eastern, New York.
2. D. Singh and F.S. Chowdhary (1986): Theory and Analysis of Sample Survey Design, Wiley Eastern (New Age International), New Delhi.
3. Montgomery D C (2001). Design and Analysis of Experiments, John Wiley.

4. **Das M N and Giri N C (1979)**. Design and Analysis of Experiments, second edition, Wiley.

References

1. **P.V.Sukhatme et.al. (1984)**: Sampling Theory of Surveys with Applications. IOWA State University Press, USA.

2. **Des Raj (1976)**: Sampling Theory. McGraw Hill

3. **Mukhopadhyay. P. (1999)**. Theory and Methods of Survey Sampling. Prentice-Hall India, New- Delhi.

4. **Chakrabarti, M.C. (1964)**. Design of experiments, ISI, Calcutta.

5. **Hinkleman and Kempthorne C (1994)**. Design and Analysis of Experiments Volume I, John Wiley.

Programme	B. Sc. STATISTICS				
Course Code	STA 7 CJ 405 (P)				
Course Title	ADVANCED STATISTICAL INFERENCE				
Type of Course	Major				
Semester	VII				
Academic Level	400-499				
Course Details	Credit	Lecture per	Tutorial	Practical	Total Hours

		week	per week	per week	
	4	3	-	2	75
Pre-requisites	Basic knowledge of statistical estimation & testing of hypothesis				
Course Summary	Understand UMVUE and related theorems, UMP tests & SPRT				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Describe the method of finding sufficient statistics, minimum variance unbiased estimators, consistent estimators and consistent and asymptotically normal estimators	U	F	Instructor-created exams
CO2	Relate sufficient statistic and ancillary statistic using Basu's theorem	Ap	C	Instructor-created exams
CO3	Determine UMVUE using complete sufficient statistic using Rao-Blackwell, and Lehmann-Scheffe theorems	Ap	C	Seminar Presentation
CO4	Explain the concept of interval estimation- SELCI, Bayesian and Fiducial Intervals	U	F	Observation of Practical Skills
CO5	Construct most powerful tests using Neyman-Pearson lemma, one-sided and two-sided UMP tests and UMP unbiased tests	C	M	Group Tutorial Work
CO6	Describe the concept of α -similar tests and construct such tests	U	F	Practical Assignment
CO7	Develop SPRT for different problems	C	P	Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C), Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I		Open-Ended	30	
		Point Estimation. Desirable properties of a good estimator, unbiasedness, efficiency, Methods of Estimation - method of maximum likelihood, Bayesian estimation method. Testing of Hypotheses; concept of testing hypotheses, simple and composite hypotheses, null and alternative hypotheses, type I and type II errors,		

		critical region, level of significance, power of test. Most powerful tests uniformly most powerful test, Neyman Pearson Lemma Problems using R/Python		
II	Sufficient statistics and minimum variance unbiased estimators		12	15
	1	Sufficient statistics, Factorization theorem for sufficiency, Joint sufficient statistics		
	2	Exponential family, Pitman family, Minimal sufficient statistics (MSS). Criteria to find the MSS, Ancillary statistics, Complete statistics		
	3	Basu's theorem		
	4	Unbiasedness, Best Linear Unbiased estimator(BLUE), Minimum variance unbiased estimator(MVUE)		
	5	Rao-Blackwell theorem		
	6	Lehman-Scheffe theorem		
	7	Necessary and sufficient condition for MVUE, Fisher Information, Cramer Rao inequality and its applications		
III	Consistent asymptotically normal estimators and Interval Estimation		12	20
	8	Consistent estimator, Invariance property of consistent estimator		
	9	Method of moments-method of percentiles to determine consistent estimators, choosing between Consistent estimators		
	10	CAN estimators		
	11	Definition of Interval estimation, Shortest expected length confidence interval-large sample confidence intervals-unbiased confidence intervals-examples		
	12	Bayesian and Fiducial intervals		
IV	UMP tests		11	20
	13	One-sided UMP tests, two- sided UMP tests and UMP unbiased tests		
	14	UMP tests for multi-parameter case: UMP unbiased test		
	15	α -similar tests and α -similar tests with Neyman structure, construction of α -similar tests with Neyman structure		
	16	Principle of invariance in testing of hypotheses, locally most powerful tests		
	17	Likelihood ratio tests		
	18	Bayesian tests		
V	Sequential Tests		10	15
	19	Some fundamental ideas of sequential sampling – Sequential Probability Ratio Test (SPRT)		
	20	Important properties, termination of SPRT – the fundamental identity of SPRT		
	21	Operating Characteristic (OC) function and Average Sample Number (ASN) of SPRT		
	22	Developing SPRT for different problems		

Text Books

1. **Kale, B.K . and Muraleedharan K.(2015)** Parametric Inference : An Introduction, Alpha Science Intl Ltd.
2. **George Casella and Roger L Berger (2002)**. Statistical inference, Second Edition, Duxbury, Australia.
3. **Manojkumar Srivastava and Namita Srivastava(2009)**. Statistical Inference: Testing of Hypothesis, Eastern Economy Edition, PHI Learning Pvt. Ltd., New Delhi.
4. **Rohatgi, V.K(1976)**. An introduction to Probability Theory and Mathematical Statistics, John Wiley and sons, New York.

References

1. **Lehmann, E.L(1983)**. Theory of point estimation, John Wiley and sons, New York.
2. **Rohatgi, V.K (1984)**. Statistical Inference, John Wiley and sons, New York.
3. **Rao, C.R (2002)**. Linear Statistical Inference and its applications, Second Edition, JohnWiley and sons, New York.
4. **Lehman, E.L. and Romano, Joseph P.(2005)**. Testing Statistical Hypotheses. Third Edition, Springer, New- York.

SEMESTER VIII

Programme	B. Sc. STATISTICS
Course Code	STA 8 CJ 406 (P)
Course Title	APPLIED STOCHASTIC PROCESSES AND TIME SERIES ANALYSIS
Type of Course	Major
Semester	VIII

Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practicum per week	Total Hours
	4	3	-	2	75
Pre-requisites	Basic knowledge of Markov chain & general aspects of time series				
Course Summary	Understand queue, renewal process and Brownian process. Thorough knowledge about auto-correlation and autoregressive moving average.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
1.	Discuss the basic characteristic of a queuing system and acquire skills in analyzing queuing models	U	F	Seminar Presentation / Group Tutorial Work
2.	Analyze a network of queues	An	P	Instructor-created exams
3.	Describe the concept of renewal process and Brownian motion	U	F	Instructor-created exams
4.	Describe the basics of time series data, its auto-covariance, auto-correlation and autoregressive moving average	U	F	Instructor-created exams / Home Assignments
5.	Learn to validate a model using residual analysis	An	P	Home Assignment
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (45 +30)	Marks (70)
I	Continuous time Markov chains and Queueing theory.		14	20
	1	Continuous Time Markov Chains		
	2	Pure birth process, Yule furry process, Pure death process, Birth and Death Processes, The transition probability function, Limiting		

		probabilities		
	3	Introduction to queueing theory, Steady state probabilities.		
	4	Exponential Models: A single server Exponential queueing system, A single server Exponential queueing system having finite capacity, Birth and Death queueing models		
	5	Network of queues: Open systems, Closed systems		
	6	Non Markovian queueing models: M/G/1 and G/M/1		
II		Renewal process and Brownian motion	9	15
	7	Renewal processes, renewal function and renewal density, renewal equation, stopping time		
	8	Wald's equation, limit theorems and their applications.		
	9	Brownian motion-Definition, limiting form of random walk, examples.		
	10	White noise, Gaussian process		
	11	Strictly stationary and weakly stationary processes (Definition and examples)		
	12	Branching process (Concept only)		
III		Time series and stationary process	12	20
	13	Time series as a discrete parameter stochastic process		
	14	Auto – Covariance, Auto- Correlation		
	15	Autoregressive, Moving Average, Autoregressive Moving Average and Autoregressive Integrated Moving Average Models		
	16	Choice of AR / MA periods		
	17	Introduction to non-linear time Series: ARCH and GARCH models		
IV		Estimation of ARMA models, ..	10	15
	18	Yule – Walker estimation for AR Processes		
	19	Maximum likelihood and least squares estimation for ARMA Processes		
	20	Discussion (without proof) of estimation of mean, Auto-covariance and auto-correlation function under large samples theory		
	21	Residual analysis and diagnostic checking		
	22	Forecasting using ARIMA models		
V		Open Ended	30	
		Problems, examples and analysis of dataset using software		

Text Books

1. Ross, S.M. (2007). Introduction to Probability Models. IXth Edition, Academic Press.
2. Medhi, J. (1996). Stochastic Processes. Second Editions. New Age International

3. **Box G.E.P and Jenkins G.M. (1994).** Time Series Analysis, Forecasting and Control. Holden-Day
4. **Brockwell P.J. and Davis R.A. (2006).** Time Series: Theory and Methods, Springer – Verlag.
5. **Abraham B and Ledolter J.C. (1983).** Statistical Methods for Forecasting, Wiley
6. **Robert H Shumway and Davis S Stoffer (2016).** Time series analysis and its applications with R examples. Springer.

