KANNUR UNIVERSITY
കണ്ണൂർ സർവകലാശാല

(Abstract)

Five Year Integrated Masters Programme (FYIMP) in Mathematical Sciences offered by the Department of Statistical Sciences/Mathematical Sciences, Kannur University, Mangattuparamba Campus - Scheme and Syllabus -Approved and Implemented w e f the academic year 2025-26 - Orders issued.

ACADEMIC C SECTION

ACAD C/ACAD C3/20400/2025 Dated: 13.10.2025

Read:-1. U O No ACAD D/ACAD D5/23315/2023(I) dated 22.02.2025.

2. Circular No ACAD C/ACAD C3/12564/2023 dated 05.03.2025

3. E mail dated 19.09.2025 from the Head, Dept. of Mathematics /Statistics .

4. E mail dated 26.09.2025 from the Dean ,Faculty Of Science ,Kannur University

5.Minutes of Standing Committee on Academic Council held on 29.09.2025

6.Orders of Vice Chancellor in file No. Acad C/AcadC3/20400/2025 dated 13.10.2025

ORDER

1) The proposals to start 12 Five Year Integrated Masters Programmes and 3 Integrated Teacher Education Programmes at the Teaching Departments and Centres of the University were approved, as per the paper read as (1) above,

2) Subsequently, directions were given to all Heads of the Departments concerned, to submit the entire Syllabus (all semesters) of FYIMP to be offered by their Department w e f the academic year 2025-26 with the minutes of Department Council, vide the paper read (2) above.

3) Accordingly, the Head of the Department, Department of Mathematics /Statistics , vide the paper read (3) above, submitted the Scheme and Syllabus of FYIMP Mathematical Science Programme , along with the Minutes of the meeting of the Joint Council , for approval and implementation w e f the Academic year-2025 -26 .

4)The Scheme and Syllabus, submitted by the Head of the Department ,Department of Statistical Sciences/Mathematical Sciences, Kannur University, Mangattuparamba Campus were forwarded to the Dean, Faculty Science for verification and remarks.

5) The Dean, Faculty of Science (vide paper read 4), offered remarks on the full syllabus of the Five-Year Integrated Master's Programme in Mathematical Science offered by Department of Statistical Sciences/Mathematical Sciences, Kannur University, Mangattuparamba Campus

6) After considering the matter, the Vice Chancellor has ordered to place the Scheme and Syllabus of FYIMP in Mathematical Science before Standing Committee of the Academic Council for consideration.

7)The Standing Committee of the Academic Council, vide the paper read (5) above, recommended to approve the Scheme and Syllabus of FYIMP in Mathematical Sciences , for implementation w e f the Academic year-2025 -26.

8)The Vice Chancellor after considering the recommendation of the Standing Committee on Academic Council and in exercise of the powers of the Academic Council conferred under Section

11(1) Chapter III of the Kannur University Act, 1996 and all other enabling provisions read together with, approved the Scheme and Syllabus of the Five Year Integrated Masters Programme in Mathematical Sciences at the Department of Statistical Sciences/Mathematical Sciences, Kannur University, Mangattuparamba Campus and accorded sanction to implement the same w.e.f. 2025-26 academic year subject to report to the Academic Council.

9) The approved Scheme and syllabus of FYIMP in Mathematical Sciences offered by the Department of Statistical Sciences/Mathematical Sciences, Kannur University, Mangattuparamba Campus is attached with this U.O. and uploaded in the website of the University (www.kannuruniv.ac. in)

10)Orders are issued accordingly.

Sd/-

Bindu K P G

DEPUTY REGISTRAR (ACADEMIC)

For REGISTRAR

To: 1. The Controller of Examination (Through PA to CE)

2. The Head Dept., Department of Statistical Sciences/Mathematical Sciences, Kannur University, Mangattuparamba Campus

Copy To: 1.Computer programmer

2.PS to VC/ PA to R

3.DR/AR(Acad), EXCI, EP IV

4.IT Cell (for uploading on the website)

5.JR II Exam

6.SF/DF/FC

Forwarded / By Order

SECTION OFFICER

DEPARTMENT OF MATHEMATICAL SCIENCES

DEPARTMENT OF STATISTICAL SCIENCES

KANNUR UNIVERSITY

DEGREE OF

FIVE YEAR INTEGRATED MASTERS PROGRAMME IN MATHEMATICAL SCIENCES

(CHOICE BASED CREDIT AND SEMESTER SYSTEM)

SCHEME& SYLLABUS

(FOR THE STUDENTS ADMITTED FROM THE ACADEMIC YEAR 2025 – 26 ONWARDS)

SCHEME AND SYLLABUS FOR THE DEGREE OF

MSC MATHEMATICAL SCIENCES

FOR THE STUDENTS ADMITTED FROM THE ACADEMIC YEAR 2025 – 26 ONWARDS

1 PROGRAMME SPECIFIC OUTCOMES

SL #	Outcome
PSO1	Familiar with the enhanced concepts of Computational Sciences
PSO2	Attain skills to address research problems in computational science discipline
PSO3	Equip the student to attain the skill required for Industry and academia
PSO4	Enhance the knowledge about emerging topics in Science and Technology and their applications
PSO5	Promote multidisciplinary research and development activities

DEFINITIONS

- Department / School is the department / school established in the Kannur University as per the statute of Kannur University.
- Academic programme is an entire course of study comprising the details such as the programme structure, course details, and evaluation schemes designed to be taught and evaluated in the teaching department / centre or jointly under more than one such department / centre.
- Course is a segment of a programme limited to one semester subject.
- Programme Structure is a list of courses (Core Courses, Elective Courses, Ability Enhancement Courses, Value Added Courses, Skill Enhancement Courses, and MOOC) that makes up an academic programme, specifying its details such as the syllabus, credits, hours of teaching, evaluation and examination schemes, and the minimum number of credits required for successful completion the programme prepared in conformity with the FYIMP regulations-2024 of Kannur University.
- Discipline Specific Core (DSC) is a course that is to be compulsorily completed by a student admitted to a particular programme to receive the degree and which cannot be substituted by any other course.

- Discipline Specific Elective(DSE) is an optional course to be selected by a student out of such courses offered in the same department or other departments.
- Joint Department Council (JDC), is a council consists of all teaching faculties of Dept. of Information Technology, Dept. of Mathematical Sciences and Dept. of Statistical Sciences.
- Wherever in this document "the University" is mentioned, it should be taken as the Kannur University and wherever "the Department" is mentioned, it should be taken as the department concerned with the respective course is offered.

2 SCOPE

1) This regulations shall apply to FYIMP- MSc Mathematical Sciences with multiple pathways, conducted jointly by two departments, namely The Department of Mathematical Sciences and The Department of Statistical Sciences, Kannur University.

2) Choice Based Credit Semester System presupposes academic autonomy, cafeteria approach in academic environment, semester system, course credits, alphabetical grading, and inter departmental academic collaboration. There shall be a joint department council consisting of all teachers of Department of Mathematical Sciences and Department of Statistical Sciences. The Convenor of joint department council will coordinate the activities of this programme. The convenor will be a permanent faculty from any of the two participating department decided by the JDC. The convenor shall coordinate the admission process to the FYIMP programme offered by the three departments. Records associated with each student should be maintained by the corresponding department based on the pathway courses chosen by the student in addition to the central record keeping facility maintaining for this programme. The major responsibility of convener- JDC will be at the first year of the FYIMP program of every batch of the admission; there after the student will be attached to the department concerned based on the pathway courses opted by the students. Convener of the joint department council will constitute a joint departmental admission committee comprising faculties from Department of Mathematical Sciences and Department of Statistical Sciences to assist them in the admission process. The joint-department council will deliberate on courses and specify the distribution of credits semester wise and course wise. Details such as the number of credits for lectures, tutorials, and practical will also be specified for

each course by the corresponding department council who offer the specified course.

3) The Name of degree awarded when a student take exit at 3^{rd} /4^{th}/5^{th} year is specified in the different pathways mentioned as part of this regulation. "*The Name "Mathematical Sciences" is only for indicating the broad spectrum of programs not for awarding the degree*".

4) All two participating departments (Department of Mathematical Sciences and Department of Statistical Sciences) have equal stake and responsibility for the Five Year Integrated MSc (Mathematical Sciences) Program and unconditional academic and administrative support should be offered by all three participating department irrespective of the number of students who chose the various pathways.

3 Admission

1) Admission to the FYIMP MSc Mathematical Sciences programme will be done as the regulations prescribed by the university from time to time.

Eligibility for Admission:

Basic qualifications: Candidate must possess

1) pass with 50% marks/equivalent grade at 10+2 level science with mathematics programme or 10+2 level commerce with mathematics

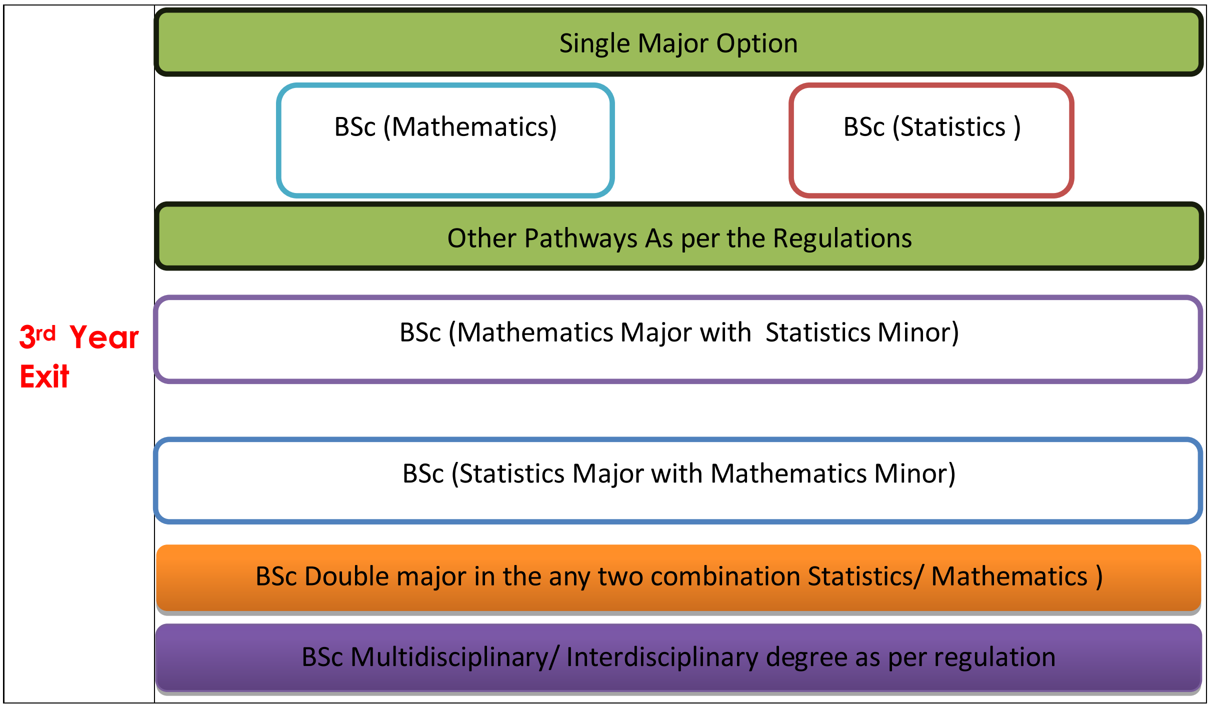
Admission to the FYIMP MSc Mathematical Sciences programmes shall be made purely based on the entrance examination conducted by the University/ or any other way decided by the university time to time. Notification In this regard shall be made well in advance. If the number of candidates admitted based on the entrance examination is less than the sanctioned strength, the department can fill the vacancy by advertising the vacancy through press releases. Admission to these seats should be granted based on the marks obtained by the candidates in the qualifying examination. Reservation norms followed by the university should be adhered to in the admission process.

4 Registration

Since students have flexibility to choose various courses and pathways, every student should register for a course for the next semester by end of the previous semester (except the first semester). Any changes in the selection of the courses are permitted up to the 5 working days of the start date of the new semester. The offering department can decide on the minimum / maximum number of registrations for a course depending on the instructional facilities and teachers availability for the listed courses. While choosing the courses students are advised to discuss with semester coordinator/ faculty advisor and also ensure that, the credit requirement for awarding the degree in various pathways as per FYIMP-2024 regulations are satisfied . Student can register for additional courses including MOOCs from second semester onwards, provided the total number of courses registered for that semester is not more than 30.

5 Programme Structure

1) Duration of the FYIMP Mathematical Sciencesprogramme shall be 5 years, divided into 10 semesters. Each semester shall have 18 weeks. Students can take exit at 3rd / 4th /5th year as mentioned in the FYIMP regulations-2024-25. The Name of the degree awarded to each student will be depending on the pathway courses opted by the students while taking exit at above mentioned years. Different Pathways and corresponding names of degree awarded is mentioned in the below diagram



4^{th} Year Exit	BSc (Hons) (Mathematics) BSc (Hons with Research) (Mathematics) BSc (Hons) (Statistics) BSc (Hons with Research) (Statistics) BSc (Hons) (Biostatistics) BSc (Hons with Research) (Bio statistics)
5^{th} Year Exit	MSc Mathematics MSc Statistics MSc Biostatistics

2) Minimum and maximum duration for completing the courses will be based on the FYIMP-2024 regulations
3) Any degree awarded after securing the minimum required credits for awarding the degree after the 3^{rd} / 4^{th} or 5^{th} year exit will be based on the FYIMP 2024 regulations
4) Upon completion of the 5^{th} year; a student will be awarded MSc (Mathematics or Statistics) if the student completed the requirement of BSc(Hons) (Mathematics or Statistics) and also earned the minimum credit requirement for MSc (Mathematics or Statistics) program along with one course from the department or from SWAYAM/ MOOC platform of minimum 3 credits approved by the department. This credit will not be counted for computing CGPA, However a pass in this course is a must for awarding the MSc (Mathematics or Statistics) falling which MSc (Mathematics or Statistics) will be awarded, provided that the minimal requirement for awarding MSc (Mathematics or Statistics) is acquired by the student. Details of additional credits earned will be listed in the final marks card, issued by the university. Students are permitted to enroll for the additional MOOC at 9^{th} semester itself so that a pass certificate can be submitted by the end of 10^{th} semester.

5) Student who take exit at 4th Year will be awarded BSc (Hon) or BSc (Hon with Research) in Statistics or Biostatistics and exiting at 5th year will be awarded MSc (Statistics) or MSc (Biostatistics) provided the student has earned the required credits form the respective pathways courses prescribed for the programme mentioned.

6 MOOC

In addition to the courses specified as part of the programme, all students should mandatorily complete 2 MOOCs of at least 3 credits to complete the requirements of getting BSc (Hons) degree in any of the discipline. The credits earned will be considered for the computation of GPA and CGPA.

7 EVALUATION

The Continuous and Comprehensive Evaluation (CCE) and the End semester Evaluation (ESE) will be conducted as per the Kannur University FYIMP Regulations- 2024 for all theory and practical courses unless it is specifically mentioned in the respective courses. The ratio of Continuous and Comprehensive Evaluation and End semester Evaluation will be 50:50.

End Semester Evaluation

End semester Evaluation will be conducted as per FYIMP Regulations-2024.

The course for the FYIMP- Mathematical Science programs have either 3 credit or 4 credit courses across various course categories i.e., DSC, DSE,AEC,SEC,VAC,MOOC, Internship. The credit for a given course is typically distributed as follows

Distribution Teaching / Learning hours for 4 Credit Course

1. 4 Credit Lecture session
2. 3 Credit Lecture Sessions and 1 Credit Practical
3. 2 Credit Lecture Session and 2 Credit Practical
4. 1 Credit Lecture Session and 3 Credit Practical
5. 4 Credit Practical Sessions

Similarly Distribution Teaching / Learning hours for 3 Credit Course

1. 3 Credit Lecture session
2. 2 Credit Lecture Sessions and 1 Credit Practical
3. 1 Credit Lecture Session and 2 Credit Practical

4. 3 Credit Practical Sessions

End Semester Examination for all these different combinations are as Follows:

ESE Scheme for 4 Credit courses		
1	4Credit Theory	Theory Examination of 50 marks . Duration of Examination 2 Hours
2	3 credit Lecture and 1 Credit Practical	• ESE(Theory) Maximum marks : 50 marks Duration:2 hours. The obtained Marks will be scaled to 37.5 • ESE(Practical) Maximum marks: 50 marks. Duration : 3 hours. Marks obtained will be scale down to 12.5 • Total marks obtained for the course will be the sum of scaled ESE marks obtained for theory and practical . ie. 50 marks
3	2 credit Lecture and 2 Credit Practical	• ESE(Theory) Maximum marks : 50 marks Duration:2 hours. The obtained Marks will be scaled to 25 • ESE(Practical) Maximum marks: 50 marks. Duration : 3 hours. Marks obtained will be scale down to 25 • Total marks obtained for the course will be the sum of scaled ESE marks obtained for theory and practical . ie. 50 marks
	1 credit Lecture and 3 Credit Practical	• ESE(Theory) Maximum marks : 50 marks Duration:2 hours. The obtained Marks will be scaled to 12.5 • ESE(Practical) Maximum marks: 50 marks. Duration : 3 hours. Marks obtained will be scale down to 37.5 • Total marks obtained for the course will be the sum of scaled ESE marks obtained for theory and practical . ie. 50 marks
	4 Credit Practical	Practical Examination of 50 marks . 3 hours Duration
ESE Scheme for 3 Credit courses (SEC/MDC/VAC) offered Dept. of IT/		

Mathematics / Statistics		
	3 Credit Theory	ESE will be conducted for 50 marks
	2 Credit theory and 1 Credit Practical	ESE (Theory) Max marks : 50; Duration : 2 Hours scaled to 30 marks ESE (Practical) Max marks : 50; Duration 2 Hours scaled to 20 marks Total marks obtained for the course will be the sum of scaled ESE marks obtained for theory and practical . ie. 50 marks
	1 Credit for Theory and 2 Credit for Practical	ESE (Theory) Max marks : 50; Duration : 2 Hours scaled to 20 marks ESE (Practical) Max marks : 50; Duration 2 Hours scaled to 30 marks Total marks obtained for the course will be the sum of scaled ESE marks obtained for theory and practical . ie. 50 marks
	3 Credit Practical	ESE will be conducted for 50 marks

If any changes in the evaluation Pattern for any courses it can be mentioned in the assessment rubrics of the corresponding course. Otherwise it will be followed the above rubrics corresponding to their credit.

Continuous and Comprehensive Evaluation (CCE).

CCE for all courses shall follow the FYIMP- Mathematical Sciences -Scheme and syllabus -2025 unless it is specifically mentioned in the course syllabus. Where ever there is a practical component associated with a course; Lab test will be conducted as part of CCE, in addition to the other evaluation methods mentioned in FYIMP-Regulations 2024 for CCE. The division of CCE marks for different courses structure shall be as follows.

Course structure	Continuous Assessment

4 Credit course	**Total Marks : 50** • Test paper 1 : 15 • Test Paper 2: 15 • Assignment : 10 • Seminar /Viva : 10
4 Credit course (3 Lecture+ 1 Lab)	**Total Marks : 50** • Test 1 : 10 • Test 2 : 10 • Lab Test and viva : 15 • Record : 5 • Assignments/case study/ seminar : 10
4 Credit (2 Credit Lecture and + 2 Credit Practical)	**Total Marks : 50** • Test 1 : 10 • Test 2 : 10 • Lab Test and viva : 15 • Record : 5 • Assignments/ case study/ seminar : 10
4 Credit (1 Credit Lecture + 3 Credit Practical)	**Total Marks 50** • Test paper 1 : 5 • Test Paper 2: 5 • Lab test 1 and viva : 10 • Lab Test 2 and viva : 10 • Lab record : 5 • Seminar/ Assignments / Case Study : 15
4 Credit Practical	Total Marks • Lab test 1 and viva : 20 • Lab test 2 and viva : 20 • Record : 10
3 Credit Courses (MDC/SEC/VAC) offered by the IT/Maths/Statistics	

3 credit Lecture	**Total Marks 50** • Test 1 : 15 • Test 2 : 15 • Seminar /Assignment/ Case Study : 20
2 Credit Lecture + 1 Credit practical	**Total Marks 50** • Test 1 : 10 • Test 2 : 10 • Lab test : 15 • Record : 5 • Seminar/Assignment / Case study : 10
1 Credit Lecture and 2 Credit Practical	**Total Marks 50** • Test 1 : 5 • Test 2: 5 • Lab test with Viva : 25 • Record : 5 • Assignment / Case study/ Seminar : 10
3 Credit Lab	**Total Marks 50** • Lab test 1 and viva : 20 • Lab test 2 and viva : 20 • Record : 10

The end semester practical examination will be conducted by a board of examiners constituted by the Head of the department of the course offered. The board of examiners consist of 2 faculty members and one should be the faculty in charge of the respective course. Total minimum requirement for every CCE component for a pass shall follow the minimum requirement mentioned in FYIMP-2024 regulations. If any other mode of assessment is proposed for a specific course; the assessment rubrics should be mentioned in the syllabus separately associated with that course. Otherwise evaluation scheme mentioned in the regulations shall be applicable for both CCE and ESE.

Evaluation criteria for the Research, Internship components will follow the criteria mentioned in FYIMP-2024 regulations.

7 Compliances with FYIMP- Regulations -2024

In general, FYIMP – Mathematical Sciences programs follows the FYIMP-regulations approved by university unless it is specifically mentioned here. Joint department council have a right to revise the scheme and syllabus based on the feedback and input from various stake holders of the program.

MATHEMATICAL SCIENCE COURSES

Semester I

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESE	CCE	T
1.1	100	KU01DSCMAT101	LOGIC AND SET THEORY	4	4	0	1	50	50	100

Semester II

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESE	CCE	T
2.1	100	KU02DSCMAT101	INTRODUCTION TO MATRIX THEORY , PARAMETRIC EQUATIONS AND POLAR CO - ORDINATES	4	4	0	1	50	50	100
2.2	100	KU02DSCMAT102	CALCULUS I	4	4	0	1	50	50	100

Semester III

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
3.1	200	KU03DSCMAT201	CALCULUS II	4	4	0	1	50	50	100

3.2	200	KU03DSCMAT202	DIFFERENTIAL EQUATIONS	4	4	0	1	50	50	100
3.3	200	KU03DSCMAT203	NUMBER THEORY	4	4	0	1	50	50	100
3.4	200	KU03DSCMAT204	NUMERICAL ANALYSIS	4	4	0	1	50	50	100

Semester IV

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
4.1	200	KU04DSCMAT201	CALCULUS III	4	4	0	1	50	50	100
4.2	200	KU04DSCMAT202	INTRODUCTION TO GRAPH THEORY	4	4	0	1	50	50	100
4.3	200	KU04DSCMAT203	LINEAR ALGEBRA I	4	4	0	1	50	50	100
4.4	200	KU04DSCMAT204	VECTOR VALUED FUNCTIONS AND MULTIVARIABLE CALCULUS	4	4	0	1	50	50	100

Semester V

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
5.1	300	KU05DSCMAT301	ALGEBRA I	4	4	0	1	50	50	100
5.2	300	KU05DSCMAT302	COMPLEX ANALYSIS I	4	4	0	1	50	50	100
5.3	300	KU05DSCMAT303	LINEAR ALGEBRA II	4	4	0	1	50	50	100
5.4	300	KU05DSCMAT304	REAL ANALYSIS I	4	4	0	1	50	50	100
5E.x	Elective -DSE (POOL D)			4	POOL D			50	50	100

S5 - List of Discipline Specific Electives (DSE) (POOL D)										
No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
5E.1	300	KU05DSEMAT301	INTRODUCTION TO GEOMETRY	4	4	0	1	50	50	100
5E.2	300	KU05DSEMAT302	MULTIPLE INTEGRALS AND VECTOR INTEGRATION	4	4	0	1	50	50	100
5E.3	300	KU05DSEMAT303	THEORY OF EQUATIONS	4	4	0	1	50	50	100

Semester VI

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
6.1	300	KU06DSCMAT301	ALGEBRA II	4	4	0	1	50	50	100
6.2	300	KU06DSCMAT302	COMPLEX ANALYSIS II	4	4	0	1	50	50	100
6.3	300	KU06DSCMAT303	REAL ANALYSIS II	4	4	0	1	50	50	100
6.4	Elective – DSE (Pool E)							50	50	100
6.5	300	KU06INTMAT301	INTERNSHIP / MINOR PROJECT	4	0	0	5	50	50	100

S6 - List of Discipline Specific Electives (DSE) (POOL E)										
No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
6E.1	300	KU06DSEMAT301	LINEAR PROGRAMMING	4	4	0	1	50	50	100
6E.2	300	KU06DSEMAT302	TOPOLOGY OF METRIC SPACES	4	4	0	1	50	50	100
6E.3	300	KU06DSEMAT303	CRYPTOGRAPHY	4	4	0	1	50	50	100

Semester VII

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
7.1	400	KU07DSCMAT401	ALGEBRA III	4	4	0	1	50	50	100

7.2	400	KU07DSCMAT402	LINEAR ALGEBRA II	4	4	0	1	50	50	100
7.3	400	KU07DSCMAT403	REAL ANALYSIS-III	4	4	0	1	50	50	100
7.4	400	KU07DSCMAT404	TOPOLOGY	4	4	0	1	50	50	100
7E.X	Elective -DSE (POOL F)			4	POOL F			50	50	100
7M	MOOC / Online course Approved by Department KU7MOOCMAT401			4						

S7 - List of Discipline Specific Electives (DSE) (POOL F)										
No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
7E.1	400	KU07DSEMAT401	ALGEBRAIC NUMBER THEORY	4	3	2	1	50	50	100
7E.2	400	KU07DSEMAT402	ANALYTIC NUMBER THEORY	4	3	2	1	50	50	100
7E.3	400	KU07DSEMAT403	NUMBER THEORY	4	3	2	1	50	50	100

Semester VIII

No	level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
8.1	400	Elective – DSE (Pool G)		4				50	50	100
8.2	MOOC / Online course Approved by Department KU8MOCCMAT401			4				-	-	-
8.3	400	KU08RPHMAT401	RESEARCH/ INTERNSHIP	12	24			50	50	100
OR										
8.4	400	KU08DSCMAT401	FUNCTIONAL ANALYSIS I	4	4	0	1	50	50	100
8.5	400	KU08DSCMAT402	MEASURE AND INTEGRATION	4	4	0	1	50	50	100
8.6	400	KU08DSCMAT403	ORDINARY DIFFERENTIAL EQUATIONS	4	4	0	1	50	50	100

S8 - List of Discipline Specific Electives (DSE) (POOL G)										
No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T

8E.1	400	KU08DSEMAT40 1	CODING THEORY	4	4	0	1	50	50	100
8E.2	400	KU08DSEMAT40 2	REPRESENTATION THEORY OF FINITE GROUPS	4	4	0	1	50	50	100
8E.3	400	KU08DSEMAT40 3	FUZZY MATHEMATICS	4	4	0	1	50	50	100

Semester IX

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
9.1	500	KU09DSCMAT50 1	ALGEBRA IV	4	4	0	1	50	50	100
9.2	500	KU09DSCMAT50 2	COMPLEX ANALYSIS III	4	4	0	1	50	50	100
9.3	500	KU09DSCMAT50 3	FUNCTIONAL ANALYSIS II	4	4	0	1	50	50	100
9.4	500	KU09DSCMAT50 4	FUNCTIONS OF SEVERAL VARIABLES AND DIFFERENTIAL GEOMETRY	4	4	0	1	50	50	100
9.5	500	KU09DSCMAT50 5	PARTIAL DIFFERENTIAL EQUATIONS	4	4	0	1	50	50	100

Semester X

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
10.1	500	KU10DSRMAT501	RESEARCH AT NATIONAL LEVEL INSTITUTE	20	36		1	50	50	100
OR										
10.2	500	KU10DSCMAT501	ADVANCED TOPICS IN ANALYSIS	4	4	0	1	50	50	100
10.3	500	KU10DSCMAT502	ALGEBRAIC TOPOLOGY	4	4	0	1	50	50	100
10.4	500	KU10DSCMAT503	HARMONIC ANALYSIS	4	4	0	1	50	50	100
10.5	500	KU10DSCMAT504	OPERATOR ALGEBRAS	4	4	0	1	50	50	100
10.6	500	KU10DSCMAT505	INTRODUCTION TO LIE ALGEBRAS	4	4	0	1	50	50	100
10.7	500	KU10DSCMAT506	COMMUTATIVE ALGEBRA	4	4	0	1	50	50	100

10.8	500	KU10DMPMAT501 / KU10MOOCMAT501	MINOR PROJECT/ MOOC COURSE	4	-	-	-	50	50	100

SKILL ENHANCEMENT COURSES (SEC)

Semester 4 SEC POOL 1										
No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
4SE.1	200	KU04SECMAT201	BASIC COURSE IN LATEX	3	2	2	0	50	50	100

MULTI DISCIPLINARY COURSES

Semester 1 MDC POOL 2										
No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
1MD.1	100	KU01MDCMAT101	ELEMENTARY MATHEMATICS -1	3	3	0	1	50	50	100
1MD.2	100	KU02MDCMAT101	ELEMENTARY MATHEMATICS -2	3	3	0	1	50	50	100

MATHEMATICAL SCIENCE PATHWAYS

BSc (Mathematics)

BSc (Hons)/ BSc (Hons. With Research) (Mathematics)

MSc (Mathematics

Model Course Structure

BSc (Mathematics) – 3rd year Exit

Model Course Distribution for the BSc (Mathematics) Programme with effect from 2024- 25 Onwards (3rd Year Exit)										
	1	2	3	4	5	6	7	8	Total Courses	Total Credits
	Discipline Specific		MDC							
#	Core Courses (DSC)	Electives (DSE)	IDE/MDC /Open	AEC 3 Credits	SEC 3 Credits	VAC	MOOC / Online	Internship		
1	KU01DSCMAT101 STAT COURSE IT COURSE		MDC -1	AEC-1 AEC-2					6	21
	12 Credits	0	3	6						
2	KU02DSCMAT101 KU02DSCMAT102 STAT COURSE STAT COURSE		MDC -2	AEC-3					6	22
	16 Credits	0	3	3						
3	KU03DSCMAT201 KU03DSCMAT202 KU03DSCMAT203 KU03DSCMAT204		MDC-3			VAC-1			6	22
	16 Credits		3 Credits			3 Credit				
4	KU04DSCMAT201 KU04DSCMAT202 KU04DSCMAT203 KU04DSCMAT204				SEC-1	VAC-2			6	22
	16	0			3	3				

5	KU05DSCMAT301 KU05DSCMAT302 KU05DSCMAT303 KU05DSCMAT304	**Elective POOL D Any One** KU05DSEMAT301 KU05DSEMAT302 KU05DSEMAT303			**SEC-2**				**6**	**23**
	16	**4**			**3**					
6	KU06DSEMAT301 KU06DSEMAT302 KU06DSEMAT303	**Elective POOL E Any One** KU06DSEMAT301 KU06DSEMAT302 KU06DSEMAT303			**SEC-3**			KU06INTMAT301	**6**	**23**
	12	**4**			**3**			**4**		
	Total Credit earned									**133**

Model Course Structure

BSc Hons. (Mathematics) / BSc Hons. with Research (Mathematics) – 4th year Exit

	1	2	3	4	5	6	7	8	Total Courses	Total Credits
	Discipline Specific		MDC							
#	Core Courses (DSC)	Electives (DSE)	IDE/MDC/Open	AEC 3 Credits	SEC 3 Credits	VAC	MOOC / Online	Internship		

1	KU01DSCMAT101 STAT COURSE IT COURSE		**MDC -1**	**AEC-1** **AEC-2**					**6**	**21**
	12 Credits	**0**	**3**	**6**						
2	KU02DSCMAT101 KU02DSCMAT102 STAT COURSE STAT COURSE		**MDC -2**	**AEC-3**						
	16 Credits	**0**	**3**	**3**					**6**	**22**
3	KU03DSCMAT201 KU03DSCMAT202 KU03DSCMAT203 KU03DSCMAT204		**MDC-3**			**VAC-1**			**6**	**22**
	16 Credits		**3 Credits**			**3 Credits**				
4	KU04DSCMAT201 KU04DSCMAT202 KU04DSCMAT203 KU04DSCMAT204				**SEC-1**	**VAC-2**				
	12	**4**			**3**	**3**			**6**	22
5	KU05DSCMAT301 KU05DSCMAT302 KU05DSCMAT303 KU05DSCMAT304	**Elective POOL D** **Any One** KU05DSEMAT301 KU05DSEMAT302 KU05DSEMAT303			**SEC-2**				**6**	**23**
	16	**4**			**3**					
6	KU06DSEMAT301 KU06DSEMAT302 KU06DSEMAT303	**Elective POOL E** **Any One** KU06DSEMAT301 KU06DSEMAT302 KU06DSEMAT303			**SEC-3**			KU06INTMAT301	**6**	**23**
	12	**4**			**3**			**4**		
7	KU07DSCMAT401 KU07DSCMAT402	**Elective Pool F** **Any One** KU07DSEMAT401					**MOOC-1** KU07MOOCMAT			

	KU07DSCMAT403 KU07DSCMAT404	KU07DSEMAT402 KU07DSEMAT403					401		**6**	**24**
	16	**4**					**4**			
8	KU08DSCMAT401 KU08DSCMAT402 KU08DSCMAT403 For BSc. Hons – in lieu of Research (12C)	Elective – DSE (Pool G)					**MOOC-2** KU08MOOCMAT401	KU08RPHMAT401 **Research** for BSc Hons with Research – in lieu of 3 DSC courses		**20**
	4	**12**					**4**	**12**		
	Total Credit earned									**177**

*** MOOC 3 and MOOC 4 / Couse offered by the Department; at least of 3 credit each should be completed. Students can enrol for MOOC 3 and MOOC 4 from second semester onwards and a pass certificate can be submitted by 8th Semester for securing BSc Hons. / BSc Hons with Research (Mathematics); however this credit will not be added for computing the CGPA.**

Model Course Structure

MSc (Mathematics) – 5th year Exit

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total Courses**	**Total Credits**
	Discipline Specific		**MDC**							
#	**Core Courses (DSC)**	**Electives (DSE)**	**IDE/MDC/Open**	**AEC 3 Credits**	**SEC 3 Credits**	**VAC**	**MOOC / Online**	**Internship**		
1	KU01DSCMAT101 STAT COURSE IT COURSE		**MDC -1**	**AEC-1** **AEC-2**						

	12 Credits	**0**	**3**	**6**					**6**	**21**
2	KU02DSCMAT101 KU02DSCMAT102 STAT COURSE STAT COURSE		**MDC -2**	**AEC-3**					**6**	**22**
	16 Credits	**0**	**3**	**3**						
3	KU03DSCMAT201 KU03DSCMAT202 KU03DSCMAT203 KU03DSCMAT204		**MDC-3**			**VAC-1**			**6**	**22**
	16 Credits		**3 Credits**			**3 Credits**				
4	KU04DSCMAT201 KU04DSCMAT202 KU04DSCMAT203 KU04DSCMAT204				**SEC-1**	**VAC-2**				
	12	**4**			**3**	**3**			**6**	22
5	KU05DSCMAT301 KU05DSCMAT302 KU05DSCMAT303 KU05DSCMAT304	**Elective POOL D Any One** KU05DSEMAT301 KU05DSEMAT302 KU05DSEMAT303			**SEC-2**				**6**	**23**
	16	**4**			**3**					
6	KU06DSEMAT301 KU06DSEMAT302 KU06DSEMAT303	**Elective POOL E Any One** KU06DSEMAT301 KU06DSEMAT302 KU06DSEMAT303			**SEC-3**			KU06INTMAT301	**6**	**23**
	12	**4**			**3**			**4**		
7	KU07DSCMAT401 KU07DSCMAT402 KU07DSCMAT403 KU07DSCMAT404	**Elective Pool F Any One** KU07DSEMAT401 KU07DSEMAT402 KU07DSEMAT403					**MOOC-1** KU07MOCCMAT 401		**6**	**24**

	16	**4**					**4**			
8	KU08DSCMAT401 KU08DSCMAT402 KU08DSCMAT403 For BSc. Hons – in lieu of Research (12C)	Elective – DSE (Pool G)					**MOOC-2** KU08MOOCMAT401	KU08RPHMAT401 **Research** for BSc Hons with Research – in lieu of 3 DSC courses	**3/5**	**20**
	4	**12**					**4**	**12**		
9	KU09DSCMAT501 KU09DSCMAT502 KU09DSCMAT503 KU09DSCMAT504 KU09DSCMAT505						**One 4 credit MOOC / Online/ Blended course in lieu of One DSC** KU09MOOCMAT501		**5**	
	16/20						**0/4**		**20**	
10	**Research (20Credits) KU10DSRMAT501** **OR**									
	KU10DSCMAT501 KU10DSCMAT502 KU10DSCMAT503 KU10DSCMAT504 KU10DSCMAT505 KU10DSCMAT506 (Either Choose Five courses from this list or Choose 4 courses from this list and choose one from KU10DMPMAT501 / KU10MOOCMAT501)						MINOR PROJECT/ MOOC COURSE **KU10DMPMAT501 /** **KU10MOOCMAT501**		**5**	**20**

	20/20						**20/4**		
	Total Credit earned								**217**

STATISTICAL SCIENCE COURSES

Semester I

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESE	CCE	T
1.1	100	KU01DSCSTA101	Descriptive Statistics	4	3	2	1	50	50	100

Semester II

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESE	CCE	T
2.1	100	KU02DSCSTA104	Probability Theory and Random Variables	4	3	2	1	50	50	100
2.2	100	KU02DSCSTA103	Introduction to R Programming	4	2	4	1	50	50	100

Semester III

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
3.1	200	KU03DSCSTA205	Probability Distributions	4	3	2	1	50	50	100
3.2	200	KU03DSCSTA206	Sampling Techniques	4	3	2	1	50	50	100
3.3	200	KU03DSCSTA203	Matrix Theory	4	3	2	1	50	50	100
3.4	200	KU03DSCSTA204	Statistical Computing Using SPSS	4	1	6	1	50	50	100

Semester IV

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
4.1	200	KU04DSCSTA211	Elementary Statistical Inference	4	3	2	1	50	50	100
4.2	200	KU04DSCSTA212	Applied Statistics-I	4	3	2	1	50	50	100
4.3	200	KU04DSCSTA213	Statistical Computing Using R	4	3	2	1	50	50	100
4.4	200	KU04DSCSTA208	Introduction to Biostatistics	4	3	2	1	50	50	100

Semester V

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
5.1	300	KU05DSCSTA301	Theory of Markov Chain	4	3	2	1	50	50	100
5.2	300	KU05DSCSTA302	Mathematical Methods for Statistics-I	4	3	2	1	50	50	100
5.3	300	KU05DSCSTA303	Linear Regression Analysis	4	3	2	1	50	50	100
5.4	300	KU05DSCSTA304	Testing of Hypothesis	4	3	2	1	50	50	100
5E.x	Elective -DSE (POOL A)			4	POOL A			50	50	100

S5 - List of Discipline Specific Electives (DSE) (POOL A)

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
5E.1	300	KU05DSESTA305	Introduction to Actuarial Statistics	4	3	2	1	50	50	100
5E.2	300	KU05DSESTA306	Official Statistics	4	3	2	1	50	50	100

Semester VI

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
6.1	300	KU06DSCSTA307	Time Series Analysis	4	3	2	1	50	50	100
6.2	300	KU06DSCSTA308	Design of Experiments	4	3	2	1	50	50	100
6.3	300	KU06DSCSTA309	Statistical Computing Using R (Practical)	4	1	6	1	50	50	100
6E.x	Elective – DSE (**Pool B**)							50	50	100
6.5	300	KU06INTSTA301	Internship	4	-	8	1	50	50	100

S6 - List of Discipline Specific Electives (DSE) (POOL B)										
No	**Level**	**Course Code**	**Course Name**	**C**	**Hrs./wk.**			**Assessment Weightage (%)**		
					L	**P**	**Tt**	**ESA**	**CE**	**T**
6E.1	300	KU06DSESTA310	Statistical Quality Control	4	3	2	1	50	50	100
6E.2	300	KU06DSESTA311	Statistical Machine Learning	4	3	2	1	50	50	100
6E.3	300	KU06DSESTA312	Statistical Methods Using Python	4	2	4	1	50	50	100

Semester VII

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
7.1	400	KU07DSCSTA401	Measure and Probability	4	3	2	1	50	50	100
7.2	400	KU07DSCSTA402	Mathematical Methods for Statistics-II	4	3	2	1	50	50	100
7.3	400	KU07DSCSTA403	Advanced Distribution Theory	4	3	2	1	50	50	100
7.4	400	KU07DSCSTA404	Statistical Inference	4	3	2	1	50	50	100
7.5	400	KU07DSCSTA405	Mathematical Methods for Biostatistics	4	3	2	1	50	50	100
7.6	400	KU07DSCSTA406	Probability and Distribution Theory	4	3	2	1	50	50	100
7.7	400	KU07DSCSTA407	Analysis of Clinical Trials	4	3	2	1	50	50	100
7.8	400	KU07DSCSTA408	Biostatistical Inference	4	3	2	1	50	50	100
7E.x	400	Elective IV -DSE (**POOL C)**		4	POOL C			50	50	100
7M	MOOC / Online course Approved by Department KU07MOCSTA401			3						

S7 - List of Discipline Specific Electives (DSE) (POOL C)										
No	**Level**	**Course Code**	**Course Name**	**C**	**Hrs./wk.**			**Assessment Weightage (%)**		
					L	**P**	**Tt**	**ESA**	**CE**	**T**
7E.1	400	KU07DSESTA409	Applied Regression Analysis	4	3	2	1	50	50	100
7E.2	400	KU07DSESTA410	Data Visualisation and Analysis Using Python	4	2	4	1	50	50	100
7E.3	400	KU07DSESTA411	Demographic Studies	4	3	2	1	50	50	100
7E.4	400	KU07DSESTA412	Biostatistical Computing Using R	4	2	4	1	50	50	100
7E.5	400	KU07DSESTA413	Biostatistical Computing Using SPSS	4	2	4	1	50	50	100

Semester VIII

No	**level**	**Course Code**	**Course Name**		**C**	**Hrs./wk.**			**Assessment Weightage (%)**		
						L	**P**	**Tt**	**ESA**	**CE**	**T**
8.1a	400	KU08DSCSTA401	Advanced Probability Theory		4	3	2	1	50	50	100
8.1b	400	KU08DSCSTA402	Survival Analysis		4	3	2	1	50	50	100
8.2	400	KU08RPHSTA401	Research/ Internship		12	24			50	50	100
OR											
8E.x	400	CODE FROM **POOL D**	DSE -1	From **POOL D**	4	3	2	1	50	50	100
8E.x	400		DSE-2		4	3	2	1	50	50	100
8E.x	400		DSE-3		4	3	2	1	50	50	100
8M	MOOC / Online course Approved by Department KU08MOCSTA402				3				--	--	--

S8 - List of Discipline Specific Electives (DSE) (POOL D)										
No	**Level**	**Course Code**	**Course Name**	**C**	**Hrs./wk.**			**Assessment Weightage (%)**		
					L	**P**	**Tt**	**ESA**	**CE**	**T**
8E.1	400	KU08DSESTA404	Multivariate Analysis	4	3	2	1	50	50	100
8E.2	400	KU08DSESTA405	Statistical Analysis of Clinical Trials	4	3	2	1	50	50	100
8E.3	400	KU08DSESTA406	Reliability Modelling	4	3	2	1	50	50	100
8E.4	400	KU08DSESTA407	Advanced Bayesian Computing with R	4	3	2	1	50	50	100
8E.5	400	KU08DSESTA408	Generalized Linear Models	4	3	2	1	50	50	100
8E.6	400	KU08DSESTA409	Analysis of Longitudinal Data	4	3	2	1	50	50	100

8E.7	400	KU08DSESTA410	Applied Regression Analysis for Biostatistics	4	3	2	1	50	50	100
8E.8	400	KU08DSESTA411	Statistical Epidemiology	4	3	2	1	50	50	100
8E.9	400	KU08DSESTA412	Statistical Ecology and Genetics	4	3	2	1	50	50	100
8E.10	400	KU08DSESTA413	Applied Multivariate Analysis	4	3	2	1	50	50	100

Semester IX

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
9.1	500	KU09DSCSTA501	Advanced Sampling Theory	4	3	2	1	50	50	100
9.2	500	KU09DSCSTA502	Stochastic Processes	4	3	2	1	50	50	100
9.3	500	KU09DSCSTA503	Statistical Simulation Techniques	4	3	2	1	50	50	100
9.4	500	KU09DSCSTA504	Advanced Multivariate Analysis	4	3	2	1	50	50	100
9.5	500	KU09DSCSTA505	Advanced Design of Experiments	4	3	2	1	50	50	100
9.6	500	KU09DSCSTA506	Generalized Linear Models for Biostatistics	4	3	2	1	50	50	100
9.7	500	KU09DSCSTA507	Advanced Time Series Analysis	4	3	2	1	50	50	100

Semester X

No	level	Course Code	Course Name		C	Hrs./wk.			Assessment Weightage (%)		
						L	P	Tt	ESA	CE	T
10.1	500	KU10CIPSTA501	Research/ Internship		20	36			50	50	100
			OR								
10E.1	500	CODE FROM **POOL E**	DSE -1	From **POOL E**	4	3	2	1	50	50	100
10E.2	500		DSE-2		4	3	2	1	50	50	100
10E.3	500		DSE-3		4	3	2	1	50	50	100
10E.4	500		DSE-4		4	3	2	1	50	50	100
10E.5	500		DSE-5		4	3	2	1	50	50	100

S10 - List of Discipline Specific Electives (DSE) (POOL E)

No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
1	500	KU10DSESTA501	Operations Research	4	4	2	1	50	50	100

10E.2	500	KU10DSESTA502	Non-parametric Inference	4	4	2	1	50	50	100
10E.3	500	KU10DSESTA503	Analysis of Financial Time Series	4	4	2	1	50	50	100
10E.4	500	KU10DSESTA504	Categorical Data Analysis	4	4	2	1	50	50	100
10E.5	500	KU10DSESTA505	Mixture Regression Models	4	4	2	1	50	50	100
10E.6	500	KU10DSESTA506	Analysis of Discrete and Longitudinal Data	4	4	2	1	50	50	100
10E.7	500	KU10DSESTA507	Advanced Queuing Theory	4	4	2	1	50	50	100
10E.8	500	KU10DSESTA508	Health Economics	4	4	2	1	50	50	100
10E.9	500	KU10DSESTA509	Life Contingencies	4	4	2	1	50	50	100

SKILL ENHANCEMENT COURSES (SEC)

Semester 4 SEC POOL 1										
No	**Level**	**Course Code**	**Course Name**	**C**	**Hrs./wk.**			**Assessment Weightage (%)**		
					L	**P**	**Tt**	**ESA**	**CE**	**T**
4SE.1	200	KU04SECSTA201	Data Analysis using Excel	3	2	2	0	50	50	100
4SE.2	200	KU04SECSTA202	Data Analysis using SPSS	3	2	2	0	50	50	100

Semester 5 SEC POOL 2										
No	**Level**	**Course Code**	**Course Name**	**C**	**Hrs./wk.**			**Assessment Weightage (%)**		
					L	**P**	**Tt**	**ESA**	**CE**	**T**
5SE.1	300	KU05SECSTA301	Basic Statistics using R	3	2	2	0	50	50	100
5SE.2	300	KU05SECSTA302	Statistical Data Visualization and Graphics	3	2	2	0	50	50	100

Semester 6 SEC POOL 3										
No	**Level**	**Course Code**	**Course Name**	**C**	**Hrs./wk.**			**Assessment Weightage (%)**		
					L	**P**	**Tt**	**ESA**	**CE**	**T**
6SE.1	300	KU06SECSTA303	Statistical Reporting and Interpretation	3	2	2	0	50	50	100
6SE.2	300	KU06SECSTA304	Data Analysis using SAS	3	2	2	0	50	50	100

MULTI DISCIPLINARY COURSES

Semester 1 MDC POOL 1										
No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
1MD.1	100	KU01MDCSTA101	Basic Statistics	3	2	2	1	50	50	100

Semester 2 MDC POOL 2										
No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
2MD.1	100	KU02MDCSTA201	Correlation and Regression Analysis	3	2	2	1	50	50	100

Semester 3 MDC POOL 3										
No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
3MD.1	200	KU03MDCSTA202	Applied Statistical Inference	3	2	2	1	50	50	100

VALUE ADDED COURSES

Semester 1 MDC POOL 1										
No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
1VA.1	200	KU03VACSTA201	Data Visualisation using Microsoft Power Bi	3	2	2	1	50	50	100

Semester 2 MDC POOL 2										
No	Level	Course Code	Course Name	C	Hrs./wk.			Assessment Weightage (%)		
					L	P	Tt	ESA	CE	T
2VA.1	200	KU04VACSTA202	Data Analysis using Tableau	3	2	2	1	50	50	100

STATISTICAL SCIENCE PATHWAYS

BSc (Statistics)
BSc (Hons)/ BSc (Hons. With Research) (Statistics)
BSc (Hons)/ BSc (Hons. With Research) (Biostatistics)
MSc (Statistics)
MSc (Biostatistics)

Model Course Structure

BSc (Statistics) – 3rd Year Exit

Model Course Distribution for the BSc (Statistics) Programme with effect from 2025- 26 Onwards (3rd Year Exit)										
Sem	1	2	3	4	5	6	7	8	Total Courses	Total Credits
	Discipline Specific		MDC							
#	Core Courses (DSC)	Electives (DSE)	IDE/MDC /Open	AEC 3 Credits	SEC 3 Credits	VAC	MOOC / Online	Internship		
1	KU01DSCSTA101 MATHS COURSE ITCOURSE		MDC -1	AEC-1 AEC-2					6	21
	12 Credits	0	3	6						
2	KU02DSCSTA104 KU02DSCSTA103 MATHS COURSE MATHS COURSE		MDC -2	AEC-3					6	22
	16 Credits	0	3	3						
3	KU03DSCSTA205 KU03DSCSTA206 KU03DSCSTA203/ MATHS COURSE KU03DSCSTA204/ MATHS COURSE		MDC-3			VAC-1			6	22
	16 Credits		3 Credits			3 Credit				
4	KU04DSCSTA211 KU04DSCSTA212 KU04DSCSTA213/ MATHS COURSE KU04DSCSTA208/ MATHS COURSE				SEC-1	VAC-2				
	12	4			3	3			6	22
5	KU05DSCSTA301	Elective POOL A			SEC-2					

	KU05DSCSTA302 KU05DSCSTA303 KU05DSCSTA304	**Any One** KU05DSESTA305 KU05DSESTA306							6	23
	16	**4**			3					
6	KU06DSCSTA307 KU06DSCSTA308 KU06DSCSTA309	**Elective POOL B** **Any One** KU06DSESTA310 KU06DSESTA311 KU06DSESTA312			SEC-3			KU06INTSTA301	6	23
	12	**4**			3			4		
	Total Credit earned									**133**

Model Course Structure

BSc Hons. (Statistics) / BSc Hons. with Research (Statistics) – 4th year Exit

	1	2	3	4	5	6	7	8	Total Courses	Total Credits
	Discipline Specific		MDC							
#	Core Courses (DSC)	Electives (DSE)	IDE/MDC/ Open	AEC 3 Credits	SEC 3 Credits	VAC	MOOC / Online	Internship		
1	KU01DSCSTA101 MATHS COURSE ITCOURSE		MDC -1	AEC-1 AEC-2					6	21
	12 Credits	**0**	**3**	**6**						
2	KU02DSCSTA104 KU02DSCSTA103 MATHS COURSE MATHS COURSE		MDC -2	AEC-3					6	22
	16 Credits	0	3	**3**						
3	KU03DSCSTA205 KU03DSCSTA206 KU03DSCSTA203 KU03DSCSTA204		MDC-3			VAC-1			6	22
	16 Credits		**3 Credits**			**3 Credit**				
4	KU04DSCSTA211 KU04DSCSTA212 KU04DSCSTA213 KU04DSCSTA208				SEC-1	VAC-2				
	12	**4**			**3**	**3**			**6**	**22**

5	KU05DSCSTA301 KU05DSCSTA302 KU05DSCSTA303 KU05DSCSTA304	**Elective POOL A** **Any One** KU05DSESTA305 KU05DSESTA306			SEC-2				**6**	**23**
	16	**4**			**3**					
6	KU06DSCSTA307 KU06DSCSTA308 KU06DSCSTA309	**Elective POOL B** **Any One** KU06DSESTA310 KU06DSESTA311 KU06DSESTA312			SEC-3			KU06INTSTA301	6	23
	12	**4**			3			4		
7	KU07DSCSTA401 KU07DSCSTA402 KU07DSCSTA403 KU07DSCSTA404	**Elective Pool C** **Any One** KU07DSESTA409 KU07DSESTA410 KU07DSESTA411					**MOOC-1** KU07MOCSTA401		6	24
	16	**4**					**4**			
8	KU08DSCSTA401	**3 Electives -Pool D** For BSc. Hons – in lieu of Research (12C) **Any three** KU08DSESTA404 KU08DSESTA405 KU08DSESTA406 KU08DSESTA407 KU08DSESTA408 KU08DSESTA409					**MOOC-2** KU08MOCSTA402	KU08RPHSTA401 **Research** for BSc Hons with Research – in lieu of 3 DSE course		20
	4	**12**					**4**	**12**		
	Total Credit earned									**177**

Model Course Structure

BSc Hons. (Biostatistics) / BSc Hons. with Research (Biostatistics) – 4th Year Exit

	1	2	3	4	5	6	7	8	Total Courses	Total Credits
	Discipline Specific		MDC							
#	Core Courses (DSC)	Electives (DSE)	IDE/MDC/Open	AEC 3 Credits	SEC 3 Credits	VAC	MOOC / Online	Internship		
1	KU01DSCSTA101 MATHS COURSE ITCOURSE		MDC -1	AEC-1 AEC-2					6	21
	12 Credits	0	3	6						
2	KU02DSCSTA104 KU02DSCSTA103 MATHS COURSE MATHS COURSE		MDC -2	AEC-3					6	22
	16 Credits	0	3	3						
3	KU03DSCSTA205 KU03DSCSTA206 KU03DSCSTA203/ MATHS COURSE KU03DSCSTA204/ MATHS COURSE		MDC-3			VAC-1			6	22
	16 Credits		3 Credits			3 Credit				
4	KU04DSCSTA211 KU04DSCSTA212 KU04DSCSTA213/ MATHS COURSE KU04DSCSTA208/ MATHS COURSE				SEC-1	VAC-2				
	12	4			3	3			6	22

5	KU05DSCSTA301 KU05DSCSTA302 KU05DSCSTA303 KU05DSCSTA304	**Elective POOL A** **Any One** KU05DSESTA305 KU05DSESTA306			SEC-2				6	23
	16	**4**			3					
6	KU06DSCSTA307 KU06DSCSTA308 KU06DSCSTA309	**Elective POOL B** **Any One** KU06DSESTA310 KU06DSESTA311 KU06DSESTA312			SEC-3			KU06INTSTA301	6	23
	12	**4**			3			4		
7	KU07DSCSTA405 KU07DSCSTA406 KU07DSCSTA407 KU07DSCSTA408	**Elective Pool F** **Any One** KU07DSESTA410 KU07DSESTA411 KU07DSESTA412 KU07DSESTA413					**MOOC-1** KU07MOCSTA401		6	24
	16	**4**					**4**			
8	KU08DSCSTA402	**3 Electives -Pool G** For BSc. Hons – in lieu of Research (12C) KU08DSESTA408 KU08DSESTA409 KU08DSESTA410 KU08DSESTA411 KU08DSESTA412 KU08DSESTA413					**MOOC-2** KU08MOCSTA402	KU08RPHSTA403 **Research** for BSc Hons with Research – in lieu of 3 DSE course		20
	4	**12**					**4**	**12**		
	Total Credit earned									**177**

Model Course Structure-

MSc (Statistics)– 5th Year Exit

SEM	1	2	3	4	5	6	7	8	Total Courses	Total Credits
	Discipline Specific		MDC							
#	Core Courses (DSC)	Electives (DSE)	IDE/MDC /Open	AEC 3 Credits	SEC 3 Credits	VAC	MOOC / Online	Internship		
1	KU01DSCSTA101 MATHS COURSE ITCOURSE		MDC -1	AEC-1 AEC-2					6	21
	12 Credits	**0**	**3**	**6**						
2	KU02DSCSTA104 KU02DSCSTA103 MATHS COURSE MATHS COURSE		MDC -2	AEC-3					6	22
	16 Credits	0	3	**3**						
3	KU03DSCSTA205 KU03DSCSTA206 KU03DSCSTA203/ MATHS COURSE KU03DSCSTA204/ MATHS COURSE		MDC-3			VAC-1			6	22
	16 Credits		**3 Credits**			**3 Credit**				
4	KU04DSCSTA211 KU04DSCSTA212 KU04DSCSTA213/ MATHS COURSE KU04DSCSTA208/ MATHS COURSE				SEC-1	VAC-2				
	12	**4**			3	**3**			6	**22**
5	KU05DSCSTA301 KU05DSCSTA302 KU05DSCSTA303 KU05DSCSTA304	**Elective POOL A Any One** KU05DSESTA305 KU05DSESTA306			SEC-2					
	16	**4**			3				6	**23**
6	KU06DSCSTA307 KU06DSCSTA308	**Elective POOL B Any One**			SEC-3			Internship KU06INTSTA301		

	KU06DSCSTA309	KU06DSESTA310 KU06DSESTA311 KU06DSESTA312							6	
	12	**4**			3			4		**23**
7	KU07DSCSTA401 KU07DSCSTA402 KU07DSCSTA403 KU07DSCSTA404	**Elective Pool C** **Any One** KU07DSESTA409 KU07DSESTA410 KU07DSESTA411					MOOC-1 KU07MOCSTA401		6	**24**
	16	**4**					**4**			
8	KU08DSCSTA401	**3 Electives -Pool D** For BSc. Hons – in lieu of Research (12C) **Any three** KU08DSESTA404 KU08DSESTA405 KU08DSESTA406 KU08DSESTA407 KU08DSESTA408 KU08DSESTA409					MOOC-2 KU08MOCSTA402	KU08RPHSTA401 **Research** for BSc Hons with Research – in lieu of 3 DSE course	6	**20**
	4	**12**					**4**	**12**		
9	KU09DSCSTA501 KU09DSCSTA502 KU09DSCSTA503 KU09DSCSTA504 KU09DSCSTA505 (Options for Internship or MOOC)						**One 4 credit internship in lieu of one DSC and / or One 4 credit MOOC / Online/ Blended course in lieu of One DSC** KU09CIPSTA501 KU09MOCSTA501			**20**
	20 /16/12						**0/4/8**			
10	KU10CIPSTA501 **Research (20C)** **OR**									**20**
		5 DSE Courses from Pool E **Any Five** KU10DSESTA501 KU10DSESTA502 KU10DSESTA503 KU10DSESTA504 KU10DSESTA505 KU10DSESTA506 KU10DSESTA507								
		20								
	Total Credit earned									**217**

Model Course Structure, MSc(Biostatistics) 5th Year Exit

	1	2	3	4	5	6	7	8	Total Courses	Total Credits
	Discipline Specific		MDC							
#	Core Courses (DSC)	Electives (DSE)	IDE/MDC/Open	AEC 3 Credits	SEC 3 Credits	VAC	MOOC / Online	Internship		
1	KU01DSCSTA101 MATHS COURSE ITCOURSE		MDC -1	AEC-1 AEC-2					6	21
	12 Credits	0	3	6						
2	KU02DSCSTA104 KU02DSCSTA103 MATHS COURSE MATHS COURSE		MDC -2	AEC-3					6	22
	16 Credits	0	3	3						
3	KU03DSCSTA205 KU03DSCSTA206 KU03DSCSTA203/ MATHS COURSE KU03DSCSTA204/ MATHS COURSE		MDC-3			VAC-1			6	22
	16 Credits		3 Credits			3 Credit				
4	KU04DSCSTA211 KU04DSCSTA212 KU04DSCSTA213/ MATHS COURSE KU04DSCSTA208/ MATHS COURSE				SEC-1	VAC-2			6	22
	12	4			3	3				
5	KU05DSCSTA301 KU05DSCSTA302 KU05DSCSTA303 KU05DSCSTA304	Elective POOL A Any One KU05DSESTA305 KU05DSESTA306			SEC-2				6	23
	16	4			3					
6	KU06DSCSTA307	Elective POOL B						Internship		

	KU06DSCSTA308 KU06DSCSTA309	**Any One** KU06DSESTA310 KU06DSESTA311 KU06DSESTA312			SEC-3			KU06INTSTA301	6	**23**
	12	**4**			3			4		
7	KU07DSCSTA405 KU07DSCSTA406 KU07DSCSTA407 KU07DSCSTA408	**Elective Pool C** **Any One** KU07DSESTA410 KU07DSESTA411 KU07DSESTA412 KU07DSESTA413					MOOC-1 KU07MOCSTA401		6	**24**
	16	**4**					**4**			
8	KU08DSCSTA402	**3 Electives -Pool D** For BSc. Hons – in lieu of Research (12C) KU08DSESTA408 KU08DSESTA409 KU08DSESTA410 KU08DSESTA411 KU08DSESTA412 KU08DSESTA413					MOOC-2 KU08MOCSTA402	KU08RPHSTA401 **Research** for BSc Hons with Research – in lieu of 3 DSE course		**20**
	4	**12**					**4**	**12**		
9	KU09DSCSTA502 KU09DSCSTA503 KU09DSCSTA505 KU09DSCSTA506 KU09DSCSTA507 (Options for Internship or MOOC)						**One 4 credit internship in lieu of one DSC and / or One 4 credit MOOC / Online/ Blended course in lieu of One DSC** KU09CIPSTA501 KU09MOCSTA501			**20**
	20/16/12						**0/4/8**			**20**
10	**Research (20Credit)** KU10CIPSTA501 **OR**									
		5 DSE Courses from Pool E **Any five** KU10DSESTA501 KU10DSESTA502 KU10DSESTA504 KU10DSESTA505 KU10DSESTA506 KU10DSESTA508 KU10DSESTA509					MOOC -5 KU09MOCSTA502			**20**
		20								
	Total Credit earned									**217**

DETAILED SYLLABUS OF MATHEMATICAL SCIENCES

Department of Mathematical Sciences

Kannur University

Syllabus of FYIMP Programme in Mathematics

Semester I

KU01DSCMAT101LOGIC AND SET THEORY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
1	CORE	100	KU01DSCMAT 101	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hr

Course Objectives: The objective is to lay a solid foundation in discrete mathematics, which is crucial for understanding more advanced topics in computer science, mathematics, and other fields.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students will demonstrate proficiency in understanding propositional logic, including the ability to construct truth tables, identify logical equivalences, and apply rules of inference to derive valid conclusions from logical statements
CO2	Students will be able to effectively use predicates and quantifiers to express mathematical statements and translate them into logical forms. They will apply nested quantifiers to formulate complex logical statements and reason about their truth values
CO3	Students will develop competence in set theory, including operations on sets (union, intersection, complement) and the ability to represent set relationships using Venn diagrams. They will solve problems involving set identities and apply set theory concepts to real-world scenarios.
CO4	Students will master the concepts of sequences and sums, including arithmetic and geometric sequences, series, and summation notation. They will apply mathematical induction to prove statements involving sequences and use induction to establish the validity of mathematical propositions

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	
CO2	✓	✓	✓	✓	
CO3	✓	✓	✓	✓	
CO4	✓	✓	✓	✓	

COURSE CONTENTS

Module 1: Propositional logic, propositional equivalence, predicates and quantifiers, (Sections 1.1, 1.2,1.3, of the Text Book)

Module 2: Nested quantifiers, rules for inference, sets (Sections 1.4,1.5.2.1, of the Text Book)

Module 3: Set operators, functions (Sections 2.2, 2.3, of the Text Book)

Module 4: Sequences and sums, mathematical induction **(**Sections 2.4, 4.1of the Text Book)

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text book: Discrete Mathematics and Its Applications. by Kenneth H. Rosen, 6th edition, McGraw Hill.

