DEPARTMENT OF MATHEMATICS

SYLLABUS FOR TWO YEAR POSTGRADUATE PROGRAMME
(FIRST AND SECOND SEMESTER)

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ARYA VIDYAPEETH COLLEGE (AUTONOMOUS)

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Content

PREFACE

“Education is not preparation for life; education is life itself.”—John Dewey

The aim of imparting education is not only to increase the knowledge but also to create the possibilities for a student to invent and discover. The purpose of this syllabus is to establish minimum basic concepts for each course to meet the needs of all our students. All the elements in this syllabus amalgamate to bring out the best in every student and enable them to be on the path of continuous progress.

The syllabus is framed based on Learning Outcome Based Education (LOCF) –the spirit of NEP, 2020. The Post Graduate programmes offered by the college, presently, are :

Sl. No.	Discipline / Subject
1	Assamese
2	Chemistry
3	Economics
4	Education
5	Mathematics
6	Political Science
7	Zoology

Programme Overview & Eligibility

Category	Details
About the Programme	Provides advanced academic training in the concerned subject.
Who Can Apply	• Students successfully completing 3 years in the Four Year Undergraduate Programme (FYUGP) and satisfying minimum credit requirements. • Students successfully completing a 3-year Bachelor's degree and satisfying minimum credit requirements.

Course & Credit Structure

Parameter	Specification
Total Credits per Semester	20
Number of Courses per Semester	5
Credits Assigned per Course	4
Course Component Structures	L-T-0 (Lecture - Tutorial - Nil) L-0-P (Lecture - Nil - Practical) 0-0-P (Nil - Nil - Practical)

Course Level:

Year	Course Level
PG 1st Year	4 (400- 499)
PG 2nd Year	5 (500- 599)

Course Coding System

The format followed for all PG courses is XXX-ABCD. Here is how the code breaks down:

Code Position	Represents	Description
XXX	Subject Code	3-letter discipline identifier (e.g., CHE, MAT)
A	Semester Number	Identifies the current semester
B	Course Level	Identifies the academic level of the course
C	Course/Paper Number	Sequential number of the paper
D	Course Credit	Number of credits assigned to the paper

Example:

For a PG course in Mathematics offered in the First Semester and Third Semester, the course codes will be assigned as follows:

Course Paper	Semester	Course Code
Paper I	First	MAT-1414
Paper II	First	MAT-1424
Paper I	Third	MAT-3514
Paper II	Third	MAT-3524

Two Years PGProgramme in Mathematics

Semester	Course Code	Course Name	Credit (L-T-0)	Total Credits	Formative Assessment Marks	Summative Assessment Marks
First Semester	MAT-1414	Graph Theory	**4(3-1-0)**	**20**	**40**	**60**
	MAT-1424	Abstract Algebra	**4(3-1-0)**		**40**	**60**
	MAT-1434	Real Analysis and Lebesgue measure	**4(3-1-0)**		**40**	**60**
	MAT-1444	Mathematical Methods	**4(3-1-0)**		**40**	**60**
	MAT-1454	Complex Analysis	**4(3-1-0)**		**40**	**60**
Second Semester	MAT-2414	Topology	**4(3-1-0)**	**20**	**40**	**60**
	MAT-2424	Number Theory-I	**4(3-1-0)**		**40**	**60**
	MAT-2434	Functional Analysis	**4(3-1-0)**		**40**	**60**
	MAT-2444	Special Functions and Partial Differential Equations	**4(3-1-0)**		**40**	**60**
	MAT-2454	Mechanics and Tensor	**4(3-1-0)**		**40**	**60**

PROGRAMME OUTCOMES

SPO-1 Knowledge: Learners are encouraged to apply the knowledge of mathematics and science fundamentals to various solutions of complex problems. As such, knowledge of the subject is the sole objective of any student learner. A student is exposed to a wide range of topics in various subjects and is given intensive training in each of the courses that have laboratory related work. The learner is encouraged to use various mathematical

acquired concepts and principles that help in studying various branches of sciences. At the end of the program, students are able to gain thorough knowledge in key areas in the subjects offered.

SPO-2 Problem Analyses: Well equipped with an understanding of the analytical methods involved, they are in a position to interpret and analyze results so obtained from experiments and draw suitable conclusions against their supported data acquired. At the end of the program, students will be able to identify, formulate and analyze scientific problems and reach concrete solutions using various principles of mathematics and sciences.

SPO-3 Designing Solutions: Having acquired knowledge of subjects, students are trained to think out of the box, design and conduct an experiment or a series of experiments that demonstrate their understanding of the methods and processes involved.

SPO-4 Modern tool usage: learners are trained to create, select, and apply appropriate techniques, resources and IT tools in the analysis and synthesis of data within limitations. (Outcome of final year project).

SPO-5 Effective Communication: Proficiency in speaking, reading, writing and listening in English and one Indian language and find meaning of the world by connecting people, ideas, books, media and technology.

SPO-6 Employability: This programme enables the learners to perform the jobs in diverse fields such as science, engineering, industries, survey, education, banking, development-planning, business, public service, self business etc. efficiently. They will also be able to appear for competitive examinations.

SPO-7 Ethics: While it is necessary to instil the spirit of competitiveness among students in a world of increasing competition, it is equally vital to develop a strong sense of ethics among learners that will help them develop some positive attitudes and values. This includes appreciation of the various principles and theories that evolved in science, the impact that science has on social, economical and environmental issues. One of the main objectives of any academic exercise, therefore, should be to produce well-groomed individuals who understand the significance of ethical values and abide by them even in the most pressing circumstances. In this programme, this process is enabled through courses and facilitators who integrate the teaching of ethics in everyday pedagogy. As exercise, ethics in their professional as well as personal practices.