References

1. **Karlin, S. and Taylor, H.M. (1975).** A First Course in Stochastic Processes, Second Edition, Academic Press.
2. **Cinlar, E. (1975).** Introduction to Stochastic Processes. Prentice Hall. New Jersey.
3. **Basu, A.K. (2003).** Introduction to Stochastic Processes. Narosa, New-Delhi
4. **Anderson T.W (1971).** The Statistical Analysis of Time Series, Wiley.
5. **Fuller W.A. (1978).** Introduction to Statistical Time Series, John Wiley
6. **William W. S. Wei (2006).** Time Series Analysis: Univariate and Multivariate Methods. Pearson. Addison Wesley.

Programme	B. Sc. STATISTICS
Course Code	STA 8 CJ 407
Course Title	APPLIED MULTIVARIATE TECHNIQUES
Type of Course	Major
Semester	VIII
Academic	400-499

Level					
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	1. Good knowledge of Multivariate Normal distribution. 2. Programming skill using R.				
Course Summary	The main objective of this course are to : 1. Inculcate deep knowledge on various multivariate techniques. 2. Develop clear idea on when and where to use dependence and interdependence multivariate methods. 3. Bridge the relation between multivariate analysis using software, to strengthen statistical applications in diversified spectrum of life.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
1.	Analysing Multivariate data using reduction techniques like Principal Component Analysis, Factor Analysis and Canonical correlation.	An	P	Seminar Presentation /
2.	Formulate multivariate hypothesis tests and drawing appropriate conclusions	C	M	Instructor-created exams
3.	Discriminate multivariate normal population.	E	C	Group Tutorial Work
4.	Identify data reduction techniques	U	C	Home Assignments
5.	Analyse multivariate data using statistical software's.	An	P	Practical Skill
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (60)	Marks (70)
I	Principle Component- Factor Analysis-Canonical correlation		16	20
	1	Principle component		
	2	Maximum likelihood estimates of the principal components and		

		their variance		
	3	Extraction of Principal Components and their variances		
	4	Factor Analysis – Mathematical model –Estimation of Factor Loading		
	5	Canonical correlation – Estimation of canonical correlation and variates		
	6	Structural equation models.		
II	Classification Problems		15	20
	7	Classification problems		
	8	Classification into one of two population (known and unknown dispersion matrix)		
	9	Classification in to one of several populations		
	10	Multivariate analysis of variance (MANOVA) – One way and two way classification		
	11	Tests independence of sets of variables		
	12	Equality of dispersion matrices and Sphericity test.		
III	Discriminant Analysis		9	15
	13	Discriminant Analysis		
	14	Likelihood ratio method		
	15	Bayes and min-max procedure		
	16	Discrimination between two multivariate normal population with common dispersion		
	17	Sample discriminate function		
	18	Estimation – Fisher’s method for discriminating among several populations.		
IV	Cluster Analysis		8	15
	19	Cluster Analysis		
	20	Proximity measures		
	21	Hierarchical clustering techniques : single, complete and average linkage algorithms.		
	22	Non-hierarchical clustering techniques : K means method.		
V	Open –End		12	
	Problems regarding Module I to IV using Statistical software			

Text Book

1. **Anderson T W (2010)** : An Introduction to Multivariate Statistical Analysis, Wiley Eastern Ltd.
2. **Johnson, R A and Wichern D W (2003)** : Applied Multivariate Statistical Analysis, Prentice-Hall of India Private Ltd., New Delhi.

Reference

1. **Morrison F (2003)** : Multivariate Statistical Methods, Brooks/Cole, 4th Revised edn., McGraw Hill Book Company
2. **Seber G A (2004)** : Multivariate Observations, John Wiley.
3. **Denis, D J (2021)** : Applied Univariate, Bivariate and Multivariate Statistics : Understanding Statistics for Social and Natural Scientists, With Application in SPSS and R, John Wiley & Sons.

Programme	B. Sc. STATISTICS				
Course Code	STA 8 CJ 408				
Course Title	GENERALIZED LINEAR MODELS				
Type of Course	Major				
Semester	VIII				
Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	Elementary ideas about linear estimation.				
Course Summary	Understand about generalized linear models.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
1.	Identify the general theory of GLM	U	C	Seminar Presentation /
2.	Describe the use of binary and multinomial Understand and logistic models and apply them for various data sets	R	F	Instructor-created exams
3.	Explain the concepts related to count data GLM and apply them for	Ap	C	Group Tutorial Work

various count data sets.			
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)			

Detailed Syllabus:

Module	Unit	Content	Hrs (60)	Marks (70)
I	Components of a generalized linear model (GLM)		10	15
	1	Random component		
	2	linear predictor, link function		
	3	Quantitative/qualitative explanatory variables and interpreting effects		
	4	Model matrices and model vector spaces		
	5	Identifiability and estimability		
II	Generalized linear models		12	20
	6	Model fitting and inference		
	7	Exponential dispersion family distributions		
	8	Likelihood and asymptotic distributions		
	9	Likelihood-ratio/Wald/Score methods of inference		
	10	Parameters, deviance, model comparison, and model checking		
	11	Goodness of fit		
III	Binary logistic models, nominal responses		10	15
	12	Baseline-category logit models		
	13	Ordinal responses: cumulative logit and probit models		
	14	Probit and complementary log-log models,		
	15	Multinomial response models		
IV	Models for count data		16	20
	16	Poisson GLMs for counts and rates		
	17	Poisson/multinomial models for contingency tables		
	18	Negative Binomial GLMS		
	19	Models for zero-inflated data		
	20	Quasi-likelihood methods		
	21	Variance inflation for over dispersed Poisson and Binomial GLMs		
	22	Beta-Binomial models and Quasi-likelihood alternatives		
	23	Quasi-likelihood and model misspecification		
V	Open –Ended		12	
	Model building and validation in practical situations using R software			

Reference

1. Agresti, A. (2015). Foundations of Linear and Generalized Linear Models, Wiley
2. Dobson, A. J. (2002). An Introduction to Generalized Linear Models, 2nd Ed. Chapman & Hall

3. **Jiang, J. (2007)**. Linear and Generalized Linear Mixed Models and their Applications, Springer
4. **Jong, P. and Heller, G. Z. (2008)** Generalized Linear Models for Insurance Data, Cambridge University Press.
5. **Lindsey, J. K. (1997)**. Applying Generalized Linear Models, Springer
6. **McCullagh, P. and Nelder, J. A. (1989)**. Generalized Linear Models, Chapman & Hall
7. **McCulloch, C. E. and Searle, S. R. (2001)**. Generalized, Linear and Mixed Models, Wiley
8. **Stroup, W. W. (2013)**. Generalized Linear Mixed Models, Modern Concepts, Methods and Applications, CRC Press

Programme	B. Sc. STATISTICS				
Course Code	STA 8 CJ 489				
Course Title	RESEARCH METHODOLOGY				
Type of Course	Major				
Semester	VIII				
Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	Basic knowledge of typesetting & publishing				
Course Summary	To understand the concept of Research, presentation & Publication.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
1.	Identify the Concept of Research in Statistics, Selection of Topics, Perform Literature Review	U	F	Seminar Presentation /
2.	Express Scientific Word Processing with LaTeX and MS-Word	U	F	Instructor-created exams
3.	Develop Simulation.	Ap	C	Group Tutorial Work

4.	Compute Computer Oriented Numerical Methods	Ap	C	Home Assignments
5.	Describe Plagiarism	U	F	Practical Assignment
6.	Write Thesis	Ap	P	Observation of Practical Skills
* - Remember (R), Understand (U), Apply (Ap), Analyze (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (60)	Marks (70)
I	Introduction to Research Methodology in Statistics		15	20
	1	Meaning of Research, Objectives of Research		
	2	Types of Research- Descriptive Vs. Analytical, Applied Vs Fundamental, Quantitative Vs Qualitative, Conceptual Vs Empirical		
	3	Concept of Research in Statistics-Importance and Need for Research Ethics		
	4	Selection of Topic for Research-Research schedules, Review of Literature and its Use in Designing a Research Work-		
	5	Mode of Literature Survey-Books and Monographs, Journals, Conference Proceedings, Abstracting and Indexing Journals, E-Journals/Books and CD-ROMS-Reports etc.		
	6	Thesis Writing		
	7	Computer Application in Scientific Research-www-Searching Scientific Articles		
	8	Statistical Data Base		
II	Scientific Word Processing with LaTeX and MS-Word		15	20
	9	Article, Thesis Report and Slides Making		
	10	Power Point Features, Slide Preparation		
	11	Statistical Programming with R: Simple Manipulations Using Numbers and Vectors-Objects & Their Attributes		
	12	Arrays and Matrices-Lists and Data Frames-Grouping, Loops and Conditions		
	13	User Defined Functions		
	14	Probability Distributions and Statistical Models in R		
III	Simulation		10	15
	15	Concepts and Advantages of Simulation		
	16	Event Type Simulation		
	17	Random Variable Generation-U(0,1), Exponential, Gamma and Normal Random Variables		
	18	Monte Carlo Integration		
	19	The MCMC Principle		
	20	Algorithms and its Variants, Bootstrap Methods		