Reference Books:

1. Susanna S Epp: Discrete Mathematics with Applications(4/e) Brooks/Cole Cengage Learning (2011) ISBN: 978-0-495-39132-6

2. Kenneth H. Rosen: Discrete Mathematics and Its Applications(7/e) McGraw-Hill, NY (2007) ISBN: 978- 0-07-338309-5

3. OScar Levin, Discrete Mathematics: An Open Introduction, 3rd edition.

TEACHING LEARNING STRATEGIES

●Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

●Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks

Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester II

KU02DSCMAT101: **INTRODUCTION TO MATRIX THEORY, PARAMETRIC EQUATIONS AND POLAR CO - ORDINATES**

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
2	CORE	100	KU02DSCMAT 101	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hr

Course Objectives: The objective is to provide students with a solid understanding of the fundamental concepts of matrix theory, which are essential in various areas of mathematics, engineering, and applied sciences.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students will demonstrate proficiency in fundamental concepts of matrices and matrix algebra, including operations such as addition, multiplication, and transposition. They will be able to solve systems of linear equations using matrix methods and apply matrix algebra to represent and solve practical problems.
CO2	Students will acquire the ability to compute determinants of square matrices and understand their geometric and algebraic interpretations. They will develop skills in finding the inverse of square matrices and apply these concepts to analyze the properties and behavior of linear transformations.
CO3	Students will gain knowledge of special types of matrices, such as symmetric, skew-symmetric, orthogonal, and diagonal matrices. They will explore applications of matrices in diverse fields, including computer science and statistics
CO4	Students will demonstrate proficiency in parametrizing plane curves, including the ability to represent curves using parametric equations and analyze their geometric properties. They will apply calculus techniques to parametric curves, such as finding derivatives and integrals, and interpret these results in the context of motion and geometry

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	
CO2	✓	✓	✓		
CO3	✓	✓	✓	✓	
CO4	✓	✓	✓		

COURSE CONTENTS

Module 1: Matrices and Matrix algebra, Systems of linear equations, The inverse of a square matrix and Determinants (Sections 1.1, 1.2, 1.3 and 1.4 of the Text Book 1).

Module 2: Some special types of matrices, more on system of linear equations, some places where matrices are found and Appendix (Sections 1.5,1.6.1.7 and 1.8, of the Text Book 1).

Module 3 Parametrizations of Plane Curves, Calculus with Parametric Curves, Polar Coordinates and Graphing Polar Coordinate Equations (Sections 11.1, 11.2, 11.3 and 11.4of the Text Book 2).

Module 4: Areas and Lengths in Polar Coordinates, Conic Sections and Conics in Polar Coordinates (Sections 11.5, 11.6 and 11.7 of the Text Book 2).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Books:

1. David W Lewis, Matrix Theory, world scientific.

2.Thomas Calculus 13Th Edition, George B. Thomas, Maurice D. Weir, Joel Hass, publisher: Pearson Education.

Reference Books:

1. Calculus early transcendentals sixth edition James Stewart McMaster University.

2. Calculus: Soo T Tan Brooks/Cole, Cengage Learning (2010) ISBN: 978-0-534-46579-

TEACHING LEARNING STRATEGIES

●Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

●Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU02DSCMAT102CALCULUS I

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
2	CORE	100	KU02DSCMAT 102	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hr

Course Objectives: The mathematics required for viewingand analyzing the physical world around us is contained in calculus. The objective of the course is to introduce students to the fundamental ideas of limit, continuity and differentiability and also to some basic theorems of differential calculus. It is also shown how these ideas can be applied in the problem of sketching of curves and in the solution of some optimization problems of interest in real life.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students would develop a solid understanding of what functions are and how they operate. They would learn about function notation, domain and range, and basic operations on functions such as addition, subtraction, multiplication, and division.

CO2	Students would become proficient in graphing functions and analyzing their behavior. This includes identifying key features such as intercepts, asymptotes, symmetry, and end behavior. Graphical analysis is crucial for visualizing functions and understanding their properties
CO3	Limits would be introduced as a foundational concept in calculus. Students would learn how to calculate limits algebraically, graphically, and numerically
CO4	Provide students with a strong foundation in pre-calculus concepts essential for success in calculus and other advanced mathematical disciplines.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Functions and Their Graphs, Combining Functions; Shifting and Scaling Graphs, Trigonometric Functions (Sections 1.1 to 1.3 of the text book)

Module 2: Graphing with Software, Exponential Functions, Inverse Functions and Logarithms (Sections 1.4 to 1.6 of the text book)

Module 3: Rates of Change and Tangents to Curves, Limit of a Function and Limit Laws, The Precise Definition of a Limit, One-Sided Limits (Sections 2.1 to 2.4 of the text book)

Module 4: Continuity, Limits Involving Infinity; Asymptotes of Graphs, Tangents and the Derivative at a Point, The Derivative as a Function (Sections 2.5 to 3.2 of the text book)

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: Thomas' Calculus Early Transcendentals (Thirteenth Edition).

Reference Books:

1. Anton, Bivens and Davis, John: Calculus single variable 10th edition, Wiley and sons, Inc. (2012).

2. Tom M. Apostol: Calculus, Vol I (Second Edition), Wiley Student Edition, (2006).

3. N. Piskunov, M.I.R. Publisher, Differential and Integral Calculus, (Vol: I), (1977).

4. A Course in Calculus and Real Analysis, Ghorpade Sudhir, Limaye Balmohan V., Springer International Edition, (2006).

5. George B. Thomas and Ross L. Finney: Calculus and Analytic Geometry. Pearson Education India; 9th Edition, (2010

6. Calculus: Soo T Tan Brooks/Cole, Cengage Learning (2010) ISBN: 978-0-534-46579-7

7.Calculus early Transcendentals sixth edition James Stewart McMaster university

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester III

KU03DSCMAT201 CALCULUS II

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
3	CORE	200	KU03DSCMAT201	4	60

<table>
<tr><td colspan="2">Learning Approach (Hours/ Week)</td><td colspan="3">Marks Distribution</td><td rowspan="2">Duration of ESE (Hours)</td></tr>
<tr><td>Lecture</td><td>Tutorial</td><td>CE</td><td>ESE</td><td>Total</td></tr>
<tr><td>4</td><td>1</td><td>50</td><td>50</td><td>100</td><td>3Hrs</td></tr>
</table>

Course Objectives: To provide students with a solid understanding of fundamental calculus concepts and techniques, preparing them for more advanced topics in calculus and their applications in science, engineering, and other disciplines.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Become proficient in finding derivatives using various techniques such as the power rule, product rule, quotient rule, chain rule, and implicit differentiation
CO2	Deepen their understanding of the derivative as a measure of instantaneous rate of change
CO3	Learn how to apply differentiation to solve problems in optimization, related rates, curve sketching, and motion
CO4	Teaching these sections would prepare students for more advanced topics in calculus, including techniques of integration, applications of integration, differential equations, and multivariable calculus

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Quick re-visit of 3.1 and 3.2, Differentiation Rules, The Derivative as a Rate of Change, Derivatives of Trigonometric Functions, The Chain Rule (Sections 3.3 to 3.6 of the text book)

Module 2: Implicit Differentiation, Derivatives of Inverse Functions and Logarithms, Inverse Trigonometric Functions, Extreme Values of Functions, (Sections 3.7,3.8,3.9 ,4.1 of the text book)

Module 3: The Mean Value Theorem, Monotonic Functions and the First Derivative Test, Concavity and Curve Sketching, Indeterminate Forms and L'Hôpital's Rule, Antiderivatives (Sections 4.2 to 4.5 and 4.8 of the text book)

Module 4: Area and Estimating with Finite Sums, Sigma Notation and Limits of Finite Sums, The Definite Integral,The Fundamental Theorem of Calculus (Sections 5.1,5.2.5.3 and 5.4 of the text book)

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

<u>**Text Book**</u>: Thomas' Calculus Early Transcendentals (Thirteenth Edition)

<u>**References:**</u>

1. Anton, Bivens and Davis, John: Calculus single variable 10th edition, Wiley and sons, Inc. (2012).

2. Tom M. Apostol: Calculus, Vol I (Second Edition), Wiley Student Edition, (2006).

3. N. Piskunov, M.I.R. Publisher, Differential and Integral Calculus, (Vol: I), (1977).

4. A Course in Calculus and Real Analysis, Ghorpade Sudhir, Limaye Balmohan V., Springer International Edition, (2006).

5. George B. Thomas and Ross L. Finney: Calculus and Analytic Geometry. Pearson Education India; 9th edition, (2010

6.Calculus: Soo T Tan Brooks/Cole, Cengage Learning (2010) ISBN: 978-0-534-46579-7

7. Calculus early Transcendentals sixth edition James Stewart McMaster University

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU03DSCMAT202 DIFFERENTIAL EQUATIONS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
3	CORE	200	KU03DSCMAT202	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: Is to provide students with a solid foundation in the theory and techniques of ordinary differential equations, preparing them to tackle more advanced topics in differential equations and their applications in science, engineering, and other fields.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Learn what an ODE is, what it means by its solution
CO2	Learn how to classify DEs, what it means by an IVP and so on
CO3	Learn to solve DEs that are in linear, separable and in exact forms
CO4	Learn toanalyze the solution

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓		✓
CO2	✓	✓	✓		✓
CO3	✓	✓	✓		✓
CO4	✓	✓	✓		✓

COURSE CONTENTS

Module1: Some Basic Mathematical Models; Direction Fields, Solutions of Some Differential Equations, Classification of Differential Equations, Linear Equations; Method of Integrating Factors, Separable Equations, Modeling with First Order Equations, (Sections 1.1 to1.3 and 2.1, 2.2 ,2.3, of text book)

Module 2: Differences Between Linear and Nonlinear Equations, Exact Equations and Integrating Factors, The Existence and Uniqueness Theorem (proof omitted), (Sections 2.4, 2.6, 2.8 of text book)

Module 3: Homogeneous Equations with Constant Coefficients, Solutions of Linear Homogeneous Equations: The Wronskian, Complex Roots of the Characteristic Equation, Repeated Roots; Reduction of Order, Nonhomogeneous Equations; Method of Undetermined Coefficients, Variation of Parameters, (Sections 3.1, 3.2,3.3, 3.4, 3.5, 3.6 of text book)

Module 4 Definition of the Laplace Transform, Solution of Initial Value Problems, Step Functions, Fourier series, The Fourier convergence theorem, Even and odd functions (Sections 6.1,6.2 and 6.3, 10.2, 10.3, 10.4 of Text book)

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

<u>Text Book</u>: Elementary Differential Equations and Boundary Value Problems (Ninth Edition) -William E. Boyce and Richard C. DiPrima -John Wiley & Sons, Inc.

<u>Reference Books:</u>

1. Dennis G Zill &Michael R Cullen: Differential Equations with Boundary Value Problems(7/e): Brooks /Cole Cengage Learning (2009) ISBN: 0-495-10836-7.

2. R Kent Nagle, Edward B. Saff & Arthur David Snider: Fundamentals of Differential Equations(8/e) Addison-Wesley (2012) ISBN: 0-321-74773-9.

3. C. Henry Edwards &David E. Penney: Elementary Differential Equations (6/e) Pearson Education, Inc. New Jersey (2008) ISBN 0-13-239730-7

4. John Polking, Albert Boggess & David Arnold: Differential Equations with Boundary Value Problems(2/e) Pearson Education, Inc New Jersey (2006) ISBN 0-13-186236-7.

5. Henry J. Ricardo: A Modern Introduction to Differential Equations(2/e) Elsevier Academic Press (2009) ISBN: 978-0-12-374746-4.

6. James C Robinson: An Introduction to Ordinary Differential Equations Cambridge University Press (2004) ISBN: 0-521-53391-0.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU03DSCMAT203NUMBER THEORY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
3	CORE	200	KU03DSCMAT203	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course objectives: The aim of the course is to give an introduction to basic concepts of elementary number theory with minimal prerequisites. It starts from the very elementary topic such as integers, its factorization, congruence relations and basic but fundamental theorems of number theory.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Basic theory of integers, divisibility of integers, prime numbers and unique factorization of integers into prime numbers which are fundamental for various concepts from advanced algebras
CO2	Understand the concepts of linear Diophantine equations and congruence relations between integers which serves as an equivalence relation in the algebra structure of integers
CO3	Students would learn a specific class of congruences known as linear congruences and basic but fundamental theorems such as Fermat and Wilson Theorems
CO4	The students will understand some number theoretic functions such as divisor function, Euler's function which counts the number of divisors of an integer and some properties of divisors.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓		✓
CO2	✓	✓	✓		✓
CO3	✓	✓	✓		
CO4	✓	✓	✓		

COURSE CONTENTS

Module 1: Integers, Contents Unique Factorization (Sections 1, 2 of the text book).

Module 2: Linear Diophantine Equations, Congruences (Sections 3,4 of the text book).

Module 3: Linear Congruences, Fermat's and Wilson's Theorems (Sections 5,6 of the text book).

Module 4: The Divisors of an Integer, Perfect Numbers, Euler's Theorem and Function (Sections 7,8 and 9 of the text book)

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: Elementary Number Theory (Second edition) – Underwood Dudley - W. H. Freeman and company, New York

References:

1. David M Burton, Elementary Number theory, 7th edition, Mc Graw Hill.

2. T.M. Apostol, Introduction to Analytic Number Theory, Springer.

3. N. Koblitz, A Course in Number theory and Cryptography (2nd edition), Springer.

4. George E Andrews: Number Theory, Dover Publications (1971).

5. Andre Weil - Basic Number Theory (3rd edn.) Springer-Verlag (1974)

6. Grosswald, E. - Introduction to Number Theory Brikhauser (2nd edition) 1984.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU03DSCMAT204NUMERICAL ANALYSIS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
3	CORE	200	KU03DSCMAT204	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The objective of numerical analysis is to provide techniques and algorithms to find approximatenumerical solution to problems in several areas of mathematics where it is impossible or hard to findthe actual/closed form solution by analytical methods and also to make an error analysis to ascertainthe accuracy of the approximate solution

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Understand several methods such as bisection method, fixed point iteration method, regula falsi method etc. to find out the approximate numerical solutions of algebraic and transcendental equations with desired accuracy
CO2	Understand the concept of interpolation and also learn some well-known interpolation techniques
CO3	Understand a few techniques for numerical differentiation and integration and also realizetheirmeritsanddemerits
CO4	Find out numerical approximations to solutions of initial value problems and also to understand the efficiency of various methods.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓		✓		✓
CO2	✓		✓		✓
CO3	✓		✓		✓

CO4	✓		✓		✓

COURSE CONTENTS

Module 1: TheBisectionMethod, Fixed-PointIteration,Newton’sMethodandItsExtensions-Newton’sMethod(Newton-Raphson method), Convergence using Newton’s Method, The Secant Method,TheMethodof FalsePosition, : Error Analysis for Iterative Methods- Order of Convergence, linear and quadratic convergence, Multiple Roots, Modified Newton’s method for faster convergence [Algoritham omitted]

(Sections 2.1 to 2.4 of the Text book).

Module 2: Interpolation and the Lagrange Polynomial- motivation, Lagrange Interpolating Polynomials, error bound, Data Approximation and Neville’s Method- motivation, Neville’s Method,recursive method to generate Lagrange polynomial approximations,Divided Differences- k^{th} divided difference, Newton’s divided difference formula, Forward Differences, Newton Forward-Difference Formula, Backward Differences, Newton Backward–Difference Formula, Centered Differences, Stirling’s formula [Algoritham omitted] (Sections 3.1 to 3.3 of the Text book).

Module 3: NumericalDifferentiation-approximation of first derivative by forwarddifferenceformula,backwarddifferenceformula,Three-PointFormulas,Three-PointEndpointFormula,Three-PointMidpointFormula[Five-PointFormulas,Five-PointEndpointFormula,Five-PointMidpointFormulaomitted]SecondDerivativeMidpointFormulatoapproximatesecondderivative,Round-OffErrorInstability. Elements of Numerical Integration-numerical quadrature, The Trapezoidal Rule, Simpson’s Rule, Measuring Precision, Closed Newton- Cotes Formulas, Simpson’s Three-Eighths rule, Open Newton-Cotes Formulas. CompositeNumericalIntegration-compositeSimpson’srule,composite trapezoidalrule,compositemidpointrule,roundofferrorstability (Sections 4.1, 4.3 and 4.4 of the Text book).

Module 4: Gaussian Quadrature-motivation, Legendre Polynomial, Gaussian Quadrature on Arbitrary Intervals [Algoritham omitted], The Elementary Theory of Initial-Value Problems, Euler’s Method-derivation using Taylor formula, Error bounds for EulerMethod. Higher-OrderTaylorMethods-local truncation error,Taylor method ofordernandorderoflocaltruncation error, Runge-Kutta Methods- only Mid-Point Method, Modified Euler’s Method and Runge-Kutta Method of Order Four are required. [derivation of formula omitted in each case] (Sections 4.7, 5.1 to 5.4 of the Text book).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in

Reference 1.

Text Book: Numerical Analysis (10/e): Richard L. Burden, J Douglas Faires, Annette M. Burden Brooks/Cole Cengage Learning (2016) ISBN:978-1-305-25366-7.

Reference Books:

1. KendallE.Atkinson,WeiminHan:ElementaryNumericalAnalysis(3/e) JohnWiley&Sons (2004)ISBN:0-471-43337-3[IndianEditionbyWileyIndiaISBN:978-81-265-0802-0].

2. JamesF. Epperson:AnIntroduction to Numerical Methods and Analysis(2/e)JohnWiley&Sons (2013) ISBN:978-1-118-36759-9.

3.SSSastri: IntroductoryMethodsofNumericalAnalysis(5/e)PHILearningPvt.Ltd. (2012)ISBN:978-81-203-4592-8.

4.TimothySauer:NumericalAnalysis(2/e)Pearson(2012)ISBN:0-321-78367-0.

TEACHING LEARNING STRATEGIES

●Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

●Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester IV

KU04DSCMAT201 CALCULUS III

Semester	Course Type	Course Level	Course Code	Credits	Total Hours

4	CORE	200	KU04DSCMAT201	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The objective is to introduce students to more advanced integration techniques beyond the basic methods covered earlier

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	**Course Outcomes**
CO1	Students would develop a deeper understanding of integration techniques such as integration by parts, trigonometric substitution, partial fractions, and integration involving trigonometric, exponential, and logarithmic functions
CO2	Will get a thorough knowledge about sequences and series also about their convergence
CO3	Teaching these sections would help students enhance their problem-solving skills by providing them with opportunities to apply advanced integration techniques to solve complex problems in various contexts, including physics, engineering, economics, and other fields.
CO4	Would equip students with advanced calculus knowledge and skills, preparing them for further study in mathematics, science, engineering, and other fields, as well as for careers that require strong analytical and problem-solving abilities

Mapping of COs to PSOs

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Volumes Using Cross-Sections, Volumes Using Cylindrical Shells, Arc Length, Areas of Surfaces of Revolution (Sections ,6.1, 6.2,6.3 and 6.4 of the text book).

Module 2: The Logarithm Defined as an Integral, Hyperbolic Functions, Using Basic Integration Formulas, Integration by Parts (Sections 7.1,7.3,8.1 and 8.2 of the text book).

Module 3: Trigonometric Integrals**,** Trigonometric Substitutions, Integration of Rational Functions by Partial Fractions, Improper Integrals (Sections 8.3,8.4,8.5, and 8.8 of the text book).

Module 4: Sequences,Infinite Series**,** Convergence of series; the integral test, comparison test, absolute convergence (Sections 10.1,10.2 ,10.3,10.4 and 10.5, of the text book).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: Thomas' Calculus Early Transcendentals (Thirteenth Edition).

Reference Books:

1. Anton, Bivens and Davis, John: Calculus single variable 10th edition, Wiley and sons, Inc. (2012).
2. Tom M. Apostol: Calculus, Vol I (Second Edition), Wiley Student Edition, (2006).
3. N. Piskunov, M.I.R. Publisher, Differential and Integral Calculus, (Vol: I), (1977).
4. A Course in Calculus and Real Analysis, Ghorpade Sudhir, Limaye Balmohan V., Springer International Edition, (2006).
5. George B. Thomas and Ross L. Finney: Calculus and Analytic Geometry. Pearson Education India; 9th edition, (2010
6. Calculus: Soo T Tan Brooks/Cole, Cengage Learning (2010) ISBN: 978-0-534-46579-7
7. Calculus early Transcendentals sixth edition James Stewart McMaster University

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 arks

KU04DSCMAT202 INTRODUCTION TO GRAPH THEORY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
4	CORE	200	KU04DSCMAT202	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: Is to provide strong basic foundation in Graph Theory.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students would gain a solid understanding of the fundamental concepts of graph theory, including definitions of graphs, vertices, edges, and the basic properties of graphs.
CO2	Students would learn different ways to represent graphs, including adjacency matrices, incidence matrices, and graph drawings. They would understand the advantages and limitations of each representation method
CO3	Students would become familiar with basic graph properties such as degree, degree sequences, and walks in graphs. They would learn to identify special types of graphs such as complete graphs, cycles, trees, and bipartite graphs.
CO4	Students would learn about graph connectivity, including connected graphs, components, and cut vertices/edges. They would study paths, cycles, and Eulerian and Hamiltonian paths in graphs

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1 - An Introduction to Graphs**;** The Definition of a graph, Graphs as models, more definitions, Vertex Degrees, Sub graphs (Theorems omitted). (Sections 1.1, 1.2, 1.3, 1.4, 1.5of the Text).

Module 2 - Trees and connectivitymatrix representation of graphs; Paths and Cycles, Definition of trees and simple properties, Bridges, (Sections 1.6, ,1.7, 2.1, 2.2 of the Text).

Module 3- Euler Tour and Hamiltonian cycles;Spanning trees, Cut vertices and connectivity**.** Euler tours (Excluding Fleury's algorithm) (Sections 2.3,2.6, 3.1, of the Text).

Module 4 - The Chinese Postman Problem, Hamiltonian Graphs, The Travelling salesman Problem (Algorithm Omitted), Plane and planar Graphs. (Sections 2, 3.2, 3.3, 3.4,5.1 of the Text).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text book: J. Clark and D.A. Holton, A First Look at Graph Theory, Allied Publishers.

Reference Books:

R. Balakrishnan and K. Ranganathan, A Text Book of Graph Theory (2nd edition), Springer.
J.A. Bondy and U.S.R. Murthy, Graph Theory with Applications, Macmillan.
F. Harary, Graph Theory, Narosa.
K.R. Parthasarathy, Basic Graph Theory, Tata-McGraw Hill.
G. Chartrand and P. Zhang, Introduction to Graph Theory, Tata McGraw Hill.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU04DSCMAT203 LINEAR ALGEBRA I

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
4	CORE	200	KU04DSCMAT203	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: Students will able to apply concepts from calculus and linear algebra to solve problems involving geometric objects in three-dimensional space. They will interpret and analyze relationships between vectors, lines, planes, and surfaces, demonstrating the connection between calculus and linear algebra in spatial contexts.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	**Course Outcomes**
CO1	Demonstrate proficiency in three-dimensional coordinate systems and vectors, including representing points and vectors in space, computing distances and magnitudes, and applying the dot product to calculate angles and projections.
CO2	Develop skills in using the cross product to compute vector products and geometric applications
CO3	Acquire knowledge of vector spaces and subspaces, including understanding concepts of null spaces and column spaces associated with matrices. They will analyze linear transformations and their properties, including injectivity, subjectivity, and linearity
CO4	Demonstrate proficiency in identifying and working with linearly independent sets and bases of vector spaces. They will be able to determine coordinate systems and represent vectors as linear combinations of basis vectors.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Three-Dimensional Coordinate Systems, Vectors and The Dot Product (Sections 12.1, 12.2, 12.3 of the Text book 1).

Module 2: The Cross Product, Lines and Planes in Space and Cylinders and Quadric Surfaces (Sections 12.4, 12.5, 12.6 of the text book 1).

Module 3: Vector Spaces and Subspaces Null Spaces, Column Spaces, and Linear Transformations

(Sections 4.1 and 4.2 of the Text Book 2).

Module 4: Linearly Independent Sets; Bases and Coordinate Systems (Sections 4.3 and 4.4 of the text book 2).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

<u>**Text Books:**</u>

1. Thomas Calculus 13Th Edition, George B. Thomas, Maurice D. Weir, Joel Hass, publisher: Pearson Education.

2. Linear Algebra and its Applications, David C Lay, Stephen R Lay and Judi J. McDonald, 5^{th} edition, Publisher: Pearson.

Reference Books:

1. Serge A Lang: Linear Algebra; Springer.

2. Paul R Halmos Finite-Dimensional Vector Spaces; Springer 1974.

3. Thomas W. Hungerford: Algebra; Springer 1980.

4. S H Fried Berg, A J Insel and L E Spence: Linear algebra, Pearson, fifth edition.

5. N H McCoy& T R Berger: Algebra-Groups, Rings & Other Topics: Allyn & Bacon.

6. S. Axler Linear Algebra Done right, Springer.

TEACHING LEARNING STRATEGIES

●Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

●Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU04DSCMAT204 VECTOR VALUED FUNCTIONS AND MULTIVARIABLE CALCULUS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
4	CORE	200	KU04DSCMAT204	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: Studying this course provide students with a solid foundation in multivariable calculus, preparing them for further studies in mathematics, physics, engineering, and other fields where multivariable calculus is applied.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students should be able to define and work with vector functions, understanding their representation and properties.
CO2	Students should be able to compute derivatives and integrals of vector-valued functions, including finding tangent vectors, normal vectors, and curvature.
CO3	Students should understand the concept of tangent planes to surfaces and how to compute them.
CO4	Students should be able to compute double and triple integrals over rectangular and non-rectangular regions.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	
CO2	✓	✓	✓	✓	
CO3	✓	✓	✓	✓	
CO4	✓	✓	✓	✓	

COURSE CONTENTS

Module 1: Curves in Space and Their Tangents, Integrals of Vector Functions; Projectile Motion,Arc Length in Space,Curvature and Normal Vectors of a Curve (Sections 13.1 to 13.4 of the Text Book)

Module 2: Tangential and Normal Components of Acceleration, Velocity and Acceleration in Polar Coordinates,Functions of Several Variables,Limits and Continuity in Higher Dimensions (Sections 13.5 to 14.2 of the Text Book)

Module 3: Partial Derivatives,The Chain Rule, Directional Derivatives and Gradient Vectors,Tangent Planes and Differentials (Sections 14.3 to 14.6 of the Text Book)

Module 4: Extreme Values and Saddle Point,Double and Iterated Integrals over Rectangles,Double Integrals over General Regions,Area by Double Integration (Sections14.7, 15.1 to 15.3 of the Text Book)

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: Thomas Calculus 13Th Edition, George B. Thomas, Maurice D. Weir, Joel Hass, publisher: Pearson Education

Reference Books:

1. Calculus: Soo T Tan Brooks/Cole, Cengage Learning (2010) ISBN: 978-0-534-46579-7.

2. Calculus early Transcendentals sixth edition James Stewart McMaster University.

TEACHING LEARNING STRATEGIES

●Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

●Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester V

KU05DSCMAT301ALGEBRA I

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	CORE	300	KU05DSCMAT301	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: This course starts with the structure of binary structure on a set. The aim of the course is to introduce the very basics of group theory starting from sets and binary operations. We focus more on exercise solving from each section.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	The student should able to be familiar with binary structures on a set
CO2	The student should able to be familiar with the notions of groups, subgroups, cyclic groups.
CO3	The student should able to be familiar with Symmetric group and its structure
CO4	The student should able to be familiar with the direct product of groups and the classification of finitely generated abelian groups.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Sets and Relations, Introduction and Examples, Binary Operations, Isomorphic Binary Structures (Sections 0,1,2,3).

Module 2: Groups, Subgroups, Cyclic Groups, Generating Sets and Cayley Digraphs (Sections 4, 5, 6 and 7).

Module 3: Groups of Permutations, Orbits, Cycles and the Alternating Groups, Cosets and the Theorem of Lagrange (Sections 8, 9, and 10).

Module 4: Direct Products and Finitely Generated Abelian Groups (Section 11).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: J. B. Fraleigh – A First Course in Abstract Algebra- Narosa (7th edn., 2003)

Reference Books:

1. Abstract Algebra, David S Dummit, Richard M Foote, John Wiley & Sons, Inc, 3rd Edition.

2. I.N. Herstein – Topics in Algebra- Wiley Eastern.

3. J.A.Gallian – Contemporary Abstract Algebra.

4. Hoffman & Kunze – Linear Algebra – Prentice Hall.

5. M. Artin, Algebra, Prentice Hall, 1991.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU05DSCMAT302 COMPLEX ANALYSIS I

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	CORE	300	KU05DSCMAT302	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course objectives: The goal of this course is to give an introduction to the field of complex numbers, its representation in the plane, basic algebraic and topological properties, functions of one complex variable, analyticity of complex functions, and properties of some particular complex functions.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Understand field of complex numbers, its representation in the plane, basic algebraic and topological properties
CO2	Understand functions of one complex variable, limit of complex functions and basic limit theorems.
CO3	Students would learn differentiability of complex functions, Cauchy Riemann Equations and the sufficient conditions for differentiability.

CO4	The students will understand the important concept of analyticity of complex functions, examples, Harmonic functions and its connection with analyticity and some class of complex functions and some identities involving them.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Sums and products, Basic Algebraic Properties, Further Properties, Vectors and Moduli, Complex conjugates, Exponential Form, Products and Power in Exponential Form, Argument of Products and Quotients, Roots of Complex Numbers, Examples, Regions in the Complex plane. (Sections 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 and 11 of the text book).

Module 2: Functions of Complex Variable, Mappings, Mappings by the Exponential Function, Limits, Theorems of Limits, Limits Involving the Point at Infinity. (Sections 12, 13, 14, 15, 16 and 17 of the Text book).

Module 3: Continuity, Derivatives and Differentiation Formulas. Cauchy-Riemann Equations, Sufficient Conditions for Differentiability, Polar Coordinates. (Sections 18, 19, 20, 21, 22 and 23 of the text book).

Module 4: Analytic Functions, Examples and Harmonic Functions. The Exponential Function, The Logarithmic Function, Some Identities Involving Logarithms, Complex Exponents, Trigonometric Functions Hyperbolic Functions Inverse Trigonometric and Hyperbolic functions. (Sections 24, 25, 26, 29, 30, 32, 33, 34 and 35 of the text book).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: J. W. Brown and R. V. Churchill, Complex Variables and Applications (8th Edition), Mc Graw -Hill, (2009).

Reference Books:

1.Conway J.B. – Functions of One Complex Variable I – Second edition, Springer international student edition.

2. J. W. Brown and R. V. Churchill, Complex Variables and Applications (8th Edition), McGraw-Hill, (2009).

3. W. Rudin: Real and Complex Analysis (3rd Edn.); Mc Graw- Hill International Editions; 1987.

4. E.T.Copson – An Introduction to the Theory of Complex Variables – Oxford.

5. S Lang - Complex Analysis, Fourth Edition, Graduate texts in Mathematics 103, Springer, Second Indian Reprint 2013.

6. Herb Silverman - Complex Variables, Houghton Mifflin Co., 1975.

7. Kunhiko Kodaidra - Complex Analysis, Cambridge studies in Advanced Mathematics 107, 2007.

8. S Ponnusami - Foundations of Complex Analysis, Second Edition, Narosa.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU05DSCMAT303 LINEAR ALGEBRA II

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	CORE	300	KU05DSCMAT303	4	60

Learning Approach (Hours/	Marks Distribution	Duration of ESE

Week)					(Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The objective of teaching this course would be to equip students with the mathematical tools and concepts necessary for further study in linear algebra, as well as applications in various fields such as engineering, physics, computer science, and economics.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students will demonstrate proficiency in understanding the concept of dimension of a vector space, including determining the dimension of subspaces and applying the rank-nullity theorem. They will be able to compute the rank of matrices and relate it to the solutions of linear systems
CO2	Students will develop skills in performing change of basis in vector spaces, including finding transition matrices between different bases and representing vectors in new coordinate systems. They will apply change of basic techniques to solve problems involving linear transformations
CO3	Students will acquire knowledge of eigenvectors and eigenvalues of matrices, including computing eigenvalues and corresponding eigenvectors. They will apply eigenvalue-eigenvector theory to diagonalize matrices and solve systems of linear differential equations
CO4	Students will demonstrate the ability to find characteristic equations of matrices and use them to compute eigenvalues. They will apply the concept of diagonalization to transform matrices into diagonal form using eigenvectors and eigenvalues.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: The Dimension of a Vector Space and Rank (Sections 4.5 and 4.6 of the text book) .

Module 2: Change of Basis and supplementary exercises (Section 4.7 of the text book).

Module 3: Eigenvectors and Eigenvalues and The Characteristic Equation (Sections 5.1 and 5.2 of the text book).

Module 4: Diagonalization, Eigen vectors and Linear Transformations (Section 5.3 and 5.4 of the text Book).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: Linear Algebra and its Applications, David C Lay, Stephen R Lay and Judi J. McDonald, 5th edition, Publisher: Pearson

Reference Books:

1. Serge A Lang: Linear Algebra; Springer.

2. Paul R Halmos Finite-Dimensional Vector Spaces; Springer 1974.

3. Thomas W. Hungerford: Algebra; Springer 1980.

4.S H Fried Berg, A J Insel and L E Spence: Linear algebra, Pearson, fifth edition.

5. N H McCoy& T R Berger: Algebra-Groups, Rings & Other Topics: Allyn & Bacon.

6. S. Axler Linear Algebra Done right, Springer.

TEACHING LEARNING STRATEGIES

●Lecturing, Demonstration, Digital Learning, Team Work.

MODE OF TRANSACTION

●Lecture, Seminar, Discussion.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU05DSCMAT304 REAL ANALYSIS I

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	CORE	300	KU05DSCMAT304	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The primary goal is for students to develop a deep understanding of the fundamental concepts of real analysis. This includes concepts such as sequences, series, limits, and convergence.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	The students will understand the construction of real numbers, properties of order, and algebraic properties. Additionally, students would learn about sets, set operations, and basic set theory.
CO2	Students would learn about sequences of real numbers, including convergence, divergence, and limits of sequences

CO3	The students will understand the concept of a limit of a sequence and to be able to determine convergence or divergence using various convergence tests
CO4	Throughout these sections, the objective is to develop students' skills in reading and writing mathematical proofs

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Sets and Functions, Mathematical Induction, Finite and Infinite Sets, The Algebraic and Order Properties of R. (Sections 1.1, 1.2, 1.3, 2.1, of Text book 1).

Module 2: Absolute Value and Real Line, The completeness Property of R, Applications of the Supremum Property, Intervals (Sections 2.2,2.3 2.4, 2.5, of Text book).

Module 3: Sequences and Their Limits, Limit Theorems, Monotone Sequences, Subsequences and the Bolzano-Weierstrass Theorem, (Sections 3.1, 3.2, 3.3, 3.4, of Text book).

Module 4: The Cauchy Criterion, Properly Divergent Sequences, Introduction to Series, (Sections 3.5, 3.6 3.7, of Text book).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: R.G. Bartle and D.N. Sherbert, Introduction to Real Analysis, Third Edition, John Wiley & Sons (2000).

Reference books:

1. G.B Folland: A Guide to Advanced Real Analysis- Mathematical Association of America Publishing.

2. Elias M. Stein, Rami Shakarchi: REAL ANALYSIS Measure Theory, Integration, and Hilbert Spaces Princeton University press.

3. Kenneth A. Ross Elementary Analysis the Theory of Calculus Springer-Verlag, New York, 2013.

4. Andrew M. Bruckner, Judith B. Bruckner, Brian S. Thomson Real analysis Prentice-Hall, 2001.

5. Sterling K. Berberian Fundamentals of Real Analysis Springer-Verlag, New York 1999.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Electives for 5th Semester

KU05DSEMAT301 INTRODUCTION TO GEOMETRY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	ELECTIVE	300	KU05DSEMAT301	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The main objective of this course is ideally be that students gain a solid understanding of basic geometric concepts, develop skills in logical reasoning and geometric proofs, and are able to apply these concepts to solve problems in geometry.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students should be able to define and identify basic geometric terms such as points, lines, planes, angles, and geometric figures.
CO2	Students should be able to identify and apply the properties of lines, angles, and their relationships, including parallel lines and transversals, angle properties, and theorems related to intersecting lines.
CO3	Students should develop skills in logical reasoning and geometric proofs. They should be able to apply deductive reasoning to prove geometric theorems and solve geometric problems.
CO4	Students should be able to apply geometric concepts and principles to solve problems in various contexts, including real-world applications and mathematical puzzles.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1		✓	✓	✓	✓
CO2		✓	✓	✓	✓
CO3		✓	✓	✓	✓
CO4		✓	✓	✓	✓

COURSE CONTENTS

Module 1: ConicSections, Focus-Directrix Definition of the Non-Degenerate Conics, FocalDistancePropertiesofEllipseandHyperbola, PropertiesofConics, PropertiesofConics (Sections 1.1.1,1.1.3,1.1.4,1.2 and 1.3 of the Text Book).

Module 2: Geometry and Transformations -Whatis Euclidean Geometry?

AffineTransformationsandParallelProjections-AffineTransformations, PropertiesofAffineTransformations, (Sections 2.1,2.2 and 2.3 of the Text Book).

Module 3: UsingtheFundamentalTheoremofAffineGeometry (sub section 2.4.4 omitted), UsingtheFundamentalTheoremofAffineGeometry, Perspective (Sections 2.4,2.5 and 3.1 of the Text Book).

Module 4: TheProjectivePlane$\mathbb{RP}^2$, Projective Transformations, Using the Fundamental Theorem of Projective Geometry (Sections 3.2, 3.3 and 3.4 of the Text Book).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: Geometry(2/e):DavidABrannan,MathewFEspen,JeremyJ GrayCambridgeUniversity Press (2012)ISBN:978-1-107-64783-1

Reference Books:

1. GeorgeAJennings:ModernGeometrywithApplicationsUniversity text,Springer (1994)ISBN:0-387-94222-X

2. Walter Meyer: Geometry (2006) ISBN:0-12-369427-0 and its Application(2/e) Elsever, Academic Press

3. JudithNCederberg: ACourseinModernGeometries(2/e)UTM,Springer(2001)ISBN:978-1-4419-3193-1

4. PatricJRyan:EuclideanandNon- Euclidean Geometry-AnAnalyticApproach CambridgeUniversityPress,InternationalStudentEdition(2009)ISBN:978-0-521-12707-3

5. Michele Audin: Geometry University text, Springer (2003) ISBN:3-540-43498-4

TEACHING LEARNING STRATEGIES

● Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

● Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU05DSEMAT302 MULTIPLE INTEGRALS AND VECTOR INTEGRATION

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	ELECTIVE	300	KU05DSEMAT302	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The objective of teaching this course is to deepen students' understanding of calculus and its applications, equip them with advanced techniques for solving mathematical problems, and prepare them for further studies in mathematics, science, engineering, or related disciplines.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	The goal is for students to become proficient in integrating a wide range of functions using different methods.
CO2	Students would learn how to identify and compute improper integrals and understand the convergence or divergence of such integrals
CO3	Students would learn how to represent curves using polar coordinates, find derivatives and integrals in polar coordinates, and understand the relationship between polar and Cartesian coordinates.

CO4	The objective would be for students to understand vector concepts and their applications in physics, engineering, and other fields.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	
CO2	✓	✓	✓	✓	
CO3	✓	✓	✓	✓	
CO4	✓	✓	✓	✓	

COURSE CONTENTS

Module 1: Double Integrals in Polar Form, Triple Integrals in Rectangular Coordinates, Triple Integrals in Cylindrical and Spherical Coordinates**,** Substitutions in Multiple Integrals (Sections 15.4,15.5,15.7 and 15.8 of the Text Book).

Module 2: Line Integrals, Vector Fields and Line Integrals: Work, Circulation, and Flux, Path Independence, Conservative Fields, and Potential Functions (Sections 15.4,15.5,15.7 and 15.8 of the Text Book).

Module 3: Green's Theorem in the Plane, Surfaces and Area, Surface Integrals (Sections 16.4,16.5,15.7 and 16.6 of the Text Book).

Module 4: Stokes' Theorem, The Divergence Theorem and a Unified Theory (Sections 16.7 and 16.8of the Text Book).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: Thomas' Calculus Early Transcendentals (Thirteenth Edition).

References:

1. Calculus: Soo T Tan Brooks/Cole, Cengage Learning (2010) ISBN: 978-0-534-46579-7

2. Calculus early Transcendentals sixth edition James Stewart McMaster university

TEACHING LEARNING STRATEGIES

●Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

●Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU05DSEMAT303 THEORY OF EQUATIONS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	ELECTIVE	300	KU05DSEMAT303	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The objective of teaching this course would be to provide students with a solid foundation in the theory and applications of equations, equip them with problem-solving skills, and prepare them for further studies in mathematics or related fields.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students might learn various methods for solving polynomial equations, including factoring, synthetic division, long division, and the use of the rational root theorem. The objective would be for students to become proficient in solving polynomial equations of different degrees.

CO2	Students might study equations in different contexts, including algebraic, geometric, and applied settings. The objective would be for students to understand how equations arise in various mathematical and real-world problems and how to formulate and solve them effectively.
CO3	Students might explore applications of equation theory in various fields, including physics, engineering, economics, and cryptography
CO4	The overarching objective might be to develop students' problem-solving skills by challenging them with a variety of equation-related problems and exercises.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	
CO2	✓	✓	✓	✓	
CO3	✓	✓	✓	✓	
CO4	✓	✓	✓	✓	

COURSE CONTENTS

Module 1: Integral rational functions or polynomials., Multiplication of polynomials, Division of polynomials, The remainder theorem, Synthetic Division, Horner's process, Taylor formula, Highest common divisor of two polynomials (Sections II.1 to II.8 of the Text Book).

Module 2: Algebraic equations, Identity theorem, The Fundamental theorem of Algebra, Imaginary roots of equations with real coefficients, Relations between roots and coefficients, Discovery of multiple roots (Sections III.1 to III.6 of the Text Book).

Module 3: Limits of roots, Method to find upper limit of positive roots, Limit for moduli of roots [only the method to find out upper limit from the auxiliary equation is required; derivation omitted] Integral roots, Rational roots (Sections IV.1 to IV.5 of the Text Book).

Module 4: What is the solution of an equation? Cardan's formulas, Discussion of solution irreducible case, Trigonometric solution, Solutions of biquadratic equations, Ferrari method[example 2 omitted] (Sections V.1 to V.6 of the Text Book).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: Theory of Equations: J V Uspensky McGraw Hill Book Company, Inc.

(1948) ISBN:07-066735-7

Reference Books:

1. DicksonL.E:ElementaryTheoryofEquationsJohnWileyandSons,Inc.NY(1914).
2. Turnbull H.W: Theory of Equations(4/e) Oliver and Boyd Ltd Edinburg (1947).

TEACHING LEARNING STRATEGIES

●Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

●Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester VI

KU06DSCMAT301 ALGEBRA II

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	CORE	300	KU06DSCMAT301	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: This course gradually moves to the core of abstract algebra. The objective of the course is to introduce an important concept of factor group and computations of various factor groups. This course also aims at introducing the theory of rings and fields which are the fundamental base for Galois theory.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Understand normal subgroups of a groups and can compute various factor groups. They also understand the concept of simple groups.
CO2	Understand the most general algebraic structure with two binary operations namely rings. Rings with more structure like integral domain, Fields are also studied.
CO3	Study one important class of rings, polynomial rings and factorization of polynomials which are fundamental in the Galois theory
CO4	Understand homomorphisms on rings and the concepts of ideals and factor rings. Students are introduced on solving number theoretic problems using the techniques of ring theory.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Homorphisms, Factor Groups, Factor Group Computations and Simple Groups (Sections 13, 14 and 15 of the text book).

Module 2: Rings and Fields, Integral Domains, Fermat's and Euler's Theorems (Sections 18, 19 and 20 of the text book)

Module 3: Rings of Polynomials, Factorization of Polynomials over a Field (Sections 22 to 23 of the text book)

Module 4: Homomorphisms and Factor Rings, Prime and Maximal ideals (Sections 26 and 27 of the text book)

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: J. B. Fraleigh – A First Course in Abstract Algebra- Narosa (7th edn., 2003)

Reference Books:

1. Abstract Algebra, David S Dummit, Richard M Foote, John Wiley & Sons, Inc, 3rd Edition.

2. I.N. Herstein – Topics in Algebra- Wiley Eastern

3. J.A.Gallian – Contemporary Abstract Algebra

4. Hoffman & Kunze – Linear Algebra – Prentice Hall

5. M. Artin, Algebra, Prentice Hall, 1991

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU06DSCMAT302 COMPLEX ANALYSIS II

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	CORE	300	KU06DSCMAT302	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course objectives: The one important goal of this course is to introduce the integration of complex valued functions across curves in the plane. Another important topic is the representation of analytic functions as power series.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	The integration of complex valued functions across curves in the plane and establishes the Cauchy – Goursat theorem of existence of anti-derivatives of complex functions
CO2	Understands the Cauchy integral formula of behavior integration along closed curves in the plane. Bounds of analytic functions are discussed and as an application Fundamental theorem of algebra is also discussed.

CO3	Students would learn sequences and series of complex numbers and special types of series such as Taylor and Laurent series which are important in the theory of analytic functions
CO4	The students will understand the power series of representation of analytic functions on simply connected domains and discusses the loss of analyticity at certain points known as singular points and behavior of functions at these points.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Derivatives of Functions w(t), Definite Integrals of Functions w(t), Contours, Con- tour Integrals, Some Examples. Upper Bounds for Moduli of Contour Integrals, Antiderivatives and Cauchy Goursat Theorem. (Sections 33, 37, 38, 39, 40, 41 43, 44, and 46 of the text book).

Module 2: Cauchy Integral Formula, An Extension of the Cauchy Integral Formula, Liouville's Theorem and the Fundamental Theorem of Algebra, Maximum Modulus Principle. (Sections 50, 51, 53 and 54 of the text book).

Module 3: Convergence of Sequences, Convergence of Series, Taylor Series, Examples, Laurent Series, Examples. (Sections 55, 56, 57, 59, 60 and 62 of Text book).

Module 4: Absolute and Uniform Convergence of Power Series, Continuity of Sums of Power Series, Integration and Differentiation of Power Series, Uniqueness of Series Representations, Multiplication and Division of Power Series, Isolated Singular Points and Residues Cauchy's Residue Theorem, Residue at Infinity. (Sections:63, 64, 65, 66, 67, 68, 69 and 71, of Text book).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

<u>Text Book</u> : J. W. Brown and R. V. Churchill, Complex Variables and Applications (8th Edition), McGraw-Hill,(2009).

<u>References Books:</u>

1. Conway J.B. – Functions of One Complex Variable I – Second edition, Springer international student edition.

1. J. W. Brown and R. V. Churchill, Complex Variables and Applications (8th Edition), Mcgraw-Hill,(2009).

2. W. Rudin: Real and Complex Analysis (3rd Edn.); Mc Graw- Hill International Editions; 1987

3. E.T.Copson – An Introduction to the Theory of Complex Variables – Oxford

4. S Lang - Complex Analysis, Fourth Edition, Grauate texts in Mathematics 103, Springer, Second Indian Reprint 2013.

5. Herb Silverman - Complex Variabies,Houghton Mifflin Co., 1975.

6. Kunhiko Kodaidra - Complex Analysis, Cambridge studies in Advanced Mathematics 107, 2007

7. S Ponnusami - Foundations of Complex Analysis, Second Edition, Narosa.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU06DSCMAT303 REAL ANALYSIS II

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	CORE	300	KU06DSCMAT303	4	60

Learning Approach (Hours/ Week)	Marks Distribution	Duration of ESE (Hours)

Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives:

To provide students with a deeper understanding of limit and continuity of functions, and basic concepts of differentiation. These sections build upon the foundational concepts introduced earlier in the text and prepare students for more advanced topics in real analysis and related areas of mathematics.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Able to find limit of a function at a given point
CO2	Able to check the continuity of a real valued function at a given point
CO3	Able to find the limit of quotient of functions
CO4	Learn point wise and uniform convergence

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: A quick review of (Limits of Functions, Limits Theorems, Some Extensions of Limit Concept). Continuous Functions, Combinations of Continuous Functions. (sections 4.1,4.2, 4.3, 5.1, 5.2, of Text book).

Module 2: Continuous functions on Intervals, Uniform Continuity, Continuity and Gauges, Monotone and Inverse functions (Sections5.3, 5.4, 5.5 and 5.6 of Text book).

Module 3: The Derivative, The Mean Value Theorem, L'Hospital Rules and Taylors Theorem (Sections 6.1, 6.2, 6.3 and 6.4 of Text book).

Module 4: Pointwise and Uniform Convergence, Interchange of Limits, The Exponential and Logarithmic Functions and Trigonometric Functions. (Sections 8.1, 8.2, 8.3 and 8.4 of Text book).

Module X: The Reimann integral, Chapter 7 of the text book

Text Book: R.G. Bartle and D.N. Sherbert, Introduction to Real Analysis, Third Edition, John Wiley & Sons (2000).

Reference books:

1. G.B Folland: A Guide to Advanced Real Analysis Mathematical Association of America Publishing.

2. Elias M. Stein, Rami Shakarchi: REAL ANALYSIS Measure Theory, Integration, and Hilbert Spaces Princeton University press.

3. Kenneth A. Ross Elementary Analysis the Theory of Calculus Springer-Verlag, New York, 2013.

4. Andrew M. Bruckner, Judith B. Bruckner, Brian S. Thomson Real analysis Prentice-Hall, 2001.

5. Sterling K. Berberian Fundamentals of Real Analysis Springer-Verlag, New York 1999.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

(Electives for 6th Semester)

KU06DSEMAT301 LINEAR PROGRAMMING

Semester	Course Type	Course	Course Code	Credits	Total Hours

		Level			
6	ELECTIVE	300	KU06DSEMAT301	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The objective of teaching this course is to equip students with a solid understanding of optimization theory and its applications, as well as the analytical skills necessary to formulate and solve optimization problems in diverse contexts.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students will be able to solve linear programming problems geometrically
CO2	Solve LP problems more effectively using Simplex algorithm *via*. the use of condensed tableau of A.W. Tucker
CO3	Understand duality theory, a theory that establishes relationships between linear programming problems of maximization and minimization
CO4	Solve transportation and assignment problems by algorithms that take advantage of the simpler nature of these problems

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓		✓	✓	
CO2	✓		✓	✓	
CO3	✓		✓	✓	
CO4	✓		✓	✓	

COURSE CONTENTS

Module 1 : Chapter1; Geometric Linear Programming: Profit Maximization and Cost Minimization, typical motivating examples, mathematical formulation, Canonical Forms for Linear Programming Problems, objective functions, constraint set, feasible solution, optimal solution , Polyhedral Convex Sets, convex set, extreme point, theorems asserting existence of optimal solutions, The Two Examples Revisited, graphical solutions to the problems, A Geometric Method for Linear Programming, the difficulty in the method, Concluding Remarks. Chapter2; The Simplex Algorithm:- Canonical Slack Forms for Linear Programming Problems; Tucker Tableaus, slack variables, Tucker tableaus, independent variables or non-basic variables, dependent variables or basic variables, .An Example: Profit Maximization, method of solving a typical canonical maximization problem. (Sections given in the Text book).

