



Adamas University
School of Basic and Applied Sciences
Department of Mathematical Sciences

Programme Structure and Syllabus
of
B.Sc (Mathematics and Computing)

Programme Code: MTH3404
Duration: 4 Years Full Time
Academic Year: 2026-27

Vision of the University

To be an internationally recognized university through excellence in inter-disciplinary education, research and innovation, preparing socially responsible well-grounded individuals contributing to nation building.

Mission of the University

- Improve employability through futuristic curriculum and progressive pedagogy with cutting-edge technology
- Foster outcomes-based education system for continuous improvement in education, research and all allied activities
- Instill the notion of lifelong learning through culture of research and innovation
- Collaborate with industries, research centers and professional bodies to stay relevant and up-to-date
- Inculcate ethical principles and develop understanding of environmental and social realities

Core Values

- Respect
- Positivity
- Commitment
- Accountability
- Innovation

Vision of the School

To be recognized globally as a provider of education in Basic and Applied Sciences, fundamental and interdisciplinary research.

Mission of the School

- Develop solutions for the challenges in sciences through value-based science education.
- Conduct research leading to innovation in sciences.
- Nurture students into scientifically competent professionals in the usage of modern tools.
- Foster in students, a spirit of inquiry and collaboration to make them ready for careers in teaching, research and corporate world.

Vision of the Department

To create a Centre of academic excellence in Mathematics and Statistics through active teaching-learning and collaborative research

Mission of the Department

- Deliver graduates with considerable Mathematical and Statistical skills along with real-world problem-solving ability.
- Create a framework to nurture students through outcome-based education towards building a strong foundation in mathematical sciences for academia and industry.
- Conduct fundamental and cutting-edge collaborative research on mathematical and interdisciplinary fields.
- Contribute towards development of mathematical foundation in pan-university level.

Programme Educational Objectives (PEO) of B.Sc (Mathematics and Computing):

PEO 01 Graduates will pursue higher education/research in recognized national/international institutes.

PEO 02 To prepare students with knowledge, abilities and insight in mathematics and related fields.

PEO 03 Graduates will work effectively as individuals and as team members in multidisciplinary projects.

PEO 04 Be able to formulate, investigate and analyze scientifically real-life problems along with ethical attitude.

PEO 05 To facilitate students to recognize the need for and the ability to engage in life-long learning.

Programme Outcomes (POs) and Programme Specific Outcomes (PSOs) of B.Sc (Mathematics and Computing)

Students of all undergraduate general degree Programmes at the time of graduation will be able to have

PO1	Academic Excellence	Apply theoretical knowledge of Mathematics for the solution of different problems related to science and technology.
PO2	Contextualized Understanding	Develop mathematical concepts in all the fields of learning and recognize the need in science and technology.
PO3	Critical Thinking and Problem-Solving Skills	Investigate various problems with effective solutions or techniques to crack competitive examinations and higher studies.
PO4	Problem Analysis	Identify, formulate and analyze complex problems using mathematical principles.
PO5	Modernization and Tools Usage	Design and solve critical problems using sophisticated mathematical modelling with modern tools and programming skills.
PO6	Societal Implication	Analyze complex social elements, their interrelation and its impact on geographically different society.
PO7	Environment and Sustainability	Design a system, component, or process to meet desired needs within realistic constraints such as environmental, health, safety, manufacturability, and sustainability.
PO8	Ethics	Understand ethical principle and commit to professional ethics, responsibly and norms in the society.
PO9	Individual and Team Work	Work as an individual or in teams on multi-disciplinary projects in research organizations, industries and participate in academic discussion.
PO10	Communication	Build up effective communication skills, both written and verbal, to specialized and non-specialized audiences.
PO11	Leadership Skills	Undertake a major, individual, mathematics-related project and discuss the results in a full scientific report with a presentation.
PO12	Life Long Learning	Develop the ability to reasoning, abstract thinking, critically evaluate theories, methods, principles, and applications of pure and applied science.
PSO1		Understand basic concepts of mathematics to develop problem solving skills which are required for higher education and get placed in gov./ private organizations.
PSO2		Develop deeper understanding and expanded knowledge in pure mathematics.
PSO3		Apply mathematical methods to other disciplines such as physics, engineering, computer science.

**School of Basic and Applied Sciences
Department of Mathematical Sciences**

B.Sc (Mathematics and Computing)

Undergraduate Course Structure & Syllabuses



School of Basic and Applied Sciences
Department of Mathematical Sciences

Programme Name: B.Sc (Mathematics and Computing)
Programme Code: MTH3404

Undergraduate Course Structure
Batch: 2026-2030

SCHOOL OF BASIC AND APPLIED SCIENCES
UNDERGRADUATE COURSE STRUCTURE
B.Sc (Mathematics and Computing)

SEMESTER I								
SL. No	Type of Course	Code	Title of the Course	Credit Distribution				Remarks
				L	T	P	C	
1	CC	MTH102	Calculus	3	0	1	4	CC-1
2	CC	MTH107	Algebra	3	1	0	4	CC-2
3	Minor	IKS101	Introduction to Indian Knowledge System	4	0	0	4	
4	MDC						3	
5	AEC	AEC101	Communicative English I	2	0	0	2	
6	AEC		Foreign Language I	2	0	0	2	Spanish/ German/ French
7	VAC	VAC101	Environmental Education-I	2	0	0	2	
8	SEC	GEN102	Principles and Applications of AI	2	0	0	2	
Total Semester Credit							23	
SEMESTER II								
SL. No	Type of Course	Code	Title of the Course	Contact Hours Per Week				Remarks
				L	T	P	C	
9	CC	MTH103	Real Analysis	3	1	0	4	CC-3
10	CC	MTH104	Ordinary Differential Equation	3	0	1	4	CC-4
11	Minor	GEN104	Basic Cyber Security and Internet of Things (IOT)	4	0	0	4	
12	MDC						3	
13	AEC	AEC102	Communicative English II	2	0	0	2	
14	AEC		Foreign Language II				2	Spanish/ German/ French
15	VAC	VAC105	Community Engagement and Social Responsibility	1	0	1	2	
16	SEC						2	
17	SEC	CLL103	Soft Skills and Aptitude I	1	0	0	1	Soft Skills and Aptitude
Total Semester Credit							24	

*MDC, AEC, VAC, and SEC are Pan-University level courses offered by different departments of the university. Students have to select one of the courses of each type from the list provided at the beginning of the semester.

**Minor subjects are also offered as Pan-University subjects. A student will obtain a degree with a 'Minor' in a subject if the student studied and obtained at least 16 credits (4 courses) in that subject.

*** L: Lecture Hour, T: Tutorial Hour, P: Practical Hour, C: Credit of the course

SEMESTER III								
SL. No	Type of Course	Code	Title of the Course	Contact Hours Per Week				Remarks
				L	T	P	C	
18	CC	MTH207	Discrete Mathematics	3	1	0	4	CC-5
19	CC	MTH205	Multivariate Calculus	3	0	1	4	CC-6
20	Minor						4	
21	MDC						3	
22	VAC	VAC102	Human Values and Ethics	2	0	0	2	
23	SEC						2	
24	SEC	CLL203	Soft Skills and Aptitude II	1	0	0	1	Soft Skills and Aptitude
Total Semester Credit							20	
SEMESTER IV								
SL. No	Type of Course	Code	Title of the Course	Contact Hours Per Week				Remarks
				L	T	P	C	
25	CC	MTH201	Linear Algebra	3	1	0	4	CC-7
26	CC	MTH208	Linear Programming and Game Theory	3	0	1	4	CC-8
27	CC	CSE281	Data Structure	3	0	1	4	CC-9
28	Minor						4	
29	VAC						2	
30	SEC						2	
31	SEC	CLL204	Soft Skills and Aptitude III	1	0	0	1	Soft Skills and Aptitude
Total Semester Credit							21	
SEMESTER V								
SL. No	Type of Course	Code	Title of the Course	Contact Hours Per Week				Remarks
				L	T	P	C	
32	CC	MTH301	Numerical Methods	3	0	1	4	CC-10
33	CC	MTH304	Complex Analysis	3	1	0	4	CC-11
34	CC	CSE382	Design and Analysis of Algorithm	3	0	1	4	CC-12
35	Minor						4	
36	SEC						2	
37	SEC	CLL303	Soft Skills and Aptitude IV	1	0	0	1	Soft Skills and Aptitude
38	INT	MTH350	Internship (Summer Project)				2	
Total Semester Credit							21	

SEMESTER VI								
SL. No	Type of Course	Code	Title of the Course	Contact Hours Per Week				Remarks
				L	T	P	C	
39	CC	CSE381	Operating Systems	3	0	1	4	CC-13
40	CC	MTH305	Integral Transform and Partial Differential Equations	3	1	0	4	CC-14
41	CC	MTH309/ MTH310/ SDS308	Computational Number Theory/Soft Computing/Machine Learning and Applications	3	0	1	4	CC-15
42	CC	MTH311	Tools and Techniques for Scientific Report Writing	0	0	2	2	CC-16
43	Minor						4	
44	SEC						2	
45	SEC	CLL304	Soft Skills and Aptitude V	1	0	0	1	Soft Skills and Aptitude
46	Project	MTH351	Project				4	
Total Semester Credit							25	
Total Credit After 3 rd Year							134	
SEMESTER VII								
SL. No	Type of Course	Code	Title of the Course	Contact Hours Per Week				Remarks
				L	T	P	C	
47	CC	MTH409	Optimization Techniques	3	0	1	4	CC-17
48	CC	MTH410	Mathematical Modelling and Simulation	3	0	1	4	CC-18
49	CC	CSE483	Cloud Computing	3	0	1	4	CC-19
50	CC (For With research)	MTH450	Research Methodology	3	1	0	4	CC-21 (With Research)
51	CC (For Without research)	SDS402/ MTH411/ MTH405	Advanced Machine Learning and Applications/Cryptography and Network Security/Operations Research	3	0	1	4	CC-22 (without Research)
52	Minor						4	
53	SEC	CLL405	Soft Skills and Aptitude VI				1	Soft Skills and Aptitude
Total Semester Credit							21	

SEMESTER VIII								
SL. No	Type of Course	Code	Title of the Course	Contact Hours Per Week				Remarks
				L	T	P	C	
54	CC	MTH408	Computational Matrix Theory	3	0	1	4	CC-20
55	CC (For Without research)	MTH412/ CSE484/ MTH413/ CSE485	Calculus of Variation and Integral Equations/Network Theory/ Numerical Methods for ODE and PDE/Computer Graphics	3 3 3 3	1 1 0 0	0 0 1 1	4	CC-23 (without Research)
56	CC (For Without Research)	MTH414/ MTH415/ SDS456	Advanced Graph Theory/ Dynamics of a Particle /Artificial Intelligence	3 3 3	1 1 0	0 0 1	4	CC-24 (without Research)
57	Minor						4	
58	Minor (For without research)						4	
59	Dissertation	MTH499	Project/Dissertation				12	
Total Semester Credit							20	
Total Credit After 4th Year							175	

*NOTE: With research is only allowed for Students *who secure 75% marks and above in the first six semesters*

Credit Distribution

Semester	Credit for the Following Types of Courses						
	Core Course (CC)	Minor Course	Multi-Disciplinary Course (MDC)	Ability Enhancement Course (AEC)	Value Added Course (VAC)	Skill Enhancement Course (SEC)	Project/Research Project/ Dissertation/ Internship
I	8	4	3	4	2	2	-
II	8	4	3	4	2	3	-
III	8	4	3	-	2	3	-
IV	12	4	-	-	2	3	-
V	12	4	-	-	-	3	2
VI	14	4	-	-	-	3	4
VII	16	4	-	-	-	1	-
VIII	4 (for with Research) 12 (for without Research)	4 (for with Research) & 8 (for without Research)	-	-	-	-	12 (for with Research)
Total Credit	82 (for with Research) 90 (for without Research)	32 (for with Research) 36 (for without Research)	9	8	8	18	18 (for with Research) 6 (for without Research)

****Total Credit attributed to Major is 94 (for with Research) and 90 (for without Research).**

Course Title	Calculus
Course Code	MTH102
Credit	4
Contact Hours (L-T-P)	3-0-1
Course Type	Hybrid
Prerequisites	10+2th Level Mathematics

Course Objectives:

The objectives of this course are as follows:

- To make students understand the concept of differentiation.
- To enable students to solve definite and indefinite integrals.
- To make students understand the concept of improper integrals, criteria of convergency, and Beta-Gamma functions.
- To make students understand the application of differentiation and integration.

Course Outcomes:

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

CO1: Recall basic concepts of differentiations and integrations

CO2: Explain indeterminate forms, maxima/minima, and concavity/convexity and interpret the convergence of improper integrals

CO3: Apply Mean Value Theorem, successive differentiation and optimization techniques including reduction formulae to solve mathematical problems

CO4: Analyze definite and indefinite integrals, and apply integration techniques

CO5: Evaluate improper integrals and analyze convergence conditions

CO6: Design mathematical models and solve real-world problems involving curve tracing, asymptotes, envelopes, curvature, arc length, and area in Cartesian and polar coordinates

Course Description:

This course provides an in-depth exploration of key concepts in differentiation and integration. Throughout the course, students will develop critical thinking and problem-solving skills, preparing them for advanced studies in mathematics and related fields. The course combines theoretical insights with practical applications, ensuring a comprehensive understanding of the material.

Course Content:

Module I [12L]

Differentiation: Successive differentiation, Leibnitz's rule, Mean Value Theorem, Taylor's and Maclaurin's theorems with remainder term, indeterminate form, Convexity, Concavity, point of inflexion, Maximum and minimum of functions of single variable

Module II [15L]

Integrals: Review of integration, Fundamental theorem of integral calculus, Reduction formulae

Improper Integration: Definition, types of improper integration, necessary and sufficient condition for convergence; Comparison and M-test, Abel's and Dirichlet's test for convergence (statement only), Beta and Gamma function

Module III**[18L]**

Applications: Curvature, circle of curvature and Radius of curvature, Evolute and Involute of a Curve, Envelope of a Family of Curves, Asymptotes, Curve tracing;
Length of plane curves, evaluation of area, area included between two curves, area in polar coordinates, Volume of Solids, Surface Area of a Solid of Revolution

Practical/Lab to be performed on a computer using MATLAB/Python/SageMath programming:

Write and execute MATLAB/Python / SageMath -code for the following programs:

1. Symbolic differentiation of algebraic, exponential, logarithmic and trigonometric functions
2. Evaluating extremum of a single variable function
3. Evaluation of indefinite integrals using symbolic computation
4. Evaluating area under the curve
5. Plotting asymptotes and envelopes of curves
6. Compute and visualize curvature and radius of curvature

Text Books:

- T1. Shanti Narayan, Differential Calculus. S. Chand publishers
- T2. Shanti Narayan, P.K. Mittal, Integral Calculus, S. Chand.
- T3. K. C. Maity and R. K. Ghosh, Differential Calculus, An Introduction to Analysis, 2011.
- T4. K. C. Maity, R. K. Ghosh, Integral Calculus, New Central Book Agency, 2024.

Reference Books:

- R1. B. N. Mukherjee, B. C. Das, Key to Differential Calculus, U N Dhur & Sons.
- R2. S. C. Malik and S. Arora, Mathematical Analysis, New Age International (P) Ltd.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Mapping COs with POs & PSOs:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1	2	1	1	1	1	2	2	1	1	3	2	2
CO2	3	3	2	3	2	1	1	1	2	2	2	2	3	2	2
CO3	3	3	3	3	3	2	1	1	2	2	2	2	3	2	3
CO4	3	3	2	3	3	2	1	1	2	2	2	1	3	3	2
CO5	3	3	3	3	3	2	1	1	2	2	2	2	3	3	3
CO6	3	3	3	3	3	3	2	2	3	3	3	3	3	3	3
	2.83	2.83	2.33	2.83	2.50	1.83	1.17	1.17	2.17	2.17	2.00	1.83	3.00	2.50	2.50

Course Title	Algebra
Course Code	MTH107
Credit	4
Contact Hours (L-T-P)	3-1-0
Course Type	Theory
Prerequisite	10+2 Mathematics

Course Objectives:

The objectives of this course are as follows:

- To introduce students to fundamental algebraic structures such as binary operations, groups, subgroups, cyclic groups, and permutation groups.
- To develop an understanding of important concepts and results in group theory, including cosets, Lagrange's theorem, normal subgroups, and factor groups.
- To introduce the basic concepts of ring theory, including rings, integral domains, fields, ideals, and ring homomorphisms.
- To develop students' ability to apply fundamental algebraic theorems and techniques to solve mathematical problems.
- To provide a foundation in algebra that supports further study in mathematics, discrete mathematics, number theory, cryptography, and mathematical computing.

Course Outcomes:

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

CO1. Define the basic algebraic structures such as binary operations, groups, subgroups, and Abelian groups, including fundamental concepts like identity, inverse, and order of elements.

CO2. Analyze permutations and cyclic groups, utilize cycle notation, understand even and odd permutations, and apply Lagrange's theorem to study subgroup properties.

CO3. Understand the advanced group concepts, including normal subgroups, factor groups, and group homomorphisms and isomorphisms

CO4. Apply key theorems like Cauchy's theorem for finite Abelian groups.

CO5. Define ring-theoretic structures such as rings, integral domains, division rings, and fields.

CO6. Analyze the concept of homomorphisms, ideals, kernels, and images within ring theory.

Course Description:

This course introduces the fundamental concepts and structures of abstract algebra, with emphasis on group theory and ring theory. The course begins with binary operations and elementary algebraic structures, followed by groups, subgroups, cyclic groups, permutation groups, cosets, and Lagrange's theorem. It further develops the concepts of normal subgroups, factor groups, group homomorphisms, and isomorphisms. The course also introduces ring-theoretic structures, including rings, integral domains, division rings, fields, ideals, and ring homomorphisms. The course emphasizes logical reasoning, theorem-based problem solving, and the application of fundamental algebraic results.

Course Content:

Module I**[20L]**

Binary operations: Definitions and examples, commutative and associative binary operations, identity and inverse element, Basic concept, definition of groupoid, semi-group, monoid, Group, Abelian group, examples of groups, Klein's 4 group, order of an element of a group, order of a group, Subgroups and related results.

Module II**[15L]**

Coset and Lagrange's theorem: Permutation groups and quaternion groups, Cycle notation for permutations, properties of permutations, even and odd permutations, alternating group, Cyclic group and its properties, classification of subgroups of cyclic groups, properties of cosets, Lagrange's theorem

Module III**[10L]**

Normal subgroup: Definition with its properties, factor groups and related theorems, Cauchy's theorem for finite abelian groups, Group homomorphism and isomorphism theorems

Module IV**[15L]**

Rings and fields: rings, domains, integral domains, division rings, fields, Subrings, Zero Divisors, characteristic and other fundamental ring theoretic topics, ideals and ring homomorphisms, kernel and image of a homomorphism, properties of ring homomorphism.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text Books:

- T1. S. K. Mapa, *Higher Algebra*, Sarat book house, 2025.
- T2. John B. Fraleigh, *A First Course in Abstract Algebra*, Pearson, 2013.
- T3. D. S. Dummit and R. M. Foote, *Abstract Algebra*, 3rd Ed., Wiley, 2003.
- T4. Sen, Ghosh and Mukhopadhyay, *Topics in abstract algebra*, University press, 2022.
- T5. Ghosh and Chakroborty, *Higher algebra*, U N Dhur & Sons, 2024.

Reference Books:

- R1. I. N. Herstein, *Topics in algebra*, Wiley India Pvt Ltd.
- R2. M. Artin, *Abstract Algebra*, 2nd Ed., Pearson, 2024.
- R3. Joseph A. Gallian, *Contemporary Abstract Algebra*, 9th Ed., Cengage Learning, 2017.