IV	Computer Oriented Numerical Methods		8	15
	21	Algorithms for Solving Algebraic and Transcendental Equations		
	22	Numerical Integration		
	23	Matrix operations		
V	Open –Ended		12	
	Solve the problems from Module I to Module IV using software and understand how to check Plagiarism			

References

1. **Anderson, J., Durston, B.H., Pooole, M. (1970)** .Thesis and Assignment Writing. Wiley Eastern. Ltd., New Delhi.4
2. **Beveridge, B. (1979)**. The Art of Scientific Investigation. W.E. Norton & Co., New York.
3. **Braun, J., Duncan, W. and Murdock, J. (2008)**. A First Course in Statistical Programming with R. Cambridge University Press, London.
4. **Chambers, J. (2008)**. Software for Data Analysis: Programming with R. Springer, New York.
5. **Crewley, M.J. (2007)** The R-.Book. John Wiley, New York.
6. **Dalgaard, P.(2008)**. Introductory Statistics with R. Springer Science, New York.
7. **Kothari, C. (2005)**. Research Methodology. New Age International. Publishers, New York.
8. **Lampont, L. (1999)**. LATEX: A Document Preparation System. Addison, Wesley, 2nd edition, New York
9. **Panneerselvam. (2006)**. Research Methodology. Prentice-Hall of India. Pvt.,New Delhi.
10. **Robert, C.P. and Casella, G. (2004)**. Monte Carlo Statistical Methods. Springer Science, New York.
11. **Venkataraman, M.K. (1998)** Numerical Methods in Science and Engineering. The National Publishing Company, Chennai.
12. **Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., (2002)**. An Introduction to Research Methodology, RBSA publishers.

ELECTIVE SEMESTER VIII

Programme	B. Sc. STATISTICS
Course Code	STA8 EJ 411

Course Title	STATISTICAL METHODS FOR MACHINE LEARNING				
Type of Course	Major Elective				
Semester	VIII				
Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	Basic knowledge in Statistics and programming skills in Python				
Course Summary	Understanding Machine learning using Statistics				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
1.	Describe the application of statistical concepts and methods in machine learning	U	F	Seminar Presentation /
2.	Apply various popular machine learning methods to practical situations	Ap	C	Instructor-created exams
3.	Apply the model assessment methods in machine learning techniques	Ap	P	Group Tutorial Work
4.	Connect computing software into machine learning problems	An	P	Home Assignments
5.	Explain basic concepts of Neural Networks in machine learning	U	F	Practical Skill
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (60)	Marks (70)
I	Statistical Learning		10	
	1	Variable types; Predictors, Features, Responses, Quantitative		

		variables, Categorical variables, Ordered categorical variables		
	2	Approaches to prediction; Least squares and nearest neighbors		
	3	Supervised and Unsupervised learning		
	4	Regression and classification problems		
	5	Assessing model accuracy, Mean square error, The bias-variance trade off		
	6	Comparison of linear regression with K-Nearest Neighbors(KNN) regression		
II	Classifications		14	
	7	Classification; concepts and its appropriateness in the case of qualitative responses		
	8	The logistic model		
	9	Linear Discriminant Analysis (LDA) with only one predictor		
	10	Confusion matrix		
	11	Comparison of logistic regression and LDA methods		
	12	Cross validation; Leave-one-out cross validation, K-Fold cross validation		
	13	Decision trees, Regression trees, Classification trees		
	14	Bagging, Random Forests, Boosting.		
III	Support Vector Machines and Clustering		10	
	15	Maximal margin classifier		
	16	Support vector classifier		
	17	Support vector machines		
	18	K-means clustering		
	19	Hierarchical clustering		
IV	Neural Networks		14	
	20	Neural Networks; The Basic Architecture of Neural networks		
	21	The perceptron, Activation and Loss functions		
	22	Multi-Layer Neural Networks		
V	Open –Ended		12	
	Apply machine learning to real-life projects using software packages in R or Python. (Based on reference books)			

Text Book

1. **Hastie, T., Tibshirani, R. and Friedman, J. (2017).**
The Elements of Statistical Learning: Data Mining, Inference and Prediction, 2nd edition. Springer, New York
2. **James, G., Witten, D., Hastie, T. and Tibshirani, R. (2013).** An Introduction to Statistical Learning with Applications in R. Springer, New York
3. **Charu C. Aggarwal (2018).** Neural Networks and Deep Learning: A Textbook, Springer

Reference

1. **Burger, S. V. (2018).** Introduction to Machine Learning with R, O'Reilly Media, Inc.
2. **Avila, J, Hauck. T. (2017).** Scikit-learn Cookbook: Over 80 Recipes for Machine Learning in Python. Packt Publishing, UK

Programme	B. Sc. STATISTICS				
Course Code	STA8 EJ 412				
Course Title	OPERATIONS RESEARCH				
Type of Course	Major Elective				
Semester	VIII				
Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	Good idea about Linear Programming Problems				
Course Summary	Understand advanced models of Linear Programming Problems and Non-Linear Programming Problems.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
1.	Express theoretical knowledge of Simplex method for solving Linear Programming Problems and Expertise with Revised Simplex method and Dual Simplex method.	U	F	Seminar Presentation /
2.	Develop and solve Integer Programming Models.	Ap	C	Instructor-created exams
3.	Identify Classical Optimization techniques and Non- linear Programming techniques.	U	F	Group Tutorial Work
4.	Formulate Network models like PERT and CPM to improve decision making and develop critical thinking objective analysis of decision making.	Ap	C	Home Assignments
5.	Develop and solve Inventory Models and acquire skills in	Ap	C	Practical Skill

	analyzing Queuing Models.			
6.	Estimate the allocation of resources to demand points in the best possible way using various techniques and minimize the cost or time of completion of jobs.	An	P	Observation of Practical Skills
* - Remember (R), Understand (U), Apply (Ap), Analyze (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (60)	Marks (70)
I	Theory of Simplex Method & Revised Simplex Method		12	20
	1	Canonical and Standard form of LP problem		
	2	Canonical and Standard form of LP problem- Reduction of Feasible solution to Basic Feasible solution		
	3	Improving a Basic Feasible Solution-Alternative optimal solutions		
	4	Unbounded Solutions-Unrestricted variables–degeneracy and its Resolution		
	5	Standard forms for Revised Simplex Method- Computational Procedure		
	6	Comparison of Simplex method and Revised Simplex method		
	7	Dual Simplex Method		
II	Integer Linear Programming & Classical Optimization Methods		12	20
	8	Types of Integer Programming Problems-Gomory's all Cutting Plane Method		
	9	Gomory's Mixed Integer Cutting Plane Method		
	10	Branch and Bound Method		
	11	Applications of Zero-One Integer Programming		
	12	Unconstrained Optimization- Optimizing single variable and Multivariable functions		
	13	Constrained Multi Variable Optimization with equality and Inequality constraints		
	14	Lagrange Multipliers Methods		
	15	Kuhn-Tucker Necessary and Sufficient Conditions.		
III	Non-Linear Programming Methods, Quadratic Programming & Dynamic Programming		12	15
	16	The General Non-Linear Programming Problem- Graphical Solution Method		
	17	Quadratic Programming -Kuhn-Tucker Conditions- Wolfe's Modified Simplex Method		
	18	Dynamic Programming -Terminology -Optimal		

		Decision Policy-General Algorithm-		
	19	Dynamic Programming Approach for solving LPP		
IV	Project Management PERT and CPM, Inventory Control Models		12	15
	20	Basic difference between PERT and CPM-Critical Path Analysis		
	21	Estimation of Project completion time- Project Time cost Trade off -Project Crashing -Resource allocation		
	22	Deterministic Inventory Models- EOQ Inventory Models without shortages and with Shortages-		
	23	Probabilistic Models-Newspaper Boy Problem.		
V	Open –Ended		12	
	Sequencing Problem, Replacement and Maintenance Models Simulation Techniques			

Reference

1. **Mital. K. V. and Mohan. C. (1996).** Optimization Methods in Operations Research and Systems Analysis Third Edition, New Age International (Pvt) Ltd., New Delhi.
2. **Taha. H.A. (2007).** Operations Research – An Introduction-Eighth Edn. Pearson Printice Hall, new Jersey.
3. **Sharma J.K. (2003).** Operations Research-Theory and Applications, Macmillan Indian Ltd., New Delhi
4. **Man Mohan, Kanti Swarup and Gupta (1999).** Operations Research, Sulthan Chand & Sons, New Delhi.