SPO-8 Environment and Sustainability: 'Environmental sustainability' has become the watchword of the 21st century. An increased engagement with environment related concerns is appearing tangibly on global fronts; academics cannot and should not remain quarantined from this massive development. Through classroom discussions and research projects, this programme facilitates active dialogues with factors which influence human-ecology interactions. As such, at the end of this programme students will be able to identify and analyze socio-political, cultural and economic problems which act as deterrents to environmental sustainability and provide creative solutions towards the same.

SPO-9 Soft-Skill Development: Apart from the attainment of knowledge and hands on skills in practical applicability of the subject, learners need to be equipped with soft-skills and values which will help them function effectively as an individual, and as a member or leader in diverse teams and in multidisciplinary groups. These soft skills include leadership, teamwork, project-management, positive outlook, innovative approaches and effective articulation. Several soft skill programs are organized for learners through various agencies that tie up with the state government. As such, at the end of this programme, students will be able to hone the soft-skills required in positively enhancing their academic, professional and personal pursuits towards self and societal advancement.

SPO-10 Science and Society: The learners are encouraged to apply logical reasoning based on the knowledge, skills, designing solutions to assess societal, health, safety issues and the responsibilities that go along with the scientific practice. As an extension activity to society, learners are encouraged to take up specific projects such as impact of salinity on fresh water wells in an adopted village, and provide effective solutions.

SPO-11 Life-long learning: With the pursuit of knowledge for either personal or professional reasons, learners are also encouraged to volunteer and be self-motivated that not only enhances society values, active participation and personality development, but also enhances self-sustainability, competiveness and employability. As such, learners will be able to recognize the need for, and have the preparation and ability to engage in independent and life-long learning in every broad context of technological changes.

PROGRAMME SPECIFIC OUTCOMES

PSO-1: Depth Understanding: Students will get adequate exposure to basic and advanced knowledge in different aspects of mathematical sciences. They will acquire the logical skills necessary to create and develop mathematical arguments. They will be capable of analyzing problems, determining computer needs and defining suitable solutions.

PSO-2: Critical Thinking: Students will be well equipped to critically analyze a given problem, understand and build a mathematical model to represent the problem, solve the resulting equations and critically interpret the resulting solution.

PSO-3: Scientific Communication Skills: Students will be able to apply their skills and knowledge thatis translate information presented verbally into mathematical form, select and use appropriate mathematical formulae or techniques in order to process the information and draw the relevant information.

PSO-4: Modern tool use: Students will learn to utilize computer technology appropriate to solveproblems and to promote understanding, to apply mathematical knowledge to a carrier related to mathematical sciences, thus cultivating a proper attitude to higher studies in mathematics.

PSO-5: Employability: Student possess the essential skills of mathematical modeling, problem-solving, creativity and effective communication necessary for various kinds of employment opportunities.

PSO-6: Evaluate and Conduct Research: Ability to pursue advanced studies and research in pure and applied mathematical science.

PSO-7: 21st Century Skills: Students will develop essential 21st-century competencies such as critical thinking, creativity, effective communication, collaboration, digital literacy, and problem-solving skills, enabling them to adapt and thrive in a dynamic and complex global environment.

Mapping of Course Learning Outcomes and Science Programme Outcomes

<u>Attributes</u>:

Co-relation Levels

“1”: Minimum Co-relation

“2”: Moderate Co-relation

“3”: Maximum Co-relation

“-”: No Co-relation

CLOs/ Course Code	PROGRAMME OUTCOMES (SPO)										
	SPO1	SPO2	SPO3	SPO4	SPO5	SPO6	SPO7	SPO8	SPO9	SPO10	SPO 11
MAT-1414	GRAPH THEORY										
CLO-01	3	2	1	-	1	3	3	-	3	3	3
CLO-02	3	3	3	2	1	3	3	-	3	3	3
CLO-03	3	3	2	-	2	3	3	-	3	3	3
CLO-04	3	1	1	3	3	3	3	-	3	3	3
MAT-1424	ABSTRACT ALGEBRA										
CLO-01	3	3	3	-	-	3	3	-	1	3	3
CLO-02	3	3	3	-	-	3	3	-	1	3	3
CLO-03	3	3	3	2	-	3	3	-	1	3	3
CLO-04	3	3	3	3	-	3	3	-	1	3	3
MAT-1434	REAL ANALYSIS AND LEBESGUE MEASURE										
CLO-01	3	3	3	-	-	3	3	-	-	2	3
CLO-02	3	3	3	-	-	3	3	-	-	2	3
CLO-03	3	3	3	-	-	3	3	-	-	2	3
CLO-04	3	3	3	-	-	3	3	-	-	2	3
MAT-1444	MATHEMATICAL METHODS										
CLO-01	3	3	3	-	-	3	3	-	-	2	3
CLO-02	3	3	3	-	-	3	3	-	-	2	3
CLO-03	3	3	3	-	-	3	3	-	-	2	3
MAT-1454	COMPLEX ANALYSIS										
CLO-01	3	3	3	-	-	3	3	-	-	3	3
CLO-02	3	3	3	-	-	3	3	-	-	3	3
CLO-03	3	3	3	-	-	3	3	-	-	3	3
CLO-04	3	3	3	-	-	3	3	-	-	3	3

