Department of Mathematics

Jaypee Institute of Information Technology, Noida

<u>Semester I</u>

Ordinary Differential Equations (19M21MA111)

Initial value problems, boundary-value problems, variation of parameters, Cauchy-Euler equation, series solution, Bessel's equation and Bessel functions, solution of system of linear differential equations by matrix method, the fundamental existence and uniqueness theorem, Sturm-Liouville boundary value problems, Green's function, nonlinear ordinary differential equations.

Course Description

<table>
<tr><td>Course Code</td><td>19M21MA111</td><td colspan="2">Semester Odd</td><td colspan="2">Semester I Session- 2023- 2024
Month from July 2023-Dec 2024</td></tr>
<tr><td>Course Name</td><td colspan="5">Ordinary Differential Equations</td></tr>
<tr><td>Credits</td><td colspan="2">4</td><td colspan="2">Contact Hours</td><td>3-1-0</td></tr>
<tr><td rowspan="2">Faculty (Names)</td><td>Coordinator(s)</td><td colspan="4"></td></tr>
<tr><td>Teacher(s) (Alphabetically)</td><td colspan="4"></td></tr>
<tr><td colspan="5">COURSE OUTCOMES</td><td>COGNITIVE LEVELS</td></tr>
<tr><td colspan="6">After pursuing the above-mentioned course, the students will be able to:</td></tr>
<tr><td>C110.1</td><td colspan="4">explain the basic theory of ordinary differential equations and solve related problems.</td><td>Applying Level (C3)</td></tr>
<tr><td>C110.2</td><td colspan="4">make use of Frobenius method in solving differential equations.</td><td>Applying Level (C3)</td></tr>
<tr><td>C110.3</td><td colspan="4">apply matrix method to solve a system of homogeneous linear ordinary differential equations.</td><td>Applying Level (C3)</td></tr>
<tr><td>C110.4</td><td colspan="4">explain the concept of existence and uniqueness theorem of initial value problems.</td><td>Understanding Level (C2)</td></tr>
<tr><td>C110.5</td><td colspan="4">make use of orthogonality of functions in solving Sturm-Liouville boundary value problems.</td><td>Applying Level (C3)</td></tr>
<tr><td>C110.6</td><td colspan="4">explain the phase plane, critical points and paths of nonlinear systems.</td><td>Understanding Level (C2)</td></tr>
<tr><td>Module No.</td><td>Title of the Module</td><td colspan="3">Topics in the Module</td><td>No. of Lectures for the module</td></tr>
<tr><td>1.</td><td>Basic theory of linear</td><td colspan="3">Initial value problems, boundary-value problems and existence of solutions, the homogeneous linear equation with constant coefficients, variation of</td><td>8</td></tr>
</table>

	differential equations	parameters, the Cauchy-Euler equation, applications to ordinary differential equations in LCR and mass spring problem.	
2.	Series solution	Power series solutions about an ordinary point, solutions about singular points; the method of Frobenius, Bessel's equation and Bessel functions.	**5**
3.	System of linear differential equations	The matrix method for homogeneous linear systems with constant coefficients: two equations in two unknown functions.	**5**
4.	Existence and uniqueness theory	The fundamental existence and uniqueness theorem, dependence of solutions on initial conditions and on the function.	**6**
5.	Sturm-Liouville boundary value problems	Theory of the homogeneous linear system, the non-homogeneous linear system, Strum Theory, Strum-Liouville problems, orthogonality of characteristic functions, the expansion of a function in a series of orthonormal functions, trigonometric Fourier series, Green's function.	**14**
6.	Nonlinear differential equations	Phase plane, paths and critical points, critical points and path of linear systems, critical points and path of non-linear systems.	**4**
		Total number of lectures	**42**

Evaluation Criteria

Components	**Maximum Marks**
T1	20
T2	20
End Semester Examination	35
TA	25 (Quiz, Assignments, Tutorials)
Total	**100**

Project based learning: Each student in a group of 3-4 will apply the concepts of homogeneous and non-homogeneous linear systems and BVPs to solve practical problems.

