UNIVERSITY OF RAJASTHAN
JAIPUR

<u>SYLLABUS</u>

M.A./M.SC. MATHEMATICS
Semester Scheme

I/II Semester Examination 2025-2026 and onwards
III/IV Semester Examination 2026-2027 and onwards

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University of Rajasthan, Jaipur

M.A./M.Sc. Syllabus in Mathematics credit-based Semester System (Four Semesters in two years) with continuous assessment [20% with inclusion in Cumulative Grade point average (CGPA)].

To obtain a Master's Degree M.A./M.Sc. in Mathematics, a candidate is required to earn 120 credits with grade C or higher. For this, each Semester will offer 36 credits. To earn credits for a paper, a candidate shall be required to obtain grade C or higher (or equivalent marks percentage) in the theory/practical examination. A candidate has to pass in the continuous assessment (internal) as well as in that paper separately. In continuous assessment and End of Semester Examination (EoSE) separate grades will be awarded. The candidate will not be permitted to appear in EoSE of a particular credit, if he/she does not meet out 75% attendance requirement, or any other requirement to be decided by the university.

The Credit Courses have been classified as

a) Compulsory Core Courses (CCC)

b) Elective Core Courses (ECC)

A course is identified by a course code designated by a string of six alphanumeric characters and a course title. In a course code the first three characters of the string indicate the Department offering the course and the later three alphanumeric characters designate a particular course. In the case of compulsory core course the fourth character identifies the semester numeric digit and in case of the elective core courses the fourth character indicates the cluster of specialization. For compulsory or elective theory core courses the fifth character is '0' and for laboratory core course it is '1'.

First Semester

S.No.	**Subject Code**	**Course Title**	**Course Category**	**Credit**	**Contact Hours per week**	**EoSE Duration (Hrs.)**
1.	MAT 701	Algebra-I	CCC	6	6	3
2.	MAT 702	Real Analysis	CCC	6	6	3
3.	MAT 703	Differential Equations-I	CCC	6	6	3
4.	MAT 704	Differential Geometry	ECC	6	6	3
5.	MAT 705	Dynamics of Rigid Bodies	ECC	6	6	3
6.	MAT 706	Calculus of Variation and Special Function-I	ECC	6	6	3
7.	MAT 707	Mathematical Statistics-I	ECC	6	6	3
		Total Credits in the Semester		36		

Candidates are required to opt any three elective core courses (6 credits each) from MAT 704, MAT 705, MAT 706, MAT 707.

Second Semester

S.No.	Subject Code	Course Title	Course Category	Credit	Contact Hours per week	EoSE Duration (Hrs.)
1.	MAT 801	Algebra-II	CCC	6	6	3
2.	MAT 802	Topology	CCC	6	6	3
3.	MAT 803	Differential Equations-II	CCC	6	6	3
4.	MAT 804	Riemannian Geometry and Tensor Analysis	ECC	6	6	3
5.	MAT 805	Hydrodynamics	ECC	6	6	3
6.	MAT 806	Special Functions-II	ECC	6	6	3
7.	MAT 807	Mathematical Statistics-II	ECC	6	6	3
		Total Credits in the Semester		36		

EoSE : End of Semester Examination

Candidates are required to opt any three elective core courses (6 credits each) from MAT 804, MAT 805, MAT 806, MAT 807.

Elective Core Courses

Specialization Clusters

A. CM Continuum Mechanics
B. BLT Boundary Layer Theory
C. MP Mathematical Programming
D. CGT Combinatorics and Graph Theory
E. ITE Integral Transforms and Integral Equations
F. RC Relativity and Cosmology
G. IM Industrial Mathematics
H. MHD Magnetohydrodynamics
I. NA Numerical Analysis
J. CA Computer Applications

Elective Course	Specialization	Paper	Prerequisite	Credit
MAT A01	CM	Continuum Mechanics-I	-	6
MAT A02	CM	Continuum Mechanics-II	MAT A01	6
MAT B01	BLT	Boundary Layer Theory-I	-	6
MAT B02	BLT	Boundary Layer Theory-II	MAT B01	6
MAT C01	MP	Mathematical Progamming-I	-	6
MAT C02	MP	Mathematical Programming-II	MAT C01	6
MAT D01	CGT	Combinatorics and Graph Theory-I	-	6

MAT D02	CGT	Graph Theory-II	MAT D01	6
MAT F01	RC	Relativistic Mechanics	-	6
MAT F02	RC	General Relativity and Cosmology	MAT F01	6
MAT G01	IM	Industrial Mathematics-I	-	6
MAT G02	IM	Industrial Mathematics-II	MAT G01	6
MAT H01	MHD	Magnetohydrodynamics-I	-	6
MAT H02	MHD	Magnetohydrodynamics-II	MAT H01	6
MAT I01	NA	Numerical Analysis-I	-	6
MAT I02	NA	Numerical Analysis-II	MAT I01	6
MAT J01	CA	Computer Applications-I	-	6
MAT J02	CA	Computer Applications-II	MAT J01	6

Third Semester

S.No.	**Subject Code**	**Course Title**	**Course Category**	**Credit**	**Contact Hours per week**	**EoSE Duration (Hrs.)**
1.	MAT 901	Functional Analysis-I	CCC	6	6	3
2.	MAT 902	Viscous Fluid Dynamics-I	CCC	6	6	3
3.	MAT 903	Integral Transforms	CCC	6	6	3
4.	MAT A01	Continuum Mechanics-I	ECC	6	6	3
5.	MAT B01	Boundary Layer Theory-I	ECC	6	6	3
6.	MAT C01	Mathematical Progamming-I	ECC	6	6	3
7.	MAT D01	Combinatorics and Graph Theory-I	ECC	6	6	3
8.	MAT F01	Relativistic Mechanics	ECC	6	6	3
9.	MAT G01	Industrial Mathematics-I	ECC	6	6	3
10.	MAT H01	Magnetohydrodynamics-I	ECC	6	6	3
11.	MAT I01	Numerical Analysis-I	ECC	6	6	3
12.	MAT J01	Computer Applications-I	ECC	6	6	3
		Total Credits in the Semester		36		

Candidates are required to opt any three elective core courses (6 credits each) from MAT A01, MAT B01, MAT C01, MAT D01, MAT F01, MAT G01, MAT H01, MAT I01, MAT J01.

Total Credits in the Semester 36

Fourth Semester

S.No.	Subject Code	Course Title	Course Category	Credit	Contact Hours per week	EoSE Duration (Hrs.)
1.	MAT X01	Functional Analysis-II	CCC	6	6	3
2.	MAT X02	Viscous Fluid Dynamics-II	CCC	6	6	3
3.	MAT X03	Integral Equations	CCC	6	6	3
4.	MAT A02	Continuum Mechanics-II	ECC	6	6	3
5.	MAT B02	Boundary Layer Theory-II	ECC	6	6	3
6.	MAT C02	Mathematical Progamming-II	ECC	6	6	3
7.	MAT D02	Combinatorics and Graph Theory-II	ECC	6	6	3
8.	MAT F02	General Relativity and Cosmology	ECC	6	6	3
9.	MAT G02	Industrial Mathematics-II	ECC	6	6	3
10.	MAT H02	Magnetohydrodynamics-II	ECC	6	6	3
11.	MAT I02	Numerical Analysis-II	ECC	6	6	3
12.	MAT J02	Computer Applications-II	ECC	6	6	3
		Total Credits in the Semester		36		

Candidates are required to opt the corresponding three elective core courses of same specialization cluster chosen in Semester Third (6 credits each) from MAT A02, MAT B02, MAT C02, MAT D02, MAT F02. MAT G02, MAT H02, MAT I02, MAT J02.

Total Credits in the Semester 36

Program Outcomes (PO)

PO1: To offer students advanced mathematical knowledge in various fields such as algebra, analysis, topology, and applied mathematics.

PO2: To enhance students' analytical and problem-solving skills by using mathematical methods.

PO3: To encourage students to engage in mathematical research

PO4: To highlight the applications of mathematics in other fields, such as physics, engineering, economics and computer science cultivate critical thinking.

PO5: To prepare students for advanced study and careers by providing a strong foundation

PO6: To keep students abreast of emerging mathematical trends, techniques, and technologies

Dy. Registrar
(Academic)
University of Rajasthan
JAIPUR

PO7: To ensure that students understand and adhere to ethical standards in mathematical research and applications.

Program Specific Outcomes (PSO)

PSO1: To provide advance understanding of core areas such as algebra, calculus, and differential equations.

PSO2: To develop techniques for tackling complex mathematical problems and applying solutions.

PSO3: To provide advanced training in statistical methods and data interpretation for research and applied work.

PSO4: To encourage interdisciplinary research and the application of mathematical concepts to real-world problems.

PSO5: To develop skills to clearly present mathematical ideas and research findings in both written and oral formats.

PSO6: To develop competencies for teaching mathematics at a variety of educational levels, including curriculum development and pedagogical techniques.

PSO7: To equip students with advanced skills in mathematical software and programming languages relevant to mathematical research and applications.

Examination Scheme:

1. As per University notifications issued time to time.

2. For Regular Students, final grade/marks in a course/paper will be calculated by adding 20% of Continuous Assessment(CA) Marks and 80% of End of Semester Examination (EoSE) Marks in a course/paper.

3. End of Semester Examination (EOSE):

For Regular students End of Semester Examination shall constitute 80% of the total weightage, based on a formal written examination. There shall be five questions in each question paper of EOSE. There shall be two parts in each question paper viz. Part 'A' and Part 'B'. Part 'A' contains 10 very short answer type questions of 2 marks each covering the syllabus (all four units).

Part 'B' of the question paper shall contain four questions by taking one question from each unit. Each question of Part 'B' will have three subparts. Candidates are required to attempt all four questions of Part 'B' by taking any two subparts of each question. All questions carry equal marks (20 Marks of each question). Candidates are required to attempt all five questions.

4. Continuous Assessment (CA):

Continuous Assessment constituting 20% of the total weightage, based on internal evaluations (Midterm test and Internal Assessment) conducted throughout the semester.

Dy. Registrar
(Academic)
University of Rajasthan
JAIPUR

The internal assessment component will comprise of assessment of students' performance on the basis of factors like Attendance, Classroom Participation, Presentation, Home Assignment/Project, etc.

5. Distribution of Continuous Assessment (CA) Marks shall be as under

S. No.	Category	Weightage (Out of total Internal Marks)	**Theory Paper**
			CCC/CCE
	Max. CA marks		100
1.	Sessional/Midterm test	80%	80
2.	Internal Assessment	20%	20

1. CA will be the sole responsibility (Paper setting and Evaluation) of the teacher concerned. For continuous assessment no remuneration will be paid for paper setting, Evaluation, Invigilation etc.
2. For continuous assessment no Answer sheets/question papers etc. will be provided by the University. Colleges are advised to keep records of continuous assessment, attendance etc.

6. The Candidate shall not be permitted to appear in EoSE –

(i) If he/she does not fulfil the minimum 75% attendance requirement,

(ii) If he/she fails to secure at least 40% marks (C Grade) in each course (paper) in the Continuous Assessment.

Note: Both components shall be mandatory and contribute to the final grade of the student in each course.

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MA/M.Sc. Mathematics
Semester I and II
Syllabus

Semester – I

Paper- 1: MAT 701: Algebra-I
(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	MAT- 701 Algebra-I	3 Hrs	100	40

Semester	Code of the Course	Title of the Course/Paper	NHEQF Level	Credits
I	MAT- 701	Algebra-I		6

Level of Course	Type of the Course	Credit Distribution			Offered to NC Student	Course Delivery Method
		Theory	Practical	Total		
Advance	Major	6	0	6	Yes	Lecture, Ninety lectures

Prerequisites	Mathematics course at UG Level.
Objectives of the Course:	The objective of this course is to provide students with a comprehensive understanding of advanced concepts in group theory and field theory. Students will explore the structure and classification of groups through the direct product, isomorphism theorems, and Sylow's theorems. Additionally, the course will cover essential topics in field theory, including polynomial rings, extension fields, and Galois theory, enabling students to analyze the solvability of polynomial equations and understand the relationships between algebraic structures.

Course Outcomes
Upon successful completion of this course, students will be able to:

1. **Analyze Group Structures:** Demonstrate a thorough understanding of the direct product of groups, isomorphism theorems, and conjugate classes, with the ability to apply these concepts to solve problems in group theory.

2. **Evaluate Normal Series and Solvability:** Examine the concepts of commutators, derived subgroups, normal series, and solvable groups, and apply the Jordan-Hölder theorem to categorize and refine group structures.
3. **Apply Field Theory Principles:** Understand and apply irreducibility criteria in polynomial rings, identify different types of extension fields, and differentiate between algebraic and transcendental extensions.
4. **Utilize Galois Theory:** Analyze the connections between field extensions and group theory through Galois theory, including the fundamental theorem of Galois theory, and evaluate the solvability of polynomial equations by radicals, particularly addressing the insolvability of the general equation of degree five.
5. **Research and Present Findings:** Conduct independent research on advanced topics in group and field theory, and effectively communicate findings through written reports and presentations, demonstrating critical thinking and problem-solving skills.

Unit-1

Direct product of groups (External and Internal). Isomorphism theorems – Diamond isomorphism theorem, Butterfly Lemma, Conjugate classes (Excluding p-groups). Sylow's theorems (without proof), Cauchy's theorem for finite abelian groups.

Unit - 2

Commutators, Derived subgroups. Normal series and Solvable groups, Composition series, Refinement theorem and Jordan-Holder theorem for infinite groups.

Unit - 3

Polynomial rings and irreducibility criteria. Field theory – Extension fields, Algebraic and Transcendental extensions, Separable and inseparable extensions, Normal extensions. Splitting fields.

Unit -4 Galois theory – the elements of Galois theory, Automorphism of extensions, Fundamental theorem of Galois theory, Solutions of polynomial equations by radicals and Insolvability of general equation of degree five by radicals.

Reference Books:

1. Deepak Chatterjee, Abstract Algebra, Prentice – Hall of India (PHI), New Delhi, 2004
2. N.S.Gopalkrishnan, University Algebra, New Age International, 1986.
3. Qazi Zameeruddin and Surjeet Singh, Modern Algebra, Vikas Publishing,2006
4. D. S. Chauhan and K. N. Singh, Studies in Algebra, JPH, 2006
5. G.C.Sharma, Modern Algebra, Shivlal Agrawal & Co., Agra,1998.
6. Joseph A. Gallian, Contemporary Abstract Algebra (4th Ed.), Narosa Publishing House, 1999.
7. David S. Dummit and Richard M. Foote, Abstract Algebra (3rd Edition), John Wiley and Sons (Asia) Pvt. Ltd, Singapore, 2004.

8. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra (4th Edition), Prentice-Hall of India Pvt. Ltd., New Delhi, 2004.
9. I.N. Herstein, Topics in Algebra (2nd edition), John Wiley & Sons, 2006.
10. Michael Artin, Algebra (2nd edition), Pearson Prentice Hall, 2011.