MAT-2414	TOPOLOGY										
CLO-01	3	3	3	-	-	-	3	3	-	3	3
CLO-02	3	3	3	-	-	-	3	3	-	3	3
CLO-03	3	3	3	-	-	-	3	3	-	3	3
CLO-04	3	3	3	-	-	-	3	3	-	3	3
MAT-2424	NUMBER THEORY-I										
CLO-01	3	3	3	-	-	3	3	-	-	3	3
CLO-02	3	3	3	-	-	3	3	-	-	3	3
CLO-03	3	3	3	-	-	3	3	-	-	3	3
CLO-04	3	3	3	-	-	3	3	-	-	3	3
MAT-2434	FUNCTIONAL ANALYSIS										
CLO-01	3	3	3	-	-	3	3	-	-	3	3
CLO-02	3	3	3	-	-	3	3	-	-	3	3
CLO-03	3	3	3	-	-	3	3	-	-	3	3
CLO-04	3	3	3	-	-	3	3	-	-	3	3
CLO-05	3	3	3	-	-	3	3	-	-	3	3
MAT-2444	SPECIAL FUNCTIONS AND PARTIAL DIFFERENTIAL EQUATIONS										
CLO-01	3	3	3	-	-	3	3	2	-	3	3
CLO-02	3	3	3	-	-	3	3	2	-	3	3
CLO-03	3	3	3	-	-	3	3	2	-	3	3
CLO-04	3	3	3	-	-	3	3	2	-	3	3
MAT-2454	MECHANICS AND TENSOR										
CLO-01	3	3	3	-	-	3	3	3	-	3	3
CLO-02	3	3	3	-	-	3	3	3	-	3	3
CLO-03	3	3	3	-	-	3	3	3	-	3	3
CLO-04	3	3	3	-	-	3	3	1	-	3	3
CLO-05	3	3	3	-	-	3	3	1	-	3	3
CLO-06	3	3	3	-	-	3	3	1	-	3	3
CLO-07	3	3	3	-	-	3	3	1	-	3	3

Mapping of Course Learning Outcomes and Programme Specific Outcomes

Attributes:

Co-relation Levels

“1”: Minimum Co-relation

“2”: Moderate Co-relation

“3”: Maximum Co-relation

“-” No Co-relation

CLOs/ Course Code	PROGRAMME SPECIFIC OUTCOMES (PSO)						
	PSO	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
MAT-1414	GRAPH THEORY						
CLO-01	3	3	3	1	2	1	3
CLO-02	3	3	3	1	2	1	3
CLO-03	3	3	3	1	2	1	3
CLO-04	2	2	3	3	2	1	3
MAT-1424	ABSTRACT ALGEBRA						
CLO-01	3	3	3	1	2	1	3
CLO-02	3	3	3	1	2	1	3
CLO-03	3	3	3	1	2	2	3
CLO-04	3	3	3	1	2	2	3
MAT-1434	REAL ANALYSIS AND LEBESGUE MEASURE						
CLO-01	3	3	3	1	2	2	3
CLO-02	3	3	3	1	2	2	3
CLO-03	3	3	3	1	2	3	3
CLO-04	3	3	3	1	2	3	3
MAT-1444	MATHEMATICAL METHODS						
CLO-01	3	3	3	1	2	2	3
CLO-02	3	3	3	1	2	2	3
CLO-03	3	3	3	1	2	2	3
MAT-1454	COMPLEX ANALYSIS						
CLO-01	3	3	3	1	2	1	3
CLO-02	3	3	3	1	2	2	3
CLO-03	3	3	3	1	2	1	3

CLO-04	3	3	3	1	2	2	3
MAT-2414	TOPOLOGY						
CLO-01	3	3	3	1	2	1	3
CLO-02	3	3	3	1	2	1	3
CLO-03	3	3	3	1	2	2	3
CLO-04	3	3	3	1	2	2	3
MAT-2424	NUMBER THEORY-I						
CLO-01	3	3	3	1	2	1	3
CLO-02	3	3	3	1	2	1	3
CLO-03	3	3	3	1	2	1	3
CLO-04	3	3	3	1	2	1	3
MAT-2434	FUNCTIONAL ANALYSIS						
CLO-01	3	3	3	1	2	1	3
CLO-02	3	3	3	1	2	1	3
CLO-03	3	3	3	1	2	2	3
CLO-04	3	3	3	1	2	2	3
CLO-05	3	3	3	1	2	2	3
MAT-2444	SPECIAL FUNCTIONS AND PARTIAL DIFFERENTIAL EQUATIONS						
CLO-01	3	3	3	1	2	1	3
CLO-02	3	3	3	1	2	1	3
CLO-03	3	3	3	1	2	1	3
CLO-04	3	3	3	1	2	1	3
MAT-2454	MECHANICS AND TENSOR						
CLO-01	3	3	3	1	2	1	3
CLO-02	3	3	3	1	2	1	3
CLO-03	3	3	3	1	2	1	3
CLO-04	3	3	3	1	2	1	3
CLO-05	3	3	3	1	2	2	3
CLO-06	3	3	3	1	2	2	3
CLO-07	3	3	3	1	2	2	3

FIRST SEMESTER

COURSE NAME: GRAPH THEORY

COURSE CODE: MAT-1414

Total Credits: 4 (Lecture: 3 +Tutorial: 1)

THEORY

Total Lectures: 45

Course Objective: Graph theory provides a vital language to model everything from abstract ideas to real-world problems. Students will learn to analyses graph structures, identify key properties, and apply various graph operations. The course also develops problem-solving skills related to spanning trees, Eulerian and Hamiltonian graphs and matrix representations of graphs. By the end, this course intends to equip students with the theoretical tools to model and solve real-world network problems.

Course Learning Outcomes:

CLO-01:*Understand the fundamental concepts of graphs, including their properties, operations, and the concept of isomorphism, as a foundation for advanced topics.*

CLO-02:*Apply the concepts of trees, connectivity, and spanning trees to solve problems related to network design and circuit analysis.*

CLO-03:*Analyze graphs for Eulerian and Hamiltonian traversability and study the concept of planer graphs and digraphs.*

CLO-04:*Evaluate and create matrix representations of graphs and utilize them for computational analysis and algorithm development.*

Unit 1: Introduction to Graph Theory: (10 lectures)

The Konigsberg bridge problem, graphs, subgraphs, isomorphism of graphs, degree, degree sequence, walk, paths, cycles, connected graphs and components, operations on graphs (union, join, product, composition, ring sum).

