Details of Revised/New Course Structure and Syllabus for

3-Year M.Sc. B.Ed. (Innovative) Mathematics (Programme)

(with effect from July 2025)

Central University of Rajasthan

Department of Mathematics

School of Mathematics, Statistics and Computational Sciences

Bandarsindari, Kishangarh, Ajmer, Rajasthan

305817

1. The NEP 2020 based Three-Year PG Programme is a 6-semester (3-year) Programme of 120 credits.
   - Students shall be eligible for a PG degree in M.Sc. B.Ed. (Innovative) Mathematics after successful completion of 120 Credit, including 16 Credits from a research project.

Outline of Courses:

1. **Major and Minor Courses:** Major and minor courses are 4 credits courses. An additional one to two credits may be for tutorials or practices.
2. **Other Courses:** The Other courses which included multi-disciplinary, Ability enhancement and skill enhancement courses.
3. **Final year research project/ dissertation:** Final year research project or dissertation will of 16 credits.

Structure of the 3-Year M.Sc. B.Ed. (Innovative) Mathematics Programme

S. No.	Broad category of Course	Minimum Credit requirement		
		PG (1-year)	PG (2-year)	PG (3-year)
1	MAJOR	36	63	75
2	MINOR	4	17	29
3	RESEARCH PROJECT/ DISSERTATION	-	-	16
	Total	**40**	**80**	**120**

CORE: MAJOR AND MINOR
IDC: INTER DISCIPLINARY COURSES
AEC: ABILITY ENHANCEMENT COURSES
SEC: SKILL ENHANCEMENT COURSES
VAC: VALUE-ADDED COURSES
INT: INTERNSHIP, DISS: DISSERTATION

Course Structure:

Semester-I:

S. No.	Course Code	Title of Courses	Type of Course	Credits
1	6.0MAT01	**Linear Algebra**	**Major**	4
2	6.0MAT02	**Real Analysis**	**Major**	4
3	6.0MAT03	**Qualitative Theory of ODEs**	**Major**	4
4	6.0EDU41	Basics of Education	**Major**	3
5	6.0EDU42	Senior Secondary Education in India	**Major**	3
6	6.0MAT81	Basic Programming in MATLAB	SEC	2
			Total	**20**

Semester-II:

S. No.	Course Code	Title of Courses	Type of Course	Credits
1	6.0MAT04	**Abstract Algebra**	**Major**	4
2	6.0MAT05	**Complex Analysis**	**Major**	4
3	6.0MAT--	Departmental Elective	Minor	4
4	6.0EDU43	Learner and Learning	**Major**	3
5	6.0EDU44	Teaching Approaches and Strategies	**Major**	3
6	6.0MAT82	Scientific Writing by Latex	SEC	2
			Total	**20**

Semester-III:

S. No.	Course Code	Title of Courses	Type of Course	Credits
1	6.5MAT01	**Functional Analysis**	**Major**	4
2	6.5MAT02	**Topology**	**Major**	4
3	6.5MAT03	**Partial Differential Equations-II**	**Major**	4
4	6.5EDU01	Learning Assessment	**Major**	3
5	6.5EDU02	Pedagogy of science	**Major**	4
6		MOOC	Minor	1
			Total	**20**

Semester-IV:

S. No.	Course Code	Title of Courses	Type of Course	Credits
1	6.5MAT--	Departmental Elective	Minor	4
2	6.5MAT--	Departmental Elective	Minor	4
3		MOOC	Minor	4
4	6.5EDU04	Classroom Organization & School Management	**Major**	3
5	6.5EDU05	Pedagogy of Mathematics	**Major**	4
6	6.5MAT81	Seminar	SEC	1
			Total	20

Semester V:

S. No.	Course Code	Title of Courses	Type of Course	Credits
1	7.0EDU01	School Internship-I	**AEC**	4
2	7.0EDU02	School Internship-II	**Major**	12
3	7.0EDU03	Action Research in Schools	SEC	2
4	7.0EDU04	Community based Participatory Research	SEC	2
			Total	**20**

Semester-VI:

S. No.	Course Code	Title of Courses	Type of Course	Credits
1	7.0MAT81	Research Project/Dissertation	**AEC**	16
2		Departmental/Generic Elective/MOOC course	Minor	4
			Total	**20**

Contents

LIST OF CORE MAJORS

LINEAR ALGEBRA (6.0MAT01)

Course Title:	**Linear Algebra**	
Course Code:	6.0MAT01	
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/ week	Internal Assessment: 40 Marks	**Theory:** 3
Tutorial: 1 Hour/Week	ESE: 60 Marks	**Tutorial:** 1
	Total:	**4**

Course Prerequisite: The student should have knowledge of

1	basic concepts in Linear Algebra and Matrices: System of linear equations, Matrices, Rank, Vector Spaces, Basis and Dimension

Course Objectives:

1	To introduce the fundamental notions of algebra of linear transformations, diagonalizability, and different canonical forms.
2	To teach the students different characterization of diagonalization of a linear operator
3	To introduce the concept of orthonormal basis and their existence.
4	To create orthogonal and orthonormal bases: Gram-Schmidt process and use bases and orthonormal bases to solve application problems.
5	To introduce adjoints of linear operators, unitary and normal operators.

Course Outcomes: The students will be able to

1	Learn algebra of linear transformations, significance and use of eigenvalue and eigenvectors.
2	explain different concepts about linear transformations and inner product spaces.
3	learn different characterization of diagonalization and canonical forms of a given linear transformation.
4	use different concepts associated with vector spaces, linear transformations, diagonalization and inner product spaces in other courses like functional analysis, differential equations.

Course Content:

Unit	Content	Hours
I	Review of vector spaces, The algebra of linear transformations, Isomorphism, Linear functionals, Annihilator, Double dual, Transpose of a linear transformation, Eigenvalues and Eigenvectors, and Eigenvectors.	15
II	Diagonalizability, Minimal Polynomial, Cayley Hamilton theorem. Invariant subspaces, Triangulability and Diagonalization in terms of the minimal polynomial, Direct-sum decompositions, Invariant direct sums.	15
III	The primary decomposition theorem, Cyclic Subspaces And annihilators, Cyclic decomposition, Rational and Jordan forms. Symmetric and Skew-symmetric Bilinear Forms, Diagonalization of symmetric bilinear forms.	15
IV	Inner product spaces: Best approximation, The adjoint of linear transformation, Unitary operators, Self-adjoint, Normal operators, Spectral theorem for self-adjoint operators.	15

Internal Assessment:

CIA-1	Unit -I
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on Unit-II and III
ESE	Unit-I, II, III, IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Textbooks:

1. Hoffmann K. and Kunze R., 1992, *Linear Algebra*, Prentice Hall of India.
2. Friedberg S. H., Insel A.J., Spence L.E., 2019, Linear Algebra, Pearson Education.
3. Kumaresan S., 2000, Linear Algebra: A Geometric Approach, Prentice Hall of India.
4. Halmos, P.R., 2011, Finite Dimensional Vector Spaces, Springer.
5. Lang, S., 2005, Introduction to Linear Algebra, Springer.

Reference Books:

1. Artin M., 2010, *Algebra*, Pearson Education.
2. Cooperstein B., 2015, *Advanced Linear Algebra*, CRC Press.

E-resources:

https://archive.nptel.ac.in/courses/111/106/111106051/

REAL ANALYSIS (6.0MAT02)

Course Title:	**Real Analysis**		
Course Code:	**6.0MAT02**		
Teaching Scheme		**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/ week		**Internal Assessment: 40 Marks**	**Theory:** 3
Tutorial: 1 Hour/Week		**ESE: 60 Marks**	**Tutorial:** 1
		Total:	4

Course Prerequisite:

1	Basics of real analysis, metric space and integral and differential calculus.

Course Objectives: To develop the concept of

1	understanding and applications of different aspects of the real number system ℝ, in the Euclidean space R^n
2	Riemann-Stieltjes integrability, properties of R-S integration and its applications.
3	uniform convergence of sequence and series of functions, solving problems and their applications.
4	bounded variation functions and their basic properties, development of derivatives as a linear transformation and understanding of important associated results.

Course Outcomes: Students will be able to

1	understand and analyze the different aspects of ℝ, in $\mathbb{R}^n$ along with their applications.
2	solve the problems of Riemann-Stieltjes integration and will be able to apply/verify its properties.
3	understand and apply the tests of uniform convergence of sequence and series of functions along with solving problems.
4	verify the conditions of bounded variation functions along with applications, understand the concept of derivatives as linear transformation in $\mathbb{R}^n$ and know about the important associated results.

Course Content:

Unit	Content	Hours
I	Introduction to Euclidean space, Open ball, Open and closed sets, Adherent points, accumulation points and isolated points, Closure and derived sets, Bolzano Weierstrass theorem, Cantor intersection theorem, Lindeloff covering theorem, Heine-Borel theorem, Compactness in $\mathbb{R}^n$, Compact subsets of a metric space.	15
II	Basics of Riemann-Stieltjes (R-S) integration, Existence of R-S integration, Conditions of R-S integrability, Properties of R-S integrals, First and second mean value theorems, Some important results on R-S integrability.	15
III	Introduction to sequence and series of functions, Concept of pointwise and uniform convergence, Important tests for uniform convergence of a sequence and series of functions, Uniform convergence and continuity, Uniform convergence and integration, Uniform convergence and differentiation, Uniform convergence and R-S integration. Term by term differentiability and term by term integrability of series.	15
IV	Functions of bounded variations and its properties, total variations. Continuity, partial derivatives, differentiability, derivatives of functions in an open set of $\mathbb{R}^n$ into $\mathbb{R}^n$ as a linear transformation, chain rule, Jacobians and its properties. Introduction to important theorems such as Inverse function theorem, Implicit function theorem etc.	15

Internal Assessment:

CIA-1	Unit-I
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on Unit-II and III
ESE	Written Exam. for Unit-I, II, III, & IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Textbooks:

1. Somasundaram, D. and Chaudhary, B., 2018, *A First Course in Mathematical Analysis (A Corrected Edition)*, Narosa Publishing House, New Delhi.
2. Malik S. C. and Arora S, 2017, *Mathematical Analysis*, New Age Int. Ltd. Publishers, New Delhi.
3. Mapa, S.K., 2019, *Introduction to Real Analysis*, Levant Books, Kolkata.

Reference Books:

1. Rudin W., 2016, *Principles of Mathematical Analysis (3rd Ed.)*, McGraw Hill International Edition.
2. Apostol T. M., 1996, *Mathematical Analysis (2nd Ed.)*, Narosa Publishing House, New Delhi.

E-resources:

https://nptel.ac.in/courses/111106053

QUALITATIVE THEORY OF ODES (6.0MAT03)

Course Title:	**Qualitative Theory of ODEs**	
Course Code:	**6.0MAT03**	
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/week	**Internal Assessment: 40 Marks**	**Theory: 3**
Tutorial: 1 hour/week	**ESE: 60 Marks**	**Tutorial: 1**
Total:		**4**

Course Prerequisite: The student should have knowledge of

1	basic concepts in Linear Algebra and Real Analysis e.g., continuity, uniform continuity, uniform convergence, system of linear equations, matrices, diagonalization
2	elementary theory of ordinary differential equations

Course Objectives:

1	To introduce the theory of existence and uniqueness theory of IVPs and system of differential equations.
2	To teach different types of boundary conditions and boundary value problems
3	To introduce stability theory of linear and nonlinear differential equations.
4	To develop some of the methods used to explore qualitative information about the behaviour of solutions of differential equations

Course Outcomes: The students will be able to

1	explain different existence and uniqueness theorems for initial value problems
2	Learn how to solve a given boundary value problem
3	To use different analytical and geometrical methods to analyze the stability of solutions of a given differential equation
4	use qualitative theory for modeling different real-life problems via differential equations

Course Content:

Unit	**Content**	**Hours**
I	General existence and uniqueness theory: Well-posedness and examples of Initial Value Problems (IVPs), Gronwall's lemma, Basic lemma and uniqueness theorem, Picard's existence and uniqueness theorem, Cauchy Peano existence theorem, Continuation of solutions.	**15**
II	System of linear differential equations: existence and uniqueness theorem, homogeneous linear systems, non-homogeneous linear system, Linear systems with constant coefficients, General system and diagonalization.	**15**
III	Boundary-value problems (BVPs): Different types of Boundary conditions and examples of BVPs, Green's functions, Sturm-Liouville BVPs: Characteristic values and characteristic functions, Orthogonality of characteristic functions, Expansion of a function in a series of orthonormal functions. System of nonlinear differential equations	**15**
IV	Autonomous system, equilibrium points and their stability, Paths of autonomous linear systems, Paths of nonlinear systems, Lyapunov functions and their construction, Limit cycles and Periodic solutions, Poincare-Bendixson theory.	**15**

Internal Assessment:

CIA-I	Unit -I
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on Unit II and III
ESE	Unit-I, II, III, IV

CIA: **Continuous Internal Assessment,** ESE: **End Semester Examination**

Textbooks:

1. Ross S.L., 2007, Differential Equations, Wiley.
2. Nandakumaran A.K., Dutti P.S. and George R.K., 2017, Ordinary Differential Equations: Principles and Applications, Cambridge University Press.
3. Brauer F. and Nohel J.A., 2005, Qualitative Theory of Differential Equations, Dover Publications.
4. Coddington E.R. and Levinson N., 2010, Theory of Ordinary Differential Equations, McGraw Hill Education.

Reference Books:

1. Nemytskii V.V., 2005, *Qualitative Theory of Differential Equations*, Princeton University Press

ABSTRACT ALGEBRA (6.0MAT04)

Course Title:	**Abstract Algebra**	
Course-Code:	6.0MAT04	
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/ week	Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 Hour/Week	ESE: 60 Marks	Tutorial: 1
	Total:	**4**

Course Prerequisite: The student should have knowledge of

1	Basic Concepts of groups and rings

Course Objectives:

1	To teach the students isomorphism theorems
2	To teach the students the Sylow theorems
3	To teach the students the properties of rings
4	To teach the students Chinese remainder theorem

Course Outcomes: The students will be able to understand

1	the concepts of group action
2	The class equation of groups
3	The properties of solvable groups
4	The arithmetic in rings

Course Content:

Unit	**Content**	**Hours**
I	Review of groups and properties, First and second Isomorphism theorems, Conjugacy relation, Group Action, Equivalent formulation of action as a homomorphism of G to Symmetric group, Stabilizer (Isotropy) subgroups	15
II	Orbit decomposition, Class equation of an action, Conjugacy class equation, Transitive actions, core of a subgroup, Sylow subgroups, Sylow's Theorem I, II and III, p-groups and applications, Direct and inverse images of Sylow subgroups, Commutator subgroup, Normal and subnormal series, composition series, Jordan-Holder theorem.	15
III	Solvable groups, Properties of solvable groups, Simple groups, simplicity of An, Review of Rings and properties, Left and right ideal, prime ideals, maximal ideals, Prime and irreducible elements, Divisibility in an Integral Domain, Units and Associates, Irreducible elements	15
IV	Greatest Common divisor, Least Common Multiple, Euclidean domains, Maximal and prime ideals, Principal ideal domains, Divisor chain condition, Unique factorization domains, Examples and counterexamples, Chinese remainder theorem for rings and PID's, Polynomial rings over domains, Unique factorization in polynomial rings over UFD's.	15

Internal Assessment:

CIA-1	Unit -I
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on Unit III
ESE	Unit-I, II, III,IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Textbooks:

1. Bhattacharya P. B., Jain S. K. and Nagpal S. R., *Basic Abstract Algebra (2^{nd} Ed.)*, Cambridge University Press.
2. Gallian J. A., 1999, Contemporary Abstract Algebra, Narosa Publication House, New Delhi.
3. Artin M., 2011, Algebra, Prentice Hall India, New Delhi.
4. Dummit D. S. and Foote R. M., 2008, Abstract Algebra, Wiley India Pvt. Ltd.

Reference Books:

1. Robinson, D. J. S., 1996, *A Course in the Theory of Groups*, Springer New York, New York

E-resources:

https://archive.nptel.ac.in/courses/

COMPLEX ANALYSIS (6.0MAT05)

Course Title:	**Complex Analysis**
Course-Code:	**6.0MAT05**

Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/ week	Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 Hour/Week	EoSE: 60 Marks	Tutorial: 1
		Total: 4

Course Prerequisite:

1	The student should have knowledge of complex numbers and their properties, basic foundation of real analysis and concepts of limit, continuity and differentiability for functions of complex variables.

Course Objectives:

1	To introduce some topics of contemporary complex analysis.
2	To provide a solid, classical foundation for the subject while exposing trails leading off in interesting directions.
3	To prepare the student to work independently in these topics and especially to use the methods of complex analysis in other areas of mathematics.

Course Outcomes: Students will be able to

1	learn the basic techniques of contemporary complex analysis as well as applications of these techniques in harmonic analysis, univalent functions theory and special functions.
2	evaluate integrals along a path, compute the Taylor and Laurent expansions, determine the nature of the singularities and calculating residues.
3	use of residue theorem to evaluate integrals.