Recommended Reading material: Author(s), Title, Edition, Publisher, Year of Publication etc. (Text books, Reference Books, Journals, Reports, Websites etc. in the IEEE format)

1.	**S. L. Ross,** Differential Equations, 3rd Ed., John Wiley & Sons, Singapore, 2007.
2.	**G. F. Simmons,** Differential Equations with Applications and Historical Notes, 3rd Ed., CRC Press, Boca Raton, 2016.
3.	**P. L. Sachdev,** A Compendium on Nonlinear Ordinary Differential Equations, Wiley-Blackwell, 1996.
4.	**E. A. Coddington and R. Carlson,** Introduction to Ordinary Differential Equations, SIAM, USA, 1997.

<u>CO-PO-PSO Mapping</u>

	PO1	PO2	PO3	PSO1
C110.1	**3**	**2**	**-**	**2**
C110.2	**3**	**2**	**-**	**2**
C110.3	**3**	**2**	**-**	**2**
C110.4	**2**	**1**	**-**	**2**
C110.5	**3**	**2**	**-**	**2**
C110.6	**2**	**1**	**-**	**1**

Real Analysis (19M21MA112)

Sets, convergence of sequences and series, absolute convergence, limit, continuity, compactness, connectedness, Riemann-Stieltjes integral, sequences and series of functions, uniform convergence, equi-continuous families of functions, Stone Weierstrass theorem, measurable sets and their properties, Lebesgue measure, measurable functions, Lebesgue integral of functions of arbitrary sign, integrable functions.

Course Description

<table>
<tr><td>Course Code</td><td colspan="2">19M21MA112</td><td colspan="2">Semester Odd</td><td colspan="2">Semester I Session- 2023- 2024
Month from July 2023-Dec 2024</td></tr>
<tr><td>Course Name</td><td colspan="6">Real Analysis</td></tr>
<tr><td>Credits</td><td colspan="3">4</td><td colspan="2">Contact Hours</td><td>3-1-0</td></tr>
<tr><td rowspan="2">Faculty (Names)</td><td colspan="2">Coordinator(s)</td><td colspan="4"></td></tr>
<tr><td colspan="2">Teacher(s) (Alphabetically)</td><td colspan="4"></td></tr>
<tr><td colspan="6">COURSE OUTCOMES</td><td>COGNITIVE LEVELS</td></tr>
<tr><td colspan="7">After pursuing the above-mentioned course, the students will be able to:</td></tr>
<tr><td>C111.1</td><td colspan="5">explain the concepts of compact sets, connected sets, metric space and their properties.</td><td>Understanding Level (C2)</td></tr>
<tr><td>C111.2</td><td colspan="5">explain the convergence of sequences, series and their properties.</td><td>Understanding Level (C2)</td></tr>
<tr><td>C1113</td><td colspan="5">make use of the concepts of continuity, compactness and connectedness of functions in solving related problems.</td><td>Applying Level (C3)</td></tr>
<tr><td>C111.4</td><td colspan="5">explain the Riemann-Stieltjes integral and its properties.</td><td>Understanding Level (C2)</td></tr>
</table>

C111.5	apply the concepts of sequence and series of functions, their uniform convergence and properties on various problems.		Applying Level (C3)
C111.6	solve the problems on Lebesgue integral of functions.		Applying Level (C3)
Module No.	**Title of the Module**	**Topics in the Module**	**No. of Lectures for the module**
1.	Review of sets	Finite, countable and uncountable sets, metric spaces, compact sets, perfect sets, connected sets.	**4**
2.	Sequences and series	Convergent sequences, sub sequences, Cauchy sequences, power series, absolute convergence, algebra of series, rearrangements of elements in a series	**5**
3.	Continuity	Limits of functions, continuous functions, compactness, connectedness, monotonic functions, infinite limits and limits at infinity.	**6**
4.	The Riemann-Stieltjes integral	Definition and existence of the Riemann-Stieltjes integral, properties of the integral, integration and differentiation, integration of vector-valued functions, rectifiable curves.	**9**
5.	Sequence and series of functions	Sequences and series of functions: interchanging order of limits for sequences of functions, uniform convergence, uniform convergence and continuity, uniform convergence and integration, uniform convergence and differentiation, equi-continuous families of functions, Stone Weierstrass theorem.	**10**
6.	Lebesgue theory	Measurable sets and their properties, Lebesgue measure, measurable functions, Lebesgue integral of functions of arbitrary sign, integrable functions.	**8**
		Total number of lectures	**42**