Unit 2: Trees, Block and Connectivity: (15 lectures)

Trees, some properties of trees, pendant vertices in a tree, spanning trees, cut-sets, cut- points, bridges and blocks, block graphs and cut-point graphs, connectivity and line connectivity.

Unit 3: Traversability, Planarity and Digraphs: **(10 lectures)**

Eulerian and Hamiltonian graphs, their characterization, and related results, planarity: basic concepts, plane graphs, digraphs, types of digraphs and properties.

Unit 4: Matrix representation of Graphs: **(10 lectures)**

Matrix Representation of graphs**:** Incidence matrix, submatrices, circuit matrix, fundamental circuit matrix, cut-set matrix, adjacency matrix.

Books Recommended:

1. Harary, F., *Graph Theory*, CRC Press, New Delhi, 2018.
2. Deo, N., *Graph Theory with Applications to Engineering and Computer Science*, Dover Publications, 2017.

Reference Books:

1.Chartrand, G., and Zhang, P., *A First Course in Graph Theory*, Dover Publication, INC, 2013.

2. West, D. B., *Introduction to Graph Theory*, (2nd edition), Pearson Education, 2017.

3.Vasudev C, *Graph Theory with Applications*, New Age International Publishers, 2006.

COURSE NAME: ABSTRACT ALGEBRA

COURSE CODE: MAT-1424

Total Credits: 4(Lecture:3+Tutorial:1)

THEORY

Total Lectures: 45

Course Objective:

This course aims to provide a deep understanding of advanced algebraic structures and their properties. Students will explore the construction and decomposition of groups through direct products, series and solvability of groups. This course provides crucial tools for determining when polynomials are irreducible, which is essential for solving equations and constructing new fields. Field extensions are studied to understand how to solve polynomial equations, which leads to the idea of Galois theory. Canonical forms are studied to understand and classify linear transformations, which is essential for solving systems of differential equations and analyzing complex models in physics and engineering.

Course Learning Outcomes:

CLO-01: *Develop an understanding of group structures through direct products, series of groups,and solvability.*

CLO-02: *Study the divisibility in rings and master concepts like PID, UFD, and irreducibility criteria.*

CLO-03:*Study the fundamental concepts of the field extension and how they apply to geometry.*

CLO-04: *Learn canonical forms of linear transformations, including Jordan form and the classification of quadratic forms.*

Unit 1:Direct Product and Solvable Groups: (10 lectures)

Direct product and direct sums of groups, decomposable groups, normal and subnormal seriesofgroups,compositionseries,JordanHoldertheorem,solvablegroups.

Unit 2:Divisibilityin Rings:(15 lectures)

Divisibilityin commutative rings, PID, UFD and their properties, Eisentein's irreducibility criterion.

Unit 3: Field Extensions: (5 lectures)

Field theory–extensions of fields, algebraic and transcendental elements, algebraic extensionsof splitting field, perfect fields, finite field (Moore's theorem etc.), construction by ruler and compass,elementsofGaloistheory.

Unit 4: Canonical forms: (15 lectures)

Canonical forms, similarity of linear transforms, invariant subspaces, reduction to triangularforms, nilpotent transformations, primary decomposition theorem, Jordan blocks and Jordan canonicalform,quadraticforms,reductionandclassificationofquadraticforms.

Books Recommended:

1. Gallian, J. A.,*Contemporary Abstract Algebra*, (8th edition), Cengage Learning Private Limited, Delhi, Fourth impression, 2015.

2. Singh, S.andZameruddin, Q.,*ModernAlgebra*,VikashPublishingHouse,2006

3. Hoffman, K.andKunz, R.,*LinearAlgebra*,(2nd edition), Prentice Hall of India, Private Limited, 2015.

Reference Books:

1. Herstein,I.N., *TopicsinAlgebra*,JohnWiley&Sons,1975, (Digitized:2010).

2. John, B. F., *A first Course in Abstract Algebra*, (7th edition), Pearson, 2002.

3. Lipschutz, S., *LinearAlgebra*,Schaum'sOutline,TheMcGraw-HillCompanies,Inc.,2013.

4. Dummit, D. S., and Foote, R. M., *Abstract Algebra*, (2nd edition), John Wiley and Sons (Asia) Private Limited,Singapore, 2003.

COURSE NAME: REAL ANALYSIS AND LEBESGUE MEASURE

COURSE CODE: MAT-1434

Total Credits: 4(Lecture:3+Tutorial:1)

THEORY

Total Lectures: 45

Course Objective: This course aims to develop an advanced understanding of real analysis, focusing on the convergence of sequences and series of functions, functions of bounded variation, the Riemann-Stieltjes integral and the powerful framework of Lebesgue measure and integration. Students will master key theorems and build essential analytical skills for further research in mathematical analysis.

Course Learning Outcomes:

CLO-01**:** *Differentiate between pointwise and uniform convergence of sequences and series of functions. Analyze and describe the properties preserved under uniform convergence.*

CLO-02**:***Determine if a function is of bounded variation and know related properties. Define the Riemann-Stieltjes integral and identify the conditions required for a function to be integrable with respect to another.*

CLO-03**:** *Explain the concept of Lebesgue measure and measurable sets. Analyze the properties of measurable functions and sequences of measurable functions, and distinguish between measurable and non-measurable sets.*

CLO-04**:** *Define the Lebesgue integral and apply its properties to bounded and unbounded functions. Use convergence theorems to evaluate limits of integrals*

Unit1: Pointwise and Uniform Convergence: **(10 lectures)**

Sequence and series of functions: Pointwise and uniform convergence, Cauchy Criterion for uniform convergence, tests for uniform convergence of sequence and series, properties of uniformly convergent sequence and series, power series, radius of convergence.