Mapping COs with POs & PSOs:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1	2	1	1	1	1	2	2	1	1	3	2	2

CO2	3	3	2	3	2	1	1	1	2	2	2	2	3	2	2
CO3	3	3	3	3	3	2	1	1	2	2	2	2	3	2	3
CO4	2	3	3	3	1	1	1	1	2	2	2	1	3	3	2
CO5	3	3	2	3	3	2	1	1	2	2	3	2	2	3	3
CO6	3	3	3	3	3	3	2	2	3	3	3	3	3	3	3
	2.67	2.83	2.33	2.83	2.17	1.67	1.17	1.17	2.17	2.17	2.17	1.83	2.83	2.50	2.50

Course Title	Real Analysis
Course Code	MTH103
Credit	4
Contact Hours (L-T-P)	3-1-0
Course Type	Theory
Prerequisite	10+2 Mathematics

Course Objectives:

The objectives of this course are as follows:

- To make students understand the concept of real line with its core properties
- To make students understand the concept of series and sequences
- To make students understand the concept of continuity and differentiability of real functions

Course Outcomes:

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

CO1: Define properties of real numbers and basic topological concepts

CO2: Explain concepts of bounded/unbounded sets and Bolzano-Weierstrass theorem

CO3: Analyze sequences, limits, subsequences, and monotone sequences

CO4: Evaluate convergence of series and use convergence tests

CO5: Design and solve complex problems involving power series and convergence

CO6: Explain the concept of continuity and differentiability of real functions

Course Description:

This course provides a depth knowledge of real numbers with its various properties which helps us to understand the applicability in various fields. Here student can learn the core techniques of sequence and series which they can apply in other aspects of mathematics.

Course Content:

Module I **[10L]**

Real number system: Mapping, Functions, Field Axioms, ordered field, bounded set, least upper bound (supremum) and greatest lower bound (infimum), completeness axiom, Characterization of $\mathbb{R}$ as a complete ordered field, Archimedean property of $\mathbb{Q}$ and $\mathbb{R}$

Module II **[15L]**

Sets in $\mathbb{R}$: Countable, Uncountable sets; Intervals, the neighborhood of a point, interior point, open set, limit point and isolated point, closed set, closure of a set, Bolzano-Weierstrass theorem on limit point.

Module III **[20L]**

Sequences of real numbers: Definition, bounded sequence, limit of a sequence, convergence and non-convergence, algebra of limits, subsequence, limit supremum and limit infimum, monotone sequences and their convergence

Series of real numbers: Definition, Cauchy convergence criterion, positive term series, geometric series, comparison test, limit form, convergence of p-series, various test for convergence of a series, alternating series, Leibnitz's test (statement only), Absolute and conditional convergence with related results; Power series

Module IV

[15L]

Continuity and Differentiability: Continuity of a function on an interval and at an isolated point. Sequential criteria for continuity. Concept of oscillation of a function at a point. Algebra of continuous functions as a consequence of algebra of limits. Continuity of composite functions. Examples of continuous functions. Bounded functions. Neighborhood properties of continuous functions regarding boundedness and maintenance of same sign. Continuous function on $[a,b]$ is bounded and attains its bounds. Intermediate value theorem. Discontinuity of functions, type of discontinuity. Step functions. Piecewise continuity. Differentiability of a function at a point and in an interval, Darboux theorem.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text Books:

- T1. S.K. Mapa, Introduction to Real Analysis, 7th Edition, Sarat Publishers, India, 2025.
- T2. S.C. Malik and S Arora, Mathematical Analysis, New Age International Private Limited, 2017.
- T3. S. Bandyopadhyay, Mathematical Analysis, Academic Publishers.

Reference Books:

- R1. R.G. Bartle and D. R. Sherbert, Introduction to Real Analysis (3rd Edition), John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2025.
- R2. R.K. Ghosh and K.C Maity, An Introduction to Analysis: Differential Calculus: Part I, 2011

Mapping COs with POs & PSOs:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1	2	1	1	1	1	2	2	1	1	3	2	2
CO2	3	3	2	3	2	1	1	1	2	2	2	2	3	2	2
CO3	3	3	3	3	3	2	2	1	2	2	2	2	3	3	3
CO4	3	3	3	3	3	2	1	1	2	2	2	2	3	3	3
CO5	3	3	3	3	3	2	1	1	2	2	2	1	3	3	3
CO6	3	3	3	3	3	3	2	2	3	3	3	3	3	3	3
	2.83	2.83	2.50	2.83	2.50	1.83	1.33	1.17	2.17	2.17	2.00	1.83	3.00	2.67	2.67

Course Title	Ordinary Differential Equation
Course Code	MTH104
Credit	4
Contact Hours (L-T-P)	3-0-1
Course Type	Hybrid
Prerequisites	Differential Calculus

Course Objectives:

The objective of this course is as follows:

- To provide students the basic concept of differential equations
- To develop skill for solving and applying first order ordinary differential equations.
- To provide skill related to solve higher order ordinary differential equations.
- To aware student about different real-life applications

Course Outcomes:

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

- CO1:** Define key concepts related to first-order and higher-order differential equations, Wronskian, and power series solutions.
- CO2:** Explain the existence and uniqueness theorems, orthogonal trajectories, and the classification of points in power series solutions.
- CO3:** Apply different methods to solve ordinary differential equations arising in theoretical and practical problems.
- CO4:** Analyze the structure of differential equations and determine appropriate solving techniques based on their characteristics.
- CO5:** Evaluate the stability and correctness of solutions to differential equations using Wronskian, singular points analysis, and eigenvalue problems in Sturm–Liouville theory.
- CO6:** Formulate and solve real-life problems through first-order and higher-order ordinary differential equations by applying suitable analytical methods.

Course Description:

Understanding of ordinary differential equation plays an important role to understand real life phenomenon. The course deals with different types of first order differential equation and their solutions with applications in biological, physical and engineering problems. This course also deals with second and higher order ordinary differential equations. The concept of eigenvalue problems in Sturm–Liouville theory is also included in this syllabus. After the successful completion of this course student may formulate some physical models in the form of ordinary differential equation and may solve by suitable method.

Course Content:**Module I: First order linear differential equation [12L]**

Overview of differential equation, first order ordinary differential equation, Existence and Uniqueness theorem, exact differential equations, integrating factors; first order linear differential equation and Bernoulli's equations; Applications of first order differential equations to Newton's law of cooling, exponential growth and decay problems.

Module II: First order non-linear differential equation [8L]

Differential equation of first order but not first degree; equations solvable for p, y, x ; Clairaut's equation; singular solutions and its geometric meaning; orthogonal trajectories and related problems

Module III: Higher order linear differential Equation [15L]

Higher order linear differential equations with Constant Coefficients, Wronskian, Complementary function, Particular integral, method of variation of parameters, Linear differential equations with variable coefficients, Cauchy-Euler's equation, Two-point boundary value problems; Systems of first order linear differential equations, Sturm–Liouville equation, eigen functions and eigen values

Module IV: Formulation and Analysis of Mathematical Models [10L]

Introduction to compartmental models, Lake pollution model; Density-dependent growth model, Interacting population models, Predator-prey model and its analysis, Equilibrium points.

Practical (30 hours)- Practical / Lab work to be performed in a Computer Lab:

Modeling of the following problems using MATLAB/Python Code

1. Solutions of first, second and third order differential equations.
2. Plotting of family of solutions of differential equations of first, second and third order.
3. Solution of differential equations using method of variation of parameters.
4. Growth and decay model (exponential case only).
5. Lake pollution model (with constant/seasonal flow and pollution concentration).
6. Density-dependent growth model.
7. Predatory-prey model (basic Volterra model)

Evaluation:

Mode of Evaluation	Hybrid		
	Comprehensive and Continuous Assessment	Mid Semester Examination	End Semester Examination
	30%	20%	50%

Text Books:

- T1. M.D. Raisinghania, Ordinary and Partial Differential Equations, S Chand Publishing, 2024.
- T2. S. L. Ross, Differential Equations, John Wiley and Sons, India, 2018.
- T3. Barnes, Belinda & Fulford, Glenn R. (2015). Mathematical Modeling with Case Studies, Using Maple and MATLAB (3rd ed.). CRC Press. Taylor & Francis Group.
- T4. Edwards, C. Henry, Penney, David E., & Calvis, David T. (2015). Differential Equations and Boundary Value Problems: Computing and Modeling (5th ed.). Pearson Education.

Reference Books:

- R1. R.K. Ghosh and K.C. Maity, An Introduction to Differential Equations, New Central Book Agency, 2011.
- R2. William E. Boyce and Richard C. Di-Prima, Elementary Differential Equations and Boundary Value Problems, 7th edition, John Wiley & Sons, Inc.
- R3. Simmons, George F. (2017). Differential Equations with Applications and Historical Notes (3rd ed.). CRC Press. Taylor & Francis Group.
- R4. Belinda Barnes and Glenn R. Fulford, Mathematical Modeling with Case Studies

CO-PO Correlation Matrix:

CO \ PO/PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	2	1	–	–	–	–	–	–	2	3	2	2
CO2	3	2	2	2	1	–	–	–	–	–	–	2	3	2	2
CO3	3	2	3	3	2	–	–	–	–	–	–	2	3	2	3
CO4	3	2	3	3	2	–	–	–	–	–	–	2	3	3	2
CO5	3	2	3	3	2	–	–	–	–	–	–	2	3	3	2
CO6	3	2	3	3	3	1	1	–	–	1	1	3	3	2	3

Course Title	Discrete Mathematics
Course Code	MTH207
Credit	4
Contact Hours (L-T-P)	3-1-0
Course Type	Theory
Prerequisites	10+2 Mathematics and Algebra

Course Objectives:

The objectives of this course are as follows:

- To develop an in-depth understanding of combinatorics, generating function, Recurrence relation, Graphs and Trees.
- To develop the ability using the above mathematical tools in computer science related courses.

Course Outcomes:

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

CO1: Recall basic concepts of combinatorics, lattice theory, logic, and graph theory

CO2: Understand theories and theorems in combinatorics, Boolean algebra, logic, and graph theory

CO3: Apply combinatorial methods, Boolean algebra, and graph theory

CO4: Analyze logical propositions, Boolean functions, and graph structures

CO5: Evaluate and derive solutions in combinatorics, Boolean algebra, and graph theory

CO6: Design algorithms and models for combinatorics, Boolean algebra, and graph theory

Course Description:

This course helps to understand and use (abstract) discrete structures and advance algebraic structure that are backbones of computer science. In particular, this course is meant to introduce logic, proofs, sets, relations, functions, counting, recurrence relation and graphs, with an emphasis on applications in computer science.

Course Content:

Module I:

[20L]

Combinatorics: Diagonalization and Pigeonhole Principle, Multinomial theorem, principle of inclusion exclusion; Recurrence relations- classification, summation method, extension to asymptotic solutions from solutions for subsequences; Linear homogeneous relations, characteristic root method, non-homogeneous relations and examples, generating functions and their application to linear homogeneous recurrence relations, non-linear recurrence relations, exponential generating functions, Polya theory of counting

Module II:

[15L]

Lattice: Relation, Poset, Hasse diagram, Lattice and its properties, Duality

Boolean Algebra: Definition and properties, Boolean Expression and Boolean Function, Identities of Boolean Algebra, Duality

Module III:**[10L]**

Logic: propositions and connectives, syntax, semantics, truth assignments and truth tables, validity and satisfiability, tautology; adequate set of connectives; Equivalence and normal forms; Compactness and resolution; Formal reducibility - natural deduction system and axiom system; Soundness and completeness. Introduction to Predicate Calculus: Syntax of first order language; Semantics: structures and interpretation; Formal deductibility; First order theory, models of a first order theory (definition only), validity, soundness, completeness, compactness (statement only), outline of resolution principle

Module IV:**[15L]**

Graph Theory: Graphs and digraphs, complement, isomorphism, connectedness and reachability, adjacency matrix, Eulerian paths and circuits in graphs and digraphs, Hamiltonian paths and circuits in graphs and tournaments, trees; Minimum spanning tree, rooted trees and binary trees, planar graphs, Euler's formula, statement of Kuratowski's theorem, dual of a planer graph, independence number and clique number, chromatic number, statement of Four-color theorem, dominating sets and covering sets

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text Books

- T1. Kenneth H. Rosen, Discrete Mathematics and its Applications, Tata McGraw – Hill, 2017.
- T2. C L Liu and D P Mohapatra, Elements of Discrete Mathematics A Computer Oriented Approach, 4th Edition by Tata McGraw – Hill, 2017.
- T3. Susanna S. Epp, Discrete Mathematics with Applications, 5th edition, Wadsworth Publishing Co Inc., 2021.

Reference Books

- R1. J.P. Tremblay and R. Manohar, Discrete Mathematical Structure and It's Application to Computer Science”, TMG Edition, Tata McGraw- Hill.
- R2. Schaum's Outlines Series, Seymour Lipschutz, Marc Lipson, Discrete Mathematics, Tata McGraw – Hill, 2009.
- R3. Norman L. Biggs, Discrete Mathematics, 2nd Edition, Oxford University Press, 2013.

Mapping COs with POs & PSOs:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	2	3	1	2	2	1	2	1	2	3	2	2
CO2	3	3	2	3	3	2	2	3	3	2	2	3	3	3	3
CO3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO4	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO6	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	3	2.83	2.67	2.83	3.00	2.50	2.50	2.83	2.67	2.67	2.50	2.83	3.00	2.83	2.83

Course Title	Multivariate Calculus
Course Code	MTH205
Credit	4
Contact Hours (L-T-P)	3-0-1
Course Type	Hybrid
Prerequisites	Calculus, Real Analysis

Course Objectives:

The objectives of this course are as follows:

- To develop the concept of differential and integral calculus for multiple variables
- To acquire the knowledge vector calculus
- To build up the concept of different tools and techniques used in multivariate calculus

Course Outcomes:

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

CO1: Recall key concepts of functions of several variables, partial differentiation, directional derivatives, and vector fields

CO2: Explain partial differentiation, geometric interpretations, extrema, and Lagrange multipliers

CO3: Apply partial differentiation, chain rule, Taylor's theorem, Lagrange multipliers, and Jacobians in optimization and integration

CO4: Analyze critical points, gradients, and theorems such as Green's, Gauss's, and Stokes' in vector fields, line integrals, and surface integrals

CO5: Evaluate accuracy of approximations, solve optimization and integration problems, and analyze integrals in real-world applications

CO6: Design complex mathematical models, solve advanced problems in vector fields, and apply Green's, Gauss's, and Stokes' theorems

Course Description:

This course offers an in-depth exploration of multivariable calculus and vector calculus, focusing on functions of several variables and their applications. Students will learn to define and analyze key concepts such as limits, continuity, and partial differentiation. They will investigate differentiability conditions and apply the chain rule, while gaining a solid understanding of vector fields, gradients, divergence, and curl. The geometric interpretations of these concepts, including tangent planes and normal lines, will be emphasized through Taylor's theorem for functions of two variables. By the end of this course, students will have developed a robust understanding of multivariable calculus and vector calculus, preparing them for advanced studies in mathematics, engineering, and the sciences.

Course Content:

Module I:

[18L]

Functions of several variables, Limit and Continuity, Partial differentiation, Differentiability, Sufficient condition for differentiability, Total derivative, Chain rule, Higher order derivatives, Homogeneous function and Euler's theorem, Tangent planes and Normal lines, Taylor's theorem for functions of two variables, Linear and Quadratic approximation and Error; Level curves and level surfaces, Vector field, Directional derivatives, Gradient, Divergence and Curl, Maximal and normal property of the gradient, Geometric interpretation

Module II:

[07L]

Extrema of a function of two or more variables, local and global extrema, Stationary points, Saddle point, method of Lagrange multipliers, constrained optimization problems; Variable transformations and Jacobian

Module III:**[20L]**

Line integral, Fundamental theorem of Line integral, Work done by force, Conservative field; Double integrals over rectangles, iterated integrals, Fubini's theorem, double integrals over general regions, change of order of integration, evaluation of triple integrals, applications of Double and Triple integrals, area by double integration, surface area, surface integral, volume of solids as double integrals, volume as triple integral, Surface area and volume of solids of revolution, Green's theorem, Gauss Divergence theorem, Stokes' theorem

Practical/Lab to be performed on a computer using MATLAB/Python programming:

Write and execute MATLAB/Python code for the following experiments:

1. Plotting and visualization of functions of two variables and level curves
2. Partial derivatives, gradient and directional derivatives
3. Tangent plane, normal line and linear approximation
4. Visualization of vector fields, divergence and curl
5. Finding and classifying maxima, minima and saddle points
6. Constrained optimization using Lagrange multipliers
7. Line integrals, work and conservative vector fields
8. Double and triple integrals with applications

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text Books:

- T1. G.B. Thomas Jr., M.D. Weir and J.R. Hass, Thomas Calculus, Pearson Education, 2024.
- T2. S. C. Mallik and S. Arora, Mathematical Analysis, S. Chand.
- T3. G.B. Thomas and R. L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2010.
- T4. S. Bandyopadhyay, Mathematical Analysis, Academic Publishers, 2025.

Reference Books:

- R1. James Stewart, Multivariable Calculus, Concepts and Contexts, 2nd Ed., Brooks/Cole, Thomson Learning, USA, 2023.
- R2. M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi.
- R3. E Marsden, A. J. Tromba and A. Weinstein, Basic Multivariable Calculus, Springer (SIE), Indian reprint.

Mapping COs with POs & PSOs:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	1	1	1	1	2	1	1	1	3	2	2
CO2	3	3	2	2	1	1	1	1	2	2	1	1	3	2	2
CO3	3	3	3	2	2	2	1	1	3	2	2	2	3	3	3
CO4	3	3	3	3	2	2	2	2	3	3	2	2	3	3	3
CO5	3	3	3	3	3	3	2	2	3	3	3	3	3	3	3
CO6	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	3	3	2.67	2.33	2.00	2.00	1.67	1.67	2.67	2.33	2.00	2.00	3.00	2.67	2.67

Course Title	Linear Algebra
Course Code	MTH201
Credit	4
Contact Hours (L-T-P)	3-1-0
Course Type	Theory
Prerequisites	10+2 Mathematics

Course Objectives:

The objectives of this course are as follows:

1. To help the students to acquire the knowledge of vector spaces
2. To enable the students to get an idea of linear independence, span, and basis
3. To give the idea about the solution procedures for solving system of linear equations and matrix equations
4. To help the students to understand the concepts of row space, column space and null space of a matrix
5. To give knowledge of linear transformations and their various properties
6. To enable the students to evaluate the eigen values and eigen vectors of a matrix.
7. To give an idea about the General Quadratic form and definiteness of matrices
8. To enable the students to inner products space, associated norms and the operators on Inner product spaces.

Course Outcomes:

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

- CO1: Recall** basic concepts of vector spaces, subspaces, linear independence, basis, and dimension, linear transformation, eigen values, eigen vectors and inner product space.
- CO2: Explain** the structure and solutions of systems of linear equations using row operations, rank, and echelon forms and quadratic form
- CO3: Apply** concepts of linear transformations, including null space, range, and the Rank-Nullity theorem, to solve transformation-related problems
- CO4: Analyze** matrices and their eigenvalues/eigenvectors to determine diagonalizability and apply the Cayley-Hamilton theorem for characteristic equations
- CO5: Evaluate** quadratic forms through transformation to normal form and determine properties like index, signature, and definiteness
- CO6: Construct** orthonormal bases using the Gram-Schmidt process and develop orthogonal projections in inner product spaces for practical applications.

