ROYAL GLOBAL UNIVERSITY
GUWAHATI

Royal School of Applied & Pure Sciences (RSAPS)
Department of Mathematics

M.Sc. in Mathematics

Learning Outcomes based Curriculum Framework (LOCF)
(Upto 20% MOOCs/Blended Mode)

2021

SYLLABUS
&
COURSE STRUCTURE

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1. Introduction

The shifting of focus from teacher centric to learner centric has been the main focus of new education policy framed by Government. With this moto, UGC has recommended to frame the course curricum for UG and PG focusing on learning outcomes- based curriculum framework (LOCF). The learning outcomes-based curriculum framework for M.Sc. Mathematics is prepared keeping focus on learner centric curriculum. The present framework aims to provide a student of mathematics with knowledge and skills in subject-specific and generic field including transferable global skills and competencies which help in personal development and prepare students for further study in the global world to enhance the chances of employability. This framework would certainly encourage students to involve in discussions, problem-solving and out of box thinking about various concepts of mathematics and their applicability to solve real world problems, which may lead to empowerment and enhancement of the social welfare at large.

2. Learning Outcomes based approach to Curriculum Planning

The Course Curriculum for Master Degree in Mathematics or M.Sc. with Mathematics for the students to attain higher level knowledge of core subjects of mathematics during the course. The course learning outcomes of Mathematics are aimed at faciliating the learners to acquire knowledge, skills understanding, values, attributes and academic standards. A student is awarded with M.Sc Mathematics on the basis of the attainment of these outcomes at the end of the programme.

2.1 Nature and extent of the M.Sc. Mathematics

Mathematics is the study of quantity (number theory), structure (algebra), space (geometry) and change (mathematical analysis). It has wide range of applications in natural sciences, engineering, economics, social sciences and even bio and medical sciences. The key areas of study advanced level in mathematics are:

I. Real & Complex analysis
II. Calculus
III. Abstract Algebra
IV. Number Theory
V. Graph Theory
VI. Differential Equations (including Mathematical Modelling)
VII. Linear Algebra
VIII. Metric Spaces and Topology
IX. Numerical Analysis
X. Mechanics
XI. Bio mathematics
XII. Fuzzy set theory
XIII. Operations research

To broaden the interest for interconnectedness between formerly separate disciplines one can choose from the list of ability enhancement Courses enable the student acquire the skill relevant to the main subject. Choices from Discipline Specific Electives provides the student with liberty of exploring his interests within the main subject. Communication English and Behavioural Science are compulsory papers for students M.Sc. in Mathematics which enable them to be better communicator and develop better personality.

As a part of effort to enhance employability of mathematics graduates, the well- structured programme empowers the students with the skills and knowledge leading to enhance career opportunities in various sectors of human activities.

2.2 Aims of M.Sc. Programme in Mathematics

The overall aims of M.Sc. Mathematics Programme are to:

- develop broad and higher knowledge and understanding of definitions, concepts, principles and theorems.
- Enable the learners to familiarize with suitable tools and skill of mathematics to solve specific problems of both theory and applications.
- provide sufficient knowledge and skills that enable the learners to undertake further studies in mathematics and the areas on multiple disciplines concerned with mathematics.
- encourage the students to develop a range of skills helpful in employment, internships and social activities.
- Encourage learner for individual research driven interest in the topics of higher mathematics
- Enable learner to collaborate and apply higher mathematics in the field of realworld problem of social nature.

3. Attributes in Mathematics for learner of M.Sc. Mathematics

Some of the attributes in mathematics are listed below:

3.1 Disciplinary knowledge: Ability of demonstrating comprehensive knowledge of mathematics and its subfields, and its applications to one or more disciplines.

3.2 Communications skills: Capability to express various concepts of higher mathematics in effective and coherent manner using examples and visualizing their geometrical meaning both in writing and speaking; ability to present the complex mathematical ideas in clear, precise and confident way; ability to explain the development and importance of mathematics in various scientific developments; capability to communicate thoughts and views in mathematically or logically correct statements.

3.3 Critical thinking and analytical reasoning:

(i) Ability to employ mathematical foundations, critical thinking in understanding the concepts in every area of mathematics and allied areas.

(ii) Capability to formulate mathematically correct arguments.

(iii) Ability to analyze the results and apply them in relevant various problems appearing in different branches of mathematics.

3.4 Problem solving: Capacity to use the earned knowledge to solve different non-familiar problems and apply the learning to real world situations; capability to solve problems in computer graphics using concepts of linear algebra; Capability to apply the acquired knowledge in differential equations to solve specific problems in other disciplines.

3.5 Research-related skills:

(i) Potentiality to think and inquire about relevant/appropriate questions, ability to define problems, formulate and test hypotheses, formulate mathematical arguments and proofs, draw conclusions; ability to write the obtained results clearly.

(ii) To know about the developments in various branches of mathematics.

(iii) To understand application of mathematics in natural, biological and social sciences.

3.6 Information/digital literacy:

(i) Ability to use ICT tools in solving problems or earning knowledge;

(ii) Capacity to use appropriate softwares and programming skills to solve problems in mathematics,

3.7 Self-directed learning: Potentiality to work independently and do in-depth study of various concepts of mathematics., ability to search relevant resources and e- resources for self-learning and amplifying knowledge in mathematics.

3.8 Moral and ethical awareness/reasoning: Ability to identify unethical behaviour such as fabrication or misrepresentation of data, committing plagiarism, infringement of intellectual property rights and adopting objective, unbiased and truthful actions in all aspects.

3.9 Lifelong learning: Ability to earn knowledge and skills through self-learning that helps in personal development as well as skill development to make them suitable for changing demands of work place.

4. Qualification descriptors for M.Sc. in Mathematics

The course structure M.Sc. in mathematics covers a full range of mathematical domain starting from Calculus to Analytical Geometry, Differential Equations, Statics and Dynamics to learn about the geometry of sciences.

Linear Algebra, Real Analysis, Complex Analysis are introduced to discuss algebraic structures on finite dimensional spaces as well as Metric Spaces and Topology, Abstract Algebra are introduced to understand algebraic structures on infinite dimensional spaces.

Also, to learn the application techniques in all the branches of engineering, sciences, biosciences, economics and finance etc. different courses like Numerical Methods & LPP, Number Theory and Graph Theory, Fourier Series and Transform Calculus, Hydrostatics, Introduction to Mathematical Modelling, Introduction to Probability & Statistics, Hydrodynamics, Rigid Dynamics, Combinatorics & Mathematical Logic are designed.

We also introduce Spherical Trigonometry and Astronomy to impart knowledge to identify and analyze the positions and directions of celestial bodies in the universe.
The Programme, M.Sc. in mathematics covers exceptionally a broad range of pure & applied mathematics. The learning parameters of M.Sc. in mathematics can impart knowledge to generate and apply analytical and logical thinking.

Ability Enhancement Compulsory Course like Communicative English / Environmental Science, Brhavioural Science enable the student acquire the skill relevant to the main subject. Discipline Specific Electives course provides liberty of exploring interests within the main subject.

The learning experience and procedures are so designed that every student with mathematics may achieve the programme learning outcomes with equal opportunity.

On pursuing post graduation in mathematics, a student should be able to demonstrate mathematical applications in engineering, science & Technology, mathematical sciences and social science. The qualification descriptors for M.Sc. Mathematics may include the following:

- develop their educational skills in each areas of pure mathematics as well as in applied mathematics and apply knowledge and skills to identify the unsolved problems in mathematics.
- identify challenging mathematical problems, analyze and evaluate these problems using appropriate methodologies and obtain well-defined solutions.
- apply the acquired knowledge in mathematics and transferable skills to real-life problems.
- achieve learning requirements in mathematics and their applications in diverse areas of mathematical sciences.
- opportunities in research, academia, and technical institutes. Career opportunities can include jobs at financial companies, government sector, software developers, marketers and bankers.

5. Programme Learning Outcomes in M.Sc. in Mathematics

The completion of the M.Sc. in Mathematics will enable a student to:

i) be effective communicator of mathematical concepts by written, computational and graphical means.
ii) illustrate mathematical ideas from basic theorems and axioms.
iii) enhance the knowledge to explain mathematical theorems and technics of proofs.
iv) Apply mathematics to solve, analyze theoreticalproblems of mathematics.
v) have critical understanding of each subject of the syllabus
vi) identify applications of mathematics in other disciplines and in the real-world, leading to enhancement of career prospects in a relevant fields and research.

6. Structure of M.Sc. in Mathematics

The M.Sc. Mathematics programme is a two-year, four-semesters course. A student is required to complete 102 credits for completion of the course.

		Semester/ Credits	**Semester**
Part – I	First Year	Semester I:22	Semester II: 24
Part – II	Second Year	Semester III: 23	Semester IV: 33

Total credit :102

Semester wise Details of M.Sc. in Mathematics Course & Credit Scheme

M.Sc. Mathematics

Course Structure

1st Semester							
Sl. No.	**Subject Code**	**Names of subjects**	**L**	**T**	**P**	**C**	**TCP**
Core Subjects							
1	MAT014C101	Algebra-I (25% Blended)	4	0	0	4	4
2	MAT014C102	Linear Algebra (25% Blended)	4	0	0	4	4
3	MAT014C103	Real Analysis	4	0	0	4	4
4	MAT014C104	Ordinary Differential Equations	4	0	0	4	4
Ability Enhancement Compulsory Course (AECC)							
5	CEN984A101	Communicative English – I	1	0	0	1	1
6	BHS984A103	Behavioural Science-I	1	0	0	1	1

Elective: Discipline Specific (DSE) (Choose any one)							
7	MAT014D101	Probability and Statistics (25% Blended)	4	0	0	4	4
8	MAT014D102	Introduction to Computing	4	0	0	4	4
9	MAT014D103	Operation Research -I (25% Blended)	4	0	0	4	4
10	MAT014D104	Introduction to Mathematical Modelling	4	0	0	4	4
TOTAL CREDIT POINTS: 22							

2nd Semester							
Sl. No.	**Subject Code**	**Names of subjects**	**L**	**T**	**P**	**C**	**TCP**
Core Subjects							
1	MAT014C201	Partial Differential Equations (25% Blended)	4	0	0	4	4
2	MAT014C202	Topology	4	0	0	4	4
3	MAT014C203	Functional Analysis	4	0	0	4	4
4	MAT014C204	Complex Analysis (25% Blended)	4	0	0	4	4
Ability Enhancement Compulsory Course (AECC)							
5	CEN984A201	Communicative English – II	1	0	0	1	1
6	BHS984A203	Behavioural Science-II	1	0	0	1	1
Ability Enhancement Elective Course (AEEC) (Skill Based)							
7		AEEC-1	2	0	0	2	2
Elective: Discipline Specific (DSE) (Choose any one)							
8	MAT014D201	Numerical analysis (50% Blended)	4	0	0	4	4
9	MAT014D202	Discrete Mathematics	4	0	0	4	4
10	MAT014D203	Operation Research -II	4	0	0	4	4
11	MAT014D204	Stochastic Process	4	0	0	4	4
TOTAL CREDIT POINTS: 24							

3rd Semester							
Sl. No.	**Subject Code**	**Names of subjects**	**L**	**T**	**P**	**C**	**TCP**
Core Subjects							
1	MAT014C301	Mathematical Methods (25% Blended)	4	0	0	4	4
2	MAT014C302	Graph Theory	4	0	0	4	4
Ability Enhancement Compulsory Course (AECC)							
3	CEN984A301	Communicative English – III	1	0	0	1	1

Ability Enhancement Elective Course (AEEC) (Skill Based)							
4		AEEC-2	2	0	0	2	2
Elective: Discipline Specific (DSE) (Choose any three)							
5	MAT014D301	Number Theory-I	4	0	0	4	4
6	MAT014D302	Algebraic Topology	4	0	0	4	4
7	MAT014D303	Mathematical Logic	4	0	0	4	4
8	MAT014D304	Classical Mechanics (25% Blended)	4	0	0	4	4
9	MAT014D305	Differential Geometry	4	0	0	4	4
10	MAT014D306	Continuum Mechanics	4	0	0	4	4
11	MAT014D307	Multivariate Analysis-I	4	0	0	4	4
12	MAT014D308	Tensor Analysis	4	0	0	4	4
13	MAT014D309	Financial Mathematics	4	0	0	4	4
14	MAT014D331	Seminar/Literature Survey	0	0	0	4	4
TOTAL CREDIT POINTS: 23							

4th Semester							
Sl. No.	**Subject Code**	**Names of subjects**	**L**	**T**	**P**	**C**	**TCP**
Core Subjects							
1	MAT014C401	Measure Theory (25% Blended)	4	0	0	4	4
2	MAT014C402	Dynamical System	4	0	0	4	4
Ability Enhancement Compulsory Course (AECC)							
3	CEN984A401	Communicative English – IV	1	0	0	1	1
	Elective: Discipline Specific (DSE) (Choose any three)						
4	MAT014D401	Algebra-II	4	0	0	4	4
5	MAT014D402	Fuzzy Set Theory (50% Blended)	4	0	0	4	4
6	MAT014D403	Operator Theory	4	0	0	4	4
7	MAT014D404	Theory of Relativity	4	0	0	4	4
8	MAT014D405	Fluid Mechanics	4	0	0	4	4
9	MAT014D406	Number Theory-II	4	0	0	4	4
10	MAT014D407	Bio-Mathematics	4	0	0	4	4
11	MAT014D408	Multivariate Analysis-II	4	0	0	4	4
	Project						
12	MAT014D421	Major Project	0	0	0	12	12
TOTAL CREDIT POINTS: 33							

SYLLABUS (1ST SEMESTER)

Paper I/Subject Name: Algebra-I **Subject Code: MAT014C101**
(25% Blended Mode)
L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Objective: The objectives of **ALGEBRA-I (MAT014C101)** are:

1. To provide the continuous approach to the subject of algebra, which is one of the basic pillars of modern mathematics and to inculcate in students the power of accurate analysis.
2. To provide an insight for further study into applications of abstract algebra in certain areas by knowing to perform algorithms.

Prerequisites:

- Concept of Groups (groups, subgroups, permutations, order of element, order of group, coset, normal subgroup, cyclic group)

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	**Group Theory:** Homomorphism of groups, Direct product and Direct sums of Groups. Decomposable groups. Normal and Subnormal series of groups, composition series, Jordan Holder theorem and its applications, solvable groups.	12
II	**Ring theory:** Ideals, Homorphisms, quotient rings, Prime and Maximal Ideals, Quotient Field of an Integral Domain, Polynomial Rings. Divisibility Theory: Euclidean Domain, Principal Ideal Domain, Unique Factorization Domain and their properties	12
III	**Fields:** Extensions of fields, Algebraic and Transcendental elements, Algebraic field extensions, Algebraic extensions of Splitting field, Separable extension, perfect Field	12
IV (Blended)	**Modules:** Modules, definition and examples, submodules, simplicity, indecomposability, Classification of finitely generated modules over PID's.	12
Total		**48**

Text Books:

1. *Modern Algebra*; Singh Surajeet and Zameeruddin Qazi; Eighth Edition; 2006; Vikash Publishing House Pvt Ltd.
2. ***2.*** *Contemporary Abstract Algebra* ; Gallian J. A.; 8th edition; 2013; Cengage Publication.

Reference Books:

1. Malik D. S., Mordeson J.N., Sen M. K. ; *Fundamentals of Abstract Algebra* ; 1996; McGraw Hill Company.
2. I. N. *Herstein*; *Topics in Algebra*; 2nd edition; 2006; John *Wiley* & Sons; New York.
3. Fraleigh John B.; *A First Course in Abstract Algebra*; 7th edition; 2013; Pearson Education India.
4. Dummit D. and Foote R.; *Abstract Algebra*; 3rd edition; 2011; *Wiley*; New York.
5. Jacobson, N.*; I & II Basic Algebra*; Second edition; 2009; Hindusthan Publishing Corporation, India.

E-Reference: **[https://nptel.ac.in/courses/111/106/111106137/] for Module IV**

Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	**Teaching and Learning Activity**	**Assessment Tasks**
The students will be able to (i)Describe the theorems and properties of certain abstract algebraic structures in groups, rings, fields and modules. (ii)Apply course material along with techniques and procedures covered in this course to solve problems.	(i) Each topic to be explaineded with examples. (ii) Students to be motivated to discover the relevant concepts to take part in discussions and ask questions. (iii) Students to be given homework/assignments to make their concept clear. (iv) Discuss and solve the theoretical problems in the class. (v) Module IV to be taught blended mode as per above E-Reference.	(a)Participation in class discussions (b)Continuous Evaluation(30Marks) (i)15 marks on • Assignments • class tests. • viva-voce or presentation (ii) Mid-term examinations :10 marks (iii) Class attendance -5 marks (c) End-term examinations.-70 marks.

