University of Kerala

Four Year Under Graduate Programme (UoK FYUGP)

Syllabus

Major Discipline Mathematics

May 2024

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About the Discipline

The mathematics discipline encompasses a vast array of topics, theories, and applications that explore the nature of numbers, shapes, patterns, and relationships. It's a fundamental science that serves as a cornerstone for many other disciplines, including physics, engineering, economics, computer science, and more. Mathematics is a dynamic field with ongoing research and innovation. Mathematicians explore new theories, develop novel techniques, and apply mathematical principles to address emerging challenges and questions across diverse domains. Overall, the mathematics discipline is a rich and multifaceted field that continues to evolve, with applications ranging from the abstract realms of pure mathematics to the practical domains of applied sciences and engineering.

Graduate Attributes

Graduate attributes bridge the gap between academia and the real world, fostering lifelong learning and meaningful contributions. They denote the skills, competencies and high-level qualities that a student should acquire during their university education. Apart from gathering content knowledge, these attributes go beyond the assimilation of information to its application in various contexts throughout a graduate's life. It aims in inculcating the art of critical thinking, problem solving, professionalism, leadership readiness, teamwork, communication skills and intellectual breadth of knowledge. The University of Kerala envisages to pave the path in guiding the student's journey to shape these attributes uniquely, making them integral to personal growth and success in various spheres of life. The University strives to ensure that these graduate attributes are not just checkboxes, but they play a pivotal role in shaping the students into capable, compassionate and responsible individuals with a high degree of social responsibility.

Programme Outcomes (PO)

PO-1: Critical thinking.

- Analyse information, objectively, and make a reasoned judgement.
- Draw reasonable conclusions from a set of information, and discriminate between useful and less useful details to solve problems or make decisions.
- Identify logical floss in the arguments of others.
- Evaluate data, fax, observable phenomena and research findings to draw valet and relevant results that are domain specific.

PO-2: Complex problem-solving.

- Solve different kinds of problems in familiar and non-familiar contexts and apply the learning to real life situations.
- Analyse a problem, generate and implement a solution and assess the success of the plan.
- Understand how the solution will affect both the people in world and the surrounding environment.

PO-3: Creativity.

- Produce or develop original work, theories and techniques.
- Think in multiple ways for making connections between seemingly unrelated concepts or phenomena.
- Add a unique perspective or improve existing ideas or solutions.
- Generate, develop and express origin ideas that are useful or have values.

PO-4: Communication skills

- Convey or share ideas or feelings effectively. Use words in delivering the intended message with utmost clarity.
- Engage the audience effectively.
- Be a good listener who are able to understand, respond and empathise with the speaker.
- Confidently share views and express himself or herself.

PO-5: Leadership qualities

- Work effectively and lead respectfully with diverse teams.
- Build a team working towards a common goal.
- Motivate a group of people and make them achieve the best possible solution.
- Help and support others in their difficult times to tide over the adverse situation with courage.

PO-6: Learning 'how to learn' skills

- Acquire new knowledge and skills, including learning how to learn skills, that are necessary for pursuing learning activities throughout life, through self past and self directed learning.
- Work independently, identify appropriate resources required for further learning.
- Acquire organisational skills and time management to set self defined goals and targets with timelines.
- Inculcate a healthy attitude to be a lifelong learner.

PO-7: Digital and technological skills

- Use ICT in a variety of learning and work situations, access, evaluate, and use a variety of relevant information sources.
- Use appropriate software for analysis of data.
- Understand the pit falls in the digital world and keep safe from them.

PO-8: Value inculcation

- Embrace and practice constitutional, humanistic, ethical, and moral values in life, including universal human values of truth, righteous conduct, peace, love, nonviolence, scientific temper, citizenship values.
- Formulate a position or argument about an ethical issue from multiple perspectives.
- Identify ethical issues related to work and follow ethical practises, including avoiding unethical behaviour, such as fabrication or misrepresentation of data, or committing plagiarism and adhering to intellectual property rights.

- Adopt an objective, and biased, and truthful actions in all aspects of work.

Programme Specific Outcomes

PSO-1: Acquire strong understanding of foundational Mathematical concepts across various areas

PSO-2: Equip the student with skills to analyze problems, formulate a hypothesis, evaluate and validate results, and draw reasonable conclusions thereof.

PSO-3: Employ mathematical ideas encompassing logical reasoning, analytical, numerical ability, theoretical skills to model real-world problems and solve them.

PSO-4: Develop critical thinking, creative thinking, self confidence for eventual success in career.

PSO-5: To prepare the students to communicate mathematical ideas effectively and develop their ability to collaborate both intellectually and creatively in diverse contexts.

PSO-6: Recognize the importance of lifelong learning and professional development in mathematics and related fields, exhibiting the motivation and initiative to stay updated with advancements in the field and continuously improve their skills and knowledge.

University of Kerala

Discipline	Mathematics				
Course Code	UK3DSCMAT200				
Course Title	Integral Calculus and Foundations of Vector Calculus				
Type of Course	DSC				
Semester	III				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical	Total Hours per week
	4	3		2	5
Pre-requisites	1.Awareness of Differential Calculus and Integral Calculus				
	2. Knowledge of various co-ordinate systems in 2-dimension				
Course Summary	The course deal with identifying the applications of integration and vector valued functions				

Detailed Syllabus

Module	Unit	Contents	Hrs
I		**Integral Calculus I**	**9**
	1	Area between two curves, Volume by Slicing (Exclude other axes of revolution), Volume by cylindrical shells (Exclude variations of the method of cylindrical shells). Chapter 5: Section 5.1, 5.2, 5.3 of Text [1]	
II		**Integral Calculus II**	**9**
	2	Length of the plane curve (exclude finding arc length by numerical methods) Area of surface of revolution, Work (Exclude calculating work from basic principles and the work energy relationship) Chapter 5: Section 5.4, 5.5, 5.6 of Text [1]	
III		**Vector Valued Functions I**	**8**

Module	Unit	Contents	Hrs
	3	Projections, Parametric equations of lines, Planes in 3-space, Cylindrical and spherical Coordinates (exclude spherical coordinates in navigation). Chapter 11: Section 11.3, 11.5, 11.6, 11.8 of Text [1]	
IV	**Vector Valued Functions II**		**10**
	4	Introduction to Vector-Valued Functions, Calculus of Vector-Valued Functions, Arc Length (arc length from the vector view point only), Unit Tangent, Normal Vectors, Curvature. Chapter 12: Section 12.1 to 12.5 of Text [1]	
V	**Suggestions for Teacher designed Module**		**9**
	5	Volume by Slicing-other axes of revolution, volume by cylindrical shells - variations of the method of cylindrical shells,Rectangular Coordinates in 3-Space; Spheres; Cylindrical Surfaces, spherical coordinates in navigation, Motion along a curve, Vectors, Dot Product, Cross Product, Binormal vectors Chapter 5: Sections 5.2, 5.3, Chapter 11: 11.1, 11.2, 11.3, 11.4, Chapter 12: 12.4, 12.6 of Text [1]	

Practical sessions and examinations – 30 hours

All the topics mentioned above can be used for practical sessions using SageMath software. Some specific problems and useful resources for solving these problems using the SageMath software are given below.

1. Finding area between curves
2. Representation of a point in different co-ordinate systems (rectangular, polar, spherical)
3. Computing length of a plane curve
4. Finding area of surface of revolution
5. Defining vectors, computing their sum, difference, norm
6. Dot and cross products of vectors
7. Computing parametric equations of planes
8. Computing arc length
9. Computing unit tangent vector, normal vector, curvature

A record should be maintained with atleast 7 problems from the main topics/teacher designed topics. Each problem in the record must have a description of the problem, algorithm (step by step procedure), commands used, input given and output obtained accordingly. For the ESE, from the list of above problems, the student should be able to answer two selected (from the 7 available in the record) by the examiner.

Textbook

1. H Anton, I Bivens, S Davis. Calculus, 10th Edition, John Wiley & Sons, 2012.

References

1. Joel Hass, Maurice D. Weir, Thomas' Calculus Early Transcendentals, 12th Edition, Addison-Weseley Publishing Company, 2004.
2. J Stewart, Calculus with Early Transcendental Functions, 7th Edition, Cengage India Private Limited, 2008.
3. G B Thomas, R L Finney, Calculus, 9th Edition, Addison-Weseley Publishing Company, 2004.

Resources for practical sessions

P1. Sagemath documentation – Introductory Sage Tutorial https://doc.sagemath.org/html/en/prep/Intro-Tutorial.html

P2. Saskia Roos, Michael Jung, *An Introductory Course on Sage, Lecture Notes* https://www.math.uni-potsdam.de/fileadmin/user_upload/An_Introductory_Course_on_Sage.pdf

P3. Sagemath documentation – Symbolic variableshttps://doc.sagemath.org/html/en/reference/calculus/sage/calculus/var.html

P4. Tuan A. Le, Hieu D. Nguyen, SageMath Advice for calculus https://users.rowan.edu/~nguyen/sage/SageMathAdviceforCalculus.pdf

P5. Sagemath documentation – Sage Quickstart for Multivariable Calculus https://doc.sagemath.org/html/en/prep/Quickstarts/Multivariable-Calculus.html

P6. Sagemath documentation – Parametric plots https://doc.sagemath.org/html/en/reference/plot3d/sage/plot/plot3d/parametric_plot3d.html#sage.plot.plot3d.parametric_plot3d.parametric_plot3d

P7. P. Zimmermann *et al*, Computational Mathematics with SageMath, https://www.sagemath.org/sagebook/english.html

P8. Gregory V. Bard, Sage for Undergraduates http://www.people.vcu.edu/~clarson/bard-sage-for-undergraduates-2014.pdf

P9. SageMath documentation – 3D Graphics https://doc.sagemath.org/html/en/reference/plot3d/index.html

Course Outcomes

CO No.	Upon completion of the course the graduate will be able to	PO/PSO	Cognitive Level	Knowledge Category	Lecture(L) Tutorial (T)	Practical (P)
CO 1	Demonstrate applications of Integration	PSO3, PO1, 2, 3, 4, 5, 6, 7, 8	U,E	F,P	L	
CO 2	Computing area and volume using Integration	PSO2, PO1, 2, 3, 4, 5, 7, 8	U,An	F, P		
CO 3	Analysing geometry of curves and surfaces using Vector Calculus	PSO2, PO1, 2, 3, 4, 5, 6, 7, 8	U, E	F, P		
CO 4	Distinguish cylindrical and spherical co-ordinates	PSO4, PO1, 2, 3, 4, 5, 6, 7, 8	R, An	F, P		

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

Mapping of CO with PSOs and POs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1			3				3	3	2	2	1	2	2	1
CO2		3					3	3	1	1	2		2	1
CO3		3					3	2	1	1	2		2	1
CO4				3			3	2	1	1	1	2	3	1

(- -Nill, 1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High)

Assessment Rubrics

- Quiz/Assignment/Discussion/Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics

	Internal Examination	Assignment	Project Evaluation	End Semester Exam
CO1		✓		
CO2	✓	✓		✓
CO3	✓	✓		✓
CO4	✓	✓		✓

University of Kerala

Discipline	Mathematics				
Course Code	UK3DSCMAT201				
Course Title	Differential Equations, Multiple Integrals and Vector Calculus				
Type of Course	DSC				
Semester	III				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours per week
	4	3	-	2	5
Pre-requisites	1. Differential calculus 2. Vectors 3. Integration				
Course Summary	The course enable the students to find the solutions of certain differential equations, identifying the applications of multiple integrals and to get a brief idea of vector calculus.				

Detailed Syllabus

Module	Unit	Contents	Hrs
I	**First Order Ordinary Differential Equations**		**9**
	1	Basic Concepts. Modeling, Separable ODEs.Modeling (exclude extended method : reduction to separable form), Exact ODEs. In tegrating factors, Linear ODEs. Bernoulli equation (exclude Population Dynamics). Sections 1.1,1.3,1.4,1.5 of Text [1]	
II	**Second Order Linear Ordinary Differential Equations**		**9**
	2	Homogeneous linear ODEs of second order, Homogeneous linear ODEs with constant coefficients (exclude derivation in case III- complex exponential function), Existence and uniqueness of solutions. Wronskian, solving non-homogeneous ODE via the method of undetermined coefficients. Statement of theorems only. Sections 2.1,2.2,2.6,2.7 of Text [1]	

Module	Unit	Contents	Hrs
III		**Multiple Integrals**	**9**
	3	Double Integrals, Double integrals over non rectangular regions, Double integrals in polar coordinates, Triple integrals (definition of a triple integral, properties of triple integrals and evaluating triple integrals over rectangular boxes). Chapter 14: Section 14.1, 14.2, 14.3, 14.5 of Text [2]	
IV		**Vector Calculus**	**9**
	4	Vector Fields (definition), Inverse square field, Gradient field, Conservative fields and potential function, Divergence and Curl, Δ operator, The Laplacian Δ^2, line integrals (Integrating a vector field along a curve only), Independence of path ; conservative vector fields (exclude conservative vector fields in 3- Space, and conservation of Energy) Green's theorem and applications (with out proof).Chapter 15: Section 15.1, 15.2, 15.3, 15.4 of Text [2].	
V		**Suggestions for teacher designed module**	**9**
	5	Triple integrals in cylindrical and spherical coordinates, Defining and evaluating surface integrals, their applications, Orienta- tion of surfaces, evaluating flux integrals, The divergence theorem, Gauss' Law, Stoke's theorem, applications of these theorems. Chapter 15: Section 15.5, 15.6, 15.7, 15.8 of Text [2]	

Practical sessions and examinations – 30 hours

All the topics mentioned above can be used for practical sessions using SageMath software. Some specific problems and useful resources for solving these problems using the SageMath software are given below.

1. Defining symbolic functions and evaluating them
2. Formation of differential equations eliminating constants
3. Solving differential equations using desolve
4. Evaluating multiple integrals
5. Conversion of points between cartesian and polar co-ordinates
6. Evaluating triple integrals
7. Computing gradient, curl, divergence of functions
8. Evaluating using Green's theorem
9. Evaluating using Divergence and Stoke's theorems

A record should be maintained with atleast 7 problems from the main topics/teacher designed topics. Each problem in the record must have a description of the problem, algorithm (step by step procedure), commands used, input given and output obtained accordingly. For the ESE, from the list of above problems, the student should be able to answer two selected (from the 7 available in the record) by the examiner.