Paper – 2 : MAT 702 : Real Analysis
(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	**MAT 702 : Real Analysis**	**3 Hrs**	**100**	**40**

<table>
<tr><th>Semester</th><th>Code of the Course</th><th colspan="4">Title of the Course/Paper</th><th>NHEQF Level</th><th>Credits</th></tr>
<tr><td>I</td><td>MAT 702</td><td colspan="4">Real Analysis</td><td></td><td>6</td></tr>
<tr><th rowspan="2">Level of Course</th><th rowspan="2">Type of the Course</th><th colspan="3">Credit Distribution</th><th rowspan="2">Offered to NC Student</th><th colspan="2" rowspan="2">Course Delivery Method</th></tr>
<tr><th>Theory</th><th>Practical</th><th>Total</th></tr>
<tr><td>Advance</td><td>Major</td><td>6</td><td>0</td><td>6</td><td>Yes</td><td colspan="2">Lecture, Ninety lectures</td></tr>
<tr><td colspan="2">Prerequisites</td><td colspan="6">Mathematics course at UG Level.</td></tr>
<tr><td colspan="2">Objectives of the Course:</td><td colspan="6">The objective of this course is to provide students with a deep understanding of measure theory and its applications in real analysis. Through a systematic exploration of algebra of sets, measurable functions, and convergence, students will gain the foundational knowledge necessary to work with Lebesgue measure and integration. The course will also introduce students to key theorems related to function approximation and Fourier analysis, equipping them with the tools to analyze and manipulate functions in various mathematical contexts.</td></tr>
</table>

Course Outcomes

Upon successful completion of this course, students will be able to:

Understand Measure Theory: Demonstrate a clear understanding of algebra of sets, Borel sets, and Lebesgue measure, including the definitions and properties of measurable and non-measurable sets.

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University of Rajasthan
JAIPUR

1. **Analyze Measurable Functions:** Identify and construct measurable functions, realizing non-negative measurable functions as limits of increasing sequences of simple functions, and apply convergence concepts in measure.
2. **Apply Integral Theory:** Utilize the Lebesgue integral for bounded measurable functions, demonstrating knowledge of Weierstrass's theorem on function approximation and the passage to the limit under the integral sign.
3. **Explore Summability and Fourier Analysis:** Investigate summable functions and the space of square summable functions, applying Parseval's identity and understanding the Riesz-Fisher theorem in the context of Fourier series.
4. **Communicate Mathematical Concepts:** Present mathematical arguments clearly and effectively, both in written and verbal forms, demonstrating the ability to articulate complex ideas in measure theory and analysis.

Unit - 1

Algebra and algebras of sets, Algebras generated by a class of subsets, Borel sets, Lebesgue measure of sets of real numbers, Measurability and Measure of a set, Existence of Non-measurable sets.

Unit - 2

Measurable functions, Realization of non-negative measurable function as limit of an increasing sequence of simple functions, Structure of measurable functions, Convergence in measure, Egoroff's theorem.

Unit - 3

Lebesgue integral of bounded measurable functions, Lebesgue theorem on the passage to the limit under the integral sign for bounded measurable functions. Summable functions.

Unit - 4

Space of square summable functions. Fourier series and coefficients, Parseval's identity, Riesz-Fisher Theorem.

Reference Books:

1. Shanti Narayan, A Course of Mathematical Analysis, S. Chand & Co., N.D., 1995.
2. S.C.Malik and Savita Arora, Mathematical Analysis, New Age International, 1992.
3. T. M. Apostol, Mathematical Anslysis, Narosa Publishing House, New Delhi, 1985.
4. R.R. Goldberg, Real Analysis, Oxford & IBH Publishing Co., New Delhi, 1970.
5. S. Lang, Undergraduate Analysis, Springer-Verlag, New York, 1983.
6. Walter Rudin, Real and Complex Analysis, Tata McGraw-Hill Pub. Co. Ltd., 1986.
7. I.N. Natansen, Theory of Functions of a Real Variable, Fredrik Pub. Co., 1964.

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Paper – 3 : MAT 703 : Differential Equations- I
(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	MAT 703 : Differential Equations- I	3 Hrs	100	40

<table>
<tr><th>Semester</th><th>Code of the Course</th><th colspan="3">Title of the Course/Paper</th><th>NHEQF Level</th><th colspan="2">Credits</th></tr>
<tr><td>I</td><td>MAT 703</td><td colspan="3">Differential Equations- I</td><td></td><td colspan="2">6</td></tr>
<tr><td rowspan="2">Level of Course</td><td rowspan="2">Type of the Course</td><td colspan="3">Credit Distribution</td><td rowspan="2">Offered to NC Student</td><td colspan="2" rowspan="2">Course Delivery Method</td></tr>
<tr><td>Theory</td><td>Practical</td><td>Total</td></tr>
<tr><td>Advance</td><td>Major</td><td>6</td><td>0</td><td>6</td><td>Yes</td><td colspan="2">Lecture, Ninety lectures</td></tr>
<tr><td colspan="2">Prerequisites</td><td colspan="6">Mathematics course at UG Level.</td></tr>
<tr><td colspan="2">Objectives of the Course:</td><td colspan="6">The objective of this course is to provide students with a thorough understanding of non-linear ordinary differential equations (ODEs) and partial differential equations (PDEs). Students will explore various solution techniques for specific forms of ODEs, including Riccati's equation and total differential equations, as well as series solutions and methods applicable to second-order PDEs. This foundational knowledge will enable students to analyze complex dynamical systems and understand the geometrical interpretations of differential equations.</td></tr>
</table>

Course Outcomes

Upon successful completion of this course, students will be able to:

1. **Solve Non-linear ODEs:** Analyze and solve non-linear ordinary differential equations, particularly Riccati's equation, utilizing known particular solutions to derive general solutions.
2. **Understand Total Differential Equations:** Recognize forms of total differential equations, apply necessary and sufficient conditions for their solutions, and interpret their geometric meanings, including those involving three and four variables.

Dy. Registrar
(Academic)
University of Rajasthan
JAIPUR

3. **Apply Series Solution Techniques:** Determine the radius of convergence for series solutions, differentiate power series, and solve Cauchy-Euler equations and problems near regular singular points using the method of Frobenius.
4. **Address Second-Order PDEs:** Employ Monge's method to solve partial differential equations of second order with variable coefficients, demonstrating an understanding of the complexities involved in such equations.
5. **Communicate Mathematical Concepts:** Effectively communicate the methods and solutions of differential equations through written reports and presentations, showcasing the ability to articulate complex mathematical ideas clearly.

Unit - 1

Non-linear ordinary differential equations of particular forms. Riccati's equation –General solution and the solution when one, two or three particular solutions are known.

Unit - 2

Total Differential equations. Forms and solutions, necessary and sufficient condition, Geometrical Meaning Equation containing three and four variables, total differential equations of second degree.

Unit - 3

Series Solution: Radius of convergence, method of differentiation, Cauchy-Euler equation, Solution near a regular singular point (Method of Forbenius) for different cases, Particular integral and the point at infinity.

Unit - 4

Partial differential equations of second order with variable co-efficients- Monge's method.

Reference Books:

1. J.L.Bansal and H.S.Dhami, Differential Equations Vol-II, JPH, 2004.
2. M.D. Raisinghania, Ordinary and Partial Differential Equations, S. Chand & Co., 2003.
3. L. C. Evans, Partial Differential Equations, Graduate Studies in Mathematics, Vol. 19, AMS, 1999.
4. I.N. Sneddon, Elements of Partial Differential Equations, McGraw-Hill, 1988.
5. E.A. Codington, An Introduction to Ordinary Differential Equations, Prentice Hall of India, 1961.
6. Frank Ayres, Theory and Problems of Differential equations, TMH, 1990.
7. D.A. Murray, Introductory Course on Differential Equations, Orient Longman,1902.
8. A.R.Forsyth, A Treatise on Differential Equations, Macmillan & Co. Ltd., London, 1956.

Paper- 4 : MAT 704 : Differential Geometry
(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	MAT 704 : Differential Geometry	3 Hrs	100	40

<table>
<tr><th>Semester</th><th>Code of the Course</th><th colspan="3">Title of the Course/Paper</th><th>NHEQF Level</th><th>Credits</th></tr>
<tr><td>I</td><td>MAT 704</td><td colspan="3">Differential Geometry</td><td></td><td>6</td></tr>
<tr><th rowspan="2">Level of Course</th><th rowspan="2">Type of the Course</th><th colspan="3">Credit Distribution</th><th rowspan="2">Offered to NC Student</th><th rowspan="2">Course Delivery Method</th></tr>
<tr><th>Theory</th><th>Practical</th><th>Total</th></tr>
<tr><td>Advance</td><td>Major</td><td>6</td><td>0</td><td>6</td><td>Yes</td><td>Lecture, Ninety lectures</td></tr>
<tr><th colspan="2">Prerequisites</th><td colspan="5">Mathematics course at UG Level.</td></tr>
<tr><th colspan="2">Objectives of the Course:</th><td colspan="5">The objective of this course is to provide students with an in-depth understanding of differential geometry, focusing on the properties and characteristics of curves and surfaces in three-dimensional space. Students will explore fundamental concepts such as curvature, torsion, and the various forms and metrics of surfaces. This foundational knowledge will enable them to analyze and apply geometric principles to both theoretical and practical problems in mathematics and physics.</td></tr>
</table>

Course Outcomes

Upon successful completion of this course, students will be able to:

1. **Analyze Space Curves:** Understand and compute the properties of space curves, including tangent, curvature, and torsion, and apply Serret-Frenet formulas to describe their geometric behavior.
2. **Characterize Surfaces:** Identify and categorize various types of surfaces, including ruled and developable surfaces, and apply the necessary conditions for a surface to be classified as developable.
3. **Compute Principal Curvatures:** Determine normal curvature, principal directions, and mean curvature, and relate these concepts to the fundamental forms associated with surfaces.

4. **Explore Asymptotic Lines:** Derive and solve differential equations related to asymptotic lines, and compute the curvature and torsion of these lines while applying Gauss's formulas and Weingarten equations.
5. **Apply Differential Geometry Concepts:** Utilize the fundamental existence theorem for surfaces and analyze Gaussian and mean curvature in the context of parallel surfaces, demonstrating a comprehensive understanding of differential geometry principles.

Unit - 1

Space curves, Tangent, Contact of curve and surface, Osculating plane, Principal normal and Binormal, Curvature, Torsion, Serret-Frenet's formulae, Osculating circle and Osculating sphere.

Unit - 2

Bertrand curves, Involute and Evolutes, Conoids, Inflexional tangents, Singular points, Indicatrix. Ruled surface, Developable surface, Tangent plane to a ruled surface. Necessary and sufficient condition that a surface $\zeta = f(\xi,\eta)$ should represent a developable surface.

Unit - 3

Metric of a surface, First, Second and Third fundamental forms. Fundamental magnitudes of some important surfaces, Orthogonal trajectories. Normal curvature. Pricipal directions and Principal curvatures, First curvature, Mean curvature, Gaussion curvature, Radius of curvature of a given section through any point on $z = f(x,y)$.

Unit - 4

Lines of curvature, Principal radii, Relation between fundamental forms, Asymptotic lines, Differential equation of an asymptotic line, Curvature and Torsion of an asymptotic line. Gauss's formulae, Gauss's characteristic equation, Mainardi-Codazzi equations.

Reference Books:

1. R.J.T. Bell, Elementary Treatise on Co-ordinate geometry of three dimensions, Macmillan India Ltd., 1994.
2. Mittal and Agarwal, Differential Geometry, Krishna publication, 2014.
3. Barry Spain, Tensor Calculus, Radha Publ. House Calcutta,1988.
4. J.A. Thorpe, Introduction to Differential Geometry, Springer-Verlog , 2013.
5. T.J. Willmore - An Introduction to Differential Geometry. Oxford University Press.1972.
6. Weatherbum, Reimanian Geometry and Tensor Clculus, Cambridge Univ. Press, 2008.
7. Thorpe, Elementary Topics in Differential Geometry, Springer Verlag, N.Y. (1985).
8. R.S. Millman and G.D. Parker, Elements of Differential Geometry, Prentice Hall, 1977.

Paper- 5 : MAT 705: Dynamics of Rigid Bodies
(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	MAT 705: Dynamics of Rigid Bodies	3 Hrs	100	40

Semester	Code of the Course	Title of the Course/Paper			NHEQF Level	Credits
I	MAT 705	Dynamics of Rigid Bodies				6
Level of Course	Type of the Course	Credit Distribution			Offered to NC Student	Course Delivery Method
		Theory	Practical	Total		
Advance	Major	6	0	6	Yes	Lecture, Ninety lectures
Prerequisites		Mathematics course at UG Level.				
Objectives of the Course:		The objective of this course is to provide students with a comprehensive understanding of classical mechanics, focusing on the dynamics of rigid bodies and the principles governing their motion. The course will cover fundamental concepts such as D'Alembert's principle, conservation laws, and the equations of motion in various contexts, including both analytical and geometric approaches. Students will also explore advanced topics such as Lagrangian and Hamiltonian mechanics, equipping them with the tools to analyze complex dynamical systems.				

Course Outcomes
Upon successful completion of this course, students will be able to:

1. **Apply D'Alembert's Principle:** Utilize D'Alembert's principle to derive the general equations of motion for rigid bodies, understanding both the motion of the center of inertia and motion relative to it.
2. **Analyze Compound Pendulums:** Investigate the dynamics of compound pendulums, calculate the center of percussion, and apply conservation laws of linear and angular momentum in both finite and impulsive contexts.

3. **Understand Motion in Three Dimensions:** Describe motion in three dimensions using Euler's dynamical and geometrical equations, and analyze scenarios involving motion under no forces and impulsive forces, including the dynamics of spinning tops.
4. **Utilize Lagrangian Mechanics:** Formulate Lagrange's equations for holonomic systems, derive energy equations for conservative fields, and analyze small oscillations, enhancing understanding of the principles of analytical mechanics.
5. **Explore Hamiltonian Dynamics:** Apply Hamilton's equations of motion and comprehend Hamilton's principle and the principle of least action, demonstrating the ability to analyze and solve complex dynamical problems using advanced theoretical frameworks.

Unit - 1

D'Alembert's principle. The general equations of motion of a rigid body. Motion of centre of inertia and motion relative to centre of inertia. Motion about a fixed axis.

Unit - 2

The compound pendulum, Centre of percussion. Conservation of momentum (linear and angular) and energy for finite as well as impulsive forces.

Unit - 3

Motion in three dimensions with reference to Euler's dynamical and geometrical equations. Motion under no forces, Motion under impulsive forces, Motion of a top,

Unit - 4

Lagrange's equations for holonomous dynamical system, Energy equation for conservative field, Small oscillations, Hemilton's equations of motion, Hamilton's principle and principle of least action.

Reference Books:

1. N. C. Rana and P.S. Joag, Classical Mechanics, Tata McGraw-Hill, 1991.
2. M. Ray and H.S. Sharma, A Text Book of Dynamics of a Rigid Body, Students' Friends & Co., Agra, 1984.
3. H. Goldstein, Classical Mechanics, Narosa, 1990.
4. J. L. Synge and B. A. Griffith, Principles of Mechanics, McGraw-Hill, 1991.
5. L. N. Hand and J. D. Finch, Analytical Mechanics, Cambridge University Press, 1998.