Unit 2: Functions of Bounded Variation and Riemann-Stieltjes Integral: (12 lectures)

Functions of bounded variation and its properties, definition and existence of Riemann-Stieltjes integral, condition of integrability, properties of the integral, integration and differentiation, fundamental theorem of calculus.

Unit 3: Lebesgue Measure: (10 lectures)

Set functions, measurable sets and their properties, non-measurable sets, definition and properties of measurable functions and sequence of measurable functions.

Unit 4: Lebesgue Integration: (13 lectures)

Lebesgue integration, properties of Lebesgue integral for bounded measurable functions, Lebesgue integral for non-negative and unbounded functions, general Lebesgue integral, Lebesgue's monotone convergence theorem, Lebesgue's dominated convergence theorem.

Books Recommended:

1. Rudin, W., *Principles of Mathematical Analysis*, McGraw-Hill International Editions (3rd edition), reprint 2004.
2. Royden, H. L., *Real Analysis*, Prentice Hall of India (4th edition), 2011.
3. Malik, S. C. and Arora, S., *Mathematical Analysis*, New Age International (P) Limited (2nd edition), 2017.

Reference Book:

1. Bartle, R.G. and Sherbert, R. D., *Introduction to Real Analysis*, John Wiley & Sons, Inc (3rd edition), 2011.

COURSE NAME: MATHEMATICAL METHODS

COURSE CODE: MAT-1444

Total Credits: 4(Lecture:3+Tutorial:1)

THEORY

Total Lectures: 45

Course Objective: The main objective of this course is to help students understand and apply the concepts of integral equations**,** integral transforms, and the calculus of variations to solve mathematical and physical problems. It aims to develop analytical skills for converting and solving differential equations using integral methods. Also, to introduce techniques for finding functions that optimize given functionals.

Course Learning Outcomes:

CLO-01***:****Apply analytical and iterative methods to solve Fredholm and Volterra integral equations and understand their properties.*

CLO-02***:*** *Learn about Fourier and Laplace transforms and use them to solve differential equations.*

CLO-03***:****Learn to formulate and solve variational problems to determine functions that optimize given functionals.*

Unit 1: Integral Equations: **(15 lectures)**

Fredholm Integral Equations: Definition of Integral Equation, reductionof ordinary differential equations into integral equations, Fredholm integral equations with separable kernels, eigen values and eigen functions, method of successive approximation, iterative scheme for Fredholm Integral equations of second kind.

Volterra Integral Equations: Volterra Integral Equations of second kind, resolvent kernal of Volterra equation and its results, application of iterative scheme to Volterra equation of the second kind, convolution type kernels.

Unit 2: Integral Transforms: **(15 lectures)**

Fourier Transform: Fourier integral transform, properties of Fourier Transform, Fourier sine and cosine transforms, application of Fourier transform to ordinary and partial differential equations of initial and boundary value problems, evaluation of definite integrals.

Laplace Transform:Basic propertiesof LaplaceTransform, convolutiontheorem andproperties of convolution, inverse Laplace Transform, application of Laplace Transform to solution of ordinary and partial differential equations of initial and boundary value problems, evaluation of definite integrals, the inversion theorem, evaluation of inverse transforms by residue method.

Unit 3: Calculus of Variations: **(15 lectures)**

Calculus ofvariation withone independent variable**:** Basic ideas of calculus of variations, Euler's equation with fixed boundary of the functional containing only the first order derivativeof theonly dependent variable, variational problems with functional having higher order derivatives of the only dependent variable, general case of Euler's equation, applications.

Calculus of Variation with several independent variables**:** Variational problems with functional dependent on functionsof severalindependent variableshaving firstorder derivatives, variationalproblems inparametric form, isoperimetricproblems, applications.

Books Recommended:

1. Kanwal, R. P.,*Linear Integral Equations, Theory and Techniques*, Birkhäuser,New York, 2012.
2. Spiegel, M. R.,*Theory and Problems of Laplace Transforms*, Schaum's Outline Series,Mc GrawHill Book Company, reprint 2005.
3. Gupta, A. S., *Calculus of variation with Applications*, Prentice Hall of India, 1999.

Reference Books:

1. Mikhlin, S. G., *Linear Integral Equations* (Translated from Russia), Dover Publications, 2020.
2. Hilderbrand, F. B.,*Methods of Applied Mathematics*, Dover Publications, 2012.

COURSE NAME: COMPLEX ANALYSIS

COURSE CODE: MAT-1454

Total Credits: 4 (Lecture:3+Tutorial:1)

THEORY

Total Lectures: 45

Course Objective: This course aims to develop a deep understanding of advanced concepts in complex analysis, including the convergence of complex series, the study of singularities and residues, and the geometric interpretation of complex functions through mappings and Riemann surfaces. Students will learn powerful analytical techniques such as Laurent and Taylor series, residue calculus for evaluating complex integrals, and methods of analytic continuation. This course will help to understand the structure, behaviors and representation of complex functions, forming the analytical tools needed for advanced studies.

Course Learning Outcomes:

CLO-01**:***Understand and analyze the convergence properties of complex sequences and series, and apply Taylor and Laurent expansions to represent analytic functions.*

CLO-02**:** *Identify and classify singularities, compute residues, and apply the residue theorem to evaluate real and complex integrals.*

CLO-03**:***Apply various conformal and linear fractional mappings to transform complex regions and understand their geometric significance.*

CLO-04**:** *Explain and apply the concept of analytic continuation, Schwarz reflection principle, and construct Riemann surfaces for multi-valued functions.*

Unit 1: Series: (10 lectures)

Convergence of complex sequences and series, Taylor and Laurent series, absolute and uniform convergence of power series, integration and differentiation of power series, uniqueness of series representation.