Evaluation Criteria

Components	**Maximum Marks**
T1	20
T2	20
End Semester Examination	35
TA	25 (Quiz, Assignments, Tutorials)
Total	**100**

Project based learning: Students will be divided in the group of 2-3 students to collect the literature and to explore the applications of series, sequences and Lebesgue integral. For ex: Lebesgue integral in probability theory.

Recommended Reading material: Author(s), Title, Edition, Publisher, Year of Publication etc. (Text books, Reference Books, Journals, Reports, Websites etc. in the IEEE format)

1.	**W. Rudin,** Principles of Mathematical Analysis, 3rd Ed., New Delhi, McGraw-Hill Inc., 2013.
2.	**H. L. Royden, and P. M. Fitzpatrick,** Real Analysis, 4rd Ed., New Delhi, Pearson, 2010.
3.	**N. L. Carothers,** Real Analysis, Cambridge University Press, 2000.
4.	**T. M. Apostol,** Mathematical Analysis –A modern approach to Advanced Calculus, New Delhi, Addison-Wesley, 1974.
5.	**R. G. Bartle, and D. R. Sherbert,** Introduction to Real Analysis, 4th Ed., Wiley, 2011.

CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1
C111.1	**2**	**1**	**-**	**1**
C111.2	**2**	**1**	**-**	**1**
C111.3	**3**	**2**	**-**	**2**
C111.4	**2**	**1**	**-**	**1**
C111.5	**3**	**2**	**-**	**2**
C111.6	**3**	**2**	**-**	**2**

Abstract Algebra (19M21MA113)

Review of basic group theory, Cayley's, Cauchy's and Sylow's theorems, rings, ideals, integral domain, polynomial rings, modules, quotient modules, cyclic modules, free modules, fields, finite fields, field extension, splitting fields and Galois theory.

Course Description

<table>
<tr><td>Course Code</td><td>19M21MA113</td><td colspan="2">Semester Odd</td><td colspan="2">Semester I Session- 2023- 2024
Month from July 2023-Dec 2024</td></tr>
<tr><td>Course Name</td><td colspan="5">Abstract Algebra</td></tr>
<tr><td>Credits</td><td colspan="2">4</td><td colspan="2">Contact Hours</td><td>3-1-0</td></tr>
<tr><td rowspan="2">Faculty (Names)</td><td>Coordinator(s)</td><td colspan="4"></td></tr>
<tr><td>Teacher(s) (Alphabetically)</td><td colspan="4"></td></tr>
<tr><td colspan="5">COURSE OUTCOMES</td><td>COGNITIVE LEVELS</td></tr>
<tr><td colspan="6">After pursuing the above-mentioned course, the students will be able to:</td></tr>
</table>

C112.1	illustrate various types of groups and their properties.	Understanding Level (C2)
C112.2	explain Cayley, Cauchy, Sylow theorems and solve related problems.	Applying Level (C3)
C112.3	explain the concepts of rings, ideals and isomorphism.	Understanding Level (C2)
C112.4	solve problems on integral domain, principal ideal domains and unique factorization domains (UFD).	Applying Level (C3)
C112.5	explain and identify modules, submodules, quotient modules and free modules.	Applying Level (C3)
C112.6	explain and analyze the concepts of fields and their extensions.	Analyzing Level (C4)

Module No.	**Title of the Module**	**Topics in the Module**	**No. of Lectures for the module**
1.	Groups	Review of basic group theory, isomorphism theorems, group actions, Cayley's theorem, class equation of a group, Cauchy's theorem, p-groups, Sylow's theorems and their applications.	**10**
2.	Rings	Rings, ideals and homomorphisms, quotient rings, isomorphism theorems, prime and maximal ideals, rings of fractions, integral domain, Euclidean domains, principal ideal domains and unique factorization domains (UFD), polynomial rings over UFDs, criteria for irreducibility of polynomials over UFD's.	**12**
3.	Modules	Basic definitions and examples, submodules and direct sums, quotient modules, homomorphism and isomorphism theorems, cyclic modules, free modules.	**10**
4.	Fields	Fields and their extensions, algebraic and finitely generated field extensions, splitting fields and normal extensions, algebraic closures, finite fields, separable and inseparable extensions, Galois groups, fundamental theorem of Galois theory.	**10**
		Total number of lectures	**42**