Paper – 6 : MAT 706: Calculus of Variation and Special Function-I

(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	MAT 706: Calculus of Variation and Special Function-I	3 Hrs	100	40

<table>
<tr><th>Semester</th><th>Code of the Course</th><th colspan="3">Title of the Course/Paper</th><th>NHEQF Level</th><th>Credits</th></tr>
<tr><td>I</td><td>MAT 706</td><td colspan="3">Calculus of Variation and Special Function-I</td><td></td><td>6</td></tr>
<tr><td rowspan="2">Level of Course</td><td rowspan="2">Type of the Course</td><td colspan="3">Credit Distribution</td><td rowspan="2">Offered to NC Student</td><td rowspan="2">Course Delivery Method</td></tr>
<tr><td>Theory</td><td>Practical</td><td>Total</td></tr>
<tr><td>Advance</td><td>Major</td><td>6</td><td>0</td><td>6</td><td>Yes</td><td>Lecture, Ninety lectures</td></tr>
<tr><td colspan="2">Prerequisites</td><td colspan="5">Mathematics course at UG Level.</td></tr>
<tr><td colspan="2">Objectives of the Course:</td><td colspan="5">The objective of this course is to develop a deep understanding of the calculus of variations and special functions, particularly focusing on functionals, their variations, and solutions to variational problems. Students will explore the properties of the Gauss hypergeometric function, Kummer's confluent hypergeometric function, and Legendre polynomials, equipping them with the analytical tools necessary for solving complex mathematical problems in applied mathematics and physics.</td></tr>
</table>

Course Outcomes

Upon successful completion of this course, students will be able to:

1. **Understand Calculus of Variations:** Define and analyze functionals, variations, and their properties. Formulate and solve variational problems with fixed boundaries using Euler’s equation.
2. **Explore Higher-Order Derivatives:** Investigate functionals that depend on higher-order derivatives and functions of multiple independent variables, and solve variational problems presented in parametric form.

3. **Analyze Gauss Hypergeometric Functions:** Derive and apply properties of the Gauss hypergeometric function, including its series solution, integral representation, and transformation formulas, as well as understand contiguous function relations.
4. **Utilize Kummer's Confluent Hypergeometric Function:** Study Kummer's confluent hypergeometric function, its properties, and integral representation, and apply it to solve Legendre's equation.
5. **Work with Legendre Polynomials:** Define and compute Legendre polynomials and functions Pn(x)Pn(x) and Qn(x)Qn(x), and apply them in relevant mathematical and physical contexts, demonstrating proficiency in dealing with special functions.

Unit - 1

Calculus of variation – Functionals, Variation of a functional and its properties, Variational problems with fixed boundaries, Euler's equation, Extremals, Functional dependent on several unknown functions and their first order derivatives.

Unit - 2

Functionals dependent on higher order derivatives, Functionals dependent on the function of more than one independent variable. Variational problems in parametric form.

Unit - 3

Gauss hypergeometric function and its properties, Series solution of Gauss hypergeometric equation. Integral representation, Linear and quadratic transformation formulas, Contiguous function relations, Differentiation formulae, Linear relation between the solutions of Gauss hypergeometric equation, Kummer's confluent hypergeometric function and its properties, Integral representation, Kummer's first transformation and series solution of Legendre's equation.

Unit - 4

Legendre polynomials and functions $P_n(x)$ and $Q_n(x)$.

Reference Books:

1. J.L.Bansal and H.S.Dhami, Differential Equations Vol-II, JPH, 2004.
2. M.D. Raisinghania, Ordinary and Partial Differential Equations, S. Chand & Co., 2003.
3. J.N.Sharma and R.K.Gupta, Differential Equations with Special Functions, Krishna Prakashan , 1991.
4. Earl D. Rainville, Special Functions, Macmillan Company, New York, 1960.
5. L. C. Evans, Partial Differential Equations, Graduate Studies in Mathematics, Vol. 19, AMS, 1999.
6. I.N. Sneddon, Elements of Partial Differential Equations, McGraw-Hill, 1988.

Paper – 7 : MAT 707: Mathematical Statistics-I

(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	MAT 707: Mathematical Statistics-I	3 Hrs	100	40

<table>
<tr><th>Semester</th><th>Code of the Course</th><th colspan="4">Title of the Course/Paper</th><th>NHEQF Level</th><th>Credits</th></tr>
<tr><td>I</td><td>MAT 707</td><td colspan="4">Mathematical Statistics-I</td><td></td><td>6</td></tr>
<tr><th rowspan="2">Level of Course</th><th rowspan="2">Type of the Course</th><th colspan="3">Credit Distribution</th><th rowspan="2">Offered to NC Student</th><th colspan="2" rowspan="2">Course Delivery Method</th></tr>
<tr><th>Theory</th><th>Practical</th><th>Total</th></tr>
<tr><td>Advance</td><td>Major</td><td>6</td><td>0</td><td>6</td><td>Yes</td><td colspan="2">Lecture, Ninety lectures</td></tr>
<tr><td colspan="2">Prerequisites</td><td colspan="6">Mathematics course at UG Level.</td></tr>
<tr><td colspan="2">Objectives of the Course:</td><td colspan="6"></td></tr>
</table>

Course Outcomes

Upon successful completion of this course, students will be able to:

1. **Analyze Measures of Central Tendency and Dispersion:** Characteristics of statistical average and effect of change of origin and scale. Apply appropriate methods to compute and interpret measures of central tendency and dispersion, including the coefficient of variation.
2. **Evaluate Moments and Their Transformations:** Compute raw and central moments for ungrouped and grouped data. Understand and apply relationships between central moments and raw moments in statistical data analysis.
3. **Understand and Apply Fundamental Concepts of Probability:** Define and identify elements of a random experiment, including sample space, sample point, and events. Analyze operations on events and distinguish between mutually exclusive, equally likely, and exhaustive events.

4. Apply Theoretical Probability Models: Understand and apply the classical, relative frequency, and axiomatic definitions of probability. Work with discrete probability spaces and apply set-theoretic properties of probability.

Unit – I

Measures of Central Tendency : Concept of central tendency of statistical data, Statistical averages, characteristics of a good statistical average. Arithmetic Mean (A.M.): Definition, effect of change of origin and scale.

Mode and Median: Definition, formulae (for ungrouped and grouped data), merits and demerits. Empirical relation between mean, median and mode (without proof) merits and demerits. Measure of Dispersion- Definition, different measures of Dispersion, merits and demerits. Coefficient of variation.

Unit – II

Moments:

Raw moments (m'_r) for ungrouped and grouped data.

Central moments (m_r) for ungrouped and grouped data, Effect of change of origin and scale. Relations between central moments and raw moments, upto 4-th order (without proof).

Unit – III

Random experiment, trial, sample point and sample space, events, operations of events, concepts of equally likely, mutually exclusive and exhaustive events.

Unit – IV

Definition of probability: Classical, relative frequency and axiomatic approaches. Discrete probability space, properties of probability under set theoretic approach. Independence of events, Conditional probability, total and compound probability theorems, Bayes theorem and its applications.

Books suggested:

1. Parzen, E.S. : Modern Probability Theory and its Applications.
2. Meyer, P. : Introductory Probability and Statistical Applications.
3. Stirzekar David (1994) : Elementry Probabilityu, Cambridge University Press.
4. Mood A.M., Graybill F.A. and Boes D.C. (1974) : Introduction to the theory of Statistics, McGraw Hill.
5. Gupta, S.C. and Kapoor, V.K.: Fundamentals of Mathematical Statistics, S Chand & Company, New Delhi
6. Mukhopadhyay, P : Mathematical Statistics, new central book agency.
7. S.P. Gupta : Statistical Methods, Sultan Chand & Sons. First edition.

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Semester – II

Paper- 1 : MAT 801 : Algebra II
(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	MAT 801 : Algebra II	3 Hrs	100	40

<table>
<tr><th>Semester</th><th>Code of the Course</th><th colspan="4">Title of the Course/Paper</th><th>NHEQF Level</th><th>Credits</th></tr>
<tr><td>I</td><td>MAT 801</td><td colspan="4">Algebra II</td><td></td><td>6</td></tr>
<tr><th rowspan="2">Level of Course</th><th rowspan="2">Type of the Course</th><th colspan="3">Credit Distribution</th><th rowspan="2">Offered to NC Student</th><th colspan="2" rowspan="2">Course Delivery Method</th></tr>
<tr><th>Theory</th><th>Practical</th><th>Total</th></tr>
<tr><td>Advance</td><td>Major</td><td>6</td><td>0</td><td>6</td><td>Yes</td><td colspan="2">Lecture, Ninety lectures</td></tr>
<tr><td colspan="2">Prerequisites</td><td colspan="6">Mathematics course at UG Level.</td></tr>
<tr><td colspan="2">Objectives of the Course:</td><td colspan="6">The objective of this course is to provide students with a thorough understanding of linear algebra, focusing on linear transformations, dual spaces, and the properties of matrices. Students will explore eigenvalues and eigenvectors, determinants, and inner product spaces, equipping them with the analytical skills necessary to solve complex problems in vector spaces and linear mappings. Additionally, the course will cover orthogonality and important theorems related to self-adjoint and orthogonal transformations.</td></tr>
</table>

Course Outcomes
Upon successful completion of this course, students will be able to:

1. **Understand Linear Transformations:** Define and analyze linear transformations between vector spaces, including dual spaces, dual basis, and properties of dual maps and annihilators.

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2. **Work with Matrices:** Compute and interpret the matrices of linear maps, composition maps, and dual maps, and understand the concepts of eigenvalues, eigenvectors, rank, nullity, and invertibility of matrices.
3. **Calculate Determinants:** Compute determinants of matrices and derive the characteristic and minimal polynomials, understanding their relation to eigenvalues.
4. **Apply Inner Product Spaces:** Utilize concepts from real inner product spaces, including the Schwarz inequality, to analyze vector relationships and perform computations related to orthogonality.
5. **Explore Orthogonal Transformations:** Investigate properties of adjoint and self-adjoint linear transformations, apply Bessel's inequality, and utilize the Principal Axis Theorem to analyze the geometry of transformations and matrices.

Unit - 1 Linear transformation of vector spaces, Dual spaces, Dual basis and their properties, Dual maps, Annihilator.

Unit - 2

Matrices of linear maps, Matrices of composition maps, Matrices of dual map, Eigen values, Eigen vectors, Rank and Nullity of linear maps and matrices, Invertible matrices, Similar matrices.

Unit - 3

Determinants of matrices and their computations. Characteristic polynomial, minimal polynomial and eigen values. Real inner product space, Schwartzs inequality.

Unit - 4

Orthogonality, Bessel's inequality, Adjoint, Self adjoint linear transformations and matrices, Othogonal linear transformation and matrices, Principal Axis Theorem.

Reference Books:

1. Deepak Chatterjee, Abstract Algebra, Prentice – Hall of India (PHI), New Delhi, 2004
2. N.S. Gopalkrishnan, University Algebra, New Age International, 1986.
3. Qazi Zameeruddin and Surjeet Singh, Modern Algebra, Vikas Publishing,2006
4. D. S. Chauhan and K. N. Singh, Studies in Algebra, JPH, 2006
5. G.C. Sharma, Modern Algebra, Shivlal Agrawal & Co., Agra,1998.
6. Joseph A. Gallian, Contemporary Abstract Algebra (4th Ed.), Narosa Publishing House, 1999.
7. David S. Dummit and Richard M. Foote, Abstract Algebra (3rd Edition), John Wiley and Sons (Asia) Pvt. Ltd, Singapore, 2004.
8. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra (4th Edition), Prentice-Hall of India Pvt. Ltd., New Delhi, 2004.
9. I.N. Herstein, Topics in Algebra (2nd edition), John Wiley & Sons, 2006.
10. Michael Artin, Algebra (2nd edition), Pearson Prentice Hall, 2011.

Paper – 2 : MAT 802 : Topology
(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	MAT 802 : Topology	3 Hrs	100	40

Semester	Code of the Course	Title of the Course/Paper			NHEQF Level	Credits
I	MAT 802	Topology				6
Level of Course	Type of the Course	Credit Distribution			Offered to NC Student	Course Delivery Method
		Theory	Practical	Total		
Advance	Major	6	0	6	Yes	Lecture, Ninety lectures
Prerequisites		Mathematics course at UG Level.				
Objectives of the Course:		The objective of this course is to introduce students to the fundamental concepts of topology, emphasizing the properties and structures of topological spaces. Students will explore open and closed sets, continuous mappings, and various separation axioms. The course will also cover compactness, connectedness, and the construction of product and quotient spaces, equipping students with the tools necessary to analyze and understand advanced topics in topology.				

Course Outcomes

Upon successful completion of this course, students will be able to:

1. **Define Topological Spaces:** Identify and characterize topological spaces, including subspaces, open sets, closed sets, and neighbourhood systems, and construct bases and sub-bases for topological spaces.
2. **Analyze Continuous Mappings:** Understand and apply the concepts of continuous mappings and homeomorphisms, and utilize nets and filters to analyze convergence and continuity in topological spaces.

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3. **Apply Separation Axioms:** Recognize and differentiate between various separation axioms (T_0, T_1, T_2, T_3, T_4) and understand their implications for the structure of topological spaces, particularly in relation to compact and locally compact spaces.
4. **Examine Compactness:** Explore the relationship between continuity and compactness, and apply compactness concepts to solve problems in topology.
5. **Work with Product and Quotient Spaces:** Construct and analyze product and quotient spaces, understand the one-point compactification theorem, and investigate the properties of connected and locally connected spaces, particularly in relation to continuity and connectedness.

Unit - 1

Topological spaces, Subspaces, Open sets, Closed sets, Neighbourhood system, Bases and sub-bases.

Unit - 2

Continuous mapping and Homeomorphism, Nets, Filters.

Unit - 3

Separation axioms (To, T_1, T_2, T_3, T_4). Compact and locally compact spaces. Continuity and Compactness.

Unit - 4

Product and Quotient spaces. One-point compactification theorem. Connected and Locally connected spaces, Continuity and Connectedness.

Reference Books:

1. Shanti Narayan, A Course of Mathematical Analysis, S. Chand & Co., N.D., 1995.
2. S.C.Malik and Savita Arora, Mathematical Analysis, New Age International, 1992.
3. James R. Munkres, Topology, 2nd Edition, Pearson International, 2000.
4. J. Dugundji, Topology, Prentice-Hall of India, 1975.
5. George F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, 1963.

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Paper 3 : MAT 803: Differential Equation-II
(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	MAT 803 : Differential Equation-II	3 Hrs	100	40

<table>
<tr><th>Semester</th><th>Code of the Course</th><th colspan="3">Title of the Course/Paper</th><th>NHEQF Level</th><th>Credits</th></tr>
<tr><td>I</td><td>MAT 803</td><td colspan="3">Differential Equation-II</td><td></td><td>6</td></tr>
<tr><th rowspan="2">Level of Course</th><th rowspan="2">Type of the Course</th><th colspan="3">Credit Distribution</th><th rowspan="2">Offered to NC Student</th><th rowspan="2">Course Delivery Method</th></tr>
<tr><th>Theory</th><th>Practical</th><th>Total</th></tr>
<tr><td>Advance</td><td>Major</td><td>6</td><td>0</td><td>6</td><td>Yes</td><td>Lecture, Ninety lectures</td></tr>
<tr><td colspan="2">Prerequisites</td><td colspan="5">Mathematics course at UG Level.</td></tr>
<tr><td colspan="2">Objectives of the Course:</td><td colspan="5">The objective of this course is to provide students with a comprehensive understanding of linear partial differential equations (PDEs) and boundary value problems. Students will explore the classification and canonical forms of second-order linear PDEs, the theory of Sturm-Liouville problems, and methods for solving both homogeneous and non-homogeneous boundary value problems. The course will also cover Green's functions and their applications in solving differential equations, equipping students with the analytical tools necessary for advanced studies in applied mathematics and engineering.</td></tr>
</table>

Course Outcomes

Upon successful completion of this course, students will be able to:

1. **Classify PDEs:** Identify and classify linear partial differential equations of second order, determining their canonical forms and applying Cauchy’s problem concepts for first-order PDEs.
2. **Solve Boundary Value Problems:** Analyze and solve linear homogeneous boundary value problems, understanding the concepts of eigenvalues and eigenfunctions, and

applying Sturm-Liouville theory to establish orthogonality and properties of eigenfunctions.