Unit 2:Residues and Poles: **(15 lectures)**

Zeros of analytic functions, limit points of zeros, singularities and their classification, behavior of the function in a neighborhood of isolated singularities, residues, Cauchy residue theorem, residue at infinity, residue at poles, evaluation of improper integrals and definite integrals involving sines and cosines, Jordan's Lemma, Integration along a branch cut, Argument principle, Rouché's theorem.

Unit 3:Mappings: **(10 lectures)**

Mapping by elementary functions, linear fractional transformation, cross ratios, mappings of the half planes and circles, conformal mappings, the Schwarz-Christoffel transformation, Riemann mapping theorem.

Unit 4: Analytic Continuation: **(10 lectures)**

Analytic continuation, Schwarz reflection principle, Riemann surfaces (for $\sqrt{z},\ logz,\ \sqrt{z^2-1}$).

Books Recommended:

1. Brown, J. W. and Churchill, R. V.,*Complex Variables and Applications* (9^{th} edition), McGraw Hill International Edition, 2021.
2. Mathews, J. H. and Howell, R. W., *Complex Analysis for Mathematics and Engineering*, (6^{th} edition), Jones and Bartlett India Pvt. Ltd, 2012.

Reference Books:

1. Ponnusamy, S., *Foundations of Complex Analysis*, Narosa Publishing House, India, (2^{nd}edition), 2011.
2. Conway, J. B., *Functions of one Complex Variable*,Springer New York, India, 2012.
3. Kumaresan S., *A pathway to Complex Analysis*, Techno World, 2022.

SECOND SEMESTER

COURSE NAME: TOPOLOGY

COURSE CODE:MAT-2414

Total Credits: 4(Lecture:3+Tutorial:1)

THEORY

Total Lectures: 45

Course Objective:

This course aims to provide a rigorous foundation in general topology, covering the abstract framework of topological spaces, continuity, and key topological properties such as compactness, connectedness, and separation. The objective is to develop the ability to think and argue rigorously in a general mathematical setting, mastering proofs of central theorems and understanding their applications, thereby building a solid foundation for further studies in advanced mathematics.

Course Learning Outcomes:

CLO-01***:*** *Define and illustrate key concepts in topological spaces, including closed sets, basis, sub-basis, subspace topology, and product topology. Analyze continuity, homeomorphism, and topological invariants in various examples.*

CLO-02***:****Identify and differentiate between first countable, second countable and separable spaces.Apply these axioms to analyze the structure of topological spaces.*

CLO-03***:*** *Classify topological spaces using separation axioms. Apply Urysohn's lemma and Tietze Extension Theorem, and understand metrizability through Urysohn's metrization theorem.*

CLO-04***:****Analyze compactness, connectedness and their variants. Investigate the preservation of these properties under continuous maps and product topologies.*

Unit 1: Topology: **(13 lectures)**

Definition and examples of topological spaces, closed sets, dense subsets, interior, exterior, boundary points, derived sets, basis and sub basis, subspace topology, Tychonoff Product topology in terms of standard subbase, continuity and related concepts, projection maps, homeomorphism.

Unit 2: Countability Axioms: **(10 lectures)**

First countable spaces, second countable spaces, separable spaces and Lindelof's theorem.

Unit 3: Separation Axioms*:* **(10 lectures)**

Hausdorff, regular and normal spaces, Urysohn's characterization of normality, Urysohn's metrization theorem, completely regular spaces, Tietze extension theorem, separation axioms of product spaces.

Unit 4: Compactness and Connectedness: **(12 lectures)**

Compactness, continuous functions and compact spaces, limit point compact and sequentially compact spaces, local compactness and one-point compactification, compactness in metric spaces. Connected spaces, components, locally connected spaces and totally disconnected spaces, compactness and connectedness of product spaces.

Books Recommended:

1. Munkres, J.R.,*Topology*: A first Course, Pearson Education, (2nd edition), 2000.
2. Wiliard, S., *General Topology*, Dover publication, 2004.

Reference Books:

1. Joshi, K.D., *An Introduction to General Topology*, Wiley Eastern Ltd., (2nd edition), 2002.
2. Simmons, G.F., *Introduction to Topology and Modern Analysis*, McGraw Hill, 2017.

COURSE NAME: NUMBER THEORY-I

COURSE CODE: MAT-2424

Total Credits: 4(Lecture:3+Tutorial:1)

THEORY

Total Lectures: 45

Course Objective:

This course intends to establish a foundational understanding of elementary number theory. Students will learn how to work with modular arithmetic to solve problems and explore important theorems like Fermat's and Wilson's. The course also covers the number theoretic functions and the concept of primitive roots, which are tools for solving more complex problems.

Course Learning Outcomes:

CLO-01**:** *Apply foundational principles of integers and the Fundamental Theorem of Arithmetic to solve problems related to divisibility, greatest common divisors, and Diophantine equations.*

CLO-02**:***Solve systems of linear congruences and analyze integer properties using classical theorems of modular arithmetic such as the Chinese Remainder Theorem and Wilson's Theorem.*

CLO-03**:***Learn about a few number theoretic functions and their properties.*

CLO-04**:***Use theconceptofprimitiverootsandindicesforsolvabilityof congruenceofhigherorder*.