Course Content:

Unit	**Content**	**Hours**
I	Functions of a complex variable, Differentiability and Analyticity, Harmonic Functions, Contour integrals, Antiderivative, Cauchy theorem, Cauchy-Goursat theorem, Simply and multiply connected domains, Cauchy integral formula, Higher order derivatives, Morera's theorem.	15
II	Cauchy's inequality, Liouville's theorem, Fundamental theorem of algebra, Maximum modulus principle, Minimum modulus principle, Taylor's series, Laurent series, Absolute and uniform convergence of power series, Weierstrass theorem for sequence of functions. Removable singularities, poles, order and singular part of a pole, Laurent expansions, essential singularities.	15
III	Cauchy residue theorem, Residue at infinity, Evaluation of integrals, Definite integrals involving sines and cosines, Zeros of analytic functions, Uniqueness theorem, Zeros of polynomials, Argument principle, Rouche's theorem, Schwarz lemma, Schwarz-Pick lemma, Open mapping theorem.	15
IV	Conformal mappings, Scale factor, Local inverses, Mappings by elementary functions, Bilinear transformation, Basic properties of Bilinear transformation, Fixed points, Cross-ratio, Mappings of half planes onto disks, Automorphisms of unit disk, Automorphism of half planes, Mappings by $w=e^z$, Mappings by $w=log\ z$, Mappings by $w=sin\ z$, Mappings by z^2 and branches of $z^{1/2}$.	15

Internal Assessment:

CIA-1	Unit -I
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on Unit-II and III
ESE	Unit-I, II, III, IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Textbooks:

1. Brown J.W. and Churchill R.V., 2009, *Complex Variables and Applications*, Tata McGraw Hill.
2. Ponnusamy S., 2005, *Foundations of Complex Analysis*, Narosa Publication House.
3. Kasana H.S., 2005, *Complex Variables: Theory and Applications*, PHI.

Reference Books:

1. Rudin W., 2006, *Real and Complex Analysis (3rd Addition)*, Tata McGraw Hill.

E-resources:

https://archive.nptel.ac.in/noc/courses/noc21/SEM2/noc21-ma39

FUNCTIONAL ANALYSIS (6.5MAT01)

Course Title:	**Functional Analysis**		
Course Code:	**6.5MAT01**		
Teaching Scheme		**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/ week		Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 Hour/Week		EoSE: 60 Marks	Tutorial: 1
		Total:	4

Course Prerequisite:

1	Basics of linear algebra, metric space and real analysis.

Course Objectives: To develop the concept of

1	the normed linear space and its completeness property.
2	linear transformation and operator in normed linear spaces and its properties along with elaboration of open mapping theorem, closed graph theorem, uniform boundedness principle, Hahn Banach theorem, and natural Embedding of normed linear spaces.
3	Hilbert spaces and its different properties, orthogonality and elaboration of Projection theorem, Bessel's inequality and Riesz's theorem.
4	different operators in a Hilbert space and elaboration of spectral theorem on a finite dimensional Hilbert space.

Course Outcomes: Students will be able to

1	verify the conditions of normed linear space and test the completeness property
2	verify the different properties of linear transformation and operators and understand the open mapping theorem, closed graph theorem, uniform boundedness principle, Hahn Banach theorem, and natural Embedding of normed linear spaces.
3	recognize the different properties of Hilbert space and orthogonal sets and understand the Projection theorem, Bessel's inequality and Riesz's theorem.
4	learn about different operators and understand the spectral theorem on a finite dimensional Hilbert space.

Course Content:

Unit	Content	Hours
I	Normed linear spaces, Examples and properties, Equivalent norms, Convexity and completeness, Banach spaces, Examples and properties, l^p spaces, L^p spaces, Function space, Quotient Space	15
II	Operators on normed linear space, Continuous linear transformations, Bounded linear transformations, The open mapping Theorem, The closed graph theorem, The conjugate of an operator, The uniform boundedness principle, Hahn Banach Theorem, Embedding of normed spaces.	15
III	Inner product spaces, Examples and properties, Hilbert spaces, Examples and properties, Polarization identity, Orthogonality, Orthogonal complements, Orthogonal Projection on Hilbert spaces, Projection theorem, Bessel's inequality, Riesz's theorem, Existence of orthogonal basis in Hilbert spaces.	15
IV	The adjoint of an operator, Self-adjoint operators, Normal and unitary operators, projections, Eigenvalues and eigenvectors of an operator on a Hilbert space, The spectral theorem on a finite dimensional Hilbert space.	15

Internal Assessment:

CIA-1	Unit I
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on Unit II and III
ESE	Written Exam. for Unit-I, II, III, & IV

*: Continuous Internal Assessment, **: End of Semester Examination

Textbooks:

1. Bachman G. and Narici, 1964, *Functional Analysis*, Academic Press.
2. Taylor A. E., 1958, *Introduction to Functional Analysis*, John Wiley and Sons.
3. M.T. Nair, *Functional Analysis*: A first Course, Prentice Hall of India, New Delhi, 2002 (Second Printing: 2008)

Reference Books:

1. Simmons G. F., 1963, *Topology and Modern Analysis*, McGraw Hill.
2. Erwin Kreyszig E., 1978, *Introductory Functional Analysis with Application*, Wiley

E-resources:

https://nptel.ac.in/courses/111106047
https://nptel.ac.in/courses/111106147

TOPOLOGY (6.5MAT02)

Course Title:	**Topology**		
Course Code:	6.5MAT02		
Teaching Scheme		**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/ week		**Internal Assessment:** 40 Marks	**Theory:** 3
Tutorial: 1 Hour/Week		**ESE: 60 Marks**	**Tutorial:** 1
		Total:	4

Course Prerequisite: The student should have knowledge of

1	Basic concepts of sets, relations
2	Basic concepts of functions and congruences

Course Objectives:

1	To provide motivation for topology through geometry.
2	To develop understanding of geometric and topological properties.
3	To develop understanding of the concepts of general topology as simply as possible.

Course Outcomes: The students will be able to understand

1	what are objects of study in topology and geometry?
2	the concepts and topics in hand without haste;
3	the significance of the concepts defined and the theorems proved here;
4	how this course is useful in other courses e.g., analysis, geometry and algebraic topology.

Course Content:

Unit	Content	Hours
I	Topological spaces. Open sets, closed sets. Interior points, Closure points. Limit points, Boundary points, Exterior points of a set, Closure of a set, Derived set, Dense subsets. Basis, sub base, Relative topology.	15
II	Product space, Quotient space. Continuous functions, open & closed functions, homeomorphism, Lindelof space, Separable spaces, Connected Spaces, locally connectedness, Connectedness on the real line, Components, Path connected space	15
III	Complete space, Compact Spaces, one point compactification, compact sets, properties of Compactness and Connectedness under a continuous function, Compactness, Equivalence of Compactness.	15
IV	Separation Axioms: T0 , T1, and T2 spaces, examples and basic properties, First and Second Countable Spaces, Regular, normal, T3 & T4 spaces, Tychnoff spaces, Urysohn"s Lemma, Tietze Extension Theorem, Tychnoff Theorem.	15

Internal Assessment:

CIA-1	Unit -I
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on Unit II and III
ESE	Unit-I, II, III, IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Textbooks:

1. Simmons G.F., 1963, *Topology and Modern Analysis*, McGraw Hill.
2. Vicker, 1996, Topology via Logic, Cambridge University Press.
3. Munkers, J.R., 2015, Topology- A First Course, Pearson Education India.
4. Joshi, K.D., 2017, Introduction To General Topology, New Age International Private Limited.

Reference Books:

1. Kell, J.L., 2017, *General Topology,* Dover Publications.

E-resources:

https://archive.nptel.ac.in/courses/111/106/111106159/

PARTIAL DIFFERENTIAL EQUATIONS-II (6.5MAT03)

Course Title:	**Partial Differential Equations-II**	
Course-Code:	**6.5MAT03**	
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/ week	Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 Hour/Week	ESE: 60 Marks	Tutorial: 1
	Total:	4

Course Prerequisite: Students should have knowledge of

1	solution methods of ODE
2	differential calculus

Course Objectives: To teach

1	theory of partial differential equations and solution methods.
2	the nature of PDEs like parabolic, elliptic, hyperbolic.
3	Green's Function method to find the solution of Non-homogeneous PDE
4	variational formulation of boundary value problems.

Course Outcomes: Students will be able to

1	solve the PDEs independently
2	convert partial differential equations to canonical form.
3	use Green’s function method to solve non-homogeneous PDE
4	apply to Variational formulation of boundary value problems

Course Content:

Unit	Content	Hours
I	Formation of PDEs: First order PDE in two and more independent variables, Derivation of PDE by elimination method of arbitrary constants and arbitrary functions. Lagrange’s first order linear PDEs, Charpit’s method for non-linear PDE of first order, Jacobi’s method and Cauchy problem for first order PDEs.	15
II	PDEs of second order with variable coefficients: classification of second order linear PDEs, Canonical forms of Parabolic, Elliptic and Hyperbolic PDEs, Monge’s methods for nonlinear second order PDEs, Method of separation of variables for Laplace, Heat and Wave equations.	15
III	Eigenvalues and Eigenfunctions of BVP, Orthogonality of Eigen function, D-Almbert’s solutions to wave equations, Fundamental solution of Laplace Equation, Green’s function for Laplace Equation, Wave equation, Diffusion Equation.	15
IV	General solution of higher order PDEs, Variational formulation of boundary value problem.	15

Internal Assessment:

CIA-1	Unit -I, II
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on Unit II and III
ESE	Unit-I, II, III, IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Textbooks:

1. Rao S. K, *Introduction to Partial Differential* Equations, Phi Learning.
2. Sneddon I. N., Elements of Partial Differential Equations, Dover Publications.
3. Birkhoff G., Rota G. C., Ordinary Differential Equations, Wiley.

Reference Books:

1. Amaranath T., *An Elementary Course in Partial Differential Equations*, Narosa Publication.
2. Bhamra, K. S., *Partial Differential Equations: An Introductory Treatment with Applications,* PHI.

E-resources:

https://archive.nptel.ac.in/courses/111/105/111105093

List of Minor/Elective

BIOMATHEMATICS (6.0MAT31)

Course Title:	**Biomathematics**		
Course Code:	**6.0MAT31**		
Teaching Scheme	**Examination Scheme**		**Credits Allotted**
Theory: 3 hours/week	Internal Assessment: 40 Marks		Theory: 3
Tutorial: 1 hour/week	ESE: 60 Marks		Tutorial: 1
		Total:	4

Course Prerequisite: The student should have knowledge of

1.	basic concepts in elementary Calculus and Linear Algebra

Course Objectives:

1.	To introduce basic principles, assumptions and hypotheses for mathematical formulations of different biological systems
2.	To teach the students the mathematical modeling of growth of single species and interacting populations
3.	To introduce the compartmental epidemic models e.g., SIR, SEIR and SIS
4.	To discuss the dynamical analysis of different models using linearization, stability analysis and bifurcation theory
5.	To introduce the modeling of chemical kinetics

Course Outcomes: The students will be able to

1.	use results from differential equations, dynamical systems, bifurcation and stability theory to analyze a given biological system
2.	model a particular biological system and to predict its different dynamical behaviour
3.	learn modeling and analysis of single species and interacting population models
4.	do modeling and analysis of different compartmental epidemic models
5.	to predict the disease burden and prevalence of a particular disease, long term persistence of a species

Course Content:

Unit	Content	Hours
I	Introduction: Goals and Challenges of mathematical modeling in biology. Idealization and general principles of model building, Different types of mathematical models in biology, Bacterial growth, Relevant mathematical techniques: Non-dimensionalization, Steady states and linearization	15
II	Review of linear systems, Stability analysis, Phase diagrams, Single Species population models (discrete and continuous): Exponential, Logistic, and Gompertz growth, Allee effect, Harvesting models and bifurcations, Delay models	15
III	Models with interacting populations: Different types of interactions and examples, Lotka Volterra Competition, Predator-prey model, Chemostat models, Structured (spatial, age and sex) population models, Population biology of infectious diseases: Classification of infectious diseases, SIR, SIRS and SIS epidemic models,	15
IV	Basic reproduction number, Models for molecular events: Michaelis-Menten enzyme example, Timescale decomposition, Quasi steady state analysis, sigmoidal functions, multisite systems, Chemical kinetics: Mass action law, Hopf-bifurcations, Subcritical Hopf, Poincare-Bendixson-I, Poincare-Bendixson-II, Index Theory.	15

Internal Assessment:

CIA-I	Unit -I
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on Unit II and III
ESE	Unit-I, II, III, IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Textbooks:

1. Brauer F. and Chavez C. C., 2000, *Mathematical Models in Population Biology and Epidemiology*, Springer.
2. Kot M., 2001, *Elements of Mathematical Ecology,* Cambridge University Press
3. Keshet L. E., 2005, *Mathematical Models in Biology*, SIAM.
4. Keeling M. J. and Rohani P., 2008, *Modeling Infectious Diseases in Humans and Animals*, Princeton Uni. Press.
5. Martcheva M., 2010, *An Introduction to Mathematical Epidemiology*, Springer.

Reference Books:

1. Murray J. D., 2007, *Mathematical Biology: An Introduction*, Springer.
2. Smith H., 2010, *An Introduction to Delay Differential Equations with Applications to Life Sciences*, Springer.

E-resources:

https://open.uci.edu/courses/math_113b_intro_to_mathematical_modeling_in_biology.html
https://www.youtube.com/playlist?list=PL5zWDs2j0YF3kPPvs4L5FGlLc7x13Uwjn

PROBABILITY AND MATHEMATICAL STATISTICS (6.0MAT32)

Course Title:	**Probability and Mathematical Statistics**	
Course Code:	**6.0MAT32**	
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/week	Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 hour/week	ESE: 60 Marks	Tutorial: 1
	Total:	4

Course Prerequisite: The student should have knowledge of

1.	basic concepts of linear algebra and calculus

Course Objectives:

1.	To present the type of the data and tabulate statistical information given in descriptive form and to use graphical techniques to interpret.
2.	To discuss probability, probability distributions, joint probability distributions and concepts associated with a random variable.
3.	To explain essential tools for statistical analyses.
4.	To discuss central limit theorem and order statistics.

Course Outcomes: The students will be able to

1.	learn descriptive statistics and to calculate probability for various types of problems.
2.	work out various probability distributions and statistical tools.
3.	explain order statistics and central limit theorem

Course Content:

Unit	Content	Hours
I	Exploratory data analysis: summary statistics, box and whisker plots, histogram, P-P and Q-Q plots. Random Experiment and its sample space, probability as a set function on a collection of events, stating basic axioms, random variables, c.d.f., p.d.f., p.m.f.	15
II	absolutely continuous and discrete distributions, Some common distributions (Negative Binomial, Pareto, lognormal, beta, etc). Transformations, moments, m.g.f., p.g.f., quantiles and symmetry. Random vectors, Joint distributions, copula, joint m.g.f. mixed moments, variance covariance matrix.	15
III	Independence, sums of independent random variables, conditional expectation and variances, compound distributions, prior and posterior distribution, best predictors. Sampling distributions of statistics from univariate normal random samples, chi-square, t and F distributions.	15
IV	Order statistics and the distribution of rth order statistics, joint distribution of rth and sth order statistics. Statement and application of central limit theorem for a sequence of independent and identically distributed random variables.	15

Internal Assessment:

CIA-I	Unit -I
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on Unit II and III
ESE	Unit-I, II, III, IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Textbooks:

1. Sheldon R.M., 2010, *Introductory Statistics,* Academic Press.
2. Rohatgi V.K. and Md. Ehsanes Saleh A.K., 2015, *An Introduction to Probability and Statistics (3rd Ed.)*, John Wiley & Sons.
3. Rao C. R., 1965, *Linear Statistical Inference and its Applications (2nd Ed.)*, John Wiley & Sons, INC.
4. Dharmaraja S. and Das D., 2018, *Introduction to Statistical Methods, Design of Experiments and Statistical Quality Control*, Springer.
5. Mayer P. L., 1970, *Introductory Probability and Statistical Applications*, Addison-Wesley.

Reference Books:

1. Feller W., 2000, *An Introduction to Probability Theory and its Applications (3rd Ed.)*, Wiley Eastern.

E-resources:

1. https://archive.nptel.ac.in/courses/111/105/111105090/
2. https://archive.nptel.ac.in/courses/111/102/111102160/

NUMERICAL ANALYSIS (6.0MAT33)

Course Title:	**Numerical Analysis**		
Course Code:	**6.0MAT33**		
Teaching Scheme		**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/week		Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 hour/week		ESE: 60 Marks	Tutorial: 1
		Total:	4

Course Prerequisite: The student should have knowledge of

1.	differential calculus
2.	difference operator, ODE

Course Objectives:

1.	To introduce different numerical methods and their error to solve systems of linear equations, nonlinear equations, initial value problems and eigenvalue problems.
2.	to analyze the notion of interpolation and approximation.
3.	To provide the numerical treatment for the BVP governed by ODE

Course Outcomes: The students will be able to

1.	apply a finite difference method to find the interpolation, differentiation and integration for the given discrete data values.
2.	analyze and choose the best suitable numerical method for the given mathematical problem.
3.	apply the numerical techniques to solve research problems of fluid dynamics, mathematical modeling.

Course Content:

Unit	Content	Hours
I	Introduction to significant digits and errors, Solution of system of linear Equations (direct methods, Iterative methods, Ill-conditioned systems), Eigenvalue problem: Gershgorin circle theorem, power method, Jacobi method, Householder method.	15
II	Finite difference operators, difference tables, Lagrange interpolation, Newton's divided difference interpolation, Hermite interpolation, Cubic spline interpolation.	15
III	Numerical solution of ordinary differential equations: initial value problems, existence and uniqueness of the solution of initial value problem, Single step methods- Taylor series, Picard's method, Euler's method, modified Euler method, Runge-Kutta method, Multi-step methods: Predictor-corrector method, Stability Analysis.	15
IV	Boundary value problems (BVPs), Methods to solve BVPs: Finite-difference method, The Shooting method, The Cubic Spline method.	15

Internal Assessment:

CIA-I	Unit-I, II
CIA-II	Written Exams/ Quizzes/Assignment/Presentation/Viva-Voce
ESE	Unit-I, II, III, IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Textbooks:

1. Atkinson K. E., 1989, *An Introduction to Numerical Analysis* (2^{nd} Ed.), Wiley-India.
2. Jain M. K., Iyengar S. R. K. and Jain R. K., 2012, *Numerical Methods for Scientific and Engineering Computation* (6^{th} Ed.), New Age International Publishers.
3. Sastry S. S. 2019, *Introductory Methods of Numerical Analysis*, PHI.