Textbooks

1. Erwin Kreyszig, *Advanced Engineering Mathematics*, 10^{th} Edition Wiley, 2018.
2. Howard Anton, Irel Bivens, Stephens Davis, *Calculus* 10^{th} Edition Wiley, 2012.

References

1. Ian Sneddon, *Elements of Partial Differential Equations*, Mc Graw- Hill, 2013.
2. Peter. V. O Neil, *Advanced Engineering Mathematics*, Thompson Publications, 2007.
3. M. D. Raisinghaniya, *Ordinary and Partial Differential Equations*, S Chand 18^{th} Edition, 2008.
4. G. F. Simmons, *Differential Equations with Applications and Historical Notes*, Tata McGraw-Hill, 2003.
5. G. B. Thomas, R. L. Finey, *Calculus*, 9^{th} Edition, Addison-Weseley Publishing Company, 2004.

Resources for practical sessions

1. SageMath Documentation - Solving ordinary differential equations https://doc.sagemath.org/html/en/reference/calculus/sage/calculus/desolvers.html
2. Sage Quickstart for Differential Equations https://doc.sagemath.org/html/en/prep/Quickstarts/Differential-Equations.html
3. Saskia Roos, Michael Jung, *An Introductory Course on Sage, Lecture Notes* https://www.math.uni-potsdam.de/fileadmin/user_upload/An_Introductory_Course_on_Sage.pdf
4. Sagemath documentation – Symbolic variableshttps://doc.sagemath.org/html/en/reference/calculus/sage/calculus/var.html

5. Tuan A. Le, Hieu D. Nguyen, SageMath Advice for calculus https://users.rowan.edu/~nguyen/sage/SageMathAdviceforCalculus.pdf

6. Sagemath documentation – Sage Quickstart for Multivariable Calculus https://doc.sagemath.org/html/en/prep/Quickstarts/Multivariable-Calculus.html

7. Sagemath documentation – Parametric plots https://doc.sagemath.org/html/en/reference/plot3d/sage/plot/plot3d/parametric_plot3d.html#sage.plot.plot3d.parametric_plot3d.parametric_plot3d

8. SageMath documentation – 3D Graphics https://doc.sagemath.org/html/en/reference/plot3d/index.html

Course Outcomes

CO No.	Upon completion of the course the graduate will be able to	PO/PSO	Cognitive Level	Knowledge Category	Lecture(L) Tutorial (T)	Practical (P)
CO 1	Understand the concepts of ordinary differential equations, integration over multi variables geometric and physical interpretations of vector integration	PSO1, 2, PO3, 6, 7, 8	U, Ap	F,C	L	
CO 2	Analyze the solutions of ordinary differential equations, Multiple Integrals and Vector Integration	PSO 2,3, PO1, 2, 3, 6, 7, 8	U, An	C,P	L	
CO 3	Develop problem-solving skills and application skills	PSO 1, 2, 3, 4, PO1, 2, 3, 6, 7, 8	An, E	P	L	

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

Mapping of CO with PSOs and POs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	1					3	-	1	-	-	2	1	1
CO2		3	1				1	1	3	-	-	2	1	1
CO3	1	3	2	3	2		1	3	3	-	-	3	1	1

(- -Nill, 1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High)

Assessment Rubrics

- Quiz/Assignment/Discussion/Seminar
- Midterm Exam
- Programming Assignments
- End Semester Exam

Mapping of COs to Assessment Rubrics

	Internal Examination	Assignment	Project Evaluation	End Semester Exam
CO1	✓	—-	—-	✓
CO2	✓	✓		✓
CO3	✓	✓		✓

University of Kerala

Discipline	Mathematics				
Course Code	UK3DSCMAT202				
Course Title	Group Theory and Probability				
Type of Course	DSC				
Semester	III				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours per week
	4	3	-	2	5
Pre-requisites	Sets, relations, functions and matrices				
Course Summary	This course provides a foundational understanding of key concepts in abstract algebra and probability. It develops logical thinking and structural reasoning through the study of algebraic systems and their properties. The probability section introduces basic principles . The course encourages analytical skills and abstract thinking				

Detailed Syllabus

Module	Unit	Contents	Hrs
I		**Binary operations, Groups and Subgroups**	**8**
	1	Definitions and Examples related to Binary operations. Section 2 of Text[1]	
	2	Definition, Examples and elementary properties of Groups. Section 4 of Text[1]	
II		**Cyclic groups and Permutation groups**	**10**
	3	Subgroups and Cyclic Subgroups. Section 5 of Text[1]	
	4	Elementary properties and structure of cyclic groups (Proofs of 6.3, 6.10, 6.14 can be omitted). Section 6 of Text[1]	

Module	Unit	Contents	Hrs
	5	Permutation groups and Cayley's Theorem (without proof). Section 8 of Text[1]	
III	**Probability and statistics**		**9**
	6	Probability and sample space: Definition and examples. Chapter 15: Section 1 and 2 of Text[2]	
	7	Probability theorems. Chapter 15: Section 3 of Text[2]	
	8	Random Variables.Chapter 15: Section 5 of Text[2]	
IV	**Probability Distributions**		**9**
	9	Continuous Distribution. Chapter 15: Section 7 of Text[2]	
	10	Binomial Distribution (Omit joint distribution) . Chapter 15: Section 6 of Text[2]	
	11	Normal Distribution . Chapter 15: Section 8 of Text[2]	
V	**Suggestions for the teacher designed module**		**9**
	12	Isomorphic binary structures. Section 3 of Text[1]	
	13	Orbits, cycles and the Alternating Groups, Proof of Cayley's theorem. Section 9 of Text[1]	
	14	Poisson distributions. Chapter 15: Section 9 of Text[2]	

Practical sessions and examinations – 30 hours

All the topics mentioned above can be used for practical sessions using SageMath software. Some useful resources for solving these problems using the SageMath software are given against each problem/type of problem.

1. Define congruence groups and list the elements in them
2. Perform various operations in the congruence groups
3. Finding inverse of elements in congruence groups
4. Prepare a group table of the congruence groups $\mathbb{Z}_n$ (for some selected values of n)
5. Compute symmetric groups, and perform operations among elements in them.
6. Create Cayley table of selected groups.
7. Define a group, find the cyclic group generated by an element in it.
8. Problems involving continuous distributions.
9. Problems involving binomial distribution
10. Problems involving normal distributions

A record should be maintained with the above (or problems related to the topics in the syllabus) 7 problems from the main topics/teacher designed topics. Each problem in the record must have a description of the problem, algorithm (step by step procedure),

commands used, input given and output obtained accordingly. For the ESE, from the list of above 10 problems, the student should be able to answer two selected (from the 7 available in the record) by the examiner.

Textbook

1. J B Fraleigh, A first course in abstract algebra, 7th Edn, Pearson, 2013.
2. M L Boas, Mathematical methods in physical sciences, 3rd Edn, John Wiley and Sons, 2006.

References

1. Joseph. A. Gallian, Contemporary Abstract Algebra, Eighth Edition, Brroks/cole Cengage Learning, 2012.
2. I. N. Herstein, Topics in Algebra, Second Edition, Wiley, 2006.
3. Michael Artin, Algebra, Second Edition, Pearson Education, 2023.
4. Sheldon Ross, A first course in probability, 5th Edn, Prentice Hall, 1998.
5. Ajit Kumar, Vikas Bist, Group Theory : An expedition with SageMath, Narosa Publications, New Delhi 2021
6. Group Theory and Sage, Online tutorial, https://doc.sagemath.org/html/en/thematic_tutorials/group_theory.html
7. Probaility : Sage 9.4 Reference Manual https://doc-gitlab.sagemath.org/pdf/en/reference/probability/probability.pdf
8. Probability Distributions : SageMath documentation https://doc.sagemath.org/html/en/reference/probability/sage/probability/probability_distribution.html

Course Outcomes

CO No.	Upon completion of the course the graduate will be able to	PO/PSO	Cognitive Level	Knowledge Category	Lecture(L) Tutorial (T)	Practical (P)
CO 1	Define and work with binary operations and recognize isomorphic structures.	PO 2, PSO1, 2,3	U, Ap	C, P	L	
CO 2	Understand the structure and properties of groups, subgroups, and cyclic groups.	PO1, PSO1, 2,3	U	F,C	L	
CO 3	Apply group-theoretic concepts to permutation groups and prove results like Cayley's Theorem	PO2, PSO1, 2,3	Ap, An	P, C	L	
CO 4	Explain the basic principles of probability and solve problems involving random variables.	PO2, PSO1, 2,3	U, Ap	F,C	L	

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(F-Factual, C-Conceptual, P-Procedural, M-Metacognitive)

Mapping of CO with PSOs and POs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	-	2	-	-	-	-	-	-	-	-	-	-	-
CO2	3	-	2	-	-	-	-	-	-	-	-	-	-	-
CO3	3	2	3	-	-	-	-	3	-	-	-	-	-	-
CO4	3	2	3	-	-	-	-	3	-	-	-	-	-	-

(- -Nill, 1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High)

Assessment Rubrics

- Quiz/Assignment/Discussion/Seminar

- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics

	Internal Examination	Assignment	Project Evaluation	End Semester Exam
CO1	✓	✓		✓
CO2	✓	✓		✓
CO3	✓	✓		✓
CO4	✓	✓		✓

University of Kerala

Discipline	Mathematics				
Course Code	UK3DSCMAT203				
Course Title	Numerical Analysis				
Type of Course	DSC				
Semester	III				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours per week
	4	3	-	2	5
Pre-requisites	1. Differentiation 2. Integration 3. Solution of system of equations				
Course Summary	This course enable the students to gain a thorough understanding of various numerical methods used for solving mathematical problems				

Detailed Syllabus

Module	Unit	Contents	Hrs
I		**Solution of Algebraic and Transcendental equations**	**9**
	1	Introduction, Bisection Method, Method of false position. Chapter 2: Section 2.1 to 2.3 of Text[1]	
	2	Iteration Method (excluding acceleration of convergence: Aitken's Δ^2 -process), Newton-Raphson method (excluding generalized Newton's method) . Chapter 2: section 2.4 to 2.5 of Text[1]	
II		**Interpolation**	**10**
	3	Finite differences. Chapter 3: Section 3.3 excluding 3.3.4	
	4	Newton's formulae for interpolation, Central difference interpolation formulae, Chapter 3: Section 3.6, 3.7 of Text[1]	
III		**Numerical Differentiation**	**8**
	5	Numerical differentiation. Chapter 6: Section 6.2 (excluding 6.2.1 and 6.2.2) of Text[1]	

Module	Unit	Contents	Hrs
	6	Maximum and Minimum values of a tabulated function. Chapter 6: Section 6.3 of Text[1]	
IV	**Numerical Integration and Solution of Ordinary Differential equations**		**9**
	7	Numerical integration Chapter 6: Section 6.4.1 to 6.4.4 of Text[1]	
	8	Solution by Taylor's series Chapter 8: Section 8.2 of Text[1]	
	9	Picard's method of Successive Approximations. Chapter 8: Section 8.3 of Text[1]	
V	**Suggestions for the teacher designed module**		**9**
	10	Ramanujan's method, Secant method, Muller's method. Chapter 2: Section 2.6 to 2.8 of Text[1]	
	11	Divided differences and their properties. Chapter 3: Section 3.10 of Text[1]	
	12	Euler's method Chapter 8: Section 8.4 of Text[1]	
	13	Runge- Kutta Methods.Chapter 8: Section 8.5 of Text[1]	

Practical sessions and examinations – 30 hours

All the topics mentioned above should be used for practical sessions using SageMath software. Some useful resources for solving these problems using the SageMath software are given below.

1. SageMath – documentation https://doc.sagemath.org/html/en/tutorial/introduction.html
2. Online SageMath server https://sagecell.sagemath.org/
3. Solving equations using SageMath https://doc.sagemath.org/html/en/tutorial/tour_algebra.html
4. Bisection method https://wiki.sagemath.org/interact/calculus#Root_Finding_Using_Bisection
5. Newton-Raphson method https://www.sfu.ca/~jtmulhol/calculus-applets/html/sagemath-cell-newtonsmethod.html
6. Interpolation problems https://www.youtube.com/watch?v=2lPNfYNSoJA
7. Numerical methods https://www.cfm.brown.edu/people/dobrush/am33/sage/ch3/part3.html

A record should be maintained with atleast 7 problems from the main topics/teacher designed topics. Each problem in the record must have a description of the problem, algorithm (step by step procedure), commands used, input given and output obtained accordingly. For the ESE, from the list of above 10 problems, the student should be able to answer two selected (from the 7 available in the record) by the examiner.

Textbook

1. S.S. Sastry, *Introductory Methods of Numerical Analysis*, Fifth edition, PHI Learning Pvt. Ltd, 2012

References

1. A. C. Faul, *A Concise Introduction to Numerical Analysis* , CRC Press, 2016.
2. Richard L. Burden, J. Douglas Faires,*Numerical Analysis* , Ninth Edition, Cengage Learning, 2011.
3. Timo Heister, Leo G. Rebholz, Fei Xue, *Numerical Analysis An Introduction* , De Gruyter, 2019.
4. Timothy Sauer, *Numerical Analysis*, Third Edition, Perason Education, 2018.