Course Description:

This course is intended to provide the concept of vector spaces. This course is also intended to provide some tools for performing basic operations on matrices and use those tools for solving system of linear equations and matrix equations. Furthermore, some basic ideas about row-space, column-space, and null-space are there. Concepts of eigen values and eigen vectors of a matrix and their applications in real world will be discussed in this course. Some basic ideas about linear transformation and its relationship with matrix algebra can be found in this course. Also, an idea about of general quadratic form and the definiteness of the associated matrices is provided through this course.

Course Content:**Module I: Vector space****[14L]**

Definitions and examples of vector spaces, subspaces, algebra of subspaces, linear combination of vectors, linear span, linear independence, basis and dimension, replacement theorem, extension theorem, deletion theorem, finite dimensional vector space, dimension of subspaces

Module II: Systems of Linear Equations**[16L]**

Row space and column space of matrix, echelon matrix, rank of a matrix, elementary matrices and related results, normal form of a matrix under congruence, row rank and column rank of matrix

Systems of linear equations, Consistency, solution space, applications of linear systems

Module III: Linear transformations**[12L]**

Definition and related results, Null space, Range space, Rank-Nullity theorem, composition of linear transformation, isomorphism between two finite-dimensional vector spaces, Matrix representation and various properties

Module IV:**[10L]**

Eigen Values and Eigen Vectors: Eigenvalues and eigenvectors with their properties, Cayley-Hamilton theorem, Algebraic Multiplicity and Geometric Multiplicity, Similar matrices, Diagonalization

Quadratic Form: Real quadratic form involving three variables, reduction to normal form, general quadratic form, index, signature, characteristics of quadratic forms

Module V: Inner product spaces**[08L]**

Inner product spaces and norms, various results of inner product spaces, Orthogonal projections and Spectral theorem, Gram-Schmidt orthogonalization process, orthogonal complements

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text Books

- T1. S. Kumaresan, Linear Algebra- A Geometric Approach, Prentice Hall of India, 2023.
- T2. S. K. Mapa, Higher Algebra- Abstract and Linear, revised 15th Edition, Sarat Book House, 2020.
- T3. Gilbert Strang, Linear Algebra and its Applications, Thomson, 2023.
- T4. Hoffman and Kunze, Linear algebra, Pearson, 2015.
- T5. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra, Pearson, 2022.

Reference Books

- R1. R.K. Jain and S.R.K. Iyenger, Advanced Engineering Mathematics, Narosa Publishing House, 2019.
- R2. B. S. Vaatsa, Theory of matrix, New age publication.
- R3. A Kurosh, Higher Algebra, Mir Publisher.
- R4. D.T. Finkbeiner, Introduction to matrices and linear transformations, CBS Publishers, New Delhi.

Mapping COs with POs & PSOs:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	1	1	1	1	2	2	1	1	3	2	2
CO2	3	3	3	2	2	2	2	1	3	2	2	2	3	2	2
CO3	3	3	3	3	3	2	2	1	3	2	2	2	3	3	3
CO4	3	3	3	3	3	2	2	2	3	3	3	2	3	3	3
CO5	3	3	3	3	3	3	2	2	3	3	3	3	3	3	3
CO6	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	3	3	2.83	2.67	2.5	2.2	2	1.67	2.83	2.5	2.33	2.17	3	2.67	2.67

Course Title	Linear Programming and Game Theory
Course Code	MTH209
Credit	4
Contact Hours (L-T-P)	3-0-1
Course Type	Hybrid
Pre-requisites/Exposure	10+2th Level Mathematics

Course Objectives:

The objectives of this course are as follows:

- To develop the concept of formulation of linear programming problem (LPP) and solution procedure of LPP by using Graphical method, simplex method.
- To acquire the knowledge of special classes of LPPs such as Transportation problem, Assignment problem and Travelling salesman problem
- To build up the concept of application procedures of LPP to Game Theory.

Course Outcomes:

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

CO1: Define key concepts of LPP, simplex, transportation, assignment, and game theory

CO2: Explain the methods and basic principles of LPP, transportation, assignment, and game theory

CO3: Apply simplex method, transportation and assignment problem solving methods, and game theory

CO4: Analyze solutions in LPP, duality theory, and optimization methods for transportation and assignment problems

CO5: Evaluate methods for solving LPP, transportation, assignment problems, and game theory problems

CO6: Design and create complex models for LPP, transportation, assignment problems, and games

Course Description:

Linear Programming Problem (LPP) deals with the problem of minimizing or maximizing a linear function in the presence of linear equalities/inequalities. Since the development of the simplex method, linear programming has been extensively used in the military, industrial, governmental, and urban planning fields, among others. A large class of optimization problems are solved by techniques under the heading mathematical programming. There are several other techniques to solve the optimization problems but LPP concerned with only solving the linear programming models in an iterative procedure which yields an exact solution in a finite number of steps. LPP is useful to solve the allocation problems. These problems require the allocation of limited available resources to the jobs that are to be done. There is a class of games which are intimately related to linear programming.

Course Content:

Module I:

[10 L]

Review of linear programming problem (LPP) formation, convex set & Convex function, convex hull and convex polyhedron, Extreme points, Hyperplane, Basic solutions and basic feasible solution (BFS), Degenerate and non-degenerate BFS, Optimality condition, Unboundedness, Alternate optima, Infeasibility

Module II:

[15 L]

Theory of simplex method, the simplex algorithm, optimality and un-boundedness, two-phase method, Big-M method, Duality, formulation of the dual problem, primal-dual relationships, Duality theorem

Module III:

[12L]

Transportation problem and its mathematical formulation, North-West corner method, Least cost method and Vogel approximation method for determination of initial basic feasible solution, Optimality test, Modified Distribution (MODI) method; Assignment problem and its mathematical formulation, Hungarian method for solving an assignment problem; Travelling salesman problem (TSP)

Module IV:

[08L]

Concept of game theory, rectangular games, pure strategy and mixed strategy, saddle point, optimal strategy and value of the game, concept of dominance, formulation of two-person zero-sum games, solving two-person zero-sum games, games with mixed strategies, graphical solution procedure, linear programming solution of games

Practical/Lab to be performed on a computer using MATLAB/Python/C programming:

Write and execute MATLAB/Python / C -code for the following programs:

1. Constructing LPP models with objective functions, decision variables, and constraints for maximizing profit or minimizing cost
2. Plotting feasible regions, identifying corner-point optimal solutions
3. Solving 2-variable LPPs using graphical method
4. Implementing the step-by-step Simplex method to solve LPPs with three or more variables
5. Find initial feasible solutions of transportation problems
6. Solve task allocation and routing problems using the Hungarian Method
7. Identifying the saddle point using maximin-minimax principles
8. Solving two-person zero-sum game

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text Books:

- T1. Kanti Swarup, P. K. Gupta and Man Mohan, Operations Research, S. Chand and Co. Pvt. Ltd.
- T2. Hamdy A. Taha, Operations Research, An Introduction, 8th Ed., Prentice Hall India, 2006.
- T3. G. Hadley, Linear Programming, Narosa Publishing House, New Delhi, 2002.

Reference Books:

- R1. F.S. Hillier and G.J. Lieberman, Introduction to Operations Research, 9th Ed., Tata McGraw Hill, Singapore, 2009.

- R2. N.V.R. Naidu, G. Rajendra and T. Krishna Rao-Operations Research, I.K. International Publishing House Pvt. Ltd., New Delhi, Bangalore.
- R3. D. C. Sanyal, K. Das, Linear Programming and Game Theory, U. N. Dhur and sons Pvt Ltd, 2008.

Mapping COs with POs & PSOs:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	1	1	1	1	2	1	1	1	3	2	2
CO2	3	3	2	2	1	1	1	1	2	1	1	1	3	2	2
CO3	3	3	3	2	2	2	1	1	3	2	2	2	3	3	3
CO4	3	3	3	3	2	2	2	2	3	2	3	2	3	3	3
CO5	3	3	3	3	3	3	2	2	3	3	3	3	3	3	3
CO6	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	3	3	2.67	2.33	2	2	1.67	1.67	2.67	2	2.17	2	3	2.67	2.67

Course Title	Data Structures
Course Code	CSE281
Credit	4
Contact Hours (L-T-P)	3-0-2
Course Type	Hybrid
Prerequisite	Discrete Mathematics

Course Objectives:

The objectives of this course are as follows:

To make students familiar with data structures.

To enable students to understand stack, queue, and linked list concepts.

To enhance the ability to solve real-time data problems.

Course Outcomes:

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

CO1: Define the concept of dynamic memory management, data types, and algorithms.

CO2: Illustrate advantages and disadvantages of specific algorithms and data structures.

CO3: Solve bugs in programs and recognize necessary operations on data structures.

CO4: Interpret algorithms and data structures in terms of time and memory complexity.

CO5: Compare the computational efficiency of key algorithms for sorting, searching, and hashing.

Course Description:

Study of advanced programming topics focused on logical structures of data as well as the design, implementation, and analysis of algorithms operating on these structures. Students will gain the fundamental concepts of data structures and understand their role in the development of efficient algorithms.

Course Content:

Module I: Introduction

[10L]

Concepts on Pointers, Dynamic Memory Allocation, Structure, Recursion. Elementary Data Organizations, Data Structure Operations: insertion, deletion, traversal. Algorithm analysis, Asymptotic Notations, Time-Space Trade-off. Arrays: 1D, 2D, memory representation, operations, Linear and Binary Search.

Module II: Stacks and Queues

[08L]

ADT Stack: operations and applications. Expression conversion and evaluation: algorithms and complexity. ADT Queue: Simple, Circular, Priority Queue operations and their analysis.

Module III: Linked Lists**[10L]**

Types: Singly, Doubly, Circular, and Circular Doubly Linked Lists. Memory representation, traversal, insertion, deletion operations. Linked representation of Stack, Queue, and Polynomial.

Module IV: Trees and Graphs**[12L]**

Tree types: Binary Tree, Threaded Binary Tree, Binary Search Tree, AVL Tree. Tree operations and their algorithms with complexity analysis. B Tree and B+ Tree definitions, algorithms, and analysis. Graph terminology, representation, traversal algorithms, and MST.

Module V: Trees and Graphs**[10L]**

Sorting: Selection, Bubble, Insertion, Quick, Merge, Heap. Performance analysis and comparisons. Hashing: Functions, Collisions, Collision Resolution Techniques.

Practical/Lab to be performed on a computer using C programming:

1. Implement array operations: insertion, deletion, searching.
2. Implement stack using arrays and linked lists.
3. Implement queue and circular queue using arrays.
4. Implement singly, doubly, and circular linked lists.
5. Write recursive functions for factorial, Fibonacci series, and Tower of Hanoi.
6. Implement sorting algorithms: Bubble, Selection, and Insertion sort.
7. Implement Merge Sort and Quick Sort with performance analysis.
8. Implement linear and binary search algorithms.
9. Create a binary search tree and perform insertion, deletion, and traversal operations.
10. Implement AVL tree and demonstrate balancing after insertions.
11. Represent graphs using adjacency matrix and list, perform BFS and DFS.
12. Implement hash tables with chaining and open addressing.
13. Implement string pattern matching using KMP or Rabin-Karp algorithms.
14. Mini project: Implement a real-world application using appropriate data structures (e.g., Student record system, Library system).

Evaluation:

Mode of Evaluation	Theory		Practical	
	Comprehensive and Continuous Assessment	End Semester Examination	Comprehensive and Continuous Assessment	End Semester Examination
Weightage	25%	25%	25%	25%

Text Books:

CO/P O	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	3	2	1										2		
CO2	3	3	2										2		2
CO3	3	3	3										2		
CO4	3	3	3										2		2
CO5	3	3	3										2		2
	3	2.8	2.4	-	-	-	-	-	-	-	-	-	2		2

Course Title	Numerical Methods
Course Code	MTH301
Credit	4
Contact Hours (L-T-P)	3-0-1
Course Type	Hybrid
Prerequisites	Calculus and Linear Algebra

Course Objectives:

The objectives of this course are as follows:

- To understand and analyze various numerical errors and their propagation in numerical computations
- To understand and apply numerical techniques for solving non-linear equations, linear systems, interpolation problems, numerical integration, and ordinary differential equations.
- To implement numerical algorithms using C/MATLAB for practical problem-solving.
- To assess the accuracy and convergence of numerical techniques.

Course Outcomes

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

CO1: Recall basic concepts of errors, and methods for solving equations, interpolation, numerical integration and ordinary differential equations (ODEs)

CO2: Understand error propagation and explain root-finding, linear equation-solving Methods, interpolation and numerical integration

CO3: Apply numerical methods to solve equations, linear systems, and interpolation problems

CO4: Analyze the convergence, stability, and accuracy of numerical methods

CO5: Evaluate the effectiveness of methods for integration, interpolation, and solving ODEs

CO6: Design and implement algorithms for solving equations, ODEs, and numerical integration

Course Description:

Numerical analysis is the subject of study to find the numerical solutions of mathematical problems by computational methods. Numerical techniques are effective tools for providing solutions to mathematical problems which are not solved by analytical methods. It studies the numerical solutions to the problems involving nonlinear equations, system of linear algebraic equations, interpolation and approximation, differences, integrals, ordinary and partial differential equations, finite differences, etc. Numerical methods are normally being used to find the solution to a problem whose analytical solution is difficult to achieve; thus, it is felt that a study in applied sciences and engineering is essential and found wide applications in all areas of science, technology and economics.

Course Content:

Module I:

Approximation and Errors in Numerical Computation: Approximation of a number, Significant figures, Rounding off, Different types of errors, Propagation of errors

Solution of Algebraic and Transcendental Equations: Intermediate value property, Bisection method, Regular-Falsi method, Secant method, Fixed point iteration method, Newton-Raphson method; Rate of convergence

Module II:

Solution of Simultaneous Linear Algebraic Equations: Gauss Elimination method, Ill-conditioned system and its solution, LU-decomposition methods, Gauss-Jacobi method, Gauss-Seidel method

Module III:

Finite Difference and Interpolation: Finite difference operators and their relations, Newton's forward, backward and central difference interpolation formulae, Lagrange's interpolation formula, Divided difference, Newton's divided difference interpolation formula

Module IV:

Numerical Differentiation and Integration: Derivatives using Newton's forward and backward interpolation formulae, Newton-Cotes quadrature formula, Trapezoidal rule, Simpson's rules, Weddle's rule

Numerical Solutions of ODE: Euler's method, Modified Euler's method, Second and fourth order Runge-Kutta methods.

Practical/Lab to be performed on a computer using MATLAB/C programming:

Write and execute C/MATLAB-code for the following programs:

1. Obtain the root of a non-linear equation using Bisection Method.
2. Obtain the root of a non-linear equation using Regula-Falsi Method.
3. Obtain the root of a non-linear equation using Newton-Raphson Method.
4. Solve a system of linear equations using Gauss Elimination Method.
5. Solve a system of linear equations using Gauss-Seidel Iteration Method.
6. Perform interpolation using Newton's Forward Interpolation Formula.
7. Perform interpolation using Newton's Backward Interpolation Formula.
8. Perform interpolation using Lagrange's Interpolation Method.
9. Calculate a definite integral using Trapezoidal Rule.
10. Calculate a definite integral using Simpson's Rule.
11. Solve a differential equation using Euler's Method.
12. Solve a differential equation using Runge-Kutta Methods.

Evaluation Scheme:

Mode of Evaluation	Theory		Practical	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination	Comprehensive and Continuous Assessment	End Semester Examination
	25%	25%	25%	25%

Text Books:

- T1.** M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical Methods for Scientific and Engineering Computation, New age International Publisher, India, 2022.
- T2.** S. A. Mollah, Numerical Analysis and Computational Procedures, Books & Allied (P) Ltd, 8th Edition, 2022.
- T3.** B. S. Grewal, Numerical Methods in Engineering & Science with Programs in C & C++, Khanna Publications, 2025.

Reference Books:

- R1.** T. Veerarajan, T. Ramachandran, Numerical Methods with Programs in C, Tata McGraw Hill Publications, 2008.

- R2.** S. Dey, S. Gupta, Numerical Methods, McGraw Hill Education, 2017.
- R3.** S. S. Sastry, Introductory Methods of Numerical Analysis. PHI Learning Pvt. Ltd, 2012.
- R4.** S. S. Ray, Numerical Analysis with Algorithms and Programming. Chapman and Hall/CRC, 2018.
- R5.** A Gupta and S C Bose, Introduction to Numerical Analysis, Academic Publishers, 3rd Edition, 2012.

Course Title	COMPLEX ANALYSIS
Course Code	MTH304
Credit	4
Contact Hours (L-T-P)	3-1-0
Course Type	Theory
Prerequisites	Classical Algebra and Real Analysis

Course Objectives:

The objectives of this course are as follows:

- Develop a solid grasp of complex numbers, analytic functions, and key concepts such as limits, continuity, and differentiability in the complex plane.
- Master the application of major theorems - such as Cauchy's Integral Theorem, Cauchy's Integral Formula, and the Residue Theorem - to evaluate complex integrals and solve real-world problems.
- Explore and analyze power series, Taylor and Laurent series expansions, and apply conformal mappings to transform and solve problems in physics and engineering contexts.

Course Outcomes:

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

CO1: Find the basic idea of complex number systems and differentiability.

CO2: Find the concept analytic functions and unbox the concept of elementary functions like exponential and logarithmic function.

CO3: Illustrate the idea of complex integration along with Cauchy integral theorem and Cauchy's integral formula with their applications..

CO4: Build the concept of infinite series (Taylor series, Laurent series etc.) and study of their convergent analysis. Learn Liouville's theorem with applications.

CO5: Demonstrate the idea of bilinear transformation.

CO6: Identify singularity of a complex function and classification of various singular points. As an application, evaluate the contour integrals.

Course Description:

This course introduces the fundamental concepts of Complex Analysis, including complex numbers, differentiability, and analytic functions. It covers elementary complex functions, contour integration, Cauchy's Integral Theorem and Integral Formula, Taylor and Laurent series, and Liouville's Theorem. Students learn the concepts of bilinear transformations, singularities, residues, and contour integration techniques. Emphasis is placed on both theoretical understanding and problem-solving skills, enabling students to analyze complex functions, classify singularities, evaluate contour integrals, and apply the principles of complex analysis in mathematics, engineering, and related scientific disciplines.

Course Content:**Module I:** [12L]

Review of complex numbers, functions of complex variable, mappings, Derivatives, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability, Elementary functions, Exponential function, Logarithmic function, Trigonometric function

Module II: [18L]

Analytic functions, examples of analytic functions, derivatives of functions, Harmonic function, Milne-Thomson Method, definite integrals of functions, contours, Contour integrals and its examples, upper bounds for moduli of contour integrals, Cauchy- Goursat theorem, Cauchy integral formula, Morera's theorem

Module III: [12L]

Maximum modulus principle, Schwarz' lemma, Liouville's theorem and the fundamental theorem of algebra, Taylor series, Laurent series, uniform convergence of power series, Bilinear transformation

Module IV: [18L]

Zeros and Singularities, Classification of singularities, removable singularities, poles, isolated singularities at infinity, Meromorphic functions, essential singularities, Residues, Cauchy's residue theorem, Rouché's theorem, Evaluation of real integrals

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text Books:

- T1. S. Ponnusamy and H. Silverman, Complex Variables with Applications, 2011, Birkhäuser, Boston.
- T2. Murray. R. Spiegel, Theory and Problems of Complex Variables, Schaum outline series.
- T3. J. B. Conway, Functions of one Complex variable. Springer, Verlag, 2011.

Reference Books:

- R1. James Ward Brown and Ruel V. Churchill, Complex Variables and Applications, 9th Ed., McGraw Hill International Edition, 2021.
- R2. H K Kasana, Complex Variables: Theory and Applications: Second Edition, Prentice Hall India Learning Private Limited, 2023.
- R3. P. Duraipandian and K. Pachaiyappa, Complex Analysis, S. Chand Publishing.
- R4. S. Ponnusamy, Foundations of Complex Analysis, Narosa Pub. House, 2011.