Unit 1: Integer Fundamentals: (10 lectures)

Well ordering principle of integers, Archimedian property, first principle of finite induction, second principle of finite induction, the division algorithm of integers, the greatest common divisor, least common multiple, the Euclidean algorithm, the Diophantine equation $ax+by=c$, fundamental theorem of arithmetic.

Unit 2: Congruences: (15 lectures)

Congruence modulo of a fixed positive integer, basic properties of congruences, binary and decimal representation of integers, linear congruences, Chinese remainder theorem, Fermat’s little theorem, pseudo primes, Wilson’s theorem.

Unit 3: Number Theoretic Functions: **(10 lectures)**

Number theoretic functions: The sum(σ) and number of divisors(τ) of a positive integer, multiplicative functions, Mobius functions(μ), the Mobius inversion formula, the greatest integer function, Euler's Phi-function(φ), properties of Euler's Phi function, Eulers's theorem, RSA cryptography (application).

Unit 4: Primitive Roots: **(10 lectures)**

Primitive roots: order of an integer mod *m*, primitive roots for primes, composite numbers havingprimitiveroots,theory ofindices.

Book Recommended:

1. Burton, D. M., *ElementaryNumberTheory*, McGrawHillEducation,(7th edition), 2023.

Reference Books:

1. Jones, G. A. and Jones, J. M., *Elementary Number Theory*,Springer Undergraduate Mathematics Series2025.
2. Robinns, N., *Beginning Number theory*,(2nd edition), Narosa Publishing house Pvt. Ltd., Delhi, 2007.

COURSE NAME: FUNCTIONAL ANALYSIS

COURSE CODE:MAT-2434

Total Credits: 4(Lecture:3+Tutorial:1)

THEORY

Total Lectures: 45

Course Objective:

The objective of this course is to get an abstract approach to analysis and thus apply the mathematical structures to analyze and solve problems in both pure and applied mathematics. The course aims to strengthen the ability of the students to construct proofs and derive theoretical results based on existing literature.

Course Learning Outcomes:

CLO-01: *Introduction of the concept of both finite and infinite dimensional abstract spaces accompanied by a normed structure.*

CLO-02: *Understanding of mappings or functions between normed spaces and their behavior and properties.*

CLO-03: *Learn fundamental theorems, hence forming the basis for a better understanding of the subject.*

CLO-04:*Introduction of the theory of the special normed space called the inner product space.*

CLO-05:*Understanding of the basic idea of spectral theory, both in case of finite and infinite dimensional normed linear spaces.*

Unit 1: Normed Linear Spaces: (10 lectures)

Normed linear spaces, Banach spaces with examples, properties of normed linear spaces, finite dimensional normed linear spaces and subspaces, equivalent norms, Riesz's lemma.

Unit 2: Linear Operators on a Normed Linear Space: (10 lectures)

Linear operators, bounded and continuous linear operators, linear functionals, normed space of operators, dual space as a Banach space, dual spaces of $\mathbb{R}^n$, l^1,l^p.

Unit 3: Fundamental Theorems for Normed Linear Spaces: (10 lectures)

Adjoint operator on a normed space, uniform boundedness theorem, open mapping theorem, closed graph theorem, Hahn-Banach theorem for complex vector spaces and normed linear spaces.

Unit 4: Inner Product Spaces: **(10 lectures)**

Inner product spaces, Hilbert spaces-examples and properties,Schwarz inequality, triangle inequality, orthogonal complements and direct sum, orthonormal sets, Bessel's inequality, Gram-Schmidt orthonormalization, orthonormal basis, Riesz representation theorem, Hilbert adjoint operator and its properties, self adjoint, unitary and normal operators.

Unit 5: Spectral Theory: **(5 lectures)**

Spectral theory in finite dimensional normed spaces, basic concepts of spectrum and numerical range of an operator.

Books Recommended:

1. Kreyszig, E., *Introductory Functional Analysis with Applications*, John Wiley & Sons, 2007.
2. Limaye, B. V., *Functional Analysis*, New Age International Publisher, 2021.

Reference Books:

1. Megginson, R.E., *An Introduction to Banach Space Theory*, Springer New York, 2012.
2. Rudin, W.,*Functional Analysis*, McGraw Hill, 2000.

COURSE NAME: SPECIAL FUNCTIONS AND PARTIAL DIFFERENTIAL EQUATIONS

COURSE CODE: MAT-2444

Total Credits: 4 (Lecture: 3 + Tutorial: 1)

THEORY

Total Lectures: 45

Course Objective:

The objective of this course is to develop a thorough understanding of some special functions and their role in solving complex mathematical problems. Through the study of elliptic, hyperbolic, and parabolic partial differential equations, the course seeks to enhance theability of the students to model and solve problems arising in physics, engineering, and applied sciences.

Course Learning Outcomes:

CLO-01:*To apply special functions such as Gamma, Beta, Legendre, and Bessel functions in solving differential equations.*

CLO-02:*Solve Laplace's equationin various coordinate systems using separation of variables technique.*

CLO-03:*Apply the theory of wave equations to derive and interpret D'Alembert's solution, and also solve real life problems using the method of separation of variables.*

CLO-04:*Formulate and solve diffusion equations, boundary-value problems, using separation of variables method and the Laplace transform method.*

Unit 1: Special Functions: (10 lectures)

The origin of special functions, the Gamma and Beta functions and their related functions, linear homogeneous differential equation-ordinary and singular points, series solution, Legendre polynomials, recurrence relations for the Legendre polynomials, Rodrigues formula, series of Legendre polynomials, Legendre's associated functions, Bessel function, recurrence relations, integrals involving Bessel functions.

Unit 2: Laplace's equation: (10 lectures)

Laplace's equation (Elliptic equation): Occurrence of Laplace's equation, fundamental solutions of Laplace's equation in two and three independent variables, Laplace and wave equations in polar, spherical polar and cylindrical polar coordinates,use of the separation of variables method for the solution of Laplace's equations in two and three dimensions.