3. **Address Non-Homogeneous Problems**: Apply methods of eigenfunction expansion to non-homogeneous Sturm-Liouville boundary value problems, and utilize the method of separation of variables to solve Laplace, wave, and diffusion equations.
4. **Utilize Green's Functions:** Construct and apply Green's functions for non-homogeneous boundary value problems, understanding their properties and the procedure for their construction, including the treatment of inhomogeneous boundary conditions.
5. **Apply Advanced Techniques:** Employ advanced mathematical techniques such as the Dirac delta function and bilinear formulas for Green's functions, demonstrating proficiency in solving complex boundary value problems in various contexts.

Unit - 1

Classification of linear partial differential equation of second order, Canonical forms, Cauchy's problem of first order partial differential equation.

Unit - 2

Linear homogeneous boundary value problem, Eigen values and eigen functions, Sturm-Liouville boundary value problems, orthogonality of eigen functions, Lagrange's identity, properties of eigen functions, important theorems of sturm Liouville system, Periodic functions.

Unit - 3

Non-homogeneous boundary value problems, Non-homogeneous Sturm-Liouville boundary value problems (method of eigen function expansion). Method of separation of variables, Laplace, wave and diffusion equations.

Unit - 4

Green's Functions: Non-homogeneous Sturm-Liouville boundary value problem (method of Green's function), Procedure of constructing the Green's function and solution of boundary value problem, properties of Green's function, Inhomogeneous boundary conditions, Dirac delta function, Bilinear formula for Green's function, Modified Green's function.

Reference Books:

1. J.L.Bansal and H.S.Dhami, Differential Equations Vol-II, JPH, 2004.
2. M.D. Raisinghania, Ordinary and Partial Differential Equations, S. Chand & Co., 2003.
3. L. C. Evans, Partial Differential Equations, Graduate Studies in Mathematics, Vol. 19, AMS, 1999.
4. I.N. Sneddon, Elements of Partial Differential Equations, McGraw-Hill, 1988.
5. E.A. Codington, An Introduction to Ordinary Differential Equations, Prentice Hall of India, 1961.
6. Frank Ayres, Theory and Problems of Differential equations, TMH, 1990.
7. D.A. Murray, Introductory Course on Differential Equations, Orient Longman,1902.
8. A.R.Forsyth, A Treatise on Differential Equations, Macmillan & Co. Ltd., London, 1956.

Paper – 4 : MAT 804 : Riemannian Geometry and Tensor Analysis
(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	MAT 804 : Riemannian Geometry and Tensor Analysis	3 Hrs	100	40

Semester	Code of the Course	Title of the Course/Paper			NHEQF Level	Credits
I	MAT 804	Riemannian Geometry and Tensor Analysis				6
Level of Course	Type of the Course	Credit Distribution			Offered to NC Student	Course Delivery Method
		Theory	Practical	Total		
Advance	Major	6	0	6	Yes	Lecture, Ninety lectures
Prerequisites		Mathematics course at UG Level.				
Objectives of the Course:		The objective of this course is to provide students with a comprehensive understanding of differential geometry, focusing on the study of geodesics, tensor analysis, and Riemannian geometry. Students will explore the mathematical foundations of geodesics on surfaces, the properties of tensors, and the curvature of Riemannian spaces. The course aims to equip students with the analytical skills necessary to apply these concepts in advanced theoretical and applied contexts, such as general relativity and differential geometry.				

Course Outcomes
Upon successful completion of this course, students will be able to:

1. **Analyze Geodesics:** Derive and solve the differential equations of geodesics, including those on surfaces of revolution, and understand concepts such as geodesic curvature and torsion, as well as the Gauss-Bonnet theorem.
2. **Understand Tensor Analysis:** Define and classify different types of tensors, including contravariant, covariant, and symmetric tensors, and apply the quotient law and relative tensor concepts in Riemannian spaces.

3. **Utilize Christoffel Symbols:** Calculate and apply Christoffel symbols, understand their properties, and perform covariant differentiation of tensors, including the study of intrinsic derivatives and geodesic coordinates.
4. **Explore Riemannian Curvature:** Analyze the Riemann-Christoffel tensor and covariant curvature tensor, understanding their properties and significance in the context of Einstein spaces and Bianchi's identity.
5. **Apply Theoretical Concepts:** Discuss and apply concepts such as the Einstein tensor, flat spaces, isotropic points, and Schur's theorem, demonstrating the ability to work with advanced topics in differential geometry and their implications in theoretical physics.

Unit - 1

Geodesics, Differential equation of a geodesic, Single differential equation of a geodesic, Geodesic on a surface of revolution, Geodesic curvature and torsion, Gauss-Bonnet Theorem.

Unit - 2

Tensor Analysis– Kronecker delta. Contravariant and Covariant tensors, Symmetric tensors, Quotient law of tensors, Relative tensor. Riemannian space. Metric tensor, Indicator, Permutation symbols and Permutation tensors.

Unit - 3

Christoffel symbols and their properties, Covariant differentiation of tensors. Ricci's theorem, Intrinsic derivative, Geodesics, Differential equation of geodesic, Geodesic coordinates, Field of parallel vectors.

Unit - 4

Reimann-Christoffel tensor and its properties. Covariant curvature tensor, Einstein space. Bianchi's identity. Einstein tensor, Flat space, Isotropic point, Schur's theorem.

Reference Books:

1. R.J.T. Bell, Elementary Treatise on Co-ordinate geometry of three dimensions, Macmillan India Ltd., 1994.
2. Mittal and Agarwal, Differential Geometry, Krishna publication, 2014.
3. Barry Spain, Tensor Calculus, Radha Publ. House Calcutta,1988.
4. J.A. Thorpe, Introduction to Differential Geometry, Springer-Verlog, 2013.
5. T.J. Willmore - An Introduction to Differential Geometry. Oxford University Press.1972.
6. Weatherbum, Reimanian Geometry and Tensor Clculus, Cambridge Univ. Press, 2008.
7. Thorpe, Elementary Topics in Differential Geometry, Springer Verlag, N.Y. (1985).
8. R.S. Millman and G.D. Parker, Elements of Differential Geometry, Prentice Hall, 1977.

Paper – 5 : MAT 805: Hydrodynamics
(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	MAT 805 : Hydrodynamics	3 Hrs	100	40

<table>
<tr><th>Semester</th><th>Code of the Course</th><th colspan="4">Title of the Course/Paper</th><th>NHEQF Level</th><th>Credits</th></tr>
<tr><td>I</td><td>MAT 805</td><td colspan="4">Hydrodynamics</td><td></td><td>6</td></tr>
<tr><td rowspan="2">Level of Course</td><td rowspan="2">Type of the Course</td><td colspan="3">Credit Distribution</td><td rowspan="2">Offered to NC Student</td><td colspan="2" rowspan="2">Course Delivery Method</td></tr>
<tr><td>Theory</td><td>Practical</td><td>Total</td></tr>
<tr><td>Advance</td><td>Major</td><td>6</td><td>0</td><td>6</td><td>Yes</td><td colspan="2">Lecture, Ninety lectures</td></tr>
<tr><td colspan="2">Prerequisites</td><td colspan="6">Mathematics course at UG Level.</td></tr>
<tr><td colspan="2">Objectives of the Course:</td><td colspan="6">The objective of this course is to provide students with a comprehensive understanding of fluid dynamics, focusing on the kinematics and dynamics of ideal fluids. Students will explore the fundamental principles governing fluid motion, including Lagrange’s and Euler’s methods, the equations governing fluid flow, and the characteristics of vortices. This course aims to equip students with the theoretical and practical knowledge necessary for analyzing fluid behavior in various physical contexts.</td></tr>
</table>

Course Outcomes

Upon successful completion of this course, students will be able to:

1. **Analyze Fluid Kinematics:** Describe the kinematics of ideal fluids using Lagrange's and Euler's methods, and derive the equations of continuity in Cartesian, cylindrical, and spherical coordinates.
2. **Understand Fluid Dynamics:** Apply Euler’s hydrodynamic equations and Bernoulli’s theorem to solve problems related to fluid motion, and comprehend the Helmholtz equations and Cauchy’s integral in fluid dynamics.

3. **Examine Motion Due to Impulsive Forces:** Analyze fluid motion due to impulsive forces, particularly in two dimensions, utilizing concepts such as the stream function and complex potential to study sources, sinks, and doublets.
4. **Explore Vortex Motion:** Define and analyze vortex motion, including rectilinear vortices and properties of vortex tubes, and apply theoretical concepts to understand the behavior of vortex pairs and doublets in various configurations.
5. **Apply Fluid Dynamics Concepts**: Demonstrate proficiency in applying fluid dynamics principles to analyze and solve complex problems involving vortices, streamlines, and fluid motion around obstacles, enhancing understanding of ideal fluid behavior in real-world scenarios.

Unit - 1

Kinematics of ideal fluid. Lagrange's and Euler's methods. Equation of continuity in Cartesian, cylindrical and spherical polar coordinates. Boundary surface. Stream-lines, path-lines and streak lines, velocity potential, irrotational motion.

Unit - 2

Euler's hydrodynamic equations, Bernoulli's theorem. Helmholtz equations. Cauchy's integral.

Unit – 3

Motion due to impulsive forces. Motion in two-dimensions, Stream function, Complex potential. Sources, Sinks, Doublets, Images in two-dimensions.

Unit – 4

Vortex motion definition, rectilinear vortices, centre of vortices, properties of vortex tube, two vortex filaments, vortex pair, vortex doublet, vortex inside and outside circular cylinder, four vortices, motion of vortex situated at the origin and stream lines.

Reference Books:

1. M.D. Raisinghania, Hydrodynamics, S. Chand & Co. Ltd., N.D. 1995.
2. M. Ray and G.C. Chadda, A Text Book on Hydrodynamics, Students' Friends & Co., Agra, 1985.
3. N. C. Rana and P.S. Joag, Classical Mechanics, Tata McGraw-Hill, 1991.
4. H. Goldstein, Classical Mechanics, Narosa, 1990.
5. J. L. Synge and B. A. Griffith, Principles of Mechanics, McGraw-Hill, 1991.
6. L. N. Hand and J. D. Finch, Analytical Mechanics, Cambridge University Press, 1998.

Paper-6 : MAT 806 : Special Functions- II
(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	MAT 806 : Special Functions- II	3 Hrs	100	40

<table>
<tr><th>Semester</th><th>Code of the Course</th><th colspan="3">Title of the Course/Paper</th><th>NHEQF Level</th><th>Credits</th></tr>
<tr><td>I</td><td>MAT 806</td><td colspan="3">Special Functions- II</td><td></td><td>6</td></tr>
<tr><th rowspan="2">Level of Course</th><th rowspan="2">Type of the Course</th><th colspan="3">Credit Distribution</th><th rowspan="2">Offered to NC Student</th><th rowspan="2">Course Delivery Method</th></tr>
<tr><th>Theory</th><th>Practical</th><th>Total</th></tr>
<tr><td>Advance</td><td>Major</td><td>6</td><td>0</td><td>6</td><td>Yes</td><td>Lecture, Ninety lectures</td></tr>
<tr><th colspan="2">Prerequisites</th><td colspan="5">Mathematics course at UG Level.</td></tr>
<tr><th colspan="2">Objectives of the Course:</th><td colspan="5">The objective of this course is to provide students with a thorough understanding of special functions, focusing on Bessel functions, Hermite polynomials, Laguerre polynomials, Jacobi polynomials, and Chebyshev polynomials. Students will explore their definitions, properties, applications, and the role these functions play in solving differential equations and in various fields of applied mathematics and engineering.</td></tr>
</table>

Course Outcomes
Upon successful completion of this course, students will be able to:

1. **Understand Bessel Functions:** Define and analyze Bessel functions Jn(x)Jn(x), including their properties, applications, and solutions to Bessel's differential equation.
2. **Explore Orthogonal Polynomials:** Identify and apply Hermite polynomials Hn(x)Hn(x), Laguerre polynomials, and associated Laguerre polynomials, understanding their significance in probability theory and quantum mechanics.
3. **Analyze Jacobi Polynomials:** Define Jacobi polynomials, explore their special cases, and apply Bateman’s generating function and Rodrigue’s formula to derive properties such as orthogonality and recurrence relations.

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University of Rajasthan
JAIPUR

4. **Work with Chebyshev Polynomials:** Define Chebyshev polynomials Tn(x)Tn (x) and Un(x)Un(x), derive solutions to Chebyshev's equation, and utilize their properties in generating functions, expansions, and orthogonality relations.
5. **Apply Special Functions:** Demonstrate the ability to apply special functions to solve problems in differential equations and other applied mathematics contexts, showcasing how these functions are used in real-world applications.

Unit - 1

Bessel functions $J_n(x)$.

Unit - 2

Hermite polynomials $H_n(x)$, Laguerre and Associated Laguerre polynomials.

Unit - 3

Jacobi Polynomial: Definition and its special cases, Bateman's generating function, Rodrigue's formula, orthogonality, recurrence relations, expansion in series of polynomials.

Unit - 4

Chebyshev polynomials $T_n(x)$ and $U_n(x)$: Definition, Solutions of Chebyshev's equation, expansions, Generating functions, Recurrence relations, Orthogonality.

Reference Books:

1. J.L. Bansal and H.S.Dhami, Differential Equations Vol-II, JPH, 2004.
2. M.D. Raisinghania, Ordinary and Partial Differential Equations, S. Chand & Co., 2003.
3. J.N. Sharma and R.K.Gupta, Differential Equations with Special Functions, Krishna Prakashan , 1991.
4. Earl D. Rainville, Special Functions, Macmillan Company, New York, 1960.
5. L. C. Evans, Partial Differential Equations, Graduate Studies in Mathematics, Vol. 19, AMS, 1999.
6. I.N. Sneddon, Elements of Partial Differential Equations, McGraw-Hill, 1988.

Paper – 7 : MAT 807: Mathematical Statistics-II

(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	MAT 807: Mathematical Statistics-II	3 Hrs	100	40

<table>
<tr><th>Semester</th><th>Code of the Course</th><th colspan="4">Title of the Course/Paper</th><th>NHEQF Level</th><th>Credits</th></tr>
<tr><td>I</td><td>MAT 807</td><td colspan="4">Mathematical Statistics-II</td><td></td><td>6</td></tr>
<tr><th rowspan="2">Level of Course</th><th rowspan="2">Type of the Course</th><th colspan="3">Credit Distribution</th><th rowspan="2">Offered to NC Student</th><th colspan="2" rowspan="2">Course Delivery Method</th></tr>
<tr><th>Theory</th><th>Practical</th><th>Total</th></tr>
<tr><td>Advance</td><td>Major</td><td>6</td><td>0</td><td>6</td><td>Yes</td><td colspan="2">Lecture, Ninety lectures</td></tr>
<tr><td colspan="2">Prerequisites</td><td colspan="6">Mathematics course at UG Level.</td></tr>
<tr><td colspan="2">Objectives of the Course:</td><td colspan="6"></td></tr>
</table>

Course Outcomes

Upon successful completion of this course, students will be able to:

1. **Understand and Analyze Random Variables and Distributions:** Define and distinguish between discrete and continuous random variables. Analyze joint, marginal, and conditional distributions of two random variables.

2. **Apply Expectation and Variance Properties**: Compute and interpret the expectation, variance, and covariance of random variables. Explore the properties and behavior of expectation and variance under linear transformations.