Mapping COs with POs & PSOs:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	1	2	1	1	1	1	1	2	1	1	3	2	1
CO2	3	3	2	3	1	1	1	1	1	2	1	2	3	2	2
CO3	3	3	2	3	2	2	1	1	1	2	1	2	3	2	3
CO4	2	3	3	3	2	2	1	1	2	2	1	2	3	3	3
CO5	3	3	2	2	1	1	1	1	1	2	1	2	2	3	3
CO6	3	3	3	3	1	1	2	2	2	2	1	2	3	3	3
	2.67	3	2.17	2.67	1.34	1.34	1.17	1.17	1.34	2	1	1.84	2.84	2.50	2.50

Course Title	Design and Analysis of Algorithms
Course Code	CSE382
Credit	4
Contact Hours (L-T-P)	3-0-2
Course Type	Hybrid

Course Objectives:

- To introduce the fundamental concepts of algorithm design and analysis.
- To learn algorithmic strategies like divide-and-conquer, greedy, dynamic programming, and backtracking.
- To develop the ability to analyze time and space complexity of algorithms.
- To explore advanced topics like graph algorithms, string matching, and NP-completeness.
- To implement and test algorithms in a laboratory setting.

Course Outcomes:

CO1: Understand the mathematical foundation of algorithm analysis and performance metrics.

CO2: Apply various algorithmic strategies to solve computational problems.

CO3: Analyze and compare algorithms in terms of complexity and efficiency.

CO4: Design efficient algorithms using standard paradigms and implement them effectively.

Course Description:

This course offers an in-depth understanding of algorithm design techniques and complexity analysis. It includes core algorithm paradigms, recurrence solving, sorting, dynamic programming, greedy strategies, graph algorithms, and NP-completeness. Students will learn to design, implement, and analyze algorithms using rigorous methods and real-world problems.

Course Content:

Module I: Introduction and Algorithm Analysis (9 Lecture Hours)

- Characteristics of an algorithm
- Algorithm analysis: Best, average, worst-case analysis
- Asymptotic notation: Big-O, Omega, Theta
- Time and space trade-offs
- Solving recurrence relations: Substitution method, Recursion tree, Master's theorem
- Introduction to algorithm design paradigms

Module II: Sorting and Divide and Conquer

(9 Lecture Hours)

- Sorting algorithms: Selection, Insertion, Bubble sort
- Merge sort, Quick sort (analysis included)
- Binary search, Matrix multiplication
- Strassen's algorithm for matrix multiplication
- Recurrence solving techniques revisited

- Binary search trees

Module III: Greedy Algorithms and Dynamic Programming

(9 Lecture Hours)

- Greedy method: Activity selection, Fractional knapsack
- Minimum Spanning Trees: Prim's and Kruskal's algorithms
- Dijkstra's algorithm for shortest path
- Dynamic Programming: Principle of Optimality
- Problems: 0/1 Knapsack, Matrix Chain Multiplication, Longest Common Subsequence

Module IV: Graph Algorithms and Backtracking

(9 Lecture Hours)

- Graph representation: Adjacency list and matrix
- BFS, DFS, Topological sort, Strongly connected components
- All-pairs shortest path: Floyd-Warshall, Johnson's algorithm
- Max Flow: Ford-Fulkerson method
- Backtracking and Branch and Bound techniques

Module V: String Matching, Approximation, NP-Completeness

(9 Lecture Hours)

- String Matching: Naïve, Rabin-Karp, KMP, Finite automata
- Approximation Algorithms: Vertex cover, TSP, Set cover
- NP-Completeness: P, NP, NP-Hard, NP-Complete
- Reductions and NP-completeness proofs

Laboratory Work (30 Hours Total:

15 Labs x 2 Hours Each)

- Implement and analyze time complexity of basic sorting algorithms.
- Implement Merge Sort and Quick Sort with performance comparison.
- Solve matrix multiplication using Strassen's algorithm.
- Binary Search and solving recurrence relations.
- Implement greedy algorithms (Activity selection, MST).
- Apply Dijkstra's algorithm for shortest path.
- Implement 0/1 Knapsack using dynamic programming.
- Matrix chain multiplication using DP.
- LCS and Memoization techniques.
- Implement BFS, DFS and topological sort.
- Floyd-Warshall algorithm for all-pairs shortest paths.
- Ford-Fulkerson algorithm for max flow.
- Backtracking: N-Queens or Sudoku solver.
- String matching: Naïve, KMP algorithms.
- NP-complete case simulation (e.g., vertex cover approximation).

Mode of Evaluation	Theory		Practical	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination	Comprehensive and Continuous Assessment	End Semester Examination
	25%	25%	25%	25%

Text Books:

1. Cormen, Leiserson, Rivest, and Stein, Introduction to Algorithms, MIT Press.
2. Horowitz, Sahni, and Rajasekaran, Fundamentals of Computer Algorithms, Galgotia Publications.

Reference Books:

1. Aho, Hopcroft, and Ullman, The Design and Analysis of Computer Algorithms, Addison Wesley.
2. Dasgupta, Papadimitriou, and Vazirani, Algorithms, McGraw Hill.
3. Kleinberg and Tardos, Algorithm Design, Pearson.

Course Title	Operating Systems
Course Code	CSE381
Credit	4
Contact Hours (L-T-P)	3-0-1
Course Type	Hybrid

Course Objectives:

The objectives of this course are as follows:

- To understand the students to study the basic principles and functionality of operating systems.
- To provide the students to identify the concepts of CPU scheduling, concurrent processes, deadlock
- To allow the students to identify the significance of memory management and virtual memory.
- To enhance the skill of students to identify the disk scheduling, file systems, and device management.
- To understand the students to explain the performance trade-offs inherent in advance OS implementation

Course Outcomes:

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

CO1: Understand functionalities and features of Operating System.

CO2: Analyze various scheduling algorithms and threading concepts to identify a suitable algorithm for a Given criterion.

CO3: Assess various solutions for critical Section problem. Applying deadlock avoidance principles and Check for the occurrence of deadlock.

CO4: Explain different memory management techniques and its uses Structuring an overview of file Systems and mass storage.

CO5: Understand the functionalities of modern operating system like Android, oxygen, Windows11 etc.

Course Description:

The course will begin with an overview of the structure of computer operating systems. The purpose of this course is to provide students basic knowledge of operating systems, difference between the kernel and user modes, concepts of application program interfaces, methods and implementations of interrupts. Students are introduced to the schedulers, policies, processes, threads, memory management, virtual memory, protection, access control, and authentication. Students learn system calls in different popular operating systems used in the industry. Particular emphasis will be given to three major OS subsystems: process management (processes, threads, CPU scheduling, synchronization, and deadlock), memory management (segmentation, paging, swapping), and file systems; and on modern operating system architecture.

Course Content:

Module I: [20L]

Introduction: Concept of Operating Systems, Operating Systems Objectives and Functions, Generations of Operating systems, Types of Operating Systems, OS Services, System Calls, Structure of an OS - Layered, Protection and Security, Case study on UNIX and WINDOWS Operating System.

Module II: [10L]

Process Management – Process concept- process scheduling, operations, Inter process communication. Multi-Thread programming models. Process scheduling criteria and algorithms (FCFS, SJF, Priority, RR, Multilevel queue Scheduling), and their evaluation.

Module III: [10L]

Process synchronization, the critical-section problem, Peterson's Solution, synchronization Hardware, semaphores, classic problems of synchronization, monitors, Producer Consumer problem, Readers & Writers Problem, Dining-Philosopher Problem.

Deadlocks: Definition, Necessary and sufficient conditions for Deadlock, Deadlock Prevention, and Deadlock Avoidance: Banker's algorithm, Deadlock detection and Recovery.

Module IV: [12L]

Memory Management: Swapping, contiguous memory allocation, paging, structure of the page table, segmentation, Virtual memory, demand paging, page-Replacement, algorithms, Allocation of Frames, Thrashing.

File Management: Concept of File, Access methods, File types, File operation, Directory structure, File System structure, Allocation methods (contiguous, linked, indexed), Free-space management (bit vector, linked list, grouping), directory implementation (linear list, hash table), efficiency and performance.

Module V: [8L]

Case Study on: Android, Windows 11, Mac, oxygen OS and other contemporary Operating system.

Practical/Lab to be performed on a computer using VI editor in LINUX/UNIX OS:

1. Understating the functionality of basic Unix commands.
2. Understanding of the basics of shell programming.
3. Problem solving with decision control structure with if-else statement.
4. Problem solving with decision control structure with switch statement.
5. Problem solving with iterative structure with for loop statement.
6. Problem solving with iterative structure with while and do-while loop statement.
7. Problem solving with array and string.
8. Implementation of different CPU scheduling algorithms like FCFS, SJF, RR etc.
9. Implementation of Bankers Algorithm.

10. Implementation of different Memory Management schemes like paging etc.

11. Implementation of different page replacement schemes like FIFO, LRU etc.

Evaluation:

Mode of Evaluation	Theory		Practical	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination	Comprehensive and Continuous Assessment	End Semester Examination
	25%	25%	25%	25%

Text Books

T1. Operating System Concepts- Abraham Silberchatz, Peter B. Galvin, Greg Gagne 9th Edition, John Wiley publishers, 2012

T2. Operating Systems' – Internal and Design Principles, Stallings, Sixth Edition, Pearson education, 2005.

Reference Books

R1. Operating System a Design Approach-Crowley, 3 rd Edition, TMH, 2009.

R2. Operating systems- A Concept based Approach-D. M. Dhamdhare, 2nd Edition, Tata Mcgraw Hill, 2012

R3. Modern Operating Systems, Andrew S Tanenbaum 3rd edition Prentice-Hall, Inc, 2008

Mapping COs with POs & PSOs:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO1	3	2	3	2	1	-	-	-	-	-	2	3			
CO2	3	3	3	3	3	-	-	-	-	-	2	3			
CO3	3	3	3	3	3	-	-	-	-	-	1	3			
CO4	2	3	2	2	3	-	-	-	-	-	1	3			
CO5	2	2	2	2	2	-	-	1	-	-	1	2			
	2.6	2.6	2.6	2.4	2.4	-	-	1	-	-	1.4	2.8	-	-	-

Course Title	Integral Transforms and Partial Differential Equations
Course Code	MTH305
Credit	4
Contact Hours (L-T-P)	3-1-0
Course Type	Theory
Prerequisites	Integral Calculus and Differential Calculus

Course Objectives:

The objectives of this course are as follows:

- To make students gain a strong understanding of Fourier and Laplace transforms and their application in solving differential equations and boundary value problems.
- To make students learn to classify partial differential equations (elliptic, parabolic, and hyperbolic) and apply methods such as separation of variables for their solution.
- To make students utilize integral transforms to model and solve problems in heat conduction, wave propagation, and fluid dynamics.

Course Outcomes:

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

CO1: Define the fundamental concepts of integral transformation techniques and partial differential equations (PDEs)

CO2: Explain the theorems, properties, and methods related to Laplace and Fourier transforms

CO3: Apply Lagrange's and Charpit's for solving first-order PDEs

CO4: Analyze different types of PDEs to choose appropriate solution methods under varying boundary and initial conditions

CO5: Evaluate physical phenomena using Laplace and Fourier transform techniques in solutions

CO6: Design and formulate boundary value problems and solve them using Separation of Variables method, Laplace and Fourier transforms

Course Description:

The course on Integral Transforms and Partial Differential Equations (PDEs) introduces students to methods for solving complex differential equations that arise in physics, engineering, and applied mathematics. The course covers Laplace and Fourier transforms, which are powerful tools for converting PDEs into simpler algebraic equations. These techniques are used to solve boundary value problems and initial value problems in various fields such as heat conduction, wave propagation, and fluid flow. Key topics include classification of PDEs (elliptic, parabolic, and hyperbolic), separation of variables, and Green's functions. The course also delves into the application of Fourier series in solving PDEs and how integral transforms aid in simplifying problems in both time and frequency domains. By the end of the course, students will be able to apply integral transforms effectively to solve

linear PDEs, providing insight into real-world phenomena across multiple scientific disciplines.

Course Content:

Module I: Laplace Transform [20L]

Definition, existence conditions for Laplace transform, Linearity property, shifting theorems, Laplace transform of derivatives and integrals, Initial and final value theorem, Laplace transform of periodic functions, Laplace transform of some special functions, Inverse Laplace transform and its properties, Convolution theorem, Solution Initial/Boundary value problems using Laplace transform

Module II: Fourier Transform [15L]

Fourier integrals, Fourier sine and cosine integrals, Complex form of Fourier integral representation, Fourier transform, Fourier transform of derivatives and integrals, Fourier sine and cosine transforms and their properties

Module III: Partial Differential Equation [25L]

Formation of first order partial differential equations (PDE), linear and non-linear PDE of first order, special types of first-order equations, solutions of linear first order PDE, Lagrange's method, Charpit's method.

Linear second order homogeneous and non-homogeneous PDE with constant coefficients, Complementary function and Particular integral, Separation of variable, Solutions of Laplace Equation, Wave Equation, and Heat Equation

Evaluation:

Mode of Evaluation	Theory		
Weightage	Comprehensive and Continuous Assessment	Mid Semester Examination	End Semester Examination
	30%	20%	50%

Text Books:

- T1. A R Vasishtha and R K Gupta, Integral Transforms, Krishna Prakashan Media (P) Ltd. 2014.
- T2. Sudhir K Pundir, Integral Transforms Methods in Science & Engineering, CBS Publishers & Distributions Pvt. Ltd. 2017.
- T3. M.D. Raisinghania, Advanced Differential equations, S. Chand. 19th Ed. 2018.

Reference Books:

- R1. E. Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons, 10th Ed., 2023.
- R2. S. L. Ross, Differential equations, 3rd Ed., John Wiley and Sons, India, 2018.
- R3. I.N. Sneddon, Elements of Partial Differential Equations, McGraw-Hill book, 2013.

CO-PO & CO-PSO Correlation Matrix:

CO \ PO/PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	2	2	–	–	–	–	–	–	2	3	3	2
CO2	3	2	2	2	2	–	–	–	–	–	–	2	3	3	2
CO3	3	2	3	3	2	–	–	–	–	–	–	2	3	3	3
CO4	3	2	3	3	3	–	–	–	–	–	–	3	3	3	3
CO5	3	2	3	3	3	–	–	–	–	–	–	3	3	3	3
CO6	3	2	3	3	3	–	–	–	–	–	–	3	3	3	3

Course Title	COMPUTATIONAL NUMBER THEORY
Course Code	MTH309
Credit	4
Contact Hours (L-T-P)	3-0-2
Course Type	Hybrid
Prerequisites	Elementary Number Theory and Discrete Mathematics

Course Objectives:

The objectives of this course are as follows:

- To develop a solid foundation in number theory topics relevant to computation, including prime numbers, modular arithmetic, congruences, and Diophantine equations.
- To make them understand primitive roots, quadratic residues and related symbols, and solving congruences.
- To apply computational number theory techniques to practical fields like cryptography, coding theory, and secure communications, emphasizing real-world problem-solving and algorithmic efficiency.

Course Outcomes:

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

CO1: Learn Fermat's theorem, Euler-Phi function along with its properties.

CO2: Use of Mobius inversion formula and compute greatest integer function.

CO3: Explain primitive roots and integer modulo n . Apply theorems to solve problems in normed spaces.

CO4: Learn quadratic residues and non-quadratic residues, law of quadratic reciprocity with various symbols, like Legendre symbols and Jacobi symbols.

CO5: Understand key cryptographic techniques and their mathematical foundations, including classical ciphers, RSA, Diffie-Hellman, encryption, and digital signatures, along with their security properties.

CO6: Learn to develop real-world problem-solving skill on number theory. Use SageMath for core number theory operations and basic cryptographic algorithm implementations.

Course Content:

Module I:

[18L]

Fermat's Theorem, Euler's Generalization of Fermat's Theorem, Sum and Number of divisors, Mobius Inversion Formula, Greatest Integer function, Euler's Phi- Function, Euler's theorem, Properties of Phi function

Module II:

[20L]

Primitive Roots, Indices and Quadratic Reciprocity Law, Order of an Integer Modulo n , Primitive Roots for Primes, Composite Numbers having primitive Roots, Theory of Indices, Euler's Criterion, Legendre Symbol and its Properties, Quadratic Congruences with Composite Moduli, Quadratic residues and non-Quadratic residues, Jacobi symbols

Module III:**[07L]**

Caesar cipher, Vigenère cipher, One-time pad, Block ciphers, Hill cipher, Digital signature scheme and security properties, Diffie-Hellman Key exchange and Discrete Logarithm Problem RSA and its security

List of Lab Experiments:

SageMath Computation: How to compute GCD of integers, extended Euclidean algorithm, Euler's φ -function, and the Chinese remainder theorem, how to compute modular powers, eg $51^{2006} \pmod{97}$, Discrete log of $a \pmod{m}$, Divisors and sum of divisors of N , Quadratic residues and non-residues of N , Hill cipher, Diffie-Hellman Key exchange, RSA algorithm.

Text Books:

- T1. Neville Robinns, Beginning Number Theory, 2nd Ed., Narosa Publishing House Pvt. Ltd., Delhi, 2017.
- T2. David M. Burton, Elementary Number Theory, 7th Ed., Tata McGraw Hill, Indian reprint, 2023.
- T3. Introduction to computer and Programming Using Python: John V. Guttag. 2nd Ed., 2016.

Reference Books:

- R1. Gareth A Jones and J Mary Jones; Elementary Number Theory; Springer International Edition. 1998.
- R2. Kenneth H. Rosen, Elementary Number Theory and Its Applications, 6th Ed., Pearson Education, 2011.
- R3. Richard A. Mollin, An Introduction to Cryptography, 2nd Ed., Chapman and Hall/CRC, 2018.

Course Title	Soft Computing
Course Code	MTH310
Credit	4
Contact Hours (L-T-P)	3-0-1
Course Type	Hybrid
Pre-requisites/Exposure	Set theory and logics

Course Objectives:

To acquire the basic notion of fuzzy set theory, fuzzy logic, artificial neural network, evolutionary algorithms and their applications to the real-world decision-making problems.

Course Outcomes

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

CO1. **Describe** the fundamental concepts of soft computing, distinguish soft computing from hard computing, and recall the basic principles of fuzzy sets, neural networks, and genetic algorithms

CO2. **Explain** the concepts of fuzzy sets, fuzzy relations, fuzzy numbers, linguistic variables, approximate reasoning, inference mechanisms, and the learning principles of artificial neural networks

CO3. **Apply** fuzzy logic, fuzzy optimization techniques, artificial neural network models, and genetic algorithms to solve computational and real-world problems

CO4. **Analyze** fuzzy inference systems, neural network architectures, learning algorithms, and the performance of different genetic algorithm operators for solving optimization problems

CO5. **Evaluate** the effectiveness of fuzzy logic, artificial neural networks, and genetic algorithms in solving intelligent decision-making and optimization problems, and compare alternative soft computing techniques for specific applications

CO6. **Design** intelligent hybrid soft computing models by integrating fuzzy logic, artificial neural networks, and genetic algorithms to address complex engineering, scientific, and data-driven applications

Course Description:

The notion of a fuzzy set provides a convenient point of departure for the construction of a conceptual frame-work which parallels in many respects the framework used in the case of ordinary sets, but is more general than the crisp set. Fuzzy set theory provides a strict mathematical framework in which vague conceptual phenomena can be precisely and rigorously studied. This course provides possible hybrid combinations with other intelligent algorithms, especially neural network and genetic algorithms. It introduces rough sets which are applied to process imprecise, uncertain and incomplete data. The key thinking of the rough set theory is to make use of the known knowledge database, and depict roughly the imprecise or uncertain knowledge with the help of the known knowledge in the knowledge database.