Programme	B. Sc. STATISTICS
Course Code	STA 8 EJ 413
Course Title	QUEUEING MODELS
Type of Course	Major Elective
Semester	VIII

Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	Basic knowledge of Markov Chain & Stochastic process				
Course Summary	Detail analysis of Queueing Models				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
1.	Identify basic concepts of queueing theory	U	F	Seminar Presentation
2.	Analyze behaviors of queueing models	An	P	Instructor-created exams
3.	Explain on queueing networks	Ap	F	Group Tutorial Work
4.	Apply queueing models	Ap	F	Home Assignments
5.	Evaluate performance measures	An	P	Practical Skill
6.	Create significance and applications of queueing theory	C	M	Group Tutorial Work

* - Remember (R), Understand (U), Apply (Ap), Analyze (An), Evaluate (E), Create (C)
- Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P)
Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (60)	Marks (70)
I	Queueing Theory		12	20
	1	Introduction to queueing theory, Cost Equations, Steady-State Probabilities		
	2	Characteristics of queueing processes, Measures of effectiveness		
	3	Markovian queueing models		
	4	steady state solutions of the M/M/I model, waiting time distributions		
	5	Little's formula, queues with unlimited service, finite source queues		
II	Transient Behavior		12	15
	6	Transient behavior of M/M/1 queues		
	7	Transient behavior of M/M/∞		
	8	Busy period analysis for M/M/1 and M/M/c models		
	9	Advanced Markovian models		

	10	Bulk input $M^{[X]}$ /M/1 model, Bulk service $M/M^{[Y]}$ /1 model		
	11	Erlangian models, M/Ek/1 and Ek/M/1		
	12	A brief discussion of priority queues		
III	Queueing Networks		12	20
	13	Queueing networks-series queues		
	14	Open Jackson networks		
	15	Closed Jackson network		
	16	Cyclic queues		
	17	Extension of Jackson networks		
	18	Non Jackson networks		
IV	General Queueing Models		12	15
	19	Models with general arrival pattern, The M/G/1 queueing model		
	20	The Pollaczek-khintchine formula, Departure point steady state systems size probabilities, ergodic theory		
	21	Special cases M/Ek/1 and M/D/1, waiting times, busy period analysis, general input and exponential service models,		
	22	Arrival point steady state system size probabilities		
V	Open –Ended		12	
	Problems regarding Module I to Module IV			

Reference

1. **Gross, D. and Harris, C.M.(1985).** Fundamentals of Queuing Theory, 2nd Edition, John Wiley and Sons, new York.
2. **Kleinrock L (1975).** Queuing Systems, Vol. I &Vol 2, John Wiley and Sons, New York.
3. **Ross, S.M. (2007).** Introduction to Probability Models. 9th Edition, Academic Press, New York.
4. **Bose, S.K. (2002).** An Introduction to Queuing Systems, Kluwer Academic/Plenum Publishers, New York.

Programme	B. Sc. STATISTICS
Course Code	STA 8 EJ 414
Course Title	STATISTICAL DECISION THEORY
Type of Course	Major Elective
Semester	VIII

Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	Statistical testing hypothesis, Priori & Posterior probability				
Course Summary	To understand different decision rule using statistics and Bayesian analysis .				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
1.	Explain different loss functions and decision principle	Ap	C	Seminar Presentation /
2.	Describe the use of prior information in decision making.	R	F	Instructor-created exams
3.	Calculate Posterior distribution and check the admissibility of Bayes rules	Ap	C	Group Tutorial Work
4.	Develop general techniques for solving games	Ap	C	Home Assignments

* - Remember (R), Understand (U), Apply (Ap), Analyze (An), Evaluate (E), Create (C)
- Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (60)	Marks (70)
I	Statistical decision Problem		12	15
	1	Decision rule		
	2	Loss-randomized decision rule		
	3	Decision Principle - sufficient statistic and convexity		
	4	Utility and		
	5	Loss-loss functions		
	6	Standard loss functions vector valued loss functions		
II	Prior information		12	20
	7	subjective determination of prior density		
	8	Non-informative priors		
	9	Maximum entropy priors he marginal distribution to determine the prior		
	10	the ML-II approach to prior selection		
	11	Conjugate priors		

III	The posterior distribution		12	20
	12	Bayesian inference		
	13	Bayesian decision theory		
	14	Empirical Bayes analysis		
	15	Hierarchical Bayes analysis		
	16	Bayesian robustness Admissibility of Bayes rules		
IV	Game theory		12	15
	17	Basic concepts		
	18	General techniques for solving games		
	19	Games with finite state of nature		
	20	the supporting and separating hyper plane theorems		
	21	The minimax theorem		
	22	Statistical games		
V	Open –Ended		12	
	Problems regarding Module I to Module IV			

Text Book

Berger, O.J. (1985). Statistical Decision Theory and Bayesian Analysis – Second Edition. Springer, New York.

Reference

1. **Ferguson, T.S. (1967).** Mathematical Statistics-A Decision Theoretic Approach. Academic Press, New York.
2. **Lehman, E.L. (1998).** Theory of Point Estimation-Second Edition. John Wiley, New York.

Programme	B. Sc. STATISTICS
Course Code	STA 8 EJ 415
Course Title	ANALYSIS OF CLINICAL TRIALS
Type of Course	Major Elective
Semester	VIII

Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	Different sampling techniques and design of experiments				
Course Summary	To understand different methods to analyze medical data				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
1.	Appraise the basic concepts of clinical trials	E	P	Seminar Presentation /
2.	Plan and develop the design of clinical trials	An	C	Instructor-created exams
3.	Determine the sample size in clinical trials	Ap	C	Group Tutorial Work
4.	Conduct bioassays and assimilate the concepts of meta-analysis in clinical trials	Ap	C	Home Assignments

* - Remember (R), Understand (U), Apply (Ap), Analyze (An), Evaluate (E), Create (C)
- Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (60)	Marks (70)
I	Basics of Clinical Trials		12	20
	1	Introduction to clinical trials		
	2	The need and ethics of clinical trials, bias and random error in clinical studies		
	3	Protocols, conduct of clinical trials, over view of Phase I-IV trials		
	4	Data management-data definitions, standard operating Procedure		
	5	Informed consent form, case report forms, database design		
	6	Data collection systems for good clinical practice		
II	Design of Clinical Trials		12	15
	7	Design of clinical trials		
	8	Different phases, Comparative and controlled trials, Random allocation, Randomization, response adaptive methods and restricted randomization		
	9	Methods of Blinding, Parallel group designs, Crossover designs, Symmetric designs, Adaptive designs, Group sequential designs		

	10	Zelen's designs, design of bioequivalence trials		
	11	Outcome measures		
III	Sample Size Determination and Testing		12	20
	12	Sample size determination in one and two sample cases		
	13	Comparative trials, activity studies, testing and other purposes		
	14	Unequal sample sizes and case of anova		
	15	Surrogate endpoints-selection and design of trials with surrogate endpoints		
	16	analysis of surrogate end point data		
	17	Reporting and Analysis		
	18	Interpretation of result, multi-center trials		
IV	Meta-Analysis		12	15
	19	Meta-analysis in clinical trials-concept and goals, fixed and random effect approaches		
	20	Bioassay: Direct and indirect assays		
	21	Quantal and quantitative assays		
	22	Parallel line and slope ratio assays, Design of bioassays		
V	Open –Ended		12	
	Problems regarding Module I to Module IV			

Text Book

1. **Friedman, L. M., Furburg, C. D. Demets, L. (1998).** Fundamentals of Clinical Trials, Springer Verlag.
2. **Jennison and Turnbull, B.W. (1999).** Group Sequential Methods with Applications to Clinical Trials, CRC Press.
3. **Kulinskaya, E, Morgeathaler, S and Staudte R G (2008).** Meta-analysis, Wiley.

Reference

1. **Fleiss, J. L. (1989).** The Design and Analysis of Clinical Experiments, Wiley.
2. **Marubeni, E. and M. G. Valsecchi (1994).** Analyzing Survival Data from Clinical Trials and Observational Studies, Wiley and Sons.
3. **Piantadosi S. (1997).** Clinical Trials: A Methodological Perspective. Wiley.
4. **W Rosenberger, J MLachin (2002).** Randomization in Clinical Trials Theory and Practice, Wiley

Programme	B. Sc. STATISTICS
Course Code	STA 8 EJ 416
Course Title	APPLIED ALGORITHMS AND BIG DATA TECHNIQUES
Type of Course	Major Elective

Semester	VIII				
Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	Statistical Machine Learning				
Course Summary	To understand how handle big data using EM algorithm, supervisory and unsupervisory learning				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
1.	Explain the concept of EM clustering algorithms.	U	F	Seminar Presentation /
2.	Understand the classification techniques and the concept of support vector machines	U	F	Instructor-created exams
3.	Explain the basic concepts related to big data	Ap	C	Group Tutorial Work
4.	Illustrate the multidimensional scaling techniques in unsupervised learning	Ap	C	Home Assignments

* - Remember (R), Understand (U), Apply (Ap), Analyze (An), Evaluate (E), Create (C)
- Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P)
Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (60)	Marks (70)
I	EM Algorithm		12	20
	1	Two-Component Mixture Model		
	2	Gaussian Models		
	3	The EM Algorithm in General		
	4	EM as a Maximization–Maximization Procedure		
II	Support Vector Machines		10	15
	5	Maximal Margin Classifier		
	6	Support Vector Classifiers		
	7	Support Vector Machines		
	8	SVMs with More than Two Class- One- Versus-One Classification and One-Versus-All Classification		
III	Big Data		10	15
	9	Definition, Characteristics		
	10	Data Analytics		