SYLLABUS (1ST SEMESTER)

Paper II/Subject Name: Linear Algebra **Subject Code: MAT014C102**
(25% Blended Mode)
L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Objectives: The objectives of **Linear Algebra** (**MAT014C102)** are

- to impart learning behaviour of different types of linear spaces and its applications.
- to make the student understanding behaviour of linear mappings on linear spaces.
- to enable learning the concept of basis and dimension of vector spaces, orthogonality of vectors in inner product spaces, matrix representation of linear transformation.
- to train on the use of canonical forms and bilinear forms.

Prerequisites: Idea of Matrix algebra, Group, Ring, Field (B.Sc. level).

Detailed Syllabus:

Modules	Topics / Course Content	Periods
I	**VECTOR SPACES:** Metric space, convergence, Cauchy sequence, completeness / Definition and examples of normed linear space / Inner product space, properties of inner product and norms/ Cauchy-Schwarz Inequality and applications/ orthogonality, orthogonal complements/ orthogonal sets and bases / projections, Gram-Schmidth algorithm, applications.	**12**
II (Blended)	**LINEAR MAPPINGS:** Linear Mappings: Linear Mappings, Properties of Linear Mappings / kernel and image of linear mapping, computing the kernel and image of linear mappings / singular and non-singular linear mappings, isomorphism / Application to geometry and convex set. Spaces of Linear Mappings: Vector space of linear mappings / Invertible operators / Matrix representation of a linear operator, matrices and linear operator on R^3 / matrices and linear mappings. Change of basis (transition) matrix / change of basis and linear operators / similarity transformations /change of basis and linear mappings.	**12**
III	**CANONICAL FORMS:** Characteristic value, annihilator polynomial, invariant subspaces, direct sum decomposition, invariant direct sum	**12**

	Cyclic subspaces and annihilators, cyclic decomposition and rational forms, Jordan canonical form.	
IV	**BILINEAR FORMS:** Bilinear forms, symmetric bilinear forms, skew-symmetric bilinear forms, quadratic forms, positive definite quadratic forms and theorems, Signature and Sylvester's law of inertia.	**12**
	TOTAL	**48**

Text Books:

1. *Linear Algebra*, Hoffman Kenneth and Kunze Ray , 2nd edition, 2015, PHI learning private limited.

Reference Books:

1. Lipschutz Seymour , *Linear Algebra*, 2004,Tata McGraw-Hill publishing Co Ltd
2. **Axler** Sheldon, *Linear Algebra Done Right*, 2nd edition, 2010, Springer.
3. **Strang Gilbert, *Linear Algebra and Its Applications*, 4th edition 2007, Nelson Engineering.**
4. Friedberg, Insel, Spence, *Linear Algebra* , 4th edition 2015, Pearson Education India.
5. Sharma A. K. , "*Linear Algebra" ,* 2007, Discovery Publishing House.

E- Reference: **[https://nptel.ac.in/courses/111/108/111108098/] for Module II**

Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
The students will be able to i) Construct basis and dimension of linear spaces and their applications. ii) Define linear mappings and its matrix representation on various linear spaces. iii) Justify positivity of a linear mapping. iv) Construct Jordan form and bilinear form.	i) Each topic to be expounded with examples. ii) Students to be motivated to take part in discussions and ask questions. iii) Students to be given homework/assignments. iv) Discuss and solve the theoretical problems in the class. v) Students to be encouraged to give short presentations. vi) Module II to be taught blended mode as per above E-Reference.	(a) Participation in class discussions (b)Continuous Evaluation(30Marks) (i)15 marks on • Assignments • class tests. • viva-voce or presentation (ii) Mid-term examinations :10 marks (iii) Class attendance -5 marks (c) End-term examinations: 70 marks.

SYLLABUS (1ST SEMESTER)

Paper III/Subject Name: Real Analysis		**Subject Code: MAT014C103**
L-T-P-C: 4-0-0-4	**Credit Units: 4**	**Scheme of Evaluation: T**

Objective: Objectives of the course **Real Analysis (MAT014C103)** is

- To introduce the concepts of various types of integrals and convergences of functions.
- To enable learning fundamental concepts of multivariable analysis.
- To impart understanding fundamental concepts of Real analysis and its application.

Prerequisite:

- Real analysis of B.Sc. level.

Detailed Syllabus:

Modules	Topics / Course Contents	Periods
I.	**The Riemann Integral:** Definitions and existence of the integral, Integration and differentiation, The fundamental theorem of calculus, Mean value theorem of integral calculus, Integration by parts (Special cases only)	**12**
II.	**The Riemann-Stieltjes Integral and Improper Integrals:** Definitions and existence of the integral, some important theorems, Types of improper integrals, Tests for convergence of improper integrals.	**12**
III	**Sequences and Series of Functions:** Definition of point-wise and uniform convergence, Weirstrass M-test, Abel's test and Dirichlet's test for uniform convergence, Uniform convergence and integration, Uniform convergence and differentiation.	**12**
IV	**Multivariable Analysis:** Power series, Uniqueness theorem for power series, Functions of several variables, linear transformation, derivatives in an open subset of R^n, Chain rule, partial derivatives, interchange of order of differentiation, derivatives of higher order, Taylor's theorem.	**12**
Total		**48**

Text Book:

1. *Principles of Mathematical Analysis*; Rudin Walter; Third Edition; 2017; McGraw Hill Education..

Reference Books:

1. Bartle, Robert G.; Sherbert Donald R.; *Introduction to Real Analysis*, Fourth Edition; 2014; Wiley India Pvt. Ltd.
2. Apostol T.M.; *Mathematical Analysis*; Second Edition; 2002; Narosa Publishing House; New Delhi.
3. Malik,S.C. and Arora Savita; *Mathematical Anslysis*; Fifth edition; 2017; New Age Science Ltd.

Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
The students will be able 1. Learn to determine the Riemann integrability and the Riemann-Stieltjes integrability of a bounded function and prove a selection of theorem concerning integration. 2. Understand different types of improper integrals. 3. Recognize the difference between pointwise and uniform convergence of a sequence of functions. 4. Learn the effect of uniform convergence on the limit function with respect to continuity, differeniability and integrability.	(i) Each topic to be expounded with examples. (ii) Students to be motivated to take part in discussions and ask questions. (iii) Students to be given homework/assignments. (iv) Discuss and solve the theoretical problems in the class. (v) Students to be encouraged to give short presentations.	(a)Participation in class discussions (b)Continuous Evaluation(30Marks) (i)15 marks on • Assignments • class tests. • viva-voce or presentation (ii) Mid-term examinations :10 marks (iii) Class attendance -5 marks (c) End-term examinations.-70 marks.

SYLLABUS (1ST SEMESTER)

Paper IV/Subject Name: Ordinary Differential Equations **Subject Code: MAT014C104**

L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Objective: The objectives of **Ordinary Differential Equations (MAT014C104)** are

- To provide fundamental concepts of ODE theories and where and how such equations arise in applications to scientific and engineering problems.
- To enable developing the ability to apply differential equations to significant applied and/or theoretical problems.
- To explain most of the physical phenomena from Science and Engineering which are modelled by differential equations.
- To enable finding and interpreting the solutions of the ODE appearing in dynamical systems, stability theory and a number of applications to scientific and engineering problems.

Prerequisites:

- Concept of Differential Calculus and Integral Calculus.
- Concept of Differential Equations from B.Sc. level.

Detailed Syllabus:

Modules	Topics / Course content	Periods
I.	Uniqueness and existence theorem, Wronskian and Exact differential equations Uniqueness and existence theorem, Linearly dependent and independent solutions, Wronskian and its properties, Exact differential equations and equations of special forms	12
II.	Series solution Ordinary and singular points, power series solution of second order homogeneous equations, Frobenius' method-solution about a regular singularity, solutions of Hypergeometric, Legendre and Bessel's equations.	12
III.	Boundary value problems Boundary value problems for second order differential equations, Green's function and its applications, Eigen value problems, self-adjoint form, Sturm –Liouville problem and its applications.	12
IV.	System of linear differential equations System of equation, Critical point, Lyapunov, Stability theory, System in matrix form, Eigen values, Fundamental set of solution.	12
Total		**48**

Text Book:

1. *Differential Equations*, Ross S. L., 3rd Edition, 2007, Wiley India.

Reference Books:

1. Raisinghania M.D., *Ordinary and Partial Differential Equations*, 19th edition, 2017, S. Chand and Co., New Delhi.
2. Coddington E. A. and Levinson N., *Theory of Ordinary Differential Equations*, Indian Edition., 2017 , Tata McGraw-Hill, New Delhi.
3. Ayers Jr Frank, *Schaum's Outline Series of Theory and problems of differential equations* , Reprint, 1989, Tata McGraw-Hill, New Delhi.

Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1. Learn to solve problems in ordinary differential equations, dynamical systems, stability theory, and a number of applications to scientific and engineering problems. 2. Demonstrate their ability to write coherent mathematical proofs and scientific arguments needed to communicate the results obtained from differential equation models. 3. Implement solution methods using appropriate theory, and 4. Investigate the qualitative behavior of solutions of systems of differential equations and interpret in the context of an underlying model.	(i) Each topic to be explained with illustrations. (ii) Students to be involved in discussions and encouraged to ask questions (iii) Solve the theoretical and practical problems in the class. (iv) Students to be given homework/assignment. (v) Students to be encouraged to apply concepts to solve real world problems and do look for new applications.	(a) Participation in class discussions (b) Continuous Evaluation (30Marks) (i)15 marks on • Assignments • class tests. • viva-voce or presentation (ii) Mid-term examinations:10 marks (iii) Class attendance -5 marks (c) End-term examinations.-70 marks.

SYLLABUS (1ST SEMESTER)

Paper I/Subject Name: Probability & Statistics (25% Blended Mode) **Subject Code: MAT014D101**

L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Objectives: The objectives of **Probability & Statistics** (**MAT014D101)** are

- To enable learning fundamental concepts of probability theory.
- To introduce the basic concepts of one dimensional and two dimensional Random Variables.
- To provide information about Estimation theory, Correlation, Regression and Testing of hypothesis.

Prerequisites:

- Sets and elements of Sets, Operation on Sets, Algebra of Sets.

Detailed Syllabus:

Modules	Topics / Course content	Periods
I (Blended)	**Probability** Introduction to Probability: Random experiments, Sample space, Simple and compound events, Event space. Definition of probability: Classical, Statistical & Axiomatic approach, their drawbacks. Some Consequences of Axiomatic approach of Probability. Inclusion-Exclusion indentity, Properties, Conditional probability, conditional probability as probability function, general multiplicative theorem Bayes theorem, independence of events. Condition for n independent events.	**12**
II (Blended)	**Random Variables and Probability distribution** Definition of single random variate, Discrete and continuous random variable, Probability mass function, Cumulative distribution function, probability density functions, Independence of random variables, Statistical regularity. Properties of PMF, CDF and PDF of random variables. Expectation. Moments, Moment generating function,characteristic function. Some important random variates Discrete: Binomial, negative binomial, Geometric, Poisson distribution Continuous: Uniform, Normal, exponential, gamma, Weibull, Cauchy, Beta, Rayleigh distribution Transformation of random variables	**12**
III	**Joint Distribution** Definition of jointly distributed random variables. Two dimensional probability distributions. Discrete and continuous distributions in two dimensions. Joint probability mass function, Joint probability density	**12**

	function, conditional distributions. Transformation of random variables in two dimensions. Joint Uniform, Gamma and Normal distributions. Two-dimensional expectation. Covariance, Correlation co-efficient, Joint characteristic function. Multiplication rule for expectations. Conditional expectation. Introduction, Chebyshev's Inequality and Weak law of large numbers, The Central Limit Theorem, The Strong Law of Large Numbers, Chernoff's bounds, Jesen's inequality	
IV	**Sampling Techniques** Random sample. Concept of sampling and various types of sampling. Sampling distribution of a statistic, Standard error of a statistic, Estimates of a population characteristic or parameter. Unbiased and consistent estimates. Sample characteristics as estimates of the corresponding population characteristics. Sampling distributions of the sample mean and variance. Statistical decisions, Statistical hypothesis and alternative hypothesis. Error in hypothesis, Level of significance and critical region. One tailed and two tailed tests. Neyman-Pearson theorem (Statement only) and its application to normal population Testing of Hypotheses, Tests based on Normal, t and F Distributions for Testing of Mean, Variance And Proportions. Chi-square test.	**12**
Total		**48**

Text Book:

1. *A First Course in Probability*, Ross S; 9th Edition, 2019; Pearson Education India.

Reference Books:

1. Gupta S. C., Kapoor V.K; "*Fundamentals of Mathematical Statistics*"; Tenth Revised Edition; 2014; Sultan Chand & Sons Publishers.
2. Spiegel Murray R, Schiller John J, Srinivasan R. Alu; "*Schaum's outline: Probability and Statistics*"; 4th Edition; 2017; McGraw –Hill Education.
3. Jacod J. andProtter P., *Probability Essentials* , 2004 Springer.
4. Grimmett G. R. andStirzaleer D. R., *Probability and Random Processes*, 3rd Edition, 2001, Oxford University Press.

E-Reference: **[https://nptel.ac.in/courses/111105090/] for Module I and II**

Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
The students will be able to (i) Measure uncertainties under some suitable circumstances. (ii)Apply theoretical probability distribution in real life problems. (iii) Find the bivariate probability distribution and their related real life problems. (iv) Estimate the best representative of the population parameter and apply it in test of significance.	(i) Each topic to be expounded with examples. (ii) Students to be motivated to take part in discussions and ask questions. (iii) Students to be given homework/assignments. (iv) Discuss and solve the theoretical problems in theclass. (v) Students to be encouraged to give short presentations. (vi) Module I and II to be taught partly blended mode as per above E-reference.	(a)Participation in class discussions (b)Continuous Evaluation(30Marks) (i)15 marks on • Assignments • Class tests. • viva-voce or presentation (ii) Mid-term examinations :10 marks (iii) Class attendance -5 marks (c) End-term examinations.-70 marks.

SYLLABUS (1ST SEMESTER)

Paper II/Subject Name: Introduction to Computing		**Subject Code: MAT014D102**
L-T-P-C: 4-0-0-4	**Credit Units: 4**	**Scheme of Evaluation: TP**

Objective: The objectives of **Introduction to Computing (MAT014D102)** are

- To provide the basic knowledge of computer peripherals.
- To impart understanding fundamental concepts of programming languages.
- To train on the use of programming languages analytically which will be useful for numerical computations also by understanding the basic implementation techniques.

Prerequisites:

- Idea of computer basics.

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	**General Concepts** Information: Definition, categories, Storage, retrieval and processing. Hardware: CPU, Primary and Secondary Storage, cache memory, I/O devices. Software: Classification System and application; Stored Program Concept and Von-Neumann Architecture. Evolution types: supercomputers, mainframes, minis and workstations, PC's, Parallel Machines. Languages: Machine language, assembly language, high level programming languages.	**12**
II.	**Digital logic Design** Number System, Bits and Byte. Base conversion, (r-I)'s and r's complement. Fixed point, Floating point representation. ASCII. EBCDIC Boolean Algebra. Combinational Logic: AND, OR, NAND, NOR. XOR gates; adder, Multiplexer, demultiplexer /decoder. Encoder. (only conceptual stud) with block diagram and truth/state table) Sequential Logic: flip-flops. Registers, counters (synchronous & asynchronous) (only conceptual study with block diagram and truth/state table)	**12**
III.	**Basic features of programming (Using C)** Data types, variables, operators, expressions, statements, control structures, functions; Advance programming features - arrays and pointers, recursion, records (structures), memory management, files, input/output, standard library functions, programming tools, testing and debugging; Fundamental operations on data - insert, delete, search, traverse and modify.	**12**

IV.	**Introduction to data structures** Fundamental data structures - arrays, stacks, queues, linked lists; Searching and sorting - linear search, binary search, insertion-sort, bubble-sort, selection-sort; Introduction to object oriented programming.	**12**
Total		**48**

NOTE: Programming laboratory will be set in consonance with the material covered in lectures. This will include assignments in a programming language like C and C++.

Text Book:

1. *Introduction to Computer Science*, Sinha P.K. and Sinha P, Reprint Edition 2017 BPB Publications;

Reference Books:

1. Reema Thareja, *"Computer Fundamentals and Programming in C"*, Second edition, 2016, Oxford University Press.
2. Venugopal K. R. and Prasad S. R., *"Mastering C*", 2017, Tata McGraw Hill.
3. Kelly A. and Pohl I., *A Book on C*, 4th edition. 2008, Pearson Education India.
4. Gottfried B. and Chhabra J., *Programming With C*, 3rd edition2017, Tata Mcgraw Hill.