Course Outcomes

CO No.	Upon completion of the course the graduate will be able to	PO/PSO	Cognitive Level	Knowledge Category	Lecture(L) Tutorial (T)	Practical (P)
CO 1	Calculate the solution of algebraic and transcendental equation using numerical methods	PO 2, PSO1, 2,3	U, Ap	F,C	L	
CO 2	Apply numerical techniques to interpolate data points effectively	PO1, PSO1, 2,3	U, Ap	F,C	L	
CO 3	Apply numerical techniques for differentiation and integration	PO2, PSO1, 2,3	U, Ap	F,C	L	
CO 4	Calculate the solution of ordinary differential equations using numerical methods	PO2, PSO1, 2,3	U, Ap	F,C	L	

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

Mapping of CO with PSOs and POs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	2	-	-	-	-	3	-	-	-	-	-	-
CO2	3	3	2	-	-	-	3	-	-	-	-	-	-	-
CO3	3	3	2	-	-	-	-	3	-	-	-	-	-	-
CO4	3	3	2	-	-	-	-	3	-	-	-	-	-	-

(- -Nill, 1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High)

Assessment Rubrics

- Quiz/Assignment/Discussion/Seminar
- Midterm Exam

- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics

	Internal Examination	Assignment	Project Evaluation	End Semester Exam
CO1	✓	✓		✓
CO2	✓	✓		✓
CO3	✓	✓		✓
CO4	✓	✓		✓

University of Kerala

Discipline	Mathematics				
Course Code	UK3DSCMAT204				
Course Title	Applications of Integration and Vector Calculus				
Type of Course	DSC				
Semester	III				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours per week
	4	3	-	2	5
Pre-requisites	1. Differentiation 2. Integration 3. Vectors				
Course Summary	This course enable the students to gain a thourough understanding of applications of integration and vector calculus				

Detailed Syllabus

Module	Unit	Contents	Hrs
I		**Applications of Integration**	**9**
	1	Area Between Two Curves, Volumes by Slicing; Disks and Washers (Chapter 5: Sections 5.1, 5.2 of Text[1])	
	2	Length of a Plane Curve, Area of revolution (Chapter 5: Sections 5.4, 5.5 of Text[1])	
	3	Work (Exclude calculating work from basic principles and the work energy relationship)(Chapter 5: Section 5.6 of Text[1])	
II		**Vector Differentiation and Vector Integration**	**11**
	4	Vector fields (Definition; graphical representation of vector fields excluded), inverse square fields, Gradient fields, Conservative Fields and potential functions, Divergence and Curl, the ∇ operator, the Laplacian ∇^2(Chapter 15: Section 15.1 of Text[1])	

Module	Unit	Contents	Hrs
	5	Line integrals - Exercise Set 15.2- problems 15-30, 33-36, 41-46, Green's Theorem (Exclude Green's Theorem for multiply connected regions) (Chapter 15: Section 15.2, 15.4 of Text[1])	
	6	Independence of Path; Conservative Vector Fields (Exclude conservation of energy), (Chapter 15: Sections 15.3 of Text[1])	
III	**Surface Integrals and Applications**		**8**
	7	Surface integrals (Chapter 15: Section 15.5 of Text[1])	
	8	Applications of surface integrals; Flux (evaluating flux integrals for parametric and non-parametric surfaces) (Chapter 15: Section 15.6 of Text[1])	
IV	**Divergence theorem and Stoke's Theorem**		**8**
	9	The divergence theorem (without proof), using the divergence theorem to find flux (Chapter 15: Sections 15.7 of Text[1])	
	10	Stoke's theorem (without proof), using Stoke's Theorem to calculate work (Chapter 15: Section 15.8 of Text[1])	
V	**Teacher Designed Module - Suggested Topics**		**9**
	11	Moments, Centers of Gravity, and Centroids (Chapter 5: Section 5.7 of Text[1])	
	12	Volumes by Cylindrical Shells (Chapter 5: Section 5.3 of Text[1])	
	13	Relationships between Green's theorem and Stoke's theorem (Chapter 15: Section 15.8 of Text[1])	

Practical sessions and examinations – 30 hours

All the topics mentioned above can be used for practical sessions using SageMath software. Some useful resources for solving these problems using the SageMath software are given in the references.

1. Finding area between curves
2. Computing length of a plane curve
3. Sketching the vector fields
4. Computing the gradient, curl, and divergence of functins
5. Verifying Green's theorem for selected functions
6. Computing surface integrals
7. Computing flux
8. Verifying the Divergence, Stoke's theorems

A record should be maintained with atleast 7 problems from the main topics/teacher designed topics. Each problem in the record must have a description of the problem, algorithm (step by step procedure), commands used, input given and output obtained accordingly. For the ESE, from the list of above problems, the student should be able to answer two selected (from the 7 available in the record) by the examiner.

Textbook

1. H Anton, I Bivens, S Davis, *Calculus*, 10th Edition, John Wiley & Sons, 2012.

References

1. Joel Hass, Maurice D. Weir, *Thomas' Calculus Early Transcendentals*, 12th Edition, Addison-Weseley Publishing Company, 2004.
2. J Stewart, *Calculus with Early Transcendental Functions*, 7th Edition, Cengage India Private Limited, 2008.
3. G B Thomas, R L Finney, *Calculus*, 9th Edition, Addison-Weseley Publishing Company, 2004.

Resources for practical sessions

1. Sagemath documentation – Introductory Sage Tutorial https://doc.sagemath.org/html/en/prep/Intro-Tutorial.html
2. Saskia Roos, Michael Jung, *An Introductory Course on Sage, Lecture Notes* https://www.math.uni-potsdam.de/fileadmin/user_upload/An_Introductory_Course_on_Sage.pdf
3. Sagemath documentation – Symbolic variableshttps://doc.sagemath.org/html/en/reference/calculus/sage/calculus/var.html
4. Tuan A. Le, Hieu D. Nguyen, SageMath Advice for calculus https://users.rowan.edu/~nguyen/sage/SageMathAdviceforCalculus.pdf
5. Sagemath documentation – Sage Quickstart for Multivariable Calculus https://doc.sagemath.org/html/en/prep/Quickstarts/Multivariable-Calculus.html
6. Tutorial: Vector Calculus in Euclidean Spaces https://doc.sagemath.org/html/en/thematic_tutorials/vector_calculus.html
7. Sagemath documentation – Parametric plots https://doc.sagemath.org/html/en/reference/plot3d/sage/plot/plot3d/parametric_plot3d.html#sage.plot.plot3d.parametric_plot3d.parametric_plot3d

8. P. Zimmermann *et al*, Computational Mathematics with SageMath, https://www.sagemath.org/sagebook/english.html

9. Gregory V. Bard, Sage for Undergraduates http://www.people.vcu.edu/~clarson/bard-sage-for-undergraduates-2014.pdf

10. SageMath documentation – 3D Graphics https://doc.sagemath.org/html/en/reference/plot3d/index.html

Course Outcomes

CO No.	Upon completion of the course the graduate will be able to	PO/PSO	Cognitive Level	Knowledge Category	Lecture(L) Tutorial (T)	Practical (P)
CO 1	Demonstrate various applications of integration	PSO 1, PO1, 6	U	F, C	L	
CO 2	Compute tangent lines to polar curves, arc length and area	PSO 2, 4, PO6	Ap, An	P	L	
CO 3	Describe the concepts Vector fields, Gradient fields, potential functions and vector integrals	PSO1, PO1, 6	U	F, C	L	
CO 4	Apply vector integrals to find areas	PSO 3, 4, PO1, 6	Ap, An	P	L	

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

Mapping of CO with PSOs and POs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	-	-	-	-	-	1	-	-	-	-	2	-	-
CO2	-	2	-	3	-	-	-	-	-	-	-	2	-	-
CO3	3	-	-	-	-	-	2	-	-	-	-	2	-	-
CO4	-	-	3	3	-	-	2	-	-	-	-	2	-	-

(- -Nill, 1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High)

Assessment Rubrics

- Quiz/Assignment/Discussion/Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics

	Internal Examination	Assignment	Project Evaluation	End Semester Exam
CO1	✓			✓
CO2	✓	✓		✓
CO3	✓			✓
CO4	✓	✓		✓

University of Kerala

Discipline	Mathematics				
Course Code	UK3DSCMAT205				
Course Title	Multivariate Calculus and Multiple Integrals				
Type of Course	DSC				
Semester	III				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours per week
	4	3	-	2	5
Pre-requisites	1. Differentiation 2. Integration				
Course Summary	This course gives an insight into Multi Variable Calculus, Multiple Integrals, Vector Calculus				

Detailed Syllabus

Module	Unit	Contents	Hrs
I		**Multivariable Calculus**	**9**
	1	Functions of Two or More Variables, Limits and Continuity (Chapter13: Sections 13.1, 13.2 of Text[1], Continuity at Boundary Points and Extensions of Three Variables may be omitted.)	
	2	Partial Derivatives, The Chain Rule (Chapter 13 Section 13.3, 13.5 of Text[1]) (Estimating Partial Derivatives From Tabular Data, Partial Derivatives and Continuity, The Wave Equation may be omitted)	
II		**Multiple Integrals**	**9**
	3	Double Integrals, Double Integrals over Non-rectangular Regions (Chapter 14: Section 14.1, 14.2 of Text[1]	

Module	Unit	Contents	Hrs
	4	Double Integrals in Polar Coordinates (Chapter 14: Section 14.3 of Text[1])	
	5	Triple Integrals (Chapter 14: Section 14.5 of Text 1). Definition of Triple Integral, Properties of Triple Integrals, Evaluating Triple Integrals over Rectangular Boxes.	
III	**Vector Differentiation**		**9**
	6	Vector fields (Definition), inverse square fields, Gradient fields, Conservative Fields and potential functions, Divergence and Curl, the ∇ operator (Chapter 15: Section 15.1 of Text[1])	
IV	**Vector Integration**		**9**
	7	Line integrals, Integrating a vector field along a curve - Exercise Set 15.2- problems 15-30, 33-36, 41-46. (Chapter 15: Section 15.2 of Text[1])	
	8	Independence of Path; Conservative Vector Fields, Green's Theorem (Chapter 15: Sections 15.3, 15.4 of Text[1])	
V	**Suggestion for Teacher Designed Module**		**9**
	9	Level Curves, Contour Plots Using Technology, Level Surfaces (Chapter 13 of Module 1), Directional Derivatives, Maxima and Minima Of Functions of Two Variables(Chapter 13: 13.6, 13.7 of Text 1)	
	10	Triple Integrals(Chapter 14: Section 14.5 of Text 1), Evaluating Triple Integrals over more General regions, Volume Calculated as a triple Integral, Integration in other orders.	

Practical sessions and examinations – 30 hours

All the topics mentioned above can be used for practical sessions using SageMath software. Some useful resources for solving these problems using the SageMath software are given against each problem/type of problem.

1. Define a function with two/three variables and evaluate it at any given point.
2. Sketch the graphs and level surfaces of two variable functions and (using 3 dimensional plot)
3. Evaluate the limit of two variable functions
4. Compute partial derivatives of two/three variable functoins and evaluate them at given points.
5. Evaluate double integrals in rectangular co-ordinates.
6. Convert representation of points among rectangular, polar, spherical co-ordinate systems
7. Compute the maxima and minima of two variable functions using second partials test

8. Sketch vector fields.
9. Compute the gradient of function.
10. Compute the divergence, curl.
11. Verify Green's theorem for selected functions.

Resources for practical sessions

1. SageMath – documentation
   https://doc.sagemath.org/html/en/tutorial/introduction.html
2. Online SageMath server https://sagecell.sagemath.org/
3. Graphing Functions of two variables using Technology
   https://doc.sagemath.org/html/en/tutorial/tour_algebra.html
4. Maxima and Minima Of Functions Of Two Variables
   https://wiki.sagemath.org/interact/calculus#Root_Finding_Using_Bisection
5. Sagemath documentation – Sage Quickstart for Multivariable Calculus
   https://doc.sagemath.org/html/en/prep/Quickstarts/Multivariable-Calculus.html
6. Tutorial: Vector Calculus in Euclidean Spaces https://doc.sagemath.org/html/en/thematic_tutorials/vector_calculus.html
7. Sagemath documentation – Parametric plots
   https://doc.sagemath.org/html/en/reference/plot3d/sage/plot/plot3d/parametric_plot3d.html#sage.plot.plot3d.parametric_plot3d.parametric_plot3d

A record should be maintained with atleast 7 problems from the main topics/teacher designed topics. Each problem in the record must have a description of the problem, algorithm (step by step procedure), commands used, input given and output obtained accordingly. For the ESE, from the list of above 10 problems, the student should be able to answer two selected (from the 7 available in the record) by the examiner.

Textbook

1. H Anton, I Bivens, S Davis, Calculus, 10th Edition, John Wiley & Sons, 2012.

References

1. Joel Hass, Maurice D. Weir, Thomas' Calculus, Early Transcendentals, 12th Edition, Addison-Weseley Publishing Company, 2004.

2. Joel Hass, Maurice D. Weir, Thomas' Calculus Early Transcendentals, 12th Edition, Addison-Weseley Publishing Company, 2004.

3. G B Thomas, R L Finney, Calculus, 9 th Edition, Addison-Weseley Publishing Company, 2004.

Course Outcomes

CO No.	Upon completion of the course the graduate will be able to	PO/PSO	Cognitive Level	Knowledge Category	Lecture(L) Tutorial (T)	Practical (P)
CO 1	Define the concept of functions of several variables, their limit, continuity and derivative	PSO 1, PO1, 2, 6	U	F,C	L	
CO 2	Illustrate various applications of multivariable calculus	PSO 2, 4, PO1, 2, 6	Ap, An	P	L	
CO 3	Describe the concepts Vector fields, Gradient fields, potential functions and vector integrals	PSO 1, PO1, 2, 6	U	F,C	L	
CO 4	Apply vector integrals to find areas	PSO 3, 4, PO1, 2, 6	Ap, An	P	L	

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

Mapping of CO with PSOs and POs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	-	-	-	-	-	2	1	-	-	-	3	-	-
CO2	-	-	3	3	-	-	2	1	-	-	-	3	-	-
CO3	3	-	-	-	-	-	1	1	-	-	-	2	-	-
CO4	-	-	3	3	-	-	2	1	-	-	-	3	-	-

(- -Nill, 1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High)

Assessment Rubrics

- Quiz/Assignment/Discussion/Seminar

- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics

	Internal Examination	Assignment	Project Evaluation	End Semester Exam
CO1	✓			✓
CO2	✓	✓		✓
CO3	✓			✓
CO4	✓	✓		✓

University of Kerala

Discipline	Mathematics				
Course Code	UK3DSCMAT206				
Course Title	Complex Analysis				
Type of Course	DSC				
Semester	III				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours per week
	4	3	-	2	5
Pre-requisites	1. Complex numbers 2. Partial derivatives				
Course Summary	Equips students with the fundamental knowledge and skills necessary to understand and apply complex analysis in various scientific and engineering disciplines. Students will be prepared for more advanced studies in complex analysis and its applications.				