Module 2: The Pivot Transformation, The Pivot Transformation for Maximum and Minimum Tableaus, An Example: Cost Minimization, method of solving a typical canonical minimization problem, The Simplex Algorithm for Maximum Basic Feasible Tableaus, The Simplex Algorithm for Maximum Tableaus, Negative Transposition; The Simplex Algorithm for Minimum Tableaus, Cycling, Simplex Algorithm Anticycling Rules, Concluding Remarks. Chapter 3; Noncanonical Linear Programming Introduction, Unconstrained Variables, Equations of Constraint, Concluding Remarks (Sections given in the text book).

Module 3: Chapter 4; Duality Theory: - Duality in Canonical Tableaus, The Dual Simplex Algorithm, The Dual Simplex Algorithm for Minimum Tableaus, The Dual Simplex Algorithm for Maximum Tableaus, Matrix Formulation of Canonical Tableaus, The Duality Equation, The Duality Theorem, Concluding Remarks. (Sections given in the text book).

Module 4:Chapter 6; Transportation and Assignment Problems: - The Balanced Transportation Problem, The Vogel Advanced-Start Method (VAM), The Transportation Algorithm, Another Example, Unbalanced Transportation Problems, The Assignment Problem, The Hungarian Algorithm, Concluding Remarks, The Minimum-Entry Method, The Northwest-Corner Method (Sections given in the text book).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: Linear Programming and Its Applications: James K. Strayer Under-Graduate Texts in Mathematics Springer (1989) ISBN: 978-1-4612-6982-3.

Reference Books:

1. A. Ravindran, D.T. Philips and J.J. Solberg: Operations Research-Principles and Practices (2nd Edn.); John Wiley & Sons, 2000

2. G. Hadley: Linear Programming; Addison-Wesley Pub Co Reading, 1975.

3. Hamdy A. Taha: Operations Research-An Introduction, Prentice Hall of India, 2000.

4. H.S. Kasana and K.D. Kumar: Introductory Operations Research-Theory and Applications, Springer-Verlag, 2003.

5. James K. Strayer: Linear Programming and Its Applications,Under graduate Texts in Mathematics Springer (1989), Springer-Verlag, 2003.

6. R. Panneerselvam: Operations Research, PHI, New Delhi (Fifth printing), 2004

7. Robert J.Vanderbei: Linear Programming: Foundations and Extensions(2/e) Springer Science, Business Media LLC (2001) ISBN: 978-1-4757-5664-7

8. Frederick S Hiller, Gerald J Lieberman: Introduction to Operation Research(10/e) McGraw-Hill Education, 2 Penn Plaza, New York (2015) ISBN: 978-0-07-352345-3

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU06DSEMAT302 TOPOLOGY OF METRIC SPACES

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	ELECTIVE	300	KU06DSEMAT302	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The objective of teaching these chapters would be to equip students with a solid understanding of fundamental concepts in metric spaces and their applications, preparing them for more advanced studies in mathematics.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students would learn about metric spaces, basic definitions, and examples.
CO2	Students would learn the definitions and properties of open and closed sets in metric spaces. Students might learn about the relationships between these sets, as well as basic properties and examples.
CO3	Would learn the concept of topological spaces, which are generalizations of metric spaces where the notion of distance is replaced by a notion of closeness. Students might study basic definitions, topological properties, and examples of topological spaces
CO4	Would be to equip students with a solid understanding of fundamental concepts in metric spaces and their applications, preparing them for more advanced studies in Mathematics.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1:MetricSpaces,MetricSubspacesandMetricSuperspaces , Isometries,MetricsonProducts,:MetricsandNormsonLinearSpaces-[example1.7.8omitted], Distances from Points to Sets , Inequalities for Distances, Distances to Unions and Intersections 2.5: Isolated Points, Accumulation Points, Distances from Sets to Sets (Sections from Chapters1 and 2 of the Text book).

Module 2: Boundary Points, Sets with Empty Boundary, Boundary Inclusion, Closure and Interior, Inclusion of Closures and Interiors, Open and Closed Subsets, Dense Subsets, Topologies Topologies on Subspaces and Super spaces, Topologies on Product Spaces (Sections from Chapters 3 and 4 of the Text book).

Module 3: Open and Closed Balls, Using Balls,Definition of Convergence for Sequences, Limits, Convergence in Subspaces and Super spaces, Convergence Criteria for Interior and Closure, Convergence of Subsequences, Cauchy Sequences (Sections from Chapters5 and 6 of Text book).

Module 4: Bounded Sets, Spaces of Bounded Functions, Convergence and Boundedness, Uniform and Pointwise Convergence, Local Continuity, Global Continuity, Continuity of Compositions, Connected Metric Spaces, Connected Subsets, Connectedness and Continuity (Sections from Chapters7,8 and 11 of Text book).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text book:Metric Spaces:Mícheál Ó Searcóid Undergraduate Mathematics Series Springer-Verlag London Limited (2007) ISBN: 1-84628-369-8

Reference books:

1. S. Kumaresan, Topology of Metric Spaces, Alpha Science International Ltd, 2005.
2. Irving Kaplansky: Set Theory and Metric Spaces Allyn and Bacon,Inc. Boston(1972).
3. E.T.Copson: Metric Spaces Cambridge University Press(1968)ISBN:0 521 35732 2.
4. Wilson A Sutherland: Introduction to Metric and Topological Spaces(2/e) Oxford University Press (2009) ISBN:978-0-19-956308-1.
5. Mohamed A. Khamsi and William A. Kirk: An Introduction to Metric.
6. Spaces and Fixed-Point Theory John Wiley & Sons, Inc (2001) ISBN 0-471- 41825-0

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU06DSEMAT303 CRYPTOGRAPHY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	ELECTIVE	300	KU06DSEMAT303	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	

4	1	50	50	100	3Hrs

Course Objectives: The objective of teaching these chapters is to provide students with a solid foundation in both the theoretical principles and practical applications of cryptography, preparing them to understand, implement, and analyze cryptographic algorithms and protocols in various contexts, including communication security, data protection, and authentication

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students will gain a solid understanding of the fundamental principles of cryptography, including encryption, decryption, key generation, and cryptographic protocols.
CO2	Students will learn about classical encryption techniques such as substitution ciphers and transposition ciphers, as well as basic cryptanalysis techniques for breaking these ciphers
CO3	Students will become proficient in symmetric-key encryption algorithms, including block ciphers and stream ciphers, understanding their design principles, modes of operation, and practical implementations
CO4	Students will master public-key encryption algorithms such as RSA, ElGamal, and elliptic curve cryptography, including key generation, encryption, decryption, digital signatures, and the underlying mathematical principles

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Some Simple Cryptosystems; Introduction, The Shift Cipher, The Substitution Cipher, The Affine Cipher, The Vigenere Cipher, The Hill Cipher, The Permutation Cipher, Stream Ciphers (Section 1.1 of Chapter 1 in the Text).

Module 2: Shannon'sTheory; Introduction, Elementary Probability Theory, Perfect Secrecy, Entropy, Huffman Encodings and Entropy, Properties of Entropy, Spurious Keys and Unicity Distance, Product Cryptosystems (Chapter 2 in the Text).

Module 3: More on Number Theory; The Euclidean Algorithm, The Chinese Remainder Theorem, Other Useful Facts (Proof of Lagrange's theorem omitted), Legendre and Jacobi Symbols (Sections 5.2 and 5.4.1 of Chapter 5 in the Text).

Module 4: -The RSA System and Factoring ; Introduction to Public-key Cryptography, The RSA Cryptosystem, Implementing RSA, Primality Testing, The Solovay Strassen Algorithm, The Miller Rabin Algorithm, Square roots modulo *n* (Sections 5.1, 5.3, 5.4.2, 5.4.3, 5.5 of Chapter 5 in the Text).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book:

Douglas R. Stinson, Cryptography: Theory and Practice- Third Edition, CRC Press, 2006.

Reference Books:

1. David M. Burton, Elementary Number Theory- Seventh Edition, Mc Graw Hill.

2. William Stallings, Cryptography and Network Security Principles and Practices- Fourth Edition, Prentice Hall.

3. Christof Paar-Jan Pelzl, Understanding Cryptography- A Text for Students and Practitioners, Springer.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work.

MODE OF TRANSACTION

- Lecture, Seminar, Discussion.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester VII

KU07DSCMAT401 ALGEBRA III

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	CORE	400	KU070DSCMAT401	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The main goal of this course is to introduce and discuss some advanced topics in group theory. The main topic covered in this course is the Sylow theorems which provides a partial converse to the Lagrange's theorem. This course also introduces the generalization of direct products and some particular classes of groups which will establish an inclusion order among all groups.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	From the quick review of group theory, students can understand complete structure of subgroups of Dihedral groups, Symmetric groups and Quaternion groups.
CO2	Understand the concept of group actions and its application to counting problems occurs in real life.
CO3	Students would become proficient in understanding Sylow theorems and in finding whether a group is simple or not and there by classifying groups of finite order
CO4	They can understand generalizations of direct products and some special types of groups such as solvable and nilpotent groups.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓

CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Quick review of group theory (Sections 1.1 – 1.6, 2.1 – 2.5 of the text book).

Module 2: Quotient groups and homomorhisms – Definition and Examples, More on Cosets and Lagrange's Theorem, The Isomorphism Theorems, Composition Series and the Holder Program, Transpositions and the Alternation groups (Sections 3.1 – 3.5 of the text book).

Module 3: Group actions – Group actions and Permutation Representations, Groups Acting on Themselves by Left Multiplication – Cayley's Theorem, Grous Acting on Themselves by Conjugation – The class equation, Automorphisms, The Sylow Theorems, The Simplicity of A_n (without proof) (Sections 1,7, 4,1 – 4.5 of the text book).

Module 4: Further topics in group theory – Review of direct products, semidirect products, p-groups, Nilpotent groups, Solvable groups, Free groups (Section 5.1, 6.1 and 6.3 of the text book).

<u>Text Book</u>: 1. Abstract Algebra, David S Dummit, Richard M Foote, John Wiley & Sons, Inc, 3rd Edition.

<u>Reference Books:</u>

1. J. B. Fraleigh – A First Course in Abstract Algebra- Narosa (7th edn., 2003).

2. I.N. Herstein – Topics in Algebra- Wiley Eastern.

3. J.A.Gallian – Contemporary Abstract Algebra.

4. Hoffman & Kunze – Linear Algebra – Prentice Hall.

5. M. Artin, Algebra, Prentice Hall, 1991.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU07DSCMAT402 LINEAR ALGEBRA III

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	CORE	400	KU07DSCMAT402	4	60

<table>
<tr><td colspan="2">Learning Approach (Hours/ Week)</td><td colspan="3">Marks Distribution</td><td rowspan="2">Duration of ESE (Hours)</td></tr>
<tr><td>Lecture</td><td>Tutorial</td><td>CE</td><td>ESE</td><td>Total</td></tr>
<tr><td>4</td><td>1</td><td>50</td><td>50</td><td>100</td><td>3Hrs</td></tr>
</table>

Course Objectives: The objective is to provide students with a comprehensive understanding of advanced topics in linear algebra, preparing them for further study in mathematics, engineering, and other related fields.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students will grasp the concept of linear transformations between vector spaces and understand how they relate to matrices.
CO2	Through the study of elementary matrix operations and systems of linear equations, students will become adept at solving such systems using methods like Gaussian elimination and Gauss-Jordan elimination.
CO3	They will be able to compute determinants efficiently and use them to solve systems of linear equations, compute inverses of matrices, and understand geometric concepts such as volume.
CO4	They will be able to work with orthonormal bases, orthogonal complements, and projections, which are essential in various applications such as signal processing, optimization, and quantum mechanics

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Vector spaces (Quick review), Linear Transformations, The Algebra of Linear Transformations Isomorphism (Chapter 2, Chapter-3; Sections 3.1, 3.2,3.3 of the text book 1).

Module 2: Representation of Transformation by Matrices, Linear Functionals, The Double Dual the Transpose of a Linear Transformation. (Chapter 3, sections 3.4, 3.5, 3.6, 3.7 of the text book 1).

Module 3: Elementary Canonical Forms: Introductions, Characteristic Values Annihilating Polynomials, Invariant Subspace (Chapter-6: Sections 6.1, 6.2, 6.3, 6.4 of the text book 1).

Module 4: Jordan Canonical form and applications (Chapter 5, 5.1 to 5.3 of the text book 2) Inner Product Spaces: Inner Products, Inner Product Spaces, (Chapter-8: Sections 8.1, 8.2 of the text book 1).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

<u>Text Books</u>:

1. Kenneth Hoffman & Ray Kunze; Linear Algebra; Second Edition, Prentice-Hall of India Pvt. Ltd

2. D W Lewis, Matrix Theory, World Scientific

<u>Reference Books:</u>

1. Serge A Lang: Linear Algebra; Springer

2. Paul R Halmos Finite-Dimensional Vector Spaces; Springer 1974.

3. Thomas W. Hungerford: Algebra; Springer 1980

4. S H Fried Berg, A J Insel and L E Spence: Linear algebra, Pearson, fifth edition

5. N H McCoy& T R Berger: Algebra-Groups, Rings & Other Topics: Allyn & Bacon.

6. S. Axler Linear Algebra Done right, Springer

TEACHING LEARNING STRATEGIES

●Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

●Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks

Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU07DSCMAT403 REAL ANALYSIS-III

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	CORE	400	KU07DSCMAT403	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: Gaining a comprehensive understanding of advanced real analysis , which is the primary means of comprehending higher mathematics is the primary goal of this course

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Determine if a particular function on a metric space is continuous or not, as well as distinguish between countable and uncountable sets
CO2	Possess the ability to recognize differentiable functions as well as the continuity of derivatives. Also able to understand the various applications of the mean value theorem with clarity as well
CO3	Will gain understanding of Reiman Stieltjes integrals and be able to calculate a function's integral if it is integrable.
CO4	Will gain understanding of the notion of the series of functions' point-wise and uniform convergence.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5

CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Basic Topology,Continuity.

Module 2: Differentiation.

Module 3: Riemann – Stieltjes integral.

Module 4: Sequences and series of functions.

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1 and 2.

Text Book: Walter Rudin – Principles of Mathematical Analysis (3rd edition) – McGraw Hill, Chapters2,4, 5,6, and 7(up to and including 7.27 only).

Reference Books:

1.T.M. Apostol – Mathematical Analysis (2nd edition) –Narosa.

2. B.G. Bartle – The Elements of Real Analysis – Wiley International.

3. G.F. Simmons – Introduction to Topology and Modern Analysis – McGraw Hill.

4. Pugh, Charles Chapman: Real Mathematical Analysis, springer, 2015.

5. Sudhir R. Ghorpade , Balmohan V. Limaye, A Course in Calculus and Real Analysis (Undergraduate Texts in Mathematics), springer, 2006.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	

Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU07DSCMAT404 TOPOLOGY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	CORE	400	KU07DSCMAT404	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives:The Course aims Introduction to topological spaces. Emphasize the role of basis and sub basis in a topological space. Discuss the properties like connectedness, compactness and separation axioms in topological spaces. Identify homeomorphic objects.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Recognize closed and open sets within a specific topological space. Comprehend the idea of topological spaces and the basis of a topology
CO2	Able to determine if a particular function is continuous or not between two topological spaces. Also capable of understanding the notions of product and metric topologies
CO3	Capable of recognizing compact and connected topological spaces
CO4	Able to provide examples of topological spaces meeting various separation axioms

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5

CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Topological spaces, Basis for a topology, The order topology, The product topology(finite),The subspace Topology, Closed sets and limit points,(sections 12 to 17).

Module 2:Continuous functions, The product topology, The metric topology, The metric topology (continued),The quotient topology (Sections 18-22).

Module 3: Connected spaces, Connected subspace of the real line, Compact spaces, compact subset of the real line (sections 23,24, 26, 27).

Module 4: The countability axioms, The separation axioms, Normal spaces, The Urysohn lemma, The Urysohn Metrization Theorem (without proof), Tietze extension Theorem (without proof), The Tychonoff theorem (without proof) (sections 30, 31, 32, 33,34, 35, 37).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1 and 2.

Textbook: J.R. Munkres – Topology, Second edition Pearson India, 2015.

Reference Books:

1. K Parthasarathy, Topology an invitation, Springer (2022).

2. K.D. Joshi – Introduction to General Topology, New age International (1983).

3. G.F. Simmons–Introduction to Topology & Modern Analysis–McGrawHill.

4. M.Singer and J.A. Thorpe – Lecture Notes on Elementary Topology and Geometry, Springer Verlag 1967.

5. Kelley J.L. – General Topology, von Nostrand.

6. Stephen Willard – General Topology, Dover Books in Mathematics.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

(Semester 7 Electives)

KU07DSEMAT401 ALGEBRAIC NUMBER THEORY

Semester	Course Type		Course Level	Course Code	Credits	Total Hours
7	ELECTIVE		400	KU07DSEMAT401	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The objective is to provide a gentle introduction to the fundamental concepts of algebraic number theory.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students will get a basic introduction and motivation into the subject.
CO2	Will get a knowledge about the historical background and basics of quadratic fields, cyclotomic fields and concepts of factorization.
CO3	Will get knowledge about unique and non-unique factorizations, prime factorization and Euclidean quadratic fields.
CO4	Knowledge of ideals, prime factorization, factorization in cyclotomic fields, lattices are obtained.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Algebraic background, Symmetric Polynomials, modules, Free abelian groups, Algebraic numbers, Conjugates and discriminants, algebraic integers, integral basis, norms and traces, Rings of integers. (Sections 1.4-1.6, 2.1-2.6 of the text book).

Module 2: Quadratic fields. Cyclotomic fields. Factorization into irreducible: Historical back ground. Trivial factorization int irreducible (Sections 3.1, 3.2, 4.1-4.3 of the text book).

Module 3: Examples of non-unique factorization into irreducible. Prime factorization, Euclidean domains, Euclidean quadratic fields. Congruences of unique factorization Ramanujan-Nagell theorem. (Sections 4.4-4.9 of the text book)

Module 4: Ideals, Historical background, Prime factorization of ideals. The norm of an ideal. Non-unique factorization in cyclotomic fields. Lattices. The quotient torus. (Sections 5.1-5.4, 6.1, 6.2 of the text book)

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

<u>Text Book:</u>N. Stewart & D.O.Tall-Algebraic Number Theory (2nd edn.) Chapman & Hall (1987)

<u>Reference Books:</u>

1. P.Samuel- Theory of Algebraic numbers-Herman Paris Houghton Mifflin (1975).

2. S Lang-Algebraic Number Theory-Addison Wesley (1970).

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU07DSEMAT402 ANALYTIC NUMBER THEORY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	ELECTIVE	400	KU07DSEMAT402	4	90

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The aim of this course is to provide an introduction to analytic number theory. Prime number theorem and Dirichlet's theorem on primes in arithmetic progressions are discussed.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes

CO1	Students understands the fundamental theorem of arithmetic there by understanding prime numbers. Arithmetical functions like divisor function, Euler totient functions and their Dirichlet product is discussed.
CO2	Averages of arithmetical functions is studied. Chebyshev function is introduced and its relation with prime number distribution is discussed. Main outcome of this chapter is the understanding of the famous prime number theorem
CO3	The congruence relation between numbers is discussed and the famous Euler – Fermat theorem is studied. Some group theoretical aspects of finite abelian groups and their characters are studied in the perspective of number theory.
CO4	The Dirichlet theorem of infiniteness of prime n umbers in discussed. Periodicity of arithmetic functions and the Gauss sum of a Dirichlet character is studied.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: The Fundamental theorem of Arithmetic, Arithmetical functions and Dirichlet multiplications.

Module 2: Averages of arithmetical functions. Some elementary theorems on the distribution of prime numbers.

Module 3: Congruences, Finite abelian groups and their characters.

Module 4: Dirichlet’s theorem on primes in arithmetic progressions. Periodic Arithmetical Functions and Gauss sums.

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: Tom M. Apostol - Introduction to Analytic Number Theory (Springer International Edn. 1998) Relevant portions from Chapters 1-8.

Reference Books:

1. G.H.Hardy & Wright Introduction to Theory of Numbers (Oxford) 1985

2. H.Davenport- The Higher Arithmetic (Cambridge) (6th edn.) 1992.

TEACHING LEARNING STRATEGIES

●Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

●Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU07DSEMAT403 NUMBER THEORY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	ELECTIVE	400	KU07DSEMAT403	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The aim of the course is to give an introduction to basic concepts of elementary number theory in a combinatorial approach. Both multiplicative and additive problems are discussed.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	This module is intended to learn basic concepts and results in number theory including Fermat's little theorem, Wilson's theorem and Chinese remainder theorem
CO2	This module aims to understand Euler phi function, mobiles inversion formula and Tchebychev's theorem
CO3	This module gives an idea of quadratic congruences, Legendre symbols and quadratic residues.
CO4	This module deals with the elementary partition theory, Euler's partition theorem and partition generation functions

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Basic representation theorem. The fundamental theorem of arithmetic; combinatorial and computational number theory: Permutations and combinations, Fermat's little theorem, Wilson's theorem, generating functions; Fundamentals of congruences- Residue systems, Riffling; Solving congruences- Linear congruences, Chinese remainder theorem, Polynomial congruences. (Chapters 1-5 of the Text Book).

Module 2: Arithmetic functions- combinatorial study of phi (n), Formulae for d (n) and sigma (n), multivariate arithmetic functions, Mobius inversion formula; Primitive roots- Properties of reduced residue systems, Primitive roots modulo p; Prime numbers- Elementary properties of Pi (x), Tchebychev's theorem. (Chapters: 6 - 8 of the Text Book).

Module 3: Quadratic congruences: Quadratic residues- Euler's criterion, Legendre symbol, Quadratic reciprocity law; Distribution of Quadratic residues- consecutive residues and nonresidues, Consecutive triples of quardratic residues. (Chapters: 9 - 10 of the Text Book).

Module 4: Additivity: Sums of squares- sums of two squares, Sums of four squares; Elementary partition theory- Graphical representation, Euler's partition theorem, searching for partition identities; Partition generating functions- Infinite products as generating functions, Identities between infinite series and products. (Chapters: 11 - 13 of the Text Book).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: George E Andrews: Number Theory, Dover Publications (1971) Chapter1 Section1.2, Chapters 2-13.

Reference Books:

1. Andre Weil-Basic Number Theory (3rd edn.) Springer-Verlag (1974).

2. Grosswald, E.-Introduction to Number Theory Brikhauser (2nd edition) 1984.

TEACHING LEARNING STRATEGIES

●Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

●Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester VIII

KU08DSCMAT401 FUNCTIONAL ANALYSIS I

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	CORE	400	KU08DSCMAT401	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The aim of the course is to the study some of the features of bounded operators in Banach spaces and Hilbert spaces. Discusses the fundamental results like Hahn- Banach Theorem, Closed graph Theorem, Open mapping Theorem and their consequences

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students will be able to analyse properties vector spaces, normed spaces, and Banach spaces, including the properties and characteristics that define these mathematical structures
CO2	Students will get the ability to analyse and manipulate linear operators algebraically and apply them to solve problems in functional analysis
CO3	Students will demonstrate proficiency in the representation of functionals on Hilbert spaces, showcasing their ability to work with Hilbert-Adjoint operators, and analyse the properties of self-adjoint, unitary, and normal operators. They will be able to apply these concepts to represent various classes of operators and functionals, highlighting their importance in functional analysis
CO4	Students will get proficiency in understanding and working with adjoint operators, reflexive spaces, and various convergence concepts, including strong and weak convergence.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓

CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Vector space, Normed space, Banach space, Further Properties of Normed spaces, Finite dimensional normed spaces and subspaces, compactness and finite dimension, linear operators, Bounded and continuous linear operators, linear functionals (Section 2.1 to 2.8 of the Text book).

Module 2: Linear operators and functionals on finite-dimensional spaces, normed spaces of operators. Dual space, (up to 2.10.6), Inner Product spaces. Hilbert spaces, Further properties of inner product spaces, Orthogonal complements and direct sums, Orthonormal sets and sequences, series related to orthonormal sequences and sets (Definitions and statement of results), total orthonormal sets and sequences (up to 3.6.4), Legendre, Hermite and Laguerre Polynomials (Definitions), (Section 2.9 to 3.7of the Text book).

Module 3: Representation of Functionals on Hilbert spaces, Hilbert-Adjoint operator, Self-adjoint, unitary and normal operators, Zorn's lemma, Hahn-Banach theorem, Hahn-Banach theorem for complex vector spaces and normed spaces, Application to bounded linear functional on C[a,b] (Definitions only), (section 3.8 to 4.4of the Text book).

Module 4: Adjoint operator (4.5, up to 4.5.2), Reflexive spaces (4.6, Definitions), Category Theorem, Uniform Boundedness Theorem (4.7.1-4.7.3), Strong and weak convergence (4.8, up to 4.8.3), Open mapping theorem (4.12), closed linear operators, closed graph theorem (4.13).(sections 4.5 (up to 4.5.2) to 4.8.3, 4.12 to 4.13of the Text book).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

<u>Text Book</u>: E. Kreyszig, Introductory Functional Analysis with Applications (Wiley).

<u>Reference Books</u>

1. B.V. Limaye – Functional Analysis (3rd edition) – New Age International, 2014.

2. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill, 1963.

3. M.Thamban Nair, Functional Analysis: A First Course, PHI, 2014.

4. R. Bhatia: Notes on Functional Analysis TRIM series, Hindustan Book Agency,

5. Kesavan S: Functional Analysis TRIM series, Hindustan Book Agency, 2009

6. George Bachman & Lawrence Narici: Functional Analysis, Dover books on mathematics (1966, 2000)

7. Yuli Eidelman, Vitali Milman, and Antonis Tsolomitis, : Functional analysis An Introduction. Graduate Studies in Mathematics Vol. 66 American Mathematical Society 2004.

TEACHING LEARNING STRATEGIES

●Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

●Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU08DSCMAT402 MEASURE AND INTEGRATION

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	CORE	400	KU08DSCMAT402	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The main aim is to get a clear picture of the abstract measure theory and Lebesgue integral, which are essential for the study of advanced analysis

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students are able to: understand the reason for the development of Lebesgue integral in comparison with the Reimann integral. Also, will get an idea of measure and measure space
CO2	Will get an idea on how the Lebesgue integral of measurable functions can be computed. Will get an idea of the concept of L_p spaces
CO3	Will get the concept of convergence in measure and almost uniform convergence. Two important theorems viz Egoroff's theorem and Vitali convergence theorem are stated and proved
CO4	Will learn the different ways of decomposing measures and charges. Also learn how to construct Lebesgue measure on the real line from the length of an interval

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Introduction. Measurable functions. Measures

Module 2: The integral. Integrable functions. Lp – spaces

Module 3: Modes of convergence

Module 4: Generation of measures. Decomposition of measures

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: R.G. Bartle – The Elements of Integration (1966), John Wiley & Sons (Chapters 1 to 10)

Reference Books:

1. H.L. Royden – Real Analysis –Macmillan.

2. de Barra – Measure and Integration.

3. Inder K. Rana – Measure and Integration – Narosa.

TEACHING LEARNING STRATEGIES

●Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

●Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU08DSCMAT403 ORDINARY DIFFERENTIAL EQUATIONS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	CORE	400	KU08DSCMAT403	4	90

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The objective of this course is to understand and analyze the solutions of some important types of ODEs. This serves as an important path from mathematics to physics and engineering

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Get a proper understanding about existence and uniqueness of solutions of first order ODE
CO2	Able to understand the existence of power series solutions and get used to the problem solving
CO3	Able to learn about some very important special functions of mathematical physics
CO4	Able to get an understanding about nonlinear ODE and its solutions.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Population growth model, An atomic waste disposal problem, Review of Chapter 1, 2 and 3 of reference 4 in connection with Chapter 3 of the Text Book (Chapter 1: Sections – 1.2.1, 1.2.2, Chapter 3(review)).

Module 2: Sufficient condition for uniqueness of solution, Sufficient condition for existence of solution, Continuous dependence of the solution on initial data and dynamics, Continuation of a solution into larger intervals and maximal interval of existence, Existence and uniqueness of a system of equations (Chapter 4, Section 4.1 - 4.7).

Module 3: General n-th order equations and and linear systems, Autonomous homogeneous systems, Two-dimensional systems, Stability analysis, Higher dimensional systems, Invariant subspaces, Non homogeneous autonomous systems (Chapter 5, Sections 5.1 – 5.8.).

Module 4: Real analytic functions, Equations with analytic coefficients, Regular singular, Basic result and orthogonality, oscillation results, Existence of eigen functions (Chapter 6, Sections 6.1 – 6.5, 7.1 – 7.5.).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text book: Ordinary differential equations: Principles and applications by Ian A. K. Nandakumaran, P. S. Datti and Raju K. George Cambridge University Press, 1983).

Reference Books:

1. Differential equations with applications and historical notes by George F. Simmons (CRC Press, Third Edition, 2017).

2. An introduction to ordinary differential equations by Earl A. Coddington (Dover Books, 1989).

3. Ordinary differential equations by Birkhoff G. and G. C. Rota (Wiley, 1989).

4. Elementary differential equations and boundary value problems by W. E. Boyce and R. C. DiPrima, John Wiley and Sons (2009).

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

(Semester 8 Electives)

KU08DSEMAT401 CODING THEORY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	ELECTIVE	400	KU08DSEMAT401	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The aim is to provide an introduction to the fundamental concepts of coding theory

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	By studying these concepts empowers students, to design, analyses, and implement error-correcting codes for reliable communication systems. They develop problem-solving skills, mathematical reasoning abilities, and a deep understanding of the principles underlying modern digital communication technology.
CO2	Equips students with advanced knowledge and skills in designing, analyzing, and implementing error-correcting codes for reliable communication systems.
CO3	Studying these advanced topics in coding theory equips students with the knowledge, skills, and analytical abilities needed to design, analyze, and implement sophisticated coding schemes for reliable and efficient communication systems
CO4	Studying BCH codes, decoding algorithms for BCH codes, Reed-Solomon codes, and related topics provides students with a strong foundation in advanced coding techniques and prepares them for careers in fields where error-correction coding is essential for ensuring reliable and efficient communication and storage of digital information.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Introduction to Coding Theory. Correcting and detecting error patterns. Weight and distance. MLD and its reliability. Error-detecting codes. Error correcting codes. Linear codes (Chapter 1 of the Text and sections 2.1 to 2.5 of chapter 2 of the text).

Module 2: Generating matrices and encoding. Parity check matrices. Equivalent codes. MLD for linear codes. Reliability of IMLD for linear codes, Some bounds for codes, Perfect codes, Hamming codes. Extended codes extended Golay code and Decoding of extended Golay code (Sections 2.6 to 2.12 of Chapter 2 and sections 3.1 to 3.6 of chapter 3of the text).

Module 3: The Golay code, Reed-Muller codes, Fast decoding of RM (1, m), Cyclic linear codes. Generating and parity check matrices for cyclic codes. Finding cyclic codes. Dual cyclic codes (Sections 3.7 to 3.9 of Chapter 3 and Chapter 4 complete.

Module 4: BCH codes. Decoding 2-error-correcting BCH code. Reed-Solomon codes. Decoding

(Chapter 5 complete and sections 6.1, 6.2 and 6.3 of chapter 6).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: Coding Theory and Cryptography the Essentials (2nd edition) – D. R. Hankerson, D. G. Hoffman, D. A. Leonard, C. C. Lindner, K. T. Phelps, C. A. Rodger and J. R. Wall – Marcel Dekker (2000).

Reference Books:

1. J. H. van Lint – Introduction to Coding Theory – Springer Verlag (1982)

2. E. R. Berlekamp – Algebraic Coding Theory – McGraw Hill (196

TEACHING LEARNING STRATEGIES

●Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

●Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU08DSEMAT402 REPRESENTATION THEORY OF FINITE GROUPS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	ELECTIVE	400	KU08DSEMAT402	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The aim of this course is to give an introduction to representation theory. Representation theory is an area of mathematics which studies symmetry in linear spaces. The theory, roughly speaking, is a fundamental tool for studying symmetry by means of linear algebra.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes

CO1	It introduces the definition of representations of a finite group and there by introduces the notion of group modules. Some basics theorems are also discussed
CO2	This chapter introduces the crucial notion of orthogonality relations between representations, character table. Also, representation theory of finite abelian group is more specifically understood
CO3	It introduces the concepts of induced and discusses the Frobenius law of reciprocity which relates inner products of restricted and induced characters.
CO4	Students will learn the crucial notion of orthogonality relations between representations, character table. Also, representation theory of finite abelian group is more specifically understood.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Introduction, G- modules, Characters, Reducibility, Permutation Representations, Complete reducibility, Schur's lemma, The commutant (endomorphism) algebra. (Sections:1.1 to 1.8of the text book).

Module 2: Orthogonality relations, the group algebra, the character table, finite abelian groups, the lifting process, linear characters. (section: 2.1 to 2.6of the text book).

Module 3: Induced representations, reciprocity law, the alternating group A_5, Normal subgroups (Sections: 3.1 to 3.4 of the text book).

Module 4: Transitive groups, the symmetric group, induced characters of S_n. (Sections: 4.1 to 4.3of the text book).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

<u>Text Book:</u>Walter Ledermann, Introduction to Group Characters, Cambridge university press

1087. (Second Edition).

Rreference Books:

1. C. W. Kurtis and I. Reiner, Representation Theory of Finite Groups and Associative Algebras. American Mathematical society 2006.

2. Algebras, John Wiley & Sons, New York (1962)W Fulton, J. Harris, Representation Theory, A first course. Springer 2004.

3. Fulton, The Representation Theory of Finite Groups, Lecture Notes in Mathematics, No. 682, Springer 1978.

4. C. Musli, Representations of Finite Groups, Hindustan Book Agency, New Delhi (1993)

5. J.P. Serre, Linear Representation of Finite Groups, Graduate Text in Mathematics, Vol 42, Springer (1977).

6. Bruce E Sagan, The symmetric group – Representations, combinatorial algorithms and symmetric functions.

TEACHING LEARNING STRATEGIES

●Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

●Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU08DSEMAT403 FUZZY MATHEMATICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	ELECTIVE	400	KU08DSEMAT403	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The aim of this course is to provide an introduction to the fundamental concepts of Fuzzy Mathematics.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students will be able to comprehend the similarities and distinctions between crisp sets and fuzzy sets
CO2	Students will develop an understanding of the fundamental concepts of union and intersection within fuzzy sets, enabling them to effectively navigate the nuances of set operations in fuzzy environment
CO3	Students will gain a comprehensive understanding of the concept of fuzzy relations, including an exploration of various types of fuzzy relations and the operations involved in manipulating them
CO4	Provides students with insight into the limitations of classical two-valued logic in addressing the imprecision, uncertainty, and complexity inherent in the real world. It also introduces the concepts of multi-valued logic and fuzzy logic, offering a broader perspective on handling such complexities effectively.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: From classical (crisp) sets to fuzzy sets: characteristics and significance of the paradigm shift. Additional properties of α-cuts. Representation of fuzzy sets. Extension principle for fuzzy sets. (Chapters. 1 & 2 of the Text Book).

Module 2: Operations on fuzzy sets. Types of operations. Fuzzy complements. t-norms, t-conorms. Combinations of operations. Aggregate operations, Fuzzy numbers Arithmetic operations on intervals. Arithmetic operations on fuzzy numbers. Lattice of fuzzy numbers (Sections 3.1 to 3.4 of Chapters. 3 of the Text and sections 4.1 to 4.5).

Module 3: Crisp and fuzzy relations, projections and cylindric extensions, binary fuzzy relations, binary relations on a single set, Fuzzy equivalence relations, Compatibility and ordering relations. Fuzzy morphisms. sup-i, inf- ωI compositions of fuzzy relations. (Sections 5.1 to5.6 and sections 5.8 to 5.10 of chapter 5 of the text book).

Module 4: Fuzzy logic. Fuzzy propositions. Fuzzy quantifiers. Linguistic hedges. Inference from conditional, conditional and qualified and quantified propositions (Chapter 8 of the text).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: Fuzzy sets and Fuzzy logic Theory and Applications – G. J. Klir & Bo Yuan – PHI (1995)

Reference Books:

1. Zimmermann H. J. – Fuzzy Set Theory and its Applications, Kluwer (1985).

2. Zimmermann H. J. – Fuzzy Sets, Decision Making and Expert Systems, Kluwer (1987).

3. Dubois D. & H. Prade – Fuzzy Sets and Systems: Theory and Applications – Academic Press (1980).

TEACHING LEARNING STRATEGIES

●Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

● Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

<u>**Semester IX**</u>

KU09DSCMAT501 ALGEBRA IV

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
9	CORE	500	KU09DSCMAT501	4	60

<table>
<tr><td colspan="2">Learning Approach (Hours/ Week)</td><td colspan="3">Marks Distribution</td><td rowspan="2">Duration of ESE (Hours)</td></tr>
<tr><td>Lecture</td><td>Tutorial</td><td>CE</td><td>ESE</td><td>Total</td></tr>
<tr><td>4</td><td>1</td><td>50</td><td>50</td><td>100</td><td>3Hrs</td></tr>
</table>

Course objectives: The main goal of this course is to give a complete description of Galois theory. The main tool for the discussion is the theory of extension fields and factorization of polynomials in the rings of polynomials.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Understand the concept of field of quotients of integral domain, Euclidean domain, principal ideal domain and unique factorization domain which are generalizations of the well-known polynomial rings

CO2	Understand a complete structure of polynomial rings and factorization of polynomials.
CO3	Students would learn field extensions, algebraically closed fields and hence about the existence of roots of polynomials
CO4	The students will understand the important Galois theory and computation of Galois group of polynomials

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Review of Ring theory, Rings of fractions (Sections 7.1 to 7.4, 7.5).

Module 2: Euclidean domain, Principal Ideal domains, Euclidean Domains, Revisit of polynomial rings (Sections 8.1-8.3, 9.1 – 9.4).

Module 3: Basic Theory of Field Extensions, Algebraic Extensions, Classical Straightedge and Compass Constructions, Splitting Fields and Algebraic Closures, Separable and Inseparable Extensions, Cyclotomic Polynomials and Extensions (Sections 13.1 – 13.6, of Text book).

Module 4: Basic definitions, The Fundamentals of Galois Theory, Finite Fields, Composite Extensions and Simple Extensions, Cyclotomic Extensions and Abelian Extensions over Q. (Sections 14.1 – 14.5).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: 1. Abstract Algebra, David S Dummit, Richard M Foote, John Wiley & Sons, Inc, 3rd Edition.

Reference Books:

1. J. B. Fraleigh – A First Course in Abstract Algebra- Narosa (7th edn., 2003

2. I.N. Herstein – Topics in Algebra- Wiley Eastern

3. J.A.Gallian – Contemporary Abstract Algebra

4. Hoffman & Kunze – Linear Algebra – Prentice Hall

5. M. Artin, Algebra, Prentice Hall, 1991

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU09DSCMAT502 COMPLEX ANALYSIS III

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
9	CORE	500	KU09DSCMAT502	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course objectives: This course gives a foundation to the theory of complex numbers. Assuming the prerequisites on the algebraic and topological properties of complex numbers, this course begins by introducing the integration of complex valued functions across curves in the plane, analyticity, power series representation of analytic functions, bounds of analytic function and a description and classification of points at which a complex function loss its analyticity.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students will be able to interpret and work with the extended plane, gaining proficiency in understanding its topological properties and how it is represented on the sphere. Students will develop a comprehensive understanding of power series, analytic functions, Cauchy Riemann equations, how analytic functions serve as mappings between complex planes. They will be able to analyze the behavior of these mappings, including the preservation of angles and conformal properties
CO2	Students will develop a deep understanding of Riemann-Stieltjes integrals, power series representation of analytic functions including the theory behind the integration of functions. They will investigate the properties of zeros of analytic functions, understanding the relationship between the zeros and the behavior of the function. Also develop a solid understanding of the index of a closed curve in the complex plane. They will be able to calculate the index using various methods, such as the winding number and contour integration
CO3	Students will demonstrate proficiency in applying advanced concepts such as Cauchy's theorem homotopic version of Cauchy's Theorem, Schwarz's Lemma, and Goursat's Theorem, counting zeros of analytic functions and open mapping theorem. They will be able to analyze regions in the complex plane, determine simple connectivity, and establish properties of holomorphic functions using these concepts.
CO4	Students will develop a comprehensive understanding of singularities in complex functions and their classification into removable, poles, and essential singularities. They will also master the calculation of residues, maximum principle, Schwarz's Lemma and its implications for holomorphic functions. They will understand how this lemma provides information about the mapping properties of holomorphic functions on the unit disk.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: The extended plane and its spherical representation, power series, analytic functions, Analytic functions as mapping, Mobius transformations ((Chapter I -6, Chapter III – 1,2, and 3)).

Module 2: Riemann Stieltjes integrals, power series representation of analytic functions, Zeros of an analytic function, index of a closed curve (Chapter IV – 1,2,3 and 4).

Module 3: Cauchy's theorem and integral formula, homotopic version of Cauchy's theorem and simple connectivity, counting zeros- open mapping theorem, Goursat theorem (Chapter IV - 5,6,7,8 Omit the proof of third version of Cauchy's theorem).

Module 4: Classification of singularities, residues, argument principle, maximum principle, Schwarz lemma (Chapter V – 1,2,3, Chapter VI – 1,2).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book : Conway J.B. – Functions of One Complex Variable I – Second edition , Springer international student edition.

References:

1.J. W. Brown and R. V. Churchill, Complex Variables and Applications (8th Edition), Mcgraw-Hill,(2009).

2.W. Rudin: Real and Complex Analysis (3rd Edn.); Mc Graw- Hill International Editions; 1987.

3. E.T.Copson – An Introduction to the Theory of Complex Variables – Oxford.

4. S Lang - Complex Analysis, Fourth Edition, Grauate texts in Mathematics 103, Springer, Second Indian Reprint 2013.

5. Herb Silverman - Complex Variabies,Houghton Mifflin Co., 1975.

6. Kunhiko Kodaidra - Complex Analysis, Cambridge studies in Advanced Mathematics 107, 2007.

7. S Ponnusami - Foundations of Complex Analysis, Second Edition, Narosa.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU09DSCMAT503 FUNCTIONAL ANALYSIS II

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
9	CORE	500	KU09DSCMAT503	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objective: The objective of this course is to delve into the spectral theory concerning both compact linear operators and bounded self-adjoint linear operators.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students will able to Understand approximation methods and techniques in normed spaces, which allows for the approximation of functions or elements by simpler or more manageable ones
CO2	Able to understand spectral properties, which is crucial for analyzing linear operators in various contexts, including differential equations and quantum mechanics
CO3	Will get knowledge of spectral properties, which helps in characterizing the eigenvalues, eigenvectors, and spectrum of compact operators, enabling their use in solving integral equations, Fredholm theory, and approximation problems

CO4	Will get good Knowledge of positive operators allows for the analysis of positivity-preserving transformations and the study of properties such as monotonicity, convexity, and order structures.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Approximation in normed spaces, Uniqueness, strict convexity, Uniform approximation, Approximation in Hilbert space, Spectral Theory in finite dimensional normed spaces, Basic concepts, (Section 6.1, 6.2, 6.3, 6.5, 7.1 & 7.2 of the Text Book).

Module 2: Spectral properties of bounded linear operators, Further properties of resolvent and spectrum, Use of complex analysis in spectral theory, Banach algebras, Further properties of Banach algebras, compact linear operators on normed spaces, Further properties of compact linear operators (7.3 to 8.2 of the Text Book).

Module 3: Spectral properties of compact linear operators on normed spaces, further spectral properties of compact linear operators, Operator equations involving compact linear operators, spectral properties of bounded self-adjoint linear operators, further spectral properties of bounded self-adjoint linear operators (section 8.3 to 8.5 & 9.1 to 9.2of the Text Book).

Module 4: Positive operators, square root of a positive operator, projection operators, further properties of projections, spectral family, spectral family of a bounded self-adjoint linear operators, spectral representation of bounded self-adjoint linear operators. (sections 9.3 to 9.9 of the Text Book).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book : E. Kreyszig, Introductory Functional Analysis with Applications (Wiley)

Reference Books

1 B.V. Limaye – Functional Analysis (3rd edition) – New Age International, 2014.

2. M.Thamban Nair, Functional Analysis: A First Course, PHI, 2014.

3. R. Bhatia: Notes on Functional Analysis TRIM series, Hindustan Book Agency, 2009

4. Sunder V.S.: Functional Analysis spectral theory, TRIM Series, Hindustan Book Agency,1997

5. George Bachman & Lawrence Narici: Functional Analysis, Dover books on mathematics (1966, 2000)

6 . Yuli Eidelman, Vitali Milman,and Antonis Tsolomitis, : Functional analysis An Introduction, Graduate Studies in Mathematics Vol. 66 American Mathematical Society 2004.

TEACHING LEARNING STRATEGIES

●Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

●Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU09DSCMAT504 FUNCTIONS OF SEVERAL VARIABLES AND DIFFERENTIAL GEOMETRY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
9	CORE	500	KU09DSCMAT504	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The course gives an introduction to the elementary concepts of differential geometry using the calculus of vector fields so that the students also attain a deep understanding of several variable calculus.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	The main aim of this module is to get a proper understanding of the functions of several variables and the differentiation of such function
CO2	This module is intended to make students comfortable in the preliminaries of differential geometry. The students are expected to understand graphs, level sets, tangent spaces and surfaces.
CO3	This module is intended to understand important concepts such as Weingarten map and curvature. As a first step to understand the curvature of surfaces, it is important to learn about the curvature of plane curves
CO4	This module deals with line integrals and curvature of surfaces. These are the most important objectives of this differential geometry course

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓

CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Functions of Several variables (Text 1, Chapter 9, Sections 1-29).

Module 2: Surfaces and vector fields:(Text 2, Chapters 1-6).

Module 3: Weingarten map and curvature (Text 2, Chapters 7-10).

Module 4: Curvature of surfaces:(Text 2, Chapters 11-12).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book 1: Principles of Mathematical Analysis by W. Rudin (Mc.Graw Hill, 1986).

Text Book 2: Elementary Topics in Differential Geometry by J. A. Thorpe (Springer-Verlag, 2011).

Reference Books:

1. Elementary Differential Geometry by Andrew Pressley (Springer-Verlag, 2010)

2. Differential geometry of Curves and Surfaces by M. P. do Carmo (Dover Publications, 2016)

3. Mathematical Analysis by T. M. Apostol (Pearson, 1974).

4. Analysis on Manifolds by james R. Munkres (Addison-Wesley Publishing Company, 1991)

TEACHING LEARNING STRATEGIES

●Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

●Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks

Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU09DSCMAT505 PARTIAL DIFFERENTIAL EQUATIONS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
9	CORE	500	KU09DSCMAT505	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The objective of this course is to familiarize the students with fundamental concepts of partial differential equations

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	The aim of this module is to get familiar with the first order PD
CO2	This module is intended to learn the second order PDE and its classification
CO3	The aim of this module is to learn the well known PDE problems such as heat and Laplace equations
CO4	This module is focusing on the study of wave equations

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓

CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: First Order Partial Differential Equations: Method of Characteristics (Chapter 3: Sections - 3.1, 3.2, 3.3, 3.4 and 3.5 of the Text Book).

Module 2: Classification of second Order PDE (Chapter 6: Sections - 6.1, 6.2, 6.3 and 6.4of the Text Book).

Module 3: Laplace and Heat Equation (Chapter: Sections - 8.1. 8.2 and 8.4 of the Text Book).

Module 4: One Dimensional Wave Equation (Chapter 9: Sections - 9.1, 9.2, 9.3 and 9.4 of the Text Book).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: Partial Differential Equations: Classical Theory with a Modern Touch by A. K. Nandakumaran and P. S. Datti (Cambridge University Press, 2020).

Reference Books:

1. Partial differential Equations by Lawrence C. Evans (American Mathematical Society, 2010).

2. Elements of Partial Differential Equations by Ian Sneddon (McGraw Hill, 1983).

3. An elementary Course in partial differential Equations by T. Amarnath (Narosa Publishing House 2003).

TEACHING LEARNING STRATEGIES

●Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

●Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks

Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester X

Dissertation (From institutes of National reputation), Total Credits 20

OR

[5 DSC Courses, each worth 4 credits, comprising one MOOC course at the 500 level and /or a 4-credit internship/minor project]

KU10DSCMAT501 ADVANCED TOPICS IN ANALYSIS

Core

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
10	CORE	500	KU10DSCMAT501	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: To get an overall knowledge on basic analysis which helps to do further advanced reading in this direction. It also touches the fundamental areas of measure theory, point set topology and Lebesgue spaces so that students get a connection with various tools used in advanced analysis**.**

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	The main aim of the first module is to understand the Lebesgue-radon-Nikodym theorem

CO2	The second module is intended to make students comfortable about complex measures and functions of bounded variation
CO3	Third module uses the knowledge the students in basic point set topology and deals with the locally compact Hausdorff spaces and The Stone-Weiersrtrass theorem.
CO4	The fourth module is dealing with Lp spaces mainly. It is expected that after the completion of this module students would be comfortable with some important inequalities, basics of distribution and interpolation

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1:Signed measures (Chapter 1 and 2 review, chapter 3, Sections - 3.1 - 3.3 of the text book)

Module 2: Differentiation: (Chapter 3, Sections 3.3 -3.5 of the text book)

Module 3: Point set topology: (Chapter 4, Sections 4.1 - 4.7 of the text book)

Module 4: Lebesgue Spaces: (Chapter 6 - Section 6.1 - 6.5 of the text book)

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: Real Analysis: Modern Techniques and Their Applications by Gerald B. Folland, Second edition, John Willey and Sons, Inc, 1999

Reference Books:

1. Foundations of Real and Abstract Analysis by D. S. Bridges, GTM Series, Springer Verlag 1997.

2. Real and Complex Analysis by W. Rudin, Tata McGraw.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU10DSCMAT502ALGEBRAIC TOPOLOGY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
10	CORE	500	KU10DSCMAT502	4	60

<table>
<tr><td colspan="2">Learning Approach (Hours/ Week)</td><td colspan="3">Marks Distribution</td><td rowspan="2">Duration of ESE (Hours)</td></tr>
<tr><td>Lecture</td><td>Tutorial</td><td>CE</td><td>ESE</td><td>Total</td></tr>
<tr><td>4</td><td>1</td><td>50</td><td>50</td><td>100</td><td>3Hrs</td></tr>
</table>

Course Objectives: The course discusses simplicial homology theory, the Euler Poincare theorem and the fundamental group. The purpose of this course is to give students the opportunity to see how algebraic concepts or abstract algebra can be used as a tool to learn topology, another branch of mathematics

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	The students will grasp how Algebraic Topology elucidates the structure of a topological space by correlating it with algebraic systems, particularly groups
CO2	Students will gain an understanding of homology groups
CO3	Students will learn to compare two topological spaces based on the algebraic similarities between their associated homology groups
CO4	Students will comprehend how the structure of two topological spaces can be explored through the analysis of paths within those spaces.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Geometric complexes and polyhedra. Orientation of geometric complexes.

Module 2:Simplicial homology groups. Structure of homology groups. The Euler-Poincare theorem. Pseudomanifolds and the homology groups of Sn.

Module 3: Simplicial approximation. Induced homomorphisms on homology groups. Brouwer fixed point theorem and related results.

Module 4:The fundamental groups. Examples. The relation between H1(K) and π1(|K|).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: Fred H. Croom – Basic Concepts of Algebraic Topology – Springer Verlag (1978)

Reference Books:

1. Maunder – Algebraic Topology – Van Nostrand-Reinhold (1970).

2. Munkres J.R. – Topology, A First Course – Prentice Hall (1975).

3. Allen Hatcher-Algebraic Topology Cambridge University Press 2002.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU10DSCMAT503 HARMONIC ANALYSIS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
10	CORE	500	KU10DSCMAT503	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: Many Branches of Mathematics come together In Harmonic Analysis. Each adding richness to the subject and each giving insights Into the subject. The course is a gentle introduction to Fourier Analysis and Harmonic Analysis.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	The student will understand the Dirichlet problem and periodic functions
CO2	The student will about the Fourier series and its convergences
CO3	The student will learn some important notions in functional analysis which is useful to study Fourier analysis
CO4	The student will learn the concept of Fourier transforms.

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Quick review of chapter 0, The Dirichlet Problem for a Disk, Continuous functions on the unit Disc, the method of Fourier, Uniform convergence, the formulas of Euler, Cesaro convergence, Fejer's theorem, at last the solution. Chapters 0 (sections 1 to 8) and 1 of the Text Book.

Module 2: Functions on (-pi, pi), Functions on other intervals, Functions with special properties, pointwise convergence of the Fourier series, (Chapter 2 of the text book).

Module 3:Normed vector spaces, Convergence in normed spaces, inner product spaces, infinite orthonormal sets, Hilbert spaces, the completion, wavelets. (Chapter 3 of the Text Book).

Module 4:The Fourier transform on Z, Invertible elements in l^1(Z), The Fourier transform on R, Finite Fourier transform. Chapter 4 sections 1, 2, 3 and 6 of the Text Book.

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

<u>Text Book:</u> Carl L. DeVito, Harmonic Analysis, A gentle Introduction.

<u>Reference Books</u> :

1. Yitzhak Katznelson, An Introduction to Harmonic Analysis,

2. Geral B. Folland, a course in abstract harmonic analysis.

3. Anton Deitmar, A first course in harmonic analysis, Springer.

4. Elias M. Stein and Guido Weiss, Introduction to Fourier analysis on Euclidean spaces.

5. Edwin Hewitt; Kenneth A. Ross, Abstract Harmonic Analysis. Springer

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU10DSCMAT504 OPERATOR ALGEBRAS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
10	CORE	500	KU10DSCMAT504	4	60

Learning Approach (Hours/	Marks Distribution	Duration of ESE

Week)					(Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: The objective of this course is to introduce fundamental topics in operator theory. It is a field that has great importance for other areas of mathematics and physics, such as algebraic topology, differential geometry, quantum mechanics. We discuss the basics results of Banach algebras and C* algebras

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students will understand the concepts of functional analysis, including Banach spaces and Banach algebras
CO2	Students will master the Gelfand transform and its applications in the study of Banach algebras
CO3	Students will gain a comprehensive understanding of C* algebras, including their definition, properties, and applications
CO4	Students will comprehend the concept of positive linear functionals and states in the context of C* algebras

Mapping of COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Review on Functional analysis, Banach algebras and the invertible group, The spectrum, Multiplicative linear functional, (Sections 1 to 4).

Module 2: The Gelfand Transform and applications, Examples of maximal ideal spaces, Non-unital Banach algebras, (Sections 5 to 7).

Module 3: C* algebras, Commutative C* algebras, the spectral theorem (up to 10.3), Polar Decomposition (Sections 8, 9, 10, 12).

Module 4: Positive linear functional and states, The GNS construction, non-unital C* algebras, Strong and weak –operator topologies (Sections 13,14,15, 16).

Module X: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

<u>Text Book:</u> Kehe Zhu, An introduction to operator algebras CRC Press 1993.

<u>Reference Books:</u>

1. Introduction to topology and modern analysis, McGraw Hill Education ,2017.
2. R V Kadison and JR. Ringrose: Fundamentals of the theory of Operatoralgebras, volume 1, II Academic press, 1983.
3. W. Arveson, An invitation to C* algebras, springer 1998.
4. W. Rudin, Functional analysis, McGraw Hill Education.
5. V S Sunder, An invitation to von Newmann algebras, springer 1998.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks

Seminar/Viva	20 Marks
Total	50 Marks

KU10DSCMAT505 INTRODUCTION TO LIE ALGEBRAS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
10	CORE	500	KU10DSCMAT505	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: This course is mainly designed for a beginner to give a very basic algebraic introduction to the theory of Lie algebras and representation theory. Lie algebras have become essential to many parts of mathematics and theoretical physics.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students will understand the definition of Lie algebras, examples and some fundamental concepts, including ideals, homomorphisms, derivations and structure constants.
CO2	Students will understand quotient Lie algebras, construction of ideals, small dimensional examples and very basics of Solvable, semisimple and Nilpotent Lie algebras.
CO3	Students will gain a basic idea of representation theory of Lie algebras. They also understand module theory in the context of Lie algebras and some fundamental concepts of modules and discusses the Schur's lemma explaining the structure of a Lie module.
CO4	Students will comprehend the important concept of root system in the Euclidean spaces and they will understand the combinatorial descriptions of root systems of Lie algebras via the Dynkin diagrams.

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Definition of Lie Algebras, Some Examples, Subalgebras and Ideals, Homomorphisms, Algebras, Derivations, Structure Constants (Sections 1.1 to 1.7).

Module 2: Construction with Ideals, Quotient Algebras, Correspondence between Ideals, Low – Dimensional Lie Algebras – Dimensions 1 and 2, Dimension 3, Solvable, Semi simple and Nilpotent Lie algebras (Definitions and Examples only) (Sections 2.1 – 2.3, 3.1 and 3.2,4.1 and 4.2).

Module 3: Some representation theory - Definitions, Examples of Representations, Modules for Lie algebras, Submodules and Factor modules, Irreducible and Indecomposable module, Homomorphisms and Schur's Lemma (Sections 7.1 – 7.7).