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1. Understand the basic terminology used in computer programming 2. Write, compile and debug pr ograms in C language. 3. Use different data types in a computer program. 4. Design programs involving decision structures, loops and functions. 5. Explain the difference between call by value and call by reference 6. Understand the dynamics of memory by the use of pointers. 7. Use different data structures and create/update basic data files.	(i) Each topic to be expounded with examples. (ii) Students to be motivated to take part in discussions and ask questions. (iii) Students to be given homework/assignments. (iv) Discuss and solve the theoretical problems in the class. (v) Students to be encouraged to give short presentations.	(a)Participation in class discussions (b)Continuous Evaluation(30Marks) (i)15 marks on • Assignments • Class tests. • viva-voce or presentation (ii) Mid-term examinations :10 marks (iii) Class attendance -5 marks (c) End-term examinations.-70 marks.

SYLLABUS (1ST SEMESTER)

Subject Name: Operations Research-I (25% Blended Mode) **Subject Code: MAT014D103**

L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Objective: The objectives of **Operations Research**-I (**MAT014D103**) are

- To make the students understand operations research and its importance in human decision making.
- To impart learning fundamentals of the OR models.
- To explain how to formulate and solve different linear programming models.

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	(a) **Basics of Operations Research:** definition of OR, Characteristics, Scope of OR, Phases and Models in OR, Characteristics of a good model, Advantage and limitation of a model, Difficulties of OR , Limitation of OR. (b) **Linear Programming**: Formulationof LPP, Graphical Method of solution,General LPP, Cannonical and standard form of LPP, Simplex Method, Artificial variable Techniques, Big M method, Two Phase method. Application of Simplex method	**12**
II	. (a)**Transportation model**: Introduction to the model, Definition of transportation model, Matrix terminology, Formulation and solution of Transportation model, Variations In Transportation model, Post optimality analysis, dual of the transportation problem. (b) **Assignment model**: Definition of Assignment Problem, mathematical representation of the assignment problem, Comparison of assignment problem with transportation problem, The Hungarian method for solution of Assignment problem, Variation of assignment problem, The travelling Salesman problem.	**12**
III (Blended)	**Game theory**: Basic Concept and Terminologies, Two-person Zero-sum Game, and Game with Pure and Mixed Strategies, Dominance Principle, Arithmetic Method, and Graphical Method for Solving (2× n) Game ,Graphical Method for Solving (m×2) Game and Solution of Game by Simplex Method	**12**
IV	**Dynamic Programming**: Introduction, Optimal Subdivision problem, System reliability, Solution of LPP by Dynamic programming	**12**
Total		**48**

Text book:

1. *Problems in Operations research (Principles and Solutions)*, Gupta P.K. and Hira D.S., Revised Edition, 2015, Sultan Chand and Sons New Delhi.

Reference books:

1. Swarup Kanti, Gupta P.K. and Mohan M., *Operations Research*, 2014, Sultan Chand and Sons New Delhi.
2. Hadley G., *Linear programming*, 2002, Narosa Publishing House.
3. Hillier F.S. and.Lieberman G.J, *Introduction to operations Research*, 9th Edition, 2011, Mc Graw Hill International Edition.
4. Taha H.A, *Operations Research – In Introduction*, 9th Edition, 2014, Pearson Education India.

E- Reference: [https://onlinecourses.swayam2.ac.in/cec21_ma13/preview#] for Module III

Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
The students will be able 1. To Define and formulate linear programming problems and appreciate their limitations. 2. To conceptualize the feasible region. 3. To identify the special features of the transportation and assignment problem. 4. To understand the types of problems that can be solved by applying transportation and assignment model. 5. To differentiate between feasible and optimal solutions. 6. To understand basics of game theory. 7. To acquire an idea about the computational procedure of DP	(i) Each topic to be expounded with examples. (ii) Students to be motivated to take part in discussions and ask questions. (iii) Students to be given homework/assignments. (iv) Discuss and solve the theoretical problems in the class. (v) Students to be encouraged to give short presentations. (vi) Module III will be taught in blended mode.	(a)Participation in class discussions (b)Continuous Evaluation(30Marks) (i)15 marks on • Assignments • class tests. • viva-voce or presentation (ii) Mid-term examinations :10 marks (iii) Class attendance -5 marks (c) End-term examinations.-70 marks.

SYLLABUS (1ST SEMESTER)

Paper IV/Subject Name: Introduction to Mathematical Modelling
Subject Code: MAT014D104
L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Objective: The objectives of **Introduction to Mathematical Modelling** (**MAT014D104**) are

- To expose student to understand the importance of Mathematical modelling.
- To impart understanding fundamental techniques of mathematical modelling.
- To enable learning different classifications and simple illustrations of mathematical modelling.

Prerequisites:

- Differential and Integral calculus
- Linear Algebra (linear systems of equations, Eigenvalues of a matrix)
- Differential equations.

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Introduction to Mathematical Modelling, need of mathematical modeling, Techniques of mathematical modeling, Classification and simple Illustrations. Mathematical modeling through differential equation Ordinary differential equations partial differential equations	12
II	. Mathematical Modeling Through Graphs. Mathematical modeling through functional integral delay, Differential and differential-difference equations.	12
III	Mathematical modeling through calculus of variations and dynamic programming, Mathematical modeling through mathematical programming,	12
IV	Maximum principle and minimum entropy principle. Multivariable optimization models, Computational methods for optimization models, Introduction to probability models, Stochastic models..	12
Total		**48**

Text Books:

1. *Mathematical Modeling*, J.N. Kapur , 2015, New Age International Publication.

Reference Books:

1. Edward A. Bender: *An introduction to mathematical Modeling*, 2002, CRC Press.
2. Walter J. Meyer, *Concepts of Mathematical Modeling*, 2004, Dover Publ.
3. Mark M. Meerschaert, *Mathematical Modeling*, 2013, Academic Press,.

Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
The students will be able to (i) Describe the real world problems in the form of mathematics by using differential equations. (ii) Develop the models graphically and with the help of delay method, differential difference equations etc. (iii) Understand optimization models, computational method of solving the models.	(i) Each topic to be expounded withexamples. (ii) Students to be motivated to take part in discussions and ask questions. (iii) Students to be given homework/assignments. (iv) Discuss and solve the theoretical problems in theclass. (v) Students to beencouraged to give shortpresentations.	(a)Participation in classdiscussions (b)Continuous Evaluation(30Marks) (i)15 marks on • Assignments • classtests. • viva-voce or presentation (ii) Mid-term examinations :10 marks (iii) Class attendance -5 marks (c) End-term examinations.-70 marks.

SYLLABUS (2nd SEMESTER)

Paper I/Subject Name: Partial Differential Equations (25% Blended Mode) **Subject Code: MAT014C201**

L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Objective: The objectives of **Partial Differential Equations (MAT014C201)** are

- To introduce the concepts and explain how to solve Partial Differential with different methods.
- To enable developing the ability to apply partial differential equations to significant applied and/or theoretical problems.
- To enable finding and interpreting the solutions of the PDE appearing in dynamical systems, stability theory and a number of applications to scientific and engineering problems.

Prerequisites:

- Concept of Differential Calculus and Integral Calculus.
- Concept of Ordinary and Partial Differential Equations from B.Sc. level.

Detailed Syllabus:

Modules	Topics /Course content	Periods
I	**First and second Order PDE** Classification of first order PDE, complete and general integral, solution by Lagrange's method, Partial differential equations of second order, linear equations with constant coefficient, classification of linear 2nd order PDE in two independent variables, characteristic curve.	12
II	**Hyperbolic Equations** Wave equation: Solution of one-dimensional wave equation, Cauchy problem, Mixed type problems, General solutions of the wave equation and corresponding solution in two dimensions, the non-homogeneous Wave equation, Duhamel's Principle.	12
III	**Parabolic Equations** The diffusion equation (Heat Conduction equation) Elementary solutions of the Diffusion Equation, Separation of variables, Similarity solutions, Use of Laplace Transform, Maximum and minimum principle, Duhamel's Principle.	12
IV (Blended)	**Elliptic Equations** Laplace Equation: Boundary value problems, Fundamental solution, Solution of Dirichlet problem on a rectangle by method of separation of variables, Mean value property, Maximum principles, Dirichlet principle.	12
Total		**48**

Text Book:

1. *Elements of partial differential equations*, Sneddon Ian Naismith, Reprint, 2006, Dover Publications Inc.

Reference Books:

1. Raisinghannia M.D., *Advanced Differential Equations*, 19th Edition, 2018, S. Chand and Co., New Delhi.
2. Evans L. C. *Partial Differential Equations*, Vol. 19, 1998, American Mathematical Society.
3. Logan J. David, *Applied Partial Differential Equations*, 3rd Edition, 2014, Springer Nature.
4. Tveito Aslak, Winther Ragnar**.,** *Introduction to partial differential equations: a computational approach*, Vol. 25, 2005, Springer-Verlag Berlin Heidelberg.

***E-Reference*: [https://onlinecourses.nptel.ac.in/noc21_ma51/preview]** for Module IV

Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1. Develop fundamental concepts of PDE theories and their applications to scientific and engineering problems 2. Learn to solve the heat equation, wave equation, and the Laplace equation subject to boundary conditions 3. Demonstrate their ability to write coherent mathematical proofs and scientific arguments needed to communicate the results obtained from partial differential equation models. 4. Investigate the qualitative behaviour of solutions of systems of partial differential equations and interpret in the context of an underlying model.	(i) Each topic to be explained with illustrations. (ii) Students to be involved in discussions and encouraged to ask questions (iii) Solve the theoretical and practical problems in the class. (iv) Students to be given homework/assignment. (v) Students to be encouraged to apply concepts to solve real world problems and do look for new applications. (vi) Module IV to be taught in blended mode as per above E-Reference.	(a) Participation in class discussions (b) Continuous Evaluation (30Marks) (i)15 marks on • Assignments • class tests. • viva-voce or presentation (ii) Mid-term examinations:10 marks (iii) Class attendance -5 marks (c) End-term examinations.-70 marks.

SYLLABUS (2nd SEMESTER)

Paper II/Subject Name: Topology **Subject Code: MAT014C202**

L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Objective: The objectives of **Topology-I** (**MAT014C202)** are

- To enable learning cardinality of sets, topological space, different types of topology, continuity in terms of topological space, connectedness, compactness and countability of sets.
- To impart understanding behaviour of limit points, neighbourhoods and continuity in metric spaces and topological spaces.

Prerequisites: Basic operations on sets, relations and functions, denseness of R, Metric spaces.

Detailed Syllabus:

Modules	Topics / Course Content	Periods
I	**Cardinal Number and Topological Spaces :** Axiom of Choice and its equivalents, Equipotent sets, Cardinality and denumerability, cardinal numbers, order types and ordinal numbers. Definition and examples of topological spaces, open sets, usual topology for R, metric topologies, closed sets, closure, dense subsets, neighbourhoods, accumulation point and derived sets, bases, sub-bases and relative topologies.	**12**
II	**Continuity , Homeomorphism and Connectedness:** Continuity in topological spaces , homeomorphism, theorems on continuity and homeomorphism. Connected and disconnected sets, continuity and connectedness, components, totally disconnected spaces, locally disconnected spaces, Arcwise connectivity.	**12**
III	**Compactness and Countable Spaces:** Compactness, Heine-Borel theorem, countable, sequential and local compactness, compactness in metric spaces, continuity and compactness. First and second countable spaces, Lindelof's theorem, separable spaces, second countability and separability.	**12**
IV	**Countability and Seperation axioms :** T_0 spaces, T_1 spaces, T_2 spaces (Housdorff spaces), T_3 spaces (Regular spaces), T_4 spaces (normal spaces), their characterizations and basic properties, Urysohn's lemma.	**12**
	TOTAL	**48**

Text Books:

1. *Topology*; Hocking John G. and Young Gail S.; Revised ed. Edition; 2012 Dover Publications.
2. *Topology;* Sharma J.N.; 28th Edition; 2014; Krishna Prakashan Media P. Ltd.; Meerut.

Reference Books:

1. Pervin William J.; *Foundations of General Topology*; 2014; Academic Press.
2. Joshi K. D.; *Introduction to General Topology*; Second Edition, 2017; New Age International (P) Limited.
3. Steen Lynn Arthur and Seebach J. A.; *Counterexamples in Topology*; New edition; 1996 Dover Publications Inc.
4. Dugundji James; *Topology*; 1st Edition; 1966; Allyn and Bacon, Inc.; (Reprinted in India by PHI).

Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	**Teaching and Learning Activity**	**Assessment Tasks**
Students will be able to 1. Learn concept of different types of topologies, familiarize with limit points, bases, subbases of topologies. 2. Understand continuity, homomorphism, connectedness of topological spaces 3. Know the concept of compactness in topological spaces. 4.Familiarize with Housdorff spaces, Regular spaces, normal spaces.	(i) Each topic to be expounded with examples. (ii) Students to be motivated to take part in discussions and ask questions. (iii) Students to be given homework/assignments. (iv) Discuss and solve the theoretical problems in the class. (v) Students to be encouraged to give short presentations.	(a)Participation in class discussions (b)Continuous Evaluation(30Marks) (i)15 marks on • Assignments • class tests. • viva-voce or presentation (ii) Mid-term examinations :10 marks (iii) Class attendance -5 marks (c) End-term examinations.-70 marks.

SYLLABUS (2nd SEMESTER)

Paper III/Subject Name: Functional Analysis **Subject Code: MAT014C203**

L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Objective: The objectives of **Functional analysis** (**MAT014C203)** are

- to provide information of spaces of functions.
- to enable learning the concept of completeness of inner product spaces and normed vector spaces.
- to make the student understand boundness of linear operators, and its spectrum.
- to impart understanding the basic concepts and theorems of functional analysis and its applications.

Prerequisites:

- Concept of vector spaces, metric space and completeness.

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	**Normed Linear Spaces, Banach Spaces:** Normed linear spaces / Banach spaces and examples / further properties of normed linear spaces / finite dimensional normed linear spaces / compactness and finite dimension / linear operator, bounded and continuous operator/compact operator / normed linear spaces of linear operators and dual space.	**12**
II	**Inner Product Space, Hilbert Space:** Inner product space, Hilbert space and examples / Cauchy-Schwarz Inequality and applications / orthogonal complement and direct sums / orthonormal sets and sequences, Bessel inequality, Gram-Scmidth process / Riesz's theorem(functional on Hilbert spaces) / Riesz's representation (sesquilinear form) / Hilbert adjoint operator and its properties /self adjoint, unitary and normal operators.	**12**
III	**Fundamental Theorems for Banach Spaces:** Zorn's lemma / Hahn-Banach theorem(vector space version), Hahn-Banach theorem(normed linear space version) / reflexive space / Baire's category theorem/Zabreiko's lemma /Uniform boundedness theorem / strong and weak convergence / convergence of sequences of operators and functionals / Open mapping theorem / closed graph theorem.	**12**

IV	**Banach Fixed Point and Spectral Theory :** Banach fixed Point, contraction, Banach fixed point theorem (contraction theorem) Spectrum of bounded linear operators, resolvent set, point spectrum, continuous spectrum, residual spectrum and numerical range. Banach algebra, spectrum and spectral radius, spectral mapping theorem.	**12**
Total		**48**

Text Book:

1. *Introductory Functional Analysis with Applications*, Kreyszig Erwin, 2007, Wiley India Pvt. Ltd.

Reference Books:

1. Conway John B., *A Course in Functional Analysis*, 1st edition, 2010, SpringerVerlag.
2. Rudin Walter, *Functional Analysis*, 2nd edition, 2017, McGraw-Hill Education(ISE Editions)
3. Balmohan V. Limaye , *Functional Analysis*, 2014, New Age International Private Limited.
4. Nair M. Thamban , *Functional Analysis: A First Course*, 2001, PHI Learning Pvt. Ltd.

Facilitating the Achievement of Course Learning Outcomes:

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
The students will be able to i) describe properties of normed linear spaces and construct examples of such spaces. ii) extend basic notions from calculus to Inner product spaces and normed vector space. iii) Analyse various mappings on finite and infinite dimensional normed vector spaces. iv) Understand decomposition of complex plane in terms of spectrum	i) Each topic to be expounded with examples. ii) Students to be motivated to take part in discussions and ask questions. iii) Students to be given homework/assignments. iv) Discuss and solve the theoretical problems in the class. v) Students to be encouraged to give short presentations. vi) Students to be motivated to derive useful theoretical tools .	a) Participation in class discussions (b)Continuous Evaluation(30Marks) (i)15 marks on • Assignments • class tests. • viva-voce or presentation (ii) Mid-term examinations :10 marks (iii) Class attendance -5 marks (c) End-term examinations: 70 marks.

SYLLABUS (2nd SEMESTER)

Paper IV/Subject Name: Complex Analysis (25% Blended Mode) **Subject Code: MAT014C204**

L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Objective: The objectives of **Complex Analysis** (**MAT014C204)** are

- To extend the concepts of analysis of real variables to complex variables.
- To develop specific skills throughout the course to solve problems and for further study in the related fields.