3. **Utilize Moments and Generating Functions:** Define and compute moments and moment generating functions (m.g.f.). Apply Chebyshev's inequality to estimate probabilities.

4. **Analyze and Apply Univariate Discrete and Continuous Distributions**: Understand and apply key properties of standard discrete distributions. Use appropriate distributions in modeling real-world probabilistic scenarios.

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Unit – 1

Random variables – discrete and continuous, probability mass function (pmf) and probability density function (pdf), Cumulative distribution function (cdf). Joint distribution of two random variables, marginal and conditional distributions.

Unit – 2

Expectation of a random variable and its simple properties. Addition and Multiplication theorems of Expectations. Variance and covariance and their properties.

Unit – 3

Moments, moment generating function (m.g.f.) & their properties, continuity theorem for m.g.f. (without proof). Chebyshev's inequality. Cumulant generating functions.

Unit – 4

Univariate distributions: Binomial, Poisson, Hypergeometric, Geometric and Negative Binomial. Normal and Poisson distributions as limiting case of binomial distribution.

Books suggested:

1. Parzen, E.S. : Modern Probability Theory and its Applications.
2. Gupta, S.C. and Kapoor, V.K.: Fundamentals of Mathematical Statistics, S Chand & Company, New Delhi
3. Meyer, P. : Introductory Probability and Statistical Applications.
4. Stirzekar David (1994) : Elementry Probabilityu, Cambridge University Press.
5. Mood A.M., Graybill F.A. and Boes D.C. (1974) : Introduction to the theory of Statistics, McGraw Hill.
6. Mukhopadhyay, P : Mathematical Statistics, new central book agency.
7. S.P. Gupta : Statistical Methods, Sultan Chand & Sons. First edition.

M.A./M.Sc. Mathematics

Semester Scheme (Semester III and IV)
Syllabus

Semester - III

Paper- 1 : MAT 901 : Functional Analysis- I

(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	MAT 901 : Functional Analysis- I	3 Hrs	100	40

Semester	Code of the Course	Title of the Course/Paper			NHEQF Level	Credits
I	MAT 901	Functional Analysis- I				6
Level of Course	Type of the Course	Credit Distribution			Offered to NC Student	Course Delivery Method
		Theory	Practical	Total		
Advance	Major	6	0	6	Yes	Lecture, Ninety lectures
Prerequisites		Mathematics course at UG Level.				
Objectives of the Course:		The objective of this course is to provide students with a solid foundation in the theory of metric spaces and normed linear spaces. Students will explore key concepts such as convergence, completeness, compactness, and continuity, as well as the applications of various theorems in functional analysis. By the end of the course, students will be equipped to analyze and apply these concepts in advanced mathematical contexts.				

Course Outcomes
Upon successful completion of this course, students will be able to:

1. **Analyze Metric Spaces:** Define and identify subspaces of metric spaces, product spaces, and continuous mappings, and demonstrate an understanding of sequences, including convergent and Cauchy sequences in metric spaces.

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2. **Understand Completeness:** Distinguish between complete and incomplete metric spaces, providing examples of each, and apply the Banach contraction theorem in various contexts.
3. **Explore Compactness and Connectedness:** Apply Baire's category theorem and Ascoli-Arzelà theorem, and understand the properties of compact sets, compact spaces, and connected metric spaces, including the concept of separability.
4. **Work with Normed Linear Spaces:** Define normed linear spaces and quotient spaces, and demonstrate an understanding of Banach spaces and bounded linear transformations, including their properties and examples.
5. **Utilize Advanced Theorems:** Apply theorems related to equivalent norms, compactness in finite-dimensional normed linear spaces, and understand key results such as Riesz Lemma, the Open Mapping theorem, the Closed Graph theorem, and the Uniform Boundedness theorem in the context of functional analysis.

Unit 1

Subspace of a metric space, Product space, Continuous mappings, Sequence in a metric space, Convergent sequence, Cauchy sequence.

Unit – 2

Complete metric space. Banach contraction theorem. Baire's category theorem, compact sets, compact spaces, connected spaces.

Unit - 3

Normed linear spaces. Quotient space of normed linear spaces and its completeness. Banach spaces and examples. Bounded linear transformations. Normed linear space of bounded linear transformations.

Unit – 4

Equivalent norms. Basic properties of finite dimensional normed linear spaces and compactness. Reisz Lemma. Multilinear mapping. Open mapping theorem. Closed graph theorem. Uniform boundness theorem.

Reference Books:

1. E. Kreyszig, Introductory Functional Analysis with Applications, John Wiley and Sons., 1978.
2. A. E. Taylor, Introduction to Functional Analysis, John Wiley, 1958.
3. A. Bowers and N. Kalton, An Introductory Course in Functional Analysis, Springer Verlog, 2014.
4. W. Rudin, Functional Analysis, McGraw-Hill, 1973.

Paper-2 : MAT 902 : Viscous Fluid Dynamics-I
(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	MAT 902 : Viscous Fluid Dynamics-I	3 Hrs	100	40

Semester	Code of the Course	Title of the Course/Paper	NHEQF Level	Credits
I	MAT 902	Viscous Fluid Dynamics-I		6

Level of Course	Type of the Course	Credit Distribution			Offered to NC Student	Course Delivery Method
		Theory	Practical	Total		
Advance	Major	6	0	6	Yes	Lecture, Ninety lectures

Prerequisites	Mathematics course at UG Level.
Objectives of the Course:	The objective of this course is to provide students with a comprehensive understanding of fluid mechanics, focusing on the principles of viscosity, stress, and strain, as well as the mathematical formulation of fluid motion. Students will explore the Navier-Stokes equations, dimensional analysis, and the significance of various non-dimensional parameters. The course aims to equip students with both theoretical knowledge and practical skills to analyze and solve problems related to fluid flow in various contexts.

Course Outcomes
Upon successful completion of this course, students will be able to:

1. **Understand Fluid Properties:** Define and analyze key concepts such as viscosity, stress, rate of strain, and thermal conductivity, and apply Stoke's law of friction and the generalized law of heat conduction in fluid mechanics.
2. **Apply Navier-Stokes Equations:** Derive and utilize the Navier-Stokes equations of motion, understanding their significance in describing fluid behavior under various conditions.

3. **Conduct Dimensional Analysis:** Perform dimensional analysis and apply the Buckingham theorem to derive non-dimensional parameters, recognizing their physical importance in fluid dynamics, including Reynolds number, Froude number, and others.
4. **Solve Fluid Flow Problems:** Analyze exact solutions of the Navier-Stokes equations for various flow scenarios, including plane Couette flow, plane Poiseuille flow, and Hagen-Poiseuille flow, and understand velocity distributions in tubes of uniform cross-sections.
5. **Examine Complex Flows:** Investigate flow between concentric rotating cylinders, stagnation point flows (Hiemenz and Homann flows), and flow due to a rotating disc, applying theoretical principles to practical fluid mechanics problems.

Unit – 1

Viscosity , Analysis of stress and rate of strain, Stoke's law of friction, Thermal conductivity and generalized law of heat conduction, Equations of state and continuity , Navier- Stokes equations of motion.

Unit – 2

Vorticity and circulation, Dynamical similarity, Inspection and dimensional analysis, Buckingham theorem and its application, Non-dimensional parameters and their physical importance: Reynolds number, Froude number, Mach number, Prandtl number, Eckart number, Grashoff number, Brinkmann number, Non – dimensional coefficients: Lift and drag coefficients, Skin friction, Nusselt number, Recovery factor.

Unit – 3

Exact solutions of Navier – Stokes equations, Velocity distribution for plane couette flow, Plane Poiseuille flow, Generalized plane Couette flow, Hagen- Poiseuille flow, Flow in tubes of uniform cross-sections.

Unit – 4

Flow between two concentric rotating cylinders. Stagnation point flows: Hiemenz flow, Homann flow. Flow due to a rotating disc.

Reference Books:

1. J.L. Bansal, Viscous Fluid dynamics, JPH, Jaipur, 2008.
2. M.D. Raisinghania, Fluid Dynamics, S.Chand, 2003.
3. F. Chorlton, A Text Book of Fluid Dynamics, CBC, 1985.
4. S. W. Yuan, Foundations of Fluid Mechanics, Prentice-Hall, 1976.
5. S. I. Pai, Viscous Flow Theory I- Laminar Flow, D. Van Nostrand Co., Ing., Princeton, New Jersey, N.Y., Landon, Toronto, 1956.
6. F.M. White, Viscous Fluid Flow, McGraw-Hill, N.Y., 1974.

Paper – 3 : MAT 903 : Integral Transforms

(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	MAT 903 : Integral Transforms	3 Hrs	100	40

<table>
<tr><th>Semester</th><th>Code of the Course</th><th colspan="3">Title of the Course/Paper</th><th>NHEQF Level</th><th>Credits</th></tr>
<tr><td>I</td><td>MAT 903</td><td colspan="3">Integral Transforms</td><td></td><td>6</td></tr>
<tr><th rowspan="2">Level of Course</th><th rowspan="2">Type of the Course</th><th colspan="3">Credit Distribution</th><th rowspan="2">Offered to NC Student</th><th rowspan="2">Course Delivery Method</th></tr>
<tr><th>Theory</th><th>Practical</th><th>Total</th></tr>
<tr><td>Advance</td><td>Major</td><td>6</td><td>0</td><td>6</td><td>Yes</td><td>Lecture, Ninety lectures</td></tr>
<tr><td colspan="2">Prerequisites</td><td colspan="5">Mathematics course at UG Level.</td></tr>
<tr><td colspan="2">Objectives of the Course:</td><td colspan="5">The objective of this course is to provide a comprehensive understanding of advanced integral transforms and their applications in solving differential equations and analyzing functions. The course covers Fourier, Mellin, Laplace, and Hankel transforms, focusing on their definitions, properties, and theorems. Students will learn how to apply these transforms to solve problems involving derivatives, integrals, and convolutions, and gain insight into their practical uses in various fields of mathematics and engineering. By the end of the course, students will have developed the skills needed to utilize these integral transforms for both theoretical analysis and practical problem-solving.</td></tr>
</table>

Course Outcomes

Upon successful completion of this course, students will be able to:

1. **Apply Fourier Transforms:** Understand and apply the definitions and properties of Fourier sine, cosine, and complex transforms. Use the convolution theorem to solve problems, and apply inversion theorems and Fourier transforms of derivatives to analyze functions.
2. **Utilize Mellin Transforms:** Define and use Mellin transforms, understand their elementary properties, and apply them to derivatives and integrals. Implement the

inversion theorem and convolution theorem to solve various problems involving Mellin transforms.

3. **Work with Laplace Transforms:** Define and manipulate Laplace transforms, including their properties and rules. Solve problems involving derivatives and integrals using Laplace transforms, and apply the properties of inverse Laplace transforms and the convolution theorem effectively.
4. **Implement Complex and Hankel Transforms:** Understand and use the complex inversion formula and the infinite Hankel transform. Apply the definition, properties, and inversion theorem of Hankel transforms, and utilize Parseval's Theorem in the context of Hankel transforms.

Unit – 1

Fourier transform – Defiition and properties of Fourier sine, cosine and complex transforms. Convolution theorem. Inversion theorems. Fourier transform of derivatives.

Unit – 2

Mellin transform– Definition and elementary properties. Mellin transforms of derivatives and integrals. Inversion theorem. Convolution theorem.

Unit - 3

Laplace transform– Definition and its properties. Rules of manipulation. Laplace transform of derivatives and integrals. Properties of inverse Laplace transform. Convolution theorem.

Unit – 4

Complex inversion formula. Infinite Hankel transform– Definition and elementary properties. Hankel transform of derivatives. Inversion theorem. Parseval Theorem.

Reference Books:

1. Lokenath Debnath and Dambaru Bhatta, Integral Transforms and their Applications, Taylor and Francis Group, 2014.
2. Abdul J. Jerry, Introduction to Integral Equations with applications, Marcel Dekkar Inc. NY, 1999.
3. L.G.Chambers, Integral Equations: A short Course, Int. Text Book Company Ltd. 1976.
4. Murry R. Spiegal, Laplace Transform (SCHAUM Outline Series), McGraw-Hill, 1965.

Optional Papers: (ECC)

Paper – 4 : MAT A01 : Continuum Mechanics – I
(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	**Paper – 3 : MAT A01 : Continuum Mechanics – I**	3 Hrs	100	40

<table>
<tr><th>Semester</th><th>Code of the Course</th><th colspan="4">Title of the Course/Paper</th><th>NHEQF Level</th><th>Credits</th></tr>
<tr><td>I</td><td>MAT A01</td><td colspan="4">Continuum Mechanics – I</td><td></td><td>6</td></tr>
<tr><th rowspan="2">Level of Course</th><th rowspan="2">Type of the Course</th><th colspan="3">Credit Distribution</th><th rowspan="2">Offered to NC Student</th><th colspan="2" rowspan="2">Course Delivery Method</th></tr>
<tr><th>Theory</th><th>Practical</th><th>Total</th></tr>
<tr><td>Advance</td><td>Major</td><td>6</td><td>0</td><td>6</td><td>Yes</td><td colspan="2">Lecture, Ninety lectures</td></tr>
<tr><th colspan="2">Prerequisites</th><td colspan="6">Mathematics course at UG Level.</td></tr>
<tr><th colspan="2">Objectives of the Course:</th><td colspan="6">The objective of this course is to provide students with a thorough understanding of tensor analysis and its applications in continuum mechanics. Students will explore Cartesian tensors, their transformation laws, and the mathematical tools necessary for analyzing stress, strain, and fluid motion. By the end of the course, students will be equipped to apply these concepts to complex problems in solid and fluid mechanics.</td></tr>
</table>

Course Outcomes
Upon successful completion of this course, students will be able to:

1. **Understand Tensor Notation:** Define and manipulate Cartesian tensors using index notation, and apply transformation laws for addition, subtraction, and multiplication of tensors in various contexts.
2. **Apply Vector Calculus Theorems:** Utilize the gradient, divergence, and curl of scalar and vector functions, and apply Stokes, Gauss, and Green's theorems to solve problems in vector calculus and physics.

3. **Analyze Stress and Equilibrium:** Classify continuous media, distinguish between body forces and surface forces, and derive the components of the stress tensor along with the equations of equilibrium, including principal stresses and stress invariants.
4. **Describe Deformation and Flow:** Differentiate between Lagrangian and Eulerian descriptions of motion, analyze velocity, acceleration, and strain tensors, and derive the continuity equation in the context of fluid mechanics.
5. **Interpret Strain and Rotation:** Explain the geometrical meaning of linear strain tensor components, analyze principal axes and properties of strain tensors, and evaluate the rate of strain tensors and vorticity in fluid motion, providing insights into the behavior of deformable bodies.

Unit 1:

Cartesian Tensors, Index notation and transformation laws of Cartesian tensors. Addition, Subtraction and Multiplication of cartesian tensors, Gradient of a scalar function, Divergence of a vector function and Curl of a vector function using the index notation. ε-δ identity. Conservative vector field and concept of a scalar potential function. Stokes, Gauss and Green's theorems.

Unit 2:

Continuum approach, Classification of continuous media, Body forces and surface forces. Components of stress tensor, Force and Moment equations of equilibrium. Transformation law of stress tensor. Stress quadric. Principal stress and principal axes. Stress invariants and stress deviator. Maximum shearing stress.

Unit 3:

Lagrangian and Eulerian description of deformation of flow. Comoving derivative, Velocity and Acceleration. Continuity equation. Strain tensors. Linear rotation tensor and rotation vector, Analysis of relative displacements.