Course Content

Unit-I

Soft Computing: Introduction, Requirement, Different Tools and Techniques, Soft computing vs Hard computing, Usefulness and Applications.

Fuzzy Sets and Fuzzy Logic: Introduction, Fuzzy Sets and Crisp Sets, Operations on Fuzzy Sets, Extension Principle, Fuzzy Relations and fuzzy graph, Fuzzy Numbers, Linguistic Variables, Fuzzy Logic, Linguistic Hedges, Approximate reasoning, Inference mechanism, Fuzzy Optimization

[18L]

Unit-II

Artificial Neural Network: Introduction, Basic Models, Hebb's Learning, Adaline, Perceptron, Multilayer Feed Forward Network, Back Propagation, Convergence of Multilayer Perceptron, Competitive Learning, Applications.

[13L]

Unit-III

Evolutionary Techniques: Genetic algorithms (GA) – basic concepts, encoding, fitness function, reproduction-Roulette wheel, Boltzmann, tournament, rank, and steady state selections, Cross over different types, Mutation, Bit-wise operators, Generational cycle, Convergence of GA, Classification of Genetic Algorithms, Applications

[14L]

Practical/Lab to be performed on a computer using MATLAB/C programming:

1. Performing Union, Intersection and Complement Operations
2. Implementation of De-Morgan's Law
3. Plotting Various Membership Functions
4. Implementation of Fuzzy Inference System
5. Implementation of Hebb's Network
6. Implementation of Perceptron Network
7. Implementation of fitness function
8. Solve optimization problem by Genetic Algorithm

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text Books:

- T1. D. Dubois, H. Prade, Fuzzy sets and systems: theory and applications, Academic Press, Inc. 1980.
T2. J. M. Zurada, Introduction to artificial neural systems, Jaico Publishing House, 1994.
T3. D. E. Goldberg and Addison wesley, Genetic Algorithms in Search and Optimization, and Machine Learning, 2008.

T4. S. N. Sivanandam and S. N. Deepa, Principles of Soft Computing, Wiley India Pvt. Limited, 3rd Ed. 2018.

Reference Books:

- R1. George Klir, Fuzzy Sets and Fuzzy Logic, Bo Yuan, PHI, 2015.
 R2. R. Rajasekaran and G. A. Vijayalakshmi Pai, Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis and Applications, Prentice Hall of India, New Delhi, 2013.
 R3. N. P. Padhy and S. P. Simon, Soft computing with MATLAB programming, Oxford publishers, 2015.

Mapping COs with POs & PSOs:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1	1	–	–	–	–	–	–	2	3	2	2
CO2	3	3	2	2	2	–	–	–	–	–	–	2	3	2	2
CO3	3	2	3	3	3	1	1	–	–	–	–	2	3	1	3
CO4	3	2	3	3	3	1	1	–	1	–	–	2	3	2	3
CO5	3	2	3	3	3	2	1	1	1	1	1	2	3	2	3
CO6	3	2	3	3	3	2	2	2	2	2	2	3	3	2	3
	3	2.33	2.5	2.5	2.5	1.5	1.25	1.5	1.33	1.5	1.5	2.167	3	1.83	2.67

Course Title	Machine Learning
Course Code	SDS308
Credit	4
Contact Hours (L-T-P)	3-0-2
Course Type	Hybrid

Course Objectives:

The primary objective of this course is as follows:

- To develop strong foundations in machine learning principles, statistical learning theory, and information-theoretic concepts.
- To build analytical understanding of optimization techniques, metric spaces, and regularization methods for effective model development.
- To enable practical implementation of supervised learning algorithms for accurate classification and informed decision-making.
- To equip learners with unsupervised learning and dimensionality reduction techniques for high-dimensional data analysis.
- To foster the ability to discover meaningful patterns and actionable knowledge using clustering and frequent pattern mining techniques for real-world applications.

Course Outcomes:

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

- CO1: Recall key concepts of machine learning, statistical learning theory, information theory, optimization, supervised and unsupervised learning, dimensionality reduction, and pattern mining.
- CO2: Explain theoretical foundations of learning models, including statistical principles, information measures, optimization methods, classification, clustering, and association analysis.
- CO3: Apply optimization, classification, clustering, dimensionality reduction, and frequent pattern mining techniques to solve machine learning problems.
- CO4: Analyze learning models using bias-variance trade-off, loss functions, convergence behavior, performance metrics, and clustering and pattern mining validity measures.
- CO5: Evaluate supervised and unsupervised models using regularization, optimization constraints, cross-validation, and information-theoretic and performance metrics.
- CO6: Create integrated machine learning solutions by selecting appropriate modeling, optimization, classification, clustering, dimensionality reduction, and pattern mining techniques.

Course Description:

This course introduces the fundamental principles, algorithms, and practical applications of machine learning. Students will explore supervised and unsupervised learning methods, statistical learning theory, optimization techniques, and information theoretic measures. The course emphasizes hands-on implementation of classical machine learning algorithms, dimensionality reduction, clustering, and pattern mining, preparing students for advanced studies in machine learning and data-driven problem solving.

Course Content:**Module I:**

Overview of Machine Learning: supervised, unsupervised, and semi-supervised learning; components of ML models; generative vs discriminative modelling paradigms, Empirical risk minimization (ERM), structural risk minimization (SRM), overfitting and underfitting, bias-variance trade-off, regularization principles, cross-validation techniques; Metric Space: concepts of metric space, examples in machine learning, Normed Linear Space.

Module II:

Information Theoretic Measures: entropy, cross-entropy, KL-divergence, mutual information; Feature Engineering: Feature Construction, Sparse Feature Exploration, High-Dimensional Covariance Mapping, Multi-Feature Scatterplots, Feature Ranking; Optimization and Linear Search Method

Module III:

Fundamental concepts of classification model: decision theory, loss functions, Probabilistic classification model, K-NN & Weighted K-NN, Linear Discriminant Analysis, Support Vector Machine, Decision Trees, logistic regression, Classification assessment metrics.

Module IV:

Concepts of representative based clustering, K-Means, Expectation-Maximization algorithm. Agglomerative Hierarchical Clustering. Fundamental concepts of High dimensional data, Data reduction techniques: PCA & SVD

Frequent Pattern Mining: Association analysis with the Apriori algorithm, efficiently finding frequent item sets with FP-growth.

Lab Experiments Using R/Python

1. Gradient Descent and SGD Implementation: Implement gradient descent and stochastic gradient descent on a simple regression problem; analyze convergence, step size, and effect of momentum.
2. K-Nearest Neighbors Classification: Implement K-NN and Weighted K-NN on a real dataset; study effect of K and distance metrics on accuracy.
3. Probabilistic Classification Model: Implement Bayes and Naïve Bayes Algorithm on real/simulated dataset and study the performance of the model.
4. Support Vector Machine (Linear Case): Implement linear SVM for separable datasets; visualize margin, support vectors, and classification boundaries; compare with logistic regression.
5. Linear Discriminant Analysis: Implement LDA, visualize decision boundaries and evaluate using metrics like accuracy, precision, and recall.
6. Apply K-Means, hierarchical clustering, and Gaussian Mixture Model with EM on real or simulated datasets; visualize clusters and compare clustering performance.
7. Pattern Mining: Apply Apriori and FP-growth algorithms for frequent pattern mining.
8. Dimensionality Reduction; Perform PCA and SVD on high-dimensional data, analyze dimensionality reduction effects on clustering or association tasks

Text Books:

- T1. Kevin P. Murphy (2022), Probabilistic Machine Learning: An Introduction, MIT Press.
- T2. Mohammed J. Zaki, Wagner Meira, JR (2020), Data Mining and Machine Learning: Fundamental Concepts and Algorithm, Cambridge University Press, 2nd Edition

Reference Books:

- R1. Trevor Hastie, Robert Tibshirani, Jerome Friedman (2009), The Elements of Statistical Learning: Data Mining, Inference, and Prediction, 2nd Edition, Springer (Springer Series in Statistics)
- R2. Mehryar Mohri, Afshin Rostamizadeh, Ameet Talwalkar (2018), Foundations of Machine Learning, 2nd Edition, MIT Press.

Evaluation:

Mode of Evaluation	Hybrid		
Weightage	Comprehensive and Continuous Assessment	Mid Semester Examination	End Semester Examination
	30%	20%	50%

Course Title	TOOLS AND TECHNIQUES FOR SCIENTIFIC REPORT WRITING
Course Code	MTH311
Credit	2
Contact Hours (L-T-P)	0-0-2
Course Type	Practical
Prerequisites	Basic Mathematics & Mathematical Symbols

Course Objectives:

The objectives of this course are as follows:

- Understand the structure and purpose of LaTeX
- Create professional documents using LaTeX
- Format text, lists, tables, and include mathematical expressions
- Manage references, bibliographies, and figures
- Use LaTeX for academic and technical writing.

Course Outcomes:

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

CO1. Demonstrate familiarity with the basic structure and commands of a LaTeX document, including document classes, packages, and environments.

CO2. Produce well-structured documents with properly formatted text, lists, tables, and figures suitable for academic and technical writing.

CO3. Accurately write and format mathematical expressions, equations, and symbols using LaTeX's math mode.

CO4. Manage citations and references using LaTeX tools such as bibtex or biblatex and create cross-referenced documents.

Course Content:

Module I: Introduction and Basic Document Structure

[5L]

Introduction to Latex: What is LaTeX and why use it? Structure of a LaTeX document (`\documentclass`, `\begin{document}`, etc.), Sections, paragraphs, and formatting text, Compiling and debugging LaTeX documents.

List structures: Itemize, enumerate, description etc.

Module II: Symbols and Fonts, Tables, Figures

[4L]

Symbols and Fonts: Greek letters, symbols, and operators, superscripts, subscripts, fractions, roots, integral, differential, etc. Bold fonts, emphasise, `\mathbf`, `\mathcal` etc. Changing sizes Large, Larger, Huge, tiny etc.

Tables and Figures: Creating tables with different alignments, placement of horizontal, vertical lines. Changing and placing the figures, alignments

Module III: Mathematics in LaTeX, Writing Projects, and Plagiarism

[6L]

How to write various Mathematical Equations, piecewise function, matrices, trigonometric, logarithmic, exponential functions, line, surface, volume integrals

Writing Projects: Different type of document classes, e.g., article, report, book, beamer etc. Using packages and customizing documents, Page Layout: Titles, Abstract, Chapters, Sections, subsections, paragraph, verbatim, References, Equation references, citation.

Plagiarism: An overview of plagiarism. How to check plagiarism.

List of Lab Experiments:

The following topics will be learned practically using various Latex software, e.g., TeX Live / MiKTeX / Overleaf.

1. Installing LaTeX (TeX Live / MiKTeX / Overleaf).
2. How to write a mathematical expression.
3. Structure of a book chapter.
4. Structure of a research article.
5. Report writing on a practical done in laboratory with results, tables and graphs.
6. Write a well-organized article using overleaf.
7. How to check plagiarism using various software, e.g., Copyscape, Quetext, Unicheck, Turnitin, and PlagScan.

Text Books:

- T1. LATEX- A Document Preparation System, Leslie Lamport, Addison-Wesley, 1994.
- T2. E. Krishnan, LATEX Tutorials A PRIMER, Indian TEX users group, 2020.

Reference Books:

- R1. George Gratzer, Practical LATEX, Springer, 2014.
- R2. Mittelbach F. & Fischer U. The LaTeX companion (3rd ed.) Addison-Wesley Professional.

Evaluation:

Mode of Evaluation	Practical	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Course Title	Mathematical Modelling and Simulation
Course Code	MTH410
Credit	4
Contact Hours (L-T-P)	3-1-0
Course Type	Theory
Prerequisite	Linear Algebra and Basic Statistics

Course Objectives:

The primary objective of this course is to provide students with an understanding of how biological and real-life problems can be formulated as mathematical models and subsequently analyzed using appropriate mathematical and computational techniques.

Course Outcomes:

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

CO1: Recall definitions, properties, types of dynamical systems

CO2: Understand different types of models and concepts

CO3: Apply numerical solvers, stability analysis, and model construction

CO4: Analyze behavior through stability, bifurcation, and limit cycles

CO5: Evaluate models for accuracy, relevance, and application

CO6: Design models, perform simulations, and optimization

Course Description:

This course is a modern course of Mathematics. Mathematical Modelling plays an important role in connecting real-life problems and mathematics quite effectively. Biological concepts can be interpreted as a formulation of a mathematical model. One of the main goals of this course is to study Stability Analysis of a mathematical model. For understanding stability analysis, linear algebra is a must-needed prerequisite. Also, for understanding the nature of the model, Ordinary Differential Equations are also very much needed. Students will be encountering many graphs in this course to understand the geometry of the model equations. Along with the tutorial and real-life problems, students will be able to apply the theoretical concepts in practical life.

Course Content:

Module I: Mathematical Modelling and Dynamical Systems

Definition and properties of mathematical models. Dynamical systems: basic concepts and classification. Autonomous and non-autonomous dynamical systems. Equilibrium points and their classification. Linearization of dynamical systems. Stability analysis of equilibrium points.

Module II: Continuous and Discrete Models

Continuous Models:

Exponential, Logistic, and Gompertz growth models. Models with harvesting. Compartmental models: Prey–predator models and infectious disease models. Stiff differential equations and delay differential equations.

Discrete Models:

Introduction to discrete dynamical systems. Transformation from continuous models to discrete models. Fixed points and their stability analysis. Drug delivery models. Density-dependent growth models.

Module III: Bifurcation and Limit Cycles

Bifurcation:

Concept of bifurcation and bifurcation points. Fixed points and their changes under parameter variation. Saddle-node, transcritical, Hopf, and pitchfork bifurcations.

Limit Cycles:

Introduction to limit cycles. Stable and unstable limit cycles. Existence of closed orbits. Qualitative analysis of limit cycles.

Module IV: Simulation and Mathematical Modelling

Monte Carlo simulation. Random number generation. Queuing models. Harbour system model. Morning rush-hour model. Optimisation modelling. Sensitivity analysis.

Evaluation:

Mode of Evaluation	Theory and Lab	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text Books:

1. Strogatz, S. Nonlinear Dynamics and Chaos, CRC press, 7th Ed. 2014.
2. Murrey, J.D., Mathematical Biology I-An introduction, Springer, 3rd Ed. 2007.
3. Barnes B and Fulford GR, Mathematical Modeling with Case Studies. CRC Press, 3rd Ed. 2014.
4. Kot, Mark. Elements of mathematical ecology. Cambridge University Press, 2001.

Reference Books:

1. TynMyint-U and LokenathDebnath, Linear Partial Differential Equation for Scientists and Engineers, Springer, Indian reprint, 4th Ed. 2007.
2. Mattheij RMM, Rienstra SW, ten ThijsBoonkamp JHM, Partial differential Equations, Modeling Analysis, Computation. SIAM (Dimensional analysis), 2005.

Mapping COs with POs & PSOs:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	2	3	1	2	1	2	2	2	2	3	2	2
CO2	3	3	2	3	3	2	2	2	3	2	2	3	3	3	3
CO3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO4	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO6	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	3	2.83	2.67	2.83	3.00	2.50	2.50	2.50	2.83	2.67	2.67	2.83	3.00	2.83	2.83

Course Title	Optimization Techniques
Course Code	MTH409
Credit	4
Contact Hours (L-T-P)	3-0-2
Course Type	Hybrid
Prerequisites	Calculus and Linear Algebra

Course Objectives:

The objectives of this course are as follows:

- To develop the concept of unconstrained optimization problems and build up the knowledge of local and global optima
- Able to demonstrate the concept of descent methods, conjugate direction and Quasi-Newton's methods
- To acquire the knowledge of constrained optimization problems and duality

Course Outcomes:

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

CO1: Recall and understand basic optimization concepts

CO2: Explain optimization methods for one-dimensional problems

CO3: Apply methods for multivariate optimization problems

CO4: Analyze constrained optimization problems using Lagrange and KKT conditions

CO5: Evaluate optimization techniques for unconstrained multivariate problems

CO6: Design and implement advanced optimization algorithms

Course Description:

This course provides a comprehensive overview of introduction to unconstrained and constrained optimizations. It focuses on various optimization techniques and their applications in different settings. Students will develop a deep understanding of optimization principles and strategies for solving complex real-world problems through this course. Throughout the course, practical applications and case studies related to several search techniques will be discussed to provide real-world examples of how these optimization techniques are used in decision-making processes. Students will also have the opportunity to work on assignments and projects to apply the concepts learned in the course.

Course Content:

Module I:

[22L]

Review of Convex Sets and Convex Functions, Norms and Projections, Saddle Points;

Univariate unconstrained optimization: Fibonacci Search Method, Golden Section Method, Bisection Method, Newton's Method

Multivariate Unconstrained optimization: Random search method, Grid search method, Hooke-Jeeves pattern search method, Powell's method, Cauchy's Steepest Descent Method, Conjugate gradient Method, Newton's method, Marquardt's Method, Quasi-Newton method

Module II: [10L]

Constrained Optimization: KKT condition, Fritz John optimality condition, Quadratic programming, Wolfe's Modified Simplex Method, Sequential Quadratic Programming (SQP), Penalty function method, Barrier method

Module III: [13L]

Large-Scale and Sparse Optimization: Gradient Descent Methods, Batch Gradient Descent, Stochastic Gradient Descent (SGD) and Mini-batch Methods, Momentum, Gradient Descent with Momentum, AdaGrad, RMSProp, ADAM
Population based methods, Differential Evolution, Particle Swarm Optimization (PSO)

Practical/Lab to be performed on a computer using MATLAB/Python programming:

1. Solution of unconstrained optimization problem using Fibonacci Search Method
2. Solution of unconstrained optimization problem using Golden Section Method
3. Solution of unconstrained optimization problem by Newton-Raphson Method
4. Implement Hooke-Jeeves pattern search method
5. Problem based on Cauchy's Steepest Descent Method
6. Problem based on Conjugate gradient Method
7. Problem solving by Newton's method
8. Solution of Quadratic programming problem using Sequential Quadratic Programming (SQP)/Penalty function method
9. Particle Swarm Optimization (PSO)

Evaluation:

Mode of Evaluation	Theory		Practical	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination	Comprehensive and Continuous Assessment	End Semester Examination
	25%	25%	25%	25%

Text Books

- T1. Rao, S. S., Engineering Optimization: Theory and Practice, Fourth Edition, Wiley. 3rd Ed. 2013.
- T2. J. Nocedal and S.J. Wright, Numerical Optimization, Second Edition, Springer, 2nd Ed. 2006
- T3. Kalyanmoy Deb, Optimization for Engineering Design-Algorithms and Examples, Second Edition, PHI Learning Private Limited, New Delhi, 2nd Ed. 2013.
- T4. Mykel J. Kochenderfer and Tim A. Wheeler, Algorithms for Optimization, MIT Press, 2nd Ed. 2025.

Reference Books

- R1. D. P. Bertsekas, Nonlinear Programming, 3rd edition, Athena Scientific, 3rd Ed. 2016.
- R2. Hamdy A. Taha, Operations Research: An Introduction, 10th Ed., Prentice Hall India, 2019.
- R3. D. Bertsimas, J. N. Tsitsiklis, Introduction to linear optimization, Athena Scientific, 1997.
- R4. Kanti Swarup, P. K. Gupta and Man Mohan, Operations Research, S. Chand and Co. Pvt. Ltd. 20th Revised Ed. 2021.
- R5. F.S. Hillier and G.J. Lieberman, Introduction to Operations Research, 9th Ed., Tata McGraw Hill, Singapore, 2009.