Prerequisite:

- Concept of analytic function

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	**Complex Integration** Complex line integral, Cauchy-Goursat Theorem, Cauchy's integral formula, Higher order derivatives, Morera's theorem, Cauchy's inequality, Lioville's Theorem, The fundamental theorem of Algebra, Gauss's Mean Value Theorem, Maximum Modulus principle, Minimum modulus theorem, Schwarz' lemma.	**12**
II (Blended)	**Singularities and Power Series** Zero and singularity of an analytic function, Classification of singularities, Power Series, Taylor's and Laurent's Theorem, The Argument theorem, Rouche's theorem.	**12**
III	**Theory of Residues** Residue, Calculation of Residues, Cauchy's residue theorem, Evaluation of definite integrals, Special theorems used in evaluating integrals, Mittag-Leffer's theorem.	**12**
IV	**Analytic functions as mappings** Isogonal and Conformal mapping, Necessary and sufficient condition of conformal mapping, Fixed points of a transformation, some general transformations, Successive transformation, Bilinear transformations, Invariance of cross ratio, Branch point and Branch line, Concept of the Riemann surface.	**12**
Total		**48**

Text Books:

1. *Complex Variables and Applications;* Churchill R.V. and Brown J.W.; 8th edition; 2017; McGraw Hill Education.
2. *Functions of one complex variable;* Conway J. B.; Springer International Student edition; 2012; Narosa Publishing House, New Delhi.

Reference Books:

1. Spiegel M.R.; *Schaum's Outline of Complex Variables*; 2edition; 2017; McGraw-Hill.
2. Ahlfors L. V.; *Complex Analysis*; 3nd Edition; 2000; McGraw-Hill.
3. D. Sarason; *Complex Function Theory*; 2008; Hindustan Book Agency, Delhi.
4. Rudin, W.; *Real and Complex Analysis*; 3rd edition; 2017; McGraw-Hill .
5. Needham T.; *Visual complex Analysis*; Reprint edition; 1998; Oxford University Press;USA.

E-Reference: **[https://nptel.ac.in/courses/111/106/111106141/] for Module II**

Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
• Get the concept of Integration of Complex functions and Carry out contour Integration. • State and provide proofs of the Fundamental Theorem of Algebra and various important theorems. • Apply techniques of Complex analysis to summation of series. • Compute complex line integrals and real integrals using residues. • Explain the concept of transformation in a complex space and apply conformal mappings to problems from physical sciences..	i) Each topic to be explained with examples. ii) Students to be motivated to discover the relevant concepts to take part in discussions and ask questions. iii) Students to be given homework/assignments to make their concept clear.. iv) Discuss and solve the theoretical problems in the class. v) Students to be encouraged to give short presentations.	(a)Participation in class discussions (b)Continuous Evaluation(30Marks) (i)15 marks on • Assignments • class tests. • viva-voce or presentation (ii) Mid-term examinations :10 marks (iii) Class attendance -5 marks (c) End-term examinations.-70 marks.

SYLLABUS (2nd SEMESTER)

Paper I/Subject Name: Numerical Analysis (50% Blended Mode)		**Subject Code: MAT014D201**
L-T-P-C: 4-0-0-4	**Credit Units: 4**	**Scheme of Evaluation: TP**

Objective: The objectives of **Numerical Analysis (MAT014D201)** are

- To enable solving algebraic and transcendental equations.
- To impart appropriate numerical methods to solve a differential equation.
- To derive appropriate numerical methods to solve a linear system of equations.
- To perform an error analysis for various numerical methods.
- To provide appropriate numerical methods to calculate a definite integral.
- To enable developing code for various numerical methods in a modern computer language.

Prerequisites:

- Calculus ("value theorems", Sequences and series, Taylor series both single and multivariate)
- Linear Algebra (linear systems of equations, Eigenvalues of a matrix)
- Differential equations.

Detailed Syllabus:

Modules	Topics / Course content	Periods
I (Blended)	**Errors:** Definition of errors, Error analysis, Source of errors, IEEE floating point arithmetic, Truncation and rounding errors, fixed and floating point arithmetic, Propagation of errors,. solutions of nonlinear equations; Bisection method, Newton's method and its variants, fixed point iterations, convergence analysis;	**12**
II (Blended)	**Iterative Methods**: Fundamentals - overview of matrix computations, norms of vectors and matrices, singular value decomposition (SVD), stability and ill-conditioning; Linear systems - LU factorization, Gaussian eliminations, Cholesky factorization, stability and sensitivity analysis; Jacobi, Gauss-Seidel and successive over relaxation methods,	**12**

III.	**Interpolation:** Finite differences, polynomial interpolation, Newton forward/backward interpolation, Lagrange's and Newton's divided difference Interpolation, Hermite interpolation, spline interpolation;	**12**
IV	**Quadrature**: Numerical integration - Trapezoidal and Simpson's rules, Gaussian quadrature, Richardson extrapolation; Initial value problems - Taylor series method, Euler and modified Euler methods, Runge-Kutta methods, multistep methods and stability; Boundary value problems - finite difference method, collocation method	**12**
Total		**48**

Text Book:

1. *Elementary Numerical Analysis - An Algorithmic Approach*, Conte S. D. and De Boor Carl, 3rd Edn., Reprint, 2012,.McGraw Hill.

ReferenceBooks:

1. Kincaid D. and Cheney W., *Numerical Analysis: Mathematics of Scientific Computing*, 3rd Edn., Reprint, 2012, Orient Blabkswan.
2. Atkinson K. E., *Introduction to Numerical Analysis*, 2nd Edn., 1989,John Wiley,
3. Gupta Amritava, Bose S.C , *Introduction to Numerical Analysis*, 2013, Academic Publishers.

E-Reference: **[https://onlinecourses.swayam2.ac.in/cec21_ma12/preview] for Module I and II**

Course Outcomes:

Student will be able to

- Solve an algebraic or transcendental equation using an appropriate numerical method
- Solve a differential equation using an appropriate numerical method.
- Solve a linear system of equations using an appropriate numerical method
- Perform an error analysis for a given numerical method
- Calculate a definite integral using an appropriate numerical method
- Code a numerical method in a modern computer language

LAB PROGRAMMES

- Bisection method
- Regula Falsi method
- Newton-Raphson method
- Gauss Elimination method
- Gauss – Jordan method
- Gauss Seidel method
- LU factorization

- Solution of Differential Equations (Euler's method, RK4 method)
- Numerical Integration (Trapezoidal and Simpsons' rule)

Note: More Programming laboratory will be set in consonance with the material covered in lectures.

Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
The students will be able to • Solve an algebraic or transcendental equation using an appropriate numerical method • Solve a differential equation using an appropriate numerical method. • Solve a linear system of equations using an appropriate numerical method. • Perform an error analysis for a given numerical method . • Calculate a definite integral using an appropriate numerical method. • Develop applicability of a particular method. • Code a numerical method in a modern computer language	(i) Each topic to be expounded with examples. (ii) Students to be motivated to take part in discussions and ask questions. (iii) Students to be given homework/assignments. (iv) Discuss and solve the theoretical problems in the class. (v) Students to be encouraged to give short presentations. (vi) Students to be encouraged to do computer programming for different types of problems of the course.	(a)Participation in class discussions (b)Continuous Evaluation(30Marks) • Lab Component :20 marks • Mid-term examinations :10 marks (c) End-term examinations.-70 marks.

SYLLABUS (2nd SEMESTER)

Paper I/Subject Name: Discrete Mathematics **Subject Code: MAT014D202**

L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Objective: The objectives of **Discrete Mathematics (MAT014D202)** are

- To enable learning fundamental concepts of relations and functions.
- To impart understanding basic knowledge of number theory.
- To enable learning fundamental concept of coding theory.

Prerequisite:

- Basic concept of sets, relations and functions (10+2 level).
- Permutation and combinations.

Detailed syllabus:

Modules	Topic/course content	Periods
I	**Combinatorics-I**—Fundamental Principle, Sum rule, product rule, Permutation, distinct objects, permutation with repetition, Restricted permutation, circular permutation, Combination, combination with repetition, combination without repetition, Restricted combination, dearrangement, subfactorial, examples of dearrangements, counting dearrangements, limit of ratio of dearrangements, limit as n approaches to infinity, generalizations, computational complexity, identities, binomial and multinomial coefficients.	12
II	**Combinatorics-II**—Pigeonhole principle, application to finite sets, infinite sets, advanced mathematical proofs of lemma, generalized pigeonhole principle, inclusion-exclusion, Probability, random experiment, Sample space, Set notations, Probability of events, compound events, conditional probability, random variable, discrete probability distribution, binomial probability distribution, Poisson probability distribution, and Markov chain, definition of Markov Chain, Stochastic process, Markov process, transition probability matrix, powers of transition probability matrix, Regular Markov Chain with examples.	12
III	**Recurrence relation-** initial conditions or boundary conditions, recurrence relation model, linear recurrence relation with constant coefficients, solution of recurrence relation, iteration method, method of characteristic roots, multiple roots, mixed roots, non-homogeneous recurrence relation, generating functions, special generating functions, addition and	12

	multiplication of two generating functions, shifting properties, counting problems and generating functions, introduction to coding theory, data compression coding, error control coding, cryptographic coding, line coding.	
IV	**Boolean algebra**- unique features, basic operators, Boolean functions, De-Morgan's theorem, logic curve, sum of product and product form, normal form, expression of Boolean function as a canonical form,algebraic method, switching network, logic gates, switching circuits, functionally complete sets, Karnaugh Map method, arithmetic Circuits, introduction to cryptography, terminology, ancient cryptography, modern cryptography.	12
Total		48

Text Books:

1. *A text book of Discrete Mathematics*, Sarkar S. K., 2016, S Chand & Co Ltd.

Reference Books:

1. Rosen H K., *Discrete Mathematics and its applications*, 8th Edition, 1998, William C Brown Publication.
2. Chandrasekaran N. and Umaparvathi, *Discrete Mathematics*, 2013, PHI Publication..
3. Sharma B. K. and Siron R.S., *Discrete Mathematics*, 2013, Dhanpat Rai Publications.

Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
The students will be able to 1. Apply coding theory in the field of technology. 2. Apply logical operations basically in the field of computer science. 3. Understand mathematical algebraic structures.	(i) Each topic to be expounded with examples. (ii) Students to be motivated to take part in discussions and ask questions. (iii) Students to be given homework/assignments. (iv) Discuss and solve the theoretical problems in the class. (v) Students to be encouraged to give short presentations.	(a)Participation in class discussions (b)Continuous Evaluation(30Marks) (i)15 marks on • Assignments • class tests. • viva-voce or presentation (ii) Mid-term examinations :10 marks (iii) Class attendance -5 marks (c) End-term examinations.-70 marks.

SYLLABUS (2nd SEMESTER)

Paper III/Subject Name: Operations Research-II		**Subject Code: MAT014D203**
L-T-P-C: 4-0-0-4	**Credit Units: 4**	**Scheme of Evaluation: T**

Objective: The objectives of **Operations Research-II** (**MAT014D203**) are

- To enable understanding the meaning of duality and its role in the solutions to optimization problems.
- To impart understanding of some advanced linear programming techniques.
- To make the student understand and arrive at optimal or near-optimal solutions to complex problems involving some form of decision making.

Prerequisites:

- Concept of Matrix Algebra.
- Concept of differential calculus.

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	**Advanced Linear programming problem** Duality in LPP, Dual simplex method, Sensitivity analysis, Goal Programming, Linear Fractional Programming, Integer programming problem	**12**
II	**Queuing theory** Elements and characteristics of Queuing system, Waiting time and idle time costs, Transient and steady state of the system, Kendell's notation, Model for arrival and service time, Model I (M/M/I, FCFS/∞/∞).Model II Generalised model (M/M/I , – Birth –Death process), Model III(M/M/I, SIRO/∞/∞), Multi Channel Queuing theory model (M/M/C , FCFS/∞/∞), Erlang Family Distribution, Deterministic model.	**12**
III	**Simulation** Definition of simulation, types of simulation, advantages of simulation, phases of simulation, event type simulation, generation of random numbers, Monte-Carlo simulation	**12**
IV	**Non- Linear programming** Formulation of NLPP, Univariate and multi- Variable unconstrained optimization, Constrained Optimization Kuhn-Tucker conditions for constrained optimization, Quadratic programming.	**12**
Total		**48**

Text book:

1. *Problems in Operations research (Principles and Solutions)*, Gupta P.K. and Hira D.S., Revised Edition, 2013, Sultan Chand and Sons New Delhi.

Reference books:

1. Swarup Kanti, Gupta P.K. and Mohan M., *Operations Research*, 2014, Sultan Chand and Sons New Delhi.
2. Hadley G., *Linear programming*, 2002, Narosa Publishing House.
3. Hillier F.S. and.Lieberman G.J, *Introduction to operations Research*, Ninth Edition, 2011, Mc Graw Hill Edition.
4. Taha H.A, *Operations Research – An Introduction*, 9th Edition, 2014, Pearson Education India.
5. Natarajan A.M., Balasubramani. P, Tamilarasi A., *Operations Research*, 2005, Pearson Education.

Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
The students will be able to • Solve multi objective linear programming problems. • Solve linear programming problems with limitations on values taken by decision variables. • Understand the basic concept of queuing and simulation models. • Solve NLPP. • Understand the importance of convexity and concavity in the nonlinear optimization problems.	(i) Each topic to be expounded with examples. (ii) Students to be motivated to take part in discussions and ask questions. (iii) Students to be given homework/assignments. (iv) Discuss and solve the theoretical problems in the class. (v) Students to be encouraged to give short presentations.	(a)Participation in class discussions (b)Continuous Evaluation(30Marks) (i)15 marks on • Assignments • class tests. • viva-voce or presentation (ii) Mid-term examinations :10 marks (iii) Class attendance -5 marks (c) End-term examinations.-70 marks.

SYLLABUS (2nd SEMESTER)

Paper IV/Subject Name: Stochastic processes		**Subject Code: MAT014D203**
L-T-P-C: 4-0-0-4	**Credit Units: 4**	**Scheme of Evaluation: T**

Objective: The objectives of **Stochastic processes (MAT014D204)** are

- To impart understanding fundamental concepts of Markov chain.
- To provide exposure to probabilistic model.
- To enable learning the application of Stochastic processes in real situations.

Prerequisites:

- Concept of Probability Theory
- Concept of Calculus

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Probability Review and Introduction to Stochastic Processes (SPs): Probability spaces, random variables and probability distributions, expectations, transforms and generating functions, convergence, LLNs, CLT. Definition, examples and classification of random processes according to state space and parameter space.	**12**
II	Discrete and Continuous-time Markov Chains (MCs): Transition probability matrix, Chapman-Kolmogorov equations; n-step transition and limiting probabilities, ergodicity, stationary distribution, random walk and gambler's ruin problem, applications of DTMCs. Kolmogorov differential equations for CTMCs, infinitesimal generator, Poisson and birth-death processes, Applications to queueing theory, inventory analysis.. Brownian Motion: Wiener process as a limit of random walk; first - passage time and other problems.	**12**
III	Branching Processes: Definition and examples branching processes, probability generating function, mean and variance, Galton-Watson brancing process, probability of extinction. Renewal Processes: Renewal function and its properties, renewal theorems, cost/rewards associated with renewals, Markov renewal and regenerative processes, applications.	**12**

IV.	Stationary Processes: Weakly stationary and strongly stationary processes, moving average and auto regressive processes. Martingales: Conditional expectations, definition and examples of martingales, inequality, convergence and smoothing properties.	**12**
Total		**48**

Text Book:

1. *Stochastic Processes*, Ross S. M., 2nd Edition, Reprint, 2008, Wiley.

Reference Books:

1. Grimmett G. R. and Stirzaker D. R., *Probability and Random Processes*, 3rd Edition, 2001, Reprint, Oxford University Press,
2. Medhi J., *Stochastic Processes*, 3rd Edition, 2009, New Age International.
3. Taylor H.M. and Karlin S., An Introduction to Stochastic Modeling, 3rd Edition, 1998, Academic Press, New York.

Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
The students will be able to (i) Understand the application of probability in time dependent processes. (ii) Apply the processes in Markov chain, birth and death processes, queuing theory, Brownian motion, Branching and stationary processes.	(i) Each topic to be expounded with examples. (ii) Students to be motivated to take part in discussions and ask questions. (iii) Students to be given homework/assignments. (iv) Discuss and solve the theoretical problems in the class. (v) Students to be encouraged to give short presentations.	(a)Participation in class discussions (b)Continuous Evaluation(30Marks) (i)15 marks on • Assignments • Class tests. • viva-voce or presentation (ii) Mid-term examinations :10 marks (iii) Class attendance -5 marks (c) End-term examinations.-70 marks.

SYLLABUS (3rd SEMESTER)

Paper I/Subject Name: Mathematical Methods (25% Blended Mode) **Subject Code: MAT014C301**

L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Objective: The objectives of **Mathematical Methods** (**MAT014C301)** are

- To provide the concepts of different mathematical methods which have different applications.
- The make the student understand and develop specific skills throughout the course to solve problems in application fields.

Prerequisite:

- Concept of calculus and differential equations.