Detailed Syllabus

Module	Unit	Contents	Hrs
I		**Analytic functions**	**9**
	1	Derivative-Analytic Function, Cauchy–Riemann Equations Laplace's Equation (Chapter 13: Section 13.3, 13.4 of Text[1])	
II		**Cauchy's Integral Theorem**	**9**
	2	Line Integral in the Complex Plane and is properties (Except Existence of Complex Line integrals and ML Inequality) (Chapter 14: Section 14.1 of Text[1])	
	3	Cauchy's Integral Theorems (without proof) Cauchy's Integral Formula (without proof) (Chapter 14: Sections 14.2, 14.3 of Text[1])	
III		**Series**	**9**

Module	Unit	Contents	Hrs
	4	Power Series, Radius of Convergence, Taylor and Maclaurian Series (Chapter 15: Section 15.2, 15.4 of Text[1])	
	5	Laurents Series Singularities, Zeros - (exclude Riemann's Sphere) (Chapter 16: Section 16.1, 16.2 of Text[1])	
IV	**Complex Integration**		**9**
	6	Evaluation of an Integral by means of a Residue (Chapter 16: Section 16.3 of Text[1])	
	7	Evaluation of an Integral by Means of a Residue, Formulas for Residues, Residue Theorem, Application of the Residue Theorem, (Chapter 16: Section 16.3 of Text [1])	
V	**Suggestion for Teacher Designed Module**		**9**
	8	Complex Numbers and Their Geometric Representation (Chapter 13: Section 13.1 of Text[1])	
	9	Polar Form of Complex Numbers-Powers and Roots (Chapter 13: Section 13.2 of Text[1])	
	10	Derivative of Analytic Functions (Chapter 13: Section 13.3 of Text[1])	
	11	Residue Integration of Real Integrals (Chapter 16: Section 16.4 of Text[1])	

Practical sessions and examinations – 30 hours

All the topics mentioned above should be used for practical sessions using SageMath software. Some useful resources for solving these problems using the SageMath software are given against each problem/type of problem.

1. Verifying Cauchy-Riemann equations analytic functions
2. Verifying Laplace equations for certain functions
3. Computing partial fractions of rational functions
4. Finding exact roots of polynomial functions
5. Computing Radius of convergence
6. Taylor series expansions
7. Maclaurin series expansions

A record should be maintained with atleast 7 problems from the main topics/teacher designed topics. Each problem in the record must have a description of the problem, algorithm (step by step procedure), commands used, input given and output obtained accordingly. For the ESE, from the list of above 10 problems, the student should be able to answer two selected (from the 7 available in the record) by the examiner.

Text books

1. Erwin Kreyszig, *Advanced Engineering Mathematics*, 10^{th} Edition, Wiley Publishers, 2018

References

1. Anant R Shastri, *Basic Complex Analysis of One Variable*, Macmillan, 2010.
2. Edward B. Saff, Arthur David Snider, *Fundamentals of Complex Analysis with Applications to Engineering and Science*, 3^{rd} Edition, Pearson Education India, 2017.
3. James Ward Brown and Ruel V Churchill, *Complex Variables And Applications*, Eighth Edition, McGraw Hill International Edition, 2013.
4. John H Mathews and Russel W Howell, *Complex Analysis for Mathematics and Engineering*, Sixth Edition, Jones and Bartlett Publishers, 2012.
5. Murray R Spiegel, Seymour Lipschutz, Schaum's Outline Series, *Complex Variables*, 2009.
6. B S Tyagi, *Functions of A Complex Variable*, Kedar Nath Ram Nath, 2021.

Resources for practical sessions

1. Saskia Roos, Michael Jung, *An Introductory Course on Sage, Lecture Notes* https://www.math.uni-potsdam.de/fileadmin/user_upload/An_Introductory_Course_on_Sage.pdf
2. Sagemath documentation – Symbolic variableshttps://doc.sagemath.org/html/en/reference/calculus/sage/calculus/var.html
3. Tuan A. Le, Hieu D. Nguyen, SageMath Advice for calculus https://users.rowan.edu/~nguyen/sage/SageMathAdviceforCalculus.pdf
4. Sagemath documentation – Sage Quickstart for Multivariable Calculus https://doc.sagemath.org/html/en/prep/Quickstarts/Multivariable-Calculus.html
5. SageMath documentation – 3D Graphics https://doc.sagemath.org/html/en/reference/plot3d/index.html
6. SageMath documentation – Complex plots https://doc.sagemath.org/html/en/reference/plotting/sage/plot/complex_plot.html
7. SageMath documentation – Double precision floating point complex numbers https://doc.sagemath.org/html/en/reference/rings_numerical/sage/rings/complex_double.html
8. Ask SageMath Q & A https://ask.sagemath.org/questions/scope:all/sort:age-desc/tags:complex-analysis/page:1/

Course Outcomes

CO No.	Upon completion of the course the graduate will be able to	PO/PSO	Cognitive Level	Knowledge Category	Lecture(L) Tutorial (T)	Practical (P)
CO 1	Understand complex numbers, analytic functions, Series, Residues and conplex integration	PSO 1, PO1, 2	U	F, C	L	
CO 2	Apply Residue theory to find real integrals	PSO 2, 3, PO2	Ap, An	P	L	
CO 3	Explore applications of complex analysis in various fields	PSO 3, 4, PO2, 3	Ap, An	P	L	
CO 4	Develop problem soving skills	PSO 3, 4, 5, PO2, 3	Ap, An , E	P , M	L	

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

Mapping of CO with PSOs and POs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	-	-	-	-	-	3	3	-	-	-		-	-
CO2	-	3	3		-			3	-	-	-		-	-
CO3		-	3	3	-	-		3	3	-	-		-	-
CO4	-	-	3	3	3	-		2	2	-	-		-	-

(- -Nill, 1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High)

Assessment Rubrics

- Quiz/Assignment/Discussion/Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics

	Internal Examination	Assignment	Project Evaluation	End Semester Exam
CO1	✓			✓
CO2	✓	✓		✓
CO3	✓			✓
CO4	✓	✓		✓

University of Kerala

Discipline	Mathematics				
Course Code	UK3DSCMAT207				
Course Title	Applications of Integration, Special Functions and Fourier Series				
Type of Course	DSC				
Semester	III				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours per week
	4	3	-	2	5
Pre-requisites	1. Differentiation 2. Integration				
Course Summary	This course provides applications of integration, beta and gamma functions and Fourier series				

Detailed Syllabus

Module	Unit	Contents	Hrs
I		**Applications of Integration**	**9**
	1	Area between two curves, Volume by Slicing (Exclude other axes of revolution). Chapter 5: Section 5.1, 5.2 of Text [1]	
	2	Length of the plane curve (exclude finding arc length by numerical methods) Area of surface of revolution Chapter 5: Section 5.4, 5.5 of Text [1]	
II		**Special Functions**	**9**
	3	The Factorial Function, Definition of the Gamma Function; Recursion Relation (Chapter 11: Sections 11.1, 11.2, 11.3 of Text [3])	
	4	The Gamma Function of Negative Numbers, Formulas Involving Gamma Functions (Chapter 11: Sections 11.4, 11.5 of Text [3])	

Module	Unit	Contents	Hrs
	5	Beta Functions, Beta Functions in Terms of Gamma Functions (Chapter 11: Sections 11.6, 11.7 of Text [3])	
III		**Fourier Series- Period 2π**	**9**
	6	Fourier Series, A Basic Example, Euler Formulas without derivation.	
	7	Convergence and Sum of a Fourier Series	
IV		**Fourier Series-Arbitrary Period**	**9**
	8	Arbitrary Period, Even and Odd Functions	
	9	Half-Range Expansions	
V		**Teacher designed module - suggested topics**	**9**
	10	Volume by cylindrical shells (Exclude variations of the method of cylindrical shells) Chapter 5: Section 5.3 of Text [1]	
	11	Calculating work from basic principles[Chapter 5, Section 5.6 of Text 1]	
	12	Fluid Pressure and Force[Chapter 5, Section 5.8 of Text [1]	

Practical sessions and examinations – 30 hours

All the topics mentioned above should be used for practical sessions using SageMath software. Some useful resources for solving these problems using the SageMath software are given against each problem/ type of problems.

1. SageMath – documentation
   https://doc.sagemath.org/html/en/tutorial/introduction.html
2. Online SageMath server https://sagecell.sagemath.org/

A record should be maintained with atleast 7 problems from the main topics/teacher designed topics. Each problem in the record must have a description of the problem, algorithm (step by step procedure), commands used, input given and output obtained accordingly. For the ESE, from the list of above 10 problems, the student should be able to answer two selected (from the 7 available in the record) by the examiner.

Textbook

1. H Anton, I Bivens, S Davis, Calculus, 10th Edition, John Wiley & Sons, 2012.
2. Erwin Kreyszig, Advanced Engineering Mathematics, 10th Edition, Wiley Publishers, 2018.
3. Mary L Boas, Mathematical Methods in Physical Science, 3rd Edition, 2006.

References

1. G B Thomas, R L Finney, Calculus, 9th Edition, Addison-Weseley Publishing Company, 2004.

2. Peter V. O. Neil, Advanced Engineering Mathematics, Thompson Publications, 2007.

Course Outcomes

CO No.	Upon completion of the course the graduate will be able to	PO/PSO	Cognitive Level	Knowledge Category	Lecture(L) Tutorial (T)	Practical (P)
CO 1	Calculate the solution of algebraic and transcendental equation using numerical methods	PO 2, PSO1, 2,3	U, Ap	F,C	L	
CO 2	Apply numerical techniques to interpolate data points effectively	PO1, PSO1, 2,3	U, Ap	F,C	L	
CO 3	Apply numerical techniques for differentiation and integration	PO2, PSO1, 2,3	U, Ap	F,C	L	
CO 4	Calculate the solution of ordinary differential equations using numerical methods	PO2, PSO1, 2,3	U, Ap	F,C	L	

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

Mapping of CO with PSOs and POs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	2	-	-	-	-	3	-	-	-	-	-	-
CO2	3	3	2	-	-	-	3	-	-	-	-	-	-	-
CO3	3	3	2	-	-	-	-	3	-	-	-	-	-	-
CO4	3	3	2	-	-	-	-	3	-	-	-	-	-	-

(- -Nill, 1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High)

Assessment Rubrics

- Quiz/Assignment/Discussion/Seminar
- Midterm Exam

- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics

	Internal Examination	Assignment	Project Evaluation	End Semester Exam
CO1	✓	✓		✓
CO2	✓	✓		✓
CO3	✓	✓		✓
CO4	✓	✓		✓

University of Kerala

Discipline	Mathematics				
Course Code	UK3DSCMAT208				
Course Title	Geometry, Multivariate and Vector Calculus				
Type of Course	DSC				
Semester	III				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical	Total Hours per week
	4	3		2	5
Pre-requisites	1.Differentiation 2. Integration 3. Vectors				
Course Summary	This course enables the students to know the parametric and polar representation of curves, vector-valued functions, partial derivatives multiple integrals and vector fields				

Detailed Syllabus

Module	Unit	Contents	Hrs
I		**Parametric and polar curves: Conic sections**	**9**
	1	Parametric equations: Tangent lines and arc length of parametric curves, Polar coordinates, Tangent lines, arc length and area of polar curves, Conic sections, Conic section in Polar coordinates.	
	Chapter 10: Section 10.1 ,10.2, 10.3, 10.4, 10.6 of Text [1]		
II		**Vector-valued functions**	**9**
	2	Introduction To Vector-Valued Functions, Calculus of Vector-Valued Functions, Arc Length (arc length from the vector view point only), Unit Tangent, Normal Vectors, Curvature.	
	Chapter 12: Section 12.1 to 12.5 of Text [1]		
III		**Partial derivatives**	**9**

Module	Unit	Contents	Hrs
	3	Functions of Two or More Variables, Limits and Continuity (Continuity at Boundary Points and Extensions of Three Variables may be omitted.)	
	4	Partial Derivatives, The Chain Rule (Estimating Partial Derivatives From Tabular Data, Partial Derivatives and Continuity, The Wave Equation may be omitted)	
	Chapter 13: Section 13.1, 13.2, 13.3, 13.5 of Text [1]		
IV	**Multiple integrals**		**9**
	5	Double Integrals, Double Integrals over Non-rectangular Regions (Chapter 14: Section 14.1, 14.2 of Text[1]	
	6	Double Integrals in Polar Coordinates (Chapter 14: Section 14.3 of Text[1])	
	7	Triple Integrals (Chapter 14: Section 14.5 of Text 1). Definition of Triple Integral, Properties of Triple Integrals, Evaluating Triple Integrals over Rectangular Boxes.	
	Chapter 14: Section 14.1, 14.2, 14.3, 14.5, 14.6, 14.7, Chapter 15: Section 15.1, 15.2, 15.3 of Text [1]		
V	**Suggestions for teacher designed module**		**9**
	For internal assessment examinations only.		
	8	Binomial vectors, curvature, motion along a curve Surface area, Parametric surface, Change of variables in multiple integrals, Jacobians Vector fields, line integrals, Independence of paths, Conservative vector fields	
	These topics can be found in Chapter 12 Section 12.4, 12.5, 12.5 Chapter 14 Sections 14.4, 14.7, Chapter 15 sections 15.1, 15.2, 15.3		

Practical sessions and examinations – 30 hours

All the topics mentioned above can be used for practical sessions using SageMath software. Some useful resources for solving these problems using the SageMath software are given against each problem/type of problem.

1. Defining parametric curves
2. Computing tangent lines
3. Finding arc lengths
4. Plotting conic sections
5. Computing unit tangent, normal vectors
6. Computing curvature
7. Sketch the graphs and level surfaces of two variable functions and (using 3 dimensional plot)

8. Evaluate the limit of two variable functions
9. Compute partial derivatives of two/three variable functoins and evaluate them at given points.
10. Evaluate double integrals in rectangular co-ordinates.

A record should be maintained with atleast 7 problems from the main topics/teacher designed topics. Each problem in the record must have a description of the problem, algorithm (step by step procedure), commands used, input given and output obtained accordingly. For the ESE, from the list of above 10 problems, the student should be able to answer two selected (from the 7 available in the record) by the examiner.