	11	General Categories of Data Analytics		
	12	Structured, Unstructured and Semi Structured Data		
	13	Met data		
	14	Big Data Analytics Life Cycle.		
IV	Multi-Dimensional Scaling		16	20
	15	Definition, Perceptual Map		
	16	Decision Frame- work for Perceptual Mapping,		
	17	Non-metric versus Metric methods		
	18	Similarities Data,		
	19	Preferences Data		
	20	Aggregate and Disaggregate Analysis		
	21	De-compositional and Compositional approaches		
	22	Interpreting the MDS results		
V	Open –Ended		12	
	Practical Problems from Module I to Module IV using software's			

Text Books/ References

1. **Hastie, T., Tibshirani, R. and Friedman, J. (2017).** The Elements of Statistical Learning, Data Mining, Inference and Prediction, 2nd edition. Springer, New York.
2. **James, G., Witten, D., Hastie, T. and Tibshirani, R. (2013).** An Introduction to Statistical Learning with Applications in R. Springer, New York.
3. **Erl, T. and Khattak, W. (2016).** Big Data Fundamentals Concepts, Drivers & Techniques. Prentice Hall.
4. **Hair, J. F., Black, W. C., Babin, B. J. and Anderson, R. E. (2009).** Multivariate Data Analysis, 7th edition. Prentice Hall, New York.

Programme	B. Sc. STATISTICS
Course Code	STA 8 EJ 417
Course Title	ADVANCED TRENDS IN STATISTICS

Type of Course	Major Elective				
Semester	VIII				
Academic Level	400-499				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	4	4	-	-	60
Pre-requisites	Thorough knowledge of probability distributions				
Course Summary	To understand Johnson's system of distributions, Burr family of distributions, Infinite divisibility, U-Statistics & Stochastic ordering.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
1.	Discuss the Johnson's S_B system, Johnson's system S_u and Burr family of distributions.	U	F	Seminar Presentation
2.	Identify the general theory of infinite divisibility and its applications	U	F	Instructor-created exams
3.	Explain the concept and properties of U-statistics, and their role in non-parametric modelling	An	P	Group Tutorial Work
4.	Describe various types stochastic order relations between random variables in univariate setup.	U	C	Home Assignments

* - Remember (R), Understand (U), Apply (Ap), Analyze (An), Evaluate (E), Create (C)
- Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)

Detailed Syllabus:

Module	Unit	Content	Hrs (60)	Marks (70)
I	Distribution Theory		12	15
	1	Systems of distributions		
	2	Johnson's S_B system		
	3	Johnson's S_u system		
	4	Burr distributions		
	5	Infinite divisibility of probability distributions- (i) the non-negative integers		
	6	Infinitely divisible distribution on (ii) the non-negative real's		
II	U-Statistics		12	20
	7	Basic description of U-statistics		

	8	Variance and other moments of a U- statistic		
	9	Projection of a U-statistic on the basic observations		
	10	Almost sure behavior of U-statistics		
	11	Asymptotic distribution theory of U-statistics		
	12	Non-parametric density estimation		
III	Univariate stochastic orders		12	20
	13	Usual stochastic order		
	14	Hazard rate order		
	15	Likelihood ratio order		
	16	Convolution order		
	17	Mean residual life orders		
IV	Univariate variability orders		12	15
	18	Convex order, dispersive order,		
	19	Excess wealth order & peakedness order		
	20	Monotone convex and monotone concave orders		
	21	Transform orders: convex, star orders		
	22	Super additive orders		
V	Open –Ended		12	
	Practical applications of the concepts discussed in Module I to Module IV			

References

1. **Laha, R.G. and Rotatgi, V.K. (1979).** Probability Theory. Wiley, New York.
2. **Serfling, R.J.(1980).** Approximation Theorems of Mathematical Statistics (Chapter-5). John Wiley and Sons, Canada.
3. **Stutel, F.W. and van Harn, K. (2004).** Infinite Divisibility of Probability Distributions on the Real Line. Marcel Dekker Inc., New York.
4. **Shaked, M. and Shanthikumar, J. G. (Eds.). (2007).** Stochastic Orders. Springer, New York.

I Semester B.Sc. (CUFYUGP) Degree Examinations October 2024

ASD1CJ101: Descriptive Statistics

(Credits: 4)

Maximum Time: 2 hours

Maximum Marks: 70

Section A

[Answer All. Each question carries 3 marks] (Ceiling: 24 Marks)

1. Distinguish between Primary and Secondary data, providing examples of secondary data.
2. Define Nominal, Ordinal and Ratio scales
3. What are the differences between questionnaire and schedule?
4. Differentiate between simple and weighted mean, providing examples of each.
5. What is coefficient of variation? If arithmetic mean of 20 observations is 10 and its variance is 25, find coefficient of variation
6. Define Skewness and suggest any one measure for skewness
7. Define Kurtosis? Give any measure for kurtosis
8. What is scatter plot. How it is used to interpret relationship between two variables
9. Distinguish partial and multiple correlations
10. When `gplot()` and `ggplot()` are used?

Section B

[Answer All. Each question carries 6 marks] (Ceiling: 36 Marks)

11. Compare and contrast one-dimensional and two-dimensional data presentation methods
12. Explain the construction and interpretation of a box plot, including its use in identifying outliers and visualizing the spread of data
13. What is Quartile? Find Q1, Q2 and Q3 of following data
12, 16, 17, 18, 20, 25, 29, 29, 32, 37, 38, 35, 40, 46
14. Calculate Mean deviation about mean of 8, 24, 12, 16, 10 and 20
- 15 Define Karl Persons coefficient of correlation. Explain how relationships of two variables are interpreted with this
16. Show that correlation coefficient lies between -1 and +1
17. Explain different methods of reading data from database in R
18. Explain visualizing aggregate values with Bar plots and Pie charts

Section C

[Answer any one. Each question carries 10 marks] (1x10=10 marks)

19. Define central and non-central moments and explain their significance in statistics. Also establish relationship between central moments and raw moments
20. Following data indicates marks of Statistics and Computer Science of 10 students, Calculate Spearman's rank correlation and interpret the result

Marks in Stats :	55	60	82	46	57	95	53	78	57	60
Marks in CS :	60	62	70	50	70	90	60	70	62	70

II Semester B.Sc. (CUFYUGP) Degree Examinations October 2024

ASD2CJ102: Probability and Random Variables

(Credits: 4)

Maximum Time: 2 hours

Maximum Marks: 70

Section A

[Answer All. Each question carries 3 marks] (Ceiling: 24 Marks)

1. What is a random experiment, and how does it differ from a deterministic process?
2. Explain the concept of statistical regularity in the context of probability theory.
3. What are the three axioms of probability?
4. What is the probability of 53 Sundays in a leap year?
5. State Baye's Theorem
6. Define probability mass function? What are its properties
7. If a random variablke X has following pmf, find the value of k?
X: 1 2 3 4 5 6 7
P(x): k 2k 2k 3k k² 2k² 7k²+k
8. Define expected value of a random variable
9. If $V(X) = 2$, Obtain $V(3X+5)$
10. Define characteristic function

Section B

[Answer All. Each question carries 6 marks] (Ceiling: 36 Marks)

11. Describe the classical definition of probability
12. State and prove the addition theorem of probability
13. If three coins are tossed simultaneously, find the probability of getting
(a) all are heads (b) getting at least two heads (c) no head
14. State and prove multiplication theorem of probability
15. How does pair-wise independence differ from mutual independence?
16. If

$$f(x) = \begin{cases} x & ; 0 < x < 1 \\ 2 - x & ; 1 < x < 2 \\ 0 & ; \textit{otherwise} \end{cases}$$

is a pdf of X, Find (a) $P(0.5 < x < 1.5)$

(b) $P(x > 1.5)$

17. If X is a continuous r.v with pdf $f(x) = e^{-x}$, $0 < x < \infty$, find the pdf of $Y = 2X + 5$

18. Define moment generating function of a random variable. State its properties

Section C

[Answer any one. Each question carries 10 marks]

(1x10=10 marks)

19. Three persons A, B and C have applied for a job in a private company. The chance of their selections is in the ratio 1 : 2 : 4. The probabilities that A, B and C can introduce changes to improve the profits of the company are 0.8, 0.5 and 0.3, respectively. If the change does not take place, find the probability that it is due to the appointment of C.