Detailed Syllabus:

Modules	Topics /Course content	Periods
I	**Calculus of variations:** Linear functionals, general variation of a functional, Euler-Lagrange equation. Variational problems with fixed boundaries. Variational problems in iso-perimetric form. Variational problems with moving boundaries.	12
II	**Integral equations** I: Definition of Integral Equation, Reduction of ordinary differential equations into integral equations., Linear integral equations of the first and second kind of Fredholm and Volterra type, Fredholm integral equations with separable kernels, Eigen values and Eigen functions, Method of successive approximation, Interative scheme for Fedholm Integral equations of second kind.	12
III	**Integral equations II:** Volterra Integral Equations of second kind, Resovant Kernal of Volterra equation and its results, Application of iterative scheme to Voltera equation of the second kind. Convolution type kernals.	12
IV (Blended)	**Laplace and Fourier transforms** Introduction to Laplace transforms, Laplace transforms of some standard functions, Existence theorem for Laplace transforms, Properties of Laplace transforms, Convolution theorem for Laplace transforms, Laplace transforms of periodic functions, Applications of Laplace transforms, Fourier transforms, Fourier sine and cosine transforms, Convolution theorem for Fourier transforms.	12
Total		**48**

Textbooks:

1. *Calculus of Variations with Applications;* Gupta, A, S.; 2003; Prentice Hall of India; New Delhi
2. *Integral equations and boundary value problems*; M. D Raisinghania; 2016; S. Chand and Co.; New Delhi
3. *A Treatise on the Theory of Bessel Functions ;* Watson G. N.; 1995; Cambridge University Press
4. *Green's Functions;* Roach, G. F.; 1995; *Cambridge University Press*

Reference Books:

1. G. M. Ewing; *Calculus of Variations with Applications*; Revised Edition, 2016, Dover Publications.
2. H. Sagan; *Introduction to Calculus of Variations;* Revised Edition; 2012; Dover Publication.
3. Mikhlin, S. G.; *Integral equations; 1960, Hindustan Publishing Corp.*
4. Brown J. W. and Churchill, R.; *Fourier Series and Boundary Value Problems; 8th Edition, 2011,* 1993; McGraw Hill.
5. R.P. Kanwal; *Linear Integral Equations, Theory and Techniques*; 2014; Academic Press, New York
6. F. B. Hilderbrand; *Methods of Applied Mathematics*; 2nd Edition; 1992, Dover Publication.

E-Reference: **[https://nptel.ac.in/courses/111/107/111107098/] for Module IV**

Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
The students will be able to i) Get the knowledge of Calculus of variations as well as their applications. ii) Know in details of Integral equations and their applications. iii) Learn different special functions.	i) Each topic to be explained with examples. ii) Students to be motivated to discover the relevant concepts to take part in discussions and ask questions. iii) Students to be given homework/assignments to make their concept clear.. iv) Discuss and solve the theoretical as well as problems in the class. v) Students to be encouraged to give short presentations. vi) Module IV to be taught in blended mode as per above E-Reference.	(a)Participation in class discussions (b)Continuous Evaluation(30Marks) (i)15 marks on • Assignments • class tests. • viva-voce or presentation (ii) Mid-term examinations :10 marks (iii) Class attendance -5 marks (c) End-term examinations.-70 marks.

SYLLABUS (3rd SEMESTER)

Paper II/Subject Name: Graph Theory **Subject Code: MAT014C302**

L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Objective: The objectives of the course **Graph Theory (MAT014C302)** are

- To enable understanding and apply the fundamental concepts in graph theory.
- To impart the application of graph theory based tools in solving practical problems.

Prerequisites:

- Set theory
- Matrices

Detailed Syllabus:

Modules	Topics /Course content	Periods
I	**Introduction** Graph theoretic basic concepts- finite and infinite graphs, incidence and degree, isolated and pendant vertices, null graph; Paths and Circuits- isomorphism, subgraphs, walks, connected and disconnected graphs and components, Euler graphs, Bi-partite graphs, Hamiltonian paths and circuits. Shortest path problem, Traveling Salesman Problem. Directed graphs- definition, types, directed paths and connectedness, Euler digraph.	**12**
II	**Trees & Fundamental circuits:** Definition and Properties of trees, distance and centers, rooted and binary trees, on counting trees, spanning trees, fundamental circuits, spanning trees in weighted graphs. Cycles, cocycles, cycle space, cocycle spaces, Connectivity, cut vertices, cut edges and blocks, connectivity parameters, Menger's theorem. Cut-sets, connectivity and separability, network flows; Matrix representation of graphs- incidence matrix, submatrices, circuit matrix, cut-set matrix, path matrix, adjacency matrix; trees with directed edges.	**12**
III	**Eulerian and Traversable graphs** : Characterization theorems, characterization attempts for Hamiltonian graphs: Two necessary and sufficient conditions for a graph to be Hamiltonian, Factorization; Basic concepts, 1- factorization, 2- factorization, coverings, critical points and lines.	**12**

IV	**Planarity and colorability**: Plane and planar graphs, outer planar graphs, Euler's Polynedron formula, Kuratowski's theorems. Coloring, Covering and Partitioning- basic concepts; Chromatic number. Five colour theorem, Four Colour conjecture, chromatic polynomial.	**12**
Total		**48**

Text Books:

1. *Graph Theory*, Harary F., 1st Edition, 1994, West View Press..
2. *Basic Graph Theory*, Parthasarathy H. R., 1998, McGraw Hill Publishing.

Reference Books

1. West D. B., *Introduction to Graph Theory*, 2nd edition, 2002, Prentice Hall, India.
2. Diestel. R., *Graph Theory (Graduate Texts in Mathematics)*, 5th edition, 2017, Springer.
3. Bondy, J. A. and Murty,U.S.R., '*Graph Theory* ', 2010. Springer.
4. Deo N., *Graph Theory with Applications to Engineering and Computer Science*, 1st Edition Reprint, 2016, Dover Publication..
5. Chartrand G. and Zhang P., *Introduction to Graph Theory*, 2007, Tata McGraw Hill.

Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
Upon successful completion of this course, students will be able to • Understand and explain the basic concepts of graph theory. • Apply principles and concepts of graph theory in practical situations	(i) Each topic to be expounded with examples. (ii) Students to be motivated to take part in discussions and ask questions. (iii) Students to be given homework/assignments. (iv) Discuss and solve the theoretical problems in the class. (v) Students to be encouraged to give short presentations.	(a)Participation in class discussions (b)Continuous Evaluation(30Marks) (i)15 marks on • Assignments • Class tests. • viva-voce or presentation (ii) Mid-term examinations :10 marks (iii) Class attendance -5 marks (c) End-term examinations.-70 marks.

SYLLABUS (3rd SEMESTER)

Paper I/Subject Name: Number Theory-I **Subject Code: MAT014D301**

L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Objectives: The objectives of **Number Theory-I** (**MAT014D301)** are

- To impart understanding basic structure and properties of integers.
- To enable improving one's ability of mathematical thinking.

Prerequisites:

- Concept of Natural number, Mathematical Induction and Binomial Theorem.

Detailed Syllabus:

Modules	Topics / Course Contents	Periods
I	**Divisibility theory in the integers** Divisibility, division algorithm, greatest common divisor, least common multiple, Euclidean algorithm, prime numbers, factorization in prime numbers, fundamental theorem of arithmetic.	12
II	**The theory of congruences** Congruences, basic properties of congruence, linear congruences, the Chinese Remainder theorem, Fermat's theorem, Wilson's theorem, the Diophantine equation, linear Diophantine equations, Pythagoras equation, sum of two squares.	12
III	**Number-theoritic functions** Number-theoretic functions, divisor functions (function, σ function), perfect numbers, multiplicative function, the mobius inversion formula, the greatest integer function, Euler's phi-function, Euler's theorem, properties of phi-function.	12
IV	**Primitive Roots** Primitive roots and indices, order of an integer modulo n, primitive roots for primes, composite numbers and primitive roots, quadratic reciprocity, quadratic residue, Legender's symbol and its properties, quadratic reciprocity law, quadratic congruences with composite moduli.	12
Total		**48**

Text Books:

1. *Elementary Number Theory*, Burton, D. M., 7th edition, 2010, McGraw-Hill Education
2. *An introduction to number theory*, Ivan Nivam & H.S. Zuckerman, 5th Revised edition edition, 2008, John Wiley & Sons.

Reference Books:

1. Hardy, G.H. and Wright, E. M., *An Introduction to the Theory of Numbers*; 6th edition ,2008, Oxford University Press.
2. Andrews, G.E., *Number Theory*, Revised Edition 1994, Dover Publication.
3. Telang, S. G., *Number Theory*, 2003, Tata McGraw-Hill, New Delhi.

Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
The students will be able to 1. Identify and apply various properties of integers including primes, the division algorithm, greatest common divisor, least common multiple. 2. Learn the concept of congruence and various properties of congruence. 3. Solve certain types of Diophantine equations. 4. Identify certain number theoretic functions and their properties. 5. Understand the concept of primitive roots, quadratic reciprocity, quadratic residue.	(i) Each topic to be expounded with examples. (ii) Students to be motivated to take part in discussions and ask questions. (iii) Students to be given homework/assignments. (iv) Discuss and solve the theoretical problems in the class. (v) Students to be encouraged to give short presentations.	(a)Participation in class discussions (b)Continuous Evaluation(30Marks) (i)15 marks on • Assignments • class tests. • viva-voce or presentation (ii) Mid-term examinations :10 marks (iii) Class attendance -5 marks (c) End-term examinations.-70 marks.

SYLLABUS (3rd SEMESTER)

Paper II/Subject Name: Algebraic Topology **Subject Code: MAT014D302**

L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Objective: The objectives of **Algebraic Topology (MAT014D302)** are

- To provide tools from abstract algebra to study topological spaces.
- To enable solving algebraic problems using topology.
- To make the student understand and apply homotopy groups to classify topological spaces.

Prerequisites:

- Basic concept of topology, topological spaces, Hausdorff spaces.

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	**The Fundamental Group and some of its applications** Product spaces, Projection mappings, Quotient spaces, Fundamental Group, Homotopy of maps between topological spaces, Homotopy equivalence, Contractable and simply Connected Spaces, Fundamental Groups of S^1 and $S^1 \times S^1$.	**12**
II	**Categorical Language and The Van Kampen Theorem** Calculation of Fundamental Group of S^n, $n > 1$ using Van-Kampen's theorem, Brouwer's Fixed Point theorem, Fundamental theorem of Algebra.	**12**
III	**Covering Spaces** Covering spaces, Unique Path Lifting theorem, Covering Homotopy Theorems, Group of Covering Transformations, Criterion of lifting of maps in terms of Fundamental groups.	**12**
IV	**Homology and their applications** Singular Homology, Reduced Homology, Eilenberg-Steenrod axioms of Homology (no proof for homotopy invariance axiom, excision axiom and exact sequence axiom) and their application, Relation between fundamental group and first homology.	**12**
Total		**48**

Text Books:

1. *Algebraic Topology*, Hatcher A., 1st Edition, 2001, Cambridge University Press.
2. ***A Concise Course in Algebraic Topology***, May J. P., 1st edition, 1999, University of Chicago Press.

Reference Books:

1. Munkres J. R., ***Elements of Algebraic Topology,*** 1st edition, Reprint, 2018, CRC Press..
2. Sharma J.N., *Topology*, 2014, Krishna Prakashan Media P. Ltd.-Meerut.
3. Rotman J.J, *An Introduction to Homological Algebra*, 2nd edition 2009, Springer.

Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
The students will be able to (i) Classify topological spaces using tools of abstract algebra. (ii) Solve algebraic problems using topology. (iii) Use homotopy groups to classify topological spaces. (iv) Describe homology to associate a sequence of abelian groups	(i) Each topic to be expounded with examples. (ii) Students to be motivated to take part in discussions and ask questions. (iii) Students to be given homework/assignments. (iv) Discuss and solve the theoretical problems in the class. (v) Students to be encouraged to give short presentations. (vi) Students to be motivated to apply the concepts in application parts.	(a) Participation in class discussions (b)Continuous Evaluation(30Marks) (i)15 marks on • Assignments • class tests. • viva-voce or presentation (ii) Mid-term examinations :10 marks (iii) Class attendance -5 marks (c) End-term examinations.-70 marks.

SYLLABUS (3rd SEMESTER)

Paper III/Subject Name: Mathematical Logic **Subject Code: MAT014D303**

L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Objective: The objectives of the course **Mathematical Logic (MAT014D303)** are

- To introduce the concepts of statement and truth values assigned
- To enable establishing different theories of mathematical logic;
- To make the student understand the application of mathematical logic.

Prerequisites:

- Concept of set theory.

Detailed Syllabus:

Modules	Topics / Course content	Periods
I.	**Informal statement calculus**: Statements and connectives, truth functions and truth tables, formal forms, adequate sets of connectives, arguments and validity.	**12**
II.	**Formal statement calculus**: Formal definitions of Proof, Theorem and Deduction, the formal theory of statement calculus, the deduction theorem and its converse.	**12**
III.	**Adequacy theorem for Logic** : Valuation in Logic, tautology , the Soundness theorem, extensions of Logic, consistency of an extension, the adequacy theorem of Logic	**12**
IV.	**Informal Predicate Calculus**: Symbolism of predicate calculus, first order language, interpretation, truth-values of well-formed formulas, satisfaction and truth. **Formal Predicate Calculus**: Predicate Calculus as a normal theory, the adequacy theorem of K.	**12**
Total		**48**

Text book:

1. *Logic for Mathematicians***,** Hamilton A.G., 1988, Cambridge University Press.

***Reference Book*:**

1. Elliot Mendelson, *Introduction to mathematical Logic*, Revised 6th Edition, 2015, Chapman and Hall.
2. Stephen Cole Kleene, *Mathematical Logi*c, reprint edition 2002, Dover Publications Inc.

Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
The students will be able to (i) Express a logical sentence in terms of predicates, quantifiers, and logical connectives. formulate and interpret statements presented in Boolean logic. (ii) Reformulate statements from common language to formal logic. Apply truth tables and the rules of propositional and predicate calculus. (iii) Define logical system using valuation and consistency (iv) Understand Informal and formal predicate calculus	(i) Each topic to be expounded with examples. (ii) Students to be motivated to take part in discussions and ask questions. (iii) Students to be given homework/assignments. (iv) Discuss and solve the theoretical problems in the class. (v) Students to be encouraged to give short presentations. (vi) Students to be motivated to apply the concepts in higher studies	(a) Participation in class discussions (b)Continuous Evaluation(30Marks) (i)15 marks on • Assignments • class tests. • viva-voce or presentation (ii) Mid-term examinations :10 marks (iii) Class attendance -5 marks (c) End-term examinations.-70 marks.

SYLLABUS (3rd SEMESTER)

Paper IV/Subject Name: Classical Mechanics (25% Blended Mode) **Subject Code: MAT014D304**

L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Objective: The objectives of **Classical Mechanics** (**MAT014D304**) are

- To impart the student how to use differential equations and other advanced mathematics in the solution of the problems of classical mechanics.
- To enable applying Newton's laws of motion to solve advanced problems involving the dynamic motion of classical mechanical systems.
- To provide idea how to represent the equations of motion for complicated mechanical systems using the Lagrangian and Hamiltonian formulations of classical mechanics.

Prerequisites:

- Concept of dynamics and statics from B.Sc. level.

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	**Equilibrium of forces in 3D:** Degree of freedom, different classification of constraints of motion, Generalized coordinates, generalized velocities, momenta and force, Total kinetic energy of a system of particles in terms of generalized velocity, D'Alembert's principle and Lagrangian form of equation of motion of a dynamical system of N particles, condition of equilibrium for a system of forces in 3D, finite and infinitesimal displacements of a rigid body, work, potential energy virtual work	12
II	**Motion of a rigid body** General motion of a rigid body, momental ellipsoid and principal axes, kinetic energy and angular momentum of a rigid body, principles of energy and momentum, two dimensional motion of rigid bodies, Euler's dynamical equations for the motion of rigid body, Motion of a rigid body about an axis, Motion about revolving axes.	12
III	**Lagrange's and Hamilton theory** Generalized forces, Lagrange's equation of motion, Lagrangian function, generalized momentum, deduction of principle of energy from Lagrange's equations (conservative field), Lagrange's equations with impulsive forces, Lagrange's equations by variational methods, Hamilton's principle, Hamiltonian Function, Hamilton's Principle of	12

	least action, Hamilton's canonical equations, derivation of Lagrange's equation from Hamilton's principle.	
IV (Blended)	**Theory of small oscillations** The general theory of small oscillation, stable equilibrium and small oscillation, the approximate forms of T and V, normal modes, orthogonality of normal modes, Coupled Pendulum, Normal modes, orthogonality of normal modes, Forced Oscillation, Damped oscillation	**12**
Total		**48**

Text Book

1. *Classical Mechanics*, Goldstein, H., 3rd Edition, 2013, Pearson.