Mapping COs with POs & PSOs:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	-	-	-	-	-	-	-	-	-	2	3	-	3
CO2	3	3	2	-	2	-	-	-	-	-	-	2	3	2	3
CO3	3	3	2	2	3	-	-	-	-	-	-	2	3	3	3
CO4	3	3	2	2	2	-	-	-	-	-	-	2	3	2	3
CO5	3	3	2	3	3	-	-	-	-	-	-	2	2	3	3
CO6	3	3	3	3	3	-	-	-	2	2	2	3	3	3	3
	3.00	2.83	2.20	2.50	2.60	-	-	-	2.00	2.00	2.00	2.17	2.83	2.60	3.00

Course Title	Cloud Computing
Course Code	CSE483
Credit	4
Contact Hours (L-T-P)	3-0-2
Course Type	Hybrid

Course Objectives:

- Introduce fundamental concepts of cloud computing with a focus on mathematical applications.
- Explore service models (IaaS, PaaS, SaaS) and deployment models (public, private, hybrid).
- Examine how cloud infrastructure supports scientific computing and big data analytics.
- Provide hands-on experience with cloud platforms and tools.

Course Outcomes:

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

CO1: Understand the core concepts, architecture, and service models of cloud computing.

CO2: Use cloud platforms (e.g., Google Cloud, AWS, Azure) to perform mathematical and statistical computations.

CO3: Deploy and manage virtual machines and containerized applications in the cloud.

CO4: Analyze, visualize, and interpret data using cloud-based tools like Google Colab and RStudio Cloud.

CO5: Apply cloud-based machine learning and forecasting techniques to real-world datasets.

CO6: Evaluate cloud security principles, access control, and ethical considerations in cloud environments.

Course Description:

This course introduces the fundamentals of cloud computing and its applications in scientific and data-driven domains, particularly for mathematics and statistics. Students will learn about cloud service models, virtualization, distributed computing, storage solutions, and cloud-based tools for data analysis and modeling. Emphasis is placed on hands-on experience with platforms such as Google Cloud, AWS, and Azure, using tools like Google Colab, RStudio Cloud, and cloud-based Python/R programming environments. Students will develop the ability to deploy scalable applications, perform large-scale statistical computations, and apply machine learning models using cloud services.

Course Content:

Module I: Basics of Cloud Computing

[12L]

Definition and characteristics of Cloud Computing, History and evolution of Cloud Computing, Service Models: IaaS, PaaS, SaaS, Deployment Models: Public, Private, Hybrid, Community,

Cloud architecture and enabling technologies (Virtualization, SOA), Benefits and limitations of cloud computing

Module II: Cloud Virtualization and Machine Learning [13L]

Virtualization: Concept, Types (Full, Para), Hypervisors, Data centers: Design and Management, Cloud Storage: Concepts and Types, Compute Services: EC2, Azure VM, Networking in the cloud: VPC, Load Balancers, Introduction to containerization (Docker, Kubernetes).

Mathematical Concepts: Regression, PCA, Clustering, Training ML Models in Google Colab, Cloud Pipelines for Data Processing, Real-time Stream Analytics (e.g., Google Dataflow)

Module III: Cloud Security and Cloud Tools [20L]

Optimization and scheduling techniques in the cloud, Statistical resource allocation models, Mathematical modeling of cloud cost and performance, Probabilistic models for fault tolerance and reliability, Queueing theory basics in cloud environments, Simulation and performance evaluation of cloud systems.

Cloud security fundamentals, Identity and access management, Cryptographic techniques in cloud, Secure storage and secure computation, Compliance and legal issues (GDPR, HIPAA), Case Studies on Cloud Security breaches, Python for cloud (boto3, Google Cloud SDK), Serverless computing: AWS Lambda, Azure Functions, Scientific computing on the cloud (Jupyter, RStudio Cloud), Cloud platforms in data science: Google Colab, Azure ML, AWS SageMaker

Practical/Lab to be performed on a computer using AWS Platform:

1. Introduction to cloud computing; hands-on with AWS, Google Cloud, or Azure to explore cloud dashboards and resources.
2. Use Google Colab for performing matrix operations, solving systems of equations using NumPy, and plotting mathematical functions using Matplotlib.
3. Perform descriptive statistics, data visualization, and correlation analysis using RStudio Cloud or R in Google Colab.
4. Launch and configure a virtual machine on AWS EC2 or GCP; install necessary packages for scientific computation and run sample mathematical scripts.
5. Upload, manage, and access datasets using AWS S3 or Google Cloud Storage; integrate storage with Python/R for statistical data processing.
6. Create visualizations of mathematical and statistical data using Seaborn, Plotly, or Matplotlib in cloud-based notebooks.
7. Build and evaluate linear regression models using scikit-learn or R; apply models to real-world datasets within Google Colab.
8. Analyze and forecast time-dependent data using Python (statsmodels) or R; implement moving averages and trend visualization.

Evaluation:

Mode of Evaluation	Theory	Practical
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Weightage	Comprehensive and Continuous Assessment	End Semester Examination	Comprehensive and Continuous Assessment	End Semester Examination
	25%	25%	25%	25%

Text Books

T1: “Cloud Computing: Principles and Paradigms”

By Rajkumar Buyya, James Broberg, Andrzej Goscinski

– A foundational text covering cloud service models, architecture, and technologies.

T2: “Cloud Computing: Concepts, Technology & Architecture”

By Thomas Erl

– Comprehensive treatment of cloud architecture and service models.

T3: “Mastering Cloud Computing”

By Rajkumar Buyya, Christian Vecchiola, S. Thamarai Selvi

– Practical perspective on cloud application development with case studies.

T4: “Cloud Computing: A Hands-On Approach”

By Arshdeep Bahga, Vijay Madisetti

– Hands-on guide with programming labs and cloud use cases.

T5: “Data Science on the Google Cloud Platform”

By Valliappa Lakshmanan

– Practical implementation of data science workflows in the cloud.

Reference Books

R1: “Distributed and Cloud Computing”

By Kai Hwang, Jack Dongarra, Geoffrey C. Fox

– Focuses on parallel and distributed systems with cloud applications.

R2: “Cloud Computing Bible”

By Barrie Sosinsky

– Covers cloud storage, virtualization, and infrastructure management.

R3: “Cloud Computing for Science and Engineering”

By Ian Foster, Dennis Gannon

– Scientific computing perspective; ideal for math and stats applications.

R4: “Python and R for the Modern Data Scientist”

By Rick J. Scavetta, Boyan Angelov

– Practical examples of using Python and R on cloud platforms like AWS and Colab.

R5: “Amazon Web Services in Action”

By Michael Wittig, Andreas Wittig

– Great for labs focused on AWS services, VMs, storage, and serverless computing.

Mapping COs with POs & PSOs:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO1	3	2		2	1							1	3		
CO2	3	2	1	2	2				1				3	2	
CO3	2	2	3	2	2				1		2	1	3		1
CO4	3	3	2	3	2				2	2			2	2	
CO5	3	3	2	3	3					1			3	2	2
CO6	2			1		3	2	2	1			1		1	
	2.67	2.4	2	2.17	2	3	2	2	1.25	1.5	2	1	2.8	1.75	1.5

Course Title	Cryptography and Network Security
Course Code	MTH411
Credit	4
Contact Hours (L-T-P)	3-1-0
Course Type	Theory
Prerequisites	Discrete Mathematics and Elementary Number Theory

Course Objectives:

The objectives of this course are as follows:

1. To understand basics of Cryptography and Network Security.
2. To be able to secure a message over insecure channel by various means.
3. To learn about how to maintain the Confidentiality, Integrity and Availability of a data.
4. To understand various protocols for cyber security to protect against the threats in the cyber space.

Course Outcomes:

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

CO1. Define the basics of OSI security model and Classical Encryption Technique.

CO2. Understand and identify the application of Public Key Encryption Techniques and practices.

CO3. Demonstrate the application of Data Authentication and Authorization.

CO4. Examine the basics concept of Network Security and Web Security.

CO5. Appraise the recent threats and attacks against the technical world and design some effective prevention scheme.

CO6. Apply the concept of Elliptic curve in various cryptographic algorithms.

Course Description:

Effective network communication is an integral part of technical life. Cyber Security and Cryptography is a process of securing the data communication, all the algorithms, messages etc. In this course you will learn the inner workings of cryptographic systems and how to correctly use them in real-world applications. The course begins with a detailed discussion of how two parties who have a shared secret key can communicate securely when a powerful adversary eavesdrops and tampers with traffic. We will examine many deployed protocols and analyze mistakes in existing systems. The second half of the course discusses public-key techniques that let two parties generate a shared secret key. Throughout the course participants will be exposed to many exciting open problems in the field and work on fun (optional) programming projects. In the course cybersecurity we will cover more advanced security tasks such as zero-day vulnerability, privacy mechanisms, and other forms of encryption.

Course Content:

Module I

[15L]

Analyzing Unconditional Security: Plaintext Distribution, Key Distribution, Ciphertext Distribution, Attacker's Probabilities, Condition for Perfect Secrecy, Mechanism of Twisted Shift Cipher, Shannon's Theorem, One Time Pad (Vernam's Cipher), and Limitations of Perfect Secrecy.

Quantification of Information: Entropy, Entropy and Coding, Measurement of the Redundancy in a Language, Conditional Entropy, Joint Entropy, Entropy and Encryption, Unicity Distance.

Classical Cryptosystems: Ciphers, Symmetric Algorithms, Asymmetric Algorithms, Encryption, Attacker's Capabilities, Kerckhoff's Principle for cipher design, Shift Cipher, Substitution Cipher, Polyalphabetic Ciphers, Vigenère Cipher, Affine Cipher, Hill Cipher, Permutation Cipher, Block Ciphers, Stream Ciphers, Product Ciphers, Affine Cipher, Idempotent Ciphers, Iterative Cipher.

Module II

[10L]

Public key Cryptosystems: One Way Functions, Trapdoor One Way Function, RSA Algorithm, RSA Encryption and Decryption, Randomized Algorithms for Primality Testing using Monte-carlo method, Digital Signatures, Digital Certificates.

Factoring Algorithms: Pollard $p-1$ Factorization, Pollard Rho Algorithm, ElGamal Public Key Cryptosystem, Key Exchange Protocols: Diffie Hellman Problem

Module III

[10L]

Elementary Concepts of Coding Theory: Basic assumptions about channels (Code length preservation, Independence of errors), Basic strategy for decoding (maximal likelihood principle, nearest neighbour decoding strategy etc.), Hamming distance and its properties, Basic error correcting theorem, Binary symmetric channel, parity-check bit, two-dimensional parity code, Hadamard code, International Standard Book Number (ISBN)-code

Module IV

[10L]

Private Key Cryptosystems: Modern techniques, algorithms like DES, AES, IDEA, RC5, Blowfish.

Elliptic Curves Theory: Elliptic curve Diffie–Hellman (ECDH) key agreement scheme, Elliptic Curve Integrated.

Practical (30 hours)- Practical / Lab work to be performed in a Computer Lab:

Encryption scheme of the following problems using SageMath Code:

1. Introduction to Sage for Cryptography: modular arithmetic, Euclidean algorithm, modular inverse, congruences.
2. Implementation of Shift Cipher, Affine Cipher and Substitution Cipher; encryption and decryption.
3. Implementation of Vigenère Cipher and other polyalphabetic ciphers; frequency analysis and basic cryptanalysis.
4. Hill Cipher: Matrix operations over finite rings/fields; key generation, encryption and decryption using the Hill cipher.

5. RSA Cryptosystem: Generation of large primes, RSA key generation, encryption, decryption and verification of the RSA algorithm.
6. Diffie–Hellman Key Exchange: Primitive elements, discrete logarithm problem, generation of private/public keys and computation of a shared secret.
7. ElGamal Cryptosystem: Key generation, encryption and decryption; implementation of ElGamal digital signatures.
8. Elliptic Curve Cryptography: Implementation of ECDH key exchange and ECDSA digital signatures; key generation, signing, verification and comparison with RSA.

Evaluation:

	Hybrid		
Mode of Evaluation	Comprehensive and Continuous Assessment	Mid Semester Examination	End Semester Examination
Weightage	30%	30%	50%

Text Books:

- T1. Douglas Stinson, Cryptography Theory and Practice, 2nd Edition, Chapman & Hall/CRC, 2018.
- T2. B A Forouzan, Cryptography & Network Security, Tata Mc Graw Hill, 2007.
- T3. W Stallings, Cryptography and Network Security, Pearson Education, 2008.
- T4. Wenbo Mao, Modern Cryptography, Theory & Practice, Pearson Education, 2003.

Reference Books:

- R1. Hoffstein, Pipher and Silverman, An Introduction to Mathematical Cryptography, Springer, 2010.
- R2. J Daemen, and V Rijmen, The Design of Rijndael, Springer, 2013.
- R3. A Joux, Algorithmic Cryptanalysis, CRC Press.
- R4. S G Telang, Number Theory, Tata Mc Graw Hill, .

Mapping COs with POs & PSOs:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1	2	1	1	1	1	2	2	1	1	3	2	2
CO2	3	3	2	3	2	1	1	1	2	2	2	2	3	2	2
CO3	3	3	3	3	3	2	1	1	2	2	2	2	3	2	3
CO4	2	3	3	3	1	1	1	1	2	2	2	1	3	3	2
CO5	3	3	2	3	3	2	1	1	2	2	3	2	2	3	3
CO6	3	3	3	3	3	3	2	2	3	3	3	3	3	3	3
	2.67	2.83	2.33	2.83	2.17	1.67	1.17	1.17	2.17	2.17	2.17	1.83	2.83	2.50	2.50

Course Title	Research Methodology
Course Code	MTH450
Credit	4
Contact Hours (L-T-P)	3-1-0
Course Type	Theory
Prerequisites	Academic Writing and Literature Review Skills

Course Objectives

To equip students with a comprehensive understanding of research methodologies to formulate effective research questions and objectives. It emphasizes the improvement of scientific writing and communication skills for creating persuasive research papers, proposals, and presentations. Students will explore ethical considerations, including the avoidance of scientific misconduct and the promotion of responsible conduct, to maintain integrity in research. Additionally, the course will focus on effectively utilizing indexing and citation databases and mastering tools for scientific writing and reference management to ensure accurate documentation of sources.

Course Outcomes

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

- CO1: Identify and recall the key concepts related to the nature and significance of research, and the distinction between quantitative and qualitative research methods.
- CO2: Understand the structure and organization of research papers, the essential components of writing, and the skills required for preparing effective oral and poster presentations for scientific conferences.
- CO3: Apply ethical principles in research, demonstrating an understanding of scientific misconducts, intellectual honesty, and research integrity
- CO4: Analyze and evaluate research databases, citation metrics, and plagiarism detection tools to enhance research productivity and the impact of scholarly work.
- CO5: Evaluate and apply tools like Medley for scientific referencing and citation management, while addressing plagiarism and ensuring research integrity in academic writing.
- CO6: Design and develop high-quality research papers, presentations, and proposals by incorporating scientific writing skills, appropriate research methods, ethical guidelines, and citation standards, fostering collaboration and communication within academic and research settings.

Course Description:

This course on Research Methodology covers essential concepts in research, including various approaches, ethical considerations, and the formulation of research questions. Students will learn to structure research papers, improve scientific writing, and deliver presentations. The course also addresses ethics in research, scientific misconduct, and explores indexing databases, research metrics, and tools like LaTeX for effective writing.

Course Content:

Module I: Introduction to Research Methodology:

Understanding the nature and significance of research, Different approaches to research - Basic, Applied, Interdisciplinary, Multidisciplinary, difference between quantitative and qualitative research, identifying research objectives and formulating research questions, exploring ethical considerations and responsible conduct of research.

Module II: Research communication and scientific writing:

Structuring and organizing research papers and reports, enhancing scientific writing skills for research articles and proposals, preparing effective research presentations (oral and poster), developing communication skills for scientific conferences and collaborations

Module III: Ethics in research:

Definition, moral philosophy, scientific conduct, intellectual honesty, and research integrity, scientific misconducts, falsification, fabrication and plagiarism, Redundant publications, duplication, overlapping publications, and salami slicing.

Module IV:

Databases, Indexing databases, Citation databases: Web of Science, Scopus, etc. Research Metrics, Impact factor, SNIP, SJR, IPP, Cite Score, h-index, g-index, i10 index, altmetrics. Scientific writing, References and citations (Medley, Jabref), plagiarism, intellectual property rights, copyrights, preprints (arXiv), open access.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text Books:

- T1.** Research Design and Methods – A Process Approach, Bordens, K. S. and Abbott, B. B., Eighth Edition, McGraw-Hill, 2011.
- T2.** Research Methodology – Methods and Techniques, C. R. Kothari, Second Edition, New Age International Publishers, 2004.
- T3.** Philosophy of Science, Bird A, Routledge, 2006.
- T4.** Ethics in Competitive Research: Do not get scooped; do not get plagiarized, Praveen Chaddah, 2018.
- T5.** Research Methodology and Scientific Writing, C. George Thomas, Springer Nature, 2015.

Reference Books

- R1.** Research Methodology: A Step-by-Step Guide for Beginners, Ranjit Kumar
- R2.** Research Design: Qualitative, Quantitative, and Mixed Methods Approaches; John W. Creswell and J. David Creswell
- R3.** Writing for Science, Robert Goldbort
- R4.** Ethics in Research: Continuum Research Methods, Margaret Adolphus
- R5.** Scientific Papers and Presentations, Davis, M., Davis K., and Dunagan M., Third Edition, Elsevier
- R1.** Research Methods for Science, Michael P. Marder, Cambridge University Press, 2011

Mapping COs with POs & PSOs:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	3	1	1	2	2	1	2	1	1	3	2	2
CO2	3	3	3	3	2	2	2	2	3	3	3	3	3	2	3
CO3	3	2	3	3	2	3	2	3	3	2	2	3	3	2	2
CO4	3	3	3	3	3	3	2	2	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3

CO6	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	3	2.83	2.83	3.00	2.33	2.50	2.33	2.33	2.67	2.67	2.50	2.67	3.00	2.50	2.67

Course Title	Advanced Machine Learning and Applications
Course Code	
Credit	4
Contact Hours (L-T-P)	3-0-2
Course Type	Hybrid

Course Objectives:

The primary objective of this course is as follows:

- To understand core machine learning concepts including bias–variance and model selection.
- To apply kernel methods, kernel functions, and feature space transformations.
- To implement kernel-based, clustering, ensemble, and density estimation algorithms.
- To evaluate dimensionality reduction techniques like Kernel PCA for high-dimensional data.
- To develop reinforcement learning models using MDP, Q-learning, and policy methods.

Course Outcomes:

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

- CO1: Recall fundamental machine learning concepts including supervised and unsupervised learning, bias–variance tradeoff, cross-validation, regularization, model selection, mixture models, and linear Gaussian systems.
- CO2: Explain kernel concepts including types of kernels, kernel matrices, reproducing kernel maps, feature space operations, spectrum kernels, eigenfunctions, and kernelization techniques
- CO3: Apply unsupervised and density-based learning techniques including Kernel K-Means, DBSCAN, DENCLUE, Kernel Density Estimation, and ensemble methods like AdaBoost and Gradient Boosting.
- CO4: Analyze kernel-based learning methods such as Kernel SVM, Kernel Discriminant Analysis, and Fisherfaces for classification tasks.
- CO5: Evaluate dimensionality reduction techniques such as Kernel PCA for high-dimensional data analysis.
- CO6: Create and implement advanced machine learning models, reinforcement learning models using Markov Decision Processes (MDP), Q-learning, and policy and

Course Description:

This course provides a rigorous introduction to advanced machine learning from statistical and geometric perspectives. It covers supervised and unsupervised learning, bias–variance trade-off, cross-validation, regularization, model selection, mixture models, and linear Gaussian systems. Students will explore kernel methods, including different types of kernels, kernel matrices, reproducing kernel maps, eigenfunctions, and kernelization techniques. The course also addresses advanced algorithms such as Kernel Discriminant Analysis, Fisherfaces, Kernel SVM, Kernel K-Means, DBSCAN, DENCLUE, Kernel Density Estimation, ensemble methods, boosting (AdaBoost, Gradient Boosting), and nonlinear dimensionality reduction including Kernel PCA. Finally, it introduces reinforcement learning concepts, preparing students for advanced applications and research in machine learning.