Resources for practical sessions

1. SageMath – documentation https://doc.sagemath.org/html/en/tutorial/introduction.html
2. Online SageMath server https://sagecell.sagemath.org/
3. Graphing Functions of two variables using Technology https://doc.sagemath.org/html/en/tutorial/tour_algebra.html
4. Maxima and Minima Of Functions Of Two Variables https://wiki.sagemath.org/interact/calculus#Root_Finding_Using_Bisection
5. Sagemath documentation – Sage Quickstart for Multivariable Calculus https://doc.sagemath.org/html/en/prep/Quickstarts/Multivariable-Calculus.html
6. Tutorial: Vector Calculus in Euclidean Spaces https://doc.sagemath.org/html/en/thematic_tutorials/vector_calculus.html
7. Sagemath documentation – Parametric plots https://doc.sagemath.org/html/en/reference/plot3d/sage/plot/plot3d/parametric_plot3d.html#sage.plot.plot3d.parametric_plot3d.parametric_plot3d

Text books

Text 1 Howard Anton, Irel Bivens, Stephens Davis, *Calculus* 10^{th} *Edition Wiley*, 2012.

References

Ref. 1 Joel Hass, Maurice D. Weir, *Thomas' Calculus Early Transcendentals*, 12th Edition, Addison-Weseley Publishing Company, 2004

Ref. 2 J Stewart, *Calculus with Early Transcendental Functions*, 7th Edition, Cengage India Private Limited, 2008

Ref. 3 G B Thomas, R L Finney, *Calculus*, 9th Edition, Addison-Weseley Publishing Company, 2004.

e-resources

1. https://www.geogebra.org/m/AzVR5uU7

Course Outcomes

CO No.	Upon completion of the course the graduate will be able to	PO/PSO	Cognitive Level	Knowledge Category	Lecture(L) Tutorial (T)	Practical (P)
CO 1	Understands basic concepts of parametric and polar curves, conic section and vector-valued function	PSO1, 2, PO1	R, U	F, C	L, T	
CO 2	Evaluate multiple Integrals	PSO2, PO3, 4	An, Ap	F	L, T	
CO 3	Develop a concrete idea Partial derivatives	PSO1, PO2, 3	U, An	C	L, T	
CO 4	Apply multiple integrals to solve problems	PSO3, PO2	Ap, E	C, P	T	As

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

Mapping of CO with PSOs and POs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	1	-	-	-	-	3	-	-	-	-	-	-
CO2	-	3	-	-	-	-	-	-	1	3	-	-	-
CO3	2	-	-	-	-	-	-	2	2	-	-	-	-
CO4	-	-	2	-	-	-	-	3	-	-	-	-	-

(- -Nill, 1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High)

Assessment Rubrics

- Quiz/Assignment/Discussion/Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics

	Internal Examination	Assignment	Project Evaluation	End Semester Exam
CO1	✓			✓
CO2	✓	✓		✓
CO3	✓			✓
CO4	✓	✓		✓

University of Kerala

Discipline	Mathematics				
Course Code	UK3DSCMAT209				
Course Title	Mathematics in Social Sciences - III				
Type of Course	DSC				
Semester	III				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical	Total Hours per week
	4	4	-	-	4
Pre-requisites	Basic knowlegde of differential calculus				
Course Summary	This course include Integral calculus, Partial Differentiation and Differential equations.				

Detailed Syllabus

Module	Unit	Contents	Hrs
I		**Integral Calculus**	**12**
	1	Simple integration, Basic Definition, basic rule of integration, standard results	
	2	Methods of integration (substitution method only with simple problems), integration by parts (except trigonometeric functionss and logarithmic functions)	
	3	Definite integral, Properties of definite integrals (without problems)	
	Chapter 12: Sections 12.1, 12.2, 12.3, 12.4, 12.5 and 13.3 of Text[1]		
II		**Partial Differentiation**	**12**
	4	Partial derivatives- Technique of partial differentiation, partial differentiation of second order Cross partial differentiation	
	5	Partial derivatives of functions of more than two variables, Maxima and minima of a functions of two variables	

Module	Unit	Contents	Hrs
	Chapter 8: Sections 8.2, 8.3, 8.4, 8.5, 8.10 of Text [1]		
III	**Differential Equations I**		**12**
	6	Definition, Kinds of differential equations, order of differential equation, degree of differential equation, solutions of differential equation.	
	7	Variable separable form, general first order linear differential equation	
	Chapter 14: Sections 14.1, 14.2, 14.3, 14.4, 14.5, 14.6, 14.10, of Text[1].		
IV	**Differential Equations II**		**12**
	8	Linear differential equation with constant Coefficients	
	9	Second order linear differential equations with constant coefficients	
	10	Rules for obtaining particular integral (involving e^x only)	
	Chapter 14: Sections 14.11, 14.12 of Text[1]		
V	**Suggestions for teacher designed module**		**12**
	For internal assessment examinations only.		
	11	Applications of definite integrals, Capital Formaion, compound interest. Application of parial derivatives in Economics. Maxima and minima under given condition (Constrained extreme values) use of Lagrange multiplier first order condition Applications of differential equations: Harrold-Domar model, Domar model.	
	These topics can be found in Chapter 13: Section 13.4, 13.5, 13.6. Chapter 8: Section 8.6, 8.12, Chapter 15: Section 15.3 (A and B) of Text[1]		

Texts

Text 1 B. C. Mehta, G. M. K. Madnani, *Mathematics for Economists*, Sultan Chand & Sons, 2008.

Textbook

Ref. 1 Agarwal B.M, *Business Mathematics and Statistics*, Vikas Publishing House, New Delhi, 2009.

Ref. 2 Allen, R.G.D., *Mathematical Analysis for Economists*, AITBS Publishers, New Delhi, 2008.

Ref. 3 Yamane, Taro, *Mathematics for Economists: An Elementary Survey*, Prentice Hall of India, New Delhi, 2012.

Course Outcomes

CO No.	Upon completion of the course the graduate will be able to	PO/PSO	Cognitive Level	Knowledge Category	Lecture(L) Tutorial (T)	Practical (P)
CO 1	Understand the concepts of integration, Definite integrals and partial derivatives	PSO1, PO1, 3, 8	U	F, C	L	
CO 2	Solve different types of differential equations	PSO3, PO1, 2, 3, 8	U, E,	P, C	L	
CO 3	Applications of differential equations in Domar's models	PSO5, PO1, 2, 3, 4, 5, 6, 7, 8	Ap	C, M	L	
CO 4	Analyse different types of diferential equations	PSO2, PO1, 2, 3, 7	An	C, P	L	

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

Mapping of CO with PSOs and POs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	-	-	-	-	-	3	-	1	-	-	-	-
CO2	-	3	3	-	-	-	1	3	3	-	-	-	-
CO3	-	-	-	-	3	-	2	2	3	2	3	2	1
CO4	-	3	-	-	-	-	2	2	3	-	-	-	1

(- -Nill, 1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High)

Assessment Rubrics

- Quiz/Assignment/Discussion/Seminar
- Midterm Exam

- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics

	Internal Examination	Assignment	Project Evaluation	End Semester Exam
CO1	✓			✓
CO2	✓	✓		✓
CO3	✓			✓
CO4	✓	✓		✓

University of Kerala

Discipline	Mathematics				
Course Code	UK3DSCMAT210				
Course Title	Integral Transform				
Type of Course	DSC				
Semester	III				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours per week
	4	3	-	2	5
Pre-requisites	1. Differentiation 2. Integration				
Course Summary	This course enable the students to gain applications in modelling and solving differential equations				

Detailed Syllabus

Module	Unit	Contents	Hrs
I		**Laplace Transform**	**9**
	1	Laplace Transform, Linearity, First Shifting Theorem (s-Shifting), Existence and Uniqueness of Laplace Transforms[6.1 of Text 1]	
	2	Transforms of Derivatives and Integrals, Excluding Differential Equations and Initial Value Problems [6.2 of Text 1]	
II		**Applications of Laplace Transform**	**9**
	3	Unit Step Function, Second Shifting Theorem, Excluding *Example 3* & *Example 4* [6.3 of Text 1]	
	4	Short Impulses, Dirac's Delta Function, Excluding *Example 3* & *Example 4* [6.4 of Text 1]	
III		**Fourier Series- Period** 2π	**9**
	5	Fourier Series, A Basic Example, Euler Formulas without derivation.	

Module	Unit	Contents	Hrs
	6	Convergence and Sum of a Fourier Series	
IV	**Fourier Series-Arbitrary Period**		**9**
	7	Arbitrary Period, Even and Odd Functions	
	8	Half-Range Expansions	
V	**Teacher designed module - suggested topics**		**9**
	9	Differential Equations, Initial Value Problems[Section 6.2 of Text 1]	
	10	*Example 3* & *Example 4* [Section 6.3 of Text 1]	
	11	*Example 3* & *Example 4* [Section 6.4 of Text 1]	

Practical sessions and examinations – 30 hours

All the topics mentioned above can be used for practical sessions using SageMath software. Some useful resources for solving these problems using the SageMath software are also given below.

1. Defining symbolic functions
2. Differentiating functions and forming differential equations eliminating constants
3. Computing Laplace transforms of functions
4. Computing inverse transforms
5. Computing Fourier series of functions
6. Solving differential equations using desolve

A record should be maintained with atleast 7 problems from the main topics/teacher designed topics. Each problem in the record must have a description of the problem, algorithm (step by step procedure), commands used, input given and output obtained accordingly. For the ESE, from the list of above 10 problems, the student should be able to answer two selected (from the 7 available in the record) by the examiner.

Resources for practical sessions

1. SageMath Documentation - Solving ordinary differential equations https://doc.sagemath.org/html/en/reference/calculus/sage/calculus/desolvers.html
2. Sage Quickstart for Differential Equations https://doc.sagemath.org/html/en/prep/Quickstarts/Differential-Equations.html
3. Saskia Roos, Michael Jung, *An Introductory Course on Sage, Lecture Notes* https://www.math.uni-potsdam.de/fileadmin/user_upload/An_Introductory_Course_on_Sage.pdf
4. Sagemath documentation – Symbolic variableshttps://doc.sagemath.org/html/en/reference/calculus/sage/calculus/var.html

5. SageMath documentatin – Solving equations, Laplace transforms etc https://doc.sagemath.org/html/en/tutorial/tour_algebra.html

6. SageMath Documentation – Fourier series https://doc.sagemath.org/html/en/constructions/calculus.html

7. Tuan A. Le, Hieu D. Nguyen, SageMath Advice for calculus https://users.rowan.edu/~nguyen/sage/SageMathAdviceforCalculus.pdf

8. Sagemath documentation – Sage Quickstart for Multivariable Calculus https://doc.sagemath.org/html/en/prep/Quickstarts/Multivariable-Calculus.html

9. Sagemath documentation – Parametric plots https://doc.sagemath.org/html/en/reference/plot3d/sage/plot/plot3d/parametric_plot3d.html#sage.plot.plot3d.parametric_plot3d.parametric_plot3d

10. SageMath documentation – 3D Graphics https://doc.sagemath.org/html/en/reference/plot3d/index.html

Textbook

1. Erwin Kreyszig, Advanced Engineering Mathematics, 10th Edition, Wiley Publishers, 2018.

References

1. G B Thomas, R L Finney, Calculus, 9th Edition, Addison-Weseley Publishing Company, 2004.

2. Peter V. O. Neil, Advanced Engineering Mathematics, Thompson Publications, 2007.

Course Outcomes

CO No.	Upon completion of the course the graduate will be able to	PO/PSO	Cognitive Level	Knowledge Category	Lecture(L) Tutorial (T)	Practical (P)
CO 1	Calculate the solution of algebraic and transcendental equation using numerical methods	PO 2, PSO1, 2,3	U, Ap	F,C	L	
CO 2	Apply numerical techniques to interpolate data points effectively	PO1, PSO1, 2,3	U, Ap	F,C	L	
CO 3	Apply numerical techniques for differentiation and integration	PO2, PSO1, 2,3	U, Ap	F,C	L	
CO 4	Calculate the solution of ordinary differential equations using numerical methods	PO2, PSO1, 2,3	U, Ap	F,C	L	

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

Mapping of CO with PSOs and POs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	2	-	-	-	-	3	-	-	-	-	-	-
CO2	3	3	2	-	-	-	3	-	-	-	-	-	-	-
CO3	3	3	2	-	-	-	-	3	-	-	-	-	-	-
CO4	3	3	2	-	-	-	-	3	-	-	-	-	-	-

(- -Nill, 1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High)

Assessment Rubrics

- Quiz/Assignment/Discussion/Seminar
- Midterm Exam

- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics

	Internal Examination	Assignment	Project Evaluation	End Semester Exam
CO1	✓	✓		✓
CO2	✓	✓		✓
CO3	✓	✓		✓
CO4	✓	✓		✓

University of Kerala

Discipline	Mathematics				
Course Code	UK3DSCMAT211				
Course Title	Discrete Mathematics				
Type of Course	DSC				
Semester	III				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours per week
	4	4	-	-	4
Pre-requisites	None				
Course Summary	This course enable the students to gain a thourough understanding of various set representations and proof techniques.				

Detailed Syllabus

Module	Unit	Contents	Hrs
I		**Mathematical Logic**	**12**
	1	Proposition and Connectives, Conditional and bi-conditional, Equivalence of proposition *(These topics can be found in Chapter 1 of Text [2])*	
	2	Tautology and Contradiction, Logical implications well-formed formula, Algebra of proposition *(These topics can be found in Chapter 1 of Text [2])*	
	3	De Morgan's law *(This topic can be found in Chapter 1 of Text [1])*	
II		**Proof Methods and Logic**	**12**
	4	Formal Proof, Propositional reasoning by contradiction *(These topics can be found in Chapter 1 of Text [2])*	

Module	Unit	Contents	Hrs
	5	Boolean expressions, Normal forms - Disjunctive normal form, Conjunctive normal form, Principal Conjunctive Normal forms and principal disjunctive normal forms using truth table only *(These topics can be found in Chapter 1 of Text [2])*	
III	**Algebraic Structures**		**12**
	6	Algebra, DeMorgan's Law, Group examples and simple properties (These topics can be found in Text [1])	
	7	Communication Model - coding theory *(These topics can be found in Text [1])*	
IV	**Predicate Logic**		**12**
	8	Quantifiers: Essential and Universal quantifier, Free and Bound Variables *(These topics can be found in Chapter 1 of Text [2])*	
	9	Rules of Specifications: Rule US, ES, UG, EG. Using these, convert a given statement into symbolic notation *(These topics can be found in Chapter 1 of Text [2])*	
V	**Suggestions for the Teacher designed Module**		**12**
	10	Duality theorem *(This topic can be found in Chapter 1 of Text [1])*	
	11	Indirect method of proof *(This topic can be found in Chapter 1 of Text [2])*	
	12	Subgroups examples and simple properties *(This topic can be found in Text [1])*	
	13	Error corrections and detection, Hamming Codes (Avoid computer programs) *(This topic can be found in Text [1])*	
	14	Derivation from Premises using truth table *(This topic can be found in Chapter 1 of Text [2])*	

Textbooks

1. R M Somasundaram, Discrete Mathematical Structures, Prentice Hall of India, 2003.
2. T. Veerarajan, Discrete Mathematics with Graph Theory and Combinatorics, Tata McGraw Hill, 2007.