Evaluation Criteria

Components	**Maximum Marks**
T1	20
T2	20
End Semester Examination	35
TA	25 (Quiz, Assignments, Tutorials)
Total	**100**

Project based learning: Students in small groups will opt a topic form the concerned CO. Students must explore those areas where the theory of fields is used. For example, finite fields are used in number theory, Galois theory, coding theory and combinatorics; and again, the notion

of algebraic extension is an important tool. Such type of activity enhances student's knowledge in this domain.
Recommended Reading material: Author(s), Title, Edition, Publisher, Year of Publication etc. (Text books, Reference Books, Journals, Reports, Websites etc. in the IEEE format)

1.	**D. S. Dummit and R. M. Foote,** Abstract Algebra, 2nd Ed., John Wiley & Sons, 2008.
2.	**S. K. Jain, P. B. Bhattacharya and S. R. Nagpaul,** Basic Abstract Algebra, 2nd Ed., Cambridge University Press, 2014.
3.	**I. N. Herstein,** Topics in Algebra, 2^{nd} Ed., John Wiley & Sons, 2006.
4.	**J. B. Fraleigh, A** First Course in Abstract Algebra, 7th Ed., Pearson Education, 2013.
5.	**C. Carstensen, B. Fine, B. and G. Rosenberger,** Abstract Algebra: Applications to Galois Theory, Algebraic Geometry and Cryptography, Heldermann Verlag, 2011.

CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1
C112.1	**2**	**1**	**-**	**1**
C112.2	**3**	**2**	**-**	**2**
C112.3	**2**	**1**	**-**	**1**
C112.4	**3**	**2**	**-**	**2**
C112.5	**3**	**2**	**-**	**2**
C112.6	**3**	**2**	**-**	**2**

General Topology (19M21MA114)

Metric space, Cantor intersection theorem, topological space, basis for a topology, subspace topology, weak topology, product topology, quotient topology, Continuous maps, continuity theorems for open and closed sets, homeomorphism, connected spaces, totally disconnected space, locally connected space, compact space, continuity and compactness, Tychonoff theorem, first and second countable spaces, normal spaces, completely normal and completely regular spaces, Tietz extension theorem, Uryshon lemma, Uryshon metrization theorem.

Course Description

Course Code	**19M21MA114**	**Semester Odd**	**Semester I Session-** 2023- 2024 **Month from** July 2023-Dec 2024
Course Name	General Topology		
Credits	4	**Contact Hours**	3-1-0