Reference Books:

1. Synge, J.L. and Griffith, B.A., *Principles of Mechanics,* 2008, Milward Press.
2. Gregory, R.D., *"Classical Mechanics",* 2008, First South Asian Edition, Cambridge Univ. Press.
3. Rana, N.C and Joag, P.S, *Classical Mechanics,* 2017, Tata McGraw- Hill.

E-Reference: **[https://nptel.ac.in/courses/115/106/115106123/] for Module IV**

Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1. Understand clearly the notion of degrees of freedom, and identify them for a given mechanical system. 2. Apply mathematics skills to classical mechanics problems. 3. Learn to find the Lagrangian and the Hamiltonian, set up and solve the equations of motion for any reasonable mechanical system. 4. Identify existing symmetries and the corresponding integrals of motion; analyse the qualitative nature of dynamics on the basis of general principles without explicitly solving equations of motion.	(i) Each topic to be explained with illustrations. (ii) Students to be involved in discussions and encouraged to ask questions (iii) Solve the theoretical and practical problems in the class. (iv) Students to be given homework/assignment. (v) Students to be encouraged to apply concepts to solve real world problems and do look for new applications. (vi) Module IV to be taught in blended mode as per above E-Reference.	(a) Participation in class discussions (b) Continuous Evaluation (30Marks) (i)15 marks on • Assignments • class tests. • viva-voce or presentation (ii) Mid-term examinations:10 marks (iii) Class attendance -5 marks (c) End-term examinations-70 marks.

SYLLABUS (3rd SEMESTER)

Paper V/Subject Name: Differential Geometry **Subject Code: MAT014D305**

L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Objective: The objectives of **Differential Geometry (MAT014D305) are**

- To provide the students a minimum knowledge of Space curves
- To impart the students a minimum knowledge of Revolution of surface

Prerequisites:

- Basic Concept of differential calculus, physical quantities and geometry.

Detailed syllabus:

Modules	Topic/course content	Periods
I	**Space curves** introduction to differential geometry, parametric representation of space curves, change of parameter, arc length, unit tangent vector to a curve, point of inflexion, Normal lines and normal plane, principal normal, Binormal, Rectifying plane, curvature and torsion, helix, involutes and evolutes, Bertrand curves, Intrinsic equations, fundamental existence theorem, uniqueness theorem for space curves.	12
II	**Concept of surface** Definition of surface. Curves on a surface. Surfaces of revolution. Sphere, Helicoids, surface in Monge's form Direction on a surface, coefficients of direction. Families of curves, Intrinsic properties, orthogonal trajectories, Double family of curves.	12
III	**Curvature** Principal curvatures. Lines of curvature. Developable, Developable associated with space curves. Developable associated with curves on surfaces, Minimal surfaces and ruled surfaces, umbilics, Fundamental equations of Surface theory. Parallel surfaces, Gaussian or mean curvature. Complete surfaces, Fundamental existence theorem for surfaces, Bonnet's theorem for parallel surface.	12

IV	**Geodesics** Canonical geodesic equations, Normal property of geodesics. Existence theorems. Geodesic parallels. Geodesic curvature. Gauss Bonnet theorem. Gaussian curvature. Surfaces of constant curvature. Conformal mapping. Geodesic mapping. Conjugate points on geodesics. Intrinsically defined surfaces.	12
Total		48

Text Book:

1. T.J. Wilmore: An introduction to Differential Geometry; Reprint edition, 2013, Dover Publication.

Reference Book:

1. do Carmo , *Geometry of curves and surfaces*, 2nd edition, 2016, Dover Publication..

Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
The students will be able to • study the movements of curves. • know the Fundamental existence theorem, uniqueness theorem for space curves. • study the surface and its direction. • know Surface in Monge's form. • Developable associated with space curves, curves on surfaces. • gather knowledge on Geodesics , Gauss-Bonnet theorem,	(i) Each topic to be expounded with examples. (ii) Students to be motivated to take part in discussions and ask questions. (iii) Students to be given homework/assignments. (iv) Discuss and solve the theoretical problems in the class. (v) Students to be encouraged to give short presentations.	(a)Participation in class discussions (b)Continuous Evaluation(30Marks) (i)15 marks on • Assignments • class tests. • viva-voce or presentation (ii) Mid-term examinations :10 marks (iii) Class attendance -5 marks (c) End-term examinations.-70 marks.

SYLLABUS (3rd SEMESTER)

Paper VI/Subject Name: Continuum Mechanics		**Subject Code: MAT014D306**
L-T-P-C: 4-0-0-4	**Credit Units: 4**	**Scheme of Evaluation: T**

Objective: The objectives of **Continuum Mechanics** (**MAT014D306**) are

- To provide exposure the basic elements of continuum mechanics.
- To introduce the concepts of fundamental laws of continuum Mechanics.
- To prepare student to appreciate a wide variety of advanced courses of mechanics.
- To enable applying theory of continuum mechanics to solve problems of solid and fluid dynamics.

Prerequisites:

- Concept of dynamics and tensor from B.Sc. level.

Detailed Syllabus:

Modules	Topics / Course content	Periods
I.	**Analysis of Stress** The continuum concept, homogeneity, isotrophy, mass density, body force and surface force, Cauchy's stress principle, Stress tensor, Equations of equilibrium, Stress quadric of Cauchy, Principal stress, Stress invariants, Deviator and Sperical stress tensors	**12**
II.	**Analysis of Strain** : Continuum confiruation, Lagrangian and Eulerian descriptions, Deformation tensors, Finite strain tensor, Small deformation theory, Linear strain tensor and physical interpretation, Stress ratio and finite strain interpretation, Strain quadric of Cauchy, Principle strains, Strain invariants, Spherical and Deviator strain components, Equation of Compatibility.	**12**
III.	**Motion and Flow**: Material derivatives, Velocity and acceleration, Path lines and stream lines, Steady motion, Rate of deformation and vorticity with their physical interpretations, Material derivatives of volume, Surface and line elements, Fundamental laws of continuum Mechanics, Continuity equation, Equation of motion, Equilibrium Equation, Energy equation.	**12**

IV.	**Linear elasticity and fluids**: Generalized Hooke's Law, Strain energy function, Elastic constants for isotropic media, Elastostatic and Elastodynamic problems, Viscous stress tensor, Barotrophic flow, Stokesian fluids, Newtonian fluids, Navier stokes equations, Irrotational flow, Perfect fluids, Bermouli's equation, Circulation theorem.	**12**
Total		**48**

Text Book:

1. *Continuum Mechanics,* Mase G. E., Schaum's Outline series, 1969, McGraw Hill Co.

Reference Books:

1. Chatterjee R., *Mathematical Theory of Continuum Mechanics*, Revised Edition, 2016, Narosa Publishing House.
2. Chandrasekharaiah D.S. and Debnath Lokenath, *Continuum Mechanics,* 1994, Prism Books Pvt. Ltd.Bangalore.
3. Rutherford Aris, *Vectors, Tensors and Basic equations of Fluid Mechanics* Dover Publications Inc., 1962, New York.

Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1. Understand the basic concept and principle of continuum mechanics. 2. Learn to solve the problems of solid and fluid mechanics. 3. Appreciate a wide variety of advanced courses in solid and fluid mechanic. 4. Analyze the fluid flow problems for different coordinate systems.	(i) Each topic to be explained with illustrations. (ii) Students to be involved in discussions and encouraged to ask questions (iii) Solve the theoretical and practical problems in the class. (iv) Students to be given homework/assignment. (v) Students to be encouraged to apply concepts to solve real world problems and do look for new applications.	(a) Participation in class discussions (b) Continuous Evaluation (30Marks) (i)15 marks on • Assignments • class tests. • viva-voce or presentation (ii) Mid-term examinations:10 marks (iii) Class attendance -5 marks (c) End-term examinations.-70 marks.

SYLLABUS (3rd SEMESTER)

Paper VII/Subject Name: Multivariate Analysis-I **Subject Code: MAT014D307**

L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: Theory**

Objective: The objective of **Multivariate Analysis-I (MAT014D307)** is

- To impart the minimum knowledge of discrete probability distribution and estimation of their parameters.
- To make the student understand and apply Multivariate analysis –I in other branch of mathematics

Prerequisites:

- Basic knowledge of probability
- Knowledge of univariate distribution
- Knowledge of differential calculus

Detailed Syllabus:

Modules	Topics / Course content	Periods
I.	Binomial distribution, moments and generating functions, estimation of parameters, point estimation, interval estimation, truncated binomial distribution, multinomial distribution, genesis and definition, properties, moments, approximations, estimation of parameters, application of multinomial distribution, truncated multinomial distributions, multivariate multinomial distribution.	12
II.	Negative binomial distribution, genesis, moments and mode, estimation of parameters, applications, truncated negative binomial distribution, Negative multinomial distribution, definition, genesis, properties, moments, cumulants, estimation of parameters, multivariate negative multinomial distribution.	12
III.	Poisson distribution, moments and generating functions, estimation of parameters, point estimation and interval estimation, applications, Multivariate Poisson distribution, moments and generating functions, estimation of parameters	12
IV.	Hypergeometric distribution, moments and generating functions, estimation of parameters, applications, Multivariate Hypergeometric distribution, Logarithmic series distribution, definition, applications, estimations, Multivariate logarithmic series distribution	12
Total		**48**

Text Book:

1. *Multivariate analysis*, Kshirsagar A. M, 1st Edition, 1972, M. Dekker Publisher, New York.

Reference Books:

1. Rao C. R., *Linear statistical inference and its applications*, 2nd edition, 2002, Wiley-Blackwell.

Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
The students will be able to (i)Understand the application of binomial and multinomial distribution (ii)Apply negative binomial distribution in some problem like number of trials required to face the first success. (iii)Apply Poisson distribution, multivariate Poisson distribution in estimating rare cases. (iv)Apply Hypergeometric distribution and its multivariate extention.	(i) Each topic to be expounded with examples. (ii) Students to be motivated to take part in discussions and ask questions. (iii) Students to be given homework/assignments. (iv) Discuss and solve the theoretical problems in the class. (v) Students to be encouraged to give short presentations.	(a)Participation in class discussions (b)Continuous Evaluation(30Marks) (i)15 marks on • Assignments • Class tests. • viva-voce or presentation (ii) Mid-term examinations :10 marks (iii) Class attendance -5 marks (c) End-term examinations.-70 marks.

SYLLABUS (3rd SEMESTER)

Paper VIII/Subject Name: Tensor Analysis **Subject Code: MAT014D308**

L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Objective: The objectives of **Tensor Analysis** (**MAT014D308**) are

- To enable learning special orthogonal coordinate systems.
- To provide information of Riemannian Geometry.
- To introduce the concepts of gradient, divergence and curl in higher dimension.

Prerequisites:

- Concept of vector Analysis.

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	**Tensor Algebra:** Transformation of coordinates, Orthogonal Curvilinear Coordinates, Unit Vectors in Curvilinear System, Arc Length and Volume elements. Transformation laws of covariant and contravariant tensors, Mixed tensor, Rank of tensors, symmetric and anti-symmetric tensors and related theorems, Algebraic operations on tensors, contraction, Inner and outer product of tensors, Contraction, Quotient law, group property of tensors.	**12**
II	**Riemannian Metric:** Riemannian metric, Riemannian space, Definitions of metric tensors, Fundamental covariant tensor, Length of a curve, unit tangent vector, projection of a vector along a direction, Gradiant of a scalar function, angle between two vectors, angle between coordinate hyperspaces, n-poly-orthogonal system of hyperspaces, congruence of curves, Orthogonal ennuple, Euclidean spaces.	**12**
III	**Christoffel's Symbols of Covariant Differentiation:** Christoffel's brackets of first and second kinds, their properties, Transformation laws of Christoffel brackets. Covariant derivatives of tensors A_i, A^i, A_{ij}, A^{ij} and A^i_j, Covariant derivatives of metric tensors and scalar invariant function, Application in problems. Curl, grad, divergence of vectors.	**12**

IV.	**Curvature of a Curve, Geodesics:** Curvature of a curve, Principal normal, Geodesics, Eulerian condition, Differential equations of geodesics, Geodesic coordinates, Riemannian coordinates, Geodesic form of the line element, Geodesic in n-dimensional Euclidean space.	**12**
Total		**48**

Text Book:

1. *Tensor Calculus and Riemannian Geometry*, Agarwal D.C., 2014, Krishna Prakashan,.

Reference Books:

2. Goyal J. K. and Gupta K. P., *Tensor Calculus and Riemannian Geometr*y, 2003, Pragati Prakashan meerut.
3. Nayak P. K., *Tensor Calculus and Differential Geometry*, 2012, Prentice Hall India Learning Private Limited.
4. Kay D. , *Schaums Outline of Tensor Calculus*, 2011, McGraw-Hill Education.

Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
The students will be able to 1.Describe behaviours of vector in different coordinate system. 2.Describe advantages and application of Riemannian Geometry. 3.Describe geodesic in n-dimensional Euclidean space.	(i) Each topic to be expounded with examples. (ii) Students to be motivated to take part in discussions and ask questions. (iii) Students to be given homework/assignments. (iv) Discuss and solve the theoretical problems in the class. (v) Students to be encouraged to give short presentations.	(a)Participation in class discussions (b)Continuous Evaluation(30Marks) (i)15 marks on • Assignments • class tests. • viva-voce or presentation (ii) Mid-term examinations :10 marks (iii) Class attendance -5 marks (c) End-term examinations.-70 marks.

SYLLABUS (3rd SEMESTER)

Paper IX/Subject Name: Financial Mathematics **Subject Code: MAT014D309**

L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Objective: The objectives of **Financial Mathematics (MAT014D309)** are

- To make the student understand the basics of Financial Markets.
- To impart understanding the theory behind the Portfolio Management.
- To explore the application of probability spaces to define different aspects of financial market.
- To enable deriving discrete time and continuous time finance models.

Prerequisites:

- Elements of Probability Theory,
- Calculus
- Partial Differential Equations

Detailed Syllabus:

Modules	Topics / Course Content	Periods
I	**Basics of Financial Markets and Portfolio modeling:** Introduction and main theme of mathematical finance, financial markets and terminology, time value of money, interest rate, discount rate, bonds and bonds pricing, yield curves, duration and convexity, term structure of interest rates, spot and forward rates, net present value, net future value, financial instruments, underlying and derivative securities, types of derivatives, options, forwards, futures, swaps, concept of arbitrage. Portfolios, returns and risk, risk-reward analysis, asset pricing models, mean variance portfolio optimization, Markowitz model and efficient frontier calculation algorithm, Capital Asset Pricing Models (CAPM).	**12**
II	**Probability Theory and discrete time finance:** Probability spaces, filtrations as information content, random variables, conditional expectations, Definition and classification of random processes, martingales. Pricing by arbitrage, risk-neutral probability measures, valuation of contingent claims, fundamental theorem of asset pricing, Cox-Ross-Rubinstein (CRR) model, pricing and hedging of European and American derivatives as well as fixed-income derivatives in CRR model, general results related to prices of derivatives.	**12**
III	**Stochastic Calculus:** Brownian motion, martingales, Itô's formula, Itô integral, risk-neutral measure, SDE; Risk-neutral measure, Girsanov's	**12**

	theorem for change of measure, martingale representation theorems, representation of Brownian martingales, Feynman-Kac formula.	
IV	**Continuous-time Finance:** Black-Scholes-Merton model of stock prices as geometric Brownian motion, derivation of the Black-Scholes-Merton partial differential equation, the Black-Scholes formula and simple extensions of the model, self-financing strategies and model completeness, risk neutral measures, the fundamental theorems of asset pricing, continuous time optimal stopping and pricing of American options, forwards and futures in Black-Scholes-Merton model	**12**
	TOTAL	**48**

Text Book:

1. *Mathematics for Finance: An Introduction to Financial Engineering*, Capinski. M. and Zastawniak T. Springer, 2005.

Reference Books:

1. Hull J. C., *Options, Futures and Other Derivatives*, 7th Edition, Pearson Education, 2009.
2. Shreve S, *Stochastic Calculus for Finance*, Vol. 1 and Vol. 2, Springer, 2004.
3. Grimmett G. R. and Stirzaker D. R., Probability and Random Processes, 3rd Edition, Oxford University Press, 2001.
4. Elliott R. J and. Kopp P. E , *Mathematics of Financial Markets*, Springer, 1999.

Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
The students will be able to • understand the basics of financial market • analyse risk management in financial market • apply the probabilistic theories in the discrete and continuous models of financial market. • derive and apply Black-Scholes-Merton (BSM)models. .	(i)Each topic to be expounded with examples. (ii)Students to be motivated to take part in discussions and ask questions. (iii)Students to be given homework/assignments. (iv)Discuss and solve the theoretical problems in the class. (v) Students to be encouraged to give short presentations.	(a)Participation in class discussions (b)Continuous Evaluation(30Marks) (i)15 marks on • Assignments • Class tests. • viva-voce or presentation (ii) Mid-term examinations :10 marks (iii) Class attendance -5 marks (c) End-term examinations.-70 marks.