Module 4: Root systems - Definition of Root Systems, First steps in the Classification, Bases for Root systems, Cartan matrices and Dynkin diagrams (Sections 1.1 – 11.4).

Module 5: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: Introduction to Lie algebras - Karin Erdmann and Mark J. Wildon, Springer Undergraduate Mathematics Series.

Reference Books:
1. Introduction to Lie algebras and Representation theory - James E Humphreys.
2. Lie algebras of Finite and Affine Type - Roger Carter.
3. Reflection groups and Coxeter groups - James E Humphreys.

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU10DSCMAT506 COMMUTATIVE ALGEBRA

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
10	CORE	500	KU10DSCMAT506	4	60

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
4	1	50	50	100	3Hrs

Course Objectives: This course discusses some advanced topics in algebra more specifically commutative algebra. It discusses a deeper theory of commutative rings. Commutative algebra has mainly developed because of its hardcore applications in Algebraic number theory and Algebraic Geometry. It is very importance in the theory of Homological algebra which plays an important part in modern mathematics.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students will understand the basic definitions concerning different classes of commutative rings, elements in commutative rings, and ideals in commutative rings and some properties and operations among them. They also understand the important concept of modules over commutative rings and operations on modules.
CO2	Students will understand the concepts of exact sequences, tensor product of modules and algebras and the localization properties.
CO3	Students will understand the decomposition of ideal into primary ideals. They also understand the integral dependence and valuations in a ring.
CO4	Understand the chain conditions of rings and modules and hence the definition and some examples of Noetherian and Artinian rings.

Mapping of COs to PSOs

	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓

COURSE CONTENTS

Module 1: Rings and Ideals; Modules [Chapt I; Chapt II (upto and including `Operations on Submodules)].

Module 2: Modules; Rings and Modules of Fractions (Chapter II (from `Direct Sum and Product'); Chapter III)

Module 3: Primary Decomposition; Integral Dependence and Valuations (Chapter IV; Chapter V).

Module 4: Chain Conditions; Noetherian Rings; Artin Rings (Definition and Examples only) (Chapter VI; Chapter VII; Chapter VIII).

Module 5: Get acquainted with the concepts by studying the examples and exercises provided in Reference 1.

Text Book: Atiyah M. F. & Macdonald, I.G, Introduction to Commutative Algebra, Addison Wesley, N.Y, (1969).

Reference Books:

1. N. S. Gopalakrishnan: Commutative Algebra, Oxonian Press, 1984.
2. D. Eisenbud: Commutative algebra with a view toward algebraic geometry GTM (150), Springer-Verlag (1995).
3. H. Matsumura: Commutative ring theory, Cambridge Studies in Advanced Mathematics No. 8, Cambridge University Press (1980).
4. R.Y. Sharp: Steps in commutative algebra, LMS Student Texts (19), Cambridge Univ. Press (1995).
5. Miles Reid: Undergraduate Commutative Algebra, Cambridge University Press (1995).

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU10DSCMAT507 - a MOOC Course for 4 credits of 500 level, from the list provided by the Department Council or/One 4-credit Internship or / 4-credit Minor project (for 100 marks).

KU01MDCMAT101 ELEMENTARY MATHEMATICS-1 (MDC 1)

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
1	MDC	100	KU01MDCMAT101	3	45

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
3	1	50	50	100	2Hrs

Course Objectives: The objective is to provide a basic understanding of fundamental mathematical concepts.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students will demonstrate proficiency in understanding real numbers, including rational and irrational numbers. They will apply laws of exponents to solve problems involving powers and roots. Additionally, they will master fundamental operations with polynomials, solve linear equations, and use algebraic identities effectively in practical scenarios.
CO2	Learners will apply ratio and proportion concepts in various real-life scenarios such as scaling, mixing, and comparisons. They will calculate percentages for solving problems related to interest, discounts, and profit-loss situations, thus enhancing their quantitative reasoning skills.
CO3	Students will understand and work with basic geometric shapes, calculating perimeters and areas of simple figures. They will grasp concepts of similarity and congruence, enabling them to analyze and solve geometric problems encountered in everyday life
CO4	By studying statistics and probability, students will gain proficiency in data representation using tables and charts. They will compute measures of central tendency (mean, median, mode) and utilize basic probability concepts. Additionally, learners will acquire fundamental knowledge of financial mathematics including simple and compound interest calculations and budgeting.
CO5	Students will develop logical thinking skills through problem-solving strategies and the application of logical operations (AND, OR, NOT) in various contexts. Optionally, they will be introduced to basic trigonometry, including trigonometric ratios (sine, cosine, tangent) and their applications in solving practical problems like height and distance

CO6	The course will foster an understanding of how mathematics intersects with literature and history. Students will explore mathematical concepts used in historical and literary contexts, recognizing numerical symbolism in literature and analyzing historical data using mathematical tools.
CO7	Learners will master algebraic identities such as (a + b)^2, (a - b)^2, a^2 - b^2 and apply them to factorize algebraic expressions. This will strengthen their algebraic reasoning and problem-solving abilities.

COURSE CONTENTS

Module 1 Number System: Understanding real numbers, rational and irrational numbers, Laws of exponents and their applications, Basic Algebra: Fundamental operations with polynomials (addition, subtraction, multiplication), Solving linear equations in one variable, Understanding simple algebraic identities and their applications.

Module 2 Ratio and Proportion: Concept of ratio and proportion, Applications in scaling, mixing, and comparison problems. Percentage and its Applications: Understanding percentages, calculations involving percentage. Applications in interest, discounts, and profit-loss calculations. Basic Geometry: Understanding basic geometric shapes (lines, angles, triangles, circles). Perimeter and area of simple shapes, Introduction to concepts like similarity and congruence.

Module 3: Statistics and Probability: Basic concepts of data representation (tables, charts), Measures of central tendency (mean, median, mode), Introduction to probability and its practical applications, Financial Mathematics: Basic understanding of financial calculations such as simple interest and compound interest, Budgeting and personal finance concepts.

Module 4: Logical Reasoning: Introduction to logical thinking and problem-solving strategies, understanding logical operations (AND, OR, NOT) and their applications, Basic Trigonometry (optional, based on curriculum): Introduction to trigonometric ratios (sine, cosine, tangent), Simple applications in solving height and distance problems.

Module X: Mathematical Applications in Literature and History: Exploring mathematical concepts used in historical and literary contexts (e.g., numerical symbolism in literature, historical data analysis), Introduction to Algebraic Identities: Simple identities like (a + b) ^2, (a - b)^2, a^2 - b^2, Factorization of algebraic expressions.

References:

Mathematics: A Very Short Introduction, Timothy Gowers:

The Joy of x: A Guided Tour of Math, from One to Infinity, Steven Strogatz

The Princeton Companion to Mathematics edited, Timothy Gowers

TEACHING LEARNING STRATEGIES

●Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

●Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

KU02MDCMAT101 ELEMENTARY MATHEMATICS - 2 (MDC 2)

Remark: Course for students who have not studied mathematics at +2 level.

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
1	MDC	100	KU02MDCMAT101	3	45

<table>
<tr><td colspan="2">Learning Approach (Hours/ Week)</td><td colspan="3">Marks Distribution</td><td rowspan="2">Duration of ESE (Hours)</td></tr>
<tr><td>Lecture</td><td>Tutorial</td><td>CE</td><td>ESE</td><td>Total</td></tr>
<tr><td>3</td><td>1</td><td>50</td><td>50</td><td>100</td><td>2Hrs</td></tr>
</table>

Course Objectives: The objective is to provide a basic understanding of fundamental mathematical concepts to students who have not studied mathematics at the +2 level.

Course Outcomes: At the end of the Course, the Student will be able to:

SL No	Course Outcomes
CO1	Students will gain a solid understanding of foundational mathematical concepts including sets, relations, functions, trigonometric functions, complex numbers, sequences, series, permutations, combinations, and binomial theorem. They will be able to apply these concepts to solve problems in various mathematical contexts.
CO2	Learners will demonstrate proficiency in coordinate geometry, understanding properties of straight lines, and conic sections (circles, parabolas, ellipses, hyperbolas) as well as introductory knowledge of three-dimensional geometry. They will be able to analyze and solve problems related to these geometric figures.
CO3	Students will acquire skills in calculus, specifically focusing on limits, derivatives, continuity, differentiability, and integrals (both definite and indefinite). They will learn to apply calculus concepts to solve problems related to rates of change, tangents, normals, and area under curves.
CO4	By studying matrices, determinants, vectors, and vector operations (dot and cross products), students will enhance their problem-solving abilities in mathematical and engineering contexts. They will be able to model and solve problems using matrix algebra and vector calculus techniques.
CO5	Learners will be equipped with basic concepts in probability and statistics, enabling them to compute measures of central tendency, dispersion, and probability distributions. They will understand and apply addition and multiplication theorems of probability. Additionally, students will develop logical reasoning skills to evaluate mathematical statements and arguments.

COURSE CONTENTS

Module 1: Sets, relations and functions, trigonometric functions, complex numbers Principle of mathematical induction, Complex numbers and quadratic equations Linear inequalities Permutations and combinations Binomial theorem Sequences and series

Module 2: Coordinate Geometry: Straight lines and conic sections (like circles, parabolas, ellipses, hyperbolas) Introduction to three-dimensional geometry.

Module 3: Limits and derivatives Continuity and differentiability, Application of derivatives (like rate of change, tangents and normals), Integrals (including definite and indefinite integrals), Applications of integrals (like area under curves)

Module 4: Measures of central tendency, dispersion, and introduction to probability distribution

Probability: Basic concepts, addition and multiplication theorems of probability, Mathematical Reasoning: Mathematical statements and their truth values

Logical operations and their use in mathematics

Module X: Matrices and determinants, Differential equations; Order and degree, methods of solving first-order differential equations, Vectors and scalars, Dot and cross products of vectors.

References:

1. Thomas Calculus 13Th Edition, George B. Thomas, Maurice D. Weir, Joel Hass, publisher: Pearson Education.

2. Advanced Engineering Mathematics Erwin Kreyszig, 10th edition

3. Advanced Engineering Mathematics, Michael D. Greenberg:

4. Higher Engineering Mathematics, B S Grewall, Khanna publishers

TEACHING LEARNING STRATEGIES

●Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

●Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks

Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

SEC

KU04SECMAT201 BASICS COURSE IN LATEX

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
1	SEC	200	KU04SECMAT201	3	45

Learning Approach (Hours/ Week)		Marks Distribution			Duration of ESE (Hours)
Lecture	Tutorial	CE	ESE	Total	
3	1	50	50	100	2Hrs

Course Objectives: To understand the importance of Latex in scientific typing and importance of using online methods for typing. To understand the basic Latex typing techniques and get a practical knowledge of how to type a Project Report/ Research Paper.

COURSE CONTENTS

Module 1: Understanding the Importance of Latex and the Basics, what is Latex? The main features, online overleaf access, Title, sections, command and arguments, Labelling table of contents, font effects, coloured texts and font sizing (Relevant sections of the Text Book 1).

Module 2: Comments, spacing, special characters, Equations, Symbols and Project/Thesis Report Typing: Lists, tables and figures, Equations and symbols, Reference: Bibliography styles.

Module 3: Report typing: thesis/ project report, Document classes: article, book. beamer and slides.

Text Book: Guide to LATEX, fourth edition, Helmut Kopka, Patrick W.Daly**https://www.math.ucdavis.edu/~tracy/courses/math129/Guide_To_LaTeX.pdf**

Reference Books

1.Overleaf learning material https://www.overleaf.com/learn

2.https://mirror.niser.ac.in/ctan/macros/latex/contrib/beamer/doc/beameruserguide.pdf

TEACHING LEARNING STRATEGIES

- Lecturing, Demonstration, Digital Learning, Team Work

MODE OF TRANSACTION

- Lecture, Seminar, Discussion

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Practical Tests	20 Marks
Practical Assignments	10 Marks
Viva	20 Marks
Total	50 Marks

Detailed Syllabus of Statistical Sciences

STATISTICS/ BIOSTATISTICS

COURSE DETAILS

SEMESTER I

A1 – DISCIPLINE SPECIFIC CORE COURSE

KU01DSCSTA101: DESCRIPTIVE STATISTICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
1	CORE	100	KU01DSCSTA101	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	1	1	50	50	100	3(T)+2(P)*

COURSE DESCRIPTION

This course serves as an introduction to statistical methods, covering key concepts and techniques essential for understanding and analyzing data. Through a combination of theoretical concepts and practical applications, students will learn key statistical techniques and methodologies for summarizing and interpreting data. The course is divided into four units, each focusing on different aspects of statistical analysis.

COURSE OBJECTIVES

- Understand the fundamental concepts of statistics: Students will grasp the basic principles and terminology of statistics, including the definition and scope of the field.

- Recognize and classify types of data: Students will be able to identify and categorize different types of data, including quantitative and qualitative data, and understand the scales of measurement (nominal, ordinal, interval, and ratio).
- Utilize various data presentation techniques: Students will learn to present data effectively using tabular and graphical methods, including histograms, frequency polygons, bar charts, pie diagrams, stem and leaf charts, and ogives.
- Understand the concepts of central tendency, dispersion, skewness and kurtosis and their measures.

COURSE OUTCOMES

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

SL No	Course Outcomes
CO1	Concepts of statistical population and sample, types of variables and attributes.
CO2	Tabular and graphical representation of data based on variables.
CO3	Measures of central tendency, dispersion and their computations.
CO4	Moments, skewness and kurtosis and their uses.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔			
CO2	✔	✔		✔	
CO3	✔	✔		✔	✔
CO4	✔	✔	✔		

COURSE CONTENTS

UNIT 1

Different Aspects of Data and its Collection: Statistics as collected facts and figures and as a science for extracting information from data. Concepts of a statistical population and sample. Different types of characteristics and data qualitative and quantitative, cross sectional and time-series, discrete and continuous, frequency and non-frequency. Different types of scale- nominal and ordinal, ratio and interval. Collection of data-census and sampling. Different types of random samples-simple random sample, systematic, stratified and cluster (description only). **(15 hrs)**

UNIT 2

Measures of Central Tendency (Mathematical and positional averages) and their properties: Mean, median, mode, harmonic mean, geometric mean, weighted mean, quartiles, deciles, percentiles. Short-cut method for the evaluation of mean of raw and grouped data. **(20 hrs)**

UNIT 3

Measures of Dispersion :- Range, quartile deviation, mean deviation, standard deviation and variance. Relative and absolute measures of dispersion, coefficients of dispersion based on: - Range, quartile deviation, mean deviation, standard deviation;. Short-cut method for the evaluation of variance and standard deviation for raw and grouped data. Boxplot and Lorenze curve. **(20 hrs)**

UNIT 4

Moments, Skewness and Kurtosis: Moments, raw moments, central moments, relation between raw moments and central moments, absolute moments. Short-cut method for the evaluation of central moments of raw and grouped data, various measures of skewness and kurtosis. **(20 hrs)**

UNIT 5 (Optional)

History of Statistics, data entering using EXCEL/SPSS, understanding the usage of various statistical and mathematical functions in EXCEL/SPSS. Preparation of a questionnaire, data collection (online/offline) and analysis of data using methods explained in Units 1 to 4, preparation and submission of a report. **(15hrs)**

TEXT BOOKS

1. Gupta, S. C. and Kapoor, V. K. (2020). ***Fundamentals of Mathematical Statistics***. Sultan Chand and Sons' Publishers, New Delhi.

2. Dabas, P. (2024). ***Descriptive and Inferential Statistics Using R***. Sultan Chand and Sons' Publishers, New Delhi.

3. Mood, A.M., Graybill, F.A. and Bose, D.C. (2007).***Introduction to the Theory of Statistics***, ***3rd Edn.***, (Reprint), Tata McGraw-Hill Pub. Co. Ltd.

SUGGESTED READINGS:

1. Spiegel, M. R. and Stephens, L. J. (2017). ***Schaum's Outline of Statistics***, 6th Edn., McGraw-Hill Education.
2. Gun, A. M., Gupta, M.K. and Dasgupta, B. (2008). ***Fundamentals of Statistics***. India: World Press.
3. Armitage, P., Berry, G., and Matthews, J. N. S. (2008). ***Statistical Methods in Medical Research***. John Wiley & Sons.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

SEMESTER II

A2– DISCIPLINE SPECIFIC CORE COURSE

KU02DSCSTA104: PROBABILITY THEORY AND RANDOM VARIABLES

Semester	Course Type	Course Level	Course Code		Credits	Total Hours
2	CORE	100	KU02DSCSTA104		4	90
Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	1	1	50	50	100	3(T)+2(P)*

COURSE DESCRIPTION:

This course provides a comprehensive introduction to probability theory, covering foundational concepts, axiomatic definitions, conditional probability, independence, and the practical applications of Bayes' theorem. The course is structured into four units, each focusing on different aspects of probability theory.

COURSE OBJECTIVES:

- To develop a solid understanding of the fundamental concepts of probability theory, including random experiments, sample space, events, and basic probability calculations.
- To acquire knowledge of different definitions of probability, including classical, empirical, and axiomatic definitions, and understand the properties and limitations of each.
- To develop proficiency in applying mathematical concepts such as sets, sigma algebras, and measures to describe probability spaces and analyze probabilities of events.
- To enhance problem-solving skills by applying probability concepts to a variety of real-world scenarios and numerical problems, including conditional probability, independence, and Bayes’ theorem.

COURSE OUTCOME:

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

SL No	Course Outcomes
CO1	Understand Probability Foundations: Students will demonstrate a solid understanding of the foundational concepts of probability theory, including random experiments, sample space, events, and the distinction between mutually exclusive and exhaustive events.
CO2	Apply Axiomatic Definition of Probability: Upon completion of the course, students will be able to apply the axiomatic definition of probability, understanding probability as a measure and its representation in a probability space.
CO3	Analyze Conditional Probability and Independence: Students will demonstrate proficiency in calculating conditional and marginal probabilities, as well as joint probabilities.
CO4	Apply Bayes' Theorem in Practical Situations: By the end of the course, students will be able to apply Bayes' theorem to solve practical problems involving conditional probability and independence.

MAPPING OF COs to PSO

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	
CO2	✔		✔	✔	
CO3	✔	✔		✔	
CO4	✔		✔	✔	✔

COURSE CONTENTS

UNIT 1

Probability Theory: Random experiments. Complement, union and intersection of events and their meaning. Mutually exclusive, equally likely and Independent events. Classical, Frequency and Axiomatic approaches to probability. Monotone property, Addition theorem (up to 3 events. Conditional probability. Multiplication theorem(up to 3 events). Independence of events. Bayes' theorem. (problems based on the above topics).

(15 hrs)

UNIT 2

Probability Distribution of Univariate Random Variables: Concept of random variables. discrete and continuous random variables. Probability mass and density functions, and cumulative distribution functions. Evaluation of conditional and unconditional probabilities. Change of variables - methods of jacobian and cumulative distribution function (one variable case). (problems based on the above topics). **(20 Hours)**

UNIT 3

Probability Distribution of Bivariate Random Variables: Concept of a two-component random vector. Bivariate probability mass and density functions. Marginal and conditional distributions. Independence of bivariate random variables. (problems based on the above topics). **(20 Hours)**

UNIT 4

Correlation and Regression: Bivariate data, types of correlation. scatter diagram. Karl Pearson's product-moment and Spearman's rank correlation coefficients. Regression equations-fitting of polynomial equations of degree one and two; exponential curve, power curve. Two type of regression curves, Identification of regression equations. (problems based on the above topics). **(15 Hours)**

UNIT 5 (Teacher Specific Module- Optional)

Prerequisites to Study Probability Theory: History of probability, paradoxes in probability, basic set theory for probability, representation of sets in Venn diagram, operations of sets-union, intersection, complementation, basic principle of counting, problems related to permutation and combination. Computations using R. **(20 Hours)**

TEXT BOOKS

1. Ross, S. (2010). ***A First Course in Probability***. 8th Ed., Pearson, Prentice Hall.

2. Spiegel, M. R., Schiller, J. J., and Srinivasan, R. A. (2013). ***Schaum's outline of Probability and Statistics***. McGraw-Hill Education.

SUGGESTED READINGS

1. Gupta, S. C. and Kapoor, V. K. (2020). ***Fundamentals of Mathematical Statistics***. Sultan Chand and Sons' Publishers, New Delhi.

2. Gut, A. (2005).***Probability: A Graduate Course***. Springer, New York.

3. Baclawski, K. (2008). ***Introduction to Probability with R***. Chapman and Hall/CRC.

4. Feller, W. (1999). ***An Introduction to Probability Theory and Its Applications*** **(Vol. 1)**. Wiley.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

SEMESTER II

A3– DISCIPLINE SPECIFIC CORE COURSE

KU02DSCSTA103:INTRODUCTION TO R PROGRAMMING

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
2	CORE	100	KU02DSCSTA103	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	4	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course serves as an introduction to R programming, a powerful tool widely used for data analysis and statistical computing. Through a series of hands-on exercises and practical examples, students will learn how to use R for data manipulation, visualization, and statistical analysis.

COURSE OBJECTIVES:

- Understand the installation process of R and its basic functionalities.
- Familiarize with R preliminaries, including objects, classes, operators, and common built-in functions.
- Learn to install new packages and explore different datasets available in R packages for analysis.
- Explore graphical representations of data using R, such as histograms, bar plots, box plots, stem-and-leaf plots, scatter plots, and Q-Q plots.
- Learn to write custom functions in R for specific statistical analyses and implement them in simple R programs.

COURSE OUTCOME:

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

SL No	Course Outcomes
CO1	Demonstrate proficiency in the fundamentals of R programming, including installing R, using R as a calculator, understanding R preliminaries.
CO2	Learners will develop a solid understanding of various data structures in R such as vectors, lists, matrices, and data frames.
CO3	Students will apply R programming skills to perform descriptive statistical analysis, including calculating measures of central tendency, dispersion, skewness, and kurtosis.

CO4	Proficiency in Writing R Programs for Data Analysis: Students will develop the ability to write R programs for statistical analysis, including looping structures (for, repeat, while), conditional statements (if, if-else), and custom function creation.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔		✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔		✔	✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

UNIT 1

Introduction to R: Installation of R, R as a calculator, R preliminaries, objects and their classes, operators, methods of data input, importing and exporting data. Getting help, saving, storing and retrieving work, common built-in functions. **(15 Hours)**

UNIT 2

Data structure of R: Vectors, lists, matrices, arrays, factors, data frames, strings. Indexing and accessing data,, installation of new packages, different data sets available in R package.

(20 Hours)

UNIT 3

Simple Applications: Descriptive statistics: Measures of central tendency, measures of dispersion, skewness and kurtosis, R-Graphics- histogram, bar plot, Box-plot, stem and leaf plot, scatter plot, Q-Q plot, matrix operations: addition, multiplication, inverse, power, determinant, eigenvalue, eigenvector, solution of system of linear equations.

(20Hours)

UNIT 4

Writing R Programmes: Looping- For loop, repeat loop, while loop, if command, if else command, in-built functions and custom functions in R. Writing simple programmes in R for statistical analysis. **(15Hours)**

UNIT 5 (Teacher Specific Module- Optional)

Introduction to R-Studio and R Markdown. Practicals using R to obtain graphical representation of data, summarization of data and tabulated form of data. **(20Hours)**

TEXT BOOKS

1. Maria D.U., Ana F.M. and Alan T.A. (2008***): Probability and Statistics with R.*** CRC Press.
2. Dalgaard, P. (2008): ***Introductory Statistics with R (Second Edition)***, Springer.

SUGGESTED READINGS

1. Purohit, S.G., Gore, S. D. and Deshmukh, S. R. (2004): ***Statistics Using R***. Narosa.
2. Maria L. Rizzo (2019). ***Statistical Computing with R***, ***Second Edition.*** Chapman & Hall, CRC Press.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

SEMESTER III

A4– DISCIPLINE SPECIFIC CORE COURSE

KU03DSCSTA205: PROBABILITY DISTRIBUTIONS

<table>
<tr><td>Semester</td><td>Course Type</td><td>Course Level</td><td colspan="2">Course Code</td><td>Credits</td><td>Total Hours</td></tr>
<tr><td>3</td><td>CORE</td><td>200</td><td colspan="2">KU03DSCSTA205</td><td>4</td><td>90</td></tr>
<tr><td colspan="3">Learning Approach (Hours/ Week)</td><td colspan="3">Marks Distribution</td><td rowspan="2">Duration of ESE (Hours)</td></tr>
<tr><td>Lecture</td><td>Practical/ Internship</td><td>Tutorial</td><td>CE</td><td>ESE</td><td>Total</td></tr>
<tr><td>4</td><td>1</td><td>1</td><td>50</td><td>50</td><td>100</td><td>3(T)+2(P)*</td></tr>
</table>

COURSE DESCRIPTION:

This course provides a comprehensive understanding of probability theory and random variables, covering both discrete and continuous probability distributions, as well as joint distributions and mathematical expectations. Through a series of lectures, discussions, and practical exercises, students will gain the necessary knowledge and skills to analyze and interpret random variables in various contexts.

COURSE OBJECTIVES:

- Understand the concept of discrete random variables and their probability mass function (pmf), distribution function, and survival function.
- Analyze properties and examples of continuous probability distributions.
- Understand the Jacobian of transformation and its application in transforming random variables.
- Study joint probability mass function and distribution function for two-dimensional random variables.

- Understand moments of a random variable, including mean and variance, and compute them.

COURSE OUTCOME:

SL No	Course Outcomes
CO1	Enable to identify the situations involving discrete and continuous random variables
CO2	Explain the concept distribution function and density function.
CO3	Understand the notion of expectation and moments.
CO4	Solve various problems involving expectation and moment generating functions.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔		✔	✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	

COURSE CONTENTS

UNIT 1

Mathematical Expectation: Expectation of random variables and their functions. Definition of: Raw moments, central moments and their interrelation, A.M, G.M, HM, S.D, M.D., covariance, Pearson's correlation coefficient in terms of expectation.MGF and characteristic function and simple properties. Moments from mgf. (Problems based on these topics).

(20 Hours)

UNIT 2

Standard Probability Distributions: Uniform (discrete/continuous), Bernoulli, binomial, Poisson, geometric, hyper-geometric, exponential, gamma - one and two parameter(s), beta (type I and type II), - mean, variance, mgf, additive property, lack of memory property. Normal distribution with all properties. (Problems based on these topics). **(20 Hours)**

UNIT 3

Law of Large Numbers and Central Limit Theorem: Chebychev's inequality, Weak Law of Large Numbers - Bernoulli's and Chebychev's form. Central Limit Theorem (Lindberg - Levy form with proof). (Problems based on these topics). **(20 Hours)**

UNIT 4

Sampling Distributions: Concept of sampling from a probability distribution id. observations. Concept of sampling distributions, Statistic(s) and standard error(s). Mean and variance of sample mean when sampling is from a finite population. Sampling distribution of mean and variance from normal distribution. Chi-square, t, F distributions and Statistics following these distributions. Relation among Normal, Chi- square, t and F distributions. (Problems based on these topics). **(15 Hours)**

UNIT 5 (Teacher Specific Module- Optional)

Random Variate Generation: Random variate generation from discrete and continuous distributions using R, computation of mean, variance, correlation and moments of random variable using R, plotting pmf, pdf and df using R. **(10 Hours)**

TEXT BOOKS

1. Ross, S. (2010). ***A First Course in Probability***. 8th Ed., Pearson, Prentice Hall.

2. Gupta, S. C. and Kapoor, V. K. (2020). ***Fundamentals of Mathematical Statistics***. Sultan Chand and Sons' Publishers, New Delhi.

SUGGESTED READINGS

1. Rohatgi, V. K. and Saleh, A. K. M. E. (2015). ***An Introduction to Probability and Statistics***. Wiley.

2. Maria D.U., Ana F.M. and Alan T.A. (2008***): Probability and Statistics with R.*** CRC Press.

3. Gut, A. (2005). ***Probability: A Graduate Course***. Springer, New York.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

SEMESTER III

A9–DISCIPLINE SPECIFIC CORE COURSE

KU03DSCSTA206: SAMPLING TECHNIQUES

<table>
<tr><td>Semester</td><td>Course Type</td><td>Course Level</td><td colspan="2">Course Code</td><td>Credits</td><td>Total Hours</td></tr>
<tr><td>3</td><td>CORE</td><td>200</td><td colspan="2">KU03DSCSTA206</td><td>4</td><td>90</td></tr>
<tr><td colspan="3">Learning Approach (Hours/ Week)</td><td colspan="3">Marks Distribution</td><td rowspan="2">Duration of ESE (Hours)</td></tr>
<tr><td>Lecture</td><td>Practical/ Internship</td><td>Tutorial</td><td>CE</td><td>ESE</td><td>Total</td></tr>
<tr><td>4</td><td>1</td><td>1</td><td>50</td><td>50</td><td>100</td><td>2(T)+3(P)*</td></tr>
</table>

COURSE DESCRIPTION:

This course provides an in-depth exploration of sampling techniques and survey methodology, focusing on the principles, applications, and practical considerations involved in conducting sample surveys. Through lectures, discussions, and hands-on exercises, students will develop a comprehensive understanding of various sampling methods and their implications for estimating population quantities.

COURSE OBJECTIVES:

- Understand the definition, importance, and applications of sampling in statistical analysis.
- Understand the basic types of sampling techniques: probability sampling and non-probability sampling.
- Understand the concepts of accuracy and precision of estimates, and identify biases in surveys.
- Learn methods for estimating population mean and total under systematic sampling, and calculate variances of these estimates.
- Define stratified sampling and cluster sampling and understand their respective advantages and applications.

COURSE OUTCOME:

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

SL #	Course Outcomes
CO1	Grasp the fundamental principles of sampling, including its definition, importance, and applications in various fields
CO2	Acquire proficiency in estimating population parameters using different sampling techniques.
CO3	Develop the ability to discern between different types of sampling techniques and understand their respective advantages, limitations.
CO4	Demonstrate proficiency in implementing sampling methodologies and analyzing sample data using computational techniques.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔		✔	✔
CO3	✔	✔	✔	✔	✔

CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

UNIT 1

Introduction to Sample Surveys: Introduction to Population, Census, Sample Survey, Principles of Sample Survey, Principle Steps in Sample Survey, Sampling and Non-sampling Error, Advantages of Sampling over Census, Types of Sampling, Objectives of Sampling, Problems of Sampling Methods. **(20 Hours)**

UNIT 2

Simple Random Sampling: Introduction to Simple Random Sampling, Methods of Selection of a Sample- Lottery Method, Random Number Method, Computer Random Number Generation Method. Properties of Simple Random Sampling, Merits and Demerits of Simple Random Sampling, Simple Random Sampling of Attributes, Sample Size for Specific Precision. **(20 Hours)**

UNIT 3

Stratified Random Sampling: Principles of Stratification, Properties of Stratified Random Sampling, Mean and Variance for Proportions, Allocation of Sample Size: Proportional Allocation, Neyman's Allocation and Optimum Allocation. Stratified Sampling versus Simple Random Sampling, Proportional Allocation Versus Simple Random Sampling, Neyman's Allocation Versus Proportional Allocation, Neyman's Allocation Versus Simple Random Sampling, Merits and Demerits of Stratified Random Sampling. **(20 Hours)**

UNIT 4

Some Other Sampling Schemes: Introduction to Systematic Sampling, Methods of Systematic Sampling- Linear Systematic Sampling and Circular Systematic Sampling. Advantages and Disadvantages of Systematic Sampling, Properties of Systematic Sampling, Comparison between Simple Random, Stratified and Systematic Sampling, Introduction to Cluster Sampling, Significance of Systematic Sampling Formation of Cluster, Properties of Cluster Sampling, Introduction to Two-stage Sampling, Properties of Two-stage Sampling.

(20 Hours)

UNIT 5 (Optional)

Computational illustration of above concepts using R packages for sampling. Sample size calculation using specified packages.

(15 Hours)

TEXT BOOKS

1. Daroga Singh, Fauran S. Chaudhary (2010). ***Theory and Analysis of Sample Survey Designs.*** John Wiley.
2. Gupta. S. C & Kapoor. V. K. (2002): ***Fundamentals of Applied Statistics***, Sultan Chand & Sons (P) Ltd.

SUGGESTED READINGS

1. Cochran W.G. (1984): ***Sampling Techniques(3rd Ed.)***, Wiley Eastern.
2. Sukhatme, P. V., Sukhatme, B. V. Sukhatme, S. Asok, C.(1984). ***Sampling Theories of Survey With Application,*** IOWA State University Press and Indian Society of Agricultural Statistics.
3. Murthy M.N. (1977): ***Sampling Theory & Statistical Method***s, Statistical Pub. Society, Calcutta.

TEACHING LEARNING STRATEGIES

● Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

●Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

SEMESTER III

A5– DISCIPLINE SPECIFIC CORE COURSE

KU03DSCSTA203:MATRIX THEORY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
3	CORE	200	KU03DSCSTA203	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	1	1	50	50	100	3(T)+2(P)*

COURSE DESCRIPTION:

This course provides a comprehensive introduction to linear algebra and matrix theory, covering fundamental concepts, operations, and applications of matrices and linear equations. Through a combination of lectures, demonstrations, and practical exercises, students will develop a strong foundation in linear algebra and its applications in various fields.

COURSE OBJECTIVES:

- Gain a solid understanding of matrices, including their definition and basic operations such as addition, subtraction, scalar multiplication, and matrix multiplication.
- Understand the concept of determinants, their definition, properties, and calculation methods.
- Study the inverse of a square matrix, its existence, properties, and calculation methods, including the use of elementary row and column transformations.
- Learn about the characteristic equation and characteristic polynomial of a matrix.
- Study systems of linear equations and represent them using matrix notation.
- Understand the Gaussian elimination procedure and its application in solving systems of linear equations.

COURSE OUTCOME:

SL #	Course Outcomes
CO1	Demonstrate a thorough understanding of fundamental concepts in matrix theory, including matrix representation, basic operations (addition, subtraction, scalar multiplication, and matrix multiplication), and properties of special matrices
CO2	Compute determinants of square matrices using various methods, understand the properties of determinants, and apply them in calculating inverses of matrices.
CO3	Grasp the concepts of eigenvalues and eigenvectors, their significance in linear algebra, and their applications in diagonalizing matrices.
CO4	Acquire problem-solving skills in systems of linear equations, including representation using matrix notation, determination of solutions, and application of methods such as Gaussian elimination and Cramer's rule.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔		✔	✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔		✔	✔

COURSE CONTENTS

Unit I

Basics of Matrices: Introduction to matrices, matrix operations: addition, subtraction, scalar multiplication, matrix multiplication and properties, transpose of a matrix, special matrices: square matrix, diagonal and triangular matrices, identity matrix, diagonal matrix, symmetric matrix, skew symmetric matrix, idempotent matrix, stochastic matrix, orthogonal matrices.

(15 Hours)

Unit II

Determinants and Inverses: Determinants: definition, properties, and calculation methods, adjoint and minors of a square matrix, Inverse of a square matrix: existence, properties, and calculation methods, computation of inverse using elementary row and column transformations. Properties of invertible matrices, applications of determinants and inverses

(20 Hours)

Unit III

Eigenvalues and Eigenvectors: Eigenvalues and eigenvectors: definition and basic properties, characteristic equation and characteristic polynomial, Cayley-Hamilton theorem and its applications, diagonalization of matrices, powers of a square matrix using eigenvalues and eigenvectors, trace and determinants of square matrix.

(20Hours)

Unit IV

Systems of Linear Equations: Linear equation and solutions, system of linear equations, matrix representation, augmented and coefficient matrices of a system, degenerate linear equations, equivalent systems, elementary operations, elimination algorithm, systems in triangular and echelon forms, echelon form, pivot and free variables, Gaussian elimination procedure, Cramer's rule and its applications.

(20 Hours)

Unit V (Teacher Specific Module- Optional)

Numerical computation of various characteristics and operations of matrices and solution of system of linear equations using R.

(15 Hours)

TEXT BOOKS

1. Lipschutz, S. (2009). ***Linear Algebra (4th ed***.). McGraw-Hill.
2. Lay David C. (2000). ***Linear Algebra and Its Applications***, Addison Wesley

SUGGESTED READINGS

1. Gupta S.C. (2008). ***An Introduction to Matrices***. Sultan Chand & Sons. New Delhi
2. Datta K.B. (2002). ***Matrix and Linear Algebra.*** Prentice Hall of India Pvt. Ltd.
3. Searle S.R. (1982). ***Matrix Algebra Useful for Statistics***. John Wiley &Sons.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

SEMESTER III

A6– DISCIPLINE SPECIFIC CORE COURSE

KU03DSCSTA204:STATISTICAL COMPUTING USING SPSS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
3	CORE	200	KU03DSCSTA204	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	

2	2	1	50	50	100	3(T)+2(P)*

COURSE DESCRIPTION:

The course provides a comprehensive introduction to IBM SPSS Statistics, a powerful software package widely used for statistical analysis in various fields. It is divided into four modules, each covering specific aspects of SPSS functionality and statistical analysis techniques. Throughout the course, students will engage in practical exercises and real-world applications to reinforce their understanding of SPSS and statistical analysis techniques. By the end of the course, students will have acquired the skills necessary to effectively utilize SPSS for data management, analysis, and presentation in their academic or professional endeavors.

COURSE OBJECTIVES:

- Understanding SPSS Fundamentals: By the end of the course, students should be proficient in navigating the SPSS interface, entering and managing data, defining variables, and utilizing essential features for data manipulation and organization.
- Data Visualization and Presentation Skills: Students will develop the ability to create a variety of graphs and visualizations using SPSS, and they will learn how to customize these visuals for effective communication of statistical findings in reports, presentations, and academic papers.
- Exploratory Data Analysis Proficiency: The course aims to equip students with the skills necessary to conduct exploratory data analysis using SPSS, including generating frequency distributions, summary tables, and basic visualizations to understand the characteristics and distribution of data.
- Statistical Analysis Competence: Students will gain competence in performing basic statistical analyses such as correlation analysis and linear regression using SPSS. They will learn how to interpret statistical output, assess model fit, and report results in a clear and concise manner.
- Practical Application and Problem-Solving: Through hands-on exercises and real-world examples, students will develop problem-solving skills and learn how to apply SPSS techniques to analyze and interpret data from various fields, preparing them for practical use in academic research, business analytics, or other professional contexts.

COURSE OUTCOME:

SL No	Course Outcomes
CO1	Demonstrate proficiency in using IBM SPSS Statistics software for various tasks including data entry, manipulation, analysis, and visualization. They will be able to navigate the SPSS interface confidently and utilize its features effectively to manage and analyze datasets.

CO2	Develop the ability to conduct basic statistical analyses using SPSS and interpret the results accurately. This includes performing descriptive statistics, correlation analysis, and simple linear regression, as well as understanding the assumptions and limitations associated with these analyses.
CO3	Learn how to create informative and visually appealing graphs and charts using SPSS, and they will be able to tailor these visualizations to effectively communicate their findings to various audiences. They will also gain skills in preparing SPSS output for inclusion in reports, presentations, and academic papers.
CO4	Develop critical thinking skills and learn how to apply statistical concepts and methods to solve problems and make informed decisions. They will be able to evaluate the appropriateness of different statistical techniques for analyzing specific types of data and research questions.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔		✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔		✔	✔

COURSE CONTENTS

Module 1:

Introduction to SPSS: What is SPSS?, Versions of IBM SPSS Statistics, Getting started, Opening SPSS, Layout of SPSS, Structure of SPSS, Exiting SPS, An overview of SPSS, The data editor, Entering data into the data editor, The variable view, Creating a string variable, Creating a date variable, Creating coding variables, Creating a numeric variable, Missing values, Importing data, The SPSS viewer, Exporting SPSS output, The syntax editor, Saving files, Retrieving a file.

(15 Hours)

Module 2:

Graphics in SPSS: Exploring data with graphs, The art of presenting data, The SPSS chart builder, Histograms, Further histogram options, Boxplots (box–whisker diagrams), bar charts and error bars, Simple bar charts for independent means, Clustered bar charts for independent means, Simple bar charts for related means, Clustered bar charts for related means, Line charts, the scatterplot, Grouped scatterplot, Matrix scatterplot, density plot, Editing graphs.

(20 Hours)

Module 3:

Exploring data distributions using descriptive statistics, Creating frequency distributions and summary tables, Generating basic visualizations (e.g., histograms, box plots) in SPSS. Computing measures of dispersion, Understanding correlation and covariance, Performing correlation analysis in SPSS, Data entry for correlation analysis using SPSS, General procedure for running correlations in SPSS, Running Pearson's r in SPSS, Spearman's correlation coefficient, Kendall's tau. **(25 Hours)**

Module 4:

Introduction to linear regression and its application in SPSS, The simple linear model, Running a simple regression using SPSS, Interpreting a simple regression, Model parameters, Understanding hypothesis testing principles, Conducting hypothesis tests in SPSS, Interpreting SPSS output for hypothesis testing. **(15 Hours)**

Unit V (Teacher Specific Module- Optional)

The t-test, Independent-samples t-test, Paired-samples t-test, The independent t-test using SPSS, Output from the independent t-test, Reporting the independent t-test, Paired-samples t-test using SPSS, Output from the paired-samples t-test, Reporting the paired-samples t-test. **(15 Hours)**

TEXT BOOKS

1. Field, A. (2013). ***Discovering Statistics Using IBM SPSS Statistics***. Sage Publications.
2. Landau, S., & Everitt, B. S. (2003). ***A Handbook of Statistical Analyses Using SPSS***. Chapman and Hall/CRC.

SUGGESTED READINGS

1. Aldrich, J. O. (2018).***Using IBM SPSS statistics: An Interactive Hands-on Approach.*** Sage Publications.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

SEMESTER IV

A5– DISCIPLINE SPECIFIC CORE COURSE

KU04DSCSTA211: ELEMENTARY STATISTICAL INFERENCE

<table>
<tr><td>Semester</td><td>Course Type</td><td>Course Level</td><td colspan="2">Course Code</td><td>Credits</td><td>Total Hours</td></tr>
<tr><td>4</td><td>CORE</td><td>200</td><td colspan="2">KU04DSCSTA211</td><td>4</td><td>90</td></tr>
<tr><td colspan="3">Learning Approach (Hours/ Week)</td><td colspan="3">Marks Distribution</td><td rowspan="2">Duration of ESE (Hours)</td></tr>
<tr><td>Lecture</td><td>Practical/ Internship</td><td>Tutorial</td><td>CE</td><td>ESE</td><td>Total</td></tr>
<tr><td>4</td><td>1</td><td>1</td><td>50</td><td>50</td><td>100</td><td>3(T)+2(P)*</td></tr>
</table>

COURSE DESCRIPTION:

This course provides an in-depth exploration of probability distributions and generating functions, focusing on both discrete and continuous distributions. Through lectures, discussions, and practical exercises, students will gain a comprehensive understanding of various probability distributions and their properties, as well as the use of generating functions for analyzing random variables.

COURSE OBJECTIVES:

- Explore different types of generating functions, including probability generating function (PGF), factorial moment generating function (discrete case only), moment generating function (MGF), and characteristic function, along with their properties.
- Gain familiarity with various standard discrete distributions, including degenerated distribution, discrete uniform distribution, Bernoulli distribution, Binomial distribution, and Poisson distribution.
- Study continuous probability distributions including continuous uniform distribution, normal distribution, standard uniform, and standard normal distributions.
- Learn methods for fitting exponential and gamma distributions to data.

COURSE OUTCOME:

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

SL #	Course Outcomes
CO1	Understand the fundamental concepts of discrete and continuous probability distributions.
CO2	Analyze and interpret advanced discrete distributions including geometric, hyper geometric, and negative binomial distributions, and apply them to solve complex problems.
CO3	Apply statistical inference techniques and hypothesis testing methodologies using sampling distributions.
CO4	Utilize computational tools, particularly R programming language, to implement and illustrate probability distribution concepts effectively.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔		✔	✔	✔
CO2	✔	✔	✔	✔	
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

Unit I

Point Estimation: Concepts of Estimation, Estimators and Estimates. Point and interval estimation. Properties of good estimators - unbiasedness, efficiency, consistency and sufficiency. Factorization theorem (statement). (problems based on these topics). **(20 Hours)**

Unit II

Methods of Estimation, Interval Estimation: Methods of moments, maximum likelihood. Invariance property of ML Estimators (without proof). Minimum variance. Cramer-Rao inequality (statement only) 100(1-a)% confidence intervals for mean, variance and proportions(problems based on these topics)

(20 Hours)

Unit III

Testing of Hypotheses, Large Sample Tests: Statistical hypotheses; null and alternate hypotheses, simple and composite hypotheses, type-I and type-II errors. Critical Region. Size and power of a test, p-value, Neyman-Pearson approach. Large sample tests - z-tests for means, difference of means, proportion and difference of proportion, chi-square tests for independence, homogeneity.

(20 Hours)

Unit IV

Small Sample Tests: Normal tests for mean, difference of means and proportion (when σ known), t-tests for mean and difference of means (when σ unknown), paired t-test, test for proportion (binomial), chi-square test, F-test for ratio of variances. (derivation not required).

(15 Hours)

Unit V (Teacher Specific Module- Optional)

Random variate generation using R/SPSS, random variate generation from standard discrete and continuous distributions, fitting of the distributions using generated data. Fitting of a probability distribution for a real life data set and submission of an assignment.

(20 Hours)

TEXT BOOKS

1. Gupta. S. C and Kapoor. V. K. (2002): ***Fundamentals of Mathematical Statistics***, Sultan Chand & Sons (P) Ltd. New Delhi
2. Krishnamoorthy, K. (2015). ***A Handbook on Statistical Distributions with Applications***. Chapman and Hall/CRC, New York.
3. Bhuyan. K. C. (2010): ***Probability Distribution Theory and Statistical Inference.*** New Central Book Agency (P) Limited.

SUGGESTED READINGS

1. Robert. V. Hogg Allen T. Craig: ***Introduction to Mathematical Statistics***- Macmillan Publishing Co. Inc. NEW YORK.
2. Goon A. M, Gupta M. K. , Das Gupta. B. (1999): ***Fundamentals of Statistics, Vol. I and Vol. II***, World Press, Calcutta.
3. Maria D.U., Ana F.M. and Alan T.A. (2008***): Probability and Statistics with R.*** CRC Press.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks

Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

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Semester IV

A9–DISCIPLINE SPECIFIC CORE COURSE

KU04DSCSTA212:APPLIED STATISTICS-1

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
4	CORE	200	KU04DSCSTA212	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course provides an in-depth exploration of applied statistical techniques with a focus on sampling methods, index numbers, quality control, time series analysis, and vital statistics. The curriculum balances theory and hands-on computational practice, particularly using R. The emphasis is on real-world applications and data interpretation skills essential for statistical analysis.

COURSE OBJECTIVES:

- To understand the definition, importance, and scope of sampling in statistical surveys.
- To familiarize with concepts and computations related to index numbers and their applications.
- To develop knowledge in statistical quality control tools.
- To introduce students to the components and analysis of time series data.
- To provide insights into the computation and interpretation of vital statistics.

- To apply R programming in solving real-world problems in sampling and applied statistics.

COURSE OUTCOME:

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

SL #	Course Outcomes
CO1	Understand the concept, construction, and interpretation of various Index Numbers and their applications in economic and price statistics.
CO2	Gain proficiency in methods of Statistical Quality Control, including the use of control charts for process monitoring.
CO3	Analyze and interpret time series data using decomposition methods, and estimate trend and seasonal variations.
CO4	Compute and interpret vital statistics like fertility, mortality rates, and life tables for demographic analysis.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔		✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

UNIT 1

Index Numbers: Definition of Index Numbers. Price Index Numbers. Price Index Numbers as Simple (A.M., G.M.) and Weighted averages (A.M.) of price relatives. Laspeyer's, Paasche's and Fisher's Index Numbers. Time-Reversal and Factor-Reversal tests. Cost of living index numbers-family budget and aggregate expenditure methods. An introduction to Whole sale Price Index and Consumer Price Index.(problems based on the above topics).

(20 Hours)

UNIT 2

Quality Control: Meaning and objectives of quality control, distinction between process control and product control, control charts for variables including $\bar{X}$-chart and R-chart, control charts for attributes including p-chart, np-chart and c-chart, interpretation of control charts for detection of assignable causes, concepts of producer's risk and consumer's risk, introduction to process capability and six sigma, numerical illustrations on the construction and analysis of control charts. **(20 Hours)**

UNIT 3

Time Series: Definition and components of time series including trend, seasonal, cyclical and irregular variations, estimation of trend by graphical method, semi-average method, moving average method and least squares method (linear trend only), measurement of seasonal variation using method of simple averages, ratio-to-moving average method and ratio-to-trend method, introduction to forecasting using time series models, numerical problems on decomposition and interpretation of time series data. **(20 Hours)**

UNIT 4

Vital Statistics: Meaning and uses of vital statistics, sources of vital statistics including census, civil registration and survey methods, measures of fertility such as crude birth rate (CBR), general fertility rate (GFR), age-specific fertility rate (ASFR), and total fertility rate (TFR), measures of mortality including crude death rate (CDR), age-specific death rate (ASDR), and infant mortality rate (IMR), components of life tables and their construction, uses of life tables in demographic analysis, computation-based problems on fertility, mortality, and life expectancy.

(20 Hours)

UNIT 5 (Optional)

Computational illustration of above concepts using R packages for sampling. Sample size calculation using specified packages. **(15 Hours)**

TEXT BOOKS

1. Gupta, S. C., & Kapoor, V. K. (2020). *Fundamentals of applied statistics* (4th ed.). Sultan Chand & Sons.
2. Montgomery, D. C. (2020). *Introduction to statistical quality control* (8th ed.). Wiley.
3. Spiegel, M. R., Schiller, J., & Srinivasan, R. A. (2021). *Schaum's outline of probability and statistics* (4th ed.). McGraw-Hill.
4. Mukhopadhyay, P. (2011). *Applied statistics* (2nd ed.). Books and Allied (P) Ltd.

SUGGESTED READINGS

1. Chandan, S. (2014). *Statistics for business and economics*. Vikas Publishing.
2. Das, M. N., & Giri, N. (1986). *Design and analysis of experiments*. New Age International.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester IV

A10– DISCIPLINE SPECIFIC CORE COURSE

KU04DSCSTA213: STATISTICAL COMPUTING USING R

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
4	CORE	200	KU04DSCSTA213	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	2	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course provides a comprehensive overview of statistical estimation techniques and inference methods, focusing on both point and interval estimation for parametric models. Through lectures, demonstrations, and practical examples, students will gain a deep understanding of the principles and properties of various estimation methods and their applications in statistical analysis.

COURSE OBJECTIVES:

- Understand the concept of parameters in statistical models, parameter space, and families of parametric models.

- Study the concepts of bias and mean squared error (MSE) of an estimator, as well as variance of an estimator.
- Understand the concepts of minimum variance unbiased estimator (MVUE), Cramer-Rao inequality, Fisher's information, and efficiency.
- Explore different methods of estimation including method of moments, method of Maximum Likelihood Estimation (MLE), and method of minimum variance.
- Learn methods for constructing confidence intervals for parameters of normal, exponential, and other standard distributions.

COURSE OUTCOME:

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

SL #	Course Outcomes
CO1	Understand and utilize the basic functionalities of R including data structures, logical operations, and graphical data summaries.
CO2	Develop and implement R programs using conditional statements, loops, vectorized operations, and user-defined functions.
CO3	Perform simulation studies, generate random samples using standard methods, and understand underlying principles of random number generation.
CO4	Conduct various statistical inference procedures in R including hypothesis testing and confidence interval estimation.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔		✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	

COURSE CONTENTS

UNIT 1

Functions, Vectors, Expressions and assignments, Logical expressions, Manipulating vectors, matrices, importing of files. Graphical summaries of data-Bar chart, Pie chart, Histogram, Box-plot, Stem and leaf plot, Frequency table, Plotting of probability distributions and sampling distributions, P-P plot, Q-Q Plot.

(20 Hours)

UNIT 2

Basic programming, Branching with if, Looping with for, Looping with while, Vector-based programming, Programming with functions, Vector based programming using functions, Recursive programming, Data frames, Lists.

(20 Hours)

UNIT 3

Simulation, Seeding, Random Number Generation- Basic principles of Random number generation, Inversion method, Accept-reject method, Random number generation from discrete and continuous distributions.

(20 Hours)

UNIT 4

Statistical Inference Problems Using R-Estimation and confidence intervals-Point estimates. Confidence interval for proportion. One sample Z and t-test, two sample Z and t-test, paired t-test, F test, test for independence of attributes, chi- square goodness of fit test. **(20 Hours)**

UNIT 5

Sample generations from standard distributions using R, computation of estimators and confidence intervals using generated samples. Computation of bias and MSE. **(10 Hours)**

TEXT BOOKS

1. Matloff, N. (2011). *The art of R programming: A tour of statistical software design*. No Starch Press.
2. Wickham, H., & Grolemund, G. (2017). *R for data science: Import, tidy, transform, visualize, and model data*. O'Reilly Media.
3. Grolemund, G. (2014). *Hands-on programming with R: Write your own functions and simulations*. O'Reilly Media.

SUGGESTED READINGS

1. Moore, D. S., McCabe, G. P., & Craig, B. A. (2017). *Introduction to the practice of statistics* (9th ed.). W. H. Freeman.
2. Venables, W. N., & Ripley, B. D. (2002). *Modern applied statistics with S* (4th ed.). Springer.

TEACHING LEARNING STRATEGIES

● Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

●Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester IV

A11– DISCIPLINE SPECIFIC CORE COURSE

KU04DSCSTA208:INTRODUCTION TO BIOSTATISTICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
4	CORE	200	KU04DSCSTA208	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course provides an in-depth exploration of biostatistical methods and epidemiological techniques used in public health research and analysis. Through lectures, discussions, and practical applications, students will develop the knowledge and skills necessary to understand and interpret proportions, rates, ratios, odds, and correlation coefficients in biomedical research.

COURSE OBJECTIVES:

- Understand the fundamental concepts of proportions, rates, ratios, and odds in biomedical research and epidemiology.
- Learn the principles and techniques of comparative studies and screening tests used in public health research.
- Understand the measures of morbidity and mortality and their applications in

epidemiological studies.

- Understand the concepts of relative risk, odds, and odds ratio and their role in epidemiological analysis.

COURSE OUTCOME:

After successful completion of this course, students will be

SL #	Course Outcomes
CO1	Proficient in analyzing proportions and rates in comparative studies, screening tests, and displaying proportions effectively.
CO2	Develop a comprehensive understanding of ratios, including relative risk, odds, odds ratio, and generalized odds for ordered 2xk tables.
CO3	Equipped to handle special cases of binary data and understand coefficients of correlation, including Pearson's correlation coefficient and nonparametric correlation coefficients.
CO4	Proficiency in analyzing one-sample problems with binary data, conducting analysis of pair-matched data, and comparing two proportions using the Mantel-Haenszel method.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔		✔
CO3	✔	✔	✔	✔	✔
CO4	✔		✔	✔	✔

COURSE CONTENTS

UNIT 1

Proportions and Rates: Comparative Studies, Screening Tests, Displaying Proportions. Rates:- Changes, Measures of Morbidity and Mortality, Standardization of Rates.

(20 Hours)

UNIT 2

Ratios and Odds:Relative Risk, Odds and Odds Ratio, Generalized Odds for Ordered 2xk Tables, Mantel–Haenszel Method, Standardized Mortality Ratio.

(20 Hours)

UNIT 3

Special Case of Binary Data: Coefficients of Correlation, Pearson's Correlation coefficient, Nonparametric Correlation coefficients. Practical applications of Normal, Binomial and Poisson distributions in biomedical research, Pair-Matched Case–Control Study. **(20 Hours)**

UNIT 4

Mantel–Haenszel Method: One-Sample Problem with Binary Data, Analysis of Pair-Matched Data, Comparison of Two Proportions, Mantel–Haenszel Method. **(15 Hours)**

UNIT 5

Computational illustration of above concepts using R. Various examples from medical research **(15 Hours)**

TEXT BOOK

1. Chap T.L. (2003). ***Introductory Biostatistics***, John Wiley & Sons.

SUGGESTED READINGS

1. Rosner, B. (2010). ***Fundamentals of Biostatistics***,Cengage Learning, Harvard University.
2. Chernick, M.R. and Fris, R.H. (2003). ***Introductory Biostatistics for the Health Sciences***, John Wiley & Sons.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester V

A12– DISCIPLINE SPECIFIC CORE COURSE

KU05DSCSTA301:THEORY OF MARKOV CHAIN

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	CORE	300	KU05DSCSTA301	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	1	1	50	50	100	3(T)+2(P)*

COURSE DESCRIPTION:

Theory of Markov Chain is a foundational course in probability theory and statistical modeling, focusing on the study of random processes evolving over time or space. The course covers various types of stochastic processes, including discrete-time, discrete-state processes, Markov chains, and continuous-time processes such as Poisson processes. Emphasis is placed on understanding the fundamental properties and applications of these processes in modeling real-world phenomena across different fields.

COURSE OBJECTIVES:

- Define stochastic processes and their significance in modeling systems with randomness.
- Understand the concepts of state space and time space in stochastic processes.
- Define Markov chains and their key characteristics, including transition probabilities and states.
- Study the limiting behavior of Markov chains, including initial and stationary distributions.
- Understand the postulates for Poisson processes and their properties, such as interarrival time.