<table>
<tr><td rowspan="2">Faculty (Names)</td><td>Coordinator(s)</td><td colspan="2"></td></tr>
<tr><td>Teacher(s) (Alphabetically)</td><td colspan="2"></td></tr>
<tr><td colspan="3">COURSE OUTCOMES</td><td>COGNITIVE LEVELS</td></tr>
<tr><td colspan="4">After pursuing the above-mentioned course, the students will be able to:</td></tr>
<tr><td>C113.1</td><td colspan="2">explain metric space, topological spaces and related concepts.</td><td>Understanding Level(C2)</td></tr>
<tr><td>C113.2</td><td colspan="2">solve problems on different types of topologies.</td><td>Applying Level (C3)</td></tr>
<tr><td>C113.3</td><td colspan="2">explain continuous maps, continuity theorem, homeomorphisms and related concepts.</td><td>Understanding Level (C2)</td></tr>
<tr><td>C113.4</td><td colspan="2">apply the properties of connected spaces and compact spaces in proving various theorems.</td><td>Applying Level (C3)</td></tr>
<tr><td>C113.5</td><td colspan="2">make use of the concepts of countability and separation in various topological spaces.</td><td>Applying Level (C3)</td></tr>
<tr><td>Module No.</td><td>Title of the Module</td><td>Topics in the Module</td><td>No. of Lectures for the module</td></tr>
<tr><td>1.</td><td>Metric Space</td><td>Metric space, open sets, closed sets</td><td>2</td></tr>
<tr><td>2.</td><td>Metric Space</td><td>Convergence, completeness, continuity in metric space</td><td>3</td></tr>
<tr><td>3.</td><td>Metric Space</td><td>Cantor intersection theorem</td><td>1</td></tr>
<tr><td>4.</td><td>Topological space</td><td>Topological space, elementary concept, basis for a topology</td><td>2</td></tr>
<tr><td>5.</td><td>Topological space</td><td>Open and closed sets, interior and closure of sets, neighbourhood of a point, limit points, boundary of a set</td><td>3</td></tr>
<tr><td>6.</td><td>Topological space</td><td>Subspace topology, weak topology</td><td>2</td></tr>
<tr><td>7.</td><td>Topological space</td><td>Product topology, quotient topology</td><td>2</td></tr>
<tr><td>8.</td><td>Compactness and Connectedness</td><td>Continuous maps, continuity theorems for open and closed sets, homeomorphism</td><td>4</td></tr>
<tr><td>9.</td><td>Compactness and Connectedness</td><td>Connected spaces, continuity and connectedness, components, totally disconnected space, locally connected space</td><td>4</td></tr>
<tr><td>10.</td><td>Compactness and Connectedness</td><td>Compact space, limit point compact, sequentially compact space, local compactness</td><td>4</td></tr>
</table>

11.	Compactness and Connectedness	Continuity and compactness, Tychonoff theorem	**3**
12.	Countability and Separation	First and second countable spaces, T_1 spaces, Hausdorff spaces	**3**
13.	Countability and Separation	Regular spaces, normal spaces, completely normal space, completely regular space	**5**
14.	Countability and Separation	Tietz extension theorem, Metrizability, Uryshon lemma, Uryshonmetrization theorem	**4**
		Total number of lectures	**42**

Evaluation Criteria

Components	**Maximum Marks**
T1	20
T2	20
End Semester Examination	35
TA	25 (Quiz, Assignments, Tutorials)
Total	**100**

Project based learning: Each student in a group of 3-4 will apply the concepts countability and separation axioms to find distinct points in different types of topological spaces.

Recommended Reading material: Author(s), Title, Edition, Publisher, Year of Publication etc. (Text books, Reference Books, Journals, Reports, Websites etc. in the IEEE format)

1.	**G. F. Simmons,** Introduction to Topology and Modern Analysis, Tata Mc-Graw Hill Education, New Delhi, 2016.
2.	**J. R. Munkres,** Topology: A First Course, 2nd Ed., PHI, 2010.
3.	**Y. Min,** Introduction to Topology: Theory & Applications, Higher Education Press, 2010.
4.	**S. Lipschutz,** General Topology, Schaum's Outline Series, Mc-Graw-Hill, 1985.
5.	**C. A. R. Franzosa,** Introduction to Topology, Narosa Publishers, New Delhi, 2007.
6.	**K. D. Joshi,** Introduction to General Topology, New Age Publishers, New Delhi, 1983.

<u>CO-PO-PSO Mapping</u>

	PO1	**PO2**	**PO3**	**PSO1**
C113.1	**2**	**1**	**-**	**1**
C113.2	**3**	**2**	**-**	**2**
C113.3	**2**	**1**	**-**	**1**
C113.4	**3**	**2**	**-**	**2**
C113.5	**3**	**2**	**-**	**2**

Mathematical Methods (19M21MA115)

Introduction, Euler equation, variational problems with constraints, geodesics and isoperimetric problems, moving end problems, Rayleigh-Ritz, Galerkin's and Kantorovich method. Integral equations of Fredholm and Volterra type, integral equations with degenerate kernels, Fredholm's theorems, eigenvalues and eigen functions of integral equations, Green's function, influence function, Abel integral equation, weakly singular kernel, Laplace transform, Fourier transform, Hankel and Mellin transform, Fox's integral equation.