SYLLABUS (3rd SEMESTER)

Paper X/Subject Name: Seminar/Litereature Survey **Subject Code: MAT014D331**

L-T-P-C: 0-0-0-4 **Credit Units: 4** **Scheme of Evaluation:**

Objective: The objectives of **Seminar /Literature Survey** (**MAT014D331**) are

- To develop student's ability to individual minor research
- To inculcate critical understanding of a topic relevant research interest
- To instil the ability of writing research report
- To develop the ability to communicate through presentation

Detailed syllabus:

Modules	Topics / Course content	Periods
I	Basics of research methodology	12
II	Basic word processing techniques, Report writing skill and preparation of PPT presentation	12
III	Topic selection and research work on the selected topic under supervision	12
IV	Write report on the findings of the topic and prepare presentation for graduate seminar	12
Total		48

Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
The students will be able to • Gather in depth knowledge in a topic of their choice in doing seminar/ Literature survey. • Develop oral and written presentation skills. • Develop a taste of research in various topics of Mathematics	(i) Students to be encouraged to take part in discussions and ask questions during seminar sessions. (ii) Students to be encouraged to select topics of their own interest. (iii) One to one interaction of Guide and students. (iv) Use of research Lab to learn word processing, PPT presentation skill or any other mathematical tools needed for the seminar	(a)Participation in class discussions (b)Continuous Evaluation(30Marks) (i)25 marks on • Skill Test • Quiz. (ii) Class attendance - 5 marks (c) SEE (70) Presentation • Report writing • Presentation Skill • Depth of minor research • Viva-voce .

SYLLABUS (4thSEMESTER)

Paper VIII/Subject Name: Measure Theory **Subject Code: MAT014C401**
(25% Blended Mode)
L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Objective: The objectives of **Measure Theory (MAT014C401)** are

1. To introduce the concepts of measure and integral with respect to a measure
2. The enable the student tol develop specific skills of measure theory throughout the course to solve problems and for further study in the related fields.

Prerequisite:

- Basics of real analysis.

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	**Lebesgue measure** Lebesgue outer measure, sets of measure zero, properties of outer measure, Lebesgue measurable sets, Borel Sets, sequence of Lebesgue measurable sets, Lebesgue measurable functions and their properties, Borel Measurable Functions and their properties, Lebesgue and Borel measurability of sequence of functions.	**12**
II	**The Lebesgue integral** Simple functions, Integration of non-negative functions, Lebesgue integral, properties of Lebesgue integrals, comparison of Reimann and Lebesgue integrals, Fatou's lemma, Lebesgue monotone convergence theorem, the general Lebesgue integral, Lebesgue dominated convergence theorem.	**12**
III	**Differentiation and integration** The four derivatives, functions of bounded variation, differentiation of an integral, absolute continuity, Lebesgue Stieltje measure, Lebesgue Stieltje integrals with applications.	**12**

IV (Blended)	**Extension of measure and integration** Signed measure, properties of signed measure, measure spaces and their properties, integration with respect to a general measure, Holder and Minkowski inequalities, product spaces, product measure, convergence in measure, L(p) spaces and their properties, convex functions, Riesz Representation Theorem.	**12**
Total		**48**

Text Books:

1. *Measure Theory and Integration*, Barra, G. De.,1st Edition 2013; New Age International (P) Ltd, Publishers, New Delhi.
2. *Real Analysis;* Royden, H. L., 4rd Edition; 2015, Pearson Education India,
3. *An Introduction to Measure and Integration;* Rana, I. K.; 2nd edition; 2007, Narosa Publishing House, India.

Reference Books:

1. L. Cohn Donald, *Measure Theory*; 2nd Edition; 2013, Birkhauser.
2. Halmos P.R., *Measure Theory*; Second Reprint, 2008, Springer.

E-Reference: **[https://nptel.ac.in/courses/111/106/111106140/] for Module IV**

Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
The students will 1. Get the concept of Lebesgue measure and Measurable functions and related properties. 2. Get the knowledge of Lebesgue integral and acquainted with the proofs of the fundamental theorems underlying the theory of integration. 3. Get the concept of differentiation and integration in measure theory with important properties.	(i)Each topic to be expounded with examples. (ii)Students to be motivated to take part in discussions and ask questions. (iii)Students to be given homework/assignments. (iv)Discuss and solve the theoretical problems in the class. (v)Students to be encouraged to give short presentations. (vi) Module IV to be taught in blended mode as per above E-Reference.	(a)Participation in class discussions (b)Continuous Evaluation(30Marks) (i)15 marks on • Assignments • Class tests. • viva-voce or presentation (ii) Mid-term examinations :10 marks (iii) Class attendance -5 marks (c) End-term examinations.-70 marks.

SYLLABUS (4th SEMESTER)

Paper VIII/Subject Name: Dynamical System **Subject Code: MAT014C402**

L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Objective: The general objectives of the course **Dynamical System (MAT014C402)** are

- To introduce the concept of dynamical system and vector fields
- To provide the concept of stability and equilibrium.
- To provide the methods for solution of nonlinear differential equations.

Prerequisites:

- Differential Calculus
- Linear Algebra

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Dynamical systems and vector fields. The fundamental theorem. Existence and uniqueness. Continuity of solutions in initial conditions. On extending solutions. Global solutions. The flow of a differential equation.	**12**
II	Nonlinear sinks. Stability. Liapunov function. Saddle point, nodes, foci, centers and non-hyperbolic critical points ,Gradient systems. Gradients and Hamiltonian systems	**12**
III	Limit sets, local sections and flow boxes, monotone sequences in planar dynamical systems. The Poincare Bendixson theorem, Applications of Poincare-Bendixson theorem; one species, predator and prey, competing species.	**12**
IV	Asymptotic stability of closed orbits, discrete dynamical systems. Stability and closed orbits. Non Autonomous equations and differentiability of flows. Persistence of equilibria, persistence of closed orbits. Structural stability. Basic idea of Fractal Geometry, Construction of the middle third cantor set, Von Koch Curve, Sierpinski gasket, self similar fractals with different similariy ratio, Housdorff measure, Housdorff dimension and properties.	**12**
Total		**48**

Text Book:

1. *Differential equations, dynamical systems & an introduction to Chaos*, Hirsch M.W, 3rd, 2012, Elsevier.
2. *An introduction to Chaotic Dynamical Systems*, Devany Robert L, 2nd Edition, 2003, CRC Press..

Reference Books:

1. Perko L., *Differential Equations and Dynamical Systems*, 2012, Springer
2. Verlag N. Y., Arnold V.I., *Dynamical systems*, 1992, Springer.
3. Stronatz S. H., *Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering*, 2nd edition , 2014, CRC Press.
4. Heivz Otto Petigen, Hartmut Jurgens and Dietmar Saupe, *Chaos and fractals, New frontier of Science*, 2nd edition 2004, Springer.

Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
The students will be able to • Understand the fundamental concepts of the dynamical systems. • formulate a physical system to dynamical system model • find local and global stability of a dynamical system. • Know the importance of Poincare Bendixson's theorem. • Understand the importance of limit cycle. • learn to analyze non-linear systems described by maps and differential equations. • Know Fractal geometry	(i) Each topic to be expounded with examples. (ii) Students to be motivated to take part in discussions and ask questions. (iii) Students to be given homework/assignments. (iv) Discuss and solve the theoretical problems in the class. (v) Students to be encouraged to give short presentations.	(a)Participation in class discussions (b)Continuous Evaluation(30Marks) (i)15 marks on • Assignments • class tests. • viva-voce or presentation (ii) Mid-term examinations :10 marks (iii) Class attendance -5 marks (c) End-term examinations.-70 marks.

SYLLABUS (4th SEMESTER)

Paper I/Subject Name: Algebra-II **Subject Code: MAT014D401**

L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Objective: The objectives of **ALGEBRA II** (**MAT014D401)** are

- To provide the continuous approach to the subject of algebra, which is one of the basic pillars of modern mathematics and to inculcate in students the power of accurate analysis.
- To provide an insight for further study into applications of abstract algebra in certain areas by knowing to perform algorithms.

Prerequisites:

- Concept of Algebra I and vector space

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	**Group Theory:** Direct product (sum) of an infinite family of groups, Structure theorems for finite generated abelian groups, Sylow Theorems and their applications. Free abelian groups, free groups , free products of groups, presentation of a group	12
II	**Ring theory:** Primitive polynomials, Eisentein's irreducibility criterion , Gauss' Theorem, Nilpotent and Nil ideals ,Primitive rings, Radical, Completely reducible rings, Noetherian and Artinian Rings	12
III	**Fields:** Finite field, elements of Galois theory, Fixed field, Normal extension, Fundamental theorem of Galois theory, Polynomials solvable by radicals. R Construction by ruler and compass	12
IV	**Canonical forms:** Similarity of linear transformations. Invariant subspaces. Reduction to triangular forms. Nilpotent transformations. Index of nilpotency. Invariants of a nilpotent transformation. The primary decomposition theorem. Jordan blocks and Jordan form.	12
Total		**42**

Text Books:

1. *Modern Algebra*; Singh Surajeet and Zameeruddin Qazi; Eighth Edition; 2006; Vikash Publishing House Pvt Ltd.
2. *Contemporary Abstract Algebra* ; Gallian J. A.; 8th edition; 2012; Cengage Learning.

Reference Books:

1. Malik D. S., Mordeson J. N., Sen M. K. ; *Fundamentals of Abstract Algebra* ; 1996; McGraw Hill Company.
2. I. N. *Herstein*; *Topics in Algebra*; 2nd edition; 2006; John *Wiley* & Sons; New York.
3. *Fraleigh John* B.; *A First Course in Abstract Algebra*; 7th edition; 2003; Pearson.
4. Dummit D. and Foote R.; *Abstract Algebra*; 3rd edition; 2003; *Wiley*; New York.
5. Jacobson, N.*; I & II Basic Algebra*; Second edition; 2009; Hindusthan Publishing Corporation, India.

Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
The students will be able to • Describe the theorems and properties of more abstract algebraic structures in groups, rings, fields. • Get the knowledge of linear transformations and canonical forms. • Apply course material along with techniques and procedures covered in this course to solve problems.	i) Each topic to be explained with examples. ii) Students to be motivated to discover the relevant concepts to take part in discussions and ask questions. iii) Students to be given homework/assignments to make their concept clear.. iv) Discuss and solve the theoretical problems in the class.	(a)Participation in class discussions (b)Continuous Evaluation(30Marks) (i)15 marks on • Assignments • class tests. • viva-voce or presentation (ii) Mid-term examinations :10 marks (iii) Class attendance -5 marks (c) End-term examinations.-70 marks.

SYLLABUS (4th SEMESTER)

Paper II/Subject Name: Fuzzy Set Theory **Subject Code: MAT014D402**
(50% Blended Mode)
L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Objective: The main objective of **Fuzzy Set theory** (**MAT014D402**) is

- To impart understanding the basic mathematical elements of the theory of fuzzy sets that are widely used in science and engineering.
- To provides the idea on the differences and similarities between fuzzy sets and classical sets theories.
- To make the student understand the fuzzy logic inference with emphasis on their use in the design of intelligent or humanistic systems.
- To introduce the fuzzy arithmetic concepts and provide an insight into fuzzy inference applications

Prerequisites:

- Concept of Algebra
- Mathematical Logic (Discrete Mathematics).

Detailed Syllabus:

Modules	Topics/Course content	Periods
I	**Fuzzy Sets and Operations on Fuzzy Sets:** Classical sets vs Fuzzy Sets, Need for fuzzy sets, Definition and Mathematical representations, Level Sets, Fuzzy functions, Zadeh's Extension Principle, Operations on [0,1], Fuzzy negation, triangular norms, t-conorms, fuzzy implications, Aggregation Operations. Fuzzy Numbers.	**12**
II	**Fuzzy Relations and Fuzzy Graphs** Fuzzy Binary and n-ary relations, composition of fuzzy relations, Fuzzy Equivalence Relations, Fuzzy Compatibility Relations, Fuzzy Relational Equations, Fuzzy graphs and connectivity.	**12**
III (Blended)	**Fuzzy Logic and Approximate Reasoning** Fuzzy Logic, Linguistic hedges, Fuzzy propositions (conditional and unconditional), Inference from conditional and qualified fuzzy propositions, Fuzzy Quantifiers, Inference from quantified fuzzy propositions	**12**

IV (Blended0	**Possibility Theory** Introduction to possibility theory Possibility vs probability Belief and Plausibility, Dempsters rule	**12**
Total		**48**

Text Book:

1. *Fuzzy Sets and Fuzzy Logic: Theory and Applications* , George J Klir and Bo Yuan, Prentice Hall NJ,1995.

Reference Books:

1. Zimmermann H.J., *Fuzzy Set Theory and its Applications*, 3rd Edition, 2014, Springer.
2. John N. Mordeson and Premchand S.Nair , *Fuzzy Mathematics-An Introduction for engineers and Scientists*, 2010, Springer Books.
3. Anastassiou George *A, Fuzzy Mathematics-Approximation Theory*. 2010 Springer Publication.

E-Reference: **[https://nptel.ac.in/courses/111/102/111102130/] for Module III and IV**

Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
The students will be able to • distinguish between the crisp set and fuzzy set concepts through the learned differences between the crisp set characteristic function and the fuzzy set membership function. • draw a parallelism between crisp set operations and fuzzy set operations through the use of characteristic and membership functions respectively. • define fuzzy sets using linguistic words and	i) Each topic to be explained with examples. ii) Students to be motivated to discover the relevant concepts to take part in discussions and ask questions. iii) Students to be given homework/assignments to make their concept clear.. iv) Discuss and solve the theoretical as well as real world problems in the class. v) Module III and IV to be taught in blended mode as per above E-Reference.	(a)Participation in class discussions (b)Continuous Evaluation(30Marks) (i)15 marks on • Assignments • class tests. • viva-voce or presentation (ii) Mid-term examinations :10 marks (iii) Class attendance -5 marks (c) End-term examinations.-70 marks.

represent these sets by membership functions. • know how to perform mapping of fuzzy sets by a function and also use the α-level sets in such instances. • know fuzzy-set-related notions; such as α-level sets, convexity, normality, support, etc.		

SYLLABUS (4th SEMESTER)

Paper II/Subject Name: Operator Theory **Subject Code: MAT014D403**

L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Objective: The objectives of **Operator Theory (MAT014D403)** are

- To provide advantages of study of Banach algebras.
- To enable understanding spectral behavior of various bounded linear operators.
- To explain behavior of operators in C* algebras.

Prerequisites:

- Concept of vector spaces, normed spaces, bounded linear operators and completeness.

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	**Banach Algebras:** Definition of Banach Algebra and examples, The spectrum of an element, Gelfand Formula, Multiplicative Linear Function, and the maximal ideal space, Gleason Kahane Zelazko Theorem. The Gelfand Transforms, Isometric Gelfand Transform.	**12**
II	**Spectral properties of Compact operator:** Spectral properties of bounded linear operators, Properties of Resolvent set and spectrum. The Spectral Mapping Theorem. Compact linear operators on normed spaces, Properties of Compact linear operators. Spectral properties of compact linear operators.	**12**
III	**Spectral properties of bounded self adjoint operators:** Self adjoint linear operators, Spectral properties of bounded self adjoint linear operators, Positive operators. Square roots of a positive operator, Projection operator, properties of projections, Normal operators, Spectral family, Statement of spectral representation theorem.	**12**

IV.	**C* algebras:** $*$-algebra, $*$-isomorphism, C*-algebras (definition and examples), Properties of C*-algebras, commutative C*-algebras, Positive elements in C*-algebras, Operators and Sesquilinear form, Polar decomposition.	**12**
Total		**48**

Text Books:

1. *A Course in Functional Analysis*, Conway J. B., 2008, Springer.

Reference Books:

1. Kreyszig Erwin, *Introductory Functional Analysis with Applications*, 2007, Wiley India Pvt. Ltd.
2. Rudin Walter, *Functional Analysis*, Reprint 2nd revised edition, 2017, McGraw-Hill Education (ISE Editions).
3. Murphy G.J., *C*-algebras and operator theory*, Reprint 1st edition, 2014, Academic Press;
4. Conway J. B, *A Course in Operator Theory* , 2012, Orient Blackswan.

Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
The students will be able to (i) Describe basic notion of Banach algebras and its application in various operators. (ii) Describe spectral properties of various bounded linear operators. (iii) Describe spectral properties of self-adjoint operators. (iv) Describe basic notions of C*-algebras and its application in various operator.	(i) Each topic to be expounded with examples. (ii) Students to be motivated to take part in discussions and ask questions. (iii) Students to be given homework/assignments. (iv) Discuss and solve the theoretical problems in the class. (v) Students to be encouraged to give short presentations. (vi) Students to be motivated to apply the concepts in higher studies.	(a) Participation in class discussions (b)Continuous Evaluation(30Marks) (i)15 marks on • Assignments • class tests. • viva-voce or presentation (ii) Mid-term examinations :10 marks (iii) Class attendance -5 marks (c) End-term examinations.-70 marks.