References

1. Kenneth H Rosen, *Discrete Mathematics and its Applications* (Eighth Edition). Tata McGraw- Hill Education (India) private limited, Special Indian Edition 2021.
2. R.P. Grimaldi, *Discrete Mathematics and Combinatorial Mathematics*, Pearson Edu. India.
3. L. Mohapatra, *Elements of Discrete Mathematics*, Tata McGraw Hill.

4. Gary Haggard, John Schlipf and Sue Whitesides, *Discrete Mathematics for Computer Science*, Thomson Learning Academic Resource Center 1120 Birchmount Road 1-800-423-0563. ISBN 0-534-49501-X.

5. Rajendra Akerkar, Rupali Akerkar, *Discrete Mathematics*, Pearson Education, 2007.

6. B. V. Senthil Kumar and Hemen Dutta, *Discrete Mathematical Structures*, CRC Press, 2020

7. C L Liu, D P Mohapatra, *Elements of Discrete Mathematics*, A Computer oriented approach, Tata McGraw-Hill, 2008

Course Outcomes

CO No.	Upon completion of the course the graduate will be able to	PO/PSO	Cognitive Level	Knowledge Category	Lecture(L) Tutorial (T)	Practical (P)
CO 1	Describe memberships of sets including the empty set, equality, finite, infinite sets, relation be- tween sets using proper notation.	PO 2, PSO 1, 2, 3	U, Ap	F, C	L	
CO 2	Analyse the techniques regard- ing membership, equality, sub- set, and proper subset and two sided implications.	PO 1, PSO 1, 2, 3	U, Ap	F, C	L	
CO 3	Analyse the techniques regard- ing membership, equality, sub- set, and proper subset and two sided implications.	PO 2, PSO 1, 2, 3	U, Ap	F, C	L	
CO 4	Apply appropriate properties of the mathematical logic to prove some principles, theo- rems, formulas on sets. Discuss power sets, products, lattice and Boolean algebra	PO 2, PSO 1, 2, 3	U, Ap	F, C	L	

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

Mapping of CO with PSOs and POs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	2	-	-	-	-	3	-	-	-	-	-	-
CO2	3	3	2	-	-	-	3	-	-	-	-	-	-	-
CO3	3	3	2	-	-	-	-	3	-	-	-	-	-	-
CO4	3	3	2	-	-	-	-	3	-	-	-	-	-	-

(- -Nill, 1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High)

Assessment Rubrics

- Quiz/Assignment/Discussion/Seminar
- Midterm Exam
- Final Exam

Mapping of COs to Assessment Rubrics

	Internal Examination	Assignment	Project Evaluation	End Semester Exam
CO1	✓	✓		✓
CO2	✓	✓		✓
CO3	✓	✓		✓
CO4	✓	✓		✓

University of Kerala

Discipline	Mathematics				
Course Code	UK3DSCMAT212				
Course Title	Vector Calculus				
Type of Course	DSC				
Semester	III				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical	Total Hours per week
	4	3		2	5
Pre-requisites	1. Awareness on polynomials 2. Knowledge on the concepts of functions, differentiation and basic geometry				
Course Summary	This course includes theory of equations, differential calculus, polar co-ordinates and conic sections				

Detailed Syllabus

Module	Unit	Contents	Hrs
I		**Vector Valued Functions**	**9**
	1	Introduction to vector valued Functions, Parametric Curves in 3-Space - The parametric equations (introduction only) vector valued functions (introduction only) vector form of a line segment (introduction only)	
	2	Calculus of vector-valued Functions - Limits and Continuity, Geometric interpretations of limits, Derivatives, Geometric interpretation of the derivative, derivative rules Derivatives of dot and cross products (fundamentals only) Integrals of vector valued functions and integral rules (fundamentals only)	
	Chapter 12: Sections 12.1, 12.2 of Text [1]		

Module	Unit	Contents	Hrs
II	**Tangents and Curvature**		**9**
	3	Unit Tangent, Normal and Binormal vectors (introduction only) Normal and Tangential Components of Acceleration Curvature, radius of curvature,	
	Chapter 12: Section 12.4, 12.5 of Text [1]		
III	**Vector Differentiation**		**9**
	4	Vector fields (Definition), inverse square fields, Gradient fields, Conservative Fields and potential functions, Divergence and Curl, the ∇ operator	
	Chapter 15: Section 15.1 of Text[1]		
IV	**Vector Integration**		**9**
	5	Line integrals, Integrating a vector field along a curve - Exercise Set 15.2- problems 15-30, 33-36, 41-46, Independence of Path; Conservative Vector Fields	
	6	Chapter 15: Section 15.2, 15.3 of Text[1]	
V	**Suggestions for teacher designed module**		**9**
	For internal assessment examinations only.		
	7	Arc length parametrization Motion along a curve Green's Theorem Surface integrals evaluating surface integrals, Flux, evaluation of flux integrals The divergence theorem (without proof) using the divergence theorem to find flux. Stoke's theorem (all without proof) Relationships between Green's theorem and Stoke's theorem	
	These topics can be found in Chapter 12 Sections 12.3, 12.6, Chapter 15 Sections 15.4 to 15.8		

Practical sessions and examinations – 30 hours

All the topics mentioned above can be used for practical sessions using SageMath software. Some useful resources for solving these problems using the SageMath software are given against each problem/type of problem.

1. Defining parametric curves
2. Computing limits of vector valued functions
3. Computing dot products
4. Computing cross product
5. Differentiating dot and cross products
6. Computing unit tangent vector

7. Computing normal vector
8. Computing curvature
9. Sketching vector fields
10. Computing gradient, divergence, curl

Textbook

Text 1 H Anton, I Bivens, S Davis, *Calculus Late Transcendentals*, 10th Edition, John Wiley & Sons.

Resources for practical sessions

1. Sagemath documentation – Introductory Sage Tutorial https://doc.sagemath.org/html/en/prep/Intro-Tutorial.html
2. Saskia Roos, Michael Jung, *An Introductory Course on Sage, Lecture Notes* https://www.math.uni-potsdam.de/fileadmin/user_upload/An_Introductory_Course_on_Sage.pdf
3. Sagemath documentation – Symbolic variableshttps://doc.sagemath.org/html/en/reference/calculus/sage/calculus/var.html
4. Tuan A. Le, Hieu D. Nguyen, SageMath Advice for calculus https://users.rowan.edu/~nguyen/sage/SageMathAdviceforCalculus.pdf
5. Sagemath documentation – Sage Quickstart for Multivariable Calculus https://doc.sagemath.org/html/en/prep/Quickstarts/Multivariable-Calculus.html
6. Sagemath documentation – Parametric plots https://doc.sagemath.org/html/en/reference/plot3d/sage/plot/plot3d/parametric_plot3d.html#sage.plot.plot3d.parametric_plot3d.parametric_plot3d
7. P. Zimmermann *et al*, Computational Mathematics with SageMath, https://www.sagemath.org/sagebook/english.html
8. Gregory V. Bard, Sage for Undergraduates http://www.people.vcu.edu/~clarson/bard-sage-for-undergraduates-2014.pdf
9. SageMath documentation – 3D Graphics https://doc.sagemath.org/html/en/reference/plot3d/index.html

References

Ref. 1 Joel Hass, Maurice D. Weir, *Thomas' Calculus Early Transcendentals*, 12th Edition, Addison-Weseley Publishing Company, 2004.

Ref. 2 J Stewart, *Calculus with Early Transcendental Functions*, 7th Edition, Cengage India Private Limited.

Ref. 3 G B Thomas, R L Finney, Calculus, 9th Edition, Addison-Weseley Publishing Company, 2004.

e-resources

1. https://www.sagemath.org/help.html

Course Outcomes

CO No.	Upon completion of the course the graduate will be able to	PO/PSO	Cognitive Level	Knowledge Category	Lecture(L) Tutorial (T)	Practical (P)
CO 1	Understanding of Vector-Valued Functions and Parametric Curves	PSO 1	U	F, C	L	
CO 2	Ability to Parametrize Curves and Calculate Arc Length	PSO1, PSO2, PSO3, PSO4, PO1, PO2	R, U, E, Ap, An	P, C, F	L	
CO 3	Application of Line and Surface Integrals	PSO2, PSO3, PO1, PO2	U, Ap, E	P, F, C	L	
CO 4	Analyze and solve complex problems involving vector-valued functions and parametric curves in three-dimensional space.	PSO1, PSO2, PSO3, PSO4, PSO6, PO1, PO2, PO3	U, Ap, An, E, C	P, M	L	

(R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create)

(F-Factual, C-Conceptual, P-Procedural, M-Metacognitive)

Mapping of CO with PSOs and POs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	-	-	-	-	-	3	-	-	-	-	-	-	-
CO2	-	3	2	3	-	-	-	3	2	-	-	-	-	-
CO3	3	-	-	-	-	-	3	-	-	-	-	-	-	-
CO4	-	3	3	-	-	-	3	2	-	-	-	-	-	-

(- -Nill, 1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High)

Assessment Rubrics

- Quiz/Assignment/Discussion/Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics

	Internal Examination	Assignment	Project Evaluation	End Semester Exam
CO1	✓			✓
CO2	✓	✓		✓
CO3	✓			✓
CO4	✓	✓		✓

University of Kerala

Discipline	Mathematics				
Course Code	UK3DSCMAT213				
Course Title	Applied Linear Algebra and Integral Calculus with Computational Tools				
Type of Course	DSC				
Semester	III				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours per week
	4	3	-	2	5
Pre-requisites	1. Matrices and determinatnt 2. Integration 3. Linear equations				
Course Summary	This course enable the students to gain an understanding of various applications of linear algebra and integration				

Detailed Syllabus

Module	Unit	Contents	Hrs
I		**Euclidean Vector Spaces**	**9**
	1	Vectors in 2-space, 3-space and n-space, Norm, dot product and distance in $\mathbb{R}^n$, Orthogonality. Sessions 3.1, 3.2, 3.3 of text 1	
	2	The geometry of linear systems, Cross product Sessions 3.4, 3.5 of text 1	
II		**Real vector spaces and bases**	**9**
	3	Real vector spaces, subspaces, linear independence Sessions 4.1, 4.2, 4.3 of text 1	
	4	Coordinate and basis, Dimension, Change of basis Sessions 4.4, 4.5, 4.6 of text 1	
III		**Matrix spaces and diagonalization**	**9**
	5	Row space, column space, Null space, Rank, Nullity, and the Fundamental Matrix Spaces. Sessions 4.7, 4.8 of text 1	

Module	Unit	Contents	Hrs
	6	Eigenvalues and Eigenvectors, Diagonalization. Sessions 5.1, 5.2 of text 1	
IV	**Applications of Integration**		**9**
	7	Area between two curves. Session 5.1 of text 2	
	8	Volumes by slicing; disks and washers. Session 5.2 of text 2	
	9	Length of a plane curve, Area of surface of revolution. Session 5.4, 5.5 of text 2	
V	**Suggestions for teacher designed topics**		**9**
	10	Basic Matrix Transformations in $\mathbb{R}^2$ and $\mathbb{R}^3$, Properties of Matrix Transformations, Geometry of Matrix Operators on $\mathbb{R}^2$	
	11	Volumes by cylindrical shells, Work, Moments, Centers of Gravity and Centroids	

Practical sessions and examinations – 30 hours

All the topics mentioned above should be used for practical sessions using SageMath software. Some useful resources for solving these problems using the SageMath software are given in the references.

1. Plot vectors using plot and plot3d
2. Compute norms and distances
3. Verify orthogonality using the dot product
4. Solving the system of equations and visualizing the solution
5. Compute and plot cross products
6. Compute coordinates in different basis
7. Compute and visualize row/column/null spaces
8. Compute eigenvalues/vectors and diagonlize matrices
9. Plot two functions and find the area of the region enclosed by the curves
10. Visualize the solids of revolution, surface of revolution
11. Estimate the volume of the solid that results when the region enclosed by the curves is revolved about the stated axis.
12. Approximate the area of the surface generated by revolving the curve about the stated axis.
13. Parametrize a curve and use arc length formula

A record should be maintained with atleast 7 problems from the main topics/teacher designed topics. Each problem in the record must have a description of the problem, algorithm (step by step procedure), commands used, input given and output obtained accordingly. For the ESE, from the list of above problems, the student should be able to answer two selected (from the 7 available in the record) by the examiner.