Unit – 4

Geometrical meaning of the components of the linear strain tensor, Properties of linear strain tensors. Principal axes, Theory of linear strain. Linear strain components. Rate of strain tensors. The vorticity tensor. Rate of rotation vector and vorticity, Properties of the rate of strain tensor, Rate of cubical dilation.

Reference Books:

1. W. Prager, Introduction to Mechanics of Continua, Lexinton Mass, Ginn, 1961.
2. A.C. Eringen, Mechanics of Continua, Wiley, 1967.
3. T.J. Chung, Continuum Mechanics, Prentice- Hall, 1988.

Paper – 5 : MAT B01 : Boundary Layer Theory- I
(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	MAT B01 : Boundary Layer Theory- I	3 Hrs	100	40

<table>
<tr><th>Semester</th><th>Code of the Course</th><th colspan="4">Title of the Course/Paper</th><th>NHEQF Level</th><th>Credits</th></tr>
<tr><td>I</td><td>MAT B01</td><td colspan="4">Boundary Layer Theory- I</td><td></td><td>6</td></tr>
<tr><th rowspan="2">Level of Course</th><th rowspan="2">Type of the Course</th><th colspan="3">Credit Distribution</th><th rowspan="2">Offered to NC Student</th><th colspan="2" rowspan="2">Course Delivery Method</th></tr>
<tr><th>Theory</th><th>Practical</th><th>Total</th></tr>
<tr><td>Advance</td><td>Major</td><td>6</td><td>0</td><td>6</td><td>Yes</td><td colspan="2">Lecture, Ninety lectures</td></tr>
<tr><td colspan="2">Prerequisites</td><td colspan="6">Mathematics course at UG Level.</td></tr>
<tr><td colspan="2">Objectives of the Course:</td><td colspan="6">This course aims to provide a comprehensive understanding of boundary layer theory and its applications in fluid mechanics. Students will learn the derivation of boundary layer equations for two-dimensional and three-dimensional flows, analyze characteristic parameters, and explore various exact and approximate solutions. Emphasis will be placed on practical applications such as flow past different geometries and boundary layer behavior in complex scenarios, including jets and rotating systems. By the end of the course, students will develop the ability to model and analyze boundary layer phenomena in both academic and industrial contexts.</td></tr>
</table>

Course Outcomes

Upon successful completion of this course, students will be able to:

1. **Derive and Apply Boundary Layer Equations:** Derive the boundary layer equations for two-dimensional flows and apply them to practical problems, including flow along flat plates and wedges.
2. **Analyze Boundary Layer Solutions:** Understand and apply exact and similarity solutions to steady-state boundary layer equations, including the Blasius-Topfer and Gortler new series methods.

Dy. Registrar
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JAIPUR

3. **Model Complex Flows:** Analyze and solve boundary layer problems for various flow configurations such as flow past a symmetrically placed cylinder, jets, and flows along convergent channels.
4. **Employ Transformations and Techniques:** Use Prandtl-Mises transformation and Mangler's transformation to simplify and solve complex boundary layer problems.
5. **Understand Three-Dimensional Flows:** Analyze three-dimensional boundary layer flows, including those on bodies of revolution, yawed cylinders, and rotating discs, and understand the growth and characteristics of these layers in different contexts.

Unit 1

Derivation of boundary layer equations for two-dimensional flow. Boundary layer along a flat plate (Blasius-Topfer solution). Characteristic boundary layer parameters. Similar solutions.

Unit - 2

Exact solution of the steady state boundary layer equations in two-dimensional flow. Flow past a wedge. Flow along the wall of a convergent channel. Boundary layer separation.

Unit-3

Flow past a symmetrically placed cylinder (Blasius series solution). Gortler new series method. Plane free jet, Circular jet, Plane wall jet. Prandtl-Mises transformation and its application of plane free jet.

Unit - 4

Axially symmetrical boundary layers on bodies at rest. Boundary layers on a body of revolution. Mangler's transformation. Three-dimensional boundary layers – Boundary layer flow on yawed cylinder. Growth of three-dimensional boundary layer on a rotating disc impulsively set in motion.

Reference Books:

1. J.L. Bansal, Viscous Fluid dynamics, JPH, Jaipur , 2008.
2. M.D.Raisinghania, Fluid Dynamics, S.Chand, 2003.
3. F. Chorlton, A Text Book of Fluid Dynamics, CBC, 1985.
4. S. W. Yuan, Foundations of Fluid Mechanics, Prentice-Hall, 1976.
5. S. I. Pai, Viscous Flow Theory I- Laminar Flow, D. Van Nostrand Co., Ing., Princeton, New Jersey, N.Y., Landon, Toronto, 1956.
6. F.M.White, Viscous Fluid Flow, McGraw-Hill, N.Y., 1974.

Paper-6: MAT C01 : Mathematical Programming -I
(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	MAT C01 : Mathematical Programming -I	3 Hrs	100	40

Semester	Code of the Course	Title of the Course/Paper			NHEQF Level	Credits
I	MAT C01	Mathematical Programming -I				6
Level of Course	Type of the Course	Credit Distribution			Offered to NC Student	Course Delivery Method
		Theory	Practical	Total		
Advance	Major	6	0	6	Yes	Lecture, Ninety lectures
Prerequisites		Mathematics course at UG Level.				
Objectives of the Course:		The objective of this course is to provide a thorough understanding of various advanced optimization techniques and their applications in solving complex decision-making problems. The course covers foundational topics in linear programming, integer programming, goal programming, separable programming, and dynamic programming. Students will learn both theoretical concepts and practical algorithms for solving optimization problems, including methods for handling bounded and integer variables, achieving multiple goals, and solving problems with non-linear and fractional components. The course aims to equip students with the skills necessary to apply these methods to real-world scenarios and advanced problem-solving situations. .				

Course Outcomes
Upon successful completion of this course, students will be able to:

1. **Apply Advanced Linear Programming Techniques:** Utilize separating and supporting hyperplane theorems and apply the revised simplex method to solve linear programming problems, including those with bounded variables.

2. **Solve Integer Programming Problems:** Implement Gomory's algorithm for all and mixed integer programming problems, and apply the Branch and Bound algorithm to find optimal solutions in integer programming.
3. **Employ Goal Programming Methods:** Use graphical and simplex methods for solving goal programming problems (GPP) to achieve multiple objectives simultaneously.
4. **Address Non-Linear and Separable Programming:** Apply piece-wise linear approximations to non-linear functions, reduce separable programming problems to linear programming problems, and use appropriate algorithms for separable and fractional programming.
5. **Implement Dynamic Programming Solutions:** Understand and apply Bellman's principle of optimality, solve dynamic programming problems with finite stages, and use dynamic programming techniques to address linear programming problems.

Unit – 1

Separating and supporting hyperplane theorems. Revised simplex method to solve Linear Programming problems, Bounded variable problems.

Unit – 2

Integer programming: Gomory's algorithm for all and mixed integer programming problems, Branch and Bound algorithm; Goal programming: Graphical goal attainment method, Simplex method for GPP.

Unit – 3

Separable programming: Piece-wise Linear approximations to non-linear functions, Reduction to separable programming problem to l.p.p., separable programming algorithm, fractional programming: computational procedure.

Unit - 4

Dynamic programming: Introduction, Bellman principle of optimality, solution of problems with finite number stages, solution of l.p.p. by dynamic programming.

Reference Books:

1. Kanti Swaroop, P.K.Gupta and Manmohan, Operation Research, Sultan Chand & Sons., N.Delhi, 2007.
2. S.D.Sharma, Operations Research, Kedar Nath Ram Nath and co. Meerut, 2005.
3. F. S. Hillier and G. J. Lieberman, Introduction to Operations Research Concepts and Cases (9th Edition), Tata McGraw Hill, 2010.
4. Hamdy A. Taha, Operations Research, An Introduction (9th edition), Prentice-Hall, 2010.
5. G. Hadley, Linear Programming, Narosa Publishing House, New Delhi, 2002.

Paper – 7: MAT D01 : Combinatorics and Graph Theory- I

(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	**MAT D01 : Combinatorics and Graph Theory- I**	**3 Hrs**	**100**	**40**

<table>
<tr><th>Semester</th><th>Code of the Course</th><th colspan="4">Title of the Course/Paper</th><th>NHEQF Level</th><th>Credits</th></tr>
<tr><td>I</td><td>MAT D01</td><td colspan="4">Combinatorics and Graph Theory- I</td><td></td><td>6</td></tr>
<tr><th rowspan="2">Level of Course</th><th rowspan="2">Type of the Course</th><th colspan="3">Credit Distribution</th><th rowspan="2">Offered to NC Student</th><th colspan="2" rowspan="2">Course Delivery Method</th></tr>
<tr><th>Theory</th><th>Practical</th><th>Total</th></tr>
<tr><td>Advance</td><td>Major</td><td>6</td><td>0</td><td>6</td><td>Yes</td><td colspan="2">Lecture, Ninety lectures</td></tr>
<tr><td colspan="2">Prerequisites</td><td colspan="6">Mathematics course at UG Level.</td></tr>
<tr><td colspan="2">Objectives of the Course:</td><td colspan="6">The objective of this course is to develop a foundational understanding of combinatorial mathematics, discrete numeric functions, and graph theory. Students will explore various combinatorial techniques, including counting principles and generating functions, and will delve into the fundamentals of graph theory, including the study of different types of graphs, paths, and circuits. The course also covers advanced topics such as the Traveling Salesman Problem and operations on trees. By the end of the course, students will be equipped with the theoretical knowledge and practical skills necessary for solving complex combinatorial and graph-based problems.</td></tr>
</table>

Course Outcomes

Upon successful completion of this course, students will be able to:

1. **Apply Combinatorial Techniques:** Utilize combinatorial methods to count sets, multisets, and objects, apply binomial and multinomial coefficients, and solve problems involving unordered and ordered selections with and without repetitions. Demonstrate proficiency in using the Pigeonhole Principle and the Inclusion-Exclusion Principle.

Dy. Registrar
(Academic)
University of Rajasthan
JAIPUR

2. **Utilize Discrete Numeric Functions:** Understand and apply discrete numeric functions to solve combinatorial problems. Use generating functions and power series to model and solve recursions, including both homogeneous and non-homogeneous linear recursions.
3. **Analyze Graphs and Graph Properties:** Comprehend and apply basic graph terminology, and identify and work with simple graphs, multi-graphs, and weighted graphs. Analyze paths, circuits, and connectedness, and solve problems related to shortest paths, Eulerian and Hamiltonian paths and circuits.
4. **Solve Graph-Based Problems:** Address complex problems such as the Traveling Salesman Problem and perform operations on graphs. Understand and apply concepts related to trees, including rooted trees, spanning trees, and minimum spanning trees.

Unit-1

Introduction to diagraphs, Orientation of a graph, Underlying graph, Parallel edges, Source and Sink, Types of diagraphs, Accessibility, Arborescence, Spanning Arborescence, Euler digraphs, Handshaking dilemma, Incidence matrix of a diagraph, Circuit matrix of a diagraph.

Unit-2

Degree sequences, Graphic sequence, Havel Hakimi Theorem. Matrix representation of graphs except adjacency and incidence matrix.

Unit-3

Planer graphs Kurotowski's graphs, Maximal planar graphs, Outer planer graphs, Maximal outer planar graph, minimally non-outer planar graphs, Thickness and Crossing number of bipartite and complete bipartite graph, Euler's formula, Kuratowski's theorem.

Unit-4

Isomorphism, Homorphism. Graph theory in Network Analysis Network flows, Transport networks, Max-flow min-cut-theorem

Reference Books:

1. N. Deo, Graph Theory with Applications to Computer Science, Prentice-Hall of India, 1979.
2. C.L. Liu, Elements of Discrete Mathematics, (Second Edition), McGraw Hill, International Edition, 1986.
3. J.P. Tremblay and R. Manohar, Discrete Mathematical Structures with Applications to Computer Science, McGraw-Hill Book Co., 1995.
4. S. Wiitala, Discrete Mathematics: A Unified Approach, McGraw-Hill Book Co., 1987.
5. Ian Anderson, A First course in Combinatorial Mathematics, Springer, 1989.

Paper – 8 : MAT F01 : Relativistic Mechanics

(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	MAT F01 : Relativistic Mechanics	3 Hrs	100	40

Semester	Code of the Course	Title of the Course/Paper			NHEQF Level	Credits
I	MAT F01	Relativistic Mechanics				6
Level of Course	Type of the Course	Credit Distribution			Offered to NC Student	Course Delivery Method
		Theory	Practical	Total		
Advance	Major	6	0	6	Yes	Lecture, Ninety lectures
Prerequisites		Mathematics course at UG Level.				
Objectives of the Course:		The objective of this course is to provide a thorough understanding of the principles and mathematical framework of special relativity. Students will explore the foundational concepts such as the relativity of space and time, Lorentz transformations, and relativistic effects. The course covers the theoretical underpinnings of relativistic mechanics, including time dilation, Lorentz contraction, and the relationship between mass and energy. Additionally, students will delve into the geometrical interpretation of relativity through Minkowski space and understand the principles of equivalence and general covariance. By the end of the course, students will gain a solid grasp of both the conceptual and mathematical aspects of special relativity and their implications for modern physics.				

Course Outcomes

Upon successful completion of this course, students will be able to:

1. **Understand and Apply Relativity Principles:** Explain the principle of relativity and its postulates, derive the Lorentz transformation equations, and apply them to problems involving velocity composition, time dilation, and length contraction.
2. **Analyze Relativistic Effects:** Describe and apply concepts of simultaneity, relativistic velocity transformations, and Lorentz contraction. Understand and solve problems related to particle acceleration and relativistic aberration, and relate these concepts to Newtonian theory.
3. **Utilize Relativistic Mechanics:** Analyze the variation of mass with velocity, and understand the equivalence of mass and energy. Use transformation formulae for relativistic mass, momentum, and energy, and solve problems involving the conservation of these quantities. Apply the principles of relativistic Lagrangian and Hamiltonian mechanics.
4. **Interpret Minkowski Space and Relativistic Geometry:** Understand and apply concepts of Minkowski space, including space-like, time-like, and light-like intervals. Utilize the concepts of the null cone, proper time, and world lines. Discuss the principles of equivalence and general covariance within the context of relativity.

Unit – 1

Relative Character of space and time, Principle of Relativity and its postulates, Derivation of special Lorentz transformation equations, Composition of Parallel velocities, Lorentz-Fitzgerald contraction formula, Time dilation.

Unit – 2

Simultaneity, Relativistic transformation formulae for velocity, Lorentz contraction factor, Particle acceleration, Velocity of light as fundamental velocity, Relativistic aberration and its deduction to Newtonian theory.

Unit - 3

Variation of mass with velocity, Equivalence of mass and energy, Transformation formulae for mass, Momentum and energy, Problems on conservation of mass, Momentum and energy, Relativistic Lagrangian and Hamiltonian.

Unit - 4

Minkowski space, Space-like, Time-like and Light-like intervals, Null cone, Relativity and Causality, Proper time, World line of a particle. Principles of Equivalence and General Covariance.

Reference Books:

1. J.V. Narlikar, Lectures on General Relativity and Cosmology, Macmillan Co. Ltd. India, N. Delhi, 1978.

Dy. Registrar
(Academic)
University of Rajasthan
JAIPUR

2. C. Moller, The Theory of Relativity, Oxford Clarendon Press, 1952.
3. P.G. Bergmann, Introduction to the Theory of Relativity, Prentice Hall of India, 1969.
4. J.L. Anderson, Principles of Relativity Physics, Academic Press, 1967.
5. W. Rindler, Essential Relativity, Van Nostrand Reinhold Company, 1969.
6. V. A. Ugarov, Special Theory of Relativity, Mir Publishers, 1979.