Reference Books:

1. Buchaman J. I. and Turner P. R., 1992, *Numerical Methods and Analysis*, McGraw-Hill.

E-resources:

https://archive.nptel.ac.in/courses/111/107/111107105/

INTEGRAL TRANSFORMS (6.0MAT34)

Course Title:	**Integral Transforms**			
Course Code:	**6.0MAT34**			
Teaching Scheme		**Examination Scheme**		**Credits Allotted**
Theory: 3 hours/week		Internal Assessment: 40 Marks		Theory: 3
Tutorial: 1 hour/week		ESE: 60 Marks		Tutorial: 1
			Total:	4

Course Prerequisite: The student should have knowledge of

1.	basic concepts of Differential Calculus
2.	basic concepts of Integral Calculus

Course Objectives:

1.	To describe the ideas of Laplace transform, Fourier transform, Z-transform and Wavelet Transform
2.	To familiarize the students with the applications of the Laplace and Fourier transforms in the fields such as application of PDE, Digital Signal Processing, Theory of wave equations.
3.	To familiarize the students with the applications of the Z-transform to solve the difference equations.

Course Outcomes: The students will be able to

1.	gain the idea that by applying the theory of Integral transform the problem from its original domain can be mapped into a new domain where solving problems becomes easier.
2.	apply these techniques to solve research problems of signal processing, data analysis and processing, image processing, in scientific simulation algorithms etc.
3.	apply these transform techniques to solve the physical problem governed by ODE, PDE and difference equations.

Course Content:

Unit	Content	Hours
I	Laplace Transform-Definition and its properties, Laplace transform of some standard functions, Existence conditions for the Laplace Transform, Shifting theorems, Laplace transform of derivatives and integrals, Inverse Laplace transform and their properties.	15
II	Laplace Transform—Convolution theorem, Initial and final value theorem, Laplace transform of periodic functions, error functions, Heaviside unit step function and Dirac delta function, Applications of Laplace transform to solve ODEs and PDEs.	15
III	Fourier transforms: 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, Convolution theorem, Applications of Fourier transforms to Boundary Value Problems.	15
IV	Z-Transform: Z–transform and inverse Z-transform of elementary functions, shifting theorems, Convolution theorem, Initial and final value theorem, Application of Z-transforms to solve difference equations.	15

Internal Assessment:

CIA-I	Unit-I, II
CIA-II	Written Exams/ Quizzes/Assignment/Presentation/Viva-Voce
ESE	Unit-I, II, III, IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Text Books:

1. Debnath, L. and Bhatta B., *Integral Transforms and Their Applications*, Taylor and Francis, 2014
2. John M. Wills, *Integral Transforms in Applied Mathematics*, Cambridge University Press, 2008.
3. Murrey R Spiegal, *Laplace Transforms* (SCHAUM Outline Series), McGraw Hill,1965

Reference Books:

1. Hildebrand F. B., "*Methods of Applied Mathematics*", Courier Dover Publications,1992.

E-resources:

https://nptel.ac.in/courses/111106111

ELEMENTARY NUMBER THEORY (6.0MAT35)

Course Name	**Elementary Number Theory**
Course Code:	**6.0MAT35**

Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/week	Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 hour/week	ESE: 60 Marks	Tutorial: 1
	Total:	4

Course Prerequisite: The student should have knowledge of

1.	basic concepts of sets

Course Objectives:

1.	To teach the students integers and their properties
2.	To teach the students the congruences
3.	To teach the students the arithmetic functions
4.	To teach the students binary quadratic forms

Course Outcomes: The students will be able to

1.	Learn the concepts of linear Diophantine equation
2.	use the modular arithmetic
3.	learn the primitive root theorem
4.	discuss the binary quadratic forms

Course Content:

Unit	**Content**	**Hours**
I	Division in integers, Greatest common divisor, Euclid's Algorithm, Linear Diophantine equations, Prime numbers, Fundamental Theorem of arithmetic, Distribution of primes, Greatest integer functions	15
II	Congruence relation, Properties of Congruence relation, Linear Congruences, Solvability of Linear congruence, modular arithmetic, Residue classes and reduced residue classes, Fermat's little theorem, Wilson's theorem, Euler's theorem Chinese remainder theorem, Higher degree polynomial congruence, Polynomial congruence mod p^r	15
III	Quadratic residues, Legendre Symbol, Primitive root theorem, Arithmetic functions $\varphi(n)$, $\mu(n)$, $r(n)$, $\sigma(n)$, Ring of Arithmetic functions, Multiplicative arithmetic functions, Möbius inversion formula, Perfect numbers	15
IV	Representation of an integer as a sum of two and four squares, Diophantine equations ax+by=c, $x^2+y^2=z^2$ and $x^4+y^4=z^4$. Binary quadratic forms and Equivalence of quadratic forms, Farey sequences	15

Internal Assessment:

CIA-I	Unit -I, II
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on III
ESE	Unit-I, II, III, IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Textbooks:

1. Burton D. M., 1989, *Elementary Number Theory*, Wm. C. Brown Publishers, Dubuque, Iowa.
2. Jones G.A. and J.M. Jones, 1998, *Elementary Number Theory*, Springer-Verlag, New York
3. Sierpinski W., 1998, *Elementary Theory of Numbers*, North-Holland, Ireland.

Reference Books:

1. Zuckerman N.S.H. and Montgomery L.H., 1991, *An Introduction to the Theory of Numbers*, John Wiley.

INTRODUCTION TO SPACE DYNAMICS (6.0MAT36)

Course Name	**Introduction to Space Dynamics**	
Course Code:	**6.0MAT36**	
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/week	Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 hour/week	ESE: 60 Marks	Tutorial: 1
	Total:	4

Course Prerequisite: The student should have knowledge of

1.	Basics of linear algebra, analytical geometry, differential equations, and vector calculus

Course Objectives:

1.	kinematics of particles, understanding of different orbital paths and elaboration of conservation laws.
2.	two body problems and its application in space and visualization of Kepler's laws of planetary motion.
3.	existence of integrals in three-body problem, applications of stable equilibrium points of the restricted problem of three bodies and importance of the Jacobi integral.
4.	rocket dynamics, performance measuring parameters and needs multi-stages rockets.

Course Outcomes: The students will be able to

1.	know about the kinematics of particles, understand about different orbital paths of particles and verify the conservation laws.
2.	solve the two-body problem, verify Kepler's laws of planetary motion and visualize the application of two body problems in space.
3.	verify the existence of integrals in a three-body problem, determine and examine the stability of equilibrium points in the restricted problem of three bodies and know the importance of the Jacobi integral.
4.	know about rocket dynamics, estimate the performance parameters and understand about the needs of optimized multi-stages rockets.

Course Content:

Unit	Content	Hours
I	Some basic definitions, Conservation laws, Newton's laws of motion, Kinematics of particles, Conic-section, Central force motion, Differential equation of orbit and its solution, Geometry of different kinds of orbits.	15
II	Formulation of problem of two-body and equations of motion, relative equation of motion of two body problem, Solution of two body problem and its application. Kepler's law of planetary motion, Kepler's equation and its solution, Uniform rotating frame.	15
III	Introduction of three body problem, ten known integrals, Stationary solutions of three body problem and applications, Restricted problem of three body, Jacobi integral, prohibited regions of motion, collinear and noncollinear equilibrium points, Stability analysis of equilibrium points, Applications of restricted problem of three body in space.	15
IV	Equation of variable mass, introduction of rocket theory, governing equation of a rocket, Single-stage rocket and its performance, Effect of gravity on the dynamics of a rocket, two-stage rocket and its performance, multi-stage rocket, Optimization of multi-stage rocket.	15

Internal Assessment:

CIA-I	Written Exam.
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce
ESE	Written Exam. for Unit-I, II, III, & IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Textbooks:

1. McCuskey S. W., 1963, *Introduction to Celestial Mechanics*, Addison-Wesley Publishing Company.
2. Murray C. D., Dermott S.F., 2000, *Solar System Dynamics*, Cambridge University Press.
3. Rao K.S., 2009, *Classical Mechanics*, PHI Learning, Pvt. Ltd.
4. Goldstein H., Poole C.P. and Safko J.L., 2019, *Classical Mechanics* (Third edition), Pearson India Education Pvt. Ltd.
5. Battin, Richard H., 1999, *An Introduction to The Mathematics and Methods of Astrodynamics*, AIAA Education Series.

Reference Books:

1. Szebehely V., 1967, *Theory of orbits*. The restricted problem of three bodies, New York Acad. Press.
2. Thomson, William T., 1986, *Introduction to Space Dynamics*, Dover Publication, Inc. New York

E-resources:

https://nptel.ac.in/courses/101105029
https://nptel.ac.in/courses/101104078

FLUID DYNAMICS (6.0MAT37)

Course Name	**Fluid Dynamics**	
Course Code:	**6.0MAT37**	
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/week	Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 hour/week	ESE: 60 Marks	Tutorial: 1
	Total:	4

Course Prerequisite: The student should have knowledge of

1.	basic concepts of differential equations.
2.	basic concepts of calculus

Course Objectives:

1.	the basics characteristics of fluid, continuum hypothesis, kinematics of fluids.
2.	the Eulerian and Lagrangian methods for fluid motion.
3.	the Conservation Laws in different coordinate systems and boundary conditions.
4.	the irrotational and rotational flows
5.	the solution process of simplified examples.

Course Outcomes: The students will be able to

1.	the fluid properties, continuum hypothesis, strain rate tensor, streamline, path line, streak lines, stream function and vortex lines.
2.	the stress tensor, symmetry of stress tensor, transformation of stress
3.	the Eulerian and Lagrangian hypothesis and their differences.
4	the conservation law and their equations.
5	the methods of implementing fluid dynamics laws.
6	a number of fundamental mathematical ideas and techniques for the solution of related problems.

Course Content:

Unit	Content	Hours
I	Physical Properties of fluids. Concept of fluids, continuum hypothesis, density, specific weight, specific volume, kinematics of fluids: Eulerian and Lagrangian methods of description of fluids, equivalence of Eulerian and Lagrangian method, general motion of fluid element, integrability and compatibility conditions,	15
II	Strain rate tensor, streamline, path line, streak lines, stream function, vortex lines, circulation. Stresses in Fluids: Stress tensor, symmetry of stress tensor, transformation of stress components from one coordinate system to another, principal axes and principal values of stress tensor, conservation of mass,	15
III	Conservation of momentum, Navier Stokes equation, conservation of moments of momentum, equation of energy, basic equations in different coordinate systems, boundary conditions.	15
IV	Irrotational and Rotational Flows: Bernoulli's equation, Bernoulli's equation for irrotational flows, two dimensional irrotational incompressible flows, Blasius theorem, circle theorem, sources and sinks, sources sinks and doublets in two dimensional flows.	15

Internal Assessment:

CIA-I	Unit-I
CIA-II	Written Exams/ Quizzes/ Assignment/ Presentations/ Viva-Voce based on Unit II and III
ESE	Unit-I, II, III, IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Textbooks:

1. Rathy R.K., 1976, An Introduction to Fluid Dynamics, Oxford and IBH Publishing Co.
2. Thomson L. N. M., 1962, Theoretical Hydrodynamics, Macmillan and Co. Ltd.
3. Chorlton F., 1985, Textbook of Fluid Dynamics, CBS Publishers.
4. Landau L. D., Lipschitz E.N., 1985, Fluid Mechanics, Pergamon Press.

Reference Books:

1. Emanuel, G. 2000, Analytical Fluid Dynamics, CRC Press.
2. Nakayama, Y. and Boucher, R. F., 2000, Introduction to Fluid Mechanics, Butterworth-Heinemann

E-resources:

https://onlinecourses.nptel.ac.in/noc19_ce28/preview

GRAPH THEORY (6.0MAT38)

Course Title:	**Graph Theory**	
Course Code:	**6.0MAT38**	
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/week	Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 hour/week	ESE: 60 Marks	Tutorial: 1
	Total:	4

Course Prerequisite: The student should have knowledge of

1	basic concepts of sets

Course Objectives:

1	To teach the students basics of graphs
2	To teach the students the connectivity
3	To teach the students the planar graph
4	To teach the students incidence matrix

Course Outcomes: The students will be able to

1	the concepts of operation on graphs
2	the Eulerian graphs
3	the Kuratowski's theorem
4	the automorphism of graphs

Course Content:

Unit	Content	Hours
I	Graphs, Isomorphism of graphs, subgraph, walk, connectedness, degree, bipartite graph, Intersection graph, Operations on graphs, graph products, cut point, bridges, blocks	15
II	Tree, Center, Centroid, Connectivity, Line connectivity, Partition, Graphical partition, Eulerian graphs, Hamiltonian graphs, Line graph, Characterization of line graph	15
III	Covering, Independence, Planar graphs, Kuratowski's theorem, Chromatic Number, Chromatic polynomial	15
IV	Adjacency matrix, Incidence matrix, automorphism groups of graphs, group of composite graph	15

Internal Assessment:

CIA-I	Unit -I, II
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on Unit III
ESE	Unit-I,II,III,IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Text Books:

1. Harary F., 1969, Graph Theory, Narosa Publication House, New Delhi.
2. Balakrishnan R., Ranganathan K., 2012, A Textbook of Graph Theory, Springer, New York.
3. Deo N., 1974, *Graph Theory with Applications to Engineering and Computer Science*, Prentice-Hall of India, New Delhi.

Reference Books:

1. Diestel R., 2000, *Graph Theory*, Springer, New York

E-resources:

https://archive.nptel.ac.in/courses/

FOUNDATIONS OF SET THEORY (6.0MAT39)

Course Title:	**Foundations of Set Theory**	
Course Code:	**6.0MAT39**	
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/week	Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 hour/week	ESE: 60 Marks	Tutorial: 1
	Total:	4

Course Prerequisite: The student should have knowledge of

1	basic concepts of sets

Course Objectives:

1	To teach the students the mathematical statements
2	To teach the students the relation and map
3	To teach the students the construction of number systems
4	To teach the students ordinal numbers

Course Outcomes: The students will be able to

1	the Zermelo-Fraenkel axioms of set theory
2	the Peano's axioms
3	the dedekind cut approach
4	the cardinal arithmetic

Course Content:

Unit	Content	Hours
I	Mathematical statements, connectives, simple sentence and compound sentence, universal quantifiers, Functional Rule and Truth Table, Conjunction, Disjunction, Implication, Tautology and Contradiction, Rules of Inference and Replacement, method of contradiction, Zermelo-Fraenkel axioms of set theory, Class of sets, Russel's Paradox	15
II	Successor set and natural numbers, Ordered pair, Cartesian product, Relations and Maps on sets, Indexing set, Arbitrary intersection and union, Extension of Maps, Fundamental Theorem of Maps, Number Systems, Natural Numbers, Peano's Axioms, Pigeonhole Principle,	15
III	Construction of other number systems, Integers and Rational Numbers, Their arithmetic and ordering, Dedekind cut, Real number system as complete ordered field	15
IV	$\in$-transitive sets, Ordinals, class of ordinals, Trichotomy law between ordinals, characterization of an ordinal in terms of $\in$-transitive sets, successor and limit ordinals, Principle of Transfinite Induction, Ordinal Arithmetic, Ordinals and well ordered set, Axiom of Choice and its equivalence, The Banach-Tarski Paradox, Cardinals and its arithmetic, ordering of cardinals, countable and uncountable sets, continuum hypothesis	15

Internal Assessment:

CIA-I	Unit -I, II
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on Unit III
ESE	Unit-I,II,III,IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Text Books:

1. Levy A., 1979, Basic Set Theory, Springer-Verlag, New York.
2. Copi M., 1979, Symbolic Logic, Macmillan Publishing Co. Inc., New York.
3. Kakkar V., 2016, Set Theory: Read it, Absorb it and Forget it, Narosa Publication House, New.
4. Enderton H. B., 1977, Elements of Set Theory, Academic Press Inc., New York.

Reference Books:

1. Halmos P. R., 1960, *Naive Set Theory*, Von Nostrand Reinhold Company, New York.

E-resources:

https://archive.nptel.ac.in/courses/

PROGRAMMING IN C (6.0MAT40)

Course Title:	**Programming In C**	
Course Code:	**6.0MAT40**	
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/week	Internal Assessment: 40 Marks	Theory: 3
Practical: 1 hour/week	ESE: 60 Marks	Practical: 1
	Total:	4

Course Prerequisite: The student should have knowledge of

1	basics of set and functions

Course Objectives:

1	To introduce the basic concepts of computer programming languages.
2	To develop the logics for create programs.
3	To introduce basic programming constructs

Course Outcomes: The students will be able to

1	the concepts of computer programming languages
2	the codes the programmes in C language
3	the developing of the applications

Course Content:

Unit	Content	Hours
I	Basic concepts of programming languages: Programming domains, language evaluation criterion and language categories, Describing Syntax and Semantics, formal methods of describing syntax, recursive descent parsing, Dynamic semantics (operational semantics, denotational semantics, axiomatic semantics).	11 Hours Theory and 7 Hours Lab
II	Names, Variables, Binding, Type checking, Scope and lifetime data types, array types, record types, union types, set types and pointer types, arithmetic expressions, type conversions, relational and Boolean expressions, assignment statements, mixed mode assignment.	11 Hours Theory and 8 Hours Lab
III	Statement level control structures, compound statements, selection statements, iterative statements, unconditional branching, Character set, variables and constants, keywords, Instructions, assignment statements, arithmetic expression, comment statements, simple input and output.	11 Hours Theory and 7 Hours Lab
IV	Relational operators, logical operators, control structures, decision control structure, loop control structure, case control structure, functions, subroutines, scope and lifetime of identifiers, parameter passing mechanism, arrays and strings.	12 Hours Theory and 8 Hours Lab

Internal Assessment:

CIA-I	Unit-I
CIA-II	Written Exams/ Quizzes/ Assignment/ Presentations/ Viva-Voce/ based on Unit II and III
ESE	Unit-I, II, III, IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Text Books:

1. Sebesta R. W., 1999, Concepts of Programming Language, Addison Wesley, Pearson Education.
2. Deitel P., Deitel H., 2010, How to Program C (6th Ed.), Addison Wesley, Pearson Education.
3. Toledo R. A. M. and Cushman P. K., 2003, Introduction to Computer Science, Mc Graw Hill International Edition.
4. Appleby D., Kopple J. J V., 1997, Programming Languages (2nd Ed.), Tata McGraw Hill, India.
5. King K. N., 2008, C Programming a Modern Approach (2nd Ed.), W. W. Norton & Company.