Course Content:**Module I:**

Review of Machine Learning & Advanced Concepts, covering supervised and unsupervised learning, the bias–variance trade-off, cross-validation methods, regularization techniques, and model selection techniques. mixture models, linear Gaussian systems

Module II:

Concepts of Kernel, different types of Kernels, Kernel Matrix, Reproducing Kernel Map, Kernel Operation in Feature Space, Spectrum Kernel, Concepts of Eigenfunction, Kernelization techniques.

Module III:

Kernel Discriminant Analysis, Fisherfaces, Kernel SVM, Kernel K-Means, DENCLUE, DBSCAN, Kernel Density Estimation, Advanced Machine Learning Algorithms: Ensemble Learning, Gradient boosting, Ada-boosting, Dimension Reduction Techniques: Kernel PCA.

Module IV:

Markov Decision Processes (MDP), Q-learning, policy vs value functions, and some basic concepts in deep reinforcement learning.

Lab Experiments Using R/Python

1. Computation and Visualization of Kernel Matrices: Implement linear, polynomial, and RBF kernels and observe the resulting kernel matrices.
2. Feature Mapping using Kernel Functions: Map sample data into higher-dimensional space and visualize separability.
3. Kernelization Techniques and Eigenfunction Analysis: Apply kernel trick to simple algorithms and explore eigenvalues/eigenvectors of the kernel matrix.

4. Kernel Discriminant Analysis (KDA) on a Sample Dataset: Implement KDA for classification and visualize class separation.
5. Kernel Support Vector Machine (SVM) Implementation: Train and test SVM with linear, polynomial, and RBF kernels.
6. Kernel K-Means Clustering: Apply kernel-based K-Means for non-linearly separable data.
7. Kernel PCA for Dimensionality Reduction: Perform Kernel PCA and visualize reduced feature space.
8. DBSCAN Clustering Implementation: Apply DBSCAN on a dataset to find clusters and noise.
9. DENCLUE Clustering: Implement DENCLUE algorithm and analyze density-based clusters.
10. Bagging and Random Forest Ensemble Learning: Implement ensemble methods and compare performance with base learners.
11. Boosting Algorithm Implementation: Train a gradient boosting model and evaluate performance.
12. **Q-Learning Implementation on a Gridworld Environment:** Learn optimal policies using the Q-learning algorithm.

Text Books:

- T1. Mohammed J. Zaki, Wagner Meira, JR (2020), Data Mining and Machine Learning: Fundamental Concepts and Algorithm, Cambridge University Press, 2nd Edition
- T2. Kevin P. Murphy (2022), Advanced Probabilistic Machine Learning: An Introduction, MIT Press.

Reference Books:

- R1. Blum, A., Hopcroft, J., & Kannan, R. (2018). Foundations of data science, Hindustan Book Agency
- R2. Benyamin Ghojogh, Mark Crowley, Fakhri Karray, Ali Ghodsi, Elements of Dimensionality Reduction and Manifold Learning, 2nd Edition, Springer.

Evaluation:

Mode of Evaluation	Hybrid		
Weightage	Comprehensive and Continuous Assessment	Mid Semester Examination	End Semester Examination
	30%	20%	50%

Course Title	Operations Research
Course Code	MTH405
Credit	4
Contact Hours (L-T-P)	3-0-1
Course Type	Theory
Prerequisites	10+2 level Mathematics

Course Objectives:

The objectives of this course are:

1. To provide the basic concept of the mathematical model formulation of an optimization problem
2. To help the students to learn different methodology for solving Linear programming and Integer programming problem
3. To enable students to acquire the knowledge of dynamic programming model and methodology
4. To give the students in-depth knowledge of different models related to the inventory problem

Course Outcomes:

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

- CO1: Recall the fundamental concepts, definitions, and scope of Operations Research (OR), including various problem-solving methods
- CO2: Explain the principles, assumptions, and characteristics behind different Operations Research models
- CO3: Apply suitable OR techniques to solve real-life optimization problems
- CO4: Analyze job sequencing strategies, queuing systems, and dynamic programming models to determine performance metrics and decision policies
- CO5: Evaluate and compare different solution methods for their suitability in solving large-scale or complex OR problems
- CO6: Formulate and model real-life decision-making problems using mathematical models and develop optimal solutions using Operations Research techniques

Course Description:

To become a very good decision-maker, one needs to have a strong foundation in Operations Research (OR). To provide that foundation, this course is designed. It covers the topics related to linear programming, Dynamic programming, Network analysis, Replacement model, and Inventory model. All the lectures will be devoted on discussions of basic and advanced topics, focusing on practical implementation of knowledge. Classes will be conducted by lecture as well as power point presentation. The tutorials will familiarize the students with practical problem-solving techniques led by the course coordinator. Students will strongly grab the basic concepts of the subject via exercise and discussions with the coordinator.

Course Content:

Module I:

[14L]

Introduction to Operations Research: Origin & Development of Operations Research (OR), Basic definition, Scope, Objectives, Phases, and limitations of OR, Mathematical Modeling of Real-Life Problems

Linear Programming Problem: Duality theorems, Dual simplex method, Primal-dual Algorithm, Revised Simplex method, Post-optimal analysis, Introduction to Interior-Point Methods (Ellipsoid Method, Karmarkar's Method)

Module II: [12L]

Integer Linear Programming Problem: Integer linear programming, Pure and mixed integer programming, Gomory's cutting plane method, Branch and bound method, E-Bala's Algorithm for 0-1 programming problem, Real life applications of linear Integer Programming Problem, Application of Branch and Bound Algorithms for solving Travelling Salesman problem

Module III: [10L]

Job Sequencing: Basic Terminologies and Assumptions of Job Sequencing, and Processing of n Jobs through 2 and 3 Machines, Processing n Jobs through m Machines, Processing 2 Jobs through m Machines - Graphical Method,

Replacement Theory: Introduction to Replacement Theory and Determination of Optimal Replacement Time, Selection of the Best Machine, Individual and Group Replacement Policies

Module IV: [12L]

Dynamic Programming: Introduction, the recursive Equation Approach, Characteristics of Dynamic Programming, Developing Optimal decision Policy, Additive and Multiplicative Separable returns for objective as well as constraints functions. Discrete Dynamic programming Problems, Dynamic Programming Approach for solving Linear Programming Problem, Applications of Dynamic programming

Module V:**Queuing Theory: [12L]**

Introduction, Basic Characteristics of Queueing System, Probability Distributions in Queueing System, Performance Measures of Queueing System, Study of Queue Models: (i) Model I: (M/M/1): (∞ / FCFS) (ii) Model II: (M/M/1: N / FCFS) (iii) Model III: (M/M/s): (∞ / FCFS) (ii) Model IV: (M/E_k/1: ∞ /FCFS)

Practical/Lab to be performed on a computer using LINGO Software:

Write and execute LINGO code for the following experiments:

1. Solution of a Linear Programming problem (Large Scale)
2. Transportation Problem
3. Assignment Problem
4. Sensitivity/Post-optimal Analysis of an LPP
5. Integer Linear Programming and Binary Linear Programming
6. Travelling Salesman Problem using Integer Programming
7. Optimal Job Sequencing
8. Optimal Resource Allocation using Dynamic Programming
9. Machine Replacement using Dynamic Programming
10. Queueing System Analysis: M/M/1 and M/M/s

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text Books

- T1. G Srinivasan, Operations Research: Principles and Applications, PHI Learning Private Limited, Third Edition, 2017.

- T2. J K Sharma, Operations Research Theory & Applications, Macmillan India Ltd, Third Edition, 2022.
- T3. H A Taha, Operations Research-An Introduction, Pearson, 10th edition, 2017.

Reference Books

- R1. P K Gupta and D S Hira, Operations Research, S. Chand & Co., 2015.
- R2. S D Sharma, Operations Research: Theory and Applications, 4th edition, Laxmi Publications
- R3. Frederick S Hillier and G J Lieberman, Introduction to Operations Research, McGraw-Hill Science
- R4. S. S. Rao, Optimization: Theory and Applications, Wiley Eastern.
- R5. W. L. Winston, Operation Research: Application and algorithm, Cengage Learning; 4th edition, 2003.
- R6. A. Ravindran, D. T. Phillips and James J. Solberg: Operations Research- Principles and Practice, John Wiley & Sons, 2005.

Mapping COs with POs & PSOs:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	-	-	-	-	-	-	1	3	2	2
CO2	3	2	-	-	-	-	-	-	-	-	-	1	3	3	3
CO3	3	3	2	2	2	-	-	-	-	-	1	1	3	3	3
CO4	2	3		3	2	-	-	-	-	-	1	1	3	2	3
CO5	2	2	2	2	3	-	-	1	1	-	1	1	3	2	3
CO6	3	3	3	3	3	-	-	1	2	2	2	2	3	3	3
	2.67	2.60	2.33	2.50	2.50	-	-	1.00	1.50	2.00	1.25	1.17	3.00	2.50	2.83

Course Title	Computational Matrix Theory
Course Code	MTH408
Credit	4
Contact Hours (L-T-P)	3-0-2
Course Type	Hybrid
Prerequisites	Linear Algebra

Course Objectives:

The objectives of this course are as follows:

- The course gives classical algorithms to solve linear system of equations by different methods, and to find the eigenvalues of a matrix.
- The course details the mathematical theory behind numerical algorithms for solving a linear system and eigenvalue problems.
- Focus on iterative methods suitable for large-scale problems arising in real-life models

Course Outcomes:

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

- CO1: Recall fundamental concepts of floating-point arithmetic, algorithm stability, conditioning of problems, and algorithmic complexity
- CO2: Explain the principles behind matrix factorizations techniques and their applications to solving linear systems
- CO3: Apply numerical methods to solve system of linear equations and compute eigenvalues and eigenvectors of matrices
- CO4: Analyze the effects of perturbations in problems involving eigenvalues, conditioning, and sensitivity in linear systems
- CO5: Evaluate the effectiveness and convergence of numerical algorithms
- CO6: Develop or implement efficient numerical algorithms for solving large-scale systems and eigenvalue problems using iterative and decomposition techniques

Course Description:

Linear Algebra is one of the most widely used topics in the mathematical sciences. At undergraduate level the standard techniques for basic linear algebra tasks including the solution of linear systems, finding eigenvalues/eigenvectors and orthogonalization of bases are taught. However, these techniques are usually computationally too intensive to be used for the large matrices encountered in practical applications. Numerical linear algebra will introduce students to these practical issues and will present, analyses, and apply algorithms for these tasks which are reliable and computationally efficient.

Numerical linear algebra lab is companion course to this course in which a significant lab work using MATLAB is to be done. The theoretical material is assessed in a closed book examination.

Course Content:

Module I: Stability and Conditioning

[08L]

Floating point arithmetic, Stability of algorithms, Conditioning of a problem, Perturbation analysis, algorithmic complexity

Module II: Matrix Decomposition and Solution of System of Equations

[16L]

LU factorization using Gaussian elimination, Gaussian elimination with partial pivoting, LU factorization method for solving system of equations $Ax = b$, Cholesky decomposition - sensitivity analysis, QR factorization, Solution of $Ax = b$ Using QR Factorization, Projections

Using QR Factorization, Singular value decomposition (SVD), Least-Squares Solutions to Linear Systems, normal equations, Rank deficient least-squares problems, Sensitivity analysis of least-squares problems.

Module III: Computing Eigenvalues and Eigenvectors [11L]

Localization of the Maximal Eigenvalue, matrices in super-diagonal block form, eigenvalues and eigenvectors of a few classes of nonnegative matrices; Perturbation of eigenspaces, a perturbation bound for eigenvalues. Numerical methods to compute eigenvalues and eigenvectors: the Power Method, Inverse Iteration, and the Rayleigh Quotient Iteration.

Module IV: Iterative Methods for solving system of equations [10L]

Krylov Subspace Methods for Linear Systems, Lanczos, Arnoldi, GMRES, Conjugate Gradient, and QMR.

List of experiments. Write and execute MATLAB-code for the following programs:

1. LU factorization method
2. Cholesky decomposition method
3. QR factorization method
4. SVD
5. Power method
6. Inverse Iteration method
7. Rayleigh Quotient Iteration method
8. Conjugate Gradient method
9. Arnoldi Process method
10. GMRES
11. Lanczos Method

Evaluation:

Mode of Evaluation	Theory		Practical	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination	Comprehensive and Continuous Assessment	End Semester Examination
	25%	25%	25%	25%

Text Books:

- T1. James W. Demmel, Applied Numerical Linear Algebra, Publisher: Society for Industrial and Applied Mathematics, Year: 1997.
- T2. Biswa Nath Datta, Numerical Linear Algebra and applications, 2nd Edition, Publisher: Society for Industrial and Applied Mathematics, Year: 2010.
- T3. Alan J. Laub, Computational Matrix Analysis, SIAM, 2012.
- T4. Rajendra Bhatia, Matrix Analysis, Springer.

Reference Books:

- R1. Henryk Minc, Nonnegative Matrices. New York: Wiley, 1988.
- R2. G. H. Golub & C. F. Van Loan, Matrix Computations, 3rd Ed., Publisher: John Hopkins University Press, Year: 1996
- R3. N. Trefethen & David Bau III, Numerical Linear Algebra, Publisher: Society for Industrial and Applied Mathematics, Year: 1997

R4. Richard A. Brualdi and Herbert J. Ryser, Combinatorial Matrix Theory. Cambridge University Press.

R5. Roger A. Horn and Charles R. Johnson, Topics in Matrix Analysis. Cambridge University Press.

Mapping COs with POs & PSOs:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	-	-	-	-	-	-	-	-	-	2	3	2	2
CO2	3	3	2	2	-	-	-	-	-	-	-	2	3	2	3
CO3	3	3	3	3	2	-	-	-	-	-	-	2	3	3	3
CO4	3	3	3	3	2	-	-	-	-	-	-	2	3	3	3
CO5	3	3	3	3	3	-	-	1	1	-	1	2	3	3	3
CO6	3	3	3	3	3	-	-	1	2	2	2	3	3	3	3
	3.00	2.83	2.80	2.80	2.50	-	-	1.00	1.50	2.00	1.50	2.17	3.00	2.67	2.83

Course Title	Calculus of Variation and Integral Equations
Course Code	MTH412
Credit	4
Contact Hours (L-T-P)	3-1-0
Course Type	Theory
Prerequisites	Real Analysis, Ordinary Differential Equations and Linear Algebra

Course Objectives:

1. To give a fundamental concept of functional, Functional involving higher order derivatives, variational problems with fixed and moving boundary.
2. To develop knowledge of different method in calculus of variation with their application.
3. To gain the knowledge of fundamental of integral equation and its different types.
4. To illustrate the concept of Green function in solving boundary value problems.

Course Outcomes:

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

CO1: Identify the foundational concepts of the calculus of variations and types of integral equations (Fredholm, Volterra, convolution-type, etc.)

CO2: Explain the formulations of Euler's equations, Hamilton's principle, and the nature of degenerate kernels in Fredholm integral equations.

CO3: Apply variational methods such as the Rayleigh-Ritz and Galerkin methods to solve physical and engineering problems involving functionals.

CO4: Analyze the structure of Volterra and Fredholm integral equations and their relationship to differential equations through examples and transformations

CO5: Evaluate the solutions of Fredholm integral equations of the second kind using methods like successive approximations and resolvent kernels.

CO6: Construct Green's functions for boundary value problems and design solutions for singular integral equations and variational problems with boundary conditions.

Course Description:

This course provides an in-depth study of Calculus of Variations and Integral Equations, with applications in physics and engineering. It begins with the fundamentals of variational calculus, including functionals, Euler's equations, and problems involving higher-order derivatives. Key methods such as Rayleigh-Ritz, Galerkin's, and Hamilton's principle are covered to solve variational problems with fixed and moving boundaries. Students are introduced to the theory and applications of integral equations, focusing on Fredholm and Volterra types. This course focuses on Fredholm integral equations of the second kind, incorporating methods such as Fredholm determinants and iterated kernels. Students will also learn to construct Green's functions for boundary value problems and tackle singular integral equations. The course prepares students for advanced applications in mathematical physics, engineering analysis, and applied mathematics research.

Course Content:

Module I

[20 Lectures]

Calculation of Variation: Functionals, Euler's equations, Isoperimetric problems, Functional involving higher order derivatives, Variational problems with fixed and moving boundary,

Rayleigh-Ritz method, Galerkin's method, Hamilton's principle, Lagrange's equations, Reflection and Refraction of extremals, Diffraction of light rays.

Module II:

[24 Lectures]

Integral Equations: Basic concepts, Fredholm integral equations, Volterra integral equations, conversion of ODE into integral equations, Relationship between linear differential equations and Volterra and Fredholm integral equations, Solutions of homogeneous Fredholm integral equations of 2nd kind with degenerate kernels, Resolvent kernel, Solutions of Fredholm integral equations of 2nd kind with degenerate kernels and related examples, Method of successive approximations, Convolution type equations, Volterra equation of first kind, Abel's integral equation

Module III:

[16 Lectures]

Fredholm integral equations, Fredholm equations of the second kind, the method of Fredholm determinants, Iterated kernels, Integral equations with degenerate kernels, Eigen values and eigen functions of a Fredholm alternative, Construction of Green's function for BVP, Singular integral equations.

Evaluation:

Mode of Evaluation	Theory		
Weightage	Comprehensive and Continuous Assessment	Mid Semester Examination	End Semester Examination
	30%	20%	50%

Text Books

- T1. S. Gupta; Calculus of Variations with Applications, PHI
- T2. M.D. Raisinghania; Integral Equations and Boundary value problems, S Chand, 2021.

Reference Books

- R1. Robert Weinstock; Calculus of Variations: With Applications to Physics and Engineering, Dover Publications Inc. 2007.
- R2. Babu V R Ranganatham S, Fourier Series and Integral Transforms, S Chand & Company, New Delhi
- R3. Swarup and Singh, Integral Equations & Boundary Value Problems, Krishna publications.

Mapping COs with POs & PSOs:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	2	3	1	2	1	2	2	2	2	3	2	2
CO2	3	3	2	3	3	2	2	2	3	2	2	3	3	3	3
CO3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO4	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO6	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	3	2.83	2.67	2.83	3.00	2.50	2.50	2.50	2.83	2.67	2.67	2.83	3.00	2.83	2.83

Course Title	Network Theory
Course Code	CSE484
Credit	4
Contact Hours (L-T-P)	3-1-0
Course Type	Theory
Prerequisites	10+2 level Mathematics and Computer Programming

COURSE OBJECTIVES:

1. An understanding of the overriding principles of computer networking, including protocol design, protocol layering, algorithm design, and performance evaluation.
2. An understanding of computer networking theory, including principles embodied in the protocols designed for the application layer, transport layer, network layer, and link layer of a networking stack.
3. An understanding of specific implemented protocols covering the application layer, transport layer, network layer, and link layer of the Internet (TCP/IP) stack
4. An understanding of security issues.