Unit 3: Wave Equation: (10 lectures)

Wave equation (Hyperbolic equation): D'Alembert's formula for the vibration of an infinite string,use of the method of separation of variables for the solution of the problem of vibration of a string,wave equation in polar and cylindrical polar coordinates.

Unit 4: Diffusion equation: (15 lectures)

Diffusion equation (Parabolic equation): Elementary solutions of the diffusion equation, conduction of heat in a bounded strip, first boundary value, conduction of heat in an infinite strip (Cauchy problem), problems, diffusion equation in polar and in cylindrical polar coordinates, solution of the diffusion equation by the Laplace transform method.

Books Recommended:

1. Rao, K.S., *Introduction to Partial Differential Equations*, Prentice Hall, New Delhi, 2011.
2. Raisinghania, M. D., *Advanced Differential Equations*, S. Chand Limited, 1995.

Reference Books:

1. Sneddon, I. N., *Elements of Partial Differential Equations*, McGraw-Hill, 2006.
2. Lebedev, N. N., *Special Functions and Their Applications*, PHI, 1965.

COURSE NAME: MECHANICS AND TENSOR

COURSE CODE:MAT-2454

Total Credits: 4 (Lecture: 3 + Tutorial: 1)

THEORY

Total Lectures: 45

Course Objective:

The topics in mechanics aims to develop an understanding of the dynamics of particles and rigid bodies, emphasizing motion in different coordinate systems, inertia principles, and central forces. It introduces D'Alembert's, Lagrange's, and Hamilton's formulations to analyze mechanical systems and their motion under various force conditions.

The topics in tensor aims to develop a clear understanding of tensor algebra and calculus, including transformation laws, operations, and the concept of Riemannian geometry. Students will learn to apply tensors, Christoffel symbols and covariant differentiation to solve problems involving gradients, divergence, curl, Laplacian and geometric interpretations in physical and mathematical contexts.

Course Learning Outcomes:

CLO-01: *Understand particle motion under central forces and analyze velocity, acceleration and trajectories in cylindrical and spherical coordinate systems.*

CLO-02:*Understand and apply the concepts of moment of inertia, related theorems and principal axes to analyze rigid body dynamics.*

CLO-03:*Understand D'Alembert's principle and derive equations governing rigid bodymotion and dynamics of the center of inertia.*

CLO-04:*Understand rotational motion, compound pendulum dynamics, impulsive forces and Euler's systems for analyzing motion with or without external forces.*

CLO-05:*Understand and apply Lagrange's and Hamilton's equations to analyze the dynamics ofholonomic systems under finite forces.*

CLO-06: *Students will be able to understand types of tensor, transformation laws, operations, Riemannian metric, Christoffel symbols and apply tensor calculus to solve problems in differential geometry and continuum mechanics.*

CLO-07: *Students will understand covariant differentiation of tensors, gradient, divergence, curl and apply these concepts to analyze vector relationships and invariant functions*

Unit 1:Central Orbit: **(6 lectures)**

Velocity and acceleration in cylindrical and spherical polar coordinates, central forces, central orbit, apses, motion in three dimensions.

Unit 2: Moments of inertia **(6 lectures)**

Moments and products of inertia, parallel axes theorem, perpendicular axes theorem, theorem of six constants, the momental ellipsoid, equi-momental systems, principle axes.

Unit 3:The General Equation of Motion of a Rigid Body: **(6 lectures)**

D' Alembert's principle, the general equation of motion of a rigid body, motion of the centre of inertia and motion relative to the center of inertia.

Unit 4:Motion About a Fixed Axis: **(6 lectures)**

Motion about a fixed axis, the compound pendulum, center of percussion, motion of a body in two dimensions under finite and impulsive forces, Euler’s geometrical and dynamical systems, motion under no external forces.

Unit 5:Generalized Coordinates: **(6 lectures)**

Lagrange’s equation of motion for finite forces in holonomic systems, Hamiltonian theory: Hamilton’s equation of motion.

Unit 6:Tensor Algebra: **(8 lectures)**

Transformation laws of covariant and contravariant tensors, mixed tensor, rank of tensor,Kronecker delta, algebraic operations on tensors: contraction, inner and outer product of tensors, quotient law, group property of tensors, symmetric and anti-symmetric tensors and related theorems, Riemannian metric and fundamental tensors, Christoffel symbols of the first and second kinds and their properties, transformation laws of Christoffel symbols.

Unit 7: Covariant Derivatives: **(7 lectures)**

Covariant derivatives of tensors $A_i, A^i, A_{ij}, A^{ij}, A^i_j$generalizations, covariant derivatives of fundamental tensors and scalar invariant function, application in problems, angle between two vectors and orthogonal condition, gradient of an invariant function, divergence and curl of vectors, Laplacian in tensor form.

Books Recommended:

1. Murray Spiegel, M., *Theory & Problems of Theoretical Mechanics*, Schaum's Outline Series, McGraw Hill Education, 2017.
2. Loney, S. L., *An Elementary Treatise on the Dynamics of a Particle and Rigid Bodies*, Cambridge University Press, 2017.
3. Weatherburn, C. E.,*An Introduction to Riemannian Geometry and the Tensor Calculus*, Cambridge University Press, 2008

Reference Books:

1. B. C. Kalita, *Tensor Calculus and Applications: Simplified Tools and Techniques*, CRC Press, Taylor &Francis Group, 2019
2. David C. Kay, *Tensor Calculus*, Schaum's Outline Series, McGraw Hill Education, 2011.
3. Eisenhart, L. P., Riemannian Geometry, Creative Media Partners, LLC, 2021.

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