Reference Books:

1. Kanetkar Y., 2018, *Let Us C (16th Ed.)*, B.P.B Publications.

E-resources:

AN INTRODUCTION TO FUZZY SET THEORY AND FUZZY LOGIC (6.0MAT41)

Course Title:	**An Introduction to Fuzzy Set Theory and Fuzzy Logic**
Course Code:	**6.0MAT41**

Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/week	Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 hour/week	ESE: 60 Marks	Tutorial: 1
	Total:	4

Course Prerequisite: The student should have knowledge of

1	classical set theory, and two-valued logic.

Course Objectives:

1	To provide the basic knowledge of the fuzzy sets, operations and their properties.
2	To teach them the fundamental concepts of fuzzy functions and fuzzy relational calculus.
3	To teach them fuzzy logic in detail.
4	To teach them fuzzy numbers and evidence theory.

Course Outcomes: The students will be able to

1	the significance, need and applications of concepts of fuzziness.
2	the fundamental concepts of Fuzzy functions and Fuzzy logic
3	the fuzzy numbers and its types.
4	how to apply evidence theory.

Course Content:

Unit	Content	Hours
I	Crisp sets vs fuzzy sets: Membership function types and properties, Chance versus fuzziness, Level sets, Cardinality and fuzzy cardinality, Set theoretic operations on fuzzy sets, Inclusion and Difference, Fuzzy compliments, Fuzzy intersections: t-Norms, Fuzzy unions: t-Conorms, Algebraic operations, Averaging operators. Alpha-cut decomposition principle,	15
II	Extension principle. Crisp versus fuzzy relations, Projections, Composition of fuzzy relations, Fuzzy binary relations, Fuzzy n-ary relation, transitive closure, Fuzzy equivalence relations. Classical logic an overview, : Introduction to propositional Logic, Boolean Algebra, Multi valued logic,	15
III	Fuzzy logic, Linguistic hedges, Fuzzy propositions (conditional and unconditional), Approximate reasoning, Implication operations, Natural language, Fuzzy qualifiers, Inference from conditional and qualified fuzzy propositions, Fuzzy Quantifiers, Inference from quantified fuzzy propositions.	15
IV	Fuzzy numbers, Types of fuzzy numbers, Linguistic variables, Fuzzy arithmetic: Extension principle and Interval arithmetic, Fuzzification, Defuzzification, Methods of Defuzzification. Fuzzy measures, Evidence theory, Necessity and belief measures, Probability measures vs possibility measures.	15

Internal Assessment:

CIA-I	Unit -I
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on Unit II and III
ESE	Unit-I,II,III,IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Text Books:

1. Klir, G. J., Yuan B., 1997, Fuzzy Sets and Fuzzy Logic: Theory and Applications, Prentice Hall.
2. Ross T. J., 1995, Fuzzy Logic with Engineering Applications, McGraw Hill.
3. Zimmermann H. J., 1990, Fuzzy Set Theory and Its Application (2nd Ed.), Kluwer, Boston.
4. Lee. K. H., 2005, First Course on Fuzzy Theory and Applications, Springer-Verlag.

Reference Books:

E-resources:

1. https://archive.nptel.ac.in/courses/108/104/108104157/

COMPUTATIONAL ODE (6.0MAT42)

Course Title:	**Computational ODE**	
Course Code:	**6.0MAT42**	
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/week	Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 hour/week	ESE: 60 Marks	Tutorial: 1
	Total:	4

Course Prerequisite: The student should have knowledge of

1	basics of Linear Algebra
2	basics of Differential Equations
3	basics of Numerical Methods

Course Objectives:

1	the numerical techniques for IVP and BVP
2	the convergence and stability of finite difference schemes
3	the finite difference method for differential equations.
4	the finite element methods for differential equations.
5	the application of numerical techniques in real life problems.

Course Outcomes: The students will be able to

1	obtain numerical solutions and the concepts of consistency, stability, convergence and error analysis.
2	check the stability and convergence of numerical methods.
3	solve numerically linear and nonlinear ordinary differential equations.
4	find the numerical solution to ODEs by using a computer program.
5	apply various numerical methods in real life problems.

Course Content:

Unit	**Content**	**Hours**
I	Numerical solutions of systems of simultaneous first order differential equations and second order initial value problems (IVP) by Euler and Runge-Kutta explicit methods, numerical solutions of second order boundary value problems (BVP) of first, second and third types by shooting method.	15
II	Types of finite difference schemes of second order BVP based on difference operators (solutions of tridiagonal system of equations), solutions of such BVP by Newton-Cotes and Gaussian integration rules, convergence and stability of finite difference schemes.	15
III	Variational principle, approximate solutions of second order BVP of first kind by Rayleigh-Ritz, Galerkin, collocation and finite difference methods,	15
IV	Finite Element methods for BVP-line segment, triangular and rectangular elements, Ritz and Galerkin approximation over an element, assembly of element equations and imposition of boundary conditions.	15

Internal Assessment:

CIA-I	Unit-I
CIA-II	Written Exams/ Quizzes/ Assignment/ Presentations/ Viva-Voce based on Unit II and III
ESE	Unit-I, II, III, IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Text Books:

1. Jain M. K., Iyengar S. R. K. and Jain R. K., 2003, Numerical Methods for Scientific and Engineering Computations, New Age Publications.
2. Jain M. K., 1984, Numerical Solution of Differential Equations (2nd Ed.), Wiley-Eastern.
3. Sastry S. S., 2002, Introductory Methods of Numerical Analysis, Prentice-Hall of India.
4. Griffiths D.V. and Smith I. M., 1993, Numerical Methods for Engineers, Oxford University Press.
5. Gerald C. F. and Wheatley P. O., 1998, Applied Numerical Analysis, Addison- Wesley.

Reference Books:

1. Singh, A. K. and Singh, A. K., 2018, *Numerical Methods for Differential Equations with Programs*, Narosa Publications.

E-resources:

https://nptel.ac.in/courses/111107063

FUNCTIONAL OF SEVERAL REAL VARIABLES (6.0MAT43)

Course Title:	**Functional of Several Real Variables**	
Course Code:	**6.0MAT43**	
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/week	Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 hour/week	ESE: 60 Marks	Tutorial: 1
	Total:	4

Course Prerequisite: The student should have knowledge of

1	basic concepts of calculus of one variables

Course Objectives:

1	To explain how some concepts of calculus can be generalized in higher dimensions.
2	To introduce multivariable calculus: different types of derivatives, chain rule, mean value theorem, maxima and minima, implicit and inverse function theorems.
3	To explain how these generalized concepts impact inventions in science, technology and daily life.

Course Outcomes: The students will be able to

1	how existing concepts of calculus of one variable or two variable can be generalized in higher dimensions
2	the significance of the concepts defined and the theorems proved here;
3	the importance of these generalized concepts impacts science, technology and our daily life.

Course Content:

Unit	Content	Hours
I	$\mathbb{R}^n$ as inner product and as normed space, convergence of sequences, compactness, equivalence of norms, connected and convex sets, Functions from $\mathbb{R}^n$ to $\mathbb{R}^m$, limit and continuity, Directional derivatives, partial derivatives of a function of several real variables.	15
II	Differentiability of a function of several real variables, sufficient conditions for continuity and differentiability of a function of several real variables in terms of partial derivatives, algebra of differentiable functions, Chain rule of differentiation, Total differentials.	15
III	Mean value Theorem for real valued functions, homogeneous functions and Euler's Theorem, Equality of mixed derivatives, Young's and Schwarz Theorems, higher differentials, Taylor's Theorem.	15
IV	Maxima and minima for real valued functions of several real variables, (necessary and sufficient conditions), saddle points, Lagrange's multipliers, Hessian matrix, Jacobian matrix and determinants, Implicit and Inverse function Theorems, Functional dependence.	15

Internal Assessment:

CIA-I	Unit -I
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on Unit II and III
ESE	Unit-I,II,III,IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Text Books:

1. Lang S, 1987, Calculus of Several Variables, Springer-Verlag, New York.
2. Fleming W. H., 1977, Functions of Several Variables, Springer-Verlag, New York.
3. Ghorpade S. R., Limaye B. V., 2010, A Course in Multivariable Calculus and Analysis, Springer.

Reference Books:

1. Giaquinta M., Modica G. 2009, Mathematical Analysis: An Introduction to Functions of Several Variables, Birkhauser, Boston.
2. Spivak M., 1965, Calculus on Manifolds: A Modern Approach to Classical Theorems of Advanced Calculus, CRC Press.

E-resources:

https://onlinecourses.nptel.ac.in/noc20_ma27/preview

MATHEMATICAL MODELING (6.0MAT44)

Course Title:	**Mathematical Modeling**	
Course Code:	**6.0MAT44**	
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/week	Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 hour/week	ESE: 60 Marks	Tutorial: 1
	Total:	4

Course Prerequisite: The student should have knowledge of

1	basic concepts in Linear Algebra and Real Analysis and Differential Equations

Course Objectives:

1	To introduce students to the elements of the mathematical modeling process
2	To learn different types of mathematical models and their nature.
3	To exemplify the value of mathematics in problem solving
4	To develop students' capacity to solve problems through the use of mathematical models as a transferable process that will equip them to address novel problems in future.

Course Outcomes: The students will be able to

1	the unique system characterization approach for a given system
2	identify assumptions which are consistent with the context of the problem and which in turn shape and define the mathematical characterization of the problem
3	how to analyze a given model system using mathematical analysis results.
4	different types of mathematical models in ecology, epidemiology, chemistry, Physics, Life Sciences, Engineering etc.

Course Content:

Unit	**Content**	**Hours**
I	Introduction to modeling. Definition of System, classification of systems, classification and limitations of mathematical models, Methodology of model building, modeling through ordinary differential equations.	15
II	Linear growth and decay models, non-linear growth and decay models, Compartment models, Checking model validity, verification of models, Stability analysis, Basic model relevant to population dynamics, Epidemics modeling.	15
III	Ecology, Environment Biology through ordinary differential equation, Partial differential equation, Basic theory of linear difference equations with constant coefficients.	15
IV	Mathematical modeling through difference equations in population dynamics, genetics, Markov chains model, Gambler's ruin model, Stochastic models, Monte Carlo methods.	15

Internal Assessment:

CIA-I	Unit -I
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce
ESE	Unit-I,II,III,IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Text Books:

1. Murthy D. N. P., Page N. W. and Rodin E. Y., 1990, *Mathematical Modelling: A Tool for Problem Solving in Engineering, Physics, Biological and Social Sciences*, Pergamon Press.
2. Kapur J. N., 2008, *Mathematical Modelling*, New Age Int. Pub.
3. Law A. M. and Kelton W. D., 1991, *Simulation Modeling and Analysis*, McGraw-Hill.
4. Meerscheart M.M., 2007, *Mathematical Modeling,* Academic Press.

Reference Books:

1. Nemytskii V.V., 2005, *A Course in Mathematical Modeling*, Mathematical Association of America.

E-resources:

https://nptel.ac.in/courses/111108081

GAME THEORY (6.5MAT31)

<table>
<tr><td>Course Title:</td><td colspan="3">Game Theory</td></tr>
<tr><td>Course Code:</td><td colspan="3">6.5MAT31</td></tr>
<tr><td colspan="2">Teaching Scheme</td><td>Examination Scheme</td><td>Credits Allotted</td></tr>
<tr><td colspan="2">Theory: 3 hours/week</td><td>Internal Assessment: 40 Marks</td><td>Theory: 3</td></tr>
<tr><td colspan="2">Tutorial: 1 hour/week</td><td>ESE: 60 Marks</td><td>Tutorial: 1</td></tr>
<tr><td colspan="3" align="right">Total:</td><td>4</td></tr>
</table>

<table>
<tr><td colspan="2">Course Prerequisite: The student should have knowledge of</td></tr>
<tr><td>1</td><td>knowledge of linear programming and simplex methods.</td></tr>
<tr><td colspan="2">Course Objectives:</td></tr>
<tr><td>1</td><td>To provide a rigorous treatment of solution concepts for games with perfect and imperfect information including Nash and subgame perfect Nash equilibria.</td></tr>
<tr><td>2</td><td>To cover topics such as auction, VNM utility function, bargaining game, etc.</td></tr>
<tr><td>3</td><td>To provide detailed knowledge about cooperative games.</td></tr>
<tr><td>4</td><td>To teach about games with imperfect information.</td></tr>
<tr><td colspan="2">Course Outcomes: The students will be able to</td></tr>
<tr><td>1</td><td>model competitive real world phenomena using concepts from game theory and identify optimal strategy and equilibrium solutions for such models.</td></tr>
<tr><td>2</td><td>learn the two person zero-sum game and its equilibrium solution.</td></tr>
<tr><td>3</td><td>discuss dynamic games and cooperative games.</td></tr>
<tr><td>4</td><td>work on strategic and dynamic games with imperfect information.</td></tr>
</table>

<table>
<tr><td colspan="3">Course Content:</td></tr>
<tr><td>Unit</td><td>Content</td><td>Hours</td></tr>
<tr><td>I</td><td>A General Introduction to Game Theory-its Origin, Representation of Games, Type of Game, Games with Perfect Information-Strategic Form Game, Solution Concept- Pure and Mixed Strategies, Dominance and Best Response, Pareto Optimality, Maxmin and Minmax Strategies,</td><td>15</td></tr>
<tr><td>II</td><td>Pure and Mixed Strategies Nash Equilibrium, Existence of a Nash Equilibrium, Two-person Zero-Sum Games-its Solution, Market Equilibrium and Pricing: Cournot and Bertrand Game, Auctions.</td><td>15</td></tr>
<tr><td>III</td><td>Decision Making and Utility Theory, Von Neumann and Morgenstern Utility Function, Theory of Risk Aversion, Equilibrium Theory. Dynamic Games of Perfect Information-Extensive Form Game, Subgame Perfect Nash Equilibrium, Backward Induction, Stackelberg Model of Duopoly. Coalition Games, Core and Shapley Value, Bargaining Game, Illustrations.</td><td>15</td></tr>
<tr><td>IV</td><td>Strategic Games with Imperfect Information -Bayesian Games, Cournot's Duopoly with Imperfect Information. Dynamic Games with Imperfect Information. Finitely and Infinitely Repeated Games, The Folk Theorem, Illustrations.</td><td>15</td></tr>
</table>

<table>
<tr><td colspan="2">Internal Assessment:</td></tr>
<tr><td>CIA-I</td><td>Unit -I</td></tr>
<tr><td>CIA-II</td><td>Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on Unit II and III</td></tr>
<tr><td>ESE</td><td>Unit-I,II,III,IV</td></tr>
<tr><td colspan="2">CIA: Continuous Internal Assessment, ESE: End Semester Examination</td></tr>
</table>

Text Books:

1. Osborne M.J., 2003, An Introduction in Game Theory, Oxford University Press.
2. Osborne M. J. and Rubinstein A., 1994, A Course in Game Theory, MIT Press.
3. Fudenberg D. and Tirole J., 1991, Game Theory, MIT Press.
4. Von Neumann J. and Morgenstern O., 1944, Theory of Games and Economic Behaviour, New York: John Wiley and Sons.

Reference Books:

1. Watson J., 2013, *Strategy: An Introduction to Game Theory (3rd Ed.)*, W.W. Norton & Company, London.

E-resources:

https://archive.nptel.ac.in/courses/110/104/110104063/

AUTOMATA THEORY AND FORMAL LANGUAGES (6.5MAT32)

Course Title:	**Automata Theory and Formal Languages**	
Course Code:	**6.5MAT32**	
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/week	Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 hour/week	ESE: 60 Marks	Tutorial: 1
	Total:	4

Course Prerequisite: The student should have knowledge of

1	basic concepts of sets, relations, functions
2	basic concepts of propositional logics

Course Objectives:

1	To explain why the study of automata is an important part of the core of computer science.
2	To explain how finite automata are useful models in science and technology.
3	To develop understanding of the concepts of automata theory and formal languages.

Course Outcomes: The students will be able to

1	how automata and formal languages impact our life.
2	the concepts and topics in hand without haste;
3	the significance of the concepts defined and the theorems proved here;
4	the concepts in more generalized form to capture uncertainty and vagueness of complex systems.

Course Content:

Unit	Content	Hours
I	Theory of Computation: Finite automata, Deterministic and non-deterministic finite automata, equivalence of deterministic and non-deterministic automata, Moore and Mealy machines, Minimization of Automata, Regular expressions.	15
II	Conversion of finite automata to Regular expression. Grammars and Languages, Derivations, Language generated by a grammar, Regular language and regular grammar, Context free grammar and context-free language.	15
III	Context sensitive grammars and Languages. Context-free grammar in Chomsky normal form, Regular expressions, Formal definition of regular expression, Equivalence of regular expression and finite automata, Kleene's theorem.	15
IV	Formal definition of a Turing Machine, Representation of a Turing Machine , Turing machines as language acceptors, Universal Turing machines, decidability, undecidability, Turing Machine halting problem, Rice Theorem.	15

Internal Assessment:

CIA-I	Unit -I
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on Unit II and III
ESE	Unit-I,II,III,IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Text Books:

1. Kelly D., 1995, Automata and Formal Languages: An Introduction, Prentice-Hall.
2. Hopcroft J. E., Motwani R. and Ullman J. D., 2001, Introduction to Automata, Languages, and Computation (2nd Ed.), Pearson Edition.
3. Linz P., 2010, An Introduction to Formal Languages and Automata, Narosa.