SYLLABUS (4th SEMESTER)

Paper IV/Subject Name: Theory of Relativity		**Subject Code: MAT014D404**
L-T-P-C: 4-0-0-4	**Credit Units: 4**	**Scheme of Evaluation: T**

Objective: The objectives of **Theory of Relativity** (**MAT014D404**) are

- To impart understanding the fundamental principles of the general theory of relativity.
- To enable developing the concepts like the equivalence principles, inertial frames and gravity.
- To introduce the concepts of static and non-static cosmological models.

Prerequisites:

- Concept of dynamics and tensor analysis.

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	**Tensor:** Tensor Algebra, Inner and outer product, Contraction, Symmetric and anti-symmetric tensors, Quotient law, Christoffel symbols of first and second kind, Metric tensors, Covariant Derivative of Tensors, Gradient, Divergence and Curl of Tensors, Riemannian Tensor, Ricci Tensor, Bianchi Identities, Einstein Tensor, Geodesics.	12
II	**Principle of covariance and equivalence** Principle of covariance and equivalence, Simple consequences of principle of equivalence- equality of inertial and gravitational masses, effect of gravitational potential on the rate of a clock, the clock paradox, Energy momentum tensor and general expression for perfect fluid.	12
III	**Einstein Field Equations** Geodesic equation, Newton's equation of motion as an approximation of geodesic equation, Einstein Field Equations, Poison's equation as an approximation of Einstein Field Equations, Schwarzshild exterior solution for a gravitational fied, Planetary orbits, Crucial tests of General Theory of Relativity.	12

IV	**Cosmology** Static cosmological models, Einstein and de-Sitter line elements and their properties, Non-static cosmological model, Comoving coordinate system, Derivation of Robertson-Walker line element, Hubbles law, General relativity near massive objects, Black holes, Red shifts and Horizons, Galatic densities and the darkness of night sky.	**12**
Total		**48**

Text Books:

1. *Fundamentals of Special and General Relativity*, Krori K. D., 2010, PHI Learning Private Limited

Reference Books:

1. Weinberg S., *Gravitation and Cosmology : Principles and Applications of the general Theory of relativity*, 2008, John Wiley & Sons Inc.
2. Moller C., *The Theory of Relativity*, 2015, Andesite Press.
3. Eddington A.S., *The Mathematical Theory of Relativity*, 2016, Minkowski Institute Press.
4. Srivastava S. K., *General Relativity and Cosmology*, 2008, PHI Learning Private Limited.

Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1. Learn the fundamental concept of tensor calculus. 2. Understand the physical phenomena in different coordinate systems and to transform from one coordinate system to another. 3. Analyse the mathematical description of gravitational waves, as well as cosmological models in the context of general relativity. 4. Learn to solve Einstein's field equations for static spherically symmetric problems and for isotropic and homogeneous cosmological models.	(i) Each topic to be explained with illustrations. (ii) Students to be involved in discussions and encouraged to ask questions (iii) Solve the theoretical and practical problems in the class. (iv) Students to be given homework/assignment. (v) Students to be encouraged to apply concepts to solve real world problems and do look for new applications.	(a) Participation in class discussions (b) Continuous Evaluation (30Marks) (i)15 marks on • Assignments • class tests. • viva-voce or presentation (ii) Mid-term examinations:10 marks (iii) Class attendance -5 marks (c) End-term examinations.-70 marks.

SYLLABUS (4th SEMESTER)

Paper IV/Subject Name: Fluid Dynamics		**Subject Code: MAT014D405**
L-T-P-C: 4-0-0-4	**Credit Units: 4**	**Scheme of Evaluation: T**

Objective: The objectives of **Fluid Dynamics** (**MAT014D405**) are

- To enable developing basic concept of fluid dynamics.
- To introduce the concepts and to explain fundamental laws of fluid dynamics.
- To enable developing problem solving skills to solve the fluid flow problems.
- To make the student understand the boundary layer theory.

Prerequisites:

- Concept of dynamics and vector from B.Sc. level.

Detailed Syllabus:

Modules	Topics / Course content	Periods
I.	**Basics of fluid dynamics:** Real and ideal fluids, types of flows, Lagrarian and Eulerian methods, Velocity and acceleration, Streamlines, streaklines and pathlines, velocity potential and stream function, source, sink and doublet, , Equation of continuity. Equations of motion of a fluid, Fluid pressure, Euler's equation of motion, Bernoulli's equation.	**12**
II.	**Viscous fluid motion:** Viscous fluid, coefficient of viscosity, Navier- Strokes equation of motion, Rate of change of vorticity and circulation, Energy dissipation due to viscosity, Diffusion of vorticity.	**12**
III.	**Exact solution of Navier Strokes Equations:** Flow between plates, Flow through a pipe (circular, elliptic), Suddenly accelerated plane wall, Flow near an Oscillating flat plate, Circular motion through cylinders. Stoke's linearization process, Oseen's approximation.	**12**

IV.	**Boundary Layer Theory:** General outline of Boundary layer flow, Boundary layer thickness, Displacement thickness, Energy thickness, Similarity solution of boundary layer equations, Momentum equation and energy integral equation, Two-dimensional Boundary layer equations, Blasius solution for flow past a cylindrical surface, Separation of boundary layer.	**12**
Total		**48**

Text Book:

1. *Boundary Layer Theory*, Schlichting H. translated by Kertin J., 9th Edition, 2017, Springer.

Reference Books:

1. Goldstein S., *Modern development of Fluid Dynamics,* Vol. 1, 1965, Dover Publication, New York.
2. Batchelor G. K., *An Introduction to Fluid Dynamics,* 2007, Foundation Books, New Delhi.
3. Raisinghania M. D., *Fluid Dynamics,* 2010, S. Chand and Co., New Delhi.

Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1. Learn the basics of fluid dynamics. 2. Understand the governing equations of fluid motion and its role in fluid flow problems. 3. Analyze fluid flow problems with the application of the momentum and energy equations. 4. Learn to solve the problems of fluid flow with Navier Stokes Equations.	(i) Each topic to be explained with illustrations. (ii) Students to be involved in discussions and encouraged to ask questions (iii) Solve the theoretical and practical problems in the class. (iv) Students to be given homework/assignment. (v) Students to be encouraged to apply concepts to solve real world problems and do look for new applications.	(a) Participation in class discussions (b) Continuous Evaluation (30Marks) (i)15 marks on • Assignments • class tests. • viva-voce or presentation (ii) Mid-term examinations:10 marks (iii) Class attendance -5 marks (c) End-term examinations.-70 marks.

SYLLABUS (4th SEMESTER)

Paper VI/Subject Name: Number Theory-II **Subject Code: MAT014D406**

L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Objective: The objectives of **Number Theory-II** (**MAT014D406**) are

- To impart the basic structure and properties of integers.
- To enable improving one's ability of mathematical thinking.

Prerequisite:

- Basic concept of Number Theory.

Detailed Syllabus:

Modules	Topics / Course Contents	Periods
I.	**Numbers of special form** Numbers of special form, perfect number, Mersenne primes, Amicable numbers, Fermat number, representation of integers as sums of more than two squares.	**12**
II	**Fibonacci numbers and continued fractions** Fibonacci numbers, the Fibonacci sequence, identities involving Fibonacci numbers. Continued fractions, simple continued fractions, approximation of irrational numbers by continued fractions, solution of Pell's equation.	**12**
III	**Algebraic numbers** Algebraic numbers, number fields, discriminants, norms and traces, algebraic integers, rings of integers, integral bases, Quadratic fields.	**12**
IV	**Partition of numbers** Introduction to partitions, geometric representation, generating function, Euler's pentagonal number theorem, Jacobi triple product identity, recursion formula for P(n).	**12**

Total	48

Text Books:

1. *Elementary Number Theory,* Burton, D. M., 7th edition , 2010, McGraw-Hill Education.
2. *Introduction to Analytic Number Theory*, Apostol, T. M., 2010, Springer International StudentEdition, Narosa Publishing House, New Delhi.
3. *Algebraic Number Theory,* Mollin, R. A., 2003 , CRC Press.

Reference Books:

1. Hardy, G.H. and Wright, E. M., *An Introduction to the Theory of Numbers*; 6th edition, 2008, Oxford University Press.
2. Andrews, G.E., *Number Theory*, Revised Edition 1994, Dover Publication.
3. Telang S. G., *Number Theory*, 2003, Tata McGraw-Hill, New Delhi.

Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
The students will be able to 1.Identify numbers of special forms like , perfect number, Mersenne primes, Amicable numbers, Fermat number. 2.Represent integers as sum of squares. 3.Understand the concept of continued fraction and how number theory is used in continued fraction. 4.Learn algebraic numbers, number fields, algebraic integers, rings of integers, Quadratic fields. 5.Know the concept of partition of numbers, generating function.	(i) Each topic to be expounded with examples. (ii) Students to be motivated to take part in discussions and ask questions. (iii) Students to be given homework/assignments. (iv) Discuss and solve the theoretical problems in the class. (v) Students to be encouraged to give short presentations.	(a)Participation in class discussions (b)Continuous Evaluation(30Marks) (i)15 marks on • Assignments • class tests. • viva-voce or presentation (ii) Mid-term examinations :10 marks (iii) Class attendance -5 marks (c) End-term examinations.-70 marks.

SYLLABUS (4th SEMESTER)

Paper VII/Subject Name: Bio-Mathematics **Subject Code: MAT014D407**

L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Objective: The main objective of **Bio-Mathematics** (**MAT014D407**) are

- To introduce the basic concepts of Mathematical modeling which is applicable in every physical system.
- To impart knowledge on theories and techniques of mathematical modeling in different biological systems
- To enable dealing with the formulation as well as stability analysis of the models.

Prerequisites: Concept of Ordinary and partial differential equations, Numerical integration.

Detailed Syllabus:

Modules	Topics/Course content	Periods
I	**Continuous Population Models for Single Species** Introduction to Mathematical Modelling-Need, Techniques, Classification and simple Illustrations. Continuous Growth Models, Insect Outbreak Model: Spruce Budworm, Delay Models , Linear Analysis of Delay Population Models: Periodic Solutions , Delay Models in Physiology: Periodic Dynamic Diseases , Harvesting a Single Natural Population,. Population Model with Age Distribution.	**12**
II	**Discrete Population Models for Single Species** Introduction: Simple Models,Cob webbing: A Graphical Procedure of Solution, Discrete Logistic-TypeModel: Chaos ,Stability, eriodic Solutions and Bifurcations , Discrete Delay Models, Fishery Management Model, Ecological Implications and Caveats Tumour Cell Growth.	**12**
III	**Models for Interacting Populations** Predator–Prey Models: Lotka–Volterra Systems,Complexity and Stability, Realistic Predator–Prey Models , Analysis of a Predator–Prey Model with Limit Cycle Periodic Behaviour: Parameter Domains of Stability , Competition Models: Competitive Exclusion Principle.	**12**

IV	**Epidemic and Disease Models** Simple epidemic model, S-I-S.Model, SIS with constant number of carriers, Epidemic model with removal,Epidemic model with remival and immigration. Modeling diseases such as Diabetes and Cancer.	**12**
Total		**48**

Text Books:

1. *Mathematical Modeling*, J.N. Kapur, 2nd Edition, 2015, New Age International Pub.

***Reference Books*:**

1. Edward A. Bender, *An introduction to mathematical Modeling*, 2002, CRC Press.
2. Walter J. Meyer, *Concepts of Mathematical Modeling*, 2000.Dover Publ.
3. Mark M. Meerschaert, *Mathematical Modeling*, 2007, Elsevier Publ.
4. J.D. Murray, *Mathematical Biology:I. An Introduction*, third Edition, Springer

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Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
The students will be able to (i)Express various real world problems into a mathematical problem. (ii)Validate the models numerically. (iii)Study the stability of the system. (iv)Develop Delay model, Prey-predator model, epidemic model etc.	(i) Each topic to be expounded withexamples. (ii) Students to be motivated to take part in discussions and ask questions. (iii) Students to be given homework/assignments. (iv) Discuss and solve the theoretical problems in theclass. (v) Students to beencouraged to give shortpresentations.	(a)Participation in classdiscussions (b)Continuous Evaluation(30Marks) (i)15 marks on • Assignments • classtests. • viva-voce or presentation (ii) Mid-term examinations :10 marks (iii) Class attendance -5 marks (c) End-term examinations.-70 marks.

SYLLABUS (4th SEMESTER)

Paper VIII/Subject Name: Multivariate Analysis-II **Subject Code: MAT014D408**

L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Objective: The objective of **Multivariate Analysis-II (MAT014D408)** is

- To impart understanding minimum knowledge of continuous probability distribution.
- To make the student understand and apply **Multivariate Analysis-II** to solve real value problems.

Prerequisites:

- Knowledge of bivariate distribution
- Knowledge of correlation and regression
- Knowledge of matrix

Detailed Syllabus:

Modules	Topics / Course content	Periods
I.	**Correlation**: Multiple and partial correlation. Linear and multiple regression co-efficient of determination and its uses. Tests of significance of multiple and partial correlation coefficient. Multivariate normal distribution, singular and nonsingular normal distribution, characteristic function, moments, marginal and conditional distributions maximum likelihood estimators of the parameters of multivariate normal distribution and their sampling distribution, distribution of sample mean vector.	12
II.	**Wishart matrix-** Wishart matrix-its distribution without proof and properties. Distribution of sample generalized variance, Applications in testing and interval estimation, Wilks λ [Introduction, definition, distribution (statement only)].	12
III.	**Hotelling's T2** Hotelling's T2 statistic and its null distribution. Application in tests on mean vector for one and more multivariate normal populations and also on the equality of the components of a mean vector in a multivariate normal population. Application of T2 statistic and its relationship with Mahalanobis' D2 statistic. Confidence region for the mean vector. Applications of D2 statistics.	12

IV.	**Classification and discrimination** : Procedures for discrimination between two multivariate normal populations. Fisher's discriminant function, tests associated with discriminant function, Sample discriminant function. Probabilities of misclassification and their estimation. Classification into more than two multivariate populations. Principal components. Dimension reduction. Canonical variables and anonical correlation, definition, uses, estimation and computation.	**12**
Total		**48**

Text Book:

1. *An introduction to multivariate statistical analysis*, Anderson T. W., 3rd Edition (Reprint), 2003, Wiley Eastern Private Ltd., New Delhi.

Reference Books:

1. Kshirsagar A. M., Multivariate analysis, 1st Edition, 1972, M. Dekker Publication, NewYork.
2. Rao C. R., *Linear statistical inference and its applications*, 2nd edition, 2002, Wiley-Blackwell ***Course Outcomes:***

Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
The students will be able to (i) Understand the continuous probability distribution, Cause and effect relation of multivariate distribution. (ii) Test the multivariate normal distribution and its confidence region. (iii) Apply the discriminant analysis in multivariate populations.	(i) Each topic to be expounded withexamples. (ii) Students to be motivated to take part in discussions and ask questions. (iii) Students to be given homework/assignments. (iv) Discuss and solve the theoretical problems in theclass. (v) Students to beencouraged to give shortpresentations.	(a)Participation in classdiscussions (b)Continuous Evaluation(30Marks) (i)15 marks on • Assignments • classtests. • viva-voce or presentation (ii) Mid-term examinations :10 marks (iii) Class attendance -5 marks (c) End-term examinations.-70 marks.

SYLLABUS (4th SEMESTER)

Paper VIII/Subject Name: Major Project		**Subject Code: MAT014D408**
L-T-P-C: 0-0-0-12	**Credit Units: 12**	**Scheme of Evaluation:**

Objective: The objectives of **Major Project** (**MAT014D408**) are

- To develop student's ability to individual major research
- To inculcate critical understanding of a topic relevant research interest
- To instill the ability of writing research report
- To develop the ability to communicate through presentation

Detailed Syllabus

Modules	**Topics / Course content**	*Periods*
I	Ethics of research	**12**
II	Literature Review. Learn new and relevant tools of mathematics for the topic of interest	**12**
III	Topic selection and research work on the selected topic under supervision	**12**
IV	Write thesis on the findings of the topic and prepare presentation for graduate seminar	**12**
Total		**48**

Facilitating the Achievement of Course Learning Outcomes

Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
• Learn about the ethical part of any research. • Learn how a choice of research and associated methodology relates to how a research problem is conceptualized. • Learn to develop critically understand the topic. • Learn to demonstrate the role of research, investigation and creative work in production of knowledge and meaning. • Learn to communicate through presentation • Learn how to write research reports	(i)One to one interaction of Guide and students (ii) Use of research Lab to learn word processing, PPT presentation skill or any other mathematical tools needed for the seminar .	(a)Participation in class discussions (b)Continuous Evaluation(30Marks) (i)25 marks on • Skill Test • Quiz. (ii) Class attendance - 5 marks (C) SEE (70) Presentation • Report writing • Presentation Skill • Depth of minor research • Viva-voce .