COURSE OUTCOME:

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

SL #	Course Outcomes
CO1	Develop a solid understanding of stochastic processes, including their definition, classification, and basic properties.
CO2	Gain proficiency in Markov chains, understanding their definition, transition probabilities, state space, and transition probability matrix.
CO3	Analyze Markov processes with discrete state space, including the Poisson process, pure birth process, and birth and death process.
CO4	Grasp the concept of Markov chains, including transition probabilities, state space, and transition probability matrices.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔	✔	
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

UNIT 1

Introduction to Stochastic Processes: Definition of a stochastic process, examples, state space, time space, discrete time discrete state stochastic process, basic properties, examples, stationary processes, strict stationary process and weak stationary process, Markov property**.**

(15 Hours)

UNIT 2

Markov Chains: Definition, transition probabilities, transition probability matrix and its properties, examples, higher order transition probabilities, Chapman-Kolmogorov equations. Probability distribution, Strong Markov property, order of a Markov chain, Markov chains as Graphs, random walk. **(20 Hours)**

UNIT 3

Classification of States: Communication relations, class property, Transience, recurrence, periodicity, first passage time distribution. limiting behavior of Markov chains: initial distribution and stationary distributions, ergodicity, ergodic theorem. **(20 Hours)**

UNIT 4

Continuous Time Markov Chain: Continuous time random process, Poisson Process, postulates for Poisson process, properties of Poisson process, interarrival time, introduction to Markov-Chain Monte Carlo (MCMC) methods.**(20 Hours)**

UNIT 5

Computational illustration of above concepts using R.
(15 Hours)

TEXT BOOKS

1. Medhi, J. (1994). ***Stochastic processes***. New Age International.
2. Norris JR (1998). ***Markov Chains***. Cambridge Series.

SUGGESTED READINGS

1. Madhira, S., & Deshmukh, S. (2023). ***Introduction to Stochastic Processes Using R***. Springer.
2. Ross, S. M. (1996). ***Stochastic Processes (2nd Ed.)***. New York: John Wiley.

TEACHING LEARNING STRATEGIES

● Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

●Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester V

A13– DISCIPLINE SPECIFIC CORE COURSE

KU05DSCSTA302:MATHEMATICAL METHODS FOR STATISTICS-I

<table>
<tr><td>Semester</td><td>Course Type</td><td>Course Level</td><td colspan="2">Course Code</td><td>Credits</td><td>Total Hours</td></tr>
<tr><td>5</td><td>CORE</td><td>300</td><td colspan="2">KU05DSCSTA302</td><td>4</td><td>75</td></tr>
<tr><td colspan="3">Learning Approach (Hours/ Week)</td><td colspan="3">Marks Distribution</td><td rowspan="2">Duration of ESE (Hour/*/s)</td></tr>
<tr><td>Lecture</td><td>Practical/ Internship</td><td>Tutorial</td><td>CE</td><td>ESE</td><td>Total</td></tr>
<tr><td>4</td><td>1</td><td>1</td><td>50</td><td>50</td><td>100</td><td>3(T)</td></tr>
</table>

COURSE DESCRIPTION:

This course provides a comprehensive introduction to fundamental mathematical concepts in calculus and analysis. Starting with sequences and limits, the course progresses to series, functions of a single variable, the Riemann integral, and an introduction to complex analysis. Emphasis is placed on understanding the theoretical foundations of calculus and developing problem-solving skills through rigorous mathematical reasoning.

COURSE OBJECTIVES:

- Gain a solid understanding of set theory, properties of the real number system, and the basics of complex analysis.
- Study sequences and their limits, including limit theorems and convergence criteria such as the Cauchy criteria.
- Analyze different types of series and their convergence properties using tests such as the comparison test, root test, and ratio test.
- Study limits and continuity of functions, including continuity at a point and on closed intervals.
- Define and comprehend the Riemann integral, including its existence and properties.

COURSE OUTCOME:

SL #	Course Outcomes
CO1	Understand the fundamental concepts of analysis, including set theory, properties of the real number system, and sequences.
CO2	Apply various convergence tests and criteria for series convergence, including the comparison test, Cauchy's root test, and D'Alembert's ratio test
CO3	Proficiency in understanding series, convergence tests, and criteria for convergence.
CO4	Apply properties of functions of a single variable, limits of functions, continuity, types of continuity, and the maximum-minimum theorem.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔		✔

COURSE CONTENTS

UNIT 1

Sequences and Limits: Basics of set theory, properties of real number system, sequences and their limits, limit theorems, monotone sequence, subsequences, Bolzano-Weierstrass theorem, Cauchy criteria. **(12 Hours)**

UNIT 2

Series and Convergence: Definition of series, positive term series, comparison test, Cauchy's root test, D'Alembert's ratio test, Raabe's test, logarithmic test, alternative series, Leibnitz test, absolute convergence and conditional convergence, power series, radius of convergence. **(18 Hours)**

UNIT 3

Functions of Single Variable: Limits of a function, continuous function, continuity at a point, continuity in closed interval, types of continuity, continuity on closed intervals, maximum-minimum theorem, uniform continuity, Weierstrass approximation theorem. **(15 Hours)**

UNIT 4

The Riemann Integral: Definition and existence of the integral, partitions, refinement of partitions, conditions of integrability, properties of Riemann integral, integral as a limit of sums. Integrability of continuous and monotonic functions. **(15 Hours)**

UNIT 5(Optional)

Introduction to complex analysis, complex number system, Complex functions-analytic function, Cauchy- Riemann equation, harmonic function, necessary condition for a function to be analytic, sufficient condition for function to be analytic. Complex integration. **(15 Hours)**

TEXT BOOKS

1. Robert G Bartle(2000). ***Introduction to Real Analysis***, **4th Edition,** Wiley Eastern Ltd.
2. James Ward Brown, Paul Churchill (2009). ***Complex Variables and Applications***, **8 th Edition**, McGraw Hill.

SUGGESTED READINGS

1. S.C.Malik & Savita Arora. (2017). ***Mathematical Analysis***, **5th Edition**, Wiley Eastern Ltd.
2. Shanti Narayanan(2003). ***Elements of Real Analysis***, Sultan Chand & Sons.
3. Goldberg, R. R. (2020). ***Methods of Real Analysis***. Oxford and IBH Publishing.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks

Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester V

A14– DISCIPLINE SPECIFIC CORE COURSE

KU05DSCSTA303:LINEAR REGRESSION ANALYSIS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	CORE	300	KU05DSCSTA303	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	1	1	50	50	100	3(T)+2(P)*

COURSE DESCRIPTION:

Regression Analysis is a fundamental course in statistics that focuses on modeling the relationship between a dependent variable and one or more independent variables. This course provides a comprehensive introduction to correlation analysis, simple linear regression, inference in regression, and goodness of fit of regression models. Emphasis is placed on understanding the underlying principles, assumptions, and interpretation of regression models, as well as practical applications in various fields.

COURSE OBJECTIVES:

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

- Develop a solid understanding of the principles underlying regression analysis, including correlation, linear regression models, and inference techniques.
- Master techniques for modeling relationships between variables using regression models, including simple linear regression and alternative regression methods.
- Apply regression analysis techniques to real-world data sets to analyze

relationships between variables and make predictions.
- Develop the ability to interpret regression results, including coefficient estimates, hypothesis tests, confidence intervals, and measures of goodness of fit.
- Evaluate the goodness of fit of regression models and assess their predictive capabilities using measures such as the coefficient of determination and prediction intervals.

COURSE OUTCOME:

SL #	Course Outcomes
CO1	Develop a thorough understanding of correlation analysis, including its definition and various types such as Pearson correlation coefficient, Spearman rank correlation coefficient, and Kendall's tau.
CO2	Proficient in formulating simple linear regression models, understanding their assumptions, and interpreting the results.
CO3	Perform inference in regression analysis using methods such as Ordinary Least Squares (OLS) estimation and maximum likelihood estimation.
CO4	Learn inference techniques for regression analysis, including OLS estimation, maximum likelihood estimation, hypothesis testing, and confidence interval estimation for regression parameters.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔		✔	✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	

COURSE CONTENTS

UNIT 1

Introduction to Correlation Analysis: Definition of correlation, types of correlation: Pearson correlation coefficient, Spearman rank correlation coefficient, Kendall's tau, Properties of correlation coefficients, Interpretation of correlation coefficients, Significance testing for correlation coefficients, Scatter plot. **(15 Hours)**

UNIT 2

Introduction to Regression Analysis: Simple linear regression model: Model formulation, assumptions, and interpretation, orthogonal regression, reverse (or inverse) regression method, reduced major axis regression method, least absolute deviation regression, Centered Model, No intercept term model. **(20 Hours)**

UNIT 3

Inference in Regression: Method of Ordinary Least Squares (OLS) estimation, Method of maximum likelihood estimation, Testing of hypotheses and confidence interval estimation for slope parameter and for intercept term. Confidence interval for error variance. **(20 Hours)**

UNIT 4

Goodness of fit of Regression: ANOVA, coefficient of determination, prediction of values of study variable, prediction interval estimation, prediction of actual value, estimation of parameters when regressors are stochastic (Concept only). (**15 Hours)**

UNIT 5

Computational illustration of above concepts using R. (Practical) **(20 Hours)**

TEXT BOOKS

1. Montgomery, D. C., Peck, E. A., and Vining, G. G. (2021). ***Introduction to Linear Regression Analysis***. John Wiley & Sons.
2. Faraway, J. J. (2002). ***Practical Regression and ANOVA Using R*** **(Vol. 168)**. University of Bath.

SUGGESTED READINGS

1. Monahan, J. F. (2008). ***A Primer on Linear Models***. CRC Press.
2. Khuri, A. I. (2009). ***Linear Model Methodology***. Chapman and Hall/CRC.
3. Gujarati, D. N., & Porter, D. C. (2009). ***Basic Econometrics*****.** McGraw-Hill.
4. Draper, N. R., & Smith, H. (1998). ***Applied Regression Analysis*** . John Wiley & Sons.

TEACHING LEARNING STRATEGIES

● Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

●Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester V

A15– DISCIPLINE SPECIFIC CORE COURSE

KU05DSCSTA304:TESTING OF HYPOTHESIS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	CORE	300	KU05DSCSTA304	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	1	1	50	50	100	3(T)+2(P)*

COURSE DESCRIPTION:

Statistical Hypothesis Testing is a fundamental course in statistics that focuses on testing hypotheses about population parameters based on sample data. This course provides a comprehensive introduction to statistical hypotheses, including null and alternative hypotheses, critical regions, Type I and Type II errors, and various hypothesis tests for different types of data distributions. Emphasis is placed on understanding the principles of hypothesis testing, choosing appropriate tests for different scenarios, and interpreting test results.

COURSE OBJECTIVES:

- Develop a comprehensive understanding of the principles of hypothesis testing, including null and alternative hypotheses, Type I and Type II errors, and significance levels.
- Master various hypothesis testing techniques for different types of data distributions, including small and large samples, as well as parametric and non-parametric tests.
- Learn how to apply hypothesis testing procedures to real-world scenarios, including choosing appropriate tests, conducting tests, and interpreting results effectively.
- Develop the ability to interpret the results of hypothesis tests accurately and draw meaningful conclusions based on statistical evidence.
- Enhance critical thinking skills and problem-solving abilities necessary for statistical analysis and decision-making in various fields.

COURSE OUTCOME:

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

SL #	Course Outcomes
CO1	Demonstrate proficiency in hypothesis testing methodologies, including formulating null and alternative hypotheses, understanding the concepts of Type I and Type II errors, and interpreting p-values.
CO2	Gain a deep understanding of advanced testing techniques, such as the Neymann-Pearson lemma and likelihood ratio tests.
CO3	Learn when and how to apply parametric and non-parametric tests, interpret results, and draw valid conclusions from statistical analyses.
CO4	Gain practical experience in implementing statistical tests and visualizing results.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔		✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

UNIT 1

Statistical Hypotheses: Simple and composite hypotheses, null and alternative hypotheses, critical region, best critical region (BCR), acceptance region, Type I and Type II errors, size and power of a test, most powerful tests, p-value, Neymann - Pearson Lemma, computation of BCR based on Binomial, Poisson, Normal and Exponential distributions.
(20 Hours)

UNIT 2

Small Sample/Exact Tests : Tests based on samples from a normal population**:-** z-tests for one sample and two sample cases, one sample t-test, independent sample t-test, paired t-test, Levene's test, test for significance of correlation coefficient, chi-square test for significance of variance, F-test for equality of variances, test for significant difference between two correlation coefficients.
(15 Hours)

UNIT 3

Large Sample Tests and Chi-square Tests: Tests based on normal approximation-tests for significance of mean, equality of means, significance of proportion and equality of two proportions, tests based on Chi-square distribution: Chi-square test for goodness of fit, test for homogeneity and independence of attributes, tests for significance of variance.
(20 Hours)

UNIT 4

Tests for Normality and Non- Parametric Tests:Q-Q plot, P-P plot, Shapiro-Wilks's test for normality of data; One sample tests- run test, test for randomness, sign test, signed rank test. Two sample tests-Mann-Whitney 'U' Test, Median test, Kolmogrov-Smirnov test for one sample and two sample cases. The Kruskal-Wallis Test. **(20 Hours)**

UNIT 5 (Optional)

Computational illustration of above concepts using simulated data from standard distributions using R.**(15 Hours)**

TEXT BOOKS

1. B.W. Lindgren (2017). ***Statistical Theory***, 4thEdn., CRC Press, London.

2. Buyan, K. C. (2010). ***Probability Theory and Statistical Inference,1 stEdn.*** New Central Book Agency. .

SUGGESTED READINGS

1. V.K. Rohatgi and Saleh A. K. Md. E. (2015). ***An Introduction to Probability Theory and Statistics***, 3rdEdn. Wiley, New York .
2. Daniel, W.W. (2000). ***Applied Nonparametric Statistics,*** Duxbury Press Boston
3. Mood, A.M. Graybill, F.Boes, D. (2017). ***Introduction to Theory of Statistics, 3rd Edn***., Mc-Graw Hill Series.
4. Kale, B. K. (2005). ***A First Course on Parametric Inference.*** Alpha Science Int'l Ltd..

TEACHING LEARNING STRATEGIES

● Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

●Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

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Semester V

DSE1– DISCIPLINE SPECIFIC ELECTIVE COURSE

KU05DSESTA305: INTRODUCTION TO ACTUARIAL STATISTICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	ELECTIVE	300	KU05DSESTA305	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	1	1	50	50	100	3(T)+2(P)*

COURSE DESCRIPTION:

Actuarial Statistics is a specialized course that focuses on the mathematical principles and techniques used in the insurance industry. This course provides a comprehensive introduction to the insurance business, actuarial science, life tables, present values, annuities, and premium calculations. Emphasis is placed on understanding the concepts, models, and calculations used in insurance mathematics and their practical applications in risk management and insurance products.

COURSE OBJECTIVES:

- Develop a comprehensive understanding of the insurance industry, including its role as a financial intermediary and risk management tool.
- Acquire proficiency in actuarial science principles, including the calculation of future lifetime distributions, life tables, and present values.
- Learn to analyze various insurance products, including life insurance policies and annuities, using mathematical techniques such as present value calculations and premium calculations.
- Apply mathematical models and techniques to assess risk, price insurance products, and determine appropriate premium levels.
- Enhance problem-solving skills and critical thinking abilities in the context of insurance mathematics through practical exercises and real-world applications.

COURSE OUTCOME:

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

SL #	Course Outcomes
CO1	Develop a comprehensive understanding of insurance and utility theory, including the concepts of risk aversion, utility functions, and decision-making under uncertainty.
CO2	Proficiency in modeling individual insurance claims using probability distributions such as Poisson, exponential, and gamma distributions.

CO3	Understand survival functions, curtate future lifetime, and the force of mortality.
CO4	Apply life tables to analyze mortality and survival patterns.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	
CO2	✔	✔	✔	✔	✔
CO3	✔		✔	✔	✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

UNIT 1

Introduction to Insurance Business: Introduction, actuarial science, insurance Companies as business organizations, concept of risk, operation of the Insurance Business, role of statistics in insurance, insurance business in India, expected value principle, notion of utility, risk models for short term. **(15 Hours)**

UNIT 2

Future Lifetime Distribution and Life Tables: Future lifetime random variable, curtate future- lifetime, life tables, construction of life tables, assumptions for fractional ages, select and ultimate life tables, numerical examples. **(15 Hours)**

UNIT 3

Actuarial Present Values and Annuities: Concept of present values, actuarial present valuesof benefit in life insurance products, compound interest and discount factor, benefit payable at the moment of death, benefit payable at the end of year of death, introduction to annuities,annuities certain, continuous life annuities,discrete life annuities, life annuities with monthly payments. **(15 Hours)**

UNIT 4

Premiums: Introduction to premium calculations, loss at issue random variable, fully continuous premiums, fully discrete premiums, true monthly payment premiums, gross premiums, introduction to multiple life contracts. **(15 Hours)**

UNIT 5

Computational illustration of above concepts using R.
(15 Hours)

TEXT BOOK

1. Deshmukh, S. R. (2009). ***Actuarial Statistics: An Introduction Using R***. Universities Press (India).
2. Beard, R.E., Penlikainen, T. and Pesonnen, E (1984): ***Risk Theory: The Stochastic Basis of Insurance, 3rd Edition***, Chapman and Hall, Londan.

SUGGESTED READINGS

1. Bowers, N.L., Gerber, H.U., Hickman, J.E., Jones, D.A. and Nesbitt, C.J. (2014): ***Actuarial Mathematics, Society of Actuaries,*** Ithaca, Illiois, U.S.A., second Edition.
2. Neill, A. (1977): ***Life Contingencies***, Heineman.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

SEMESTER V
DSE2-DISCIPLINE SPECIFIC ELECTIVE COURSE
KU05DSESTA306: OFFICIAL STATISTICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	ELECTIVE	300	KU05DSESTA306	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	-	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

Official Statistics is a foundational course that introduces students to the structure and function of statistical systems at the state, national, and international levels. This course also covers vital statistics, including fertility, mortality, and demographic methods, as well as index numbers used in economic analysis. Emphasis is placed on understanding the role of statistical organizations, methods of data collection, and the calculation and interpretation of vital statistics and index numbers.

COURSE OBJECTIVES:

- Gain a comprehensive understanding of the structure, functions, and activities of central and state statistical organizations, as well as their role in data collection, analysis, and dissemination.
- Acquire proficiency in vital statistics concepts, including fertility, mortality, and migration rates, and learn how to calculate and interpret these statistics accurately.
- Develop skills in analyzing demographic data from various sources, such as census, registers, surveys, and hospital records, and understand how to interpret demographic profiles and life tables.
- Learn the principles of index numbers, including their definition, construction methods, and applications in economic analysis. Gain proficiency in constructing and interpreting simple and weighted index numbers, including consumer price index numbers.
- Apply statistical methods and techniques learned in the course to analyze real-world data sets related to population demographics, economic trends, and index numbers. Develop the ability to draw meaningful insights and conclusions from statistical analysis.

COURSE OUTCOME:

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

SL #	Course Outcomes
CO1	Calculate and interpret vital statistics, including fertility rates, mortality rates, and migration rates, using appropriate statistical methods and techniques. They will demonstrate proficiency in analyzing demographic data and drawing meaningful insights from vital statistics.
CO2	Construct and interpret index numbers, including consumer price index numbers, and apply them in economic analysis. They will understand the significance of index numbers in measuring inflation, price changes, and economic trends, and be able to use them to make informed decisions.
CO3	Develop the ability to interpret demographic profiles and life tables accurately. They will understand the components of life tables, including survival probabilities and mortality rates, and be able to analyze demographic data from various sources to assess population demographics and trends.
CO4	Evaluate the structure, functions, and activities of central and state statistical organizations. They will understand the role of these organizations in data collection, analysis, and dissemination, and be able to assess their effectiveness in meeting the statistical needs of society.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

UNIT 1

Introduction to State, National and International Statistical System - Role, function and activities of Central and State Statistical Organizations; organization of large scale sample surveys; role of national sample survey organization (NSSO), functions of Ministry of Statistics and Program Implementation (MOSPI). **(20 hrs)**

UNIT 2

Vital Statistics: Methods of obtaining vital statistics. Measurement of Fertility- crude birth rate, specific fertility rate. crude death rate, standardized death rates, infant mortality rate, maternal mortality rate, reproduction rate, rate of net migration. **(15 hrs)**

UNIT 3

Demographic Methods:- Sources of demographic data - census, register, ad hoc survey, hospital records, demographic profiles of Indian census; life tables, Complete life tables – its main features, mortality rate and probability of dying, use of survival tables.**(20 hrs)**

UNIT 4

Index Numbers - Definition- price and quantity relatives, simple and weighted index numbers, methods of constructing simple and weighted index numbers, consumer price index numbers, tests for index numbers, chain based and fixed base index numbers, base shifting.**(20 hrs)**

UNIT 5 (Optional)

History of Indian Statistical system, Indian Statistical Heritage, Indian Statistical Institute, International Statistical Institute, National Statistics Day, International Statistics Day, Indian Statistical Service, Computation of Demographic measures and Vital statistics using R. **(15 hrs)**

TEXT BOOKS

1. Gupta, S. C., Kapoor, V. K. (2007). ***Fundamentals of Applied Statistics.*** India: Sultan Chand & Sons.
2. Gupta, S. P. (2011). ***Statistical Methods.*** India: Sultan Chand & Sons.

SUGGESTED READINGS

1. ***Guide to Current Indian Official Statistics***, CSO, Govt. of India, New Delhi.
2. Saluja M.P. (2006). ***Indian Official Statistical Systems***, Statistics Publishing Society, Calcutta
3. Mukhopadhyay, P. (1999). ***Applied statistics***. India: Books and Applied.

TEACHING LEARNING STRATEGIES

● Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

●Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester VI

A16– DISCIPLINE SPECIFIC CORE COURSE

KU06DSCSTA307:TIME SERIES ANALYSIS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	CORE	300	KU06DSCSTA307	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

Time Series Analysis is a specialized course that focuses on the analysis and forecasting of time series data. This course covers various methods and techniques used to analyze and model time series data, including exponential smoothing, Box-Jenkins methodology, and estimation of ARMA models. Emphasis is placed on understanding the different components of time series, identifying trends and seasonal fluctuations, and using statistical models for forecasting.

COURSE OBJECTIVES:

- Comprehensive Understanding of Time Series Concepts: Develop a thorough understanding of time series data and its components, including trend, seasonality, and randomness.
- Proficiency in Time Series Modeling Techniques: Master various methods and techniques for analyzing and modeling time series data, including exponential smoothing, Box-Jenkins methodology, and ARMA models.
- Application of Statistical Models for Forecasting: Learn how to apply statistical

models and techniques to forecast future values of time series data accurately.

- Evaluation of Model Performance: Acquire skills in evaluating the performance of time series models, including assessing forecasting accuracy and model adequacy.
- Real-world Application of Time Series Analysis: Apply time series analysis techniques to real-world data sets and scenarios, gaining practical experience in analyzing and interpreting time series data.

COURSE OUTCOME:

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

SL #	Course Outcomes
CO1	Develop a thorough understanding of time series analysis, including its objectives and different components such as trend, seasonality, and noise.
CO2	Proficiency in various exponential smoothing techniques, including single and double exponential smoothing, Holt smoothing, Holt-Winters smoothing, and seasonal smoothing.
CO3	Understand autoregressive (AR), moving average (MA), and autoregressive moving average (ARMA) models, and their applications in time series analysis.
CO4	Estimate time series models using methods such as conditional least squares, conditional maximum likelihood, and the Yule-Walker method.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔		✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔		✔	✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

UNIT 1

Time Series Analysis: Introduction to time series, objectives of time series, different components, illustrations, additive and multiplicative decompositions, determination of trend, growth curves, analysis of seasonal fluctuations, autocorrelation function, sample autocorrelation function. **(15 Hours)**

UNIT 2

Exponential Smoothing:, Single and double exponential smoothing, optimal choice of smoothing coefficients and initial values, Holt smoothing, Holt-Winter additive seasonal smoothing, multiplicative seasonal smoothing, adaptive smoothing. Introduction to ETS methodology. **(15 Hours)**

UNIT 3

Introduction to Box-Jenkins Methodology:Stationarity, nonstationarity, Autoregressive (AR) models, Moving Average (MA) models, Autoregressive Moving Average (ARMA) models, stationarity and invertibility conditions of ARMA models, Yule-Walker equations, partial autocorrelation function, Durbin-Levinson algorithm, ACF and PACF of ARMA models, identification of ARMA models.**(15 Hours)**

UNIT 4

Estimation of ARMAModels: Conditional least squares, conditional maximum likelihood, Yule –Walker method, model diagnostics using residuals, Portmanteau test, model selection using AIC, BIC, forecasting and measures of forecasting accuracy. **(15 Hours)**

UNIT 5

Computational illustration of above concepts using R. **(15 Hours)**

TEXT BOOK

1. Box, G. E., Jenkins, G. M., Reinsel, G. C., & Ljung, G. M. (2015). ***Time Series Analysis: Forecasting and Control (5th Edition)*.** John Wiley & Sons.
2. Shumway, R. H., Stoffer, D. S., & Stoffer, D. S. (2017). ***Time Series Analysis and its Applicationswith R Examples (Vol. 4).*** New York: Springer.

SUGGESTED READINGS

1. Cryer, J. D., Chan, K. S., & Kung-Sik.. Chan. (2008). ***Time Series Analysis: With Applications in R*** **(Vol. 2)**. New York: Springer.
2. Hyndman, R. J., & Athanasopoulos, G. (2018). ***Forecasting: Principles and Practice***. OTexts.
3. Makridakis, S., Wheelwright, S. C., & Hyndman, R. J. (2008). ***Forecasting Methods and Applications***. John Wiley & Sons.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester VI

A17– DISCIPLINE SPECIFIC CORE COURSE

KU06DSCSTA308: DESIGN OF EXPERIMENTS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	CORE	300	KU06DSCSTA308	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

Design of Experiments is a foundational course that introduces students to the principles and techniques of designing and analyzing experiments. The course covers basic concepts of experimental design, linear estimation, basic experimental designs, and factorial designs. Emphasis is placed on understanding the principles of randomization, replication, and local control, as well as the analysis of variance (ANOVA) and interpretation of experimental results.

COURSE OBJECTIVES:

- Gain a thorough understanding of the basic principles of experimental design, including randomization, replication, and local control (blocking).
- Develop proficiency in linear estimation techniques and hypothesis testing using ANOVA for one-way and two-way classifications.
- Learn to analyze and interpret results from various basic experimental designs, such as completely randomized design, randomized block design, and factorial designs.
- Acquire skills in comparing treatment effects using ANOVA techniques and performing post-hoc analysis to identify significant differences.
- Apply theoretical knowledge to real-world scenarios through hands-on exercises and projects, gaining practical experience in designing and analyzing experiments.

COURSE OUTCOME:

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

SL #	Course Outcomes
CO1	Develop a thorough understanding of the basic concepts of experiments, the objectives of experimentation, and the principles of experimental design including randomization, replication, and blocking.
CO2	Proficiency in linear estimation, including the estimation space, error space, estimability of parametric functions, and the Best Linear Unbiased Estimator (BLUE) according to the Gauss-Markov theorem.
CO3	Perform analysis of variance for one-way and two-way classification designs with a single observation per cell. They will understand how to partition the total variation
CO4	Apply theoretical knowledge to real-world scenarios through hands-on exercises and projects, gaining practical experience in designing and analyzing experiments.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

UNIT 1

Basic Concepts: Definition of experiments, objectives of experimentation, principles of experimental design: Randomization, Replication, Local control-Blocking. Types of Experimental Designs, Sources of Variation: Treatment effects, random error, systematic error, experimental error. **(15 Hours)**

UNIT 2

Linear Estimation: Estimation space, error space, estimability of parametric functions and BLUE – Gauss – Markov theorem – Linear hypothesis, Analysis of variance: One way and two way classification (with single observation per cell). **(20 Hours)**

UNIT 3

Basic Designs: Analysis and interpretation ofcompletely randomized design, randomized block design, Latin square design, graeco- Latin design, ANOVA, missing plot technique, estimation of missing observation, comparison of efficiency, relative efficiency,post-hoc analysis. **(20 Hours)**

UNIT 4

Factorial Designs: Basic concepts of factorial experiments, introduction to factorial designs, advantages of factorial designs, two factor factorial designs, interpretation of main effects and interactions, hypothesis testing. **(20 Hours)**

UNIT 5

Optional module: Computational illustration of above concepts using SPSS/R. **(15 Hours)**

TEXT BOOK

1. Gupta, S. C., & Kapoor, V. K. (2007). ***Fundamentals of Applied Statistics***. Sultan Chand & Sons..
2. Montgomery, D. C. (2017).***Design and Analysis of Experiments***. John wiley & sons.
3. M.N. Das & N. Giri (2017). ***Design of Experiments, Third Edition.*** New Age International

SUGGESTED READINGS

1. D.D. Joshy (1990). ***Linear Estimation and Design of Experiments***, Wiley Eastern.
2. Panneerselvam, R. (2012). ***Design and Analysis of Experiments***. PHI Learning Pvt. Limited, New Delhi.

TEACHING LEARNING STRATEGIES

● Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

●Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester VI

A11– DISCIPLINE SPECIFIC CORE COURSE

KU06DSCSTA309: STATISTICAL COMPUTING USING R (PRACTICAL)

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	CORE	300	KU06DSCSTA309	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
1	4	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

Statistical Computing is a practical course. The practical is based on all the courses in the fifth and sixth semesters.The course "Statistical Computing" is designed to provide students with practical experience in applying statistical methods and techniques learned in their fifth and sixth semesters. It serves as a hands-on complement to the theoretical knowledge acquired in previous statistical courses. Through practical exercises and real-world applications, students will develop proficiency in using statistical software tools to analyze data, interpret results, and solve problems encountered in various fields.

COURSE OBJECTIVES:

- Proficiency in Statistical computing: By the end of the course, students should demonstrate proficiency in using statistical software packages such as SPSS, R, or Python for data analysis, manipulation, and visualization.
- Data Management Skills: Students will develop skills in data manipulation and cleaning techniques, including importing, preprocessing, and managing datasets to ensure data quality and integrity.
- Understanding of Descriptive and Inferential Statistics: The course aims to provide students with a solid understanding of descriptive statistics to summarize and visualize data, as well as inferential statistics to make inferences and test hypotheses about populations.
- Ability to Interpret and Communicate Results: Students will learn how to interpret statistical output, draw meaningful conclusions from data analysis, and effectively communicate their findings through written reports, visualizations, and presentations.
- Application of Advanced Statistical Techniques: The course will introduce students to advanced statistical techniques such as Time series analysis, design of experiments, linear regression analysis, Theory of Markov chain and testing of hypotheses, enabling them to apply these methods to analyze complex datasets and solve real-world problems.

COURSE OUTCOME:

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

SL #	Course Outcomes
CO1	Demonstrate proficiency in using statistical software packages such as SPSS, R, or Python for data analysis, manipulation, and visualization.
CO2	Acquire skills in data preprocessing, including handling missing data, outliers, and data transformation. They will learn data manipulation techniques such as sorting, merging, and reshaping datasets to prepare them for analysis
CO3	Gain competence in applying descriptive and inferential statistical techniques to analyze datasets and draw meaningful conclusions.
CO4	Develop problem-solving skills and critical thinking abilities in the context of statistical analysis. They will learn how to identify appropriate statistical methods for different types of data and research questions, and how to adapt and apply these methods effectively to solve real-world problems.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

UNIT 1

Markov chain: Computation of transition probability matrix of a Markov chain, properties and classification of states, “markovchain” R package, Creating Markov chain objects, Handling markovchain objects, Markov chain plot with diagram, Conditional distributions, Stationary states, Classification of states, First passage time distributions and means. **(15 Hours)**

UNIT 2

Regression and Testing: Creating a Linear Regression in R, lm function in R, summary and anova, extracting coefficients, standard errors, significance of coefficients, significance of regression, residuals, R squared and adjusted R squared, extracting information measures like AIC and BIC, model selection, prediction, regression through origin. Testing of hypothesis concepts: computation of Type I error, power and power function, plotting power function, empirical size and power calculations. One sample test, two sample tests, Z test, t-test, chi square test, F test. **(25 Hours)**

UNIT 3

Design of experiments and Quality control : One factor design and the ANOVA, notation and terminology, reading data sets into R, the aov() function, summary, boxplot, CRD, RBD, LSD. Quality control using R, the qcr package, control charts in qcr, Process capability analysis, Process capability pl, Estimated process capability plot. **(20 Hours)**

UNIT 4

Time series analysis: Plotting Time Series, plot.ts() function in R,Decomposing Time Series, the decompose() function, Simple Exponential Smoothing, the "HoltWinters()" function in R, forecast package, acf and pacf plots, Holt-Winters Exponential Smoothing, ARIMA Models, simulation of ARMA models, fitting a ARMA model, Selecting a Candidate ARIMA Model,the auto.arima() function, Forecasting Using an ARIMA Model, forecasting accuracy measures.**(20 Hours)**

UNIT 5

Optional module: Computational illustration of topics from elective courses. **.** **(15 Hours)**

TEXT BOOKS

1. ***The markovchain Package: A Package for Easily Handling Discrete Markov Chains in R.*** https://cran.r-project.org/web/packages/markovchain/vignettes/an_introduction_to_markovchain_package.pdf
2. Lawson, J. (2014).***Design and Analysis of Experiments with R***. CRC press.
3. Flores, M., Fernández-Casal, R., Naya, S., & Tarrío-Saavedra, J. (2021). ***Statistical Quality Control with the qcr Package***. *R Journal*, *13*(1), 194-217.
4. Cowpertwait, P. S., & Metcalfe, A. V. (2009). ***Introductory Time Series with R***. Springer Science & Business Media.

SUGGESTED READINGS

1. Hyndman, R. J., & Khandakar, Y. (2008). ***Automatic time series forecasting: the forecast package for R.*** *Journal of statistical software*, *27*, 1-22..

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester VI

DSE2– DISCIPLINE SPECIFIC ELECTIVE COURSE

KU06DSESTA310: STATISTICAL QUALITY CONTROL

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	ELECTIVE	300	KU06DSESTA310	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	

4	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

Statistical Quality Control (SQC) is a vital discipline that focuses on ensuring the quality of products and processes in various industries. This course provides students with a comprehensive understanding of SQC principles, techniques, and tools, including control charts, process capability analysis, acceptance sampling, and quality improvement methods.

COURSE OBJECTIVES:

- Develop a deep understanding of the principles and concepts of Statistical Quality Control (SQC), including the importance of quality management in various industries and the role of SQC in ensuring product and process quality.
- Master the use of statistical tools and techniques used in SQC, including control charts, process capability analysis, and acceptance sampling, to monitor, analyze, and improve product and process quality.
- Learn how to construct and interpret control charts, including X-bar, R, p, np, and c-charts, to monitor process performance, detect variations, and identify process shifts and trends.
- Acquire skills in assessing process capability using capability indices such as Cp, Cpk, and Cpmk, and understanding the relationship between process capability and specification limits.
- Gain practical knowledge of designing acceptance sampling plans to ensure product quality and minimize risks associated with producer's and consumer's risks.

COURSE OUTCOME:

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

SL #	Course Outcomes
CO1	Understand the fundamental concepts of quality and its importance in various industries.
CO2	Differentiate between common cause and special cause variation and understand their implications on process performance.
CO3	Interpret control charts effectively, including calculating control limits, identifying control chart patterns, and detecting process shifts and trends.

CO4	Proficiency in using statistical tools such as control charts, process capability analysis, acceptance sampling, and quality improvement techniques.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔		✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔		✔

COURSE CONTENTS

UNIT 1

Basic Concepts: Definition of quality, historical perspective of statistical quality control (SQC), importance of SQC in various industries. Types of Variation: Common cause variation, special cause variation, understanding sources of variation. Statistical Tools in SQC: Control charts, process capability analysis, acceptance sampling, quality improvement techniques.
(15 Hours)

UNIT 2

Introduction to Control Charts: Purpose and benefits, types of control charts , X-bar chart, R chart, p-chart, np-chart, c-chart. Construction and Interpretation of Control Charts: Calculation of control limits, interpretation of control chart patterns, detecting process shifts and trends. Control Chart Selection: Factors influencing control chart selection, considerations for variable and attribute data.
(15 Hours)

UNIT 3

Process Capability Indices: Definition of process capability indices , Cp, Cpk and Cpmk, interpretation of capability indices, relationship between process capability and specification limits. Process Performance vs. Process Capability: Differentiating between process performance and process capability, practical implications. Assessing Process Capability: Methods for assessing process capability, estimation of process capability indices. **(15 Hours)**

UNIT 4

Introduction to Acceptance Sampling: Purpose of acceptance sampling, types of acceptance sampling plans , single, double and multiple sampling. Sampling Plans and OC Curves: Operating characteristic (OC) curves, relationship between producer's risk, consumer's risk, and sample size, designing acceptance sampling plans. **(15 Hours)**

UNIT 5

Computational illustration of above concepts using R.
(15 Hours)

TEXT BOOK

1. Montgomery, D. C. (2019). ***Introduction to Statistical Quality Control (8th Edition)***. John wiley & sons..
2. Grant,E. L. and Leavenworth, R. S.(2017). ***Statistical Quality Control.*** McGraw Hill.

SUGGESTED READINGS

1. Duncan, A.J.(1986).***Quality Control and Industrial Statistics.*** Wiley
2. Mittage, H.J. and Rinne, H. (1993). ***Statistical Methods for Quality Assurance.*** Chapman and Hall.
3. Oakland,J.S.and Follorwel, R.F.(1990).***Statistical Process Control***. East-West Press.
4. Schilling,E.G.(1982).***Acceptance Sampling in Quality Control***. Marcel Dekker.

TEACHING LEARNING STRATEGIES

● Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

●Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester VI

DSE2– DISCIPLINE SPECIFIC ELECTIVE COURSE

KU06DSESTA311:STATISTICAL MACHINE LEARNING

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	ELECTIVE	300	KU06DSESTA311	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

Statistical Machine Learning is a rapidly evolving field with applications in various domains such as finance, healthcare, and marketing. This course provides an in-depth exploration of machine learning algorithms and techniques, focusing on both supervised and unsupervised learning methods.

COURSE OBJECTIVES:

- Develop a deep understanding of fundamental concepts, techniques, and algorithms in machine learning, including supervised and unsupervised learning methods.
- Gain proficiency in selecting appropriate machine learning models based on the bias-variance tradeoff and evaluating their performance using various metrics.
- Acquire practical experience in implementing machine learning algorithms using popular tools and libraries such as scikit-learn, TensorFlow, or PyTorch.
- Apply machine learning techniques to real-world datasets and problems across different domains, including classification, regression, and feature extraction.
- Explore advanced topics in machine learning such as nonparametric methods, regularization techniques, and wavelet smoothing, and understand their applications in cutting-edge research and industry.

COURSE OUTCOME:

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

SL #	Course Outcomes
CO1	Apply various machine learning techniques, including supervised and unsupervised learning methods, to analyze and interpret real-world datasets.
CO2	Select appropriate machine learning models based on the characteristics of the data and evaluate their performance using relevant metrics such as accuracy, precision, recall, and F1-score.
CO3	Develop proficiency in implementing machine learning algorithms using programming languages such as Python and utilizing machine learning libraries like scikit-learn, TensorFlow, or PyTorch for model development and evaluation.
CO4	Enhance their critical thinking and problem-solving skills by applying machine learning techniques to solve complex real-world problems across various domains, including healthcare, finance, and marketing.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	
CO2	✔	✔	✔	✔	✔
CO3	✔		✔	✔	✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

UNIT 1

Variable Types and Terminology: Least Squares and Nearest Neighbours, Local Methods in High Dimension, Supervised Learning and Function Approximation, A Statistical Model for the Joint Distribution of input and output vectors, Function Approximation, Structured Regression Models, Classes of Restricted Estimators: Roughness Penalty and Bayesian Methods, Kernel Methods and Local Regression, Basis Functions and Dictionary Methods.
(15 Hours)

UNIT 2

Model Selection: The Bias–Variance Tradeoff. Linear Methods for Regression: Least squares, Subset selection, Shrinkage Methods, Methods using derived input directions, Multiple outcome shrinkage and selection, Lasso and related path algorithms. **(15 Hours)**

UNIT 3

Classification: Linear methods for classification using linear regression of an indicator matrix, linear discriminant analysis, logistic regression and separating hyperplanes. Basis expansions and regularizations: Piecewise polynomials and splines, Filtering and feature extraction, smoothing splines, Automatic Selection of the Smoothing Parameters. **(15 Hours)**

UNIT 4

Nonparametric logistic regression, multidimensional splines, regularization and reproducing kernel Hilbert spaces, wavelet smoothing. **(15 Hours)**

UNIT 5

Computational illustration of above concepts using R. **(15 Hours)**

TEXT BOOK

1. Hastie, T., Tbishirani, 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.

SUGGESTED READINGS

1. James, G., Witten,D., Tibshirani, R. and Hastie, T. ***Neural Networks and Deep Learning: A Textbook***.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester VI

DSE2– DISCIPLINE SPECIFIC ELECTIVE COURSE

KU06DSESTA312: STATISTICAL METHODS USING PYTHON

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	ELECTIVE	300	KU06DSESTA312	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	2	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course serves as an introduction to Statistical computing using the Python programming language. Students will learn fundamental programming concepts, data structures, control structures, and object-oriented programming principles. Additionally, the course covers basic file handling, exception handling, and introduces students to random number generation and testing techniques.

COURSE OBJECTIVES:

- Develop a foundational understanding of computer programming concepts, including variables, control structures, data types, and modularization, using the Python programming language.

- Attain proficiency in writing and executing Python code to solve basic programming problems, manipulate data, and implement algorithms using fundamental Python syntax and libraries.
- Gain an introduction to object-oriented programming (OOP) principles, including class definition, inheritance, encapsulation, and polymorphism, and understand their application in Python programming.
- Understand error handling and exception mechanisms in Python, and learn how to effectively handle errors and exceptions to write robust and reliable Python code.
- Gain exposure to statistical programming concepts such as random number generation, probability distributions, and simulation techniques, and learn how to implement them using Python for statistical analysis and modeling.

COURSE OUTCOMES

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

SL #	Course Outcomes
CO1	Demonstrate a foundational understanding of computer principles, including the relationship between computers and programs, basic principles of computers, file systems, binary computation, and input/output operations.
CO2	Develop proficiency in Python programming by understanding data types, variables, expressions, statements, operators, and control structures such as loops and decision-making constructs.
CO3	Learn modularization techniques, including the use of standard modules, packages, defining classes, and functions.
CO4	Acquire advanced numerical computation skills, including random number generation, testing random number generators, inverse transformation method (ITM), acceptance-rejection method (ARM), and computation of integrals using techniques such as Monte Carlo methods and Gaussian integration.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	

COURSE CONTENTS

UNIT I

Introduction - Relationship between computers and programs -- Basic principles of computers -- File systems - Using the Python interpreter - Introduction to binary computation -- Input / Output. Data types and control structures -Operators (unary, arithmetic, etc.)**(15 Hours)**

UNIT II

Data types, variables, expressions, and statements -Assignment statements - Strings and string operations -- Control Structures: loops and decision. Modularization and Classes -- Standard modules -- Packages -- Defining Classes -- Defining functions -- Functions and arguments (signature) **(20 Hours)**

UNIT III

Exceptions and data structures - Data Structures (array, List, Dictionary) - Error processing - Exception Raising and Handling, Object oriented design - Programming types -Object Oriented Programming -Object Oriented Design. **(20 Hours)**

UNIT IV

Random number generation, testing a random number generator, inverse transformation method (ITM), Quantile function, properties, Acceptance-Rejection method (ARM), Conditional distribution, exponential tilting, ARM based algorithms, Composition and convolution methods, chi-square, t and F-distributions. **(15Hours)**

UNIT V (Teacher Specific Module-Optional)

Computation of integrals, quadrature formula, double integration, Gaussian integration, Monte Carlo methods, expected values and probabilities, Importance Sampling, rare-event simulation, verification of WLLN, CLT and other approximations through simulation. Empirical computation of level of significance and power of tests. **(15 Hours)**

TEXT BOOKS

1. Haslwanter T. (2016). ***An Introduction to Statistics with Python: With Applications in the Life Sciences,*** Springer
2. Kateri, M. and Agresti, A. (2022). ***Foundations of Statistics for Data Scientists With R and Python,*** Chapman and Hall

TEACHING LEARNING STRATEGIES

● Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester VII

A19– DISCIPLINE SPECIFIC CORE COURSE

KU07DSCSTA401:MEASURE AND PROBABILITY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	CORE	400	KU07DSCSTA401	4	75

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	-	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course provides a rigorous introduction to measure theory and probability theory, essential foundations for advanced studies in mathematics, statistics, and related fields. Students will explore fundamental concepts such as measure spaces, integration theory, probability spaces, random variables, and expectations.

COURSE OBJECTIVES:

- Develop Understanding of Measure Spaces: Students will develop a comprehensive understanding of measure spaces, including the concepts of σ-fields, measurable sets, and the Lebesgue measure, laying the foundation for rigorous analysis in probability theory.
- Master Integration Theory: Through the study of integration theory, students will become proficient in techniques for integrating functions over measure spaces, including the Lebesgue integral and its properties, enabling them to analyze complex functions in probabilistic contexts.
- Understand Axiomatic Probability: Students will grasp the axiomatic foundations of probability theory, including probability spaces, conditional probability, and independence of events, providing a rigorous framework for analyzing uncertain events and random processes.
- Analyze Random Variables and Expectations: By studying real and vector-valued random variables, along with their distribution and density functions, students will learn to characterize and analyze uncertainty in probabilistic models, including computing expectations and moments.
- Apply Inequalities and Convergence: Through the study of inequalities such as Jensen's inequality, Markov's inequality, and convergence theorems like the monotone convergence theorem and dominated convergence theorem, students will learn powerful tools for analyzing probabilistic models and deriving results.

COURSE OUTCOME:

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

SL #	Course Outcomes
CO1	Understand the concepts of measure and probability and their properties.
CO2	Understand convergence of sequence of sets, sequence of measurable functions and sequence of integrals.
CO3	Develop strong problem-solving and analytical skills, enabling them to apply measure-theoretic techniques to solve complex problems in probability theory, statistical inference, and related areas.
CO4	Acquire a high level of mathematical rigor and proficiency in writing formal proofs, allowing them to rigorously analyze and justify mathematical arguments in measure theory and probability theory.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔		✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	

COURSE CONTENTS

UNIT 1

Measure and Measure Space: Class of sets, limits of sequence of sets, fields and σ-fields, minimal σ-fields and Borel field, monotone class. Measurable space, measure, measure space, Lebesgue measure and counting measure, measurable functions and their properties. Limit of a sequence of measurable functions, simple functions, non-negative measurable functions as limit of simple functions. **(15 Hours)**

UNIT 2

Integral: Integral of a simple function, integral of a measurable function. The monotone convergence theorem, Fatou's lemma. Bounded convergence theorem, Lebesgue dominated convergence theorem, normed linear spaces, Lp spaces, Holder's inequality, Minkowski's inequality. **(15 Hours)**

UNIT 3

Axiomatic Approach to Probability: Probability space, conditional probability space, independence of events and sigma fields, Bayes theorem. Real and vector-valued random variables, distribution function, density function and properties, expectation of a random variable and properties. Sequence of random variables and different modes of convergence: in probability, in distribution, in r-th mean and almost sure, their mutual implications. **(15 Hours)**

UNIT 4

Expectation and Inequalities: Expectation of a function of a random variable as Riemann - Stieltjes integral, moments of a random variable. Inequalities involving moments, Cr-inequality, Jensen's inequality, basic inequality, Markov equality and their applications. **(15 Hours)**

UNIT 5

A short review on set theory and real analysis, history on measure and probability. **(15 Hours)**

Books for study

1. Bhat, B.R. (2004). ***Modern Probability Theory***, New Age Publishers, New Delhi.
2. Robert G. Bartle (1995). ***The Elements of Integration and Lebesgue Measure***. John Wiley & Sons, New York.

Reference books

1. Basu, A.K. (1999). ***Measure Theory and Probability***, Prentice-Hall.
2. Billingsley, P. (1986). ***Probability and Measure, Second Edition***, John Wiley.
3. Parthasarathy, K.R. (2005). ***Introduction to Probability and Measure***, Hindustan Book Agency.
4. Royden, H. L. (1988). ***Real Analysis, Third Edition***, MacMillan Publishing Company, New-York.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester VII

A20– DISCIPLINE SPECIFIC CORE COURSE

KU07DSCSTA402:MATHEMATICAL METHODS FOR STATISTICS-II

Semester	Course Type	Course Level	Course Code		Credits	Total Hours
7	CORE	400	KU07DSCSTA402		4	75
Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	-	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course provides a comprehensive exploration of advanced mathematical topics in analysis, linear algebra, and their applications. Spanning four units, students will delve into fundamental concepts, theoretical frameworks, and practical techniques essential for understanding and solving complex problems in mathematics and related disciplines. Throughout the course, emphasis is placed on theoretical rigor, problem-solving skills, and the application of mathematical concepts to real-world problems in various statistical fields.

COURSE OBJECTIVES:

- Mastering Fundamental Concepts: Gain a deep understanding of fundamental concepts in analysis and linear algebra, including limits, continuity, derivatives, integrals, vector spaces, matrices, and linear transformations.
- Developing Analytical Skills: Enhance analytical skills through rigorous mathematical reasoning, proof techniques, and problem-solving strategies applied to advanced mathematical topics.
- Exploring Advanced Topics: Explore advanced topics such as spectral decomposition, eigenvalue problems, quadratic forms, and special functions, extending the knowledge beyond basic mathematical principles.
- Applying Mathematical Techniques: Apply mathematical techniques and theoretical frameworks to solve complex problems in various domains, including physics, engineering, data science, and optimization.

- Building Theoretical and Practical Competence: Develop both theoretical understanding and practical competence, enabling students to analyze, model, and solve real-world problems using advanced mathematical tools and methodologies.

COURSE OUTCOME:

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

SL #	Course Outcomes
CO1	Demonstrate proficiency in understanding the concepts of limits and continuity of functions in metric spaces.
CO2	Evaluate limits of functions and determine their continuity at various points.
CO3	Develop a strong understanding of the Riemann-Stieltjes integral and its properties, including convergence criteria and applications.
CO4	Gain competence in analyzing sequences and series of functions, including understanding uniform convergence and its implications on continuity, integration, and differentiation.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔	✔	
CO4	✔	✔	✔	✔	

COURSE CONTENTS

Unit I

Limit and Continuity of Functions: Metric spaces, compact set, perfect set, connected set, limit of functions, continuous function, continuity and compactness, continuity and connectedness, discontinuities, monotone functions, derivative of a real-valued function, mean value theorem. Riemann-Stieltjes integral and properties. **(15 Hours)**

Unit II

Sequence of Functions and Functions of Several Variables: Sequences and series of functions, uniform convergence. Uniform convergence and continuity, uniform convergence and integration, uniform convergence and differentiation, Weierstrass theorem, improper integrals, the Beta and Gamma functions. Functions of several variables, limits and continuity. Taylor's theorem and its applications. Conditions for the optima of multivariate functions.
(15 Hours)

Unit III

Vector Spaces and Matrices: Vector space, subspaces, linear dependence and independence, basis and dimensions, direct sum and complement of a subspace, inner product and orthogonality. Algebra of matrices, linear transformations, different types of matrices. Row and column space of a matrix, inverse of a matrix, rank, factorization of a matrix, elementary operations and reduced forms.
(15 Hours)

Unit IV

Spectral Decomposition and Quadratic Forms: Eigenvalues and eigenvectors, spectral representation and singular value composition, Cayley-Hamilton theorem, algebraic and geometric multiplicities, Jordan canonical form. Linear equations, generalized inverses and quadratic forms, rank-nullity theorem, generalized inverses, Moore-Penrose inverse, computation of the g-inverse. Quadratic forms, classification of quadratic forms, rank and signature, positive definite and non-negative definite matrices, simultaneous diagonalization of matrices. **(15 Hours)**

Unit V

Computational illustrations of above concepts in R/Mathematica-cloud
(15 Hours)

Books for Study

1. Rudin, W. (2013). ***Principles of Real Analysis (3rd Ed.)***, McGraw-Hill.
2. Ramachandra Rao and Bhimasankaran (1992). ***Linear Algebra***. Tata McGraw Hill, New-Delhi.
3. Malik, S.C & Arora, S. (2006). ***Mathematical Analysis, Second Edition,*** New Age International Publishers.
4. Mathai, A. M. and Haubold, H. J. (2017). ***Linear Algebra – A Course for Physicists and Engineers***, De Gruyter, Germany.

Reference Books:

1. Apostol, T.M. (1974). ***Mathematical Analysis, Second Edition.*** Narosa, New Delhi.
2. Lewis, D.W. (1995). ***Matrix Theory***, Allied publishers, Bangalore.
3. Mathai, A.M. (1998). ***Linear Algebra Part I, II & III***., Centre for Mathematical Sciences.
4. Rao C.R. (2002). ***Linear Statistical Inference and Its Applications, Second Edition***, John Wiley and Sons, New York.
5. Seymour Lipschutz, Marc Lipson (2005). ***Schaum's Outline Series - Linear Algebra (3rd edition).*** Tata McGraw Hill.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester VII

A21– DISCIPLINE SPECIFIC CORE COURSE

KU07DSCSTA403:ADVANCED DISTRIBUTION THEORY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	CORE	400	KU07DSCSTA403	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course offers a comprehensive exploration of advanced topics in probability theory and statistical distributions. Through a series of four units, students will delve into the intricacies of generating functions, lifetime distributions, multivariate distributions, non-central distributions, and density estimation techniques. Throughout the course, students will develop a deep understanding of advanced probability and statistical concepts, preparing them to analyze complex datasets and apply sophisticated statistical methods in various fields.

COURSE OBJECTIVES:

- Advanced Understanding of ProbabilityDistributions: Gain a deep understanding of advanced topics in probability theory, including generating functions, multivariate distributions, and non-central distributions.
- Statistical Distributions Mastery: Develop proficiency in analyzing and interpreting various statistical distributions, such as Weibull, Pareto, multivariate normal, and chi-square distributions.
- Quantitative Analysis Skills: Enhance quantitative analysis skills by exploring order statistics, quadratic forms of normal variables.
- Statistical Modeling Competence: Acquire the ability to model and analyze complex datasets using advanced probability and statistical techniques, including compound distributions and mixture distributions.
- Application of Density Estimation Techniques: Learn how to apply non-parametric density estimation techniques, such as kernel density estimation, to analyze and visualize data distributions effectively.

COURSE OUTCOME:

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

SL #	Course Outcomes
CO1	Develop a comprehensive understanding of various probability distributions, including discrete and continuous distributions, and their properties.

CO2	Proficiency in analyzing multivariate distributions, including multinomial and multivariate normal distributions.
CO3	Gain mastery in analyzing lifetime distributions such as Weibull, Pareto, generalized gamma, Gumbel, and extreme value distributions.
CO4	Develop an understanding of non-central distributions including chi-square, t, and F distributions, and their properties.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔		✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔		✔	✔

COURSE CONTENTS

Unit 1

An overview of generating functions: factorial moment generating function, factorial moments, cumulant generating function, cumulants, relationships between moments and cumulants, power series distributions, generalized power series distribution, compound distributions, compound binomial, compound poisson, truncated distributions, mixture distributions.
(15 Hours)

Unit 2

Lifetime distributions: Weibull, Pareto, generalized gamma, Gumbel, extreme value; Pearson system of curves, properties. Exponential family of distributions, properties; Order statistics, pdf of a single order statistic, joint pdf of k-order statistics, pdf of maximum and minimum order statistics, distribution of median, distribution of range.
(15 Hours)

Unit 3

Multivariate distributions: Multinomial distributions, multivariate normal distribution (both singular and nonsingular)- characteristic function, marginal and conditional distributions, properties and characterizations, Cramer-Wold theorem, Jacobians of matrix transformations Y= AXB, Y=AXA', X= TT'. Quadratic forms of normal variables and vectors, distribution of quadratic forms in normal variables (both scalar and vector quadratic forms), Cochran's theorem, Independence of quadratic forms. **(15 Hours)**

Unit 4

Non-central distributions: Non central chi-square, t, F and their properties, multivariate gamma and beta distributions, Wishart distribution, characteristic function, additive property, distribution of generalized variance.Introduction to non-parametric density estimation, kernel density estimation. **(15 Hours)**

Unit 5 (Optional)

Review of univariate discrete and continuous distributions. Bivariate exponential distribution of Marshall and Olkin - marginal distribution, characteristic function and lack of memory property. **(15 Hours)**

TEXT BOOKS

1. Anderson, T.W. (2003): ***Multivariate Analysis.*** John-Wiley, New York.
2. Rohatgi, V.K. (2001). ***An Introduction to Probability and Statistics***, 2nd Edition. John Wiley and Sons.
3. Krishnamurthy, K. (2006). ***Handbook of Statistical Distributions with Applications***. Chapman & Hall/CRC, New York.

Reference books

1. Johnson, N.L., Kotz, S. and Balakrishnan, N. (1995). ***Continuous Univariate Distributions, Vol. I & Vol. II***, John Wiley and Sons, New York.
2. Johnson, N.L., Kotz. S. and Kemp. A.W. (1992). ***Univariate Discrete Distributions***, John Wiley and Sons, New York.
3. Stuart, A. Ord, A. (1994). ***Kendall's Advanced Theory of Statistics, Distribution Theory, 6th Edition***. Wiley-Blackwell.
4. Gupta, S.C. and Kapoor, V.K. (2000). ***Fundamentals of Mathematical Statistics, 10th Revised Edition.*** Sultan Chand & Sons, New Delhi.