Reference Books:

1. Sipser M., 2012, *Introduction to the Theory of Computation (3^{rd} Ed.)*, Cengage Learning.

E-resources:

1. https://archive.nptel.ac.in/courses/111/103/111103016/
2. https://nptel.ac.in/courses/106105196

ALGEBRAIC NUMBER THEORY (6.5MAT33)

Course Title:	**Algebraic Number Theory**	
Course Code:	**6.5MAT33**	
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/week	Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 hour/week	ESE: 60 Marks	Tutorial: 1
	Total:	4

Course Prerequisite: The student should have knowledge of	
1	basic concepts of ring and elementary number theory
Course Objectives:	
1	To teach the students properties of number fields
2	To teach the students the quadratic fields
3	To teach the students the class group
Course Outcomes: The students will be able to	
1	the arithmetic of algebraic number fields
2	Minkowski's theorem
3	Dirichlet unit theorem
4	the diophantine equation

Course Content:

Unit	Content	Hours
I	Number fields, the ring of algebraic integers, calculation for quadratic, cubic and cyclotomic cases, norms and traces, integral bases and discriminants,	15
II	Dedekind domains, unique factorization of ideals, norm of ideals, factorization of prime ideals in extensions, The ideal class group, lattices in R^n, Minkowski's theorem,	15
III	Finiteness of the class number and its consequences, some class number computations, Dirichlet unit theorem, units in real quadratic fields	15
IV	Some Diophantine equations, Cubic residue symbol, Jacobi sums, Cubic reciprocity law, biquadratic reciprocity law and Eisenstein reciprocity law	15

Internal Assessment:

CIA-I	Unit -I, II
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on Unit III
ESE	Unit-I,II,III,IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Text Books:

1. Esmonde J., Murty M. R., 1999, Problems in Algebraic Number Theory, GTM, Springer-Verlag.
2. Mollin R.A., 2001, Algebraic Number Theory, CRC Press.
3. Alaca S., Williams K. S., 2004, Introductory Algebraic Number theory, Cambridge University Press.
4. Zuckerman N.S.H., Montgomery L.H., 1991, An Introduction to the Theory of Numbers, John Wiley.

Reference Books:

1. Marcus D. A., 1977, *Number Fields, Springer-Verlag*.

E-resources:

https://archive.nptel.ac.in/courses/

ALGEBRAIC TOPOLOGY (6.5MAT34)

Course Title:	**Algebraic Topology**	
Course Code:	**6.5MAT34**	
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/week	Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 hour/week	ESE: 60 Marks	Tutorial: 1
	Total:	4

Course Prerequisite: The student should have knowledge of

1	concepts of general topology

Course Objectives:

1	To teach the students one point compactification
2	To teach the students the fundamental groups
3	To teach the students the lifting problems and its uniqueness
4	To teach the students Van Kampen Theorem

Course Outcomes: The students will be able to

1	the concepts of pushout and adjunct spaces
2	The calculation of some fundamental groups
3	The Deck transformation
4	The homology groups

Course Content:

Unit	Content	Hours
I	Review of General Topology, Continuous maps, compactness, one point compactification, Locally compact spaces, Proper maps, Quotient space, Real Projective space, Mobius band, Klein's bottle, torus, Wedge product, Co-product of groups, pushout, adjunct spaces, Cone	15
II	Path, Homotopy, Reparametrization, First fundamental groups, Simply connected spaces, Category and functors between categories, Category of pointed topological space, Functorial property of fundamental group, Retraction map, Brower's fixed point theorem, fundamental group of product spaces,	15
III	Deformation Retract, Covering projections, the lifting problems and its uniqueness, lifting of path and homotopy, Action of fundamental groups on fibers, regular covering, Deck transformation, group of Deck transformations, its action on fibres	15
IV	Van Kampen Theorem, fundamental group of some adjunct spaces, n-simplex, face maps, chain, boundary operator, Chain complexes, homology groups, Convex sets and barycentric coordinates, Homotopy invariance of homology, Mayer Vitory sequence and its applications, Maps on sphere and degree	15

Internal Assessment:

CIA-I	Unit -I, II
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on Unit III
ESE	Unit-I,II,III,IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Text Books:

1. Munkres J. R., 2000, *Topology*, Prentice-Hall of India.
2. Greenberg M. J. and Harper J. R., 1997, Algebraic Topology: A First Course, Addison-Wesley Publishing company.
3. Deo S., 2006, Algebraic Topology: A Primer, Hindustan Book Agency.
4. Vick J. W., 1994, Homology Theory, An Introduction to Algebraic Topology, Springer Verlag.

Reference Books:

1. Hatcher A., 2002, *Algebraic Topology*, Cambridge University Press.

E-resources:

https://archive.nptel.ac.in/courses/

COMPUTATIONAL PDE (6.5MAT35)

Course Title:	**Computational PDE**		
Course Code:	**6.5MAT35**		
Teaching Scheme		**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/week		Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 hour/week		ESE: 60 Marks	Tutorial: 1
		Total:	4

Course Prerequisite: The student should have knowledge of

1	basic of Linear Algebra
2	basic of Differential Equations
3	basic of Numerical Methods

Course Objectives:

1	the numerical techniques for partial differential equations
2	the convergence, truncation errors and stability of finite difference schemes
3	the explicit methods for partial differential equations.
4	the implicit methods for partial differential equations
5	the finite element methods for partial differential equations.
6	the application of numerical techniques in real life problems.

Course Outcomes: The students will be able to

1	obtain numerical solutions and the concepts of truncation errors, stability, convergence.
2	check the stability and convergence of numerical methods.
3	solve numerically parabolic, elliptic and hyperbolic equations.
4	find the numerical solution to PDEs by using a computer program.
5	apply various numerical methods in real life problems.

Course Content:

Unit	Content	Hours
I	Numerical solutions of parabolic equations of second order in one space variable with constant coefficients:- two and three levels explicit and implicit difference schemes, truncation errors and stability, Difference schemes for diffusion convection equation,	15
II	Numerical solution of parabolic equations of second order in two space variables with constant coefficients-improved explicit schemes, implicit methods, alternating direction implicit (ADI) methods.	15
III	Numerical solution of hyperbolic equations of second order in one and two space variables with constant and variable coefficients-explicit and implicit methods, alternating direction implicit (ADI) methods.	15
IV	Numerical solutions of elliptic equations, Solutions of Dirichlet, Neumann and mixed type problems with Laplace and Poisson equations in rectangular, circular and triangular regions, Finite element methods for Laplace, Poisson, heat flow and wave equations	15

Internal Assessment:

CIA-I	Unit-I
CIA-II	Written Exams/ Quizzes/ Assignment/ Presentations/ Viva-Voce based on Unit II and III
ESE	Unit-I, II, III, IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Text Books:

1. Jain M. K., Iyengar S. R. K., Jain R. K., 1994, Computational Methods for Partial Differential Equations.
2. Jain M. K., 1984, Numerical Solution of Differential Equations (2nd Ed.), Wiley Eastern.
3. Sastry S. S., 2002, Introductory Methods of Numerical Analysis, Prentice-Hall of India.
4. Griffiths D. V., Smith I. M., 1993, Numerical Methods of Engineers, Oxford University Press.
5. General C. F., Wheatley P. O., 1998, Applied Numerical Analysis, Addison- Wesley.
6. Bathe K. J. , Wilson E. L., 1987, Numerical Methods in Finite Element Analysis, Prentice-Hall.

Reference Books:

1. Mazumder, S., 2016, Numerical Methods for Partial Differential Equations: Finite Difference and Finite Volume Methods, Academic Press.
2. Sewell, G., 2015, THe Numerical Solution of Ordinary and Partial Differential Equations, 3rd Ed., World Scientific Publications.

E-resources:

https://ocw.mit.edu/courses/18-336-numerical-methods-for-partial-differential-equations-spring-2009/

DIFFERENTIAL GEOMETRY (6.5MAT36)

Course Title:	**Differential Geometry**
Course Code:	**6.5MAT36**

Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/week	Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 hour/week	ESE: 60 Marks	Tutorial: 1
	Total:	4

Course Prerequisite: The student should have knowledge of

1	

Course Objectives:

1	To introduce the basic concept of smooth manifolds with a variety of examples
2	To elaborate the basic notions of smooth maps between manifolds and tangent spaces.
3	To convey applications of manifolds

Course Outcomes: The students will be able to

1	the concepts of smooth manifold, smooth map, and tangent space.
2	the inverse function theorem to describe the local structure of immersions and submersions;
3	the applications and significances of topic in hands.

Course Content:

Unit	Content	Hours
I	Smooth manifold, chart and atlas, Compatible charts, Smooth maps between manifolds, Diffeomorphisms, Partial derivatives on manifolds, the inverse function theorems, Quotient manifolds	15
II	Real projective spaces, Standard smooth atlas for real projective space, Tangent spaces, Differential of a map, local expressions for differentials, Immersions and submersions, Rank, critical and regular points,	15
III	Submanifolds and level sets, the rank of a smooth maps, Whitney's embedding theorem; Tangent bundle, Smooth sections and smooth frames, Vector fields and local flows.	15
IV	Differential 1-Forms, Cotangent bundle, Characterization of smooth 1-Forms, Pullback of 1-forms, Differential k-Forms, local expression for k-Form, Pullback of k-Forms, the Wedge Product, Differential forms on a circle.	15

Internal Assessment:

CIA-I	Unit -I
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on Unit II and III
ESE	Unit-I,II,III,IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Text Books:

1. Tu W. L., 2010, An Introduction to Manifolds (2nd Ed.), Springer-Verlag, New York.
2. O'Neill B., 1966, Elementary Differential Geometry, Academic Press, New York.
3. Thorpe J. A., 1979, Elementary Topics in Differential Geometry, Springer Verlag.
4. Somasundaram D., 2010, Differential Geometry: A First Course, Narosa Pub. House.

Reference Books:

1. Willmore T. J., 1965, *An Introduction to Differential Geometry*, Oxford University Press

E-resources:

1. https://ocw.mit.edu/courses/18-950-differential-geometry-fall-2008/

DIFFERENTIAL EQUATION AND DYNAMICAL SYSTEMS (6.5MAT37)

Course Title:	**Differential Equation and Dynamical Systems**	
Course Code:	**6.5MAT37**	
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/week	Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 hour/week	ESE: 60 Marks	Tutorial: 1
	Total:	4

Course Prerequisite: The student should have knowledge of

1	differential Equations, calculus and linear algebra

Course Objectives:

1	To introduce the theory, properties and applications of various dynamical systems
2	To make the students familiar with stable and unstable subspaces and manifolds
3	To teach an important theorems: Hartman-Grobman, stable manifold
4	To introduce center manifold theory and normal form theory
5	To discuss global existence theorem and Poincare-Bendixon theory

Course Outcomes: The students will be able to

1	to analyze and solve system of linear differential equations
2	learn theory of nonlinear system: existence, maximal interval of existence and linearization
3	to apply different important theorem and theories e.g., Hartman-Grobman, stable manifold theorems, centre and normal form theory
4	to learn global existence theorem
5	to discuss about limit sets, limit cycles and periodic orbits for a given dynamical system

Course Content:

Unit	Content	Hours
I	Linear Systems: Exponentials of operators, Planar linear systems and their phase portraits, complex eigenvalues, multiple eigenvalues, Jordon forms, Stability theory	15
II	Generalized eigenvectors and invariant subspaces, Non-homogeneous linear systems, Nonlinear Systems: The fundamental existence-uniqueness theorem, The maximal interval of existence, The flow defined by a differential equation, Linearization, The stable manifold theorem, The Hartman-Grobman theorem	15
III	Stability and Lyapunov functions, Saddles, Nodes, Foci and Centers, Center manifold and Normal form theory, Dynamical systems and global existence theorems, Limit sets and Attractors, Periodic orbits	15
IV	Limit Cycles, and Seperatrix cycles, Poincare map, Stable manifold theorem for periodic orbits, Poincare-Bendixon theory in xy-plane, Lineard Systems, Bendixson's Criteria.	15

Internal Assessment:

CIA-I	Unit -I
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on Unit II and III
ESE	Unit-I, II, III, IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Text Books:

1. Perko L., 2006, Differential Equations and Dynamical Systems, Springer-Verlag.
2. Hirsch M. W., Smale S. and Robert L.D., 2013, Differential Equations, Dynamical Systems and An Introduction to Chaos, Academic Press.
3. Stuart A. M. and Humphries A. R., 1998, Dynamical Systems and Numerical Analysis, Cambridge University Press.
4. Lynch S., 2004, Dynamical Systems with Applications using MATLAB, Birkhause Press.

Reference Books:

1. Strogatz, S. H., 2000, *Nonlinear Dynamics and Chaos with Applications to Physics, Biology, Chemistry and Engineering*, Westview Press.

E-resources:

https://www.youtube.com/playlist?list=PLbN57C5Zdl6j_qJA-pARJnKsmROzPnO9V
https://www.youtube.com/watch?v=BRaliLNuvNg&list=PL6hB9Fh0Z1ELbHIAL22dCk173qykDgeoz

FINANCIAL MATHEMATICS (6.5MAT38)

Course Title:	**Financial Mathematics**		
Course Code:	**6.5MAT38**		
Teaching Scheme	**Examination Scheme**		**Credits Allotted**
Theory: 3 hours/week	Internal Assessment: 40 Marks		Theory: 3
Tutorial: 1 hour/week	ESE: 60 Marks		Tutorial: 1
		Total:	4

Course Prerequisite: The student should have knowledge of

1	elementary Mathematics and Probability

Course Objectives:

1	To provide the theoretical foundations required to understand the financial mathematics
2	To make the students familiar with the concepts life insurance contracts.
3	To teach Black Scholes model and Black Scholes equation
4	To introduce Binomial methods and Monte Carlo simulation
5	To discuss finite difference methods

Course Outcomes: The students will be able to

1	theoretical foundations required to understand the financial mathematics
2	binomial methods
3	how to do Monte Carlo simulation
4	finite difference methods

Course Content:

Unit	Content	Hours
I	Introduction to options and markets: types of options, interest rates and present values, Black Scholes model : arbitrage, option values, pay offs and strategies, put call parity, Black Scholes equation	15
II	Similarity solution and exact formulae for European options, American option, call and put options, free boundary problem, Binomial methods: option valuation, dividend paying stock, general formulation and implementation	15
III	Monte Carlo simulation : valuation by simulation, Lab component: implementation of the option pricing algorithms and evaluations for Indian companies, different concepts associated with Finite difference methods	15
IV	Finite difference methods: explicit and implicit methods with stability and conversions analysis methods for American options- constrained matrix problem, projected SOR, time stepping algorithms with convergence and numerical examples	15

Internal Assessment:

CIA-I	Unit -I
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on Unit II and III
ESE	Unit-I, II, III, IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Text Books:

1. Luenberger D. G., 1998, Investment Science, Oxford University Press.
2. Hull J. C., 2000, Options, Futures and Other Derivatives (4th Ed.), Prentice-Hall New York.
3. Cox J. C. and Rubinstein M., 1985, Option Market, Englewood Cliffs, N. J. Prentice-Hall.
4. Jones C.P., 1996, Investments, Analysis and Measurement (5th Ed.), John Wiley and Sons.
5. Capinski M., Zastawnaik T., Mathematics for Finance, Springer

Reference Books:

1. Wahidudin A.N., , 2000, *Financial Mathematics and Its Applications,* Ventus Publishing ApS

E-resources:

https://nptel.ac.in/courses/11110312

LIE ALGEBRAS (6.5MAT39)

Course Title:	**Lie Algebras**
Course Code:	**6.5MAT39**

Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/week	Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 hour/week	ESE: 60 Marks	Tutorial: 1
	Total:	4

Course Prerequisite: The student should have knowledge of

1	concepts of linear algebra

Course Objectives:

1	To teach the students how to utilize various techniques for working with Lie algebras
2	To teach the students the parts of a major classification result
3	To teach the students the representations of sl(2, C)
4	To teach the students root Space Decomposition

Course Outcomes: The students will be able to

1	the construction of Lie algebra
2	The low-dimensional Lie algebras
3	The semisimple Lie Algebras
4	The root system

Course Content:

Unit	**Content**	**Hours**
I	Definition of Lie Algebras, Some Examples, classical Lie Algebras, Subalgebras and Ideals, Homomorphisms, Derivations, Structure Constants, Ideals and Homomorphisms, Constructions with Ideals, Quotient Algebras, Correspondence between Ideals,	15
II	Low-Dimensional Lie Algebras, Dimensions 1,2and3, Solvable Lie Algebras, Nilpotent Lie Algebras, Subalgebras of gl(V), Weights, The Invariance Lemma , Engel's Theorem, Lie's Theorem, Some Representation Theory , Definitions, Examples of Representations, Modules for Lie Algebras, Irreducible and Indecomposable Modules, Schur's Lemma	15
III	Representations of sl(2, C), Classifying the Irreducible sl(2, C)-Modules, Weyl's Theorem, Cartan's Criteria, Jordan Decomposition , Testing for Solvability, The Killing Form, Testing for Semisimplicity, Derivations of Semisimple Lie Algebras	15
IV	The Root Space Decomposition, Cartan Subalgebras, Subalgebras Isomorphic to sl(2, C), Root Strings and Eigenvalues, Cartan Subalgebras as Inner-Product Spaces, Root Systems, Bases for Root Systems, Cartan Matrices and Dynkin Diagrams	15

Internal Assessment:

CIA-I	Unit -I, II
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on Unit III
ESE	Unit-I,II,III,IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Text Books:

1. Humphreys J. E., 1972, Introduction to Lie Algebras and Representation Theory, Springer-Verlag New York.
2. Jacobson N., 1962, Lie Algebras, Wiley-Interscience, New York.
3. Erdmann K. and Wilson M.J., 2006, Introduction to Lie Algebras, Springer-Verlag, New York.