20. If $f(x) = 2(1 - x)$; $0 < x < 1$ is the pdf of X. Find mgf of X. Hence find its mean and variance

Programme	B. Sc. Statistics				
Course Code	STA1FM105(1)				
Course Title	Quality Control				
Type of Course	MDC				
Semester	I				
Academic Level	100-199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	3	3	-	-	45
Pre-requisites	HSE level Mathematics Course				
Course Summary	To make students aware of Various Quality or standards in Industrial Production, Detecting, Controlling and Maintaining Quality and Total Quality Management				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Explain notion of Quality of products	U	C	Instructor-created exams / Quiz
CO2	Recall various meaning of Quality and critically evaluate ethical implications of statistical methods aligning with human values.	R	C	Quiz / Instructor-created exams
CO3	Explain causes of variation and Statistical Control and analyze data to help entrepreneurial decisions using critical thinking skills	U	F	Seminar Presentation / Group Tutorial Work/ Instructor-created exams
CO4	Construction of Control Charts and OC curves	Ap	C	Instructor-created exams / Home Assignments

CO5	Distinguish Process and Product Control	U	F	One Minute Reflection Writing assignments/ Instructor-created exams
CO6	Illustrate measures of central tendency using spread sheet.	Ap	P	Viva Voce/ Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Module	Unit	Content	Hrs (36+9)	Marks (50)
I	Understanding Quality and Sources of Variation		9	15
	1	Meaning of Quality. Various Aspects of Quality.		
	2	Causes of Variation, assessing within and between sample		
	3	variation using Statistical Measures		
	4	Concept of Statistical Quality Control, Process Control and Product Control		
Sections from References:				
II	Quantitative and Qualitative Variables		9	15
	5	Variables and Attributes.		
	6	Concept of Control Charts for Process Control		
	7	Structure of a Control Chart		
	8	Assessment of Statistical control using control charts		
Sections from References:				
III	Construction of Charts		9	10
	9	Construction of \bar{X} (mean) chart		
	10	Construction of R (Range)chart		
	11	Construction of σ (Standard Deviation) chart		
	12	Construction of P (Proportion Defective) chart		
	13	Construction of np (Number of Defectives) chart		
	14	Construction of C (Number of Defects) chart.		
Sections from References:				
IV	Sampling Inspection Plan		9	10
	15	Acceptance Sampling Plan		
	16	Incoming Quality and Outgoing Quality		
	17	Acceptable Quality Level, Rejectable Quality Level, LTPD		
	18	AOQ, AOQL		
	19	Errors in Sampling Inspection Plan Producers and Consumers Risk		
Sections from References:				
V	Open Ended Module: Spread sheet		9	

	1	Exercises to compute Arithmetic Mean, Range, Standard Deviation for a set of data, Basic concepts of Probability		
		Sections from References:		
Books and References:				
1. Statistical Quality Control Khanna Publishers 2. Statistical Quality Control by Douglas C. Montgomery 3. Fundamentals of Applied Statistics by Gupta S C and V. K. Kapoor				

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	2	-	-	-	2	2	1	-	-	-	-
CO 2	2	-	-	-	-	3	2	2	-	-	-	3
CO 3	-	-	3	-	-	2	1	-			3	
CO 4	-	-	2	2	-	-	2		2	3		
CO 5	-	-	2	2	2	-	2	3	2	-	-	-
CO 6	3	2	-	-	-	2	3	-	-	3	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

18. Quiz / Assignment/ Quiz/ Discussion / Seminar
19. Midterm Exam
20. Programming Assignments (20%)
21. Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal	Assignm	Project	End Semester

	Exam	ent	Evaluation	Examinations
CO 1	✓	✓		✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6	✓			

Programme	BSc Statistics				
Course Code	STA1FM105(2)				
Course Title	Fundamentals of Statistics				
Type of Course	MDC				
Semester	I				
Academic Level	100 - 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	3	3	-	-	45
Pre-requisites	Basic mathematical knowledge				
Course Summary	Students will learn about different types of data, scales of measurement, and techniques for representing and summarizing data using measures of central tendency and dispersion, as well as exploring concepts of skewness and kurtosis.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Define statistics and its scope in various fields of study, including its role in decision-making.	U	C	Instructor-created exams / Quiz
CO2	Construct tables and diagrams to organize and summarize data efficiently for analysis and analyze data to help entrepreneurial decisions using critical thinking skills.	Ap	C	Instructor-created exams / Seminar Presentation
CO3	Create various types of diagrams such as bar graphs, pie charts, and histograms for visual representation of	Ap	F	Seminar Presentation / Group Tutorial Work/

	data and critically evaluate ethical implications of statistical methods aligning with human values.			Instructor-created exams
CO4	Compute measures of central tendency including mean, median, and mode to identify typical or central values within a data set.	Ap	C	Instructor-created exams / Home Assignments
CO5	Interpret partition values such as quartiles and percentiles to identify specific data points within a distribution.	U	F	One Minute Reflection Writing assignments/ Instructor-created exams
CO6	Illustrate measures of central tendency and dispersion using spread sheet.	Ap	P	Viva Voce/ Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

COURSE CONTENT

Module	Content	Hours (36+9)	Marks (50)
1	Introduction to Statistics	8	10
	1 Definition of Statistics	1	
	2 Scope of Statistics	2	
	3 Concepts of statistical population and sample	2	
	4 Collection of data	3	
	Sections from References: Unit 1: 1.1&1.2 [Ref 1] Unit 2: 1.3 [Ref 1] Unit 3: 1.3 [Ref 2] Unit 4: 1.4 [Ref 2]		
2	Organizing and Graphing Data	12	15
	5 Types of data	3	
	6 Scale of measurements	2	
	7 Classification of data	2	
	8 Tabulation of data	2	
	9 Diagrammatic representation of data	3	

	Sections from References: Unit 5: 2.1 [Ref 2] Unit 6: 2.1 [Ref 1] Unit 7: 2.1[Ref 1] Unit 8: 2.3[Ref 2] Unit 9: 2.2 [Ref 1 and 2]		
3	Measures of Central Tendency & Dispersion	11	15
	10 Arithmetic Mean	2	
	11 Geometric Mean	1	
	12 Harmonic Mean	1	
	13 Median & Mode	2	
	14 Measures of Dispersion - Definition	1	
	15 Absolute Measures of Dispersion	4	
	Sections from References: Unit 10: 2.3, 2.4 & 2.5 [Ref 1] Unit 11: 2.8 [Ref 1] Unit 12: 2.9[Ref 1] Unit 13: 2.6 & 2.7[Ref 1] Unit 14: 3.1 [Ref 1] Unit 15: 3.4,3.5,3.6, & 3.7 [Ref 1]		
4	Skewness & Kurtosis	5	10
	16 Partition values	3	
	17 Skewness	1	
	18 Kurtosis	1	
	Sections from References: Unit 16: 2.11 [Ref 1] Unit 17: 3.13 [Ref 1] Unit 18: 3.14[Ref 1]		
5	Open ended: practical problems Using Spreadsheet	9	
1	Frequency distributions for organizing and summarizing data	3	
2	Measures of Central Tendency	3	
3	Measures of Dispersion	3	
	Sections from References: Unit 1: 2.1Ref [3] Unit 2: 2.2 Ref [3] Unit 3: 3.2 Ref [3]		
	Books and References:		

	<ul style="list-style-type: none"> ▪ Gupta, S. C. and Kapoor, V. K. (2002). Fundamentals of Mathematical Statistics. , 11th edition, Sulthan Chand, New Delhi. ▪ Prem. S. Mann (2010). Introductory Statistics, 7th edition, Wiley ▪ Mario F Triola, Elementary Statistics using Excel, (2018), 6th edition. 		
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Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	-	-	1	-	2	-	2	1	-	-	-	-
CO 2	2	2	-	-	-	2	2	2	-	-	-	3
CO 3	-	-	3	-	-	-	1	-	-	-	3	-
CO 4	2	2	3	-	3	2	2	-	2	3	-	-
CO 5	-	2	-	2	2	3	2	3	2	-	-	-
CO 6	3	2	-	-	-	3	3	-	-	3	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

6. Quiz / Assignment/ Quiz/ Discussion / Seminar
7. Midterm Exam
8. Programming Assignments (20%)
9. Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations	
CO 1	✓			✓	
CO 2	✓	✓		✓	
CO 3	✓	✓		✓	
CO 4		✓		✓	
CO 5		✓		✓	
CO 6	✓				
Programme	B. Sc. Statistics				
Course Code	STA2FM106(1)				
Course Title	Managerial Decision Making				
Type of Course	MDC				
Semester	II				
Academic Level	100-199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	3	3	-	-	45
Pre-requisites	HSE level Mathematics Course				
Course Summary	To make students aware of importance of managerial decisions and the use of Statistical theories in developing scientific decisions				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Explain various decision making environments in management	U	C	Instructor-created exams / Quiz/ Seminar presentation
CO2	Discuss the outcome of any payoff	R	F	Practical Assignment / Instructor-created exams
CO3	Assessing the purpose of Inventory for smooth Business operations and critically evaluate ethical implications of statistical methods aligning with human values.	U	C	Seminar Presentation / Group Tutorial Work/ Instructor-created exams
CO4	Explain the simulation of a real system	U	C	Instructor-created exams / Home Assignments