Paper – 9: MAT G01: Industrial Mathematics- I

(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	MAT G01: Industrial Mathematics- I Mechanics	3 Hrs	100	40

Semester	Code of the Course	Title of the Course/Paper			NHEQF Level	Credits
I	MAT G01	Industrial Mathematics- I				6
Level of Course	**Type of the Course**	**Credit Distribution**			**Offered to NC Student**	**Course Delivery Method**
		Theory	**Practical**	**Total**		
Advance	Major	6	0	6	Yes	Lecture, Ninety lectures
Prerequisites		Mathematics course at UG Level.				
Objectives of the Course:		The objective of this course is to provide students with a thorough understanding of various mathematical techniques and computational methods used in solving partial differential equations (PDEs), linear programming (LP) problems, and assignment and transportation problems. The course covers finite difference methods for PDEs, operational techniques in LP, including the Simplex method and its variations, and explores assignment models and transportation problems in optimization. By integrating theoretical knowledge with practical applications, particularly in fluid mechanics and industrial contexts, students will gain the skills necessary to address complex problems in operations research and applied mathematics.				

Course Objective

The objective of this course is to provide students with a thorough understanding of various mathematical techniques and computational methods used in solving partial differential equations (PDEs), linear programming (LP) problems, and assignment and transportation problems. The course covers finite difference methods for PDEs, operational techniques in LP, including the Simplex method and its variations, and explores assignment models and transportation problems in optimization. By integrating theoretical knowledge with practical applications, particularly in fluid mechanics and industrial contexts, students will gain the skills necessary to address complex problems in operations research and applied mathematics.

Course Outcomes

Upon successful completion of this course, students will be able to:

1. **Solve Partial Differential Equations (PDEs):** Apply techniques for solving PDEs, including finite difference methods. Analyze and solve industry-related problems, particularly in fluid mechanics, using these methods.
2. **Apply Operational Techniques in Linear Programming:** Utilize linear programming techniques to solve optimization problems. Implement computational procedures for the Simplex method, including the Two-Phase Simplex method and Big-M method, to find optimal solutions.
3. **Utilize Advanced Linear Programming Methods:** Employ the Revised Simplex method and understand the concept of duality in linear programming. Analyze the relationship between duality and the Simplex method to solve complex LP problems.
4. **Formulate and Solve Assignment and Transportation Problems:** Develop mathematical formulations for assignment and transportation problems. Apply the Hungarian method to solve assignment problems, and address transportation models including finding initial basic feasible solutions and handling degeneracy and unbalanced problems.

Unit -1

Partial differential equations and techniques of solution. Finite difference methods for solving PDE. Application to problems of industry with special reference to Fluid Mechanics.

Unit -2

Operational Techniques.Linear Programming problems. Computational procedure of Simplex method, Two-phase Simplex method, Big-M-method.

Unit - 3

Revised Simplex method, Duality in linear programming, Duality and Simplex method.

Unit - 4

Assignment models. Mathematical formulation, Hungarian method. Travelling Salesman problem. Transportation models. Mathematical formulation. Initial basic feasible solution. Degeneracy and unbalanced transportation problems.

Reference Books:

1. Kanti Swaroop, P.K. Gupta and Manmohan, Operation Research, Sultan Chand & Sons., N. Delhi, 2007.
2. S.D. Sharma, Operations Research, Kedar Nath Ram Nath and co. Meerut, 2005.
3. H.A. Taha, Operations Research: An Introduction; MacMillan Publishing Company, New York, 1982.
4. F.S. Hillier and G.J. Leiberman, Introduction to Operations Research; Holden Day, 1962.
5. I.N. Sneddon, Elements of Partial Differential Equations, McGraw-Hill, 1988.

Paper – 10: MAT H01: Magnetohydrodynamics - I

(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	MAT H01: Magnetohydrodynamics - I	3 Hrs	100	40

<table>
<tr><th>Semester</th><th>Code of the Course</th><th colspan="4">Title of the Course/Paper</th><th>NHEQF Level</th><th>Credits</th></tr>
<tr><td>I</td><td>MAT H01</td><td colspan="4">Magnetohydrodynamics - I</td><td></td><td>6</td></tr>
<tr><th rowspan="2">Level of Course</th><th rowspan="2">Type of the Course</th><th colspan="3">Credit Distribution</th><th rowspan="2">Offered to NC Student</th><th colspan="2" rowspan="2">Course Delivery Method</th></tr>
<tr><th>Theory</th><th>Practical</th><th>Total</th></tr>
<tr><td>Advance</td><td>Major</td><td>6</td><td>0</td><td>6</td><td>Yes</td><td colspan="2">Lecture, Ninety lectures</td></tr>
<tr><td colspan="2">Prerequisites</td><td colspan="6">Mathematics course at UG Level.</td></tr>
<tr><td colspan="2">Objectives of the Course:</td><td colspan="6">The objective of this course is to provide an in-depth understanding of magnetohydrodynamics (MHD) and its applications in fluid mechanics and electromagnetic theory. Students will explore Maxwell's equations in the context of fluid motion, the fundamental principles of MHD, and various MHD approximations and boundary conditions. The course also emphasizes the use of dimensional analysis to interpret key dimensionless numbers in fluid dynamics and MHD. Practical applications of MHD will</td></tr>
</table>

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University of Rajasthan
JAIPUR

	be studied through analysis of different flow scenarios, including those in channels, pipes, and rotating systems. By the end of the course, students will be equipped with both theoretical knowledge and practical skills to analyze and solve complex MHD problems.

Course Objective

The objective of this course is to provide an in-depth understanding of magnetohydrodynamics (MHD) and its applications in fluid mechanics and electromagnetic theory. Students will explore Maxwell's equations in the context of fluid motion, the fundamental principles of MHD, and various MHD approximations and boundary conditions. The course also emphasizes the use of dimensional analysis to interpret key dimensionless numbers in fluid dynamics and MHD. Practical applications of MHD will be studied through analysis of different flow scenarios, including those in channels, pipes, and rotating systems. By the end of the course, students will be equipped with both theoretical knowledge and practical skills to analyze and solve complex MHD problems.

Course Outcomes

Upon successful completion of this course, students will be able to:

1. **Understand Maxwell's Equations and MHD Fundamentals:** Comprehend Maxwell's electromagnetic field equations and the constitutive equations for fluid motion, including the Stokes hypothesis. Analyze the Maxwell stress tensor and fundamental equations of magnetohydrodynamics.
2. **Apply MHD Approximations and Boundary Conditions:** Use MHD approximations to solve problems involving magnetic field equations and frozen-in fluid effects. Understand and apply boundary conditions specific to MHD, and analyze Alfven transverse waves.
3. **Utilize Dimensional Analysis in MHD:** Perform inspection and dimensional analysis using π-products to determine dimensionless numbers such as Reynolds number, Mach number, Prandtl number, Magnetic Reynolds number, Magnetic pressure number, Hartmann number, Magnetic parameter, Magnetic Prandtl number, and Nusselt number.
4. **Analyze MHD Flow Scenarios:** Solve practical problems involving MHD flow in various geometries including Hartmann plane Poiseuille flow, plane Couette flow with temperature distribution, MHD flow in rectangular cross-section tubes, pipes, annular channels, and between rotating coaxial cylinders.

Unit -1

Maxwell electromagnetic field equations. Constitutive equations of fluid motion, Stokes hypothesis. Maxwell stress tensor. Fundamental equations of Magnetofluid-dynamics.

Unit - 2

Magnetofluiddynamic approximations. Magnetic field equation, Frozen in fluid, Alfven transverse waves. MHD boundary conditions.

Unit - 3

Inspection and Dimensional analysis, π-products. Reynolds number, Mach number, Prandtl number, Magnetic Reynolds number, Magnetic pressure number, Hartmann number, Magnetic parameter, Magnetic Prandtl number and Nusselt number.

Unit - 4

Hartmann plane Poiseuille flow and plane Couette flow including temperature distribution. MHD flow in a tube of rectangular cross-section. MHD pipe flow. MHD flow in annular channel. MHD flow between two rotating coaxial cylinders.

Reference Books:

1. J.L. Bansal, Magnetofluiddynamics of Viscous Fluids, JPH, Jaipur, 1994.
2. K.R. Cramer and S.I. Pai, Magnetofluiddynamics for Enginners and Applied Physicists, McGraw-Hill, N.Y., 1973.
3. P.A. Davidson, An Introduction to Magnetohydrodynamics, Cambridge Univ. Press, U.K., 2001.
4. J.A. Shercliff, A Textbook of Magnetohydrodynamics, Pergamon Press., 1965.
5. K.R. Cramer and S.I. Pai, Magnetofluid Dynamics for Engineers and Applied Physicists, McGraw- Hill Book Co., 1973.

Paper – 11: MAT I01: Numerical Analysis – I

(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	MAT I01 : Numerical Analysis – I	3 Hrs	100	40

Semester	Code of the Course	Title of the Course/Paper			NHEQF Level	Credits
I	MAT I01	Numerical Analysis – I				6
Level of Course	Type of the Course	Credit Distribution			Offered to NC Student	Course Delivery Method
		Theory	Practical	Total		
Advance	Major	6	0	6	Yes	Lecture, Ninety lectures
Prerequisites		Mathematics course at UG Level.				

Objectives of the Course:	The objective of this course is to provide a comprehensive understanding of numerical methods for solving algebraic and differential equations. The course covers iterative methods, polynomial equations, systems of simultaneous linear equations, and eigenvalue problems. Students will explore various techniques for accelerating convergence, solving polynomial equations, and handling systems of linear equations using direct and iterative methods. Additionally, the course will delve into eigenvalue problems, including methods for finding eigenvalues and eigenvectors. By the end of the course, students will have acquired the skills necessary to apply these numerical techniques effectively in practical and theoretical problems.

Course Outcomes
Upon successful completion of this course, students will be able to:

1. **Apply Iterative Methods:** Understand and implement iterative methods, including the theory of iteration, acceleration of convergence, Chebyshev method, Muler's method, and methods for finding multiple and complex roots.
2. **Utilize Polynomial Equation Techniques:** Solve polynomial equations using various methods, including synthetic division, the Birge-Vieta method, Bairstow's method, and Graeffe's root squaring method. Understand the real and complex roots of polynomials and apply these methods to find polynomial solutions.
3. **Solve Systems of Simultaneous Linear Equations:** Use direct methods such as determinants, Gauss-Jordan elimination, and LU-Factorization techniques (Doolittle's, Crout's, and Cholesky's methods) to solve systems of simultaneous linear equations. Apply partition methods and relaxation techniques for iterative solutions.
4. **Analyze Eigenvalue Problems:** Understand and apply methods for finding eigenvalues and eigenvectors, including the Power method, Jacobi method, Givens' method, and Rutishauser method. Analyze complex eigenvalues and apply these methods to solve eigenvalue problems.

Unit – 1

Iterative methods – Theory of iteration method, Acceleration of the convergence, Chebyshev method, Muler's method, Methods for multiple and complex roots.

Unit - 2

Newton-Raphson method for simultaneous equations, Convergence of iteration process in the case of several unknowns. Solution of polynomial equations – Polynomial equation, Real and complex roots, Synthetic division, the Birge-Vieta, Bairstow and Graeffe's root squaring method.

Unit - 3

System of simultaneous Equations (Linear)- Direct method, Method of determinant, Gauss-Jordan, LU-Factorizations-Doolitte's, Crout's and Cholesky's. Partition method. Relaxation methods.

Unit - 4

Eigen value problems– Basic properties of eigen values and eigen vector, Power methods, Method for finding all eigen values of a matrix. Jacobi, Givens' and Rutishauser method. Complex eigen values.

Reference Books:

1. S.S. Sastry, Introductory Methods of Numerical Analysis, PHI, 1979.
2. V.Rajaraman, Computer Oriented Numerical Methods, PHI, 1993.
3. M.K. Jain, S.R.K. Eyenger and R.K. Jain, Numerical Methods for Mathematics and Applied Physicists, Wiley-Eastern Pub., N. Delhi, 2005.
4. B. Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, India, 2007.
5. C. F. Gerald and P. O. Wheatley, Applied Numerical Analysis, Pearson Education, India,7th edition, 2008.
6. C.F. Gerald, P.O. Wheatley, Applied Numerical Analysis, Addison-Wesley, 1998.
7. S. D. Conte, C de Boor, Elementary Numerical Analysis, McGraw-Hill, 1980.
8. C.E. Froberg, Introduction to Numerical Analysis, (Second Edition), Addition-Wesley, 1979.

Paper – 12: MAT J01: Computer Applications-I
(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	MAT J01: Computer Applications-I	3 Hrs	100	40

<table>
<tr><th>Semester</th><th>Code of the Course</th><th colspan="3">Title of the Course/Paper</th><th>NHEQF Level</th><th>Credits</th></tr>
<tr><td>I</td><td>MAT J01</td><td colspan="3">Computer Applications-I</td><td></td><td>6</td></tr>
<tr><th rowspan="2">Level of Course</th><th rowspan="2">Type of the Course</th><th colspan="3">Credit Distribution</th><th rowspan="2">Offered to NC Student</th><th rowspan="2">Course Delivery Method</th></tr>
<tr><th>Theory</th><th>Practical</th><th>Total</th></tr>
<tr><td>Advance</td><td>Major</td><td>6</td><td>0</td><td>6</td><td>Yes</td><td>Lecture, Ninety lectures</td></tr>
</table>

Prerequisites	Mathematics course at UG Level.
Objectives of the Course:	The objective of this course is to provide a foundational understanding of computer systems, including hardware, software, and operating systems, and to develop practical skills in programming and problem-solving using popular computational tools. Students will learn about computer organization, input-output devices, and memory systems, as well as gain proficiency in using system and application software, including MS Word and MS Excel. The course emphasizes hands-on experience with programming languages and computational tools such as MATLAB, Mathematica, or Maple, focusing on variables, matrix operations, and algorithmic problem-solving. By the end of the course, students will be equipped to use computational tools effectively for a variety of tasks and problems.

Course Outcomes

Upon successful completion of this course, students will be able to:

1. **Understand Computer Systems:** Explain the basic components of computer systems, including hardware (input-output devices, memory systems) and software (operating systems). Demonstrate knowledge of computer organization and the interaction between hardware and software.
2. **Use System and Application Software:** Navigate and utilize system software and application software effectively. Manage files and folders, configure printers and modems, and use accessories in Windows. Demonstrate proficiency in MS Word and MS Excel, including basic operations and file management.
3. **Perform Computational Programming:** Write and execute programs using MATLAB, Mathematica, or Maple. Understand and apply basic programming concepts such as variables, vector and matrix computation, built-in functions, and plotting. Create and manage M-files for computational tasks.
4. **Implement Advanced Programming Techniques:** Develop more advanced programming skills using MATLAB, Mathematica, or Maple, including creating and using functions, implementing loops, conditional execution, and performing matrix multiplication.

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University of Rajasthan
JAIPUR

Unit 1: Computing Fundamentals, Programming Logic, and Algorithms

Evolution of computer systems, classification of programming languages, components of modern computing environments, number systems and their conversions, Boolean algebra and logic gates, processing of mathematical instructions by computers, algorithm design through flowcharts and pseudocode, and computational modeling of basic mathematical problems.