Reference Books:

1. Serre J. P., 1965, *Lie Algebras and Lie Groups*, Benjamin, New York.

E-resources:

https://archive.nptel.ac.in/courses/

MODULE THEORY (6.5MAT40)

Course Title:	**Module Theory**	
Course Code:	**6.5MAT40**	
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/week	Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 hour/week	ESE: 60 Marks	Tutorial: 1
	Total:	4

Course Prerequisite: The student should have knowledge of

1	concepts of rings and linear algebra

Course Objectives:

1	To teach the students linear algebra over certain rings
2	To teach the students the basic definitions and elementary results
3	To teach the students the classification of finitely generated abelian groups
4	To teach the students Jordan Canonical form

Course Outcomes: The students will be able to

1	the concepts of isomorphism theorems
2	the projective and injective modules
3	the torsion and torsion-free modules
4	the Jordan canonical form

Course Content:

Unit	Content	Hours
I	Modules over a ring, Endomorphism ring of an abelian group, R-Module structure on an abelian group M as a ring homomorphism from R to EndZ (M), submodules, Direct summands, Annihilators, Faithful modules, Homomorphism, Factor modules, Isomorphism theorems	15
II	Free Module, Noethrian and Artinian Module, Hilbert basis theorem, Wedderburn Artin Theorem, Split exact sequences and their characterizations, Left exactness of Hom sequences and counterexamples for non-right exactness, Projective modules, Injective modules, Baer's characterization, Divisible groups, Examples of injective modules. (M, M) as a ring, Exact sequences, Five lemma,	15
III	External and internal direct sums and their universal property, Submodules of finitely generated free modules over a PID, Torsion submodule, Torsion and torsion-free modules, Direct decomposition into T(M) and a free module, primary components, Decomposition of p-primary finitely generated torsion modules	15
IV	Elementary divisors and their uniqueness, Decomposition into invariant factors and uniqueness, Reduction of matrices over polynomial rings over a field, Similarity of matrices and F[x]-module structure, Rational canonical form of matrices, Elementary Jordan matrices, Reduction to Jordan canonical form, Diagonalizable and nilpotent parts of a linear operator, Smith normal form over PID, Uniqueness of Smith normal form	15

Internal Assessment:

CIA-I	Unit -I, II
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on Unit III
ESE	Unit-I,II,III,IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Text Books:

1. Dummit D. S. and Foote R. M., 2003, Abstract Algebra, John Wiley NY.
2. Gopalakrishnan N. S., 1986, University Algebra, Wiley Eastern Ltd., New Delhi.
3. Lam T. Y., 2007, *Exercises in Module and Rings*, Springer.

Reference Books:

1. Anderson F. W. and Fuller K. R., 1974, *Rings and Categories of Modules*, Springer, N.Y.

E-resources:

https://archive.nptel.ac.in/courses/

NONLINEAR DYNAMICS AND CHAOS (6.5MAT41)

Course Title:	**Nonlinear Dynamics and Chaos**	
Course Code:	**6.5MAT41**	
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/week	Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 hour/week	ESE: 60 Marks	Tutorial: 1
	Total:	4

Course Prerequisite: The student should have knowledge of

1	differential equations and calculus

Course Objectives:

1	To provide knowledge of different topics in Nonlinear dynamics and chaos
2	To teach one dimensional systems and different types of bifurcations
3	To introduce some real model systems and applications of one dimensional bifurcations and stability theory
4	To introduce two dimensional systems and associated bifurcations
5	To discuss one dimensional maps and different topics in chaos

Course Outcomes: The students will be able to

1	different topics in nonlinear dynamics and chaos
2	bifurcations for one dimensional system and associated applications
3	bifurcation theory for two dimensional systems and application
4	different aspects associated with chaos and applications

Course Content:

Unit	Content	Hours
I	The importance of being nonlinear, A dynamical view of the world, One dimensional flows: Flows on the lines: a geometric way of thinking, Fixed points, Local stability analysis, Overdamped beam on a rotating hoop, Existence and Uniqueness, Impossibility of oscillations, Potentials, Bifurcations: Saddle-node bifurcations, Transcritical and Pitchfork bifurcations, Supercritical and Subcritical Pitchfork bifurcations, Laser threshold, Imperfect bifurcations and Catastrophes	15
II	Insect outbreak: Model, Dimensionless formulation, Analysis of fixed points, Two dimensional flows: Linear systems, Definitions and examples, Classification of linear systems, Dynamics of love affairs, Rabbit Versus Sheep, Conservative Systems, Limit cycles, Ruling out closed orbits, Poincare-Bendixson theorem, Lienard systems, Weakly nonlinear oscillators,	15
III	Bifurcations in case of two dimensional systems, Hopf-bifurcations in aeroelastic stabilities and chemical oscillators, Global bifurcations of cycles, chaotic waterwheels, waterwheel equations and Lorentz equations, Chaos in the Lorentz equations, Strange attractor of Lorentz equations	15
IV	One dimensional map, Universal aspects of periodic doubling, Feigenbaum's renormalization analysis and periodic doubling, Renormalization: Function space and hands-on calculation, Fractals and the geometry of strange attractors, Henon map, Using chaos to send secret messages	15

Internal Assessment:

CIA-I	Unit -I
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on Unit II and Unit III
ESE	Unit-I,II,III,IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Text Books:

1. Strogatz S., 2001, Nonlinear Dynamics and Chaos, Springer.
2. Ermentrout B., 2005, Simulating Analyzing and Animating Dynamical Systems, SIAM.
3. Hirsch M. W., Smale S. and Devaney R. L., 2002, Differential Equations, Dynamical Systems and an Introduction to Chaos, Academic Press.
4. Guckenheimer J. and Holmes P., 2000, Nonlinear Oscillations, Dynamical Systems and Bifurcations of Vector Fields, Springer, New York.

Reference Books:

E-resources:

FIELDS AND GALOIS THEORY (6.5MAT42)

Course Title:	**Fields and Galois Theory**	
Course Code:	**6.5MAT42**	
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/week	Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 hour/week	ESE: 60 Marks	Tutorial: 1
	Total:	4

Course Prerequisite: The student should have knowledge of

1	groups and rings

Course Objectives:

1	To teach the students symmetries of roots of a polynomial
2	To teach the students the solubility in terms of simple algebraic formulae
3	To teach the students the algebraic properties of field extensions
4	To teach the students geometric problems such as doubling the cube

Course Outcomes: The students will be able to

1	the algebraic extension
2	the splitting field
3	the Finite field
4	the construction of regular polygon

Course Content:

Unit	Content	Hours
I	Eisenstein's irreducibility criterion, Characteristic of a field, Prime subfields, Field extensions, Finite extensions, Simple extensions, Algebraic and transcendental extensions. Factorization of polynomials in extension fields. Splitting fields and their uniqueness.	15
II	Separable field extensions, Perfect fields, Separability over fields of prime characteristic, Transitivity of separability, Automorphisms of fields, Dedekind's theorem, Fixed fields, Normal extensions, Splitting fields and normality, normal closures,	15
III	Galois extensions, Fundamental theorem of Galois theory, Computation of Galois groups of polynomials., Primitive element theorem, Finite fields, Existence and uniqueness, Subfields of finite fields, Characterization of cyclic Galois groups of finite extensions of finite fields, fundamental theorem of algebra	15
IV	Cyclotomic extensions and polynomials, cyclic extensions, Solvability by radicals, Galois' characterization of such solvability, Generic polynomials, Abel-Ruffini theorem, geometrical constructions, construction of real number by ruler and compass, Impossibility of trisection of angle, Construction of regular polygon	15

Internal Assessment:

CIA-I	Unit -I, II
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on Unit III
ESE	Unit-I,II,III,IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Text Books:

1. Dummit D. S. and Foote R. M., 2003, Abstract Algebra, John Wiley & Sons, New York.
2. Hungerford T. W., 2004, Algebra, Springer (India), Pvt. Ltd.
3. Roman S., 2007, Field Theory, Springer, New York.
4. Stewart I. N., 2004, Galois Theory, Chapman & Hall, New York.

Reference Books:

1. Artin E., 1997, *Galois Theory*, Dover Publications.

E-resources:

https://archive.nptel.ac.in/courses/

OPERATIONS RESEARCH (6.5MAT43)

Course Title:	**Operations Research**		
Course Code:	**6.5MAT43**		
Teaching Scheme		**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/week		Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 hour/week		ESE: 60 Marks	Tutorial: 1
		Total:	4

Course Prerequisite: The student should have knowledge of

1	mathematical programming
2	probability theory

Course Objectives:

1	To teach how to determine an optimal sequence out of a series of jobs.
2	To teach the PERT/CPM techniques to plan, schedule, and control project activities.
3	To teach solution methodologies for deterministic and probabilistic inventory models.
4	To introduce the basic concepts of stochastic processes.
5	To teach what is a queueing model and how to analyze some specific queueing models.

Course Outcomes: The students will be able to

1	to find the optimal job sequencing.
2	to get a deep understanding of the PERT/CPM techniques to plan, schedule, and control project activities.
3	to learn deterministic and probabilistic inventory models.
4	to learn the basic concepts of stochastic processes.
5	to learn the theory behind queueing models and to characterize a queue & its key performance indicators.

Course Content:

Unit	Content	Hours
I	Job sequencing: Principal assumptions, processing n jobs through m machines. Project management by PERT-CPM technique: Network representation, critical path computations, construction of the time schedule, project evaluation and report technique.	15
II	Deterministic inventory models: General Inventory models, static economic order quantity (EOQ) model, dynamic EOQ models, deterministic models with price breaks. Review of Probability theory, Probabilistic Inventory models, Probabilistic EOQ model, Single period model.	15
III	Stochastic processes, Classification and its properties, Markov process, types of Markov processes, infinitesimal generator matrix, transition probability matrix, steady state distributions, transient distributions.	15
IV	Queueing models: Elements of Queueing models, Kendall notations, Poisson process, pure birth model, pure death model, birth-death model, Chapman-Kolmogorov equations, Little's Law, distribution of waiting time and response time, Burke's Theorem, M/M/1 model, M/M/1/N models.	15

Internal Assessment:

CIA-I	Unit -I,
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on Unit II and III
ESE	Unit-I,II,III,IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Text Books:

1. Castaneda L. B., Arunachalam V. and Dharmaraja S., 2012 Introduction to Probability and Stochastic Processes with Applications, Wiley, Hoboken, NJ, USA.
2. Hillier F. S., Lieberman G. J., Nag B. and Basu P., 2012, Introduction to Operations Research, Tata McGraw Hill Education Pvt. Ltd.
3. Taha H. A., 2007, Operations Research-An Introduction, Prentice Hall of India Pvt. Ltd.
4. Trivedi K.S., 2016, Probability and Statistics with Reliability, Queuing and Computer Science Applications, John Wiley & Sons, Inc., Hoboken, NJ, USA.

Reference Books:

1. Trivedi K.S., 2016, Probability and Statistics with Reliability, Queuing and Computer Science Applications, John Wiley & Sons, Inc., Hoboken, NJ, USA.
2. Medhi J., 2009, Stochastic Processes (3rd Ed.), New Age International Publishers.

E-resources:

https://archive.nptel.ac.in/courses/111/107/111107128/

REPRESENTATION THEORY OF FINITE GROUPS (6.5MAT44)

Course Title:	**Representation Theory of Finite Groups**			
Course Code:	**6.5MAT44**			
Teaching Scheme		**Examination Scheme**		**Credits Allotted**
Theory: 3 hours/week		Internal Assessment: 40 Marks		Theory: 3
Tutorial: 1 hour/week		ESE: 60 Marks		Tutorial: 1
			Total:	4

Course Prerequisite: The student should have knowledge of

1	concepts of groups and module

Course Objectives:

1	To teach the students the representation theory of finite groups
2	To teach the students the finite dimensional algebras
3	To teach the students Maschke's Theorem
4	To teach the students the character of the representation

Course Outcomes: The students will be able to

1	the concepts of Faithful Representation
2	the group algebra
3	the Schur's lemma
4	the character of the representation

Course Content:

Unit	Content	Hours
I	Representation of into group of Matrices, Examples, Faithful Representation, Equivalent Representation, FG-module, Equivalent formulation of Representation as FG module	15
II	Permutation module, FG-submodule, Irreducible Representation, Group algebra, Regular FG-module, Action of FG on FG-module, FG-homomorphism, FG-isomorphism, Direct sum of FG-submdule.	15
III	Maschke's Theorem, Completely reducible FG-submodule, Schur's Lemma and its application, Representation of abelian groups, Irreducible submodules of CG-module, Composition factor,	15
IV	Character of the representation, class function, Character table, irreducible characters, degree of character, regular and permutation character, Orthogonality relation between characters.	15

Internal Assessment:

CIA-I	Unit -I, II
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on Unit III
ESE	Unit-I,II,III,IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Text Books:

1. Burrow M., 1965, Representation Theory of Finite Groups, Academic Press.
2. Jacobson N., 1983, Basic Algebra-II, Hindustan Publishing Corporation, New Delhi.
3. Lang S., 2004, Algebra (3rd Ed.), Springer.
4. Serre J. P., 1977, *Linear Representation of Groups*, Springer-Verlag.

Reference Books:

1. Dornhoff L., 1971, *Group Representation Theory-Part A*, Marcel Dekker, Inc., New York.

E-resources:

https://archive.nptel.ac.in/courses

SPECIAL FUNCTIONS (6.5MAT45)

Course Title:	**Special Functions**		
Course Code:	**6.5MAT45**		
Teaching Scheme		**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/week		Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 hour/week		ESE: 60 Marks	Tutorial: 1
		Total:	4

Course Prerequisite: The student should have knowledge of

1	

Course Objectives:

1	the fundamentals of special functions including Gamma functions,
2	Riemann Zeta functions, Hypergeometric functions, Generalized Hypergeometric functions
3	Bessel functions, Legendre polynomials, Hermite Polynomials and Laguerre Polynomials.

Course Outcomes: The students will be able to

1	Gamma functions
2	Hypergeometric functions
3	Basic theory, property and applications of special functions

Course Content:

Unit	Content	Hours
I	Infinite product of complex numbers, Factorization of entire functions, Gamma functions, Order symbols o and O, Beta functions, Euler reflection formula, Factorial function, Legendre's duplication formula, Gauss's multiplication formula, Integral representations for Gamma function and Beta functions, Walli's products, Stirling formula.	15
II	Asymptotic expansion, Riemann Zeta functions, Euler product formula, Riemann Functional equations, Riemann hypothesis, Gauss Hypergeometric Function, Elementary Properties, Conditions of convergence, Contiguous function relations, Integral Representation, Simple transformation, Quadratic transformation.	15
III	Generalized Hypergeometric Functions, Integral representation, Elementary Properties, Integral Representation, Legendre polynomials and functions, Solution of Legendre's differential equations, Generating Functions, Rodrigue's Formula, Orthogonality of Legendre polynomials, Recurrence relations.	15
IV	Bessel functions, Bessel differential equation and it's solution, Recurrence relation, Generating functions, Integral representation, Hermite Polynomials, Laguerre Polynomials	15

Internal Assessment:

CIA-I	Unit -I, II
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on Unit III
ESE	Unit-I,II,III,IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Text Books:

1. Rainville E. D., 1960, Special Functions, The MacMillan Comp.
2. Bell W.W., 1968, Special Functions for Scientists and Engineers, D. Van Nostrand Comp. Ltd.
3. Andrews G.E., Askey R. and Roy R., 1999, Special Functions, Encyclopedia of Mathematics and Its Applications, Cambridge University Press.

Reference Books:

E-resources:

CLASSICAL MECHANICS (6.5MAT46)

Course Title:	**Classical Mechanics**	
Course Code:	**6.5MAT46**	
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/week	Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 hour/week	ESE: 60 Marks	Tutorial: 1
	Total:	4

Course Prerequisite: The student should have knowledge of

1	Basics of linear algebra, differential equations, and vector calculus.

Course Objectives: To develop the concept of

1	kinematics of particles, frame of references and relative changes in equation of motion and MI.
2	of expressing kinetic energy and angular momentum about a fixed axis in terms of MI and in terms of Eulerian angle along with application of these.
3	of generalized coordinates and degree of freedom and understanding the differences between Lagrangian dynamics and Hamiltonian dynamics.
4	Hamilton's principle and its uses, applications of canonical transformations along with uses of Lagrange and Poisson brackets.

Course Outcomes: The students will be able to

1	know about the kinematics of particles, describe the relative changes in the equation of motion in different frames, and calculate moment of inertia of a given mass about a line.
2	express kinetic energy and angular momentum of a mass about a fixed axis in terms of moment of inertia and in terms of Eulerian angle and use these expressions to describe the motion of Earth.
3	recognize the degree of freedom of a mass in motion and formulate the motion of a rigid body using Lagrangian function and Hamiltonian function.
4	use the Hamilton's principle, apply the canonical transformations and the Lagrange and Poisson brackets.