CO5	Describe the role of game theory in business and analyze data to help entrepreneurial decisions using critical thinking skills	U	F	One Minute Reflection Writing assignments/ Instructor-created exams
CO6	Define probability and discuss expected values.	R	F	Viva Voce/ Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Module	Unit	Content	Hrs (36+9)	Marks (50)
I	Concepts of Decision Making		9	
	1	Environment Uncertainty and Conflict		
	2	Decision Alternatives		
	3	States of Nature		
	4	Pay Off		
	5	Computation of Expected Monetary Value		
Sections from References:				
II	Inventory		9	
	5	Inventory Management.		
	6	Need and necessity of Inventory		
	7	Parameters of Inventory management.		
	8	Economic Order Quantity with and without lead time		
Sections from References:				
III	Simulation of Inventory		9	
	9	Simulation		
	10	Monte Carlo Method		
	11	Use of simulation in Inventory		
	12	Game theory		
	13	Strategy, Pay off, Pay off matrix,		
	14	Pure and Mixed strategies, Value of game		
Sections from References:				
IV	Solving games		9	
	15	Minmax and Maxmin Criteria		
	16	Saddle Point and solution		
	17	Principle of Dominance		
	18	Solving 2x2 games		
	19	Graphical solution of 2xn and nx2 games		
Sections from References:				
V	Open Ended Module		9	
	1	Basics of Matrices, Scalar and Vector multiplication, Concepts of Probability and Expected Value of Variables		

Sections from References:		
Books and References: 1. Operations Research V K Kapoor Sultan Chand & Sons 2. Operations Research Kanti Swarup		

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	3	-	2	2	3	3	-	3	-	2	2
CO 2	3	-	-	-	-	-	2	-	-	-	-	2
CO 3	-	-	2	-	-	2	2	2	-	-	3	-
CO 4	-	-	3	-	-	2	2	2	-	-	3	3
CO 5	-	-	3	-	-	2	1	-	-	2	3	2
CO 6	3	2	-	-	-	3	3	3	-	-	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

6. Quiz / Assignment/ Quiz/ Discussion / Seminar
7. Midterm Exam
8. Programming Assignments (20%)
9. Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations	
CO 1	✓	✓		✓	
CO 2	✓			✓	
CO 3	✓			✓	
CO 4		✓		✓	
CO 5		✓		✓	
CO 6	✓				
Programme	BSc Statistics				
Course Code	STA2FM106(2)				
Course Title	Statistical Sampling and Probability Theory				
Type of Course	MDC				
Semester	II				
Academic Level	100 - 199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	3	3	-	-	45
Pre-requisites					
Course Summary	Students will learn a comprehensive understanding of fundamental concepts in statistics, including data, variables, attributes, and methods of data collection and explore various types of sampling methods and understand the basics of probability theory.				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Define and differentiate between data, variables, and attributes, and understand their role in statistical analysis.	U	C	Instructor-created exams / Quiz
CO2	Demonstrate proficiency in preparing questionnaires for data collection, considering factors such as clarity, relevance, and reliability and critically evaluate ethical implications of statistical methods aligning with	U	F	Seminar Presentation / Instructor-created exams

	human values..			
CO3	Identify and describe different types of sampling methods, including simple random sampling, stratified random sampling, systematic sampling, and cluster sampling and analyze data to help entrepreneurial decisions using critical thinking skills.	R	C	Seminar Presentation / Group Tutorial Work/ Instructor-created exams
CO4	Define random experiment, sample space, and event, and understand their relevance in probability theory.	U	C	Instructor-created exams / Home Assignments
CO5	Define probability and understand its interpretation as a measure of uncertainty.	U	F	One Minute Reflection Writing assignments/ Instructor-created exams
CO6	Represent how to list different types of data using any software	Ap	P	Viva Voce/ Instructor-created exams
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

COURSE CONTENT

Module	Content	Hours (36+9)	Marks (50)
	Basic Statistics	10	10
1	1 Data	2	
	2 Variables and Attributes	2	
	3 Definition of Population and Sample	3	
	4 Preparation of questionnaire for data collection	3	
	Sections from References: Unit 1: 2.1 [Ref 2] Unit 2: 1.5[Ref 2] Unit 3: 1.3 [Ref 2] Unit 4: 1 [Ref 2]		
	Census and Sampling	6	10

2	5	Census and Sampling	2	
	6	Principal steps in a sample survey	2	
	7	Types of sampling	1	
	8	Sampling methods	1	
Sections from References: Unit 5: 15.2,15.3,15.6 [Ref 3] Unit 6: 15.8 [Ref 3] Unit 7:15.10[Ref 3] Unit 8:15.10[Ref 3]				
Random Sampling Methods			9	15
3	9	simple random sampling with and without replacement	5	
	10	Stratified random sampling (concept only)	2	
	11	Systematic Sampling (concept only)	1	
	12	Cluster sampling (concept only)	1	
Sections from References: Unit 9:15.11,15.11.1 [Ref 3] Unit 10: 15.12,15.12.1 [Ref 3] Unit 11: 15.13 [Ref 3] Unit 12:A2 [Ref 2]				
Introduction to Probability			11	15
4	13	Random experiment	1	
	14	Sample space	1	
	15	event	2	
	16	Statistical regularity	3	
	17	Definition of Probability	2	
	18	Concept of conditional probability of two events	2	
Sections from References: Unit 13: 4.5.1 Ref [1] Unit 14: 4.5.1 Ref [1] Unit 15: 4.5.2 Ref [1] Unit 16: 4.5 Ref [1] Unit 17: 4.6 Ref [1] Unit 18: 4.6 Ref [1]				
5	Open ended - Practical problems using softwares		9	
	1	Data collection	3	

	2	Sample selection	3	
	3	Probability	3	
	Books and References:			
	6. Gupta, S. C. and Kapoor, V. K. (2002). Fundamentals of Mathematical Statistics. , 11 th edition, Sulthan Chand, New Delhi.			
	7. Prem. S. Mann (2010). Introductory Statistics, 7th edition, Wiley			
	8. Gupta, S. C. (2015). Fundamentals of Statistics, Himalaya Publishing House			

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	3	-	-	-	3	3	3	-	-	-	-
CO 2	2	2	-	-	-	2	2	2	-	-	-	3
CO 3	-	2	3	2	2	3	1	3	2	3	3	-
CO 4	3	2	-	-	-	3	3	3	-	-	-	-
CO 5	-	-	-	-	-	3	2	3	-	-	-	-
CO 6	-	-	3	-	-	-	2	2	-	3	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

10. Quiz / Assignment/ Quiz/ Discussion / Seminar
11. Midterm Exam

12. Programming Assignments (20%)

13. Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓	✓		✓
CO 3	✓	✓		✓
CO 4		✓		✓
CO 5		✓		✓
CO 6	✓			

Programme	B. Sc. Statistics				
Course Code	STA5FS112				
Course Title	Statistical analysis using Python				
Type of Course	SEC				
Semester	V				
Academic Level	100-199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	3	3	-	-	45
Pre-requisites	HSE level Mathematics Course				
Course Summary	To make students aware of Various Quality or standards in Industrial Production, Detecting, Controlling and Maintaining Quality and Total Quality Management				

Course Outcomes (CO):

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Explain the basics of Python programming language and its syntax.	U	F	Instructor-created exams / Quiz
CO2	Identify common types of errors and their underlying causes such as incorrect syntax, invalid variable assignments, and type mismatches.	R	C	Instructor-created exams / Home Assignments/ Seminar Presentation

CO3	Describe the fundamental data structures in Pandas and their role in data manipulation and analyze data to help entrepreneurial decisions using critical thinking skills.	U	F	Instructor-created exams / Home Assignments/ Seminar Presentation
CO4	Familiarize themselves with popular data visualization libraries in Python and critically evaluate ethical implications of statistical methods aligning with human values.	R	C	Instructor-created exams / Quiz
CO5	Discuss the importance of random number generation in computational simulations and statistical analysis.	U	F	Instructor-created exams / Quiz/ Viva-Voce
CO6	Apply the basic concepts and principles of machine learning.	Ap	P	Instructor-created exams / Home Assignments/ Seminar Presentation
<p>* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C)</p> <p># - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)</p>				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I	Introduction to Python Programming		12	
	1	Interactive Python Environment: Jupyter notebooks, basic syntax, interactive shell	2	
	2	Data Fundamentals: Variables, assignments, arithmetic operators, expressions	3	
	3	Program Readability: Comments in code, interpreting error messages	3	
	4	Modular Programming: Importing modules, control flow statements	2	
	5	Function Fundamentals: Built-in and user-defined functions, arguments, return values, formal vs. actual parameters, named arguments	2	
	Sections from References: 2, 3, 5, 6			
II	Data Manipulation with Pandas		10	