TEACHING LEARNING STRATEGIES

● Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

●Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks

Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester VII

A22– DISCIPLINE SPECIFIC CORE COURSE

KU07DSCSTA404:STATISTICAL INFERENCE

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	CORE	400	KU07DSCSTA404	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course offers a comprehensive exploration of advanced topics in statistical theory and methodology, providing students with a solid foundation in estimation and hypothesis testing techniques. Through a series of four units, students will delve into key concepts such as sufficiency, completeness, and minimum variance unbiased estimation, gaining a deep understanding of the theoretical underpinnings of estimation theory. Overall, this course aims to provide students with the knowledge and skills necessary to tackle complex statistical problems, equipping them with the tools to make informed decisions based on data analysis and hypothesis testing.

COURSE OBJECTIVES:

- Develop a deep understanding of advanced topics in statistical theory, including sufficiency, completeness, and minimum variance unbiased estimation.

- Gain proficiency in estimation techniques such as method of moments, method of maximum likelihood, and minimum chi square method, and understand their theoretical underpinnings.
- Acquire practical skills in statistical testing methodologies, including Neyman-Pearson lemma, most powerful tests, likelihood ratio tests, and sequential probability ratio tests (SPRT).
- Learn how to design and conduct statistical tests effectively, considering factors such as level of significance, power function, and nuisance parameters.
- Apply theoretical knowledge to real-world statistical problems, developing the ability to make informed decisions based on data analysis and hypothesis testing.

COURSE OUTCOME:

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

SL #	Course Outcomes
CO1	Mastery of advanced statistical concepts: Students will demonstrate a thorough understanding of advanced statistical theories, including sufficiency, completeness, and minimum variance unbiased estimation, and their applications in real-world scenarios.
CO2	Proficiency in estimation techniques: Students will be proficient in employing various estimation methods such as method of moments, method of maximum likelihood, and minimum chi square method, and applying them effectively to estimate parameters from data.
CO3	Competence in statistical testing methodologies: Students will develop competence in statistical testing methodologies, including Neyman-Pearson lemma, likelihood ratio tests, and sequential probability ratio tests, and will be able to apply these techniques to test hypotheses and draw meaningful conclusions.
CO4	Ability to design and conduct statistical experiments: Students will acquire the skills necessary to design and conduct statistical experiments effectively, considering factors such as level of significance, power function, and nuisance parameters, and will be able to interpret and analyze the results accurately.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	
CO3	✔		✔	✔	✔

CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

UNIT 1

Sufficiency and Completeness: A brief review on properties of estimators, consistent asymptotically normal (CAN) estimators, efficiency, sufficiency, Fisher-Neymann factorization theorem for sufficiency (proof for discrete distributions only), joint sufficient statistics, minimal and complete sufficient statistics, ancillary statistics, Basu's theorem, examples. **(15 hours)**

UNIT 2

Minimum Variance Unbiased Estimation: Minimum variance unbiased estimator (MVUE), Likelihood and score functions. Fisher information, Cramer–Rao Lower Bound (CRLB), Minimum variance bound d estimator (MVB), uniformly minimum variance unbiased estimator (UMVUE), Rao-Blackwell and Lehmann-Scheffe theorems. Method of moments and method of maximum likelihood, maximum likelihood estimator (MLE) and its asymptotic properties. Method of minimum chi square and method of modified minimum chi square. **(25 hours)**

UNIT 3

Neyman-Perason Lemma and Most Powerful Tests: p-value, level of significance and size of test, power function, Neymann-Pearson lemma, most powerful (MP) and uniformly most powerful (UMP) tests. Monotone likelihood ratio (MLR) and UMP tests, unbiased tests, uniformly most powerful unbiased (UMPU) tests, testing in the presence of nuisance parameters, similar test,, alpha similar tests, Neymann structure, problems. **(20 hours)**

UNIT 4

Likelihood Ratio Test and SPRT : Likelihood ratio test, monotone likelihood ratio property, asymptotic distribution of LRT statistic, sequential testing, sequential probability ratio test, properties, introduction of non-parametric tests and confidence interval estimation, connection between confidence interval estimation and testing of hypotheses. **(20 hours)**

UNIT 5(Teacher Specific Module-Optional)

History of estimation and testing, illustration of the concepts in unit 1 to 4 using R, use of special R packages for the computation of MLE, non parametric tests and confidence intervals. **(10 hours)**

Text Books

1. Casella,G.and Berger, R.L. (2002). ***Statistical Inference, SecondEdition***, Duxbury, Australia.
2. Vijay K. Rohatgi, A. K. Md. Ehsanes Saleh (2015). ***An Introduction to Probability and Statistics,3rd Edition,*** John Wiley and Sons, NewYork.
3. Kale, B. K. (2005). ***A First Course on Parametric Inference***. Alpha Science Int'l Ltd.

Reference Books

1. Lehman, E. L. (1986):***Testing of Statistical Hypotheses***. John Wiley, New York.
2. Lehmann, E. L(1983). ***Theory of Point Estimation***, John Wiley and Sons, New York.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester VII
A19-DISCIPLINE SPECIFIC CORE COURSE
KU07DSCSTA405: MATHEMATICAL METHODS FOR BIOSTATISTICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	CORE	400	KU07DSCSTA405	4	75

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	-	1	50	50	100	3(T)

COURSE DESCRIPTION

This course provides a rigorous treatment of advanced mathematical methods essential for understanding and solving complex problems in various fields such as mathematics, physics, engineering, and computer science. The course covers topics including sequences, series, convergence, functions of several variables, linear algebra, and quadratic forms.

COURSE OBJECTIVES:

- Understand the concepts of limit and continuity of functions and their properties
- Understand convergence of sequences and series of real numbers and functions.
- Understand the vector space, matrices and its properties
- Understand the properties of quadratic forms and its reduction.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Understand and apply various tests for convergence of sequences and series.
CO2	Understand and apply the beta and gamma functions along with their properties and applications.
CO3	Develop a strong foundation in linear algebra, including vector spaces, subspaces, linear dependence and independence, basis and dimensions, matrices and determinants.
CO4	Acquire proficiency in eigenvalues and eigenvectors, spectral decomposition, algebraic and geometric multiplicities.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔		✔	✔
CO3	✔	✔	✔	✔	
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

UNIT 1

Sequences, series and their convergence, limit superior, limit inferior, limit of sequences, Cauchy sequence. Comparison test, D'Alembert's ratio test, Cauchy's root test, Raabi's test, Gauss test, Cauchy's integral test, Absolute convergence of series, Leibnitz's test for the convergence of alternating series, conditional convergence, indeterminate form, L'Hospital 's rule (problems only).
(**20 Hours**)

UNIT 2

The beta and gamma functions, duplication formula for gamma function, incomplete beta and gamma functions, functions of several variables, Limits and continuity, Taylor's theorem and its applications, Conditions for the optima of multivariate functions, Lagrange's method for constrained optimum, examples (bivariate case only) (**20 Hours**)

UNIT 3

Vector space, Subspaces, Linear dependence and independence, Basis and dimensions, Matrices and determinants, symmetric, orthogonal and idempotent matrices, Row and column space of matrix, Rank, inverse, Characteristic polynomial, Cayley-Hamilton Theorem (statement and problem).
(**15 Hours**)

UNIT 4

Eigen values and eigen vectors, Spectral decomposition, Algebraic and geometric multiplicities, Generalized inverse, Quadratic forms, Classification of quadratic forms, Properties and reductions. (**15 Hours**)

UNIT 5

Introduction to set theory, limit point of a set, closed, countable and uncountable sets.
(**5 Hours**)

TEXT BOOKS

1. Malik, S.C & Arora, S. (2006***). Mathematical Analysis***, ***Second Edition,*** New-age international publishers.
2. Mathai, A. M. & Haubold, H. J. (2017***). Linear Algebra – A course for Physicists and Engineers,*** De Gruyter, Germany.

SUGGESTED READINGS

1. Rudin, W. (2013). ***Principles of Real Analysis, (3rdEd.)***.McGraw Hill.
2. Ramachandra Rao and Bhimasankaran (1992). ***Linear Algebra.*** Tata McGraw Hill, New Delhi.
3. Apostol, T. M. (1974). ***Mathematical Analysis***, ***Second Edition***. Narosa, New Delhi.
4. Rao, C. R. (2002). **Linear Statistical Inference and Its Applications**, Second Edition, John Wiley and Sons, New York.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester VII

A20-DISCIPLINE SPECIFIC CORE COURSE

KU07DSCSTA406: PROBABILITY AND DISTRIBUTION THEORY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	CORE	400	KU07DSCSTA406	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	1	1	50	50	100	3(T)+2(P)*

COURSE DESCRIPTION

This course provides a comprehensive understanding of probability theory and statistical distributions, covering both discrete and continuous random variables. Students will learn the fundamental concepts of probability, random variables, distribution functions, and moments, along with their applications in various fields including biostatistics. Additionally, the course explores different modes of convergence of random variables and their significance in statistical inference.

COURSE OBJECTIVES:

- Understand the concepts of probability and properties.
- Understand characteristic function and its properties.
- Understand various laws of large numbers and central limit theorems.
- Understand the concepts of discrete and continuous distributions.
- Understand the normal distribution and various non-normal distributions, their properties and applications for scientific research.

COURSE OUTCOME:

SL #	Course Outcomes
CO1	Understand various discrete probability distributions.
CO2	Develop a strong grasp of continuous probability distributions.

CO3	Comprehend the various modes of convergence of sequences of random variables and their definitions.
CO4	Learn about moment generating functions and their limitations, as well as characteristic functions and their elementary properties.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

UNIT 1

Computation of probability based on classical and empirical definitions: Axiomatic approach to probability, probability space, conditional probability space, independence of events, Bayes' theorem and examples, random variable, distribution function, density function, expectation, variance and moments of a random variable and properties. (**20 Hours**)

UNIT 2

Definition of moment generating function and its limitations: characteristic function, elementary properties, characteristic functions and moments. Sequence of random variables, various modes of convergence of sequence random variables (definition only), Weak law of large numbers, strong law of large numbers, central limit theorem, DeMoivre-Laplace and Lindbergh- Levy forms of CLT. Applications of CLT in biostatistics. (**20 Hours**)

UNIT 3

Discrete distributions: Discrete Uniform, Bernoulli, Binomial, Poisson, Geometric, Negative binomial, Hyper geometric, Multinomial. Properties of these distributions. Sample simulation and fitting of discrete distributions. (**20 Hours**)

UNIT 4

Continuous distributions: ContinuousUniform, Exponential, Beta, Gamma, Normal, Weibull, Pareto, Laplace, Logistic, Cauchy and log-normal distributions. Properties of these distributions. Sample simulation and fitting of continuous distributions. (**20 Hours**)

UNIT 5

Revisit to distribution function, discrete random variable, probability mass function, continuous random variable, probability density function. Simulation from standard distributions. (**10 Hours**)

TEXT BOOKS

1. Krishnamurthy, K.(2006). ***Handbook of Statistical Distributions with Applications*** .Chapman & Hall/CRC, New-York.
2. Schinazi, R.B. (2010). ***Probability with Statistical Applications*** *Second Ed* . Springer, New York.

SUGGESTED READINGS

1. Bhat, B.R. (2004).***Modern Probability Theory***, New Age Publishers, New Delhi.
2. Rohatgi, V. K. (2020). ***An Introduction to Probability Theory and Mathematical Statistics***, Wiley Eastern
3. Johnson, N.L., Kotz, S.and Balakrishnan, N. (1995).***Continuous Univariate Distributions****, Vol. I & Vol. II,* John Wiley and Sons, New-York.
4. Johnson, N.L., Kotz. S. and Kemp. A.W.(1992). ***Univariate Discrete Distributions,*** John Wiley and Sons, New York.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester VII

A21-DISCIPLINE SPECIFIC CORE COURSE

KU07DSCSTA407-ANALYSIS OF CLINICAL TRIALS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	CORE	400	KU07DSCSTA407	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	-	1	50	50	100	3(T)+2(P)*

COURSE DESCRIPTION

This course provides a comprehensive overview of the fundamental principles and methodologies involved in designing, conducting, and analyzing clinical trials. It delves into the ethical considerations, protocol development, data management, and statistical techniques essential for the successful implementation of clinical research studies.

OURSE OBJECTIVES:

- Understand the importance and ethical considerations of clinical trials in medical research.

- Describe the different phases of clinical trials and their purposes.
- Calculate sample sizes for one-sample and two-sample cases in comparative trials and activity studies.
- Define and understand the goals of meta-analysis in clinical trials

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Comprehensive understanding of clinical trials, including their introduction, the necessity and ethical considerations, identification of bias and random errors, protocol development, conduct, and an overview of phases I-IV trials.
CO2	Acquire the ability to determine sample sizes in one and two-sample cases for comparative trials, activity studies, testing, and other purposes.
CO3	Gain proficiency in meta-analysis in clinical trials, understanding its concept, goals, and approaches including fixed and random effect approaches.
CO4	Develop practical skills in applying principles learned in clinical trial design, sample size determination, surrogate endpoint selection, and meta-analysis to real-world scenarios.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔		✔
CO4	✔		✔	✔	✔

COURSE CONTENTS

UNIT 1

Introduction to clinical trials: the need and ethics of clinical trials, bias and random error in clinical studies, Protocols, conduct of clinical trials, overview of Phase I-IV trials, Data management-data definitions, standard operating procedure, informed consent form, case report forms, database design, data collection systems for good clinical practice. (**15 Hours**)

UNT 2

Design of clinical trials: Different phases, Comparative and controlled trials, Random allocation, Randomization, response adaptive methods and restricted randomization. Methods of Blinding, Parallel group designs, Crossover designs, Symmetric designs, Adaptive designs, Group sequential designs, Zelen’s designs, design of bioequivalence trials. Outcome measures. (**15 Hours**)

UNIT 3

Sample size determination in one and two sample cases: comparative trials, activity studies, testing and other purposes, unequal sample sizes and case of ANOVA. Surrogate endpoints-selection and design of trials with surrogate, analysis of surrogate end point data. Reporting and analysis-Interpretation of result, multi-center trials. (**15 Hours**)

UNIT 4

Meta analysis in clinical trials: concept and goals, fixed and random effect approaches. Bioassay: Direct and indirect assays, Quantal and quantitative assays, Parallel line and slope ratio assays, Design of bioassays. (**10 Hours**)

UNIT 5

Review of basic designs in clinical trials. **(5 Hours)**

TEXT BOOKS

1. Chen, D.G. and Peace, K.E. (2011). ***Clinical Trial Data Analysis Using R***. Chapman & Hall
2. Friedman, L. M., Furburg, C. D. Demets, L. (1998):***Fundamentals of Clinical Trials***, Springer Verlag.
3. Kulinskaya E, Morgeathaler S, Staudte R G(2008). ***Meta analysis***, Wiley.

SUGGESTED READINGS

1. Das, M. N. and Giri(2008). ***Design of Experiments***, New Age, India.
2. Turnbull (1999*)*: ***Group Sequential Methods with Applications to Clinical Trails***, CRC Press.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester VII
A22 -DISCIPLINE SPECIFIC CORE COURSE
KU07DSCSTA408 - BIOSTATISTICAL INFERENCE

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	CORE	400	KU07DSCSTA408	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course provides an in-depth exploration of the fundamental concepts and methodologies in statistical estimation and hypothesis testing. Students will gain a comprehensive understanding of the properties of estimators, minimum variance unbiased estimation, tests of hypotheses, and parametric tests.

COURSE OBJECTIVES:

- Understand the concepts of Sufficiency and Completeness
- Understand the concepts of Minimum Variance Unbiased Estimation.
- Understand various estimation methods and applications in real life problems.
- Apply various parametric and sequential testing procedures to deal with real life problems.

- Understand Most Powerful Tests for testing simple null hypothesis and developing MP tests for different problems.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	A thorough understanding of important properties of estimators of a parameter such as sufficiency, consistency, unbiasedness and efficiency.
CO2	Understanding the notion of Fisher-Neyman factorization theorem for sufficiency,minimal and complete sufficient statistics.
CO3	Derivation of the Cramer-Rao lower bound and the conditions for the existence of MVB estimator, apply the concept of Rao-Blackwell and Lehmann-Scheffe theorems to obtain UMVUE of a parameter.
CO4	To introduce the concept of testing of hypothesis, critical region, significance level, power of the test and p-value.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

UNIT 1

Sufficiency, Ancillary Statistic and Completeness: A brief review on properties of estimators, consistent asymptotically normal (CAN) estimators and their properties, sufficiency, minimal sufficiency Fisher-Neymann factorization theorem for sufficiency (proof for discrete distributions only), joint sufficient statistics, complete sufficient statistic, ancillary statistic and Basu's theorem. (**15 Hours**)

UNIT 2

Minimum Variance Unbiased Estimation: Minimum variance unbiased estimator (MVUE), Likelihood and score functions. Fisher information, Cramer–Rao Lower Bound (CRLB), Minimum variance bound unbiased estimator (MVB). uniformly minimum variance unbiased estimator (UMVUE), Rao-Blackwell and Lehmann-Scheffe theorems.

Method of moments and method of maximum likelihood and asymptotic properties of MLE.
(25 Hours)

UNIT 3

Neyman-Perason Lemma and Most Powerful Tests: p-value, level of significance and size of test, power function, Neymann-Pearson lemma, most powerful (MP) and uniformly most powerful (UMP) tests. Monotone likelihood ratio (MLR) and UMP tests, unbiased tests, uniformly most powerful unbiased (UMPU) tests, testing in the presence of nuisance parameters, similar test,, alpha similar tests, Neymann structure, problems.**(20 Hours)**

UNIT 4

Likelihood Ratio Test and SPRT : Likelihood ratio test, monotone likelihood ratio property, asymptotic distribution of LRT statistic, sequential testing, sequential probability ratio test, properties, introduction of non-parametric tests and confidence interval estimation, connection between confidence interval estimation and testing of hypotheses.
(20 Hours)

UNIT 5

History of estimation and testing, illustration of the concepts in unit 1 to 4 using R, use of special R packages for the computation of MLE, non parametric tests and confidence intervals, applications in biostatistics.
(10 Hours)

TEXT BOOKS

1. Hogg, R. V., McKean, J. W., & Craig, A. T. (2013). ***Introduction to Mathematical Statistics***. Pearson Education India.
2. Vijay K. Rohatgi, A. K. Md. Ehsanes Saleh (2015). ***An Introduction to Probability and Statistics***,3rd Edition, John Wiley and Sons, NewYork.
3. Mood, A. M., & Graybill, F. A. (6). Boes, DC (1974). ***Introduction to the Theory of Statistics***.Third edition. McGraw Hill.

SUGGESTED READINGS

1. Casella,G.andBerger,R.L.(2002).***Statistical Inference***,SecondEdition,Duxbury,Australia.
2. Lehman, E. L. (1986):***Testing of Statistical Hypotheses***. John Wiley, New York.
3. Lehmann, E. L(1983). ***Theory of Point Estimation***, John Wiley and Sons, New York.

TEACHING LEARNING STRATEGIES

● Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

●Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

SEMESTER VII
DSE– DISCIPLINE SPECIFIC ELECTIVE COURSE
KU07DSESTA409:APPLIED REGRESSION ANALYSIS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	ELECTIVE	400	KU07DSESTA409	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course provides a comprehensive understanding of regression analysis techniques, ranging from multiple linear regression models to non-linear regression methods. Students will learn how to apply these techniques to real-world datasets and interpret the results effectively. Through hands-on exercises and case studies, participants will gain practical skills in regression analysis and model diagnostics.

COURSE OBJECTIVES:

- Understand the fundamental principles and assumptions underlying multiple linear regression models.
- Learn to apply Ordinary Least Squares (OLS) and Maximum Likelihood (ML) estimators in regression analysis.

- Develop proficiency in diagnosing and addressing common issues in regression models, such as multicollinearity, heteroscedasticity, and autocorrelation.
- Acquire knowledge of nonparametric regression techniques, including polynomial regression and spline smoothing, and their applications.
- Gain insight into non-linear regression methods, such as Generalized Linear Models (GLM), logistic regression, and Poisson regression, and their interpretation and model selection criteria.

COURSE OUTCOME:

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

SL #	Course Outcomes
CO1	Understanding and applying multiple linear regression models and also estimating parameters using least square estimation, assessing statistical assumptions, and interpreting the properties of estimators.
CO2	Concepts and techniques of multiple regression analysis along with addressing issues such as multicollinearity, heteroscedasticity, and autocorrelation, including detection and remedial measures.
CO3	Nonparametric regression techniques and spline smoothing methods.
CO4	Generalized linear models, with a focus on logistic regression and Poisson regression and their applications.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔		✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔		✔

COURSE CONTENTS

Unit 1

Multiple Linear Regression Models: Multiple regression models, OLS and ML estimators, statistical assumptions and properties of estimators, standard error of estimates, tests of significance and confidence intervals for the parameters, error and residual plots. **(15 Hours)**

Unit 2

Model Diagnostics: Multicollinearity, heteroscedasticity, autocorrelation: their nature, consequences, detection, remedial measures and estimation in the presence of them. Tests for autocorrelation, Durbin-Watson test, outliers and influential points, robust estimation, indicator variables as regressors, model selection.**(25 Hours)**

Unit 3

Nonparametric Regression: Polynomial regression in one and several variables, estimation and order selection, Nonparametric regressions and concept of spline smoothing. Kernel density regression, Nataray -Watson estimation, Diagnostic checks and correction. **(15 Hours)**

Unit 4

Non-Linear Regression: Linearization transforms, Generalized linear models (GLM), logistic regression, Poisson regression, maximum likelihood estimation of GLM, model selection, deviance and deviance information criterion, residuals and cox-snell residuals, interpretation of coefficients in logistic regression. **(15 Hours)**

Unit 5

Fitting regression model using R/SPSS/SAS

Books for Study:

1. Draper, N.R. and Smith, H. (1998): ***Applied Regression Analysis, 3rd Ed***. John Wiley.
2. Gujarati, D.N. (2007): ***Basic Econometrics (Fourth Edition)***, McGraw-Hill, New York.
3. Montgomery, D.C, Peek, E.A. and Vining, G.G. (2006): ***Introduction to Linear Regression Analysis,*** John Wiley.

Reference Books:

1. Seber, G.A.F. and Lee, A.J. (2003): ***Linear Regression Analysis***, Wiley
2. Johnston, J. (1984): ***Econometric Methods, 3rd ed.***, McGraw Hill, New York.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester VII

DSE– DISCIPLINE SPECIFIC ELECTIVE COURSE

KU07DSESTA410: DATA VISUALISATION AND ANALYSIS USING PYTHON

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	ELECTIVE	400	KU07DSESTA410	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course aims to build statistical knowledge from the ground up by enabling the learner to understand the ideas behind inferential statistics and begin to formulate hypotheses that form the foundations for the applications and algorithms in statistical analysis, business analytics, machine learning, and applied machine learning. This course begins with the basics of programming in Python and data analysis, to help construct a solid basis in statistical methods and hypothesis testing, which are useful in many modern applications. This course is intended to serve as a bridge in statistics for graduates and business practitioners interested in using their skills in the area of data science and analytics as well as statistical analysis in general.

COURSE OBJECTIVES:

- Develop a solid foundation in Python programming language, including understanding data types, collections, logic, and control flow structures.
- Gain proficiency in creating and organizing reusable code through functions, scripts, and modules.
- Acquire skills in utilizing numerical and scientific Python libraries like NumPy and SciPy for mathematical and scientific computations.
- Master the art of data visualization by learning various techniques to represent statistical quantities, including textual, tabular, and graphical methods.
- Explore different visualization libraries such as matplotlib, pandas, seaborn, bokeh, and plotly to create a wide range of charts and visualizations.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Proficiency in Python Programming: Students will demonstrate proficiency in Python programming, including understanding basic syntax, data types, control flow structures, and functions, enabling them to solve computational problems efficiently.
CO2	Manipulate and analyze data effectively using Python, including handling different data types, collections, and utilizing libraries such as NumPy, SciPy, and pandas for numerical and scientific computing tasks.
CO3	Develop competence in data visualization techniques, including creating various types of plots and charts using libraries like matplotlib, seaborn, bokeh, and plotly, and effectively presenting data insights through graphical representations.

CO4	Acquire proficiency in conducting descriptive statistical analysis, including calculating measures of central tendency, dispersion, and performing hypothesis testing, enabling them to derive meaningful insights and make informed decisions based on data analysis.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

Unit 1

Introduction to Python programming, Starting Up with Python, scripting and interacting, Jupyter notebook, types in python, collections in python, logic and control flow, functions, scripts, modules, numerical python-Numpy, Scientific python-SciPy, panel data-pandas. **(15 Hours)**

Unit 2

Data visualization: presenting statistical quantities, textual presentation, tabular presentation, graphical presentation, design and visual representation, plotting and visualising-mathplotlib, plotting functions, line style and colors, titles and labels, grids, multiple plots, sub plots, plotting surfaces. **(20 Hours)**

Unit 3

Creating charts, data visualisation with pandas, seaborn, bokeh, plotly, scatterplot, line chart, barchart, pie chart, histogram, box plot, area plot, heatmap, examples. **(15 Hours)**

Unit 4

Descriptive statistics: central tendency, measures of dispersion, probability distributions, hypothesis testing and confidence interval, normality test, chi square test, analysis of variance, pearson correlation, examples. **(20 Hours)**

Unit 5 (Teacher Specific Module-Optional)

Practical lab session **(20 Hours)**

Text Books:

1. Rogel-Salazar, J. (2023). ***Statistics and Data Visualisation with Python***. Chapman and Hall/CRC.

Reference Books:

1. McKinney, W. (2022). ***Python for Data Analysis***. " O'Reilly Media, Inc."

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester VII

DSE-DISCIPLINE SPECIFIC ELECTIVE COURSE

KU07DSESTA411:DEMOGRAPHIC STUDIES

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	ELECTIVE	400	KU07DSESTA 411	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	

4		1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course provides an in-depth exploration of demographic concepts, measures, and methods used in the analysis of population dynamics. Students will learn about the sources of demographic data, mortality and fertility measures, population growth indicators, and concepts related to mobility and migration.

COURSE OBJECTIVES:

- Understand the field of demography and its significance in understanding population dynamics.
- Define mortality statistics and their importance in demographic analysis.
- Understand the measurement of population growth using Pearl’s vital index, gross reproductive rate (GRR), and net reproductive rate (NRR).
- Define mobility and migration and differentiate between different types of migration.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Identify the various sources of demographic data and their respective strengths and limitations.
CO2	Calculate and interpret mortality measures including crude death rate, age-specific death rates, and infant mortality rate.
CO3	Construct and analyze life tables, including complete and abridged life tables.
CO4	Explain migration models and their applications in demographic analysis.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔

CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

UNIT 1

Introduction to Demography, Definition and uses of demographic data, Source of vital statistics: Census method-Registration method, Sources of demography data: secondary sources - SRS– surveys. (**15 Hours**)

UNIT 2

Mortality and Fertility: Nature and uses of mortality statistics, Mortality measures: Crude death rate (CDR) and Age-specific death rates (ASDR), Infant mortality rate(IMR), Fertility measures: Basic terms and concepts used in the study of fertility, Measures of fertility: Crude birth rate(CBR), Age specific fertility rate (ASFR), General fertility rate (GFR), Total fertility rate (TFR). (**15 Hours**)

UNIT 3

Measurement of Population Growth: Pearl’s vital index, Gross reproductive rate (GRR) and Net reproductive rate (NRR). Life table: Description of life table, construction of complete and abridged life tables, uses of life table. (**15 Hours**)

UNIT 4

Concept of mobility and migration, types of migration, internal migration and its measurement, migration models, concept of international migration. Net-migration. International and postcensal estimates. Projection method including logistic curve fitting.Decennial population census in India. (**15 Hours**).

TEXT BOOKS

1. Goon A.M., Gupta M. K., Dasgupta B. (2008): ***Fundamentals of Statistics***, Published by Prentice Hall, 2nd edition.
2. Gupta S.C. and Kapoor V.K. (2000): ***Fundamentals of Mathematical Statistics***, Sultan Chand Sons 10th edition.

SUGGESTED READINGS

1. Pathak, K.B. and Ram F. (1998): ***Techniques of Demographic Analysis***, Mumbai, Himalaya Publishing House.

2. Shrivastava O.S. (1995): ***Demography and population Studies***, Vikas Publishing house private limited, 2nd edition.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester VII

DSE-DISCIPLINE SPECIFIC ELECTIVE COURSE

KU07DSESTA412:BIOSTATISTICAL COMPUTING USING R

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	ELECTIVE	400	KU07DSESTA 412	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
1	4	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course offers a comprehensive exploration of biostatistical concepts and methodologies using the R programming language. Students will develop practical skills in data manipulation, analysis, and visualization, specifically tailored for applications in biomedical research.

COURSE OBJECTIVES:

- Understand various built in functions in R programming for biostatistical data analysis.
- Understand different functions in R programming for writing compute R programmes and develop computer programmes for different problems
- Understand the usage of packages in R for drawing various diagrams and computing descriptive statistics, comparison of means, ANOVA, non-parametric tests, simple correlation and regression procedures

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Define the basic concepts of R software and R packages
CO2	Describe various concepts required for developing the R Language
CO3	Illustrate different R-Graphics facilities
CO4	Describe different sampling methods using R software

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	✔

CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

UNIT 1

Basic Concepts of R Programming: Introduction to R- Objects and their classes, operators, vectors and matrices, list and data frames, indexing and accessing data, importing and exporting data. Common built-in functions, R-Graphics. **(20 Hours)**

UNIT 2

Matrices and Standard Probability Distributions: Matrices, rank, determinants and inverse. Eigen values and vectors, power of matrices, g-inverse, system of linear equations, roots of algebraic and transcendental equations. Plotting of cdf and pdf of standard distributions. Generations of random samples from standard distributions, demonstrations of the sampling distributions. **(20 Hours)**

UNIT 3

Biostatistical Sampling Methods: Random samples elections, estimation of mean proportion, variance, confidence interval and efficiency under SRS, stratified random sampling, Various kind of allocation, stratification, estimators based on ratio and regression methods pps sampling, two stage cluster sampling, and systematic sampling. **(20 Hours)**

UNIT 4

Biostatistical data analysis: Measures of Morbidity and Mortality in R, Relative Risk, Odds and Odds Ratio, Generalized Odds for Ordered 2 x k Table, Mantel–Haenszel Method, Box Plots, Estimation of Proportions and Odds Ratios, testing of hypotheses. **(20 Hours)**

UNIT 5 (Teacher Specific Module-Optional)

Advanced computing **(20 Hours)**

TEXT BOOKS

1. Maria D.U., Ana F.M. and Alan T.A. (2008*): **Probability and Statistics with R***. CRC Press.
2. Dalgaard, P. (2008): ***Introductory Statistics with R***, *(Second Edition)*, Springer.

SUGGESTED READINGS

1. Purohit, S.G, Ghore, S.D and Deshmukh, S.R. (2004): ***Statistics Using R***. Narosa.
2. Babak Shahbaba. (2012). ***Biostatistics with R: An Introduction to Statistics through Biological Data***. Springer New York.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester VII

DSE-DISCIPLINE SPECIFIC ELECTIVE COURSE

KU07DSESTA413:BIOSTATISTICAL COMPUTING USING SPSS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
7	ELECTIVE	400	KU07DSESTA 413	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	

1	4	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course provides a comprehensive overview of statistical analysis using the Statistical Package for the Social Sciences (SPSS). Students will learn how to navigate the SPSS environment, perform basic and advanced statistical analyses, and interpret the results. Practical exercises and real-world applications will be emphasized to enhance students' proficiency in using SPSS for data analysis.=

COURSE OBJECTIVES:

- The main focus of the course will be on to solve biostatistical research question using SPSS
- Illustrate different toolboxes in SPSS
- Data definition and access and data analysis and presentation.
- Apply SPSS software to develop different statistical tools
- Students get awareness to chose appropriate statistical technique and interpret results using SPSS.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Build capacity to analyzing complex information with the help of SPSS.
CO2	Summarize variables using frequencies and descriptive analysis.
CO3	Producing cross tabulation tables and testing for significant relationships with chi square test.
CO4	Understand the usage of assessing relationships between continuous variables through plots and correlations.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

UNIT 1

SPSS Environment, Basic Concepts of SPSS Programming: Introduction to SPSS- Starting SPSS, Working with data file, SPSS windows, Menus, Dialogue boxes. Preparing the Data file, Creating data file and entering data, Defining the variables, Entering data, modifying data file, import file. Variable types in SPSS and Defining variables – Creating a Codebook in SPSS. Screening and cleaning data, Manipulation of data. **(20 Hours)**

UNIT 2

Preliminary Analysis in SPSS: Computing Variables- Recoding (Transforming) Variables: Recoding Categorical String Variables using Automatic Recode - Sorting Data - Grouping or Splitting Data. Categorical variables, continuous variables. The Explore procedure - Frequencies Procedure – Descriptive - Compare Means - Frequencies for Categorical Data, different statistical distributions. **(25 Hours)**

UNIT 3

Inferential Statistics: Pearson Correlation, Chi-square Test of Independence – Inferential Statistics for Comparing Means: One Sample t Test, Paired Samples T Test, Independent Samples T Test, One-Way ANOVA. Two way ANOVA, Multivariate ANOVA. **(25 Hours)**

UNIT 4

Non-Parametric statistics: Independent Chi square Test, Mann- Whitney test , Wilcoxon signed rank test, Kruskal- Wallis test. Interpreting the output of tests, p-value computation. **(20 Hours)**

UNIT 5 (Teacher Specific Module-Optional)

Advanced computing **(20 Hours)**

TEXT BOOKS

1. Hinton, P. R., Brownlow, C, Mc Murray, I. and Cozens, B. (2004): ***SPSS Explained***, Routledge, Taylor and Francis group, New York.

SUGGESTED READINGS

1. Field, A. (2011); ***Discovering Statistics Using SPSS***, Sage Publications.
2. William E. Wagner. (2015). ***Using IBM SPSS statistics for research methods and social science statistics***, Fifth edition, SAGE Publications, Inc.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester VIII

A23– DISCIPLINE SPECIFIC CORE COURSE

KU08DSCSTA401: ADVANCED PROBABILITY THEORY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	CORE	400	KU08DSCSTA401	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course provides a comprehensive exploration of advanced topics in measure theory and probability theory, focusing on key concepts and theorems fundamental to understanding probability distributions and their properties. Throughout the course, emphasis is placed on developing students' analytical and problem-solving skills through theoretical discussions, practical applications, and examples.

COURSE OBJECTIVES:

- Mastery of Measure Theory Fundamentals: Develop a deep understanding of measure theory concepts, including signed measure spaces, singular and absolutely continuous measures, and key theorems such as the Radon-Nikodym theorem and its applications.
- Proficiency in Probability Theory: Gain proficiency in probability theory, focusing on advanced topics such as characteristic functions, moments, and theorems like Bochner’s theorem, enabling students to analyze and understand complex probability distributions.
- Understanding of Law of Large Numbers and Independence: Explore the principles of the Law of Large Numbers, including weak and strong forms, and Kolmogorov's three series theorem, along with their practical applications. Understand the concepts of independence of classes of events and random variables, and apply them in various contexts.
- Application of Central Limit Theorems: Understand and apply central limit theorems, including Lindberg-Levy, Liapounov, and Lindberg-Feller, to analyze the behavior of sums of random variables. Gain insights into their implications and practical applications in statistical inference.
- Development of Analytical and Problem-Solving Skills: Enhance analytical and problem-solving skills through theoretical discussions, proofs, and practical examples. Develop the ability to critically analyze complex mathematical concepts and apply them to solve real-world problems in probability theory and measure theory.

COURSE OUTCOME:

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

SL #	Course Outcomes
CO1	Demonstrate an advanced understanding of measure theory fundamentals, including signed measure spaces, decomposition theorems, and the Radon-Nikodym theorem, enabling them to analyze and characterize complex measures.
CO2	Proficiency in probability analysis, including the interpretation of characteristic functions, moments, and the application of theorems such as Bochner's theorem, facilitating their ability to analyze and model complex probability distributions.
CO3	Apply the principles of the Law of Large Numbers, both weak and strong forms, and Kolmogorov's three series theorem, in practical scenarios to analyze the behavior of random variables and understand the concept of independence of events and random variables.
CO4	Utilize central limit theorems, including Lindberg-Levy, Liapounov, and Lindberg-Feller, to analyze the behavior of sums of random variables and understand their implications in statistical inference, providing a solid foundation for advanced statistical analysis.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔		✔	✔
CO4	✔	✔	✔	✔	

COURSE CONTENTS

Unit 1

Signed Measures and Decompositions: Signed measure space, singular and absolutely continuous measures, Radon-Nikodym theorem (without proof) and its applications. Decomposition of measures, Hahn Decomposition theorem, Hahn-Jordan decomposition, and Lebesgue decomposition theorem. Product space and product

measure. Fubini’s theorem (without proof).
(15 Hours)

Unit 2

Characteristic Functions and Properties: Definition of a characteristic function, elementary properties, characteristic functions and moments, Taylor’s series expansion of characteristic functions, Bochner’s theorem (without proof), inversion theorem, uniqueness theorem, continuity theorem. **(15 Hours)**

Unit 3

Law of Large Numbers and Independence of the Class of Events: The Weak laws of large numbers, the strong laws of large numbers and Kolmogorov three series theorem (without proof), applications. Weak convergence of distributions. Independence of class of events and random variables. Borel 0-1 criteria and Borel-Cantelli Lemma, Kolmogorov 0-1 laws.
(15 Hours)

Unit 4

Central Limit Theorems and Martingales: The central limit theorems – Lindberg Levy, Liapounov and Lindberg-Feller (without proof) central limit theorems, their mutual implications and applications. Conditional expectation, martingales, simple properties and examples. **(15 Hours)**

Unit 5

Illustration of WLLN and CLT using packages R/SPSS/SAS.
(15 Hours)

Books for study:

1. Bhat, B.R. (2004). ***Modern Probability Theory***, New Age Publishers, New Delhi.
2. Laha, R.G. and Rohatgi, V.K. (2020). ***Probability Theory,*** Dover Publications Inc.
3. Robert G. Bartle (1995). ***The Elements of Integration and Lebesgue Measure***, John Wiley & Sons, New York.
4. Rohatgi, V.K. (1976). ***An Introduction to Probability Theory and Mathematical Statistics***, Wiley Eastern.

Reference books:

1. Basu, A.K. (1999). ***Measure Theory and Probability***, Prentice-Hall.
2. Billingsley, P. (1986). ***Probability and Measure, Second Edition***, John Wiley.
3. Parthasarathy, K.R. (2005). ***Introduction to Probability and Measure***, Hindustan Book Agency.
4. Royden, H.L. (1988). ***Real Analysis (3rd edition)*** McMillan Publishing Company, New York.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester VIII

A23 -DISCIPLINE SPECIFIC CORE COURSE

KU08DSCSTA402-SURVIVAL ANALYSIS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	CORE	400	KU08DSCSTA402	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course provides a comprehensive exploration of survival analysis, life distributions, and statistical methods for analyzing time-to-event data. Students will learn about survival functions, hazard rate functions, life distributions, nonparametric tests, censoring mechanisms, and advanced techniques such as Kaplan-Meier estimation and Cox proportional hazards regression.

COURSE OBJECTIVES:

- Understand the fundamentals of survival analysis, including discrete and continuous time models.
- Apply nonparametric tests such as the Kolmogorov-Smirnov test, sign test, signed-rank test, Mann-Whitney U test, Wilcoxon U test, and chi-square test for goodness of fit.
- Understand the concepts of censoring mechanisms including Type-I, Type-II, and random censoring.
- Apply Kaplan-Meier estimation technique to estimate survival probabilities.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Develop a solid understanding of survival analysis, including discrete and continuous time models, survival functions, hazard rate functions.
CO2	Gain proficiency in various life distributions such as exponential, Weibull, lognormal, and gamma distributions, including their characterizations.
CO3	Comprehend the concepts of censoring mechanisms, including Type-I, Type-II, and random censoring, as well as progressive censoring and truncation.
CO4	Develop practical skills in applying survival analysis techniques to real-world problems in biostatistics and epidemiology.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

UNIT 1

Basics of survival analysis- discrete and continuous time models, survival function, hazard rate function, probability density function, mean residual life time. Aging classes-IFR, IFRA and their duals, Bathtub failure rate. (**15 Hours**)

UNIT 2

Life distributions-exponential, Weibull, lognormal and gamma distributions, characterizations. Nonparametric tests- Kolmogorov-Smirnov test, sign test and signed-rank test, Mann-Whitney, Wilcoxon U test, chi- square test for goodness of fit, test for independence of attributes. (**15 Hours**)

UNIT 3

Concepts of censoring Mechanism -Type-I, Type-II and random censoring, Progressive censoring, Truncation, Methods for truncated and interval censored data. Likelihood construction and estimation of Censored and Truncated Data. Estimating survival rates using large scale data like DHS, NFHS, DLHS, etc. Comparing survival curves.
(**25 Hours**)

UNIT 4

Kaplan-Meier estimation technique: life tables, Mantel-Haenszel test. Interval estimation of survival probabilities. Introduction to survival regression. Cox proportional hazard model.
(**20 Hours**)

UNIT 5

Different characteristics of lifetime distribution: exponential, Weibull, log-normal and gamma distributions. **(15 Hours)**

TEXT BOOKS

1. Lawless, J.F. (2003): ***Statistical Methods for Lifetime*** *(Second Edition)*, John Wiley & Sons Inc., New Jersey.
2. Kalbfleisch, J. D. and Prentice, R.L. (1980): ***The Statistical Analysis of Failure Time Data***, John Wiley & Sons Inc. New Jersey.
3. Moore, D.F. (2016): ***Applied Survival Analysis Using R***, Springer.

SUGGESTED READINGS

1. Klein J.P. and Moeschberger M.L. (2003) ***Survival Analysis - Techniques for Censored and Truncated Data***, Second Edition, Springer-Verlag , New York.
2. Miller,R.G.(1981): ***Survival Analysis***, John Wiley & Sons Inc.
3. Bain,L.G.(1978***): Statistical Analysis of Reliability and Life testing Models***, Marcel Decker.

4. Cox, D.R and Oakes, D.(1984): ***Analysis of Survival Data***. Chapman and Hall.
5. Fraser, D.A.S.(1957): ***Non-parametric Methods in Statistics***, Wiley, New York.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

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Semester VIII

DSE– DISCIPLINE SPECIFIC ELECTIVE COURSE

KU08DSESTA404: MULTIVARIATE ANALYSIS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	ELECTIVE	400	KU08DSESTA404	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course provides an in-depth exploration of advanced topics in multivariate statistical analysis, focusing on estimation, hypothesis testing, classification, principal component analysis, factor analysis, and clustering techniques. Throughout the course, students gain hands-on experience with multivariate data analysis techniques through practical exercises, case studies, and real-world applications. Emphasis is placed on developing analytical skills and understanding the theoretical foundations behind each method. By the end of the course, students will be equipped with the theoretical knowledge and practical skills necessary to analyze and interpret complex multivariate data, make informed statistical decisions, and apply advanced techniques in various domains such as finance, biology, and social sciences.

COURSE OBJECTIVES:

- Mastery of Estimation Techniques: Develop a comprehensive understanding of estimation methods for multivariate normal distributions, including moment estimators, maximum likelihood estimation, and confidence intervals for mean vectors and covariance matrices.
- Proficiency in Hypothesis Testing: Gain proficiency in hypothesis testing techniques for multivariate data, including likelihood ratio tests, Hotelling's T2 test, Mahalanobis's D2 statistic, MANOVA, and tests for equality of dispersion matrices and independence of subvectors.
- Understanding of Classification Methods: Understand the principles of classification in multivariate statistics, including discriminant analysis and Fisher's linear discriminant function, and apply these techniques to classify multivariate normal populations.
- Application of Principal Component Analysis (PCA): Learn the theory and application of PCA for summarizing sample variation using principal components, and understand its utility in dimensionality reduction and data visualization.
- Familiarity with Factor Analysis and Clustering Techniques: Acquire knowledge of factor analysis for identifying latent variables and clustering techniques for grouping similar observations, including hierarchical clustering, multidimensional scaling, and correspondence analysis.

COURSE OUTCOME:

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

SL #	Course Outcomes
CO1	Develop advanced analytical skills in multivariate statistical analysis, enabling them to effectively analyze complex datasets, interpret results, and draw meaningful conclusions.
CO2	Demonstrate proficiency in statistical inference techniques for multivariate data, including estimation, hypothesis testing, and classification, allowing them to make informed decisions based on statistical evidence.

CO3	Gain competence in applying various multivariate data analysis techniques such as principal component analysis, factor analysis, and clustering methods to explore the underlying structure of data, identify patterns, and extract meaningful insights.
CO4	Applying statistical methods to real-world datasets and case studies, students will develop practical problem-solving skills and the ability to effectively communicate statistical findings and recommendations to diverse audiences.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔		✔

COURSE CONTENTS

Unit 1

Estimation: Non-singular multivariate normal distribution, sample and likelihood function, moment estimators of mean and covariance matrix, maximum likelihood estimation of mean vector (when covariance matrix is known and unknown), confidence region, estimation of variance covariance matrix, estimation of common covariance matrix of several multivariate normal populations.
(15 Hours)

Unit 2

Testing of Hypothesis: Likelihood ratio test, Hotelling's T^2 (one and two samples), Mahalanobi's D^2 statistic, relationship between T^2 and D^2 statistics, Fisher-Behren problem, MANOVA (one way and two-way), profile analysis, tests for different types of profiles, equality of dispersion matrices, testing the independence of subvectors, sphericity test.
(15 Hours)

Unit 3

Classification Problem and Principal Component Analysis: The problem of classification - classification of one of two multivariate normal populations when the parameters are known and unknown and extension to several multivariate normal populations, discriminant analysis, Fisher's linear discriminant function. Population principal components - summarizing sample variation by principal components. **(15 Hours)**

Unit 4

Factor Analysis and Clustering: The orthogonal factor model, factor rotation, factor score, cluster analysis, proximity data, hierarchical clustering, non-hierarchical clustering methods, multidimensional scaling, correspondence analysis. **(15 Hours)**

Unit 5

Data entering in multivariate case and analysis using various R packages. **(15 Hours)**

Text Books:

1. Anderson, T.W. (2003): ***Multivariate Analysis***. John-Wiley, New York.
2. Johnson, R. A., & Wichern, D. W. (2019). ***Applied Multivariate Statistical Analysis.5TH Edition***, Springer.
3. Rao, C.R. (2002): ***Linear Statistical Inference and Its Applications***, Second Edition, John Wiley and Sons, New York.

Reference Books:

1. Kshirasagar, A.M. (1972): ***Multivariate Analysis.*** Marcel Dekker, New-York.
2. Rencher, A.C. (1998): ***Multivariate Statistical Analysis***. Jon Wiley, New York.
3. Morrison, D.F. (1976): ***Multivariate Statistical Methods***, McGraw Hill, New York.

TEACHING LEARNING STRATEGIES

● Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

●Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks

Seminar/Viva	20 Marks
Total	50 Marks

Semester VIII

DSE -DISCIPLINE SPECIFIC ELECTIVE COURSE

KU08DSESTA405:-STATISTICAL ANALYSIS OF CLINICAL TRIALS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	ELECTIVE	400	KU08DSESTA405	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	-	1	50	50	100	3(T)+2(P)*

COURSE DESCRIPTION

This course provides a comprehensive overview of the fundamental principles and methodologies involved in designing, conducting, and analyzing clinical trials. It delves into the ethical considerations, protocol development, data management, and statistical techniques essential for the successful implementation of clinical research studies.

COURSE OBJECTIVES:

- Understand the importance and ethical considerations of clinical trials in medical research.
- Describe the different phases of clinical trials and their purposes.
- Calculate sample sizes for one-sample and two-sample cases in comparative trials and activity studies.
- Define and understand the goals of meta-analysis in clinical trials

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Comprehensive understanding of clinical trials, including their introduction, the necessity and ethical considerations, identification of bias and random errors, protocol development, conduct, and an overview of phases I-IV trials.
CO2	Acquire the ability to determine sample sizes in one and two-sample cases for comparative trials, activity studies, testing, and other purposes.
CO3	Gain proficiency in meta-analysis in clinical trials, understanding its concept, goals, and approaches including fixed and random effect approaches.
CO4	Develop practical skills in applying principles learned in clinical trial design, sample size determination, surrogate endpoint selection, and meta-analysis to real-world scenarios.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔		✔
CO4	✔		✔	✔	✔

COURSE CONTENTS

UNIT 1

Introduction to Clinical Trials: the need and ethics of clinical trials, bias and random error in clinical studies, Protocols, conduct of clinical trials, overview of Phase I-IV trials, Data management-data definitions, standard operating procedure, informed consent form, case report forms, database design, data collection systems for good clinical practice. (**15 Hours**)

UNIT 2

Design of Clinical Trials: Different phases, Comparative and controlled trials, Random allocation, Randomization, response adaptive methods and restricted randomization. Methods of Blinding, Parallel group designs, Crossover designs, Symmetric designs, Adaptive designs, Group sequential designs, Zelen's designs, design of bioequivalence trials. Outcome measures. (**15 Hours**)

UNIT 3

Sample Size Determination: comparative trials, activity studies, testing and other purposes, unequal sample sizes and case of ANOVA. Surrogate endpoints-selection and design of trials with surrogate, analysis of surrogate end point data. Reporting and analysis-Interpretation of result, multi-center trials. (**15 Hours**)

UNIT 4

Meta Analysis in Clinical Trials: concept and goals, fixed and random effect approaches. Bioassay: Direct and indirect assays, Quantal and quantitative assays, Parallel line and slope ratio assays, Design of bioassays. (**10 Hours**)

UNIT 5 (Teacher Specific Module-Optional)

Review of basic designs in clinical trials. **(5 Hours)**

TEXT BOOKS

1. Chen, D.G. and Peace, K.E. (2011). ***Clinical Trial Data Analysis Using R***. Chapman & Hall
2. Friedman, L. M., Furburg, C. D. Demets, L. (1998):***Fundamentals of Clinical Trials***, Springer Verlag.
3. Kulinskaya E, Morgeathaler S, Staudte R G(2008). ***Meta analysis***, Wiley.

SUGGESTED READINGS

1. Das, M. N. and Giri(2008). ***Design of Experiments***, New Age, India
2. Turnbull (1999*): **Group Sequential Methods with Applications to Clinical Trials***, CRC Press.

TEACHING LEARNING STRATEGIES

● Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

●Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester VIII

DSE– DISCIPLINE SPECIFIC ELECTIVE COURSE

KU08DSESTA406:RELIABILITY MODELING

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	ELECTIVE	400	KU08DSESTA406	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	1	1	50	50	100	3(T)+2(P)*

COURSE DESCRIPTION:

This course provides a comprehensive exploration of reliability engineering, covering fundamental concepts, life distributions, shock models, and maintenance and replacement policies. Students will gain theoretical knowledge and practical skills necessary for analyzing, modeling, and optimizing the reliability of systems and components. Through theoretical lectures, practical exercises, and case studies, students will develop the skills necessary to analyze, design, and optimize reliable systems in various engineering and industrial applications.

COURSE OBJECTIVES:

- Understanding Fundamental Reliability Concepts: Develop a solid understanding of fundamental reliability engineering concepts including reliability measures, components and systems, coherent systems, and bounds on reliability.
- Mastery of Life Distributions: Gain proficiency in analyzing life distributions, including understanding reliability functions, hazard rates, and common life distributions such as exponential, Weibull, and Gamma distributions.
- Proficiency in Shock Models: Acquire proficiency in analyzing shock models, including univariate and bivariate shock models, and understanding common bivariate exponential distributions and their properties.
- Application of Maintenance and Replacement Policies: Develop skills in modeling maintenance and replacement policies for repairable systems, including understanding non-homogeneous Poisson processes, reliability growth models, and probability plotting techniques.
- Practical Application of Reliability Engineering Techniques: Apply reliability engineering techniques to real-world scenarios, including analyzing failure times in censored life tests, estimating stress-strength reliability, and conducting accelerated life testing.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Demonstrate a proficient understanding of fundamental reliability engineering concepts, including reliability measures, coherent systems, and bounds on reliability, enabling them to analyze and evaluate the reliability of complex systems.
CO2	Possess advanced analytical skills in analyzing life distributions, including the ability to interpret reliability functions, hazard rates, and perform parameter estimation and hypothesis testing in various life distribution models.
CO3	Able to apply shock models to analyze reliability in univariate and bivariate contexts, understand common bivariate exponential distributions, and estimate reliability based on failure times in different testing scenarios.
CO4	Demonstrate proficiency in modeling maintenance and replacement policies for repairable systems using non-homogeneous Poisson processes, reliability growth models, and probability plotting techniques, facilitating optimal decision-making in system maintenance and replacement strategies.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔		✔
CO4	✔		✔	✔	✔

COURSE CONTENTS

Unit 1

Basic Reliability Concepts: Reliability concepts and measures; components and systems; coherent systems; reliability of coherent systems; cuts and paths; modular decomposition; bounds on reliability; structural and reliability importance of components. **(15 Hours)**

Unit-2

Life Distributions and Properties: Life distributions; reliability function; hazard rate; common life distributions - exponential, Weibull, Gamma, etc. Estimation of parameters and tests in these models. Notions of ageing; IFR, IFRA, NBU, DMRL, and NBUE classes and their duals; closures or these classes under formation of coherent systems, convolutions, and mixtures. **(15 Hours)**

Unit-3

Shock Models: Univariate shock models and life distributions arising out of them; bivariate shock models; common bivariate exponential distributions and their properties. Reliability estimation based on failure times in variously censored life tests and in tests with replacement of failed items; stress-strength reliability and its estimation. **(15 Hours)**

Unit -4

Maintenance and Replacement Policies: Repairable systems, replacement policies, modeling of a repairable system by a non-homogeneous Poisson process. Reliability growth models; probability plotting techniques; Hollander-Proschan and Deshpande tests for exponentiality; tests for HPP vs. NHPP with repairable systems. Basic ideas of accelerated life testing. **(15 Hours)**

Unit -5(Teacher Specific Module-Optional)

Computation of above concepts in R **(15 Hours)**

Book for Study

1. Barlow R.E. and Proschan F. (1985). ***Statistical Theory of Reliability and Life Testing***; Holt, Rinehart and Winston.

Reference Books

1. Bain L.J. and Engelhardt (1991). ***Statistical Analysis of Reliability and Life Testing Models***; Marcel Dekker.
2. Aven, T. and Jensen, U. (1999). ***Stochastic Models in Reliability***, Springer Verlag, New York, Inc.
3. Nelson, W. (1982). ***Applied Life Data Analysis***; John Wiley.
4. Zacks, S. (1992). ***Introduction to Reliability Analysis: Probability Models and Statistics Methods***. New York: Springer-Verlag.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester VIII

DSE6– DISCIPLINE SPECIFIC ELECTIVE COURSE

KU08DSESTA407:ADVANCED BAYESIAN COMPUTING WITH R

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	ELECTIVE	400	KU08DSESTA407	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	1	1	50	50	100	3(T)+2(P)*

COURSE DESCRIPTION:

This course provides a comprehensive introduction to Bayesian inference, covering foundational concepts, single and multi-parameter models, Bayesian computation techniques, and model comparison and regression models. Students will gain theoretical knowledge and practical skills necessary for performing Bayesian analysis and inference using statistical software packages. Through theoretical lectures, practical exercises, and hands-on experience with statistical software packages, students will develop the skills necessary to perform Bayesian analysis, model complex data, and make informed decisions based on Bayesian inference.

COURSE OBJECTIVES:

- Understanding Bayesian Inference Principles: Develop a thorough understanding of Bayesian inference principles, including statistical decision problems, decision rules, loss functions, and Bayes' theorem, enabling students to apply Bayesian methods to real-world problems.
- Proficiency in Single and Multi-parameter Models: Gain proficiency in modeling single and multi-parameter distributions commonly encountered in Bayesian inference, such as the normal distribution, Poisson model, multinomial model, and multivariate normal distribution, allowing students to analyze and interpret complex data sets.