Course Content:

Unit	Content	Hours
I	Introduction of conservation laws, equation of motion of a particle, Simple pendulum, Harmonic oscillator, Motion of system of particles, Principle of angular momentum, Motion of a rigid body about a fixed axis, Moving frames of reference, Moments and products of inertia, moment of inertia of a body about a line through the origin, Momental ellipsoid, rotation of coordinate axes, principal axes and principal moments.	15
II	K.E. of rigid body rotating about a fixed point, angular momentum of a rigid body, Eulerian angle, angular velocity, K.E. and angular momentum in terms of Eulerian angle. Euler's equations of motion for a rigid body rotating about a fixed point, torque free motion, symmetrical rigid body, rotational motion of Earth. Attitudinal stability of Earth's satellite.	15
III	Classification of dynamical systems, Generalized coordinates systems, geometrical equations, Lagrange's equation for a simple system using D'Alembert principle, Deduction of equation of energy, deduction of Euler's dynamical equations from Lagrange's equations, Hamilton's equations, Ignorable coordinates, Routhian Function.	15
IV	Hamiltonian principle for a conservative system, principle of least action, Hamilton- Jacobi equation, Phase space and Liouville's Theorem, Canonical transformation and its properties, Lagrange brackets, and Poisson brackets, Poisson-Jacobi identity.	15

Internal Assessment:

CIA-I	Unit -I
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce
ESE	Unit-I,II,III,IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Text Books:

1. Milne E. A., 1965, *Vectorial Mechanics*, Methuen & Co. Ltd. London.
2. Kumar N., 2004, *Generalized Motion of Rigid Body*, Narosa Pub. House, New Delhi.
3. Rao K. S., 2009, *Classical Mechanics*, PHI learning Private Ltd., New Delhi.
4. Satya D. and Rahaman R., 2023, *Classical Mechanics: An Introduction*, Narosa Pub. House, New Delhi.

Reference Books:

1. Ramsey A. S., 2017, *Dynamics (Part II)*, (2nd Ed.), CBS Publishers & Distributors, Delhi.
2. Goldstein H., 1990, *Classical Mechanics*, Narosa Publishing House, New Delhi.

E-resources:

https://www.classcentral.com/course/rigid-body-dynamics-20108

NUMERICAL LINEAR ALGEBRA (6.5MAT47)

Course Title:	**Numerical Linear Algebra**	
Course Code:	**6.5MAT47**	
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/week	Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 hour/week	ESE: 60 Marks	Tutorial: 1
	Total:	4

Course Prerequisite: The student should have knowledge of

1	basic concepts in Linear Algebra, Matrices and Calculus

Course Objectives:

1	To introduce the fundamental notions of algebra of matrices and diagonalizability
2	To teach the students different characterization of matrix decomposition
3	To introduce computer arithmetic and numerical algorithms
4	To learn singular value decomposition and use it to analyze the several properties ofmatrices.

Course Outcomes: The students will be able to

1	learn algebra of Matrices, significance and use of eigenvalue and eigenvectors
2	explain different concepts about matrix decomposition
3	learn computer arithmetic and numerical algorithms
4	use different concepts associated with vector spaces, linear transformations, diagonalization

Course Content:

Unit	Content	Hours
I	Matrix operations and type of matrices, Determinant of a Matrix, Rank of a matrix, Vector Space, Linear dependence and independence, Bases and Dimensions, Linear, Transformation, Orthogonal subspaces, Row space, column space and null Space, Eigenvalues and Eigenvectors, Diagonalizable Matrices, Orthogonal Sets, Gram Schmidt orthogonalization and orthonormal bases	15
II	Vector Norm, Matrix Norms, Convergent Matrices, Stability of non-linear system, Condition number of a matrix: Elementary properties, Sensitivity analysis, Residual theorem, Nearness to singularity, Estimation of the condition number, Singular value decomposition of a matrix, Orthogonal Projections, Algebraic and geometric properties of matrices using SVD	15
III	SVD and their applications, Perturbation theorem for singular values, Outer product expansion of a matrix, Least square solutions, Psudeo - inverse and least square solution, Householder matrices and their applications, Householder QR factorization, Basic theorems on eigenvalues and QR method, Power method, Rate of convergence of Power method, Applications of Power method with shift, Jacobi method	15
IV	Introduction to Matlab, Sign integer representation, Computer representation of numbers, Floating point representation, Round-off error, Error propagation in computer arithmetic, Addition and multiplication of floating point numbers, Numerical algorithms for numerical methods for matrix eigenstructure, Stability of numerical algorithms.	15

Internal Assessment:

CIA-I	Unit -I
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce
ESE	Unit-I,II,III,IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Text Books:

1. V. Sundarapandian, Numerical Linear Algebra, PHI, 2008.
2. Biswa Nath Dutta, Numerical Linear Algebra and Applications, SIAM, 2010.
3. Roger A. Horn and Charles R. Johnson, Matrix Analysis, Cambridge University Press, 1994
4. William Ford, Numerical Linear Algebra with Applications, Academic Press, 2014.

Reference Books:

1.

E-resources:

SOBOLEV SPACES AND PDEs (6.5MAT48)

Course Title:	**Sobolev Spaces and PDEs**	
Course Code:	**6.5MAT48**	
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/week	Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 hour/week	ESE: 60 Marks	Tutorial: 1
	Total:	4

Course Prerequisite: The student should have knowledge of

1	Basic knowledge of Functional Analysis (e.g. Banach and Hilbert spaces, linear operators, Lebesgue spaces etc).
2	Undergraduate Calculus, Real Analysis and Partial Differential Equations etc.

Course Objectives:

1	Understand the theory of distributions.
2	Understand the definition, properties and structure of Sobolev spaces.
3	Explore the abstract variational problems and applications of Sobolev spaces in elliptic boundary value problems.
4	Apply the Galerkin method and finite element method to approximate solutions to elliptic boundary value problems (BVPs).

Course Outcomes: The students will be able to

1	define and explain the concept of distributions.
2	define Sobolev spaces, understand their basic properties, and explain their relevance in the context of boundary value problems.
3	formulate elliptic boundary value problems as abstract variational problems and solve them using the Lax-Milgram Lemma, ensuring well-posedness.
4	implement the Galerkin method, Finite element method and Variational method to find the weak solutions of elliptic BVPs.

Course Content:

Unit	Content	Hours
I	Theory of distributions: Motivation and applications of distributions (generalized functions), Distribution definition, Examples, test functions, distributional derivatives, support of distribution and properties, fundamental solutions, Shwartz spaces	15
II	Sobolev Spaces: Definition and basic properties, approximation by smooth functions, dual spaces, Poincare Inequality, trace and imbedding results	15
III	Elliptic Boundary value problems: Abstract variational problems, Lax-Milgram Lemma, weak solutions and well-posedness with examples, regularity result, maximum principles, eigenvalue problems	15
IV	Solution Methods: Galerkin method, finite element method and their applications in boundary value problems, Variational methods, Mountain Pass Lemma	15

Internal Assessment:

CIA-I	Unit -I
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce
ESE	Unit-I,II,III,IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Text Books:

1. S. Kesavan, Topics in functional analysis and applications, New Age International Private Limited, 2nd ed. 2015.
2. H. Brezis, Functional Analysis, Sobolev Spaces and Partial Differential Equations, Springer, 2011.

Reference Books:

1. L.C. Evans, Partial Differential Equations, American Mathematical Society, Providence, 1998.
2. R. C. McOwen, Partial Differential Equations: Methods and Applications, 2nd ed. Pearson, 2002.

E-resources:

https://archive.nptel.ac.in/courses/111/106/111106154/

MEASURE THEORY AND INTEGRATION (6.5MAT49)

Course Title:	**Measure Theory and Integration**	
Course Code:	**6.5MAT49**	
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/ week	Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 Hour/Week	ESE: 60 Marks	Tutorial: 1
	Total:	4

Course Prerequisite: The student should have knowledge of

1	Basic concepts of sets, functions and relations

Course Objectives:

1	To provide motivation for topology through geometry.
2	To develop understanding of geometric and topological properties.
3	To develop understanding of the concepts of general topology as simply as possible.

Course Outcomes: The students will be able to understand

1	what are objects of study in topology and geometry?
2	the concepts and topics in hand without haste;
3	the significance of the concepts defined, and the theorems proved here;
4	how this course is useful in other courses e.g., analysis, geometry and algebraic topology.

Course Content:

Unit	Content	Hours
I	Countable and uncountable sets, cardinality and cardinal arithmetic, Schroder–Bernstein theorem, the Cantor's ternary set, Semi-algebras, Algebras, Monotone class, Measure and outer measures, Carathe dory extension process of extending a measure on a semi-algebra to generated algebras.	15
II	Borel sets and their measurability, Lebesgue outer measure and Lebesgue measure on R, Translation invariance of Lebesgue measure, Existence of a non-measurable set, Characterizations of Lebesgue measurable sets	15
III	The Cantor-Lebesgue function, Measurable functions on a measure space and their properties, Borel and Lebesgue measurable functions, Characteristic function, Simple functions and their integrals, Continuous function, Sequence of functions, Convergence in measure. Littlewood's three principles (statement only).	15
IV	Lebesgue integral on R and its properties, Bounded convergence theorem, Fatou's lemma, Lebesgue monotone convergence theorem, Lebesgue dominated convergence theorem, L^p-spaces, Holder-Minkowski inequalities, parseval's identity, Riesz Fisher's theorem.	15

Internal Assessment:

CIA-1	Unit -I
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on Unit II and III
ESE	Unit-I, II, III, IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Textbooks:

1. Royden H. L. and Fitzpatrick P. M., 2010, Real Analysis (4th Ed.), PHI.
2. Halmos P. R., 1994, Measure theory, Springer.
3. Hewit E. and Stromberg K., 1975, Real and abstract analysis, Springer.
4. Parthasarathy K. R., 2005, Introduction to probability and measure, Hindustan Book Agency.
5. Rana I. K., 2005, An introduction to measure and integration (2nd Ed.), Narosa Publishing House.

Reference Books:

E-resources:

ADVANCED REAL ANALYSIS (7.0MAT31)

Course Title:	**ADVANCED REAL ANALYSIS**	
Course Code:	**7.0MAT31**	
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/ week	Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 Hour/Week	ESE: 60 Marks	Tutorial: 1
		Total: 4

Course Prerequisite:

1	Basic knowledge of Mathematical Analysis

Course Objectives:

1.	The course covers advanced metric space properties
2	The course covers advanced Riemann integrability
3	The course covers Cesaro"s Method of Summability and Fourier Series

Course Outcomes: Students will be able to

1.	define the advanced properties in metric space
2.	find the Riemann integrals using Lebesgue's criterion
3.	find the bounded variations
4.	classify the Cesaro"s Method of Summability and Fourier Series.

Course Content:

Unit	**Content**	**Hours**
I	Metric spaces revisited; Baire Category theorem, completion of Metric spaces, Banach contraction principle and some of its applications. Compactness, Total boundedness, characterization of compactness for arbitrary Metric spaces; Arzella-Ascoli theorem, Stone Weierstrass theorem.	15
II	Integrations : Lebesgue"s criterion of Riemann integrability over a bounded closed interval [a, b] and its consequence, length of a rectifiable curve in a plane, Riemann-Stieltjes integral over [a, b] and its properties.	15
III	Integrators of bounded variation, Integration by parts, Stieltjes integral as a Riemann integral, Step function as integrator, Riesz theorem.	15
IV	Cesaro"s Method of Summability and Fourier Series: Cesaro"s method of summability of order 1 and order 2, Some specific examples, Regularity of Cesaro"s method, Definition of Fourier series and some examples, Dirichlet"s Kernel, Fejer"s Kernel, Fejer"s theorem, Dini"s and Jordan"s tests for point wise convergence of Fourier series.	15

Internal Assessment:

CIA*-1	Unit -I
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on Unit-II and III
EoSE**	Unit-I,II,III,IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Text Books:

1. Bruckner, A. M., Bruckner J., Thomson B., 1997, *Real Analysis*, Prentice-Hall, N.Y.
2. Goldberg, R. R., 1970, *Methods of Real Analysis*, Oxford-IBH, New Delhi.
3. Natanson, I. P.,1955, *Theory of Functions of a Real Variable*, Vol-I, F.Ungar, N.Y.
4. Hewitt, E., Stromberg, K.,1965, *Real and Abstract Analysis*, John-Willey, N.Y.

Reference Books:

1. Randolph J. F.,1968, *Basic Real and Abstract Analysis*. Academic Press, N.Y.
2. Jain P. K., Ahmad K., 1996, *Metric Spaces*, Narosa Publishing House.
3. Tolstov G., 1962, *Fourier Series*, Dover Publication, N.Y.

E-resources:

https://archive.nptel.ac.in/noc/courses/noc21/SEM2/noc21-ma63

ADVANCED NUMERICAL METHODS (7.0MAT32)

Course Title:	ADVANCED NUMERICAL METHODS	
Course-Code:	7.0MAT32	
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/ week	Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 Hour/Week	ESE: 60 Marks	Tutorial: 1
		Total: 4

Course Prerequisite:

1.	Basic knowledge of numerical analysis

Course Objectives:

1.	The course covers advanced methods for solving the system of equations,
2	The course covers advanced methods to solve eigenvalue problems, numerically.
3	The course covers advanced methods to solve IVP and BVP, numerically.

Course Outcomes: Students will be able to

1.	find the zeros of nonlinear equations
2.	find the solution of system of equations
3.	find the solutions of BVP governed by ODE, numerically
4.	find the solutions of IVP and BVP governed by PDE, numerically.

Course Content:

Unit	Content	Hours
I	Numerical solution of algebraic and transcendental equations: Introduction- iteration method, Newton-Raphson method, Graeffe"s root square method, acceleration of convergence. Numerical Solution of systems of nonlinear equations: iteration method, Newton-Raphson method.	15
II	Linear Systems of equations: Introduction- Gauss elimination method, LU decomposition, Solution of tridiagonal system, Ill-conditioned linear systems and method for Ill-conditioned matrix. EigenValue problem: Power method, Jacobi Method, Householder method.	15
III	Introduction- finite difference formulas. Boundary value problem: Introduction, BVP governed by second order ordinary differential equations, Finite difference method, shooting method, cubic splines method.	15
IV	IVP and BVP in partial differential equations: classification of linear second order partial differential equations, Finite difference methods for Laplace and Poisson equations - Jacobi method, Gauss-Seidel method and ADI (alternating direction implicit) method , Finite difference method for heat conduction equation - Bender- Schmidt recurrence relation, Crank-Nicolson formula, and Jacobi Iteration formula, Finite difference method for wave equation.	15

Internal Assessment:

CIA-1	Unit -I
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on Unit II and III
ESE	Unit-I, II, III, IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Text Books:

1. Atkinson K. E., 1989, *An Introduction to Numerical Analysis (2^{nd} Ed.),* Wiley-India.
2. Sastry S. S., 2012, *Introductory Methods of Numerical Analysis (5^{th} Ed.),* Eastern Economy Edition.
3. Jain M. K., Iyengar S. R. K., Jain R. K., 2012, *Numerical Methods for Scientific and Engineering Computation (6^{th} Ed.)*, New Age International Publishers.

Reference Books:

1. Buchaman J. I., Turner P. R., 1992, *Numerical Methods and Analysis,* McGraw-Hill.

E-resources:

https://archive.nptel.ac.in/courses/111/107/111107105/

COMPLEX DYNAMICS (7.0MAT33)

Course Title:	**COMPLEX DYNAMICS**		
Course Code:	**7.0MAT33**		
Teaching Scheme		**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/ week		Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 Hour/Week		ESE: 60 Marks	Tutorial: 1
			Total: 4

Course Prerequisite: The student should have knowledge of

1.	Complex analysis

Course Objectives:

1.	To teach students bilinear transformation of complex functions
2.	To teach students Fatou sets and Julia sets
3.	To teach students the Euler characteristic, Riemann Hurwitz formula for covering maps

Course Outcomes: Students will be able to

1.	classify the bilinear transformation of complex functions
2.	explain Fatou sets and Julia sets
3.	explain the Euler characteristic, Riemann Hurwitz formula for covering maps.

Course Content:

Unit	Content	Hours
I	Iteration of a Mobius transformation, attracting, repelling and indifferent fixed points. Iterations of R(z) = z2, z2+c, z + . The extended complex plane, chordal metric, spherical metric, rational maps, Lipschitz condition, conjugacy classes of rational maps, valency of a function, fixed points, Critical points, Riemann Hurwitz relation.	15
II	Equicontinuous functions, normality sets , Fatou sets and Julia sets, completely invariant sets, Normal families and equicontinuity, Properties of Julia sets, exceptional points Backward orbit, minimal property of Julia sets.	15
III	Julia sets of commuting rational functions, structure of Fatou set, Topology of the Sphere, Completely invariant components of the Fatou set.	15
IV	The Euler characteristic, Riemann Hurwitz formula for covering maps, maps between components of the Fatou sets, the number of components of Fatou sets, components of Julia sets.	15

Internal Assessment:

CIA-1	Unit -I
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on Unit II and III
ESE	Unit-I, II, III, IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Text Books:

1. Beardon, A.F. 1991, *Iteration of rational functions*, Springer Verlag , New York.
2. Carleson, L., Gamelin, T. W. 1993, *Complex dynamics*, Springer Verlag.
3. Morosawa, S., Nishimura, Y.,Taniguchi, M., Ueda, T., 2000, *Holomorphic dynamics*, Cambridge University Press.