Textbook

1. Elementary linear algebra–application version by *Howard Anton, Chris Rorres*, 11th Edition
2. Calculus by *Howard Anton, Irl Bivens, Stephen Davis*, 10th Edition

References

1. James Stewart–Calculus: Early transcendentals
2. George B.Thomas–Thomas's Calculus
3. Gilbert Strang–Introduction to Linear algebra
4. David C.Lay–Linear algebra and its applications
5. SageMath – documentation https://doc.sagemath.org/html/en/tutorial/introduction.html
6. Online SageMath server https://sagecell.sagemath.org/
7. Solving equations using SageMath https://doc.sagemath.org/html/en/tutorial/tour_algebra.html
8. Sage for undergraduates by Geogory V.Bard (online version)https://www.faculty.luther.edu/~bernatzr/Courses/M351/sage_for_ug_color.pdf
9. Sang-Gu LEE with Jon-Lark KIM, In-Jae KIM, Namyong LEE, Ajit KUMAR, Phong VU, Victoria LANG, Jae Hwa LEE, Linear Algebra Sagebook https://omega0.xyz/omega8008/mat220/LAwithSage.pdf

Course Outcomes

CO No.	Upon completion of the course the graduate will be able to	PO/PSO	Cognitive Level	Knowledge Category	Lecture(L) Tutorial (T)	Practical (P)
CO 1	Understand and apply vector operations, basic geometry of R^n	PO2, PSO1, 2,3	U, Ap	F,C	L	P
CO 2	Analyze real vector spaces, subspaces, linear independence, and perform basis tansformations	PO1, PSO1, 2,3	An, Ap	F,C,P	L	P
CO 3	Compute and interpret the row space, column space, null space, rank, and eigen structures of matrices	PO2, PSO1, 2,3	An, Ap	F,C	L	P
CO 4	Apply integration techniques to compute area, volume and arc lengths	PO2, PSO1, 2,3	E, Ap	C, P	L	P
CO5	Use SageMath effectively to model, visualize adn solve linear algebra and calculus problems	PO2, PSO1	Ap, C	P		P

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

Mapping of CO with PSOs and POs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	2	-	-	-	-	3	-	-	-	-	-	-
CO2	3	3	2	-	-	-	3	-	-	-	-	-	-	-
CO3	3	3	2	-	-	-	-	3	-	-	-	-	-	-
CO4	3	3	2	-	-	-	-	3	-	-	-	-	-	-
CO5	3	3	2	-	-	-	-	3	-	-	-	-	-	-

(- -Nill, 1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High)

Assessment Rubrics

- Quiz/Assignment/Discussion/Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics

	Internal Examination	Assignment	Project Evaluation	End Semester Exam
CO1	✓	✓		✓
CO2	✓	✓		✓
CO3	✓	✓		✓
CO4	✓	✓		✓

————————-DSE————————————

University of Kerala

Discipline	Mathematics				
Course Code	UK3DSEMAT200				
Course Title	Programming with LaTeX and Python				
Type of Course	DSE				
Semester	III				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours per week
	4	3	0	2	5
Pre-requisites	1. Basic computer knowledge				
Course Summary	This course provides basic skill in LaTeX typesetting and python programming				

Detailed Syllabus

Module	Unit	Contents	Hrs
I		**Basics of Type setting using LaTeX**	**9**
	1	Simple typesetting, Fonts, Type size Typesetting Mathematics,	
	2	Typesetting Equations (align, align*, cases), Matrices and Determinants (matrix, pmatrix, bmatrix, vmatrix) Putting one over another (frac, dfrac, int, lim, sum, prod). Chapter 1: Sections 8.1, 8.3.1, 8.3.2, 8.4.2 and 8.4.4 of Text [3].	
II		**Tables, Figures and Presentation**	**9**
	3	Basics of typesetting Theorems and amsthm package (Sections 9.1 to 9.2.1 of Text [3]). Do Exercise questions 4, 5, 6 and 7 of Chapter 9 of Text [3].	
	4	Typesetting basic tables. (Chapter 7: Section 7.2 of Text [3], except the portion using $\backslash renewcommand$)	

Module	Unit	Contents	Hrs
	5	Inserting pictures using Graphicx package (Chapter 12: Section 12.1.1 to 12.1.3 of Text [1], except the portion on pstricks)	
	6	Creating Floating Figures (Chapter 11: Section 11.1.1 of Text [3])	
III	**The Essentials of Python**		**9**
	7	Absolute Basics - Lists, tuples and sets - Strings - Control Flow - Functions (Chapter 4, 5 (Sections 5.6, 5.8 need not be discussed), 6 (Section 6.5 to 6.9 need not be discussed),8, 9.1 to 9.5 (Section 9.3 need not be discussed) and 13.1 to 13.4 of Text [4])	
IV	**Working with numbers**		**9**
	8	Basic Mathematical Operations - Working with different kinds of numbers - Getting user input - Math Programmes - The Programming challenges mentioned in Chapter 1 of Text [1]	
V	**Suggestions for the teacher designed module**		**9**
	9	Beamer Presentation – Set up a Beamer document and enhance it with various options	
	10	Reading and writing files in Python	

Topics and problems for Practical sessions and practical examinations – 30 hours

1. Typesetting complete documents with the following contents:
   (a) different font styles, font sizes
   (b) various greek alphabets
   (c) demonstrating mathematics equations and cases
   (d) demonstrating matrix, determinant styles
   (e) demonstrating dfrac, frac, int, sum, prod
   (f) theorems, examples using amsthm
   (g) tables
   (h) Inserting pictures
2. Writing and running the following programs
   (a) Defining lists and tuples, and accessing elements in it
   (b) Demonstrating varius actions on lists like inserting new elements, deleting, slicing
   (c) Demonstrating how to use if, else, elif, loops
   (d) Problems from mathematics like finding arithmetic mean, gcd (using Euclidean algorithm), checking primality, summing consecutive integers using loops

A record should be maintained with atleast 7 problems from the above. Each problem in the record must have a description of the problem, algorithm (step by step procedure), commands used, input given and output obtained accordingly. For the ESE, from the list of above 10 problems, the student should be able to answer two selected (from the 7 available in the record) by the examiner.

Textbooks

1. Amit Saha, Doing Math with Python, No Starch Press, 2015.
2. Donald Binder and Martin Erickson, A student's guide to the study, practice and tools of modern mathematics, CRC Press, 2010.
3. E. Krishnan, The LaTeX Tutorial: A Primer, by The Tutorial Team, Indian TeX Users Group, Sayahna Foundation, http://www.sayahna.org, 2020.
4. Naomi Ceder, The Quick Python Book, Manning, 2018.

References

1. Dilip Datta, LaTeX in 24 Hours, A Practical Guide for Scientific Writing, Springer, 2017.
2. Hubert Partl, Irene Hyna and Elisabeth Schlegl, The Not So Short Introduction to LaTeX2ϵ, Tobias Oetiker, Version 6.4, 09 March 2021.
3. H J Greenberg, A simplified introduction to LaTeX, 1997, https://ctan.org/tex-archive/info/simplified-latex?lang=en
4. Beamer Presentations: A Tutorial for Beginners, https://www.overleaf.com/learn/latex/Beamer_Presentations%3A_A_Tutorial_for_Beginners_(Part_1)%E2%80%94Getting_Started
5. E Balagurusamy, Introduction to computing and problem solving using Python, Mc Graw Hill Education, 2017.
6. Kenneth A Lambert, Fundamentals of Python, First Programs, 2nd Edition, Cengage, 2019.

E- resources

1. https://www.tug.org/texlive/
2. https://www.python.org/downloads/
3. https://www.overleaf.com/learn/latex/Learn_LaTeX_in_30_minutes
4. https://en.wikibooks.org/wiki/Python_Programming

Course Outcomes

CO No.	Upon completion of the course the graduate will be able to	PO/PSO	Cognitive Level	Knowledge Category	Lecture(L) Tutorial (T)	Practical (P)
CO 1	Understand the basics of LaTeX and python	PSO1, PO7	U	F,C	L	P
CO 2	Create documents and programs	PSO5, PO3	Ap,C	P	L	P
CO 3	Create good quality presentations	PSO5, PO3, 4	Ap, C	P	L	P
CO 4	Apply to the subject and get more insight to the mathematical concepts	PSO2	Ap	M	L	P

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

Mapping of CO with PSOs and POs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	1												3	
CO2					3				2					
CO3			-	-	3				3	3				
CO4		3												

(- -Nill, 1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High)

Assessment Rubrics

- Quiz/Assignment/Discussion/Seminar
- Midterm Exam
- Programming Assignments
- Final Exam (Theory and Practical)

Mapping of COs to Assessment Rubrics

	Internal Examination	Assignment	Project Evaluation	End Semester Exam
CO1	✓	✓		✓
CO2	✓	✓		✓
CO3	✓	✓		
CO4		✓		

University of Kerala

Discipline	Mathematics				
Course Code	UK3DSEMAT201				
Course Title	Numerical Analysis				
Type of Course	DSE				
Semester	III				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours per week
	4	3	-	2	5
Pre-requisites	1. Differentiation 2. Integration 3. Solution of system of equations				
Course Summary	This course enable the students to gain a thorough understanding of various numerical methods used for solving mathematical problems				

Detailed Syllabus

Module	Unit	Contents	Hrs
I		**Solution of Algebraic and Transcendental equations**	**9**
	1	Introduction, Bisection Method, Method of false position. Chapter 2: Section 2.1 to 2.3 of Text[1]	
	2	Iteration Method (excluding acceleration of convergence: Aitken's Δ^2 -process), Newton-Raphson method (excluding generalized Newton's method) . Chapter 2: section 2.4 to 2.5 of Text[1]	
II		**Interpolation**	**10**
	3	Finite differences. Chapter 3: Section 3.3 excluding 3.3.4	
	4	Newton's formulae for interpolation, Central difference interpolation formulae, Chapter 3: Section 3.6, 3.7 of Text[1]	
III		**Numerical Differentiation**	**8**
	5	Numerical differentiation. Chapter 6: Section 6.2 (excluding 6.2.1 and 6.2.2) of Text[1]	

Module	Unit	Contents	Hrs
	6	Maximum and Minimum values of a tabulated function. Chapter 6: Section 6.3 of Text[1]	
IV	**Numerical Integration and Solution of Ordinary Differential equations**		**9**
	7	Numerical integration Chapter 6: Section 6.4.1 to 6.4.4 of Text[1]	
	8	Solution by Taylor's series Chapter 8: Section 8.2 of Text[1]	
	9	Picard's method of Successive Approximations. Chapter 8: Section 8.3 of Text[1]	
V	**Suggestions for the teacher designed module**		**9**
	10	Ramanujan's method, Secant method, Muller's method. Chapter 2: Section 2.6 to 2.8 of Text[1]	
	11	Divided differences and their properties. Chapter 3: Section 3.10 of Text[1]	
	12	Euler's method Chapter 8: Section 8.4 of Text[1]	
	13	Runge- Kutta Methods.Chapter 8: Section 8.5 of Text[1]	

Practical sessions and examinations – 30 hours

All the topics mentioned above should be used for practical sessions using SageMath software. Some useful resources for solving these problems using the SageMath software are given below.

1. SageMath – documentation https://doc.sagemath.org/html/en/tutorial/introduction.html
2. Online SageMath server https://sagecell.sagemath.org/
3. Solving equations using SageMath https://doc.sagemath.org/html/en/tutorial/tour_algebra.html
4. Bisection method https://wiki.sagemath.org/interact/calculus#Root_Finding_Using_Bisection
5. Newton-Raphson method https://www.sfu.ca/~jtmulhol/calculus-applets/html/sagemath-cell-newtonsmethod.html
6. Interpolation problems https://www.youtube.com/watch?v=2lPNfYNSoJA
7. Numerical methods https://www.cfm.brown.edu/people/dobrush/am33/sage/ch3/part3.html

A record should be maintained with atleast 7 problems from the main topics/teacher designed topics. Each problem in the record must have a description of the problem, algorithm (step by step procedure), commands used, input given and output obtained accordingly. For the ESE, from the list of above 10 problems, the student should be able to answer two selected (from the 7 available in the record) by the examiner.

Textbook

1. S.S. Sastry, *Introductory Methods of Numerical Analysis*, Fifth edition, PHI Learning Pvt. Ltd, 2012

References

1. A. C. Faul, *A Concise Introduction to Numerical Analysis* , CRC Press, 2016.
2. Richard L. Burden, J. Douglas Faires,*Numerical Analysis* , Ninth Edition, Cengage Learning, 2011.
3. Timo Heister, Leo G. Rebholz, Fei Xue, *Numerical Analysis An Introduction* , De Gruyter, 2019.
4. Timothy Sauer, *Numerical Analysis*, Third Edition, Perason Education, 2018.

Course Outcomes

CO No.	Upon completion of the course the graduate will be able to	PO/PSO	Cognitive Level	Knowledge Category	Lecture(L) Tutorial (T)	Practical (P)
CO 1	Calculate the solution of algebraic and transcendental equation using numerical methods	PO 2, PSO1, 2,3	U, Ap	F,C	L	
CO 2	Apply numerical techniques to interpolate data points effectively	PO1, PSO1, 2,3	U, Ap	F,C	L	
CO 3	Apply numerical techniques for differentiation and integration	PO2, PSO1, 2,3	U, Ap	F,C	L	
CO 4	Calculate the solution of ordinary differential equations using numerical methods	PO2, PSO1, 2,3	U, Ap	F,C	L	

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

Mapping of CO with PSOs and POs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	2	-	-	-	-	3	-	-	-	-	-	-
CO2	3	3	2	-	-	-	3	-	-	-	-	-	-	-
CO3	3	3	2	-	-	-	-	3	-	-	-	-	-	-
CO4	3	3	2	-	-	-	-	3	-	-	-	-	-	-

(- -Nill, 1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High)

Assessment Rubrics

- Quiz/Assignment/Discussion/Seminar
- Midterm Exam

- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics

	Internal Examination	Assignment	Project Evaluation	End Semester Exam
CO1	✓	✓		✓
CO2	✓	✓		✓
CO3	✓	✓		✓
CO4	✓	✓		✓

University of Kerala

Discipline	Mathematics				
Course Code	UK3DSEMAT202				
Course Title	Discrete Mathematics				
Type of Course	DSE				
Semester	III				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical	Total Hours per week
	4	4	-	-	4
Pre-requisites	None				
Course Summary	This course enable the students to gain a thourough understanding of various set representations and proof techniques.				