	5	Pandas Introduction: Data Series, DataFrames	4	
	6	Data Operations: Importing, manipulating, merging, analyzing, and exporting DataFrames	4	
	7	Descriptive Statistics: Exploratory data analysis techniques	2	
	Sections from References: 1, 3, 7, 11			
III	Data Visualization		8	
	9	Data Visualization Libraries: Matplotlib, Seaborn, Plotly, ggplot, Geoplotlib, Pandas (and potentially others)	2	
	10	Plot-I : Line plot, bar plot, pie chart, box plot, histogram, strip plot, swarm plot,	3	
	11	Plot-II: Scatter plot, heatmap, density plot, cumulative frequencies, error bars	3	
	Sections from References: 1, 4, 9, 10			
IV	Statistical Data Analysis Using statsmodels		18	
	18	Random Number Generation	3	
	19	Correlation	2	
	20	Hypothesis Testing -I: One sample, two sample and paired t test	2	
	21	Hypothesis Testing -II: One way and Two way ANOVA	3	
	22	Hypothesis Testing -III: Non Parametric Tests	3	
		Linear Regression Modeling: Simple and multiple linear regression	3	
		Logistic Regression Models	2	
	Sections from References: 4, 9,10,11			
V	Open Ended Module:		12	
	1	Numerical Methods with NumPy: Efficient arrays and linear algebra operations	4	
	2	Machine Learning Introduction: Fundamentals of machine learning with scikit-learn	4	
	3	Web Data Scraping: Scraping web data using requests and BeautifulSoup	4	
	Sections from References: 7, 9, 11			

Books and References:

- Embarak, D. O., Embarak, & Karkal. (2018). *Data analysis and visualization using python*. Berkeley, CA, USA: Apress.
- Gowrishankar, S., & Veena, A. (2018). *Introduction to Python programming*. Chapman and Hall/CRC.
- Gutttag, J. V. (2016). *Introduction to computation and programming using Python: With application to understanding data*. MIT press.
- Haslwanter, T. (2016). *An introduction to statistics with python. With Applications in the Life Sciences*; Springer International Publishing: Cham, Switzerland.
- Lambert, K. A., & Osborne, M. (2015). *Fundamentals of PYTHON*. Cengage Learning, IE.
- Lutz, M. (2013). *Learning python: Powerful object-oriented programming*. " O'Reilly Media, Inc."
- McKinney, W. (2012). *Python for data analysis: Data wrangling with Pandas, NumPy, and IPython*. " O'Reilly Media, Inc."
- Severance, C. (2016). *Python for everybody: Exploring Data using python 3*. Charles Severance.
- Tattar, P., Ojeda, T., Murphy, S. P., Bengfort, B., & Dasgupta, A. (2017). *Practical Data Science Cookbook*. Packt Publishing Ltd.
- Unpingco, J. (2016). *Python for probability, statistics, and machine learning*. Cham, Switzerland: Springer International Publishing.
- VanderPlas, J. (2016). *Python data science handbook: Essential tools for working with data*. " O'Reilly Media, Inc."

Mapping of COs with PSOs and POs :

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	3	-	-	-	3	3	-	-	-	-	-
CO 2	3	2	-	-	-	3	3	-	-	-	-	-
CO 3	-	-	2	-	-	2	1	-	-	3	3	-
CO 4	2	-	2	-	-	-	2	-	-	3	-	2
CO 5	-	-	2	1	2	-	2	-	1	3	-	-
CO 6	2	2	-	-	-	2	3	-	-	3	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

5. Quiz / Assignment/ Quiz/ Discussion / Seminar
6. Midterm Exam
7. Programming Assignments (20%)
8. Final Exam (70%)

Mapping of COs to Assessment Rubrics :

	Internal	Assignm	Project	End Semester

	Exam	ent	Evaluation	Examinations	
CO 1	✓			✓	
CO 2	✓	✓		✓	
CO 3	✓			✓	
CO 4		✓		✓	
CO 5		✓		✓	
CO 6	✓				
Programme	B. Sc. Statistics				
Course Code	STA6FS113				
Course Title	Basic research methodology				
Type of Course	SEC				
Semester	VI				
Academic Level	100-199				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	3	3	-	-	45
Pre-requisites	HSE level Mathematics Course				
Course Summary	To make students aware of research methodology.				

Course outcome CO

CO	CO Statement	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Identify gaps, contradictions and areas for further exploration within the existing body of literature.	R	F	Instructor-created exams / Quiz
CO2	Ethically and accurately cite article references in accordance with academic integrity standards.	U	C	Instructor-created exams / Home Assignments
CO3	Develop a coherent and logically structured thesis report that adheres to academic conventions and standards.	R	P	Seminar Presentation / Group Tutorial Work

CO4	Construct text, equations, figures, tables and references in accordance with academic standards and publication guidelines and analyze data to help entrepreneurial decisions using critical thinking skills.	U	C	Instructor-created exams / Home Assignments /Seminar Presentation
CO5	Ethically and responsibly apply numerical methods in research, acknowledging limitations and uncertainties.	Ap	F	Seminar Presentation /Quiz
CO6	Identify appropriate case study designs and data collection methods for specific research questions and contexts.	R	P	Seminar Presentation/ Group Tutorial Work
* - Remember (R), Understand (U), Apply (Ap), Analyse (An), Evaluate (E), Create (C) # - Factual Knowledge(F) Conceptual Knowledge (C) Procedural Knowledge (P) Metacognitive Knowledge (M)				

Detailed Syllabus:

Module	Unit	Content	Hrs (48 +12)	Marks (70)
I	Research in Statistics		12	15
	1	Concept of Research in Statistics-Importance and Need for Research Ethics	2	
	2	Selection of Topic for Research-Research schedules	3	
	3	Review of Literature and its Use in Designing a Research Work-	3	
	4	Mode of Literature Survey	2	
	5	Thesis Writing – Computer Application in Scientific Research	2	
	Sections from References:			
II			12	15
	6	Scientific Word Processing with LaTeX	2	
	7	Article, References	2	
	8	Thesis Report and Slide Preparation	2	

	9	Statistical Programming with R: Arrays and Matrices-Lists	2	
	10	Data Frames-Grouping, Loops and Conditions	2	
	11	Probability Distributions and Statistical Models in R.	2	
	Sections from References:			
III			15	25
	112	Simulation: Concepts and Advantages of Simulation-	2	
	13	Event Type Simulation- Random Variable Generation-U(0,1)	2	
	14	Exponential, Gamma and Normal Random Variables – Monte Carlo Integration.	3	
	15	The MCMC Principle,	3	
	16	Algorithms and its Variants	2	
	17	Bootstrap Methods.	3	
	Sections from References:			
IV			9	15
	18	Computer Oriented Numerical Methods	2	
	19	Algorithms for Solving Algebraic Equations	2	
	20	Algorithms for Solving Transcendental Equations	1	
	21	Numerical Integration	2	
	22	Matrix operations.	2	
	Sections from References:			
V	Open Ended Module:		12	
	1	Analysis of a case study	12	
	Sections from References:			

Books and References:

7. Anderson, J., Durston, B.H., Poole, M. (1970) Thesis and Assignment Writing. Wiley Eastern. Ltd., New Delhi.
8. Beveridge, B. (1979) The Art of Scientific Investigation. W.E. Norton & Co., New York. Braun, J., Duncan, W. and Murdock, J. (2008) A First Course in Statistical Programming with R. Cambridge University Press, London.
9. Chambers, J. (2008) Software for Data Analysis: Programming with R. Springer, New York.
10. Crewley, M.J. (2007) The R-Book. John Wiley, New York.
11. Dalgaard, P.(2008) Introductory Statistics with R. Springer Science, New York.
12. Ghosh, J.K., Mitra, S.K. and Parthasarathy, K. R.(1992) Glimpses of India's Statistical Heritage. Wiley Eastern Limited, New Delhi.
13. Hald, A.(1998) A History of Mathematical Statistics from 1750 to 1930. John Wiley & Sons, New York.
14. Kantiswarup, S., Gupta P.K. and Man Mohan (2008) Operations Research. Sultan Chand & Sons, New Delhi.
15. Kothari, C. (2005) Research Methodology. New Age International. Publishers, New York.
16. Lamport, L. (1999) LATEX: A Document Preparation System. Addison, nd Wesley, 2
17. Pannerselvan,R. (2006) Research Methodology. Prentice-Hall of India. Pvt., NewDelhi.
18. Robert, C.P. and Casella, G. (2004) Monte Carlo Statistical Methods. Springer Science, New York.
19. Venkataraman, M.K. (1998) Numerical Methods in Science and Engineering. The National Publishing Company, Chennai.

Mapping of COs with PSOs and POs:

	PSO 1	PSO 2	PSO 3	PSO4	PSO 5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	2	3	-	-	-	2	2	3	-	-	-	-
CO 2	-	-	2	-	-	-	-	-	-	3	-	2
CO 3	-	2	-	3	2	3	1	2	3	-	-	-
CO 4	3	2	2	-	-	3	3	1	-	3	3	-
CO 5	2	-	2	-	-	-	1	-	-	3	-	3
CO 6	-	-	3	-	-	2	1	2	-	3	-	-

Correlation Levels:

Level	Correlation
-	Nil
1	Slightly / Low
2	Moderate / Medium
3	Substantial / High

Assessment Rubrics:

4. Quiz / Assignment/ Quiz/ Discussion / Seminar
5. Midterm Exam
6. Programming Assignments (20%)
7. Final Exam (70%)

Mapping of COs to Assessment Rubrics:

	Internal Exam	Assignment	Project Evaluation	End Semester Examinations
CO 1	✓			✓
CO 2	✓			✓
CO 3	✓			✓
CO 4		✓		✓
CO 5		✓		✓
CO 6			✓	