Course Description

Course Code	**19M21MA115**	**Semester Odd**	**Semester I Session-** 2023- 2024 **Month from** July 2023-Dec 2024
Course Name	Mathematical Methods		
Credits	4	**Contact Hours**	3-1-0
Faculty (Names)	**Coordinator(s)**		
	Teacher(s) (Alphabetically)		

COURSE OUTCOMES		**COGNITIVE LEVELS**
After pursuing the above-mentioned course, the students will be able to:		
C114.1	explain functionals and their variations to optimize various problems.	Understanding Level(C2)
C114.2	apply different forms of Euler's equation on different variational problems.	Applying Level (C3)
C114.3	explain and solve different types of integral equations and their eigenvalue problems.	Applying Level (C3)
C114.4	solve boundary value problems and singular integral equations.	Applying Level (C3)
C114.5	apply different linear integral transforms in solving differential and integral equations.	Applying Level (C3)

Module No.	**Title of the Module**	**Topics in the Module**	**No. of Lectures for the module**
1.	Functional and its Variation	Introduction, variation and its properties, comparison between the notion of extrema of a function and a functional, construction of functional, problem of brachistochrone, geodesics and isoperimetric problem.	**6**
2.	Variational Problems with	The system of Euler's equations, the fundamental lemma of the calculus of	**10**

	fixed and moving Boundaries	variations, examples, functionals in the form of integrals, special cases containing only some of the variables, functionals depending on the higher derivatives of the dependent variables, Euler-Poisson equation, Ostrogradsky equation, moving end problems, Rayleigh-Ritz method, Galerkin's method and Kantorovich method of solving differential equations.	
3.	Integral equations	Integral equations of Fredholm and Volterra type, Conversion from IVP and BVP. Solution by successive substitution and successive approximation, integral equations with degenerate kernels. Fredholm's theorems, integral equations with symmetric kernel, eigenvalues and eigenfunctions of integral equations and their simple properties.	**10**
4.	Applications of integral equations	Longitudinal vibrations of the rod, deformation of a rod, Green's function, influence function, construction of Green's function when the boundary value problem contains a parameter, Abel integral equation, weakly singular kernel, iteration of the singular equation.	**8**
5.	Integral transform methods	Introduction, Laplace transform, properties of the Laplace transform, application to Volterra integral equation, Fourier transform, application of Fourier transform, introduction to Hankel and Mellin transform, Fox's integral equation.	**8**
		Total number of lectures	**42**

Evaluation Criteria

Components	**Maximum Marks**
T1	20
T2	20
End Semester Examination	35
TA	25 (Quiz, Assignments, Tutorials)
Total	**100**

Project based learning: Students will be divided in the group of 2-3 students to collect the literature and explore the different methods to solve Integral equations.

Recommended Reading material: Author(s), Title, Edition, Publisher, Year of Publication etc. (Text books, Reference Books, Journals, Reports, Websites etc. in the IEEE format)

1.	**L. Elsegolc,** Calculus of Variation, Dover Publications, 2010.

2.	**I. M. Gelf and, S.V. Fomin,** Calculus of Variations, Prentice Hall, 2012.
3.	**R. P. Kenwal,** Linear Integral Equation; Theory and Techniques, Academic Press, 1971.
4.	**F. B. Hildebrand,** Methods of Applied Mathematics, Dover Publications, 1992.
5.	**S. Pal and S. C. Bhunia,** Engineering Mathematics, Oxford University Press, 2015.
6.	**I. G. Petrovsky,** Lectures on the Theory of Integral Equations, Mir Publishers, Moscow, 1971.
7.	**L. Debnath and D. Bhatta,** Integral Transforms and Their Applications, Chapman and Hall/ CRC, 2006.

CO-PO-PSO Mapping

	PO1	PO2	PO3	PSO1
C114.1	**2**	**1**	**-**	**1**
C114.2	**3**	**2**	**-**	**2**
C114.3	**3**	**2**	**-**	**2**
C114.4	**3**	**2**	**-**	**3**
C114.5	**3**	**2**	**-**	**3**