Reference Books:

1. Hua, H.X., Yang, C. C., 1998, *Dynamics of transcendental functions*, Gordan and Breach Science Pub.

E-resources:

https://archive.nptel.ac.in/courses/111/106/111106141

NUMBER THEORY (7.0MAT34)

Course Title:	**NUMBER THEORY**	
Course Code:	**7.0MAT34**	
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/ week	Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 Hour/Week	ESE: 60 Marks	Tutorial: 1
		Total: 4

Course Prerequisite: The student should have knowledge of

1.	Elementary Number Theory

Course Objectives:

1	To teach the students approximation of real numbers
2	To teach the students the Diophantine equations
3	To teach the students the arithmetic functions
4	To teach the students Chebychev's theorems

Course Outcomes: Students will be able to learn

1.	the concepts of continued fractions
2	the Waring's problem
3	the Fibonacci series
4	the Prime number theorem

Course Content:

Unit	Content	Hours
I	Jacobi's Symbol, Kronecker Symbol, Approximation of real number, Farey Sequence, Approximation by rational numbers, Continued fractions	15
II	Diophantine equation $ax^2 + by^2 + cz^2 = 0$, sum of three squares, Pell's equation, Fundamental solutions, General (Diophantine) equation of second degree, Waring's problem	15
III	Review of arithmetic functions, Character modulo k, Principal character, Additive arithmetic functions, Linear recurrence, Fibonacci series, Bonnet formula	15
IV	Bertrand's postulate, Chebychev's theorems, The function $\pi(x)$, Von Mangoldt function, Merten's theorems, Prime number theorem (statement only)	15

Internal Assessment:

CIA-1	Unit -I
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on Unit II and III
ESE	Unit-I, II, III, IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Text Books:

1. Redmond D.., 1996, *Number Theory An Introduction,* Marcel Dekker, New York.
2. Shockley J. E., 1967, *Introduction to Number Theory*, Holt, Rinehart and Winston Inc., New York.

Reference Books:

1. Nathanson M. B., 2000, *Elementary Methods in Number Theory,* Springer, New York

E-resources:

https://archive.nptel.ac.in/courses/

NONLINEAR SYSTEMS & CONTROLS (7.0MAT35)

Course Title:	**NONLINEAR SYSTEMS & CONTROLS**		
Course-Code:	**7.0MAT35**		
Teaching Scheme		**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/ week		Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 Hour/Week		ESE: 60 Marks	Tutorial: 1
			Total: 4

Course Prerequisite: Students should have knowledge of

1.	Differential Equations and Calculus

Course Objectives:

1.	To introduce control theory followed by dynamical system theory
2.	To teach different concepts in dynamical system theory
3.	To teach Lyapunov functions and Poincare-Bendixon's theorem
4.	To introduce two dimensional systems and associated bifurcations
5.	To discuss different topics in control theory

Course Outcomes: Students will be able to learn

1.	different topics in dynamical systems and control theory
2.	stability theory associated with dynamical systems
3.	Lyapunov stability-I and Lyapunov stability-II.
4.	several important aspects related to control systems
5.	different applications of control theory in computing, communications, and sensing technologies that present unprecedented opportunities to impact the economic and scientific development of a particular nation and the world.

Course Content:

Unit	Content	Hours
I	Formulation of physical systems, Existence and Uniqueness theorems, Linear systems, Solution of linear systems, Fundamental matrix, autonomous systems, solution of non-homogeneous systems, Fundamental matrices for Non- autonomous systems, solution of non-homogeneous systems.	15
II	Stability of systems: equilibrium points, stability of linear autonomous systems, Stability of linear systems, Stability of weakly non-linear systems, Linearization, Properties of phase portrait, Properties of Orbits, Phase portrait: Types of critical points, Phase portrait of linear differential equations, Poincare Bandixon's theorem, Limit cycle, Lyapunov stability-I, Lyapunov stability-II.	15
III	Introduction of control systems, Controllability of autonomous systems, Controllability of non-autonomous systems, Observability, Results on controllability and observability, Companion form, Feedback Control, State Observer, Stabilizability, Introduction to discrete systems, Lyapunov stability-I, Lyapunov stability-II, Lyapunov stability-III.	15
IV	Optimal Control, Optimal Controls for Discrete systems, Controllability of discrete systems, Observability of discrete systems-I, Stability for discrete systems, Relation between continuous and discrete systems-II.	15

Internal Assessment:

CIA-1	Unit -I
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on Unit II and III
ESE	Unit-I, II, III, IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Text Books:

1. Barun M. 2011, *Differential Equations and Their Applications*, Springer.
2. Barnett S., 1990, *Introduction to Mathematical Control Theory*, Oxford University Press.
3. Naidu R.D.S., 2010, *Optimal Control Systems*, CRC Press.
4. Lakshmikantham, V., Raghvendra, V., 2005, *Text Book of Ordinary Differential Equations*, TMH.
5. Gopal, M., 1994, *Modern Control Systems*, John Wiley and Sons.

Reference Books:

1. Simmons G.F., 203, *Ordinary Differential Equations*, Tata McGraw Hill.
2. Deo, S.G., Lakshminkantahm, V,., Raghbendra, V., 2020, *Text Book of of Ordinary Differential Equations*.

E-resources:

https://onlinecourses.nptel.ac.in/noc20_ma46/preview

CELESTIAL MECHANICS (7.0MAT36)

Course Title:	**Celestial Mechanics**	
Course Code:	**7.0MAT36**	
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/week	Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 hour/week	ESE: 60 Marks	Tutorial: 1
	Total:	4

Course Prerequisite: The student should have knowledge of

1	Basics of linear algebra, analytical geometry, differential equations, and vector calculus.

Course Objectives:

1	motion of space objects via Kepler's laws of planetary motion and Newton's laws of motion and visualization of different paths/orbits of moving mass.
2	moving frame of reference and its relation to fixed frame along with formulation and special solutions and applications of three body problems.
3	stable/unstable equilibrium points and their applications along with formulation and applications of different kinds of restricted three body problems.
4	different kinds of perturbations in space and their impacts on small space objects (e.g. asteroid, satellite, space craft etc.) along with normal form and its application.

Course Outcomes: The students will be able to

1	learn about planetary motion of space objects and visualize their orbits/paths.
2	know the need of different kinds of frames of reference and understand the formulation and importance of special solutions of three body problems.
3	verify the stable/unstable equilibrium points and understand the applications of stable points along in addition with applications of different kinds of restricted three body problems.
4	understand about the different kinds of perturbations in space and their impacts on small space objects (e.g. asteroid, satellite, space craft etc.) along with application of normal form for stable motion.

Course Content:

Unit	**Content**	**Hours**
I	Introduction, Kepler's Laws of Planetary Motion, Central force motion, Differential equation of orbit, Inverse square force and Geometry of orbits, Relative motion in two body problem, Earthbound satellite circular orbit, Classical orbital elements, Kepler's equation and its applications.	15
II	Moving frame of reference, Derivative of a vector in a rotating frame, motion of a mass relative to rotating frame, Uniform rotating frame, General three body problem, Integrals of motion, Lagrange's special solutions.	15
III	Circular RTBP, Lagrangian points and their stability, Zero velocity curves, Elliptic RTBP, Equilibrium points, Existence of ZVC, Introduction of Robe's RTBP, Hill's problem, Sitnikov problem and their applications.	15
IV	Introduction of perturbations factors, potential of oblate body, effective force of radiating body, potential due to disc or belt like structure. Introduction of normal form, Hamiltonian function, Normalization of Hamiltonian function of Circular RTBP and its applications.	15

Internal Assessment:

CIA-I	Unit I
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on Unit II and III
ESE	Written Exam. for Unit-I, II, III, & IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Text Books:

1. McCuskey S. W., 1963, Introduction to Celestial Mechanics, Addison-Wesley Publishing Company.
2. Murray C. D. and Dermott S.F., 2000, Solar System Dynamics, Cambridge University Press.
3. Strogatz S.H., 1994, Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry and Engineering, Addison-Wesley.
4. Rao K.S., 2009, Classical Mechanics, PHI Learning, Pvt. Ltd.

Reference Books:

1. Moulton F.R., 1914, An Introduction to Celestial Mechanics, the MacMillan Company.
2. Szebehely V., 1967, Theory of orbits. The restricted problem of three bodies, New York Acad. Press.

E-resources

https://mitpress.mit.edu/9780262080484/celestial-mechanics/

ADVANCED COMPLEX ANALYSIS (7.0MAT37)

Course Title:	**Advanced Complex Analysis**	
Course Code:	**7.0MAT37**	
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 3 hours/week	Internal Assessment: 40 Marks	Theory: 3
Tutorial: 1 hour/week	ESE: 60 Marks	Tutorial: 1
	Total:	4

Course Prerequisite: The student should have knowledge of

1	

Course Objectives:

1	To teach some topics of contemporary complex analysis.
2	To prepare the student to independent work in these topics
3	To teach the methods of complex analysis in other areas of mathematics.

Course Outcomes: The students will be able to

1	basic techniques of contemporary complex analysis
2	applications of these techniques in harmonic analysis
3	univalent functions theory and special functions

Course Content:

Unit	Content	Hours
I	Liouville's theorem and its different proofs, Picard's little theorem, Picard's great theorem, Week form of Picard's great theorem, Casorati-Weierstrass theorem, Harmonic conjugate, Transformation of harmonic functions, Transformations of boundary conditions.	15
II	Applications of conformal mappings, Steady temperatures, Steady temperature in a half plane and related problems, Electrostatic Potentials, Potential in cylindrical space, Open mapping theorem, Hurwitz' theorem, Analytic continuation, Direct analytic continuation Poisson integral formula, Dirichlet problem.	15
III	Infinite sums, Mittag-Leffler theorem, Infinite product of complex numbers, Convergence of infinite products, Infinite product of analytic functions, Factorization of entire functions, Gamma functions, Riemann Zeta functions, Euler product formula, Riemann Functional equations, Riemann hypothesis.	15
IV	Univalent functions, Basic results of univalent functions, Class *S*, Area theorem, Biberbach theorem and conjecture, Koebe 1⁄4 theorem, Riemann mapping theorem.	15

Internal Assessment:

CIA-I	Unit -I, II
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce based on Unit III
ESE	Unit-I,II,III,IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Text Books:

1. Brown J.W., and Churchill R.V., 2009, Complex Variables and Applications, McGraw Hill.
2. Ponnusamy S., 2005, Foundations of Complex Analysis, Narosa Publication House.
3. Kasana H.S., 2005, Complex Variables: Theory and Applications, PHI.

Reference Books:

1. Theodore G., 2003, *Complex Analysis*, Springer

E-resources:

https://archive.nptel.ac.in/courses/111/106/111106084/

LIST OF SEC SKILL ENHANCEMENT COURSES

BASIC PROGRAMMING IN MATLAB (6.0MAT81)

<table>
<tr><td colspan="2">Course Title:</td><td colspan="3">Basic Programming in MATLAB</td></tr>
<tr><td colspan="2">Course Code:</td><td colspan="3">6.0MAT81</td></tr>
<tr><td colspan="2">Teaching Scheme</td><td colspan="2">Examination Scheme</td><td>Credits Allotted</td></tr>
<tr><td colspan="2">Theory: 1 hours/week</td><td colspan="2">Internal Assessment: 40 Marks</td><td>Theory: 1</td></tr>
<tr><td colspan="2">Practical: 2 hour/week</td><td colspan="2">ESE: 60 Marks</td><td>Practical: 1</td></tr>
<tr><td colspan="4" align="right">Total:</td><td>2</td></tr>
<tr><td colspan="5">Course Prerequisite: The student should have knowledge of</td></tr>
<tr><td>1.</td><td colspan="4">Basic computer skills to download the required files and programmes needed for the course</td></tr>
<tr><td colspan="5">Course Objectives:</td></tr>
<tr><td>1.</td><td colspan="4">To introduce students to computational methods using MATLAB</td></tr>
<tr><td>2.</td><td colspan="4">To teach the basis of computational techniques for solving ordinary differential equations</td></tr>
<tr><td>3.</td><td colspan="4">To introduce the use of MATLAB for numerical integration and interpolations</td></tr>
<tr><td>4.</td><td colspan="4">To discuss different types of plotting (2D, 3D, contour etc.) using MATLAB</td></tr>
<tr><td colspan="5">Course Outcomes: The students will be able to</td></tr>
<tr><td>1.</td><td colspan="4">Learn different environment of MATLAB</td></tr>
<tr><td>2.</td><td colspan="4">do symbolic computations using MATLAB</td></tr>
<tr><td>3.</td><td colspan="4">solve a system of differential equations via MATLAB</td></tr>
<tr><td>4.</td><td colspan="4">Learn different types of plotting namely, 2D, 3D, contour etc.</td></tr>
<tr><td>5.</td><td colspan="4">do numerical integration and interpolation with unequal intervals</td></tr>
<tr><td colspan="5">Course Content:</td></tr>
<tr><td>Unit</td><td colspan="3">Content</td><td>Hours</td></tr>
<tr><td>I</td><td colspan="3">The MATLAB Environment, MATLAB Basics: Variables, Numbers, Operators, Expressions, Input and output, Vectors, Arrays: Matrices. Built-in Functions and User defined Functions, Files and File Management: Import/Export,</td><td>10</td></tr>
<tr><td>II</td><td colspan="3">Basic 2D, 3D plots, Graphic handling, Use of MATLAB in Matrix Addition, multiplication, subtraction. Symbolic Calculation-symbols, differentiation, integration, etc. Conditional Statements, Loops.</td><td>12</td></tr>
<tr><td>III</td><td colspan="3">MATLAB Programs: Programming and debugging. Mathematical Computing with MATLAB-Algebraic equations. Basic Symbolic Calculus and Differential equations</td><td>12</td></tr>
<tr><td>IV</td><td colspan="3">Ordinary Differential Equations: A first order and first-degree ODE. Interpolation with equal Interval: Newton –Gregory forward and backward interpolation formula. Numerical Integration: Trapezoidal method, Numerical Integration: Simpson method (1/3 and 3/8).</td><td>11</td></tr>
<tr><td colspan="5">Internal Assessment:</td></tr>
<tr><td>CIA-I</td><td colspan="4">Unit -I</td></tr>
<tr><td>CIA-II</td><td colspan="4">Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce</td></tr>
<tr><td>ESE</td><td colspan="4">Unit-I, II</td></tr>
<tr><td colspan="5">CIA: Continuous Internal Assessment, ESE: End Semester Examination</td></tr>
<tr><td colspan="5">Text Books:</td></tr>
<tr><td colspan="5">1. Pratap R., Getting started with MATLAB, Oxford University Press.
2. S. Lynch, 2014, Dynamical Systems with Applications using MATLAB, Birkhäuser.
3. Fousett, L.V., 2007, Applied Numerical Analysis using MATLAB, Pearson Education
4. Chapara S.C., Canale, R.P., 2006, Numerical Methods for Engineers, McGraw Hill</td></tr>
<tr><td colspan="5">Reference Books:</td></tr>
<tr><td colspan="5">1. Gilat A, 2012, MATLAB: An Introduction with Applications, Wiley</td></tr>
<tr><td colspan="5">E-resources:</td></tr>
<tr><td colspan="5">https://onlinecourses.nptel.ac.in/noc20_ge05/preview</td></tr>
</table>

SCIENTIFIC WRITING BY LATEX (6.0MAT82)

Course Title:	**Scientific Writing by LaTeX**	
Course Code:	**6.0MAT82**	
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 1 hours/week	Internal Assessment: 40 Marks	Theory: 1
Practical: 2 hour/week	ESE: 60 Marks	Practical: 1
	Total:	2

Course Prerequisite: The student should have knowledge of

1.	Basic computer skills to downloads the required files and programmes needed for the course

Course Objectives:

1.	Installation of scientific typing tools and writing environment to create documents
2.	To introduce typing tools e.g., LaTeX, Open office
3.	To introduce different commands and mathematical symbols
4.	To discuss the use of template to create impressive documents for Master and PhD thesis
5.	To make students learn how to write equations, plot graphs, and prepare presentations.

Course Outcomes: The students will be able to

1.	learn how to create a scientific document
2.	write equations, letters and do different types of mathematical calculations
3.	include Tables, Figures and Plots in a document
4.	create professional presentations
5.	cite a paper and build Bibliography

Course Content:

Unit	Content	Hours
I	Installing LaTeX and Class files, creating first LaTeX document, creating documents in overleaf, Basic document spacing, Basic typesetting	10 Hours (3 Hours Theory and 07 Hours Practical)
II	mathematical Symbols and Commands, writing of simple article, letters and applications, Mathematical symbols and commands, arrays, formulas and equations, Spacing, Borders and Colors	12 Hours (4 Hours Theory and 08 Hours Practical)
III	Figure environments, Subfigures, Tables, LaTeX presentations using Beamer, Creating different templates, Preparation of template of thesis and books	12 Hours (4 Hours Theory and 08 Hours Practical)
IV	Poster and CV templates, Pictures and Graphics, Bibliography, writing of research articles and reports etc.	11 Hours (3 Hours Theory and 08 Hours Practical)

Internal Assessment:

CIA-I	Unit -I
CIA-II	Written Exams/ Quizzes /Assignment /Presentations/ Viva-Voce
ESE	Unit-I, II, III and IV

CIA: Continuous Internal Assessment, **ESE:** End Semester Examination

Textbooks:

1. Lamport, L.W., 1994, *LaTeX: A document Preparation Systems,* Addison-Wesley Publishing Company.
2. Kopka, H., Daly, P.W., 2004, *Guide to LaTeX*, Fourth Edition, Addison Wesley.

Reference Books:

1. Shirore C., A *Beginner guide to LaTeX,* Lullu.com

E-resources:

2. https://www.udemy.com/course/become-a-good-latex-user-to-create-professional-documents/
3. https://www.overleaf.com/learn

LIST OF AEC
ABILITY ENHANCEMENT COURSES

SEMINAR (6.5MAT81)

Course Title:	**Seminar**	
Course Code:	**6.5MAT81**	
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 0 hours/week	Internal Assessment: 40 Marks	Theory: 0
Tutorial: 0 hour/week	ESE: 60 Marks	Tutorial: 0
	Total:	1

RESEARCH PROJECT/DISSERTATION (7.0MAT81)

Course Title:	**Research Project/Dissertation**	
Course Code:	**7.0MAT81**	
Teaching Scheme	**Examination Scheme**	**Credits Allotted**
Theory: 0 hours/week	Internal Assessment: 00 Marks	Theory: 0
Tutorial: 0 hour/week	ESE: 100 Marks	Tutorial: 0
	Total:	16