- Mastery of Bayesian Computation Techniques: Acquire mastery in Bayesian computation techniques, including Monte Carlo simulation, importance sampling, and Markov Chain Monte Carlo (MCMC) methods such as the Metropolis-Hastings algorithm and Gibbs sampling, enabling students to efficiently compute posterior distributions and perform Bayesian analysis.
- Ability to Compare Models and Perform Regression Analysis: Develop the ability to compare models using techniques such as Bayes factor and posterior predictive model checking. Gain proficiency in regression analysis, including hierarchical models, shrinkage estimators, and normal linear regression models, allowing students to make predictions and draw insights from data.
- Practical Application of Bayesian Methods: Apply Bayesian methods to real-world problems using statistical software packages such as R and WinBUGS, allowing students to perform Bayesian analysis, model complex data, and make informed decisions based on Bayesian inference techniques.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Demonstrate proficiency in applying Bayesian inference principles to solve a variety of statistical decision problems, effectively utilizing Bayes' theorem and decision rules to make informed decisions based on available data.
CO2	Develop advanced modeling skills in single and multi-parameter distributions commonly encountered in Bayesian inference, allowing them to accurately model and analyze complex datasets, including those with unknown parameters.
CO3	Master Bayesian computation techniques, including Monte Carlo simulation, importance sampling, and MCMC methods such as the Metropolis-Hastings algorithm and Gibbs sampling, enabling them to efficiently compute posterior distributions and perform Bayesian analysis on large datasets.
CO4	Gain proficiency in model comparison techniques such as Bayes factor and posterior predictive model checking, allowing them to assess the relative strengths of different models. Additionally, students will develop proficiency in regression analysis, including hierarchical models and normal linear regression models, enabling them to make accurate predictions and draw meaningful insights from data.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔		✔
CO4	✔		✔	✔	✔

COURSE CONTENTS

Unit 1

Bayesian Inference: Statistical decision problem, randomized decision rule, decision principle, standard loss functions, Prior information, subjective determination of prior density, non-informative priors, maximum entropy priors, conjugate priors, discrete prior. Parametric family and likelihood, exponential family, Bayes' theorem for inference, prior and posterior densities. **(15 Hours)**

Unit-2

Single and multi-parameter models: single parameter models, normal distribution with known variance and unknown mean, normal with known mean and unknown variance, Poisson model, normal distribution with both parameters unknown, multinomial model, Dirichlet prior, Bioassay experiment, comparing two proportions, predictive distribution, beta-binomial distribution, multivariate normal distribution, introduction to Learn Bayes package, Examples using Learn Bayes package. **(15 Hours)**

Unit-3

Bayesian Computation: Computing integrals using Monte-Carlo simulation, approximation based on posterior mode, importance sampling, Markov Chain Monte Carlo methods, Metropolis-Hastings algorithm, random walk, Gibbs sampling. **(15 Hours)**

Unit-4

Model Comparison and Regression models: Hierarchical models, shrinkage estimators, posterior predictive model checking, comparison of hypotheses, Bayes factor, one-sided test for normal mean, two-sided test for normal mean, normal linear regression model, prediction of future observations, examples and R codes, introduction to Win-BUGS package. **(15 Hours)**

Unit -5 (Teacher Specific Module-Optional)

Practical session in lab. **(30 Hours)**

Text Books

1. Jim Albert (2007).***Bayesian Computation with R,*** New York: Springer Verlag.
2. Berger, O.J. (1985). ***Statistical Decision Theory and Bayesian Analysis, Second Edition***, Springer Verlag.
3. Bensal, A.K. (2008). ***Bayesian Parametric Inference,*** New Age, Delhi.

Reference Books:

1. Ferguson, T.S. (1967). ***Mathematical Statistics: A Decision-Theoretic Approach***, Academic Press, New York.
2. Bolstad, W. (2004). ***Introduction to Bayesian Statistics***, Hoboken, NJ: John Wiley.
3. Gelman, A., Carlin, J., Stern, H. and Rubin, D. (2003). ***Bayesian Data Analysis***, New York: Chapman and Hall.
4. Gilks, W.R., Richardson, S. and Spiegelhalter, D.J. (1996). ***Markov Chain Monte Carlo in Practice***. Chapman & Hall/CRC, New York.
5. Robert, C. and Casella, G. (2004). ***Monte Carlo Statistical Methods***, New York: Springer.

TEACHING LEARNING STRATEGIES

● Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

●Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester VIII

DSE-DISCIPLINE SPECIFIC ELECTIVE COURSE

KU08DSESTA408: GENERALIZED LINEAR MODELS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	ELECTIVE	400	KU08DSESTA408	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course delves into the theory and applications of generalized linear models (GLMs), focusing on various advanced topics such as logistic regression, Poisson regression, log-linear models, zero-inflated models, and survival analysis. Through lectures, discussions, and practical exercises, students will gain a comprehensive understanding of GLMs and their applications in analyzing complex data sets.

COURSE OBJECTIVES:

- Define and explain the key concepts of GLMs, including the exponential family of distributions, link functions, and model specification.
- Apply the method of maximum likelihood estimation and iteratively reweighted least squares (IRLS) algorithm to estimate GLM parameters.
- Explore specialized GLM models such as Poisson regression and log-linear models for count data analysis.
- Apply GLMs to analyze hierarchical and longitudinal data using techniques such as generalized estimating equations (GEE) and mixed effects models.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Demonstrate proficiency in applying advanced GLM techniques such as logistic regression, Poisson regression, and log-linear models to analyze complex datasets.
CO2	Utilize maximum likelihood estimation and iteratively reweighted least squares (IRLS) algorithm to estimate parameters in GLMs.
CO3	Apply GLMs to analyze count data using Poisson regression and handle excessive zeros using zero-inflated models.
CO4	Interpret GLM parameters and assess the significance of predictor variables in the context of the research question.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	✔
CO3	✔		✔	✔	✔
CO4	✔	✔	✔	✔	

COURSE CONTENTS

UNIT 1

Introduction to Generalized Linear Models: Overview of generalized linear models (GLM s), exponential family of distributions, link functions and model specification, logistic regression, comparison with linear regression and logistic regression, interpretation of GLM parameters, nominal and ordinal regression. (**15 Hours**)

UNIT 2

Model Estimation and Inference: Method of maximum likelihood estimation, iteratively reweighted least squares (IRLS) algorithm, model diagnostics: residual analysis, goodness-of-fit tests, confidence intervals and hypothesis testing for model parameters, overdispersion and model assessment. **(25 Hours)**

UNIT 3

Poisson Regression and Log-linear Models: Count data, Poisson regression, Estimation and model diagnostics, Contingency tables, log-linear models, Inference for log-linear models, Numerical examples, zero-inflated Poisson models. **(20 Hours)**

UNIT 4

Advanced Topics in GLMs: Generalized estimating equations (GEE), zero-inflated and negative binomial models, hierarchical GLM s and mixed effects models, time-to-event data analysis using GLM s (survival analysis), model selection techniques: AIC, BIC. (**20 Hours)**

UNIT 5

Applications of GLM s in biomedical research, epidemiology, and social sciences, case studies and real-world examples, practical implementation of GLM s using statistical software (R or SAS or SPSS). **(10 Hours)**

TEXT BOOKS

1. Dobson, A. J., & Barnett, A. G. (2018).***An Introduction to Generalized Linear Models*** *(4th ed.)*. CRC Press.
2. McCullagh, P., & Nelder, J. A. (1989). ***Generalized Linear Models*** *(2nd ed.)*. Chapman and Hall/CRC.

SUGGESTED READINGS

1. Faraway, J. J. (2006). ***Extending the Linear Model with R: Generalized Linear, Mixed Effects and Nonparametric Regression Models.***Chapman and Hall/CRC.
2. Agresti, A. (2015). ***Foundations of Linear and Generalized Linear Models.*** John Wiley & Sons.
3. Hardin, J. W., & Hilbe, J. M. (2013). ***Generalized Linear Models and Extensions (3rd ed.).*** Stata Press.

TEACHING LEARNING STRATEGIES

● Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

●Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks

Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester VIII

DSE-DISCIPLINE SPECIFIC ELECTIVE COURSE

KU08DSESTA409-ANALYSIS OF LONGITUDINAL DATA

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	ELECTIVE	400	KU08DSESTA409	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course delves into advanced statistical methodologies for analyzing longitudinal data, focusing on discrete outcomes, generalized linear models, missing data mechanisms, time-dependent covariates, and special topics in longitudinal data analysis. Through theoretical concepts, practical applications, and case studies, students will develop proficiency in modeling longitudinal data and addressing complex research questions in various fields.

COURSE OBJECTIVES:

- Gain a comprehensive understanding of advanced statistical techniques for analyzing longitudinal data, including generalized linear models, random effects models, transition models, and likelihood-based models for categorical data.
- Learn to classify missing data mechanisms, address intermittent missing values and dropouts, and implement weighted estimating equations and modeling techniques for the dropout process.
- Recognize the challenges associated with time-dependent covariates, implement lagged covariates, and apply marginal structural models to account for time-varying confounding factors.

- Gain insight into specialized topics such as joint models for longitudinal and survival data, multivariate longitudinal data analysis, and the design of randomized and observational longitudinal studies.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Conduct analysis of longitudinal data.
CO2	Apply statistical techniques to model longitudinal data and make predictions.
CO3	Understand analysis of longitudinal data with missing data.
CO4	Understand analysis of longitudinal data with time-dependent covariates.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

UNIT 1

Discrete Data and their Measures: Inference for contingency tables, Logistic models, statistical power and sample size computations Logit models with categorical predictors, logit models with multi responses-nominal and ordinal responses. (20 Hours)

UNIT 2

Generalized Linear Model for Longitudinal Data: Generalized Linear Model for Longitudinal Data, Marginal models, for binary, ordinal, and count data: Random effects models for binary and count data: Transition models: Likelihood-based models for categorical data; GEE; Models for mixed discrete and continuous responses. (20 Hours)

UNIT 3

Longitudinal Data with Missing Data: Classification missing data mechanism; Intermittent missing values and dropouts; Weighted estimating equations; Modeling the dropout process (Selection and pattern mixture models). (15 hours)

UNIT 4

Time-dependent Covariates and Special Topics: Dangers of time-dependent covariates, Lagged covariates; Marginal Structural models; Joint models for longitudinal and survival data; Multivariate longitudinal data; Design of randomized and observational longitudinal studies. (20Hours)

UNIT 5

Exploratory Data Analysis, Modeling Approaches: Students will apply various modeling approaches discussed in earlier units, such as Generalized Linear Models (GLMs), Generalized Estimating Equations (GEE), and Marginal Structural Models (MSMs), to analyze longitudinal data using statistical software. (15 Hours)

TEXT BOOKS

1. Diggle, P.J., Heagerty, P., Liang, K.Y and Zeger. S.L (2003). ***Analysis of Longitudinal Data***, 2nd Edn. Oxford University Press, New York.
2. Fitzmaurice, G.M., Laird, N.M and Ware, J.H. (2004). ***Applied Longitudinal Analysis***, John Wiley & Sons, New York.

SUGGESTED READINGS

1. Crowder, M.J. and Hand, D.J. (1990). ***Analysis of Repeated Measures.*** Chapman and Hall/CRC Press, London.
2. Davidian, M. and Giltinan, D.M. (1995). ***Nonlinear Models for Repeated Measurement Data***. Chapman and Hall/CRC Press, London.
3. Hand, D. and Crowder, M. (1996). ***Practical Longitudinal Data Analysis.*** Chapman and Hall/CRC Press, New York.
4. McCullagh, P. and Nelder. J. A. (1989).***Generalized Linear Models. 2nd Edition***, Chapman and Hall/CRC Press, London.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

●Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester VIII

DSE-DISCIPLINE SPECIFIC ELECTIVE COURSE

KU08DSESTA410-APPLIED REGRESSION ANALYSIS FOR BIOSTATISTICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	ELECTIVE	400	KU08DSESTA410	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course provides a comprehensive exploration of regression analysis, covering simple linear regression models, multiple regression models, nonparametric regression, simultaneous equation models, polynomial regression, linearization transforms, diagnostic checks, and generalized linear models. Students will learn theoretical concepts, practical applications, and advanced techniques for analyzing and interpreting regression models.

COURSE OBJECTIVES:

- Understand various regression models including logistic regression models and simultaneous equation models.
- Understand consequences of multicollinearity, heteroscedasticity, autocorrelation, their detection, and remedial measures.
- Apply statistical techniques to model relationships between variables and make predictions.
- Acquire knowledge of various advanced econometric models, estimation methods, and related econometric theories.
- Conduct econometric analysis of data.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Understand the concepts of simple linear regression models and least square estimation.
CO2	Recognize the nature and consequences of multicollinearity, heteroscedasticity, and autocorrelation in regression models.
CO3	Understand the principles of nonparametric regression and spline smoothing techniques.
CO4	Apply linearization transforms to linearize nonlinear relationships in regression models.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

UNIT 1

The Simple Linear Regression Models, least square estimation, statistical assumptions and properties of estimators, standard error of estimates, tests of significance and confidence intervals for the parameters, error and residual plots.(**20 Hours**)

UNIT 2

Multiple Regression Models : Multiple regression models, OLS and ML estimators, testing and prediction, Multicollinearity, heteroscedasticity, autocorrelation: their nature, consequences, detection, remedial measures and estimation in the presence of them..(**20 Hours**)

UNIT 3

Nonparametric Regression - Nonparametric regressions and concept of spline smoothing. Simultaneous equation models - examples, inconsistency of OLS estimators, identification problem, rules for identification, method of indirect least squares, method of two-stage least squares. (**20 Hours**)

UNIT 4

Polynomial Regression in One and Several Variables. Linearization transforms, Diagnostic checks and correction. Generalized linear models. Logistic regression. Poisson regression, application in biostatistics. (**15 Hours**)

UNIT 5

Review of Gauss-Markov model, estimability of linear parametric function, different problems related to estimability. Hands-on exercises using statistical software. (**15 Hours**)

REFERENCE BOOKS

1. Draper, N.R. and Smith, H. (1998): ***Applied Regression Analysis***, 3rd Ed. John Wiley.
2. Gujarati, D.N. (2007): ***Basic Econometrics*** (Fourth Edition), McGraw-Hill, New York.
3. Hosmer, D.W. and Lemeshow, S. (1989): ***Applied Logistic Regression***, John Wiley.
4. Montgomery, D.C, Peek, E.A. and Vining, G.G. (2006): ***Introduction to Linear Regression Analysis***, John Wiley.

SUGGESTED READINGS

1. Seber, G.A.F. and Lee, A.J. (2003): ***Linear Regression Analysis***, Wiley
2. Johnston, J. (1984): ***Econometric Methods***, 3rd ed., McGraw Hill, New York.
3. Goon, Gupta, Das Gupta (2001):***An Outline Series in Statistics Vol I***, World Press.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

SEMESTER VIII

DSE-DISCIPLINE SPECIFIC ELECTIVE COURSE

KU08DSESTA411- STATISTICAL EPIDEMIOLOGY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	ELECTIVE	400	KU08DSESTA411	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	

4	-	1	50	50	100	2(T)+3(P) *

COURSE DESCRIPTION

This course provides an introduction to the fundamental principles and methodologies of epidemiology, focusing on understanding the distribution and determinants of health-related states or events in populations and the application of this knowledge to public health practice. Through a combination of theoretical concepts and practical examples, students will gain insight into various study designs, measures of disease frequency and association, and the role of epidemiology in disease prevention and control.

COURSE OBJECTIVES:

- Explain the concepts of health and disease and the methods for measuring them.
- Describe the characteristics and applications of cohort and case-control study designs.
- Perform estimation and hypothesis testing using confidence intervals and analysis of variance (ANOVA).
- Understand the concept of causation in epidemiology and methods for establishing causality.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Understand the different types of study designs, including observational epidemiology, cohort study designs, case-control study designs, randomized field trials, and control trials.
CO2	Comprehend the concept of cause and establishing the cause of disease.
CO3	Describe the scope and levels of disease prevention and their relevance to public health practice.
CO4	Develop practical skills in applying epidemiological principles to public health problems.

MAPPING OF COs to PSOs

Sl No	PS O1	PS O2	PS O3	PS O4	PS O5
CO1	✔	✔	✔	✔	✔
CO2	✔		✔	✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	

COURSE CONTENTS

UNIT 1

Basic concepts of epidemiology: definition and scope of epidemiology, achievements in epidemiology, measuring health and disease, definition of health and disease, measures of disease frequency, comparing disease occurrence. (**15 Hours**)

UNIT 2

Types of study: observations and experiments, observational epidemiology, cohort study designs, case control study designs, randomized, field trails, control trials, potentials errors in epidemiological studies, ethical issues. (**15 Hours**)

UNIT 3

Distribution and summary measures: distribution, measures of central tendency, measures of variability, normal and log normal distributions, estimation, testing, CI, ANOVA, relationship between two variables: chi-square test, correlation, regression, logistic regression. (**25 Hours**)

UNIT 4

Concept of cause and Study Designs: Establishing the cause of disease, scope of prevention, levels of prevention, Introduction to clinical epidemiology. Advanced Study Designs: Delve into more complex study designs beyond cohort and case-control studies, such as nested case-control studies, case-crossover studies, ecological studies, and cross-sectional studies. (**20 Hours**)

UNIT 5

Social Epidemiology: Investigate the social determinants of health and disease disparities within populations. Stay abreast of current and emerging topics in epidemiological research. (**15 Hours**)

TEXT BOOKS

1. Beaglehole,R.,Bonita,R.andKjellstorm,T.(1993).***Basic Epidemiology***.World Health Organization, Geneva.
2. Newman,S.C.(2001).***Biostatistical Methods in Epidemiology***. John Wiley & Sons, New York.
3. Virasakdi, C. (2010). ***Analysis of Epidemiological Data Using R and Epicalc*. Epidemiological Unit**, Songla University,Thailand

SUGGESTED READINGS

1. Rothan,K.J.,Greenland,S.and Lash,T.L.(2008). ***Modern Epidemiology***, *3rd Edition.* Wokers Kluver
2. Clayton,D.and Hills,M.(1993). ***Statistical methods in epidemiology***. Oxford University Press4. Karlin, S. and Taylor, H.M. (1975). **A First Course in Stochastic Processes**. Second Edition, Academic Press. New York.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester VIII

DSE-DISCIPLINE SPECIFIC ELECTIVE COURSE

KU08DSESTA412-STATISTICAL ECOLOGY AND GENETICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	ELECTIVE	400	KU08DSESTA412	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course offers a comprehensive exploration of population dynamics, ecological diversity, statistical problems in human genetics, and sequence analysis techniques. Through theoretical concepts and practical applications, students will gain insight into the dynamics of populations, ecological diversity measures, genetic inheritance, and sequence analysis algorithms.

COURSE OBJECTIVES:

- Understand the dynamics of populations, including single-species and two-species models, and analyze population growth using mathematical models such as exponential, logistic, and Gompertz models.
- Apply ecological diversity measures such as Simpson's index and Shannon-Weaver index to quantify species diversity in ecological communities and understand the concept of average rarity in biodiversity conservation.
- Explore statistical problems in human genetics, including blood group analysis, quantitative genetics, inheritance of quantitative traits, detection, and estimation of linkage, and understand the principles of Hardy-Weinberg Equilibrium and random mating.
- Gain proficiency in sequence analysis techniques, including sequence similarity, homology, and alignment algorithms such as pair and multiple sequence alignments, construction of phylogenetic trees using UPGMA, neighbor joining, maximum parsimony, and maximum likelihood algorithms.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Understanding Population Dynamics and Models.
CO2	Proficiency in Population Density Estimation and Ecological Diversity.
CO3	Application of Statistical Methods in Human Genetics.
CO4	Proficiency in Sequence Analysis and Phylogenetics.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔		✔

COURSE CONTENTS

UNIT 1

Population Dynamics: One species - exponential, logistic and Gompertz models. Two species - competition, coexistence, predator - prey oscillation, Lotka - Volterra equations, isoclines. Leslie matrix model for age structured populations. Survivorship curves - constant hazard rate, monotone hazard rate and bath-tub shaped hazard rates. **(15 Hours)**

UNIT 2

Population density estimation -Capture- recapture models, nearest neighbor models, line transect sampling. Ecological Diversity - Simpson's index, Shannon – Weaver index, Diversity as average rarity. Optimal Harvesting of Natural Resources, Maximum sustainable yield, tragedy of the commons.

(**15 Hours**)

UNIT 3

Statistical problems in human genetics: blood group analysis. Natural selection. Quantitative genetics, study of inheritance of quantitative characters in random and nonrandom mating diploid populations. Detection and estimation of linkage. Gene frequency, random mating, Hardy-Weinberg Equilibrium, Matrix theory of random mating with applications. (**15 Hours**)

UNIT 4

Sequence similarity: homology and alignment. Algorithm for pair and multiple sequence alignments, construction of phylogenetic trees, UPGMA. Neighbor joining, maximum parsimony and maximum likelihood algorithms. (**10 Hours**)

UNIT 5

Genetic Variation and Evolution: Explore the sources and maintenance of genetic variation within populations, including mutation, migration, genetic drift, and natural selection. (**5 Hours**)

TEXT BOOKS

1. Johnson, N.L., Kotz, S. and Balakrishnan, N. (1995). ***Continuous Univariate Distributions, Vol. I & Vol. II***, John Wiley and Sons, New York.
2. MacLachlan, P. and Peel, D. (2000).***Finite Mixture Models***. John Wiley & Sons, New York
3. Silverman, B. (1986). ***Density Estimation for Statistics and Data Analysis***. Chapman & Hall.

SUGGESTED READINGS

1. Johnson, N.L., Kotz, S. and Kemp, A.W. (1992). ***Univarite Discrete Distributions***, John Wiley and Sons, New York.
2. Stuart, A., Ord, A. (1994).***Kendall's Advanced Theory of Statistics***, ***Distribution Theory***, 6th Edition. Wiley-Blackwell.
3. Kagan, A.M., Linnik, Y.V. and Rao, C.R. (1975). ***Characterization Problems in Mathematical Statistics*****.** John Wiley.

TEACHING LEARNING STRATEGIES

● Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

●Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester VIII

DSE-DISCIPLINE SPECIFIC ELECTIVE COURSE

KU08DSESTA413 - APPLIED MULTIVARIATE ANALYSIS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
8	ELECTIVE	400	KU08DSESTA 413	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course offers a comprehensive exploration of multivariate statistical analysis techniques, covering topics such as multivariate normal distribution, principal component analysis, canonical correlation analysis, factor analysis, cluster analysis, MANOVA, and multidimensional scaling. Students will learn theoretical concepts and practical applications of these techniques using statistical software.

COURSE OBJECTIVES:

- Understand the fundamentals of multivariate data analysis and the notion of multivariate distributions.

- Demonstrate proficiency in analyzing multivariate data using the multivariate normal distribution, including understanding marginal and conditional distributions.
- Master the concept of characteristic functions and their application in multivariate data analysis.
- Develop skills in estimating the mean vector and covariance matrix of multivariate datasets.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Demonstrate a comprehensive understanding of various multivariate data analysis techniques.
CO2	Develop proficiency in dimensionality reduction techniques such as Principal Components Analysis (PCA) and Factor Analysis.
CO3	Acquire advanced multivariate analysis skills, including conducting comparisons of several multivariate population means using one-way MANOVA, simultaneous confidence interval construction for treatment effects.
CO4	Master the analysis of multivariate relationships using techniques such as Canonical Correlation Analysis (CCA), cluster analysis, and distance methods.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

UNIT 1

Multivariate normal distribution: Multivariate data, preliminary analysis, notion of multivariate distributions, multivariate normal distribution, marginal and conditional distributions, characteristic function, estimation of mean vector and covariance matrix. (**15 Hours**)

UNIT 2

Principal component and canonical correlation: Principal components Analysis: - population principal components, summarizing sample variation by principal components, graphing the principal components; Canonical correlation analysis: - canonical variates and canonical correlations, interpreting the population canonical variables, the sample canonical variates and sample canonical correlations. (**25 Hours**)

UNIT 3

Factor and cluster analysis: Factor analysis: - orthogonal factor model; methods of estimation, factor rotation, factor scores; Cluster analysis: - similarity measures, hierarchical clustering methods, non-hierarchical clustering methods. (**25 Hours**)

UNIT 4

MANOVA and Multidimensional scaling: Comparison of several multivariate population means (one-way MANOVA), simultaneous confidence intervals for treatment effects, two-way multivariate analysis of variance; Distance methods: - multidimensional scaling, correspondence analysis. (**15 Hours**)

UNIT 5

Multivariate Data Analysis in R: Introduction to R programming language for multivariate data analysis; Multivariate statistical techniques implementation in R: using packages like "mvtnorm" for multivariate normal distribution, "FactoMineR" for factor analysis and cluster analysis, "MASS" for MANOVA. Hands-on exercises and case studies: applying learned techniques to real-world datasets, interpreting results, and drawing conclusions. (**10 Hours**)

TEXT BOOKS

1. Johnson, R.A. and Wichern, D.W. (2007)**.** ***Applied Multivariate Statistical Analysis***, PHI Learning Private Ltd, New Delhi, Sixth edition.
2. Rencher, A.C. (1995) . ***Methods of Multivariate Analysis***, John Wiley.
3. Dillon, W.R. and Goldstein, M (1984) . ***Multivariate Analysis***, John Wiley.

SUGGESTED READINGS

1. Anderson, T.W. (1984). ***An Introduction to Multivariate Statistical Analysis***, John Wiley.

2. Seber G.A.F. (1983) . ***Multivariate Observations***, Wiley.
3. Tabachnick, B.G. and Fidell, L.S. (2018) . ***Using Multivariate Statistics***, Sixth edition, Pearson India Education Services Pvt Ltd, India.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester IX

A24– DISCIPLINE SPECIFIC CORE COURSE

KU09DSCSTA501:ADVANCED SAMPLING THEORY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
9	CORE	500	KU09DSCSTA501	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course provides a comprehensive overview of sampling methods in statistics, covering basic concepts, probability sampling techniques, auxiliary variable techniques, varying probability sampling, and cluster, multi-stage, and multi-phase sampling. Students will gain theoretical knowledge and practical skills necessary for designing and implementing sampling plans and estimating population parameters accurately. Through theoretical lectures, practical exercises, and case studies, students will develop the skills necessary to design effective sampling plans, select appropriate sampling techniques, and estimate population parameters accurately while considering various sampling complexities and constraints.

COURSE OBJECTIVES:

- Understanding Sampling Concepts: Develop a thorough understanding of basic sampling concepts, including the distinction between census and sampling, types of sampling methods, and the principles underlying probability and non-probability sampling.
- Proficiency in Probability Sampling Techniques: Gain proficiency in probability sampling techniques such as simple random sampling, systematic sampling, and stratified random sampling, including the estimation of population parameters like mean, total, and proportions.
- Mastery of Auxiliary Variable Techniques: Acquire mastery in auxiliary variable techniques, including the ratio method of estimation and regression methods of estimation, and understand concepts such as bias, relative bias, mean squared error, and comparison of estimators.
- Application of Varying Probability Sampling Methods: Develop the ability to apply varying probability sampling methods such as probability proportional to size (PPS) sampling, Des-Raj ordered estimators, Murthy's unordered estimator, and Horwitz-Thompson estimators.
- Proficiency in Cluster, Multi-Stage, and Multi-Phase Sampling: Gain proficiency in cluster sampling techniques, including equal and unequal clusters, and understand concepts such as relative efficiency and optimum cluster size. Develop skills in multi-stage and multi-phase sampling methods and recognize sources of non-sampling errors.

COURSE OUTCOME:

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

SL #	Course Outcomes
CO1	Demonstrate mastery of various sampling techniques, including probability and non-probability sampling methods, enabling them to design and implement effective sampling plans for diverse populations and research contexts.
CO2	Develop proficiency in estimation methods for population parameters such as mean, total, and proportions using different sampling techniques, auxiliary variable techniques, and varying probability sampling methods, ensuring accurate estimation of population characteristics.

CO3	Develop advanced analytical skills in evaluating the performance of different sampling methods, comparing estimators, and assessing the reliability of survey results, enhancing their ability to make informed decisions based on sample data.
CO4	Apply sampling principles to real-world scenarios and datasets, students will develop practical skills in designing sampling plans, selecting appropriate sampling techniques, and addressing potential sources of bias and error, ensuring the validity and reliability of survey findings.

MAPPING OF COs to PSOs

Sl No	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔		✔

COURSE CONTENTS

Unit-1

An Overview of Basics of Sampling: Census and sampling - basic concepts, probability sampling and non-probability sampling, simple random sampling with and without replacement, estimation of population mean and total, estimation of sample size, estimation of proportions. Systematic sampling, linear and circular systematic sampling, estimation of mean and its variance, estimation of mean in populations with linear and periodic trends. **(15 Hours)**

Unit-2

Stratified Random Sampling and Auxiliary Variable Techniques: Stratification and stratified random sampling. Optimum allocations, comparisons of variance under various allocations. Auxiliary variable techniques, Ratio method of estimation, estimation of ratio, mean, and total. Bias and relative bias of ratio estimator. Mean squared error of ratio estimator. Unbiased ratio type estimator. Regression methods of estimation. Comparison of ratio and regression estimators with simple mean per unit method. Ratio and regression method of estimation in stratified population.
(15 Hours)

Unit-3

Varying Probability Sampling: Varying probability sampling – pps sampling with and without replacements. Des-Raj ordered estimators, Murthy's unordered estimator, Horwitz-Thompson estimators, Zen-Midzuno scheme of sampling, PPS sampling. **(15 Hours)**

Unit-4

Cluster, Multi-Stage, and Multi-Phase Sampling: Cluster sampling with equal and unequal clusters. Estimation of mean and variance, relative efficiency, optimum cluster size, varying probability cluster sampling. Multi-stage and multi-phase sampling. Non-sampling errors. **(15 Hours)**

Unit -5

Practicals using various R packages for sampling. **(15 Hours)**

Books for Study

1. Singh, D. and Chowdhary, F.S. (1986). ***Theory and Analysis of Sample Survey Designs***, New Age International, New Delhi.
2. Cochran, W.G. (2007). ***Sampling Techniques***, John Wiley & Sons, New York.

Reference Books

1. Des Raj, D. and Chandhok, P. (1998). ***Sample Survey Theory***, Narosa Publishing House, New Delhi.
2. Gupta and Kapoor (2010). ***Fundamentals of Applied Statistics***. Sulthan Chand & Sons.
3. Murthy, M.N. (1967). ***Sampling Theory & Methods***. Statistical Publishing Society, Calcutta.
4. Parimal Mukopadhyay (2012). ***Theory & Methods of Survey Sampling***, PHI Learning, New Delhi.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester IX

DISCIPLINE SPECIFIC CORE COURSE

KU09DSCSTA502- STOCHASTIC PROCESSES

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
9	CORE	500	KU09DSCSTA502	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course offers a comprehensive exploration of stochastic processes, Markov chains, renewal processes, queueing theory, and Brownian motion. Students will delve into theoretical concepts and practical applications of these stochastic models in various fields such as operations research, telecommunications, finance, and engineering. Through lectures, problem-solving sessions, and hands-on exercises, students will gain proficiency in analyzing and modeling stochastic systems.

COURSE OBJECTIVES:

- Understand the concepts of Stochastic Processes.
- Understand the concepts of Markov chains, classification of its states and limiting probabilities.
- Understand continuous time Markov chains, Poisson processes and its generalizations.
- Understand the branching processes, various queueing models and Brownian motion processes.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Introduction to counting processes and their significance in modeling arrivals over time.
CO2	Exploring generalizations of Poisson processes such as non-homogeneous Poisson processes and compound Poisson processes.
CO3	Analysis of traffic intensity, expected queue size, expected system size, and waiting time in queueing systems.
CO4	Understanding Brownian motion and its applications in modeling random motion and diffusion phenomena.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

UNIT 1

Overview of basic concepts of stochastic processes and Markov Chains: Poisson Processes and Generalizations: Exponential distribution, counting process, inter-arrival time and waiting time distributions. Properties of Poisson processes - Conditional distribution of arrival times. Generalizations of Poisson processes, non-homogeneous

Poisson process, compound Poisson process.
(15 Hours)

UNIT 2

Continuous-time Markov Chains and Renewal Processes: Continuous-time Markov Chains - Birth and death processes, transition probability function, limiting probabilities. Renewal processes, limit theorems and their applications. Semi-Markov process.
(15 Hours)

UNIT 3

Queueing theory: Basic characteristics of queues- traffic intensity, expected queue size, expected system size, waiting time, Littles equation, steady-state characteristics, analysis of Markovian models (M/M/1, M/M/1/N, M/M/c), network of queues. The M/G/1 system and G/M/1 mode **(15 Hours)**

UNIT 4

Brownian motion and stationary process: hitting times, maximum variables, gambler's ruin problem, variations on brownian motion, brownian motion with drift, geometric brownian motion, applications. **(8 Hours)**

UNIT 5

Continuous-Time Stochastic Processes: Introduction to continuous-time stochastic processes beyond Markov chains, Introduction to Brownian motion and stochastic calculus and its applications. **(7 Hours)**

TEXT BOOKS

1. Ross, S.M. (2010). ***Introduction to Probability Models. Xth Edition***, Academic Press.
2. Medhi, J. (2009). ***Stochastic Processes. Third Edition.*** New Academic Science Limited. UK.

SUGGESTED READINGS

1. Basu, A.K. (2002). ***Elements of Stochastic Processes***, Narosa Publications.
2. Cinlar, E. (1975). ***Introduction to Stochastic Processes***. Prentice Hall. New Jersey.
3. Feller, W. (1965, 1968). ***An Introduction to Probability Theory and Its Applications,*** Volume I and II, Wiley Eastern.
4. Karlin, S. and Taylor, H.M. (1975). ***A First Course in Stochastic Processes. Second Edition***, Academic Press. New York.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- ●Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester IX

A26-DISCIPLINE SPECIFIC CORE COURSE

KU09DSCSTA503- STATISTICAL SIMULATION TECHNIQUES

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
9	CORE	500	KU09DSCSTA503	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course provides a comprehensive introduction to statistical simulation techniques, covering theoretical foundations, methods for generating random variables and stochastic processes, Monte Carlo simulation methods, and applications in various fields such as finance, engineering, and risk analysis. Through theoretical instruction, practical examples, and hands-on exercises, students will gain proficiency in using statistical simulation to model complex systems and make informed decisions.

COURSE OBJECTIVES:

- Theoretical foundations of statistical simulation techniques and their applications in various fields.
- Methods for generating random variables and simulating stochastic processes.
- Techniques for implementing Monte Carlo simulations to solve complex statistical problems.
- Interpretation of results from statistical simulations and their implications in decision-making and risk analysis.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Understand the theoretical foundations of statistical simulation techniques and their importance in modern statistical analysis.
CO2	Apply methods for generating random variables from different probability distributions and simulating stochastic processes.
CO3	Implement Monte Carlo simulation methods to solve problems involving uncertainty and variability.
CO4	Interpret results obtained from statistical simulations and make informed decisions based on simulation outputs.

MAPPING OF COs to PSOs

Sl No	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	✔	✔	✔	✔	✔
CO 2	✔	✔	✔	✔	✔
CO 3	✔	✔	✔	✔	✔
CO 4	✔	✔	✔	✔	✔

COURSE CONTENTS

UNIT 1

Introduction to Statistical Simulation Techniques: Definition and scope of statistical simulation, Theoretical foundations of random number generation, Basics of probability distributions and random variables. (**15 Hours**)

UNIT 2

Generation of Random Variables and Stochastic Processes: Methods for generating random variables from different distributions, Simulation techniques for discrete and continuous stochastic processes, Simulation of Markov chains and random walks. (**25 Hours**)

UNIT 3

Monte Carlo Simulation Methods: Principles of Monte Carlo simulation, Simulation of complex systems and processes, Variance reduction techniques in Monte Carlo simulation, Applications in finance, engineering, and risk analysis. (**25 Hours**)

UNIT 4

Interpretation and Applications of Statistical Simulations: Analysis and interpretation of simulation results, Applications of statistical simulations in decision-making and risk analysis, Case studies and real-world examples. **(15 Hours)**

UNIT 5(Teacher Specific Module-Optional)

Variance Reduction in Monte Carlo Simulation, Introduction to stratified sampling, importance sampling, and control variates, Implementation of variance reduction techniques in R. (**10 Hours)**

TEXT BOOK

1. Robert, C. P., & Casella, G. (2004). ***Monte Carlo Statistical Methods*.** Springer.

SUGGESTED READINGS

1. Rubinstein, R. Y., & Kroese, D. P. (2016). ***Simulation and the Monte Carlo Method (3rd ed.)***. John Wiley & Sons.
2. Gelman, A., Carlin, J. B., Stern, H. S., & Rubin, D. B. (2013). ***Bayesian Data Analysis (3rd ed.)***. CRC Press.
3. Fishman, G. S. (2013). ***Monte Carlo: Concepts, Algorithms, and Application**s*. Springer.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester IX

A27-DISCIPLINE SPECIFIC CORE COURSE

KU09DSCSTA504 - ADVANCED MULTIVARIATE ANALYSIS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
9	CORE	500	KU09DSCSTA504	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course offers a comprehensive exploration of multivariate statistical analysis techniques, covering topics such as multivariate normal distribution, principal component analysis, canonical correlation analysis, factor analysis, cluster analysis, MANOVA, and multidimensional scaling. Students will learn theoretical concepts and practical applications of these techniques using statistical software.

COURSE OBJECTIVES:

- Understand the fundamentals of multivariate data analysis and the notion of multivariate distributions.
- Demonstrate proficiency in analyzing multivariate data using the multivariate normal distribution, including understanding marginal and conditional distributions.
- Master the concept of characteristic functions and their application in multivariate data analysis.
- Develop skills in estimating the mean vector and covariance matrix of multivariate datasets.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Demonstrate a comprehensive understanding of various multivariate data analysis techniques.
CO2	Develop proficiency in dimensionality reduction techniques such as Principal Components Analysis (PCA) and Factor Analysis.
CO3	Acquire advanced multivariate analysis skills, including conducting comparisons of several multivariate population means using one-way MANOVA, simultaneous confidence interval construction for treatment effects.
CO4	Master the analysis of multivariate relationships using techniques such as Canonical Correlation Analysis (CCA), cluster analysis, and distance methods.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔		✔	✔
CO3	✔	✔	✔	✔	✔

CO4	✔	✔	✔		✔

COURSE CONTENTS

UNIT 1

.**Principal Component and Canonical Correlation:** Principal components Analysis: - population principal components, summarizing sample variation by principal components, graphing the principal components; Canonical correlation analysis: - canonical variates and canonical correlations, interpreting the population canonical variables, the sample canonical variates and sample canonical correlations. (**25 Hours**)

UNIT 2

Factor and Cluster Analysis: Factor analysis: - orthogonal factor model; methods of estimation, factor rotation, factor scores; Cluster analysis: - similarity measures, hierarchical clustering methods, non-hierarchical clustering methods. (**20 Hours**)

UNIT 3

MANOVA and Multidimensional Scaling: Comparison of several multivariate population means (one-way MANOVA), simultaneous confidence intervals for treatment effects, two-way multivariate analysis of variance; Distance methods: - multidimensional scaling, correspondence analysis. (**25 Hours**)

UNIT 4

Multivariate Linear regression models: Least Squares Estimation, Inferences Concerning the Regression Parameters, Estimating the Regression Function, Forecasting a New Observation, Model Checking and Other Aspects of Regression, Likelihood Ratio Tests for Regression Parameters, multivariate multiple regression, Other Multivariate Test Statistics, Predictions from Multivariate Multiple Regressions. (**15 Hours**)

UNIT 5 (Teacher specific module-Optional)

Multivariate Data Analysis in R: Introduction to R programming language for multivariate data analysis; Multivariate statistical techniques implementation in R: using packages like "mvtnorm" for multivariate normal distribution, "FactoMineR" for factor analysis and cluster analysis, "MASS" for MANOVA. Hands-on exercises and case studies: applying learned techniques to real-world datasets, interpreting results, and drawing conclusions. (**10 Hours**)

TEXT BOOKS

1. Johnson, R.A. and Wichern, D.W. (2007). ***Applied Multivariate Statistical Analysis***, PHI Learning Private Ltd, New Delhi, Sixth edition.
2. Rencher, A.C. (1995) . ***Methods of Multivariate Analysis***, John Wiley.

3. Dillon, W.R. and Goldstein, M (1984) . ***Multivariate Analysis***, John Wiley.

SUGGESTED READINGS

1. Anderson, T.W. (1984). ***An Introduction to Multivariate Statistical Analysis***, John Wiley.
2. Seber G.A.F. (1983) . ***Multivariate Observations***, Wiley.
3. Tabachnick, B.G. and Fidell, L.S. (2018) . ***Using Multivariate Statistics***, Sixth edition, Pearson India Education Services Pvt Ltd, India.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester IX

A28-DISCIPLINE SPECIFIC CORE COURSE

KU09DSCSTA505- ADVANCED DESIGN OF EXPERIMENTS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
9	CORE	500	KU09DSCSTA505	4	90

Learning Approach (Hours/ Week)	Marks Distribution	Duration of

Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	ESE (Hours)
4	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course provides a comprehensive overview of experimental design principles and statistical analysis techniques commonly used in research settings. Students will learn about linear models, analysis of variance (ANOVA), complete and incomplete block designs, factorial designs, and their applications in various experimental settings. Through theoretical concepts and practical examples, students will develop the skills necessary to design and analyze experiments effectively.

COURSE OBJECTIVES:

- Understand the fundamental principles of experimental design and analysis, including linear models, estimable functions, and best estimates.
- Apply appropriate statistical techniques to analyze experimental data, including ANOVA, non-parametric methods, and factorial designs.
- Demonstrate proficiency in planning and conducting experiments, including considerations for fixed, random, and mixed models.
- Interpret experimental results effectively and make informed conclusions based on statistical analysis, considering factors such as confounding and partial confounding in factorial designs.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Apply ANOVA for one-way and two-way classification, fixed effect models with equal and unequal number of observations per cell, Random and Mixed effect models.
CO2	Design and analyze incomplete block designs, understand the concepts of orthogonality, connectedness, and balance.
CO3	Identify the effects of different factors and their interactions and analyze factorial experiments.

CO4	Construct complete and partially confounded factorial designs and perform their analysis.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

UNIT 1

Linear Models: Linear model, estimable functions and best estimate, normal equations, distribution of sum of squares, estimate and error sum of squares, test of linear hypothesis, basic principles and planning of experiments. The fixed, random, and mixed models. The single and two-factor ANOVA. Non-parametric method in the analysis of variance, Kruskal-Wallis test. (**25 Hours**)

UNIT 2

Complete Block Designs: Complete Block Designs - Completely Randomized Design, Randomized Block Design, Latin Square Design, Greaco Latin Square Design, Analysis with Missing Values, ANCOVA. (**15 Hours**)

UNIT 3

Incomplete Block Designs: Incomplete Block Designs - BIBD, recovering of Intra Block Information in BIBD, construction of BIBD, PBIBD, Youden square, Lattice Design. (**20 Hours**)

UNIT 4

Factorial Designs: Factorial designs - basic definitions and principles, two-factor factorial design – general factorial design, 2^k factorial design - Confounding and Partial Confounding, 3^2 - factorial, asymmetric factorial, two-level fractional factorial, Split Plot Design. (**20 Hours**)

UNIT 5 (Teacher Specific Module-Optional)

Advanced Topics: Connectedness and orthogonality of designs, Response surface designs, response surface methodology, first and second order designs. Analysis of real world problems using statistical software. (**10 Hours**)

TEXT BOOKS

1. Das, M.N. and Giri, N.S. (2002):***Design and Analysis of Experiments*,** 2nd Edition, New Age International (P) Ltd., New Delhi.
2. Joshi, D.D. (1987):***Linear Estimation and Design of Experiments***. Wiley Eastern Ltd., New Delhi.
3. Montgomery, D.C. (2001): ***Design and Analysis of Experiments***. 5th Edition, John Wiley & Sons - New York.

SUGGESTED READINGS

1. Gupta, S.C. and Kapoor, V.K. (2010). ***Fundamentals of Applied Statistics*.** Sulthan Chand & Co, New Delhi.
2. Dean, A. and Voss, A. (1999): ***Design and Analysis of Experiments*.** Springer Verlag, New York.
3. Box, G.E.P. Hunter, W. (2005):***Statistics for Experimental Design***, Innovations and Discovery, Vol. II, Wiley.

TEACHING LEARNING STRATEGIES

● Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

●Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester IX

DISCIPLINE SPECIFIC CORE COURSE

KU09DSCSTA506:GENERALIZED LINEAR MODELS FOR BIOSTATISTICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
9	CORE	500	KU09DSCSTA506	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course delves into the theory and applications of generalized linear models (GLMs), focusing on various advanced topics such as logistic regression, Poisson regression, log-linear models, zero-inflated models, and survival analysis. Through lectures, discussions, and practical exercises, students will gain a comprehensive understanding of GLMs and their applications in analyzing complex data sets.

COURSE OBJECTIVES:

- Define and explain the key concepts of GLMs, including the exponential family of distributions, link functions, and model specification.
- Apply the method of maximum likelihood estimation and iteratively reweighted least squares (IRLS) algorithm to estimate GLM parameters.
- Explore specialized GLM models such as Poisson regression and log-linear models for count data analysis.
- Apply GLMs to analyze hierarchical and longitudinal data using techniques such as generalized estimating equations (GEE) and mixed effects models.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Demonstrate proficiency in applying advanced GLM techniques such as logistic regression, Poisson regression, and log-linear models to analyze complex datasets.
CO2	Utilize maximum likelihood estimation and iteratively reweighted least squares (IRLS) algorithm to estimate parameters in GLMs.
CO3	Apply GLMs to analyze count data using Poisson regression and handle excessive zeros using zero-inflated models.
CO4	Interpret GLM parameters and assess the significance of predictor variables in the context of the research question.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

UNIT 1

Introduction to Generalized Linear Models: Overview of generalized linear models (GLM s), exponential family of distributions, link functions and model specification, logistic regression, comparison with linear regression and logistic regression, interpretation of GLM parameters, nominal and ordinal regression. (**15 Hours**)

UNIT 2

Model Estimation and Inference: Method of maximum likelihood estimation, iteratively reweighted least squares (IRLS) algorithm, model diagnostics: residual analysis, goodness-of-fit tests, confidence intervals and hypothesis testing for model parameters, overdispersion and model assessment. **(25 Hours)**

UNIT 3

Poisson Regression and Log-linear Models: Count data, Poisson regression, Estimation and model diagnostics, Contingency tables, log-linear models, Inference for log-linear models, Numerical examples, zero-inflated Poisson models. (**20 Hours)**

UNIT 4

Advanced Topics in GLMs: Generalized estimating equations (GEE), zero-inflated and negative binomial models, hierarchical GLM s and mixed effects models, time-to-event data analysis using GLM s (survival analysis), model selection techniques: AIC, BIC. (**20 Hours)**

UNIT 5

Applications of GLM s in biomedical research, epidemiology, and social sciences, case studies and real-world examples, practical implementation of GLM s using statistical software (R or SAS or SPSS). (**10 Hours)**

TEXT BOOKS

1. Dobson, A. J., & Barnett, A. G. (2018).***An Introduction to Generalized Linear Models** (4th ed.)*. CRC Press.
2. McCullagh, P., & Nelder, J. A. (1989). ***Generalized Linear Models*** *(2nd ed.)*. Chapman and Hall/CRC.

SUGGESTED READINGS

1. Faraway, J. J. (2006). ***Extending the Linear Model with R: Generalized Linear, Mixed Effects and Nonparametric Regression Models.***Chapman and Hall/CRC.
2. Agresti, A. (2015). ***Foundations of Linear and Generalized Linear Models*****.** John Wiley & Sons.
3. Hardin, J. W., & Hilbe, J. M. (2013). ***Generalized Linear Models and Extensions (3rd ed.).*** Stata Press.

TEACHING LEARNING STRATEGIES

● Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

●Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	

Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester IX

A24-28-DISCIPLINE SPECIFIC CORE COURSE

KU09DSCSTA507 - ADVANCED TIME SERIES ANALYSIS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
9	CORE	500	KU09DSCSTA507	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course provides a comprehensive overview of time series analysis, focusing on the analysis and modeling of data collected over time. Students will learn fundamental concepts, methods, and techniques for exploring, modeling, and forecasting time series data, with a particular emphasis on applications in various fields such as finance, economics, and engineering.

COURSE OBJECTIVES:

- Gain a thorough understanding of fundamental concepts in time series analysis, including stochastic processes, auto-covariance, auto-correlation, and spectral density.
- Learn techniques for exploratory time series analysis, including identifying trends, seasonality, and smoothing methods such as exponential and moving average smoothing.

- Understand autoregressive models (AR), moving average models (MA), autoregressive moving average models (ARMA), and autoregressive integrated moving average models (ARIMA).
- Learn about non-linear time series models, including spectral analysis, periodogram, and correlogram analysis.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Understand exploratory time series analysis and its real data application.
CO2	Understand autoregressive models and their estimation methods.
CO3	Understand non-linear time series models and their estimation methods.
CO4	Apply statistical techniques to time series data and make predictions.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔		✔	✔	✔
CO2	✔	✔	✔		✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔		✔	✔

COURSE CONTENTS

UNIT 1

Time Series Basic Concepts: Motivation, Time series as a discrete parameter stochastic process, Auto-Covariance, Auto-Correlation, and spectral density and their properties. Exploratory time series analysis, Test for trend and seasonality, Exponential and moving average smoothing, Holt-Winters smoothing, forecasting based on smoothing, Adaptive smoothing. **(25 Hours)**

UNIT 2

Autoregressive Models: Detailed study of the stationary process: Autoregressive, Moving Average, Autoregressive Moving Average, and Autoregressive Integrated Moving Average Models. Choice of AR/MA orders. Seasonal ARIMA models. **(15 Hours)**

UNIT 3

Estimation of ARMA and ARIMA Models: Estimation of ARMA models: Yule-Walker estimation for AR Processes, Maximum likelihood and least square estimation for ARMA Processes, Discussion (without proof) of estimation of mean, Auto-covariance, and autocorrelation function under large samples theory, residual analysis and diagnostic checking. Forecasting using ARIMA models. **(25 Hours)**

UNIT 4

Non-Linear Time Series Models: Spectral analysis of weakly stationary processes. Periodogram and correlogram analysis. Introduction to financial time series, return series, special features of financial return series, volatility, volatility modeling, ARCH and GARCH models, properties and estimation. Introduction to stochastic volatility models, threshold autoregression. **(15 Hours)**

UNIT 5

Hands-on exercises using statistical software (e.g., R or Python) to implement advanced time series models. Analysis of real-world financial time series data using ARCH, GARCH, and stochastic volatility models. Interpretation of model outputs and forecast results. **(10 Hours)**

TEXT BOOKS

1. Box G.E.P and Jenkins G.M. (1970). ***Time Series Analysis, Forecasting, and Control***. Holden-Day.
2. Brockwell P.J. and Davis R.A. (1987). ***Time Series: Theory and Methods***, Springer Verlag.

SUGGESTED READINGS

1. Abraham B. and Ledolter J.C. (1983). ***Statistical Methods for Forecasting***, Wiley.
2. Anderson T.W. (1971). ***Statistical Analysis of Time Series***, Wiley.
3. Fuller W.A. (1978). ***Introduction to Statistical Time Series***, John Wiley.

TEACHING LEARNING STRATEGIES

● Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

●Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester X

DSE -DISCIPLINE SPECIFIC ELECTIVE COURSE

KU10DSESTA501: OPERATIONS RESEARCH

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
10	ELECTIVE	500	KU10DSESTA501	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	2	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course provides a comprehensive overview of operations research techniques and optimization methods, focusing on linear programming, duality, network analysis, integer programming, and game theory. Students will learn theoretical concepts and practical applications of these techniques in solving complex decision-making problems in various fields such as business, engineering, and management.

COURSE OBJECTIVES:

- Gain a deep understanding of linear programming problems (LPPs), including the algebraic formulation, graphical solution methods, and the concept of feasible, basic feasible, and optimum basic feasible solutions.
- Comprehend the duality concept in linear programming, including the formulation of dual problems, duality theorems, and the dual simplex method.
- Learn about network analysis, focusing on critical path analysis, the Critical Path Method (CPM), and Program Evaluation and Review Technique (PERT). The distinction between CPM and PERT will be emphasized.
- Learn the fundamentals of game theory, including pure and mixed strategies, and the conversion of two-person zero-sum games into linear programming problems.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Demonstrate proficiency in formulating linear programming problems (LPPs) and understanding their graphical solutions.
CO2	Understand the concept of duality in linear programming and apply duality theorems to formulate dual problems.
CO3	Apply cutting plane methods and the branch and bound technique to solve integer programming problems.
CO4	Analyze decision-making scenarios using game theory concepts, including pure and mixed strategies.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔		✔	✔	✔
CO3	✔	✔	✔		✔
CO4	✔	✔		✔	✔

COURSE

CONTENTS

UNIT 1

Algebra of linear programming problems: Introduction to linear programming problem (LPP), graphical solution, feasible, basic feasible, and optimum basic feasible solution to an LPP. Analytical results in general LPP, theoretical development of simplex method.
(**15 Hours**)

UNIT 2

Duality and Dual Simplex Method: Artificial variables, Big-M method, two-phase simplex method. Duality, duality theorems, dual simplex methods. Transportation problem, assignment problem. (**10 Hours**)

UNIT 3

Integer Programming and Network Analysis: Integer programming: Cutting plane methods, branch and bound technique. Network analysis, Critical path analysis, -CPM, PERT, distinction between CPM and PERT. (**15 Hours**)

UNIT 4

Game Theory: Game theory, pure and mixed strategies, conversion of two-person zero-sum game into a linear programming problem. Solution to game through algebraic, graphical, and linear programming methods. (**10 Hours**)

UNIT 5

Sensitivity Analysis and Parametric Programming: Interpretation of shadow prices and sensitivity ranges, Application of sensitivity analysis in decision-making and risk management. (**10 Hours**)

TEXT BOOKS

1. K.V. Mital and Mohan, C (1996). ***Optimization Methods in Operations Research and Systems Analysis, 3rd Edition,*** New Age International (Pvt.) Ltd.
2. Kanti Swamp, Gupta, P.K. and John, M.M. (1985): ***Operations Research***., Sultan Chand & Sons.

SUGGESTED READINGS

1. Hadley, G. (1964).***Linear Programming***, Oxford & IBH Publishing Co, New Delhi.
2. Taha. H.A. (1982): ***Operation Research***, An Instruction, Macmillan.

3. Hiller F.S. And Lieberman, G.J. (1995).***Introduction to Operations Research***, McGraw-Hill

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester X

DSE-DISCIPLINE SPECIFIC ELECTIVE COURSE

KU10DSESTA502:NON-PARAMETRIC INFERENCE

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
10	ELECTIVE	500	KU10DSESTA502	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	2	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course offers a comprehensive introduction to non-parametric statistical methods, focusing on inference techniques that do not rely on assumptions about the underlying probability distributions. Through theoretical discussions and practical applications, students will learn about the advantages, limitations, and various non-parametric tests used for data analysis.

COURSE OBJECTIVES:

- Gain a solid understanding of the principles underlying non-parametric inference, including the rationale behind using distribution-free tests and resampling methods.
- Learn and be able to apply one-sample non-parametric tests, including the Wilcoxon signed-rank test, sign test, runs test, chi-square test for goodness of fit, and tests for normality such as the Kolmogorov-Smirnov and Shapiro-Wilk tests.
- Proficiency in performing two-sample non-parametric tests, such as the Mann-Whitney U test (Wilcoxon rank-sum test), Mood's median test, Hodges-Lehmann estimator, Kruskal-Wallis test for multiple independent samples, and Friedman test for multiple related samples.
- Learn about non-parametric methods for assessing association and correlation between variables, including Spearman's rank correlation coefficient, Kendall's tau rank correlation coefficient, chi-square test and Fisher's exact test for contingency tables, and rank-based measures of association such as Somers' D.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Understanding fundamental principles of non-parametric inference, including the rationale for using distribution-free tests and resampling methods.
CO2	Demonstrate proficiency in applying one-sample non-parametric tests, including the Wilcoxon signed-rank test, sign test, runs test, chi-square test for goodness of fit, and tests for normality such as the Kolmogorov-Smirnov and Shapiro-Wilk tests.
CO3	Able to perform two-sample non-parametric tests, such as the Mann-Whitney U test (Wilcoxon rank-sum test), Mood's median test, Hodges-Lehmann estimator, Kruskal-Wallis test for multiple independent samples, and Friedman test for multiple related samples.
CO4	Apply non-parametric statistical methods to analyze real-world datasets, identifying appropriate tests based on the characteristics of the data and interpreting the results in the context of the research question or problem at hand.

MAPPING OF COs to PSO

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	
CO3	✔	✔	✔	✔	
CO4	✔	✔	✔	✔	

COURSE CONTENTS

UNIT 1

Introduction to Non-parametric Methods: overview of non-parametric inference, advantages and limitations compared to parametric methods, distribution-free tests and their applications, resampling methods, permutation tests and bootstrapping.

(**15 Hours**)

UNIT 2

One-Sample Non-parametric Tests: Wilcoxon signed-rank test, sign test, runs test, chi-square test for goodness of fit , Kolmogorov-Smirnov test, Shapiro-Wilk test for normality. **(15 Hours)**

UNIT 3

Two-Sample Non-parametric Tests: Mann-Whitney U test (Wilcoxon rank-sum test), Mood's median test, Hodges-Lehmann estimator, Kruskal-Wallis test for multiple independent samples, Friedman test for multiple related samples.

(**25 Hours**)

UNIT 4

Non-parametric Methods for Association and Correlation: Spearman's rank correlation coefficient, Kendall's tau rank correlation coefficient, non-parametric methods for contingency tables - chi-square test, Fisher's exact test, rank-based measures of association - Somers' D.

(25 Hours)

UNIT 5

Application of Non-parametric Methods in Real-world Data Analysis: Data preparation and exploration, one-sample non-parametric tests in practice, two-sample non-parametric tests and beyond. **(25 Hours)**

TEXT BOOKS

1. Daniel, W. W. (2010).***Applied Nonparametric Statistics*** *(3rd ed.)*. Cengage Learning.
2. Gibbons, J. D., & Chakraborti, S. (2010). ***Nonparametric Statistical Inference*** *(5th ed.)*. CRC Press.

SUGGESTED READINGS

1. Hollander, M., & Wolfe, D. A. (1999). ***Nonparametric Statistical Methods*** *(2nd ed.)*. Wiley.
2. Conover, W. J. (1999). ***Practical Nonparametric Statistics*** *(3rd ed.)*. Wiley.
3. Siegel, S., & Castellan Jr, N. J. (1988). ***Nonparametric Statistics for the Behavioral Sciences*** *(2nd ed.)*. McGraw-Hill.
4. Hollander, M., & Wolfe, D. A. (1973). ***Nonparametric Statistical Methods***. Wiley.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester X

DSE-DISCIPLINE SPECIFIC ELECTIVE COURSE

KU10DSESTA503:ANALYSIS OF FINANCIAL TIME SERIES

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
10	ELECTIVE	500	KU10DSESTA503	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	2	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course provides a comprehensive exploration of financial time series analysis, covering various models and techniques used in the analysis of asset returns, volatility modeling, high-frequency data analysis, and risk estimation. Through theoretical lectures, practical exercises, and hands-on applications using financial data, students will develop the skills necessary to analyze and model financial time series data effectively, making informed decisions in financial markets.