COURSE OUTCOMES:

- CO1. **Understand** the fundamental concepts of data communication, network topologies, protocols, reference models (OSI & TCP/IP), and bandwidth utilization techniques.
- CO2. **Explain and analyze** error detection and correction methods, flow control protocols, and multiple access protocols at the data link and MAC layers.
- CO3. **Apply** addressing schemes, switching concepts, and routing protocols to ensure efficient data delivery in networks.
- CO4. **Examine** transport layer services and mechanisms, including TCP/UDP, congestion control, and Quality of Service techniques.
- CO5. **Explore** and evaluate application layer services and protocols such as DNS, HTTP, FTP, SMTP, and understand basic security mechanisms like cryptography and firewalls.

Course Content:

Unit-I

[15L]

Introduction/Data communication Components: Representation of data and its flow Networks, Various Connection Topology, Protocols and Standards, OSI model, TCP/IP protocol suite, Transmission Media, LAN: Wired LAN, Wireless LANs, Connecting LAN and Virtual LAN, Techniques for Bandwidth utilization: Multiplexing - Frequency division, Time division and Wave division, Concepts on spread spectrum.

Unit-II

[15L]

Data Link Layer and Medium Access Sub Layer: Error Detection and Error Correction - Fundamentals, Block coding, Hamming Distance, CRC; Flow Control and Error control protocols - Stop and Wait, Go back – N ARQ, Selective Repeat ARQ, Sliding Window, Piggybacking, Random Access, Multiple access protocols -Pure ALOHA, Slotted ALOHA, CSMA/CD, CDMA/CA, Controlled access, Channelization

Unit-III**[10L]**

Network Layer: Switching, Logical addressing – IPV4, IPV6; Address mapping – ARP, RARP, BOOTP and DHCP–Delivery, Forwarding and Unicast Routing protocols, Routing, forwarding and delivery, Static and dynamic routing, Routing algorithms and protocols.

Unit-IV**[10L]**

Transport Layer: Process to Process Communication, User Datagram Protocol (UDP), Transmission Control Protocol (TCP), Simple Transport Protocol, Congestion Control; Quality of Service, QoS improving techniques: Leaky Bucket and Token Bucket algorithm.

Unit-V**[10L]**

Application Layer: Domain name system (DNS), electronic mail (E-mail), World Wide Web (WWW): architectural overview, dynamic web document and HTTP. Application layer protocols: Simple Network Management Protocol, File Transfer Protocol, Simple Mail Transfer Protocol, Telnet, Bluetooth, Firewalls, Basic concepts of Cryptography.

REFERENCE BOOKS:

- R1. Computer Communications and Networking Technologies, Michael A. Gallo, William M. Hancock, Cengage Learning.
- R2. Computer Networks, Bhushan Trivedi, Oxford.
- R3. Computer Networks: Principles, Technologies and Protocols for Network Design, Natalia Olifer, Victor Olifer, Wiley India.
- R4. Data Communications and Networking, Behrouz A. Forouzan, Fourth Edition, Tata McGraw Hill.
- R5. Understanding Communications and Networks, Third Edition, W.A.Shay, Cengage Learning.
- R6. Computer and Communication Networks, Nader F. Mir, Pearson Education

Course Title	Computer Graphics
Course Code	CSE485
Credit	4
Contact Hours (L-T-P)	3-0-2
Course Type	Hybrid
Prerequisites	10+2 level Mathematics and Computer Fundamentals

Course Objectives:

The objectives of this course are as follows:

- To understand the fundamental concepts of Computer Graphics with focus on modelling and rendering.
- To understand the interaction aspects of computer graphics.
- To enhance the skill of students to understand the basic principles needed to design, use and understand computer graphics system.

Course Outcomes:

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

CO1: Describe Standard raster and vector scan devices as well as Graphical Input and output devices

CO2: Implement algorithms for drawing basic primitives such as line circle and ellipse.

CO3: Implement algorithms for line clipping and polygon clipping and filling.

CO4: Implement a 3D object representation scheme and carryout 2D and 3D Transformation, 3D projections and also implement visible surface determination algorithms, Illumination models and surface rendering methods, color models.

CO5: Implement a simple computer animation algorithm.

Course Description:

This course introduces the fundamental concepts and techniques of computer graphics. It covers the types and applications of graphics, graphics hardware and software systems, and input/output devices. Students will learn basic drawing algorithms, output primitives, and their attributes. The course also explores two-dimensional and three-dimensional geometric transformations, clipping algorithms, and viewing pipelines. Emphasis is placed on both theoretical foundations and practical applications in graphics programming.

Course Content:

Module I:

[18L]

An Introduction Graphics System : Computer Graphics and Its Types, Application of computer graphics, Graphics Systems : Video Display Devices, Raster Scan Systems, Random Scan Systems, Graphics Monitors and Work Stations, Input Devices, Hard Copy Devices, Graphics Software.

Module II:

[12L]

Output Primitives and Attributes of Output Primitives : Output Primitive Points and Lines, Line Drawing Algorithms, Circle Generating Algorithms, Scan-Line Polygon Fill Algorithm, Inside-Outside tests, Boundary-Fill Algorithm, Flood Fill Algorithm, Cell Array, Character Generation, Attributes of Output Primitives : Line Attributes, Color and Grayscale Levels, Area fill Attributes, Character Attributes, Bundled Attributes, Antialiasing.

Module III:

[10L]

Two-dimensional Geometric Transformations: Basic Transformations, Matrix Representation and Homogeneous Coordinates, Composite Transformations, Reflection and Shearing. Two-Dimension Viewing : The viewing Pipeline, Window to view port coordinate transformation, Clipping Operations, Point Clipping, Line Clipping, Polygon Clipping, Text Clipping, Exterior Clipping Three-Dimensional Concepts: Three-Dimensional Display Methods, 3D Transformations, Parallel Projection and Perspective Projection.

Module IV:

[12L]

Z-buffer algorithm, List-priority algorithm and area subdivision algorithm for visible surface determination. Illumination and shading models, RGB color model and Basics of Computer Animation.

Module V:

[8L]

Polygon Mesh Representation, Cubic Polynomial curves (Hermite and Bezier),

Practical/Lab to be performed on a computer using VI editor in LINUX/UNIX OS:

12. Write a program to implement Bresenham's line drawing algorithm.
13. Write a program to implement mid-point circle drawing algorithm.
14. Write a program to clip a line using Cohen and Sutherland line clipping algorithm.
15. Write a program to clip a polygon using Sutherland Hodgeman algorithm.
16. Write a program to fill a polygon using Scan line fill algorithm.
17. Write a program to apply various 2D transformations on a 2D object (use homogenous 64 Coordinates).
18. Write a program to apply various 3D transformations on a 3D object and then apply parallel and perspective projection on it.
19. Write a program to draw Hermite /Bezier curve.

Evaluation:

Mode of Evaluation	Theory		Practical	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination	Comprehensive and Continuous Assessment	End Semester Examination
	25%	25%	25%	25%

Text Books

Course Title	Advanced Graph Theory
Course Code	MTH414
Credit	4
Contact Hours (L-T-P)	3-1-0
Course Type	Theory
Prerequisites	Discrete Mathematics and Linear Algebra

Course Objectives:

The objectives of this course are as follows:

- To make students understand different graphs.
- To make students understand the concept of tree.
- To enable students to solve various problems related to matching.
- To make students understand the concept of network and flows.

Course Outcomes:

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

CO1: Understand the concept of graphs such as directed and undirected graphs, complete graphs, bipartite graphs, and regular graphs

CO2: Analyze the structure of a graph using adjacency and incidence matrices and determine the isomorphism between graphs

CO3: Apply algorithms to find Eulerian paths, Eulerian circuits, Hamiltonian paths, and Hamiltonian cycles in various graphs.

CO4: Evaluate the connectivity of a graph by determining cut vertices, cut edges, and connected components

CO5: Design graph coloring strategies and apply the Welsh-Powell algorithm to find chromatic numbers for different types of graphs

CO6: Apply selected advanced topics like the reconstruction problem, intersection graphs, and random graphs to real-world applications

Course Description:

This course can help students to learn and understand both basic and advance concept of graph theory. Student can learn the concept of path, cycle and tree. Student can apply the concept of graph theory in matching and network.

Course Content:

Module I:

[12L]

Basic Concepts: Graphs and digraphs, loop, isolated vertex, pendent vertex, complete graph, regular graphs, cycles, wheels, platonic graphs, sub-graphs, graphs isomorphism, operations on graphs, connected and disconnected graphs, rank and nullity of a graph, walks, paths, circuits, Eulerian graph, Eulerian path, Eulerian circuit, Hamiltonian graphs, Matrix representation of a graph, Incidence and adjacency matrices, Planar graphs, Kuratowski's graphs, bipartite graphs, Euler's formula, Kuratowski's theorem, dual of a planar graph, double dual of a graph.

Module II:**[18L]**

Trees: Equivalent definitions of trees and forests, Cayley's formula, the Matrix-Tree theorem, minimum spanning trees;

Connectivity: Cut vertices, cut edges, bonds, the cycle space and the bond space, blocks, Menger's theorem;

Paths and Cycles: Euler tours, Hamilton paths and cycles, theorems of Dirac, Ore, Bondy and Chvatal, girth, circumference, the Chinese Postman Problem, the Travelling Salesman problem, diameter and maximum degree, shortest paths;

Module III:**[18L]**

Matchings: Berge's Theorem, perfect matchings, Hall's theorem, Tutte's theorem, Konig's theorem, Petersen's theorem, algorithms for matching and weighted matching (in both bipartite and general graphs), factors of graphs (decompositions of the complete graph), Tutte's f-factor theorem;

Extremal problems: Independent sets and covering numbers, Turan's theorem, Ramsey theorems;

Colorings: Brooks theorem, the greedy algorithm, the Welsh-Powell bound, critical graphs, chromatic polynomials, girth and chromatic number, Vizing's theorem.

Module IV:**[12L]**

Directed graphs: Tournaments, directed paths and cycles, connectivity and strongly connected digraphs, Branching's;

Networks and flows: Flow cuts, Max flow min cut theorems, perfect square; Selected topics: Dominating sets, the reconstruction problem, intersection graphs, perfect graphs, random graphs.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text Books:

- T1. Graph Theory by Narsing Deo, Prentice Hall, 2017.
- T2. Reinhard Diestel, Graph Theory, 6th Edition, Springer, 2024.

Reference Books:

- R1. Introduction to Graph theory By Douglas B. West, Prentice Hall, 1st Ed. 1995.
- R2. Introduction to Graph theory By Gary Chartrand, Dover Publications, 2012.

Mapping COs with POs & PSOs:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1	2	1	1	1	1	2	2	1	1	3	2	2
CO2	3	3	2	3	2	1	1	1	2	2	2	2	3	2	2
CO3	3	3	3	3	3	2	1	1	2	2	2	2	3	2	3
CO4	2	3	3	3	1	1	1	1	2	2	2	1	3	3	2
CO5	3	3	2	3	3	2	1	1	2	2	3	2	2	3	3
CO6	3	3	3	3	3	3	2	2	3	3	3	3	3	3	3
	2.67	2.83	2.33	2.83	2.17	1.67	1.17	1.17	2.17	2.17	2.17	1.83	2.83	2.50	2.50

Course Title	Dynamics of a Particle
Course Code	MTH415
Credit	4
Contact Hours (L-T-P)	3-1-0
Course Type	Theory
Prerequisite	Calculus, Vector Algebra and Coordinate Geometry

Course Objectives:

The objectives of this course are as follows:

- To equip students with a deep understanding of the principles governing particle dynamics
- To analyze and solve problems related to motion, forces, energy, momentum, and collisions in one and two dimensions.

Course Outcomes:

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

CO1: Explain and apply basic kinematic concepts such as position, velocity, and acceleration for motion in a straight line and under gravity.

CO2: Analyze linear motion under various forces including weight, tension, and air resistance, using Newton's laws and energy methods.

CO3: Evaluate problems involving systems of connected particles, pulleys, and variable forces to determine resultant motions and energies.

CO4: Understand and compute dynamics of curved motion including circular motion, pendulum systems, and motion in vertical planes.

CO5: Analyze direct and oblique collisions between particles and objects, interpreting outcomes using principles of impulse and conservation laws.

CO6: Apply concepts of relative motion, center of mass, and angular velocity to solve complex multi-particle systems in two-dimensional settings.

Course Description:

This course provides a foundational understanding of the motion of particles under the influence of forces, focusing on both linear and curved motion. Topics include kinematics and kinetics of particles, Newton's laws, energy and momentum principles, variable forces, tension systems, circular motion, and collision mechanics. The course combines theoretical concepts with physical intuition, equipping students with analytical tools essential for studying mechanics in physics and engineering.

Course Content:

Module I

[15L]

Position, velocity, acceleration: Time, position, motion in a straight line: velocity, acceleration.

Motion in a straight line: Kinematics, Uniform velocity, falling bodies, body projected vertically upward, relative velocity and acceleration of two bodies, variable acceleration.

Module II**[18L]**

Force and mass; Motion in a straight line: Laws of motion, weight carried up by a lift, air resistance on a falling body, collision momentum impulse, shot and gun, work energy power, kinetic energy due to impulse and collision, tension of a string, two particles connected by a string, work done in stretching a string, impulsive tension in a string, system of pulleys.

Forces in two dimensions: Composition of displacement velocity and acceleration, work done by varying forces, centre of mass of a system of particles.

Module III**[15L]**

Motion in a plane curve: Angular velocity, acceleration of a point moving in a plane curve, motion in a circle, conical pendulum, motion of a particle in a smooth curve in vertical plane, motion of a bead on a vertical smooth circular wire, motion inside of a vertical smooth circle, particle tied to the end of a weightless string, effect of rotation of a body on the surface of the earth, tension in a rotating band.

Module IV**[12L]**

Collision: Direct impact of two spheres, impulse and kinetic energy, oblique impact of two smooth spheres and oblique impact of rough spheres, impact against a fixed plane.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text Books:

- T1. R.J.A. Barnard - Elementary dynamics of the particle and rigid body, Macmillan and Co. limited, 2019.
- T2. A S Ramsey – Dynamics (Part-1 & 2), CBS Publishers and Distributors Pvt. Ltd. (2002)
- T3. S Ganguly and S Saha- Analytical Dynamics of a Particle including Elements of Statics, 3rd Ed. 2020, New Central Book Agency (P) Ltd.

Reference Books:

- R1. S. L. Loney, Dynamics of a Particle and of Rigid Bodies, G. K. Publication Ltd, 2025.
- R2. Anil Rao, Dynamics of Particles and Rigid Bodies: A Systematic Approach, 2005.
- R3. E. T. Whittaker, A Treatise on the Analytical Dynamics of Particles and Rigid Bodies.
- R4. Joseph Whittington - Elementary dynamics, a textbook for engineers-University Press (1920).

Mapping COs with POs & PSOs:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1	2	1	1	1	1	2	2	1	1	3	2	2
CO2	3	3	2	3	2	1	1	1	2	2	2	2	3	2	2
CO3	3	3	3	3	3	2	1	1	2	2	2	2	3	2	3
CO4	2	3	3	3	1	1	1	1	2	2	2	1	3	3	2
CO5	3	3	2	3	3	2	1	1	2	2	3	2	2	3	3
CO6	3	3	3	3	3	3	2	2	3	3	3	3	3	3	3
	2.67	2.83	2.33	2.83	2.17	1.67	1.17	1.17	2.17	2.17	2.17	1.83	2.83	2.50	2.50

SDS456	Artificial Intelligence	L	T	P	C
Version 1.0	Contact Hours – 45+30	3	0	1	4
Pre-requisite/Exposure	Fundamentals of computer science, Operating system				
Model	Hybrid				

Course Objectives:

1. To provide the most fundamental knowledge of AI.
2. To make a computer that can learn, plan, and solve problems autonomously.
3. To give the students a perspective on the main research topics in AI i.e. problem solving, reasoning, planning, etc.
4. To enable students to acquire knowledge on some basic search algorithms for problem-solving; knowledge representation and reasoning; pattern recognition; fuzzy logic; and neural networks.

Course Outcomes:

Upon the completion of this course, the student will be able to

CO1: **Define** Artificial Intelligence and its approach.

CO2: **Describe** propositional logic and inference engine.

CO3: **Execute** Planning with state-space search.

CO4: **Construct** Bayesian networks and other temporal models.

CO5: **Explain** the types of Learning.

Course Description:

Artificial intelligence (AI) is a research field that studies how to replicate intelligent human behavior in computers. The ultimate goal of AI is to make a computer that can learn, plan, and solve problems autonomously. Main research topics in AI include problem-solving, reasoning, planning, natural language understanding, computer vision, automatic programming, machine learning, and more. Of course, these topics are closely related to each other. For example, the knowledge acquired through learning can be used for problem-solving and reasoning. The skill of problem-solving itself should be acquired through learning. Also, problem-solving methods are useful for both reasoning and planning. Further, natural language understanding and computer vision can be solved using methods developed in pattern recognition. In this course, we will study the most fundamental knowledge for understanding AI. We will introduce some basic search algorithms for problem-solving; knowledge representation and reasoning; pattern recognition; fuzzy logic; and neural networks.

Course Content:

Unit I: Artificial Intelligence

Introduction, Agents, Problem formulation, Uninformed search strategies, Heuristics, Informed search strategies, Satisfying constraints.

Unit II: Knowledge Representation, Reasoning

Logical agents, Propositional logic, Inference rules, First-order logic, Inferences in first-order logic, Ontology Engineering, knowledge representation

Unit III: Planning and Uncertainty:

Planning with state-space search, Partial-order planning, planning graphs, Planning and acting in the real world, Forward and backward chaining, Unification, and Resolution, Quantifying Uncertainty, Probabilistic Reasoning, and Probabilistic Reasoning over Time.

Unit IV: Learning

Making Simple Decisions, Making Complex Decisions, Multiagent Decision Making, Fuzzy LOGIC, MARKOV model, HMM, ANN, Learning, Data Mining

List of Practicals:

Languages and Programming Techniques for AI:

- *Metaheuristics*:

- Genetic Algorithm
- Simulated Annealing
- Particle Swarm Optimization
- Ant Colony Optimization
- Grey Wolf Optimization

- *Logic Programming*:

- LISP Basics
- Search Strategies and Logic Programming in LISP
- PROLOG Basics
- Production System examples in PROLOG
- Expert System and knowledge Representation using PROLOG

Text Books:

- T1. S. Russel and P. Norvig, Artificial Intelligence – A Modern Approach, Second Edition, Pearson Education, 2003.
- T2. Tom M. Mitchell, Machine Learning, 1st Edition, McGraw-Hill Series. In Computer Science
- T3. Simon O. Haykin, Neural Networks and Learning Machines, 3rd Edition, Prentice Hall
- T4. Ethem Alpaydin, Introduction to Machine Learning, 2nd Edition, The MIT Press.

Reference Books:

- R1. David Poole, Alan Mack worth, Randy Goebel, Computational Intelligence: a logical approach, First edition; Oxford University Press, 2004
- R2. G. Luger, Artificial Intelligence: Structures and Strategies for complex problem solving, Fourth Edition, Pearson Education, 2002.
- R3. Minsky, Marvin. "Society of Mind: a response to four reviews." Artificial Intelligence 48.3 (1991): 371-396.
- R4. P. H. Winston, LISP, 3/e, Addison Wesley, 1989.
- R5. I. Bratko, Prolog Programming for Artificial Intelligence, 3/e, Addison Wesley, 2000.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs		
Course Outcomes (COs)		Mapped Program Outcomes
CO1	Define Artificial Intelligence and its approach.	PO1, PO2
CO2	Describe propositional logic and inference engine.	PO2, PO3, PO4
CO3	Execute Planning with state-space search.	PO1, PO2, PO4
CO4	Construct Bayesian networks and other temporal models.	PO2, PO3, PO4, PO5, PSO3
CO5	Explain the types of Learning.	PO3, PO5, PSO3