Detailed Syllabus

Module	Unit	Contents	Hrs
I		**Sets**	**12**
	1	Sets - Introduction, Venn Diagrams, Subsets, Size of a Set, Power Sets, Cartesian product of Sets, (Chapter 2: Section 2.1 of Text [1])	
	2	Set Operations - Introduction, Set Identities, Generalized Unions and Intersections, (Computer Representation of Sets - avoided). (Chapter 2: Section 2.2 of Text [1])	
II		**Functions**	**12**
	3	Functions - Introduction, One-to-One and Onto Functions, Inverse Functions and Compositions of Functions, The Graphs of Func- tions, Some Important Functions, Partial Functions. (Chapter 2: Section 2.3 of Text [1])	
III		**Sequences and Summations**	**12**
	4	Sequences and Summations - Introduction, Sequences, Recurrence Relations, Special Integer Sequences, Summations. (Chapter 2: Section 2.4 of Text [1])	

Module	Unit	Contents	Hrs
	5	Cardinality of Sets - Introduction, Countable Sets, An Uncount- able Set, SCHRODER-BERNSTEIN THEOREM (Statement), Computable Function. (Chapter 2: Section 2.5 of Text [1])	
IV	**Matrices**		**12**
	6	Matrices - Introduction, Matrix Arithmetic, Transposes and Pow- ers of Matrices, Zero–One Matrices. (Chapter 2: Section 2.6 of Text [1])	
V	**Suggestions for the Teacher designed Module**		**12**
	7	Divisibility and Modular Arithmetic - Introduction, Division, The Division Algorithm, Arithmetic Modulo m, (Chapter 4: Section 4.1 of Text [1])	
	8	Primes and Greatest Common Divisors - Introduction, Primes, THE FUNDAMENTAL THEOREM OF ARITHMETIC, Greatest Common Divisors and Least Common Multiples, The Euclidean Algorithm, gcds as Linear Combinations, BEZOUTS THEOREM (Chapter 4: Section 4.3 of Text [1])	

Textbook

1. Kenneth H. Rosen, *Discrete Mathematics and Its Applications*, (Seventh Edition), Published by McGraw-Hill.

References

1. Richard Johnsonbaugh, *Discrete mathematics*, (Seventh Edition), Pearson Prentice Hall.
2. R.P. Grimaldi, *Discrete Mathematics and Combinatorial Mathematics*, Pearson Edu. India.
3. L. Mohapatra, *Elements of Discrete Mathematics*, Tata McGraw Hill.

Course Outcomes

CO No.	Upon completion of the course the graduate will be able to	PO/PSO	Cognitive Level	Knowledge Category	Lecture(L) Tutorial (T)	Practical (P)
CO 1	Describe membership of sets, subsets, power sets using proper notation; perform the operations of union, intersection, comple- ment, difference and product of sets, and be able to draw and in- terpret Venn diagrams of set rela- tions and operations.	PSO1, 2, 3, PO2	U, Ap	F, C	L	
CO 2	Classify functions into one-one, onto, many-one, into etc. and be able to graph them.	PSO1, 2, 3, PO1	U, Ap	F, C	L	
CO 3	Discuss sequences, summation, recurrence relation, countable and uncountable sets.	PSO1, 2, 3, PO2	U, Ap	F, C	L	
CO 4	Describe different matrices and matrix arithmetics..	PSO1, 2, 3, PO2	U, Ap	F, C	L	

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

Mapping of CO with PSOs and POs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	2	-	-	-	-	3	-	-	-	-	-	-
CO2	3	3	2	-	-	-	3	-	-	-	-	-	-	-
CO3	3	3	2	-	-	-	-	3	-	-	-	-	-	-
CO4	3	3	2	-	-	-	-	3	-	-	-	-	-	-

(- -Nill, 1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High)

Assessment Rubrics

- Quiz/Assignment/Discussion/Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics

	Internal Examination	Assignment	Project Evaluation	End Semester Exam
CO1	✓	✓		✓
CO2	✓	✓		✓
CO3	✓	✓		✓
CO4	✓	✓		✓

University of Kerala

Discipline	Mathematics				
Course Code	UK3DSEMAT203				
Course Title	Probability Theory				
Type of Course	DSE				
Semester	III				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical	Total Hours per week
	4	4		-	4
Pre-requisites	1. Sets, limit and continuity of functions				
Course Summary	This course provides a comprehensive idea on basic probability theory and some standard distributions				

Detailed Syllabus

Module	Unit	Contents	Hrs
I	**Introduction to probability**		**9**
	1	Basic terminology	
	2	Probability	
	Chapter 3: Sections 3.3, 3.4, 3.5, 3.8 of Text [1]		
II	**Random variables and distribution functions**		**9**
	3	Discrete random variable	
	4	Continuous random variable	
	Chapter 5: Sections 5.1, 5.2, 5.3, 5.4 of Text [1]		
III	**Mathematical Expectation**		**9**
	5	Expected value of a random variable	
	6	Expected value of function of a random variable	
	Chapter 6: Section 6.1, 6.2, 6.3, 6.4, 6.5(only the concept of covariance) of the Text [1].		
IV	**Standard Distributions**		**9**

Module	Unit	Contents	Hrs
	7	Discrete uniform distribution, Bernoulli distribution	
	8	Binomial distribution	
	Chapter 8: Sections 8.1,8.2, 8.3, 8.4 (subsections 8.4.1 to 8.4.8), Section 8.5 (subsections 8.5.2 to 8.5.6) and in Chapter 9: Sections 9.2 (subsections 9.2.1 to 9.2.5), Sections 9.5, 9.6 of the Text [1]?		
V	**Suggestions for teacher designed module**		**9**
	For internal assessment examinations only.		
	9	Axiomatic approach to probability Distribution function Properties of expectation and variance, covariance Poisson distribution Normal, Gamma and Beta distributions	
	These topics can be found in Chapter 3 Sections 3.8, Chapter 5 Section 5.1?.....		

Text book

Text 1 S C Gupta and V K Kapoor, *Fundamentals of Mathematical statistics*, 4th Edition, Sultan Chand and Sons, 2005.

References

Ref. 1 R J Larsen and M L Marx, An introduction to Mathematical Statistics and its Applications, 6th edition, Pearson, 2011.

Ref. 2 V K Rohatgi and A K Md Ehsanes Saleh, An Introduction to Probability and Statistics, 2nd edition, John-Wiley, 2001.

Ref. 3 Sheldon Ross, A first course in probability, 5th Edn, Prentice Hall, 1998.

e-resources

1. https://www.sagemath.org/help.html

Course Outcomes

CO No.	Upon completion of the course the graduate will be able to	PO/PSO	Cognitive Level	Knowledge Category	Lecture(L) Tutorial (T)	Practical (P)
CO 1	Understand the different approaches to probability and their properties	PSO 1, 2	U	F, C	L, T	As
CO 2	Develop the idea of random variables, distribution functions and their expectations	PSO2, 3	U,Ap	C, P	L, T	As
CO 3	Create a concrete idea of some standard distributions	PSO2, 3	Ap, An	C, P	L, T	As
CO 4	Apply the knowledge to solve real world problems	PSO4, 5, 6	C	M	L, T	As

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

Mapping of CO with PSOs and POs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	2	-	-	-	-	2	-	1	-	-	-	-	-
CO2	-	2	2	-	-	-	2	-	2	-	-	-	-	-
CO3	-	2	2	-	-	-	-	2	-	-	-	-	-	-
CO4	-	-	-	2	2	2	-	2	-	-	2	2	-	-

(- -Nill, 1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High)

Assessment Rubrics

- Quiz/Assignment/Discussion/Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics

	Internal Examination	Assignment	Project Evaluation	End Semester Exam
CO1	✓			✓
CO2	✓	✓		✓
CO3	✓			✓
CO4	✓	✓		✓

————————-VAC————————

University of Kerala

Discipline	Mathematics				
Course Code	UK3VACMAT200				
Course Title	Introduction to Actuarial Mathematics				
Type of Course	VAC				
Semester	III				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical	Total Hours per week
	3	3			3
Pre-requisites	1. Basics of Probability Theory, including basic concepts like probabilities, events, random variables, expected values, and variance. 2. Fundamentals of algebra, especially for solving equations and manipulating mathematical expressions.				
Course Summary	This course provides a comprehensive overview of key concepts in actuarial mathematics, including probability theory, financial mathematics and insurance principles. Through exploration of topics such as probabilities, interest calculations, life insurance premiums, and annuities, students develop the analytical skills necessary for careers in insurance, finance, and risk management.				

Detailed Syllabus

Module	Unit	Contents	Hrs
I		**Probability**	**10**
	1	Probabilities and events	
	2	Conditional probability Δ and E	

Module	Unit	Contents	Hrs
	3	Random variables	
	4	Expected values	
	5	Variance	
	Chapter 1 of Text [3]		
II	**The Theory of Interest**		**8**
	6	Simple Interest interest	
	7	Compound interest	
	8	Continuously Compounded interest	
	9	Present value	
	Chapter 1 of Text [1]		
III	**Annuity**		**9**
	10	Introduction to annuity	
	11	Types of Annuities	
	12	Amortization	
	Chapter 9 of Text [4]		
IV	**Insurance**		**9**
	13	Life insurance	
	14	Calculating life insurance premiums	
	15	Types of life insurance	
	16	Combined insurance–annuity benefits	
	17	Insurances viewed as annuities	
	Chapter 5 of Text [2]		
V	**Suggestions for teacher designed module**		**9**
	For internal assessment examinations only.		
	18	Time Varying Interest Rates, Rate of Return, Continuous Income Streams, Sinking Fund, General insurance–annuity identity	
	These topics can be found in Chapter 1 of Text [1], Chapter 9 of Text [4], Chapter 5 of Text [2]		

Text Books

Text 1 Buchanan, J. R., An undergraduate introduction to financial mathematics, 2012.

Text 2 Promislow, S. D. . Fundamentals of actuarial mathematics. John Wiley Sons, 2014.

Text 3 Ross, S. M., An elementary introduction to mathematical finance. Cambridge University Press, 2011.

Text 4 Trivedi, K., Business mathematics. Pearson Education India, 2011.

References

Ref. 1 Bowers et al., Actuarial Mathematics, Society of Actuaries, 1997.

Ref. 2 Samuel A. Broverman, Mathematics of Investment and Credit, Actex Learning, 2017.

Course Outcomes

CO No.	Upon completion of the course the graduate will be able to	PO/PSO	Cognitive Level	Knowledge Category	Lecture(L) Tutorial (T)	Practical (P)
CO 1	Examine interest calculations, including simple, compound, and continuously compounded interests, and rate of return evaluations	PSO1, 2	R, U, Ap	F, C		
CO 2	Compare various annuities and apply amortization and sinking funds principles.	PSO-5, 6	R, U, An	P		
CO 3	Develop methods for calculating life insurance premiums and distinguishing between different insurance types.	PSO-1,3	U, An	M		
CO 4	Solve practical problems using statistical and mathematical methods in actuarial contexts	PSO-3,4	C, E	C, P		
CO 5	Apply knowledge to analyze insurance-annuity benefits and explore insurance-annuity identities.	PSO-6	C, Ap, An	P		

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

Mapping of CO with PSOs and POs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	3	-	-	-	-	1	3	3	-	-	-	-	-
CO2	-	-	-	-	3	3	-	-	-	-	-	-	-	-
CO3	2	3	-	-	-	-	-	-	3	-	-	-	-	-
CO4	-	-	3	3	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	3	-	-	-	-	-	-	-	-

(- -Nill, 1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High)

Assessment Rubrics

- Quiz/Assignment/Discussion/Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics

	Internal Examination	Assignment	Project Evaluation	End Semester Exam
CO1	✓			✓
CO2	✓	✓		✓
CO3	✓			✓
CO4	✓	✓		✓

University of Kerala

Discipline	Mathematics				
Course Code	UK3VACMAT201				
Course Title	Project Management and Game Theory				
Type of Course	VAC				
Semester	III				
Academic Level	200-299				
Course Details	Credit	Lecture per week	Tutorial per week	Practical	Total Hours per week
	3	3			3
Pre-requisites	Matrix theory				
Course Summary	After completing the course student get the clear ides of the following, minimizing some measure of performance of a system such as the total completion time for the project, overall cost and so on, types of game theory, Mathematics required for solving game theory, Technique of solving for different types of games.				

Detailed Syllabus

Module	Unit	Contents	Hrs
I		**Critical Path Analysis**	**7**
	1	Network Components and Precedence Relationships	
	Chapter 13: Sections 13.4 of Text [1]		
II		**PERT**	**11**
	2	Project Scheduling with uncertain Activity Time (probability not included)	
	3	Basic Difference Between PERT and CPM	
	Chapter 13: Sections 13.6 and 13.2 of Text [1]		
III		**Games with Saddle Point**	**9**

Module	Unit	Contents	Hrs
	4	Introduction	
	5	Two Person Zero Sum Games	
	Chapter 12: Sections 12.1, 12,2 and 12.3 of Text [1]		
IV	**Games without Saddle Point**		**9**
	6	Rules of Dominance	
	7	Solution Methods of Games without Saddle Point (Arithmetic Method, Matrix Method)	
	Chapter 12: Sections 12.5 and 12.6 of Text [1]		
V	**Suggestions for teacher designed module**		**9**
	For internal assessment examinations only.		
	8	Critical Path Analysis Pure Strategies Solution Methods of Games without Saddle Points (Graphical Method)	
	These topics can be found in Chapter 13 Section 13.5, Chapter 12 Sections 12.3, 12.6		

Text books

Text 1 J K Sharma, *Operations Research - Theory and Applications*, Sixth Edition, 2016.

References

Ref. 1 Hamdy A Taha, *Operations Research an Introduction*, Tenth edition, Pearson, 2016.

Ref. 2 Kanti Swarup, P. K. Gupta, Man Mohan, *Operations Research*, Sultan Chand and Sons, 2005.

Ref. 3 G Srinivasan, *Operations Research*, Principle and Applications, Second Edition, PHI Learning, 2010.

Course Outcomes

CO No.	Upon completion of the course the graduate will be able to	PO/PSO	Cognitive Level	Knowledge Category	Lecture(L) Tutorial (T)	Practical (P)
CO 1	Understant concepts in various Mathematical modelling	PSO1, 2, PO4, 5	U	F, C		
CO 2	Evaluate project completion time in different Network	PSO2, 3, PO1, 2, 3, 5	U, E,	P, F		
CO 3	To find solutions of problems in Game theory	PSO3, 5, PO3	Ap, E	F, P		
CO 4	Apply techniques in Game theory to solve problems Game theory	PSO4, 5	Ap, E	F, P		

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

Mapping of CO with PSOs and POs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	1	-	-	2	-	-	-	-	-	2	4	-	-	-
CO2	2	-	4	1	-	-	2	2	3	-	1	-	-	-
CO3	-	-	3	-	3	-	-	-	3	-	-	-	-	-
CO4	-	-	3	3	-	-	-	-	-	-	-	-	-	-

(- -Nill, 1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High)

Assessment Rubrics

- Quiz/Assignment/Discussion/Seminar
- Midterm Exam
- Programming Assignments
- Final Exam

Mapping of COs to Assessment Rubrics

	Internal Examination	Assignment	Project Evaluation	End Semester Exam
CO1	✓			✓
CO2	✓	✓		✓
CO3	✓			✓
CO4	✓	✓		✓

University of Kerala

May 2024

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