COURSE OBJECTIVES:

- Understanding Financial Time Series: Develop a comprehensive understanding of financial time series data, including the characteristics of asset returns, distributional properties, and the basic concepts of linear time series analysis, enabling students to effectively analyze and interpret financial data.
- Proficiency in Volatility Modeling: Gain proficiency in modeling volatility in financial time series using conditional heteroscedastic models, including ARCH, GARCH, and stochastic volatility models, enabling students to accurately capture and forecast volatility dynamics in financial markets.
- Mastery of High-Frequency Data Analysis: Acquire mastery in analyzing high-frequency financial data, including nonsynchronous trading, bid-ask spread, and empirical characteristics of transactions data. Students will learn various models for price changes and duration models to effectively analyze high-frequency data.
- Proficiency in Risk Estimation: Develop proficiency in estimating extreme values and calculating Value at Risk (VaR), an essential risk measure in finance. Students will learn RiskMetrics, quantile estimation, quantile regression, extreme value theory, and multiperiod VaR, enabling them to assess and manage financial risk effectively.
- Application of Multivariate Time Series Analysis: For students who opt for the optional module, gain proficiency in multivariate time series analysis techniques such as vector autoregressive (VAR) models, impulse response functions, and vector moving-average (VMA) models, enabling students to analyze interdependencies among multiple financial variables effectively.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Demonstrate an advanced understanding of financial time series data, including its characteristics, distributional properties, and the application of linear time series analysis techniques, enabling them to analyze and interpret financial data effectively.
CO2	Acquire proficiency in modeling volatility in financial time series using conditional heteroscedastic models such as ARCH, GARCH, and stochastic volatility models. They will be able to accurately model and forecast volatility dynamics, enhancing their ability to make informed decisions in financial markets.
CO3	Master the analysis of high-frequency financial data, including nonsynchronous trading, bid-ask spread, and duration models, students will be equipped to effectively analyze and interpret high-frequency data and identify trading opportunities in financial markets.

CO4	Develop proficiency in estimating extreme values and calculating Value at Risk (VaR), an essential risk measure in finance. They will be able to assess and manage financial risk effectively, enhancing their ability to make informed risk management decisions in financial markets.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔		✔	✔	✔
CO2	✔	✔	✔	✔	
CO3	✔	✔		✔	✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

Unit- 1

Financial Time Series and Their Characteristics: Asset Returns, Distributional Properties of Returns, overview of Linear Time Series Analysis and Its Applications, Stationarity, Correlation and Autocorrelation Function, White Noise and Linear Time Series, Simple Autoregressive Models, Simple Moving-Average Models, Simple ARMA Models, Seasonal Models. **(20 Hours)**

Unit- 2

Conditional Heteroscedastic Models: Definition of volatility, Characteristics of Volatility, Structure of a Model, Testing for ARCH Effect, The ARCH Model, Properties of ARCH Models, Weaknesses of ARCH Models, Building an ARCH Model, The GARCH Model, The Integrated GARCH Model, The GARCH-M Model, The Exponential GARCH Model, The Stochastic Volatility Model. **(25 hours)**

Unit-3

High-Frequency Data Analysis: Nonsynchronous Trading, Bid–Ask Spread, Empirical Characteristics of Transactions Data, Models for Price Change-Ordered Probit Model, Duration Models, The ACD Mode, Simulation, Estimation, Nonlinear Duration Models. **(20 Hours)**

Unit -4

Extreme Values, Quantile Estimation, and Value at Risk: Value at Risk, RiskMetrics, An Econometric Approach to VaR Calculation, Quantile and Order Statistics, Quantile Regression, Extreme Value Theory, Extreme Value Approach to VaR, Multiperiod VaR, VaR for a Short Position, Use of Explanatory Variables, Model Checking. **(20Hours)**

Unit-5 (Teacher Specific module-Optional)

Multivariate Time Series Analysis and Its Applications: Weak Stationarity and Cross-Correlation Matrices, Sample Cross-Correlation Matrices, Multivariate Portmanteau Tests, Vector Autoregressive Models, Impulse Response Function, Vector Moving-Average Model, Vector ARMA Models. **(20 Hours)**

TEXT BOOKS

1. Tsay, R. S. (2005). ***Analysis of Financial Time Series.*** John wiley & sons..
2. Tsay, R. S. (2014). ***An Introduction to Analysis of Financial Data with R***. John Wiley & Sons.

SUGGESTED READINGS

1. Tsay, R. S. (2013). ***Multivariate Time Series Analysis: with R and Financial Applications.*** John Wiley & Sons.
2. Tsay, R. S., & Chen, R. (2018). ***Nonlinear Time Series Analysis*** . John Wiley & Sons..

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester X

DSE-DISCIPLINE SPECIFIC ELECTIVE COURSE

KU10DSESTA504 - CATEGORICAL DATA ANALYSIS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
10	ELECTIVE	500	KU10DSESTA504	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	2	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course provides a comprehensive exploration of advanced statistical models for analyzing longitudinal and categorical data. Students will learn theoretical concepts and practical applications of generalized linear models, logistic regression, log-linear models, and mixed-effects models. Through lectures, discussions, and hands-on exercises, students will develop the skills necessary to analyze complex data sets, make inferences, and interpret results effectively.

COURSE OBJECTIVES:

- Conduct analysis of longitudinal data.
- Apply statistical techniques to model longitudinal data and make predictions.
- Understand analysis of longitudinal data with missing data.
- Understand analysis of longitudinal data with time-dependent covariates

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Define categorical data and identify appropriate measures for analysis.
CO2	Utilize logistic regression and logit models to analyze categorical predictors.

CO3	Understand and apply general linear mixed-effects models for longitudinal data analysis, including inference for random effects.
CO4	Understand and address issues related to missing data mechanisms and dropout processes in longitudinal studies.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

UNIT 1

Categorical Data Analysis and Generalized Linear Models: Categorical data and their measures, Inference for contingency tables, Generalized linear models for binary and count data. Estimation, Inference and fitting of model. (**15 Hours**)

UNIT 2

Logistic Regression with Categorical Predictors: Logistic, logit and log linear models with categorical predictors, Logit models with multi responses- Nominal and ordinal responses. (**15 Hours**)

UNIT 3

Longitudinal Data Analysis and General Linear Mixed Models: Longitudinal data and their characteristics, The general linear model for longitudinal data-ML and REML estimation, EM algorithm, General linear mixed effect model. Inference for the random effects. BLUPs, Empirical bayes, Shrinkage model building and diagnostics, Generalised additive mixed model. (**25 Hours**)

UNIT 4

Advanced Models for Longitudinal Data Analysis: Generalized linear model for longitudinal data, Random effect model, Transition models, Poisson and logistic regression models, Analysis and test. Classification of missing data mechanism-intermittent missing values and dropouts, weighted estimating equations, Modelling the drop out process. (**25 Hours**)

UNIT 5

Practical Application: Hands-on exercises using statistical software R, Analyzing real-world datasets, Model estimation, interpretation, and diagnostics. (**10 Hours**)

TEXT BOOKS

1. Agresti, A. (2012). ***Categorical Data Analysis*** (Vol. 792). John Wiley & Sons.
2. Diggle, P.J, Heagerty, P., Liang, K.,Y & Zeger,S.,I (2003), ***Analysis of Longitudinal Data***, Oxford university press.
3. Lindsey, J.,K.(1993)**. *Models for Repeated Measurements***, Oxford

SUGGESTED READINGS

1. Weiss, R., E.(2005), ***Modeling Longitudinal Data***, Springer, New York.
2. Little, R. J. A. & Rubin, D., B(2002), ***Statistical Analysis with Missing Data***, Wiley.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester X

DSE-DISCIPLINE SPECIFIC ELECTIVE COURSE

KU10DSESTA505 - MIXTURE REGRESSION MODELS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
10	ELECTIVE	500	KU10DSESTA505	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	2	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course provides an in-depth exploration of mixture distributions and models in statistics. Students will learn theoretical concepts, simulation techniques, estimation methods, and practical applications of finite and infinite mixture models. Through lectures, hands-on exercises, and real-world examples, students will gain proficiency in analyzing complex data sets using mixture models and related statistical methodologies.

COURSE OBJECTIVES:

- Learn simulation techniques for generating random samples from finite normal, Poisson, and negative binomial mixtures.
- Study normal mixture regression and Poisson mixture regression models.
- Apply mixture regression models to real and simulated data using statistical software packages such as R and relevant libraries like FlexMix, Mixtools, and CAMAN.
- Explore examples of generalized linear mixture models, including logistic and mixture logistic models.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Identify the characteristics and properties of location and scale mixtures.
CO2	Simulate random samples from finite normal, Poisson, and negative binomial mixtures.
CO3	Estimate parameters of mixture regression models using appropriate techniques.

CO4	Apply generalized linear mixture models, including logistic and mixture logistic models.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

UNIT 1

Mixture Distributions: Finite and infinite mixtures, location and scale mixtures, non-identifiable mixtures, examples of non-identifiable mixtures, condition for identifiability when the components belong to power series family.
(**20 Hours**)

UNIT 2

Simulation and Estimation: Finite normal, Poisson and negative binomial mixtures, simulation of random samples from mixtures, applications of mixture models. Estimation of parameters of mixture models, method of moments, maximum likelihood estimation, EM algorithm. (**25 Hours**)

UNIT 3

Mixture Regression: Normal mixture regression, Poisson mixture regression, estimation of parameters, examples using real and simulated data, R-packages, FlexMix, Mixtools, and CAMAN.
(**20 Hours**)

UNIT 4

Generalized Linear Mixture Models: Exponential family, generalized linear models, examples, generalized linear mixture models, logistic and mixture logistic models, concomitant variables and varying parameter cases.
(**15 Hours**)

UNIT 5

Bayesian Estimation for Mixture Models: Introduction to Bayesian mixture models, prior specification for mixture model parameters, Markov Chain Monte Carlo (MCMC) methods for Bayesian inference. (**10 Hours**)

TEXT BOOKS

1. McLachlan, G.J. and Peel, D. (2000). **Finite Mixture Models**. John Wiley & Sons, INC, New York.

SUGGESTED READINGS

1. Schlattmann, P. (2009). **Medical Applications of Finite Mixture Models.** Springer Verlag Berlin Heidelberg.
2. Titterington, D.M., Smith, A. and Makov, U. (1985). **Statistical Analysis of Finite Mixture Distributions**. New York: Wiley.
3. Leisch, F. (2004). **Flex Mix: A general framework for finite mixture models and latent class regression in R.** Journal of Statistical Software, 11(8), 1-18. http://www.jstatsoft.org/
4. Wang, P. et al. (1996). **Mixed Poisson regression models with covariate dependent rates**. Biometrics, 52, 381-400.
5. Sapatinas, T. (1995). **Identifiability of mixtures of power-series distributions and related characterizations**. Ann. Inst. Statist. Math., 47(3), 447-459.
6. McLachlan, G.J. and Krishnan, T. (1997). **The EM algorithm and Extensions.** New York: Wiley.

TEACHING LEARNING STRATEGIES

● Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

●Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester X

DSE-DISCIPLINE SPECIFIC ELECTIVE COURSE

KU10DSESTA506-ANALYSIS OF DISCRETE AND LONGITUDINAL DATA

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
10	ELECTIVE	500	KU10DSESTA506	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	2	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course delves into advanced statistical methodologies for analyzing longitudinal data, focusing on discrete outcomes, generalized linear models, missing data mechanisms, time-dependent covariates, and special topics in longitudinal data analysis. Through theoretical concepts, practical applications, and case studies, students will develop proficiency in modeling longitudinal data and addressing complex research questions in various fields.

COURSE OBJECTIVES:

- Gain a comprehensive understanding of advanced statistical techniques for analyzing longitudinal data, including generalized linear models, random effects models, transition models, and likelihood-based models for categorical data.
- Learn to classify missing data mechanisms, address intermittent missing values and dropouts, and implement weighted estimating equations and modeling techniques for the dropout process.
- Recognize the challenges associated with time-dependent covariates, implement lagged covariates, and apply marginal structural models to account for time-varying confounding factors.
- Gain insight into specialized topics such as joint models for longitudinal and survival data, multivariate longitudinal data analysis, and the design of randomized and observational longitudinal studies.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Conduct analysis of longitudinal data.
CO2	Apply statistical techniques to model longitudinal data and make predictions.
CO3	Understand analysis of longitudinal data with missing data.
CO4	Understand analysis of longitudinal data with time-dependent covariates.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔	✔	
CO4	✔		✔	✔	✔

COURSE CONTENTS

UNIT 1

Discrete Data and their Measures: Inference for contingency tables, Logistic models, statistical power and sample size computations Logit models with categorical predictors, logit models with multi responses-nominal and ordinal responses.

UNIT 2

Generalized Linear Model for Longitudinal Data: Generalized Linear Model for Longitudinal Data, Marginal models, for binary, ordinal, and count data: Random effects models for binary and count data: Transition models: Likelihood-based models for categorical data; GEE; Models for mixed discrete and continuous responses.

UNIT 3

Longitudinal Data with Missing Data: Classification missing data mechanism; Intermittent missing values and dropouts; Weighted estimating equations; Modeling the dropout process (Selection and pattern mixture models).

UNIT 4

Time-dependent Covariates and Special Topics: Dangers of time-dependent covariates, Lagged covariates; Marginal Structural models; Joint models for longitudinal and survival data; Multivariate longitudinal data; Design of randomized and observational longitudinal studies.

UNIT 5

Exploratory Data Analysis, Modeling Approaches: Students will apply various modeling approaches discussed in earlier units, such as Generalized Linear Models (GLMs), Generalized Estimating Equations (GEE), and Marginal Structural Models (MSMs), to analyze longitudinal data using statistical software.

TEXT BOOKS

1. Diggle, P.J., Heagerty, P., Liang, K.Y and Zeger. S.L (2003). ***Analysis of Longitudinal Data***, 2nd Edn. Oxford University Press, New York.
2. Fitzmaurice, G.M., Laird, N.M and Ware, J.H. (2004). ***Applied Longitudinal Analysis***, John Wiley & Sons, New York.

SUGGESTED READINGS

1. Crowder, M.J. and Hand, D.J. (1990). ***Analysis of Repeated Measures*.** Chapman and Hall/CRC Press, London.
2. Davidian, M. and Giltinan, D.M. (1995). ***Nonlinear Models for Repeated Measurement Data***. Chapman and Hall/CRC Press, London.
3. Hand, D. and Crowder, M. (1996). ***Practical Longitudinal Data Analysis*.** Chapman and Hall/CRC Press, New York.
4. McCullagh, P. and Nelder. J. A. (1989).***Generalized Linear Models. 2nd Edition***, Chapman and Hall/CRC Press, London.

TEACHING LEARNING STRATEGIES

● Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

●Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester X

DSE-DISCIPLINE SPECIFIC ELECTIVE COURSE

KU10DSESTA507-ADVANCED QUEUEING THEORY

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
10	ELECTIVE	500	KU10DSESTA507	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	2	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course provides a comprehensive exploration of queueing theory and its practical applications in various systems. Divided into four units, the course covers a range of topics from introductory concepts to advanced models, equipping students with the knowledge and skills to analyze and optimize queueing systems effectively. Through lectures, practical exercises, and case studies, students will gain a deep understanding of queueing theory and develop the analytical skills necessary to address complex queueing problems in various domains, including telecommunications, computer systems, manufacturing, and service industries.

COURSE OBJECTIVES:

- Understanding Queueing Theory Fundamentals: Gain a comprehensive understanding of the fundamental concepts and terminology of queueing theory, including arrival processes, service patterns, queueing disciplines, and system performance metrics.
- Mastering Markovian Queueing Models: Develop proficiency in analyzing Markovian queueing models, including the M/M/1 model, and deriving steady-state solutions.
- Exploring Advanced Queueing Models: Explore advanced Markovian queueing models, including transient behavior analysis, busy period analysis for M/M/1 and M/M/c models, and Erlangian models.
- Analyzing Queueing Networks: Learn how to analyze various types of queueing networks, such as series queues, open and closed Jackson networks, cyclic queues, and extensions of Jackson networks.
- Mastering Non-Markovian Queueing Models: Develop proficiency in analyzing non-Markovian queueing models, including models with general service patterns, M/G/1 queueing models, and the Pollaczek-Khintchine formula.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Develop a comprehensive understanding of the fundamental principles, concepts, and terminology of queueing theory, including arrival processes, service patterns, queueing disciplines, and system performance metrics.
CO2	Gain proficiency in analyzing both Markovian and non-Markovian queueing models, including steady-state solutions, waiting-time distributions, and system performance metrics..
CO3	Learn how to analyze various types of queueing networks, including series queues, Jackson networks, cyclic queues, and non-Jackson networks.
CO4	Apply queueing theory concepts and techniques to analyze and optimize real-world systems in various domains, including telecommunications, computer systems, manufacturing, and service industries.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	✔

CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

Unit 1

Markovian Queueing Models: Introduction to queueing theory, Characteristics of queueing processes, Measures of effectiveness, Markovian queueing models, steady-state solutions of the M/M/1 model, waiting-time distributions, Little's formula, queues with unlimited service, finite source queues. **(15 Hours)**

Unit 2

Advanced Markovian Models: Transient behavior of M/M/1 queues, transient behavior of M/M/1. Busy period analysis for M/M/1 and M/M/c models. Advanced Markovian models. Bulk input M[X]/M/1 model, Bulk service M/M[Y]/1 model, Erlangian models, M/Ek/1 and Ek/M/1. A brief discussion of priority queues. **(25 Hours)**

Unit 3

Queueing Networks: Series queues, open Jackson networks, closed Jackson network, Cyclic queues, Extension of Jackson networks. Non-Jackson networks. **(15 Hours)**

Unit 4

Non-Markovian Queueing Models: Models with general service pattern, The M/G/1 queueing model, The Pollaczek-Khintchine formula, Departure point steady state system size probabilities, ergodic theory, Special cases M/Ek/1 and M/D/1, waiting times, busy period analysis, general input and exponential service models, arrival point steady state system size probabilities. **(25 Hours)**

Unit 5 (Teacher Specific Module-Optional)

Advanced queuing models, Bayesian estimation in queueing models. **(10 Hours)**

Books for Study:

1. Gross, D. and Harris, C.M. (1985): ***Fundamentals of Queueing Theory***, 2nd Edition, John Wiley and Sons, New York.

Reference Books:

1. Ross, S.M. (2010). ***Introduction to Probability Models***. 10th Edition, Academic Press, New York.
2. Bose, S.K. (2002). ***An Introduction to Queueing Systems***, Kluwer Academic/Plenum Publishers, New York.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester X

DSE-DISCIPLINE SPECIFIC ELECTIVE COURSE

KU10DSESTA508:HEALTH ECONOMICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
10	ELECTIVE	500	KU10DSESTA508	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	2	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course offers an in-depth exploration of the intersection between economics and healthcare, focusing on the principles, policies, and practices that shape the delivery, financing, and regulation of healthcare systems. Through theoretical frameworks, empirical analysis, and case studies, students will gain a comprehensive understanding of health economics and its implications for healthcare markets, financing, delivery, and policy.

COURSE OBJECTIVES:

- Define health economics and its scope within the broader field of economics.
- Examine the structure of healthcare markets, including public, private, and mixed systems.
- Understand healthcare production and efficiency, including production functions, economies of scale, and scope.
- Conduct health policy analysis, including defining policy objectives, evaluating policy tools, and criteria for policy evaluation.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Apply key economic concepts such as scarcity, opportunity cost, efficiency, and equity to healthcare contexts.
CO2	Analyze various health insurance and financing mechanisms, including fee-for-service, capitation, and social health insurance.
CO3	Analyze provider behavior and its impact on healthcare delivery, including physician incentives and moral hazard.
CO4	Conduct health policy analysis, including defining policy objectives, evaluating policy tools, and criteria for policy evaluation.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

UNIT 1

Introduction to Health Economics: Overview of health economics: Definition, scope, and importance, Basic economic concepts in healthcare: Scarcity, opportunity cost, efficiency, and equity. Theoretical frameworks: Supply and demand, market failure, and role of government intervention. Economic evaluation methods: Cost-benefit analysis, cost-effectiveness analysis, and cost-utility analysis.

(**15 Hours**)

UNIT 2

Healthcare Markets and Financing: Structure of healthcare markets: Public, private, and mixed systems. Health insurance and financing mechanisms: Fee-for-service, capitation, health savings accounts, and social health insurance. Equity and access: Healthcare disparities, barriers to access, and policies for addressing inequality. Pharmaceutical economics: Drug pricing, reimbursement mechanisms, and pharmaceutical regulation. (**15 Hours**)

UNIT 3

Healthcare Delivery and Organization: Healthcare production and efficiency: Production functions, economies of scale, and scope. Provider behavior: Physician incentives, supplier-induced demand, and moral hazard. Hospital economics: Cost structure, payment systems, and competition among providers. Quality and performance measurement: Value-based purchasing, pay-for-performance, and quality improvement initiatives. (**15 Hours**)

UNIT 4

Health Policy and Regulation: Health policy analysis: Policy objectives, tools, and evaluation criteria. Regulation and market interventions: Certificate of need, price controls, and antitrust policies. Health technology assessment: Assessment of new medical technologies and devices. Global health economics: Comparative healthcare systems, health disparities, and international health policy. (**10 Hours**)

UNIT 5

Health sector reforms- International and Indian experiences regulation of health sector including pharmaceutical industry access to health care with quality health care utilization. (**5 Hours**)

TEXT BOOKS

1. Banerjee D. (1982) ***Poverty class and Health Culture in India Vol. 1*** *ParchiPrakashan* New Delhi.
2. Indian Council of Social Science Research and Indian Council of Medical Research (1981) *Health for All by 2000 A. D.* ICSSR Delhi.

SUGGESTED READINGS

1. Madan T.N. (1969). ***Who Chooses Modern Medicine and Why" Economic and Political*** *Weekly pp*. 1475-84.
2. Feldstein M.S. (1977). ***Economic analysis of Health Service Efficiency*** *North-Holland Amsterdam.*
3. Cutler and Zeckhauser (1999). ***The Anatomy of Health Insurance NBER Working Paper*** 7176.
4. Levy and Deleire (2002). ***What do People Buy When They Don't Buy Health Insurance.*** *Working Paper* Harris School University of Chicago.

TEACHING LEARNING STRATEGIES

● Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

●Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

Semester X

DSE-DISCIPLINE SPECIFIC ELECTIVE COURSE

KU10DSESTA509- LIFE CONTINGENCIES

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
10	ELECTIVE	500	KU10DSESTA509	4	90

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
4	2	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION

This course provides a comprehensive examination of mortality analysis, population dynamics, insurance contracts, and risk assessment techniques within the context of actuarial science. Students will explore various models, theories, and methods used in the insurance industry to assess risk, calculate premiums, and ensure financial stability. Through theoretical discussions, practical applications, and case studies, students will gain a deep understanding of actuarial principles and their applications in insurance and pension schemes.

COURSE OBJECTIVES:

- Understanding Mortality Analysis and Models.
- Mastery of Assurance and Annuity Contracts.
- Proficiency in Modeling Cash Flows and Risks.
- Analysis of Heterogeneity in Mortality and Risk Classification.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Analyze mortality data and apply appropriate models for mortality analysis.

CO2	Adjust net premiums and provisions for changing benefits and annuities.
CO3	Identify contributing factors to heterogeneity in mortality and its implications for risk assessment.
CO4	Analyze the financial implications of guarantees on the stability and profitability of insurance products.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS

UNIT 1

Mortality analysis and models: Population growth, composition and distribution, Projection models, Stable population theory, Life tables and its relation with survival function, force of mortality, various conditional probabilities from ultimate and select life tables, monthly payments, inter-relations of various types of payments. Calculation of various probabilities from life tables, approximations, select and ultimate tables, alternatives to life tables.Calculation of various payments from life tables: principle of equivalence, net premiums, prospective and retrospective provisions/reserves, recursive relations, Thiele's equation, actual and expected death strain, mortality profit/loss. **(15 Hours)**

UNIT 2

Assurance and annuity contracts: definitions of benefits and premiums, various types of assurances and annuities, present value, formulae for mean and variance of various continuous and discrete payments,Adjustment of net premium/net premium provisions for increasing/decreasing benefits and annuities, calculations with ultimate or select mortality, with-profits contract and allied bonus, net premium provision. Gross premiums-Various expenses, role of inflation, future loss and equivalence principle, alternative principles, calculation of gross premium provisions, gross premium retrospective provisions, recursive relations. (**10 Hours**)

UNIT 3

Functions of two lives: cash-flows contingent on death/survival of either or both of two lives, functions dependent on a fixed term and on age. Cash-flow models for competing risksMarkov model, dependent probability calculations from Kolmogorov equations, transition intensities. Use of discounted emerging costs in pricing, reserving and assessing profitability: unit-linked contract, expected cash flows for various assurances and annuities, profit tests and profit vector, profit signature, net present value and profit margin, use of profit test in product pricing and determining provisions, multiple decrement tables, cash-flows contingent on multiple decrement, alternatives to multiple decrement tables, cash-flows contingent on nonhuman life risks.

(**15 Hours**)

UNIT 4

Heterogeneity in mortality: contributing factors, main forms of selection, selection in insurance contracts and pension schemes, selective effects of decrements, risk classification in 25 insurance, role of genetic information, single figure index, crude index, direct/indirect standardization, standardized mortality/morbidity ratio (SMR). Cost of guarantees: types of guarantees and options for long term insurance contracts, calculation through option-pricing and stochastic simulation.

(**10 Hours**)

UNIT 5

Introduction to Actuarial Modeling: Importance of risk assessment and management in insurance and pension industries.Role of actuaries in analyzing mortality, longevity, and financial risks.

(**10 Hours**)

TEXT BOOKS

1. P.M. Booth, R.G. Chadburn, D.R. Cooper, S. Haberman and D.E. James, (1999):***Modern Actuarial Theory and Practice***, Chapman & Hall.
2. N.L. Bowers, H.U. Gerber, J.C. Hickman, D.A. Jones, and C.J. Nesbitt (1997): ***Actuarial Mathematics*** (2nd ed), Society of Actuaries.

SUGGESTED READINGS

1. B. Benjamin and J.H. Pollard 1993.***The Analysis of Mortality and Other Actuarial Statistics***, 3rd ed., Institute of Actuaries and Faculty of Actuaries.
2. Neill, Heinemann, (1977):***Life Contingencies.***

TEACHING LEARNING STRATEGIES

● Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

●Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

SKILL ENHANCEMENT COURSES (SEC)

Semester IV

DSE-SKILL ENHANCEMENT COURSE
KU04SECSTA201- DATA ANALYSIS USING EXCEL

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
4	SEC	200	KU04SECSTA201	3	60

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	2	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:
This course is designed to provide students with a comprehensive understanding of Microsoft Excel and its applications in data analysis. Divided into four modules, the course covers essential Excel functionalities, mathematical and statistical functions, data visualization techniques, and advanced data analysis tools. Through a combination of lectures, hands-on exercises, and practical examples, students will gain proficiency in using Excel for data analysis and visualization. By the end of the course, students will be equipped with the skills and knowledge needed to effectively analyze and interpret data using Excel software.

COURSE OBJECTIVES:

- Mastering Excel Fundamentals: Develop a solid understanding of Excel basics, including navigating the interface, working with cells and ranges, and utilizing basic mathematical and statistical functions.
- Advanced Functionality Proficiency: Learn advanced Excel functions such as MIN, MAX, TRIM, LOWER, UPPER, PROPER, LEFT, RIGHT, MID, EXACT, RANDBETWEEN, RAND, LEN, SQRT, and IF function.
- Data Visualization Mastery: Acquire skills in creating a wide range of visualizations in Excel, including pie charts, bar charts, histograms, scatter plots, and box plots.

- Advanced Data Analysis Techniques:Learn advanced data analysis techniques such as calculating median, mode, standard deviation, and correlation coefficients in Excel.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Demonstrate proficiency in navigating the Excel interface, organizing data effectively, and utilizing a wide range of Excel functions and features for data manipulation and analysis..
CO2	Develop advanced data analysis skills, including the ability to perform complex calculations, analyze statistical measures, and interpret data trends using Excel's built-in functions and tools.
CO3	Acquire proficiency in creating various types of charts and graphs in Excel to visually represent and communicate data insights effectively.
CO4	Leverage Excel as a tool for informed decision-making by analyzing data, identifying patterns and trends, and deriving actionable insights to support organizational or personal goals.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔		✔
CO2	✔	✔	✔	✔	
CO3	✔	✔	✔	✔	✔
CO4	✔	✔	✔	✔	

COURSE CONTENTS:

Module 1:

Excel Introduction, Basic Navigation Tab, Concept of Cell and Cell address , row Column concept, Basic mathematical and statistical functions in Excel. (15 Hours)

Module 2:

Min, Max, Trim, Lower, Upper, Proper, Left, Right, Mid Exact, Randbetween, Rand, Len (Length of character) Paste special, SQRT, If function with Example of IF, More function like And, OR with their example, Conditional Formatting basic and advance level with OR, AND, Nested IF function, Index, Offset, Match. (15 Hours)

Module 3:

Graphics in excel-pie chart, bar chart, multiple bar diagram, sub-divided bar diagram, histogram, line chart, scatter diagram, box plot. (15 Hours)

Module 4:

Median, Mode, Standard Deviation (SD), Correlation, Large, Small, Pivot Table, Pivot Charts, Slicing, Sparkling. (15 Hours)

Suggested Readings:

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

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

DSE-SKILL ENHANCEMENT COURSE

KU04SECSTA202- DATA ANALYSIS USING SPSS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
4	SEC	200	KU04SECSTA202	3	60

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	2	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:
This course provides an in-depth exploration of data analysis techniques using SPSS (Statistical Package for the Social Sciences). Divided into four modules, the course covers fundamental to advanced concepts of data analysis, including descriptive statistics, regression analysis, hypothesis testing, and data visualization. Through a combination of lectures, hands-on exercises, and practical examples, students will develop proficiency in utilizing SPSS for data analysis and interpretation.

COURSE OBJECTIVES:

- Understanding SPSS Basics: Introduce students to SPSS software, including its interface, functionalities, and data input methods.
- Descriptive Statistics: Teach students how to explore and summarize data using descriptive statistics in SPSS.
- Regression Analysis: Familiarize students with regression analysis techniques, including simple and multiple linear regression, and their application in SPSS.
- Hypothesis Testing: Enable students to perform hypothesis tests and interpret results using SPSS.
- Data Visualization: Develop skills in creating visualizations to effectively communicate data insights using SPSS.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Navigate the SPSS interface, input data, and perform basic operations for data analysis.
CO2	Conduct descriptive statistics analysis to summarize and interpret data distributions in SPSS.
CO3	Perform regression analysis in SPSS, interpret output, and assess model fit.
CO4	Conduct hypothesis tests using SPSS and interpret results effectively.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	

CO2	✔	✔	✔	✔	✔
CO3	✔		✔	✔	✔
CO4	✔	✔	✔	✔	

COURSE CONTENTS:

Module 1

Overview of SPSS software, Opening SPSS, Layout of SPSS,Structure of SPSS Exiting SPSS, inputting data, An overview of SPSS. **(15 Hours)**

Module 2

Exploring data distributions using descriptive statistics, Creating frequency distributions and summary tables, Generating basic visualizations (e.g., histograms, box plots) in SPSS. **(15 Hours)**

Module 3

Understanding correlation and covariance, Performing correlation analysis in SPSS, Introduction to linear regression and its application in SPSS,Understanding hypothesis testing principles, Conducting hypothesis tests in SPSS, Interpreting SPSS output for hypothesis testing. **(15 Hours)**

Module 4

Generating various types of charts and graphs in SPSS, Customizing visualizations for clarity and impact, Exploring the SPSS Chart Builder tool. **(15 Hours)**

Suggested Readings:

1. Landau, S., & Everitt, B. S. (2003). *A handbook of statistical analyses using SPSS*. Chapman and Hall/CRC.
2. Tukey, J. W. (1977). *Exploratory data analysis* (Vol. 2, pp. 131-160).
3. Aldrich, J. O. (2018). *Using IBM SPSS statistics: An interactive hands-on approach*. Sage Publications.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

DSE-SKILL ENHANCEMENT COURSE

KU05SECSTA301- BASIC STATISTICS USING R

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	SEC	200	KU05SECSTA301	3	60

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	2	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course offers an introduction to basic statistics using the R programming language. Divided into four modules, the course covers foundational statistical concepts, data manipulation, visualization, and hypothesis testing using R. Through lectures, hands-on exercises, and practical examples, students will gain proficiency in performing statistical analysis and interpreting results using R.

COURSE OBJECTIVES:

- Foundational Statistical Concepts: Introduce students to basic statistical concepts such as measures of central tendency, dispersion, and probability distributions using R.
- Data Manipulation and Visualization: Teach students how to manipulate and visualize data using R packages like dplyr, ggplot2, and base R plotting functions.
- Hypothesis Testing: Enable students to perform hypothesis tests for means, proportions, and variances using R.
- Statistical Inference: Familiarize students with confidence intervals and p-values, and their interpretation in the context of statistical inference using R.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Understand basic statistical concepts and their implementation in R.

CO2	Manipulate and visualize data using R packages for data manipulation and visualization.
CO3	Perform hypothesis tests and interpret results using R.
CO4	Apply statistical inference techniques and interpret confidence intervals and p-values using R.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔		✔	✔
CO2	✔	✔	✔	✔	✔
CO3	✔	✔	✔	✔	
CO4	✔	✔	✔		✔

COURSE CONTENTS:

Module 1

Introduction to R and RStudio, Basic data types and data structures in R, Descriptive statistics: measures of central tendency and dispersion, Probability distributions in R (e.g., normal distribution, binomial distribution) **(15 Hours)**

Module 2

Data manipulation with dplyr package, Data visualization, Creating basic plots using base R plotting functions, Customizing plots for clarity and impact . **(15 Hours)**

Module 3

Introduction to hypothesis testing: null and alternative hypotheses, One-sample and two-sample t-tests in R, Chi-square test for independence, Z-test for proportions. **(15 Hours)**

Module 4

Confidence intervals for means and proportions, Interpreting p-values and making conclusions, Introduction to linear regression in R, Assessing model fit and interpreting regression output. **(15 Hours)**

Suggested Readings:

1. Kabacoff, R. I. (2015). ***R in Action: Data Analysis and Graphics with R*** (2nd ed.). Manning Publications.
2. Crawley, M. J. (2013). ***The R Book***. John Wiley & Sons.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

DSE-SKILL ENHANCEMENT COURSE

KU05SECSTA302- STATISTICAL DATA VISUALIZATION AND GRAPHICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
5	SEC	200	KU05SECSTA302	3	60

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	2	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course focuses on statistical data visualization and graphics techniques using various tools and programming languages. Divided into four modules, the course covers foundational principles of data visualization, commonly used visualization techniques, interactive visualization, and advanced graphics customization. Through lectures, practical demonstrations, and hands-on exercises, students will develop proficiency in creating informative and visually appealing statistical graphics.

COURSE OBJECTIVES:

- Foundational Principles of Data Visualization: Introduce students to the principles and importance of effective data visualization in statistical analysis.
- Commonly Used Visualization Techniques: Teach students how to create and interpret common statistical plots such as histograms, box plots, scatter plots, and bar plots.

- Interactive Visualization: Enable students to create interactive visualizations using tools like Plotly, Bokeh, or JavaScript libraries.
- Advanced Graphics Customization: Familiarize students with advanced customization techniques to enhance the clarity and impact of statistical graphics.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Understand the principles of effective data visualization and its importance in statistical analysis.
CO2	Create and interpret commonly used statistical plots such as histograms, box plots, scatter plots, and bar plots.
CO3	Develop interactive visualizations using tools like Plotly, Bokeh, or JavaScript libraries.
CO4	Apply advanced customization techniques to enhance the clarity and impact of statistical graphics.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔		✔	✔	✔
CO3	✔	✔	✔		✔
CO4	✔		✔	✔	✔

COURSE CONTENTS:

Module 1

Introduction to data visualization and its importance, Principles of effective data visualization, Choosing the right visualization for different types of data. **(15 Hours)**

Module 2

Histograms and density plots, Box plots and violin plots, Scatter plots and bubble charts, Bar plots and pie charts. **(15 Hours)**

Module 3

Introduction to interactive visualization tools, Creating interactive plots using Plotly, Interactive graphics with Bokeh, Introduction to JavaScript libraries for data visualization.
(15 Hours)
Module 4
Customizing plot aesthetics: colors, fonts, and labels, Adding annotations and text to plots, Enhancing plots with themes and templates, Creating animated and dynamic visualizations.
(15 Hours)
Suggested Readings:

1. Wickham, H., & Grolemund, G. (2016). R for Data Science. O'Reilly Media.
2. Healy, K. (2018). Data Visualization: A Practical Introduction. Princeton University Press.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

DSE-SKILL ENHANCEMENT COURSE

KU06SECSTA303- STATISTICAL REPORTING AND INTERPRETATION

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	SEC	200	KU06SECSTA303	3	60

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	2	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course focuses on statistical reporting and interpretation techniques, providing students with the skills to effectively communicate statistical findings to diverse audiences. Divided into four modules, the course covers principles of statistical reporting, best practices for presenting statistical results, interpreting statistical output, and communicating findings through written reports and presentations. Through lectures, practical exercises, and case studies, students will learn how to convey statistical information accurately and persuasively.

COURSE OBJECTIVES:

- Principles of Statistical Reporting: Introduce students to the principles and standards of statistical reporting, including clarity, accuracy, and transparency.
- Best Practices for Presenting Statistical Results: Teach students best practices for presenting statistical results in written reports and oral presentations.
- Interpreting Statistical Output: Enable students to interpret statistical output from various analyses, including hypothesis tests, regression models, and data visualizations.
- Communicating Findings: Provide students with the skills to effectively communicate statistical findings to diverse audiences through clear and compelling written reports and presentations.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Understand the principles and standards of statistical reporting.
CO2	Apply best practices for presenting statistical results in written reports and oral presentations.
CO3	Interpret statistical output from various analyses accurately and effectively.
CO4	Communicate statistical findings to diverse audiences through clear and compelling written reports and presentations.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔		✔
CO3	✔	✔	✔	✔	
CO4	✔	✔	✔	✔	

COURSE CONTENTS:

Module 1
Introduction to statistical reporting standards and guidelines, Principles of clarity, accuracy, and transparency in statistical reporting, Ethical considerations in statistical reporting. **(15 Hours)**

Module 2
Structuring written reports: introduction, methods, results, discussion, conclusion, Creating effective visualizations to support statistical findings, Best practices for designing slides and delivering oral presentations. **(15 Hours)**

Module 3
Interpreting output from hypothesis tests, including p-values and confidence intervals, Interpreting output from regression models, including coefficients and goodness-of-fit measures, Interpreting output from data visualizations, including identifying trends and patterns. **(15 Hours)**

Module 4
Writing clear and concise summaries of statistical findings, Designing effective tables and figures to illustrate statistical results, Tips for delivering persuasive presentations and addressing audience questions. **(15 Hours)**

Suggested Readings:

1. Montgomery, D. C., Peck, E. A., & Vining, G. G. (2012). Introduction to Linear Regression Analysis. John Wiley & Sons.
2. Field, A. (2013). Discovering Statistics Using IBM SPSS Statistics. SAGE Publications Ltd.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

DSE-SKILL ENHANCEMENT COURSE

KU06SECSTA304- DATA ANALYSIS USING SAS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
6	SEC	200	KU06SECSTA304	3	60

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	2	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course provides an in-depth exploration of data analysis techniques using the SAS software suite. Students will learn how to import, manipulate, analyze, and visualize data using SAS programming language. Through hands-on exercises and real-world applications, students will gain proficiency in data cleaning, transformation, exploratory data analysis (EDA), statistical analysis, and predictive modeling using SAS.

COURSE OBJECTIVES:

- Mastering SAS Environment: Equip students with the necessary skills to navigate and utilize the SAS software suite effectively, fostering confidence and proficiency in its usage.

- Data Handling Proficiency: Enable students to proficiently import, clean, and preprocess diverse datasets within SAS, ensuring data integrity and reliability for subsequent analysis.
- Exploratory Data Analysis (EDA): Cultivate students' ability to conduct thorough exploratory data analysis, empowering them to extract meaningful insights and identify patterns or trends within datasets using SAS tools and techniques
- Statistical Analysis Competence: Develop students' competency in applying basic and advanced statistical analysis techniques within SAS, enabling them to derive robust conclusions and make data-driven decisions.
- Predictive Modeling Skills: Provide students with the knowledge and skills to build predictive models using SAS, allowing them to forecast future trends, make informed predictions, and optimize decision-making processes

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Demonstrate proficiency in navigating and utilizing the SAS software suite, employing various tools and functionalities to import, manipulate, analyze, and visualize data effectively.
CO2	Exhibit competency in performing comprehensive data analysis tasks, including data cleaning, transformation, exploratory data analysis (EDA), statistical analysis, and predictive modeling using SAS programming language.
CO3	Develop critical thinking skills and the ability to approach complex data analysis problems systematically, applying appropriate SAS techniques, methodologies, and statistical tools to derive actionable insights and solutions.
CO4	Communicate their data analysis findings and insights effectively through clear and concise reports, visualizations, and presentations, demonstrating their ability to translate technical analyses into meaningful and actionable information for diverse stakeholders.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔		✔
CO3	✔	✔	✔	✔	
CO4	✔	✔	✔	✔	

COURSE CONTENTS

Module 1

Introduction to SAS and Data Import: Overview of SAS software and its applications, Installation and setup of SAS environment, Importing data from various sources, Cleaning and preprocessing data in SAS. **(15 Hours)**

Module 2

Data Manipulation and Transformation: Working with SAS datasets and data steps, Manipulating data: Sorting, merging, and appending, Introduction to SAS functions and macros, Conditional processing and subsetting data.
(15 Hours)

Module 3

Exploratory Data Analysis (EDA) and Statistical Analysis: Descriptive statistics: Mean, median, mode, variance, and standard deviation, Visualizing data using SAS procedures, Bivariate analysis: Correlation, scatter plots, and cross-tabulations, Introduction to statistical tests: T-tests, chi-square tests, and ANOVA. **(15 Hours)**

Module 4

Advanced SAS Programming and Modeling: Advanced data manipulation techniques: Arrays and SQL in SAS, Predictive modeling using linear regression and logistic regression, Model validation and evaluation techniques, Time series analysis and forecasting using SAS, Introduction to machine learning in SAS: Clustering and decision trees. **(15 Hours)**

Suggested Readings:

1. Ankerstjerne, A. (2019). ***SAS Programming for Data Science: A Beginner's Guide***. McGraw-Hill Education.
2. Cody, R. P., & Smith, J. K. (2018). ***Applied Statistics and the SAS Programming Language*** (6th ed.). SAS Institute.
3. Lora Delwiche, Susan J. Slaughter. (2019). ***The Little SAS Book: A Primer, Sixth Edition***. SAS Institute.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

MULTI DISCIPLINARY COURSES (MDC)

Semester I

MDC-1: MULTI DISCIPLINARY COURSE

KU01MDCSTA101- BASIC STATISTICS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
1	MDC	100	KU01MDCSTA101	3	60

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course provides an introduction to basic statistics, covering fundamental concepts and techniques used in statistical analysis. Divided into four modules, the course covers descriptive statistics, probability distributions, hypothesis testing, and inferential statistics. Through lectures, practical exercises, and real-world examples, students will gain a solid foundation in basic statistical methods and their applications.

COURSE OBJECTIVES:

- Descriptive Statistics: Introduce students to descriptive statistics for summarizing and visualizing data.
- Probability Distributions: Teach students about probability distributions and their properties, including the normal distribution.
- Hypothesis Testing: Enable students to understand the principles of hypothesis testing and perform basic tests of significance.
- Inferential Statistics: Introduce students to inferential statistics, including confidence intervals and simple linear regression.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Understand and apply descriptive statistics techniques to summarize and visualize data.
CO2	Demonstrate knowledge of probability distributions and their properties.
CO3	Perform basic hypothesis tests and interpret results.
CO4	Apply inferential statistics techniques such as confidence intervals and simple linear regression.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	
CO2	✔	✔	✔		✔
CO3	✔	✔		✔	✔
CO4	✔	✔	✔		✔

COURSE CONTENTS:

Module 1:

Measures of central tendency (mean, median, mode), Measures of dispersion (range, variance, standard deviation), Data visualization techniques (histograms, box plots) **(15 Hours)**

Module 2:

Introduction to probability theory, Discrete and continuous probability distributions, Properties of the normal distribution **(15 Hours)**

Module 3:

Principles of hypothesis testing, One-sample and two-sample t-tests, Chi-square test for independence. **(15 Hours)**

Module 4:

Confidence intervals for means and proportions, Introduction to simple linear regression, Assumptions and limitations of statistical methods. **(15 Hours)**

Suggested Readings:

1. Moore, D. S., McCabe, G. P., & Craig, B. A. (2016). Introduction to the Practice of Statistics. W. H. Freeman.
2. Triola, M. F. (2017). Elementary Statistics. Pearson.
3. Frost, J. (2019). ***Introduction to Statistics: An Intuitive Guide for Analyzing Data and Unlocking Discoveries.*** Jim Publishing.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

MDC-2: MULTI DISCIPLINARY COURSE
KU02MDCSTA201- CORRELATION AND REGRESSION ANALYSIS

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
2	MDC	200	KU02MDCSTA201	3	60

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course focuses on correlation and regression analysis, exploring the relationship between variables and predictive modeling techniques. Divided into four modules, the course covers correlation analysis, simple linear regression, multiple linear regression, and model evaluation techniques. Through lectures, practical exercises, and case studies, students will gain a comprehensive understanding of correlation and regression analysis and learn how to apply these techniques in real-world scenarios.

COURSE OBJECTIVES:

- Correlation Analysis: Introduce students to correlation analysis and teach them how to measure and interpret the strength and direction of relationships between variables.
- Simple Linear Regression: Teach students the principles of simple linear regression and how to build and interpret regression models with one predictor variable.
- Multiple Linear Regression: Enable students to understand multiple linear regression models and how to incorporate multiple predictor variables into regression analysis.
- Model Evaluation: Teach students techniques for evaluating regression models, including assessing model fit and identifying influential data points.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Understand and interpret correlation coefficients and their significance.
CO2	Build and interpret simple linear regression models with one predictor variable.
CO3	Construct and interpret multiple linear regression models with multiple predictor variables.
CO4	Evaluate the fit and performance of regression models and identify potential issues and limitations.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔		✔
CO3	✔	✔	✔	✔	
CO4	✔	✔	✔	✔	

COURSE CONTENTS:

Module 1
Introduction to correlation analysis, Pearson correlation coefficient, Spearman rank correlation coefficient, Interpreting correlation coefficients. **(15 Hours)**

Module 2
Principles of simple linear regression, Least squares estimation, Assessing model fit: coefficient of determination (R^2), Interpreting regression coefficients. **(15 Hours)**

Module 3
Extending simple linear regression to multiple predictors, Multiple regression equation and interpretation, Assessing model fit: adjusted R^2, Dealing with multicollinearity. **(15 Hours)**

Module 4
Residual analysis: assessing model assumptions, Influence and leverage diagnostics, Cross-validation techniques for model evaluation, Limitations and considerations in regression analysis. **(15 Hours)**

Suggested Readings:

1. Kutner, M. H., Nachtsheim, C. J., Neter, J., & Li, W. (2004). Applied Linear Statistical Models. McGraw-Hill Education.
2. Montgomery, D. C., Peck, E. A., & Vining, G. G. (2012). Introduction to Linear Regression Analysis. John Wiley & Sons.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

MDC-3: MULTI DISCIPLINARY COURSE

KU03MDCSTA202- APPLIED STATISTICAL INFERENCE

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
3	MDC	200	KU03MDCSTA202	3	60

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	1	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course focuses on applied statistical inference, exploring methods for making inferences and drawing conclusions from data. Divided into four modules, the course covers probability theory, sampling distributions, estimation, and hypothesis testing. Through lectures, practical exercises, and real-world applications, students will learn how to apply statistical inference techniques to solve problems and make informed decisions.

COURSE OBJECTIVES:

- Probability Theory: Introduce students to probability theory and its applications in statistical inference.
- Sampling Distributions: Teach students about sampling distributions and how they are used to make inferences about population parameters.
- Estimation: Enable students to understand and apply methods for estimating population parameters from sample data.
- Hypothesis Testing: Teach students how to formulate and test hypotheses using appropriate statistical tests and techniques.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Understand and apply probability theory concepts in statistical inference.

CO2	Interpret sampling distributions and their role in making inferences about population parameters.
CO3	Use estimation techniques to estimate population parameters from sample data.
CO4	Formulate hypotheses, perform hypothesis tests, and draw conclusions based on statistical evidence.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	✔
CO2	✔	✔	✔	✔	
CO3	✔	✔	✔		✔
CO4	✔	✔	✔	✔	✔

COURSE CONTENTS:

Module 1

Basics of probability: events, sample spaces, and probabilities, Conditional probability and independence, Bayes' theorem and its applications. **(15 Hours)**

Module 2

Introduction to sampling distributions, Sampling distributions of sample mean and sample proportion, Central limit theorem and its implications. **(15 Hours)**

Module 3

Point estimation: methods for estimating population parameters, Interval estimation: confidence intervals for population parameters, Margin of error and sample size determination. **(15 Hours)**

Module 4

Formulating null and alternative hypotheses, Types of errors in hypothesis testing: Type I and Type II errors, Common hypothesis tests: z-tests, t-tests, chi-square tests, Interpreting test statistics and p-values. **(15 Hours)**

Suggested Readings:

1. Casella, G., & Berger, R. L. (2002). ***Statistical Inference (2nd ed.).*** Duxbury Press.
2. Moore, D. S., McCabe, G. P., & Craig, B. A. (2016). ***Introduction to the Practice of Statistics***. W. H. Freeman.
3. Frost, J. (2020). ***Hypothesis Testing: An Intuitive Guide for Making Data Driven Decisions.***Jim Publishers, USA.

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

VALUE ADDED COURSE (VAC)

Semester III

VAC-1: VALUE ADDED COURSE

KU03VACSTA201- DATA VISUALISATION USING MICROSOFT POWER BI

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
3	VAC	200	KU03VACSTA201	3	60

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	
2	2	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course offers a comprehensive introduction to **Microsoft Power BI**, a leading business intelligence and data visualization tool used across industries. Divided into four modules, the course covers the complete workflow of data analysis—from importing and cleaning data to building data models, creating insightful visualizations, and publishing interactive reports. Through practical exercises and real-world scenarios, students will develop the skills needed to use Power BI effectively for academic research, business analytics, or professional reporting purposes.

COURSE OBJECTIVES:

- **Understanding Power BI Interface and Workflow:**
  Enable students to confidently navigate Power BI Desktop, import datasets from common formats (Excel/CSV), and understand the foundational structure of a Power BI project.
- **Data Preparation and Modeling:**
  Teach students to perform basic data cleaning using Power Query, create relationships between data tables, and use simple DAX formulas to build calculated fields and measures.
- **Data Visualization and Dashboard Development:**
  Help students design compelling, interactive visualizations and dashboards using charts, filters, and slicers—emphasizing best practices in data storytelling.
- **Publishing and Collaboration:**
  Provide knowledge on how to publish and share reports via Power BI Service, create dashboards for online viewing, and explore mobile accessibility for remote collaboration.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Demonstrate proficiency in using Microsoft Power BI for importing, transforming, and managing data from various sources such as Excel and CSV..
CO2	Demonstrate proficiency in using Microsoft Power BI for importing, transforming, and managing data from various sources such as Excel and CSV..
CO3	Develop interactive and visually effective dashboards using various Power BI visual elements like charts, slicers, and filters.

CO4	Apply Power BI tools and techniques to solve real-world problems, using data-driven decision-making skills in academic or business settings.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✔	✔	✔	✔	
CO2	✔		✔		✔
CO3	✔	✔		✔	✔
CO4		✔	✔		✔

COURSE CONTENTS:

Module 1: Introduction to Power BI and Data Concepts

What is Power BI, Installing Power BI Desktop, Overview of Power BI Interface, Importing data from Excel or CSV, Basic data cleaning using Power Query

Module 2: Working with Data

Understanding tables and columns, Creating relationships between tables, Introduction to simple DAX formulas, Creating calculated columns and measures, Building a simple data model.

Module 3: Creating Visual Reports

Creating basic charts (bar, pie, line, map), Using slicers and filters, Formatting visuals, Creating interactive dashboards, Best practices for visual design.

Module 4: Sharing and Publishing Reports

Introduction to Power BI Service, Publishing reports online, Creating and sharing dashboards, Viewing reports on mobile devices, Final mini project using sample data

Suggested Readings:

1. ***"Introducing Microsoft Power BI"***by Alberto Ferrari and Marco Russo
   Publisher: Microsoft Press (Free eBook available)
   Description: A beginner-friendly book that explains the Power BI ecosystem with real-world examples.

2. ***"Collect, Combine, and Transform Data Using Power Query in Excel and Power BI"*** by Gil Raviv

Description: Excellent for learning data transformation techniques in Power BI using Power Query.

3. **"*The Definitive Guide to DAX*"** by Marco Russo and Alberto Ferrari
Description: A more advanced reference for learning DAX formulas and functions (optional for advanced learners).

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks

SEMESTER IV

VAC-2: VALUE ADDED COURSE

KU04VACSTA202- Data Analysis using Tableau

Semester	Course Type	Course Level	Course Code	Credits	Total Hours
4	VAC	100	**KU04VACSTA202**	3	60

Learning Approach (Hours/ Week)			Marks Distribution			Duration of ESE (Hours)
Lecture	Practical/ Internship	Tutorial	CE	ESE	Total	

2	2	1	50	50	100	2(T)+3(P)*

COURSE DESCRIPTION:

This course provides a hands-on introduction to **Tableau**, one of the most widely used data visualization tools in business intelligence. Designed for beginners and intermediate users, the course guides students through the complete Tableau workflow—from data connection and preparation to creating advanced visualizations and interactive dashboards. Emphasis is placed on real-world applications, enabling students to convert raw data into meaningful insights. By the end of the course, students will be equipped with the practical skills to build, publish, and share impactful data stories using Tableau.

COURSE OBJECTIVES:

- **Understanding Tableau Environment and Data Connections:**
  Introduce students to Tableau Public/Desktop, its interface, and how to connect Tableau to a variety of data sources such as Excel, CSV, Google Sheets, and databases.
- **Data Visualization Fundamentals:**
  Enable students to create basic charts, understand dimensions vs. measures, use filters, and perform basic calculations for exploring data and identifying patterns.
- **Advanced Charting and Dashboard Skills:**
  Train students to develop complex visualizations including maps, dual-axis charts, and interactive dashboards, while applying principles of design and user experience.
- **Publishing and Storytelling with Data:**
  Provide the tools and knowledge required to share dashboards online, export them for presentations, and build compelling data stories through final projects.

COURSE OUTCOMES:

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

SL #	Course Outcomes
CO1	Demonstrate proficiency in using Tableau Public/Desktop, including connecting to various data sources and understanding different data types
CO2	Create and customize basic visualizations such as bar charts, line graphs, and pie charts, and apply sorting, filtering, and grouping techniques.
CO3	Develop advanced visualizations and dashboards using calculated fields, parameters, maps, and interactivity features like actions and filters
CO4	Apply Tableau techniques in a real-world context through a final project, showcasing the ability to analyze, visualize, and present data-driven stories.

MAPPING OF COs to PSOs

Sl No	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	✓	✓	✓	✓	
CO2		✓	✓		✓
CO3	✓	✓		✓	✓
CO4	✓	✓	✓		✓

COURSE CONTENTS:

Module 1: Introduction to Tableau and Data Connections

Introduction to Tableau, Installing Tableau Public/Desktop, Tableau interface overview, Connecting to Excel and CSV files, Connecting to Google Sheets and databases, Working with live and extracted data, Understanding data types in Tableau

Module 2: Working with Data and Basic Visualizations

Data pane and dimensions vs. measures, Creating bar charts, line charts, and pie charts, Sorting and filtering data, Using Show Me panel, Creating basic calculations, Creating hierarchies, Working with groups and sets

Module 3: Advanced Visualizations and Dashboard Design

Creating maps and geographical charts, Using parameters and calculated fields, Dual-axis charts and combined charts, Using filters and quick filters, Creating dashboards, Adding interactivity with actions, Formatting and layout design

Module 4: Sharing Insights and Final Project

Publishing to Tableau Public, Exporting dashboards to PDF or image, Embedding visualizations on websites, Dashboard best practices, Real-world project using sample data, Presenting and interpreting visualizations, Final project submission and review

Suggested Readings:

1. "Learning Tableau" by Joshua N. Milligan
   Beginner to Intermediate guide with hands-on examples

2. "Tableau for Dummies" by Molly Monsey & Paul Sochan
   Simple and beginner-friendly introduction to Tableau

TEACHING LEARNING STRATEGIES

- Lecturing, Visualization, Demonstration, Digital Learning, Team Learning

MODE OF TRANSACTION

- Direct class room lecture, Seminar, Discussion, ICT based lecture.

ASSESSMENT RUBRICS

End Semester Evaluation	50 marks
Continuous Evaluation	
Tests	20 Marks
Assignment	10 Marks
Seminar/Viva	20 Marks
Total	50 Marks