Unit 2: Programming in C – Control Structures and Logic Development

Basics of C programming language syntax, compilation, and program execution; use of data types, variables, expressions, and operators; implementation of conditional statements and loop constructs for logical control; development of programs to solve problems involving arithmetic operations, sequences, and decision-making logic in a procedural programming framework.

Unit 3: Modular Programming in C – Arrays, Functions, Pointers, and File Operations

Structured programming with functions and recursion, handling of one- and two-dimensional arrays, matrix operations, string manipulation, and pointer-based memory access; file handling techniques including reading from and writing to files; development of C programs for matrix multiplication, solving systems of linear equations, and implementing numerical methods such as integration and differentiation.

Unit 4: Document Preparation, Data Handling, and Presentation Tools

Fundamentals of word processing using MS Word, including document formatting, equation editor, use of styles, tables, referencing tools, and layout design for academic reports and mathematical content; data organization, analysis, and visualization in MS Excel using formulas, functions, charts, pivot tables, and conditional formatting; creation of structured, interactive, and visually effective presentations in MS PowerPoint with the use of templates, transitions, animations, and embedded objects.

Reference Books:

1. Y. Kanetkar, Let Us C, BPB Publications, 2008.
2. C. Ghezzi and M. Jazayeri, Programming Languages Concepts, John Wiley, 1977.
3. M. Marcotty & H.F. Ledgard, Programming Language Landscape, Galgotia Publication, 1981.
4. B.S. Gottfried, Schaum's Outline of Theory and Problems of Programming with C, McGraw-Hill, 1996.
5. Brian R. Hunt, Ronald L. Lipsman, Jonathan M. Rosenberg, A Guide to MATLAB, Cambidge Univ. Press, 2001.
6. Duane hanselman and Bruce Littlefield, Mastering Matlab-7, Pearson Education 2005.
7. William J. Palm III, Introduction to Matlab-7 for Engineers, McGraw Hill, 2005.
8. Mureşan, Marian, Introduction to Mathematica® with Applications, Springer, 2017.
9. José Guillermo Sánchez León, Mathematica Beyond Mathematics: The Wolfram Language in the Real World, Chapman and Hall/CRC, 2017.

Semester – IV

Paper -1 : MAT X01 : Functional Analysis II and Advanced Calculus

(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	MAT X01 : Functional Analysis II and Advanced Calculus	3 Hrs	100	40

Semester	Code of the Course	Title of the Course/Paper			NHEQF Level	Credits
I	MAT X01	Functional Analysis II and Advanced Calculus				6
Level of Course	Type of the Course	Credit Distribution			Offered to NC Student	Course Delivery Method
		Theory	Practical	Total		
Advance	Major	6	0	6	Yes	Lecture, Ninety lectures
Prerequisites		Mathematics course at UG Level.				
Objectives of the Course:		The objective of this course is to provide a comprehensive understanding of functional analysis, focusing on linear functionals, normed spaces, and inner product spaces, with particular emphasis on Hilbert spaces. The course covers fundamental theorems such as Hahn-Banach and Riesz Representation Theorem, explores the properties and structures of Hilbert spaces, and examines various operators and their spectral properties. By the end of the course, students will develop a deep understanding of functional analysis concepts and their applications in advanced mathematical contexts.				

Course Outcomes
Upon successful completion of this course, students will be able to:

1. **Understand and Apply Functional Analysis Theorems:** Explain the concepts of continuous linear functionals, the Hahn-Banach theorem and its consequences, and the

embeddings and reflexivity of normed spaces. Provide examples of dual spaces and understand their significance in functional analysis.

2. **Analyze Hilbert Spaces:** Describe the properties of Hilbert spaces, including the Cauchy-Schwartz inequality, orthogonality, and functionals. Apply the Pythagorean theorem and the projection theorem in Hilbert spaces. Understand and identify separable Hilbert spaces and their examples.
3. **Utilize Orthonormal Sets and Bases:** Work with orthonormal sets and apply Bessel's inequality. Use the Gram-Schmidt orthogonalization process to find orthonormal bases. Understand complete orthonormal sets, Parseval's identity, and the structure of Hilbert spaces. Apply the Riesz Representation Theorem and understand the reflexivity of Hilbert spaces.
4. **Analyze Operators on Hilbert Spaces:** Determine the adjoint of an operator on a Hilbert space. Analyze and classify operators as self-adjoint, positive, normal, and unitary, and understand their properties. Work with orthogonal projections, eigenvalues, eigenvectors, and the spectrum of operators. Apply the spectral theorem to operators in Hilbert s

Unit – 1

Continuous linear functionals. Hahn-Banach theorem and its consequences. Reflexivity of normed spaces. Dual spaces with examples. Inner product spaces.

Unit – 2

Hilbert space and its properties. Cauchy-Schwartz inequality, Orthogonality and Functionals in Hilbert Spaces. Phythagorean theorem, Projection theorem, Separable Hilbert spaces and Examples.

Unit - 3

Orthonormal sets, Bessel's inequality, Existence of orthonormal bases by Gram-schimidt orthogonalization process. Complete orthonormal sets, Parseval's identity, Structure of a Hilbert space, Riesz representation theorem, Reflexivity of Hilbert spaces.

Unit – 4

Adjoint of an operator on a Hilbert space. Self-adjoint, Positive, Normal and Unitary operators and their properties. Projection on a Hilbert space. Invariance. Reducibility. Orthogonal projections. Eigen values and eigen vectors of an operator. Spectrum of an operator Spectral theorem.

Reference Books:

1. E. Kreyszig, Introductory Functional Analysis with Applications, John Wiley and Sons., 1978.
2. A. E. Taylor, Introduction to Functional Analysis, John Wiley, 1958.
3. A. Bowers and N. Kalton, An Introductory Course in Functional Analysis, Springer Verlog, 2014.
4. W. Rudin, Functional Analysis, McGraw-Hill, 1973.

Paper – 2: MAT X02 : Viscous Fluid Dynamics – II

(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	**MAT X02: Viscous Fluid Dynamics – II**	**3 Hrs**	**100**	**40**

<table>
<tr><th>Semester</th><th>Code of the Course</th><th colspan="4">Title of the Course/Paper</th><th>NHEQF Level</th><th>Credits</th></tr>
<tr><td>I</td><td>MAT X02</td><td colspan="4">Viscous Fluid Dynamics – II</td><td></td><td>6</td></tr>
<tr><th rowspan="2">Level of Course</th><th rowspan="2">Type of the Course</th><th colspan="3">Credit Distribution</th><th rowspan="2">Offered to NC Student</th><th colspan="2" rowspan="2">Course Delivery Method</th></tr>
<tr><th>Theory</th><th>Practical</th><th>Total</th></tr>
<tr><td>Advance</td><td>Major</td><td>6</td><td>0</td><td>6</td><td>Yes</td><td colspan="2">Lecture, Ninety lectures</td></tr>
<tr><td colspan="2">Prerequisites</td><td colspan="6">Mathematics course at UG Level.</td></tr>
<tr><td colspan="2">Objectives of the Course:</td><td colspan="6">The objective of this course is to provide students with a comprehensive understanding of fluid dynamics involving unsteady flows, energy equations, and boundary layer theory. The course aims to develop the ability to analyze complex fluid flow scenarios, such as flow due to moving walls, oscillations, and suction/injection processes. Additionally, it covers temperature distribution in different geometries, the effects of variable viscosity in Couette flow, and the principles of very slow motion in fluids. Students will learn to derive and solve equations related to velocity and thermal boundary layers, preparing them for advanced studies and applications in fluid mechanics.</td></tr>
</table>

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Course Outcomes

By the end of this course, students will be able to:

1. **Understand and analyze unsteady flow phenomena,** including those caused by moving and oscillating walls, and comprehend the implications of suction and injection through porous walls.

   Derive and solve the energy equation for temperature distribution in various configurations, such as parallel plates, pipes, and concentric rotating cylinders.
2. **Apply the theory of variable viscosity to analyze plane Couette** flow and understand the principles of transpiration cooling.
3. **Explain and apply the concepts of Stokes' and Oseen's** flows in the context of very slow motion around a sphere.
4. **Derive and understand velocity and thermal boundary layer equations** in two-dimensional flows, and apply solutions to specific cases like the boundary layer on a flat plate and thermal boundary layers where the Prandtl number equals one.
5. **Integrate the theoretical knowledge of fluid dynamics** with practical applications in engineering and research scenarios, preparing for advanced topics in fluid mechanics.

Unit – 1

Concept of unsteady flow, Flow due to plane wall suddenly set in the motion (Stokes' first problem), Flow due to an oscillating plane wall (Stokes' second problem), Starting flow in plane Couette motion, Suction/injection through porous wall.

Unit - 2

Equation of energy, Temperature distribution: Between parallel plates, in a pipe, between two concentric rotating cylinders.

Unit - 3

Variable viscosity plane Couette flow, temperature distribution of plane Couette flow with transpiration cooling. Theory of very slow motion: Stokes' and Oseen's flows past a sphere.

Unit – 4

Concept of boundary layer, Derivation of velocity and thermal boundary equations in two-dimensional flow. Boundary layer on flat plate (Balsius-Topfer solution), Simple solution of thermal boundary layer equation for Pr = 1.

Reference Books:

1. J.L. Bansal, Viscous Fluid dynamics, JPH, Jaipur, 2008.
2. M.D. Raisinghania, Fluid Dynamics, S.Chand, 2003.

3. F. Chorlton, A Text Book of Fluid Dynamics, CBC, 1985.
4. S. W. Yuan, Foundations of Fluid Mechanics, Prentice-Hall, 1976.
5. S. I. Pai, Viscous Flow Theory I- Laminar Flow, D. Van Nostrand Co., Ing., Princeton, New Jersey, N.Y., Landon, Toronto, 1956.
6. F.M. White, Viscous Fluid Flow, McGraw-Hill, N.Y., 1974.

Paper – 3: MAT X03: Integral Equations
(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	MAT X03 : Integral Equations	3 Hrs	100	40

<table>
<tr><th>Semester</th><th>Code of the Course</th><th colspan="4">Title of the Course/Paper</th><th>NHEQF Level</th><th>Credits</th></tr>
<tr><td>I</td><td>MAT X03</td><td colspan="4">Integral Equations</td><td></td><td>6</td></tr>
<tr><th rowspan="2">Level of Course</th><th rowspan="2">Type of the Course</th><th colspan="3">Credit Distribution</th><th rowspan="2">Offered to NC Student</th><th rowspan="2" colspan="2">Course Delivery Method</th></tr>
<tr><th>Theory</th><th>Practical</th><th>Total</th></tr>
<tr><td>Advance</td><td>Major</td><td>6</td><td>0</td><td>6</td><td>Yes</td><td colspan="2">Lecture, Ninety lectures</td></tr>
<tr><td colspan="2">Prerequisites</td><td colspan="6">Mathematics course at UG Level.</td></tr>
<tr><td colspan="2">Objectives of the Course:</td><td colspan="6">The objective of this course is to provide students with a solid foundation in the theory and application of linear integral equations. The course aims to develop students' ability to solve various types of integral equations, including Fredholm and Volterra equations, using different mathematical techniques. Topics covered include the conversion of differential equations to integral equations, eigenvalues and eigenfunctions, resolvent kernels, symmetric kernels, and classical Fredholm theory. The course prepares students for advanced study in mathematics and engineering by equipping them with the skills needed to analyze and solve integral equations that arise in various scientific and engineering contexts.</td></tr>
</table>

Course Outcomes
By the end of this course, students will be able to:

1. **Understand the definition and classification of linear** integral equations and convert initial and boundary value problems into integral equations. Analyze and compute eigenvalues and eigenfunctions for these equations.

2. **Solve homogeneous and general Fredholm integral equations** of the second kind with separable kernels, applying methods suitable for these types of problems.
3. **Apply methods of successive substitutions and successive approximations** to solve Fredholm and Volterra integral equations of the second kind, and understand the concept of the resolvent kernel, including conditions for uniform convergence and the uniqueness of series solutions.
4. **Analyze integral equations with symmetric kernels using** the orthogonal system of functions and fundamental properties of eigenvalues and eigenfunctions. Apply the Hilbert-Schmidt theorem to solve Fredholm integral equations of the second kind.
5. **Solve Volterra integral equations of the second kind with convolution**-type kernels using Laplace transforms, and solve singular integral equations using Fourier transforms.
6. **Understand and apply classical Fredholm theory**, including Fredholm theorems, to solve Fredholm integral equations of the second kind using Fredholm's first theorem.
7. **Integrate knowledge of integral equations to solve complex mathematical** problems and apply these techniques to practical problems in physics, engineering, and applied mathematics.
8. **Demonstrate proficiency in theoretical and practical aspects** of solving integral equations, contributing to advanced research and professional practice in mathematical and engineering disciplines.

Unit – 1

Linear integral equations– Definition and classification. Conversion of initial and boundary value problems to an integral equation. Eigen values and Eigen functions. Solution of homogeneous and general Fredholm integral equations of second kind with separable kernels.

Unit - 2

Solution of Fredholm and Volterra integral equations of second kind by methods of successive substitutions and successive approximations. Resolvent kernel and its results. Conditions of uniform convergence and uniqueness of series solution.

Unit – 3

Integral equations with symmetric kernels– Orthogonal system of functions. Fundamental properties of eigen values and eigen functions for symmetric kernels. Expansion in eigen functions and bilinear form. Hilbert-Schmidt theorem. Solution of Fredholm integral equations of second kind by using Hilbert-Schmidt theorem.

Unit - 4

Solution of Volterra integral equations of second kind with convolution type kernels by Laplace transform. Solution of singular integral equations by Fourier transform.

Classical Fredholm theory– Fredholm theorems. Solution of Fredholm integral equation of second kind by using Fredholm first theorem.

Reference Books:

1. Shanti Swarup, Integral Equations, Krishna Publications, Meerut.
2. M.D.Raisinghania, Integral Equations and Boundary Value Problems, S.Chand, 2010.
3. Abdul J. Jerry, Introduction to Integral Equations with applications, Marcel Dekkar Inc. NY, 1999.
4. L.G.Chambers, Integral Equations: A short Course, Int. Text Book Company Ltd. 1976.

Optional Paper (ECC)

Paper – 4: MAT A02: Continuum Mechanics – II
(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	**MAT A02 : Continuum Mechanics – II**	3 Hrs	100	40

<table>
<tr><th>Semester</th><th>Code of the Course</th><th colspan="3">Title of the Course/Paper</th><th colspan="2">NHEQF Level</th><th>Credits</th></tr>
<tr><td>I</td><td>MAT A02</td><td colspan="3">Continuum Mechanics – II</td><td colspan="2"></td><td>6</td></tr>
<tr><td rowspan="2">Level of Course</td><td rowspan="2">Type of the Course</td><td colspan="3">Credit Distribution</td><td rowspan="2">Offered to NC Student</td><td colspan="2" rowspan="2">Course Delivery Method</td></tr>
<tr><td>Theory</td><td>Practical</td><td>Total</td></tr>
<tr><td>Advance</td><td>Major</td><td>6</td><td>0</td><td>6</td><td>Yes</td><td colspan="2">Lecture, Ninety lectures</td></tr>
<tr><td colspan="2">Prerequisites</td><td colspan="6">Mathematics course at UG Level.</td></tr>
<tr><td colspan="2">Objectives of the Course:</td><td colspan="6">The objective of this course is to provide students with a thorough understanding of fundamental principles in fluid mechanics and thermodynamics, as well as their applications in elasticity and fluid dynamics. The course focuses on the conservation laws, equations of motion, thermodynamic principles, and elasticity theories. It aims to equip students with the knowledge to analyze fluid flow problems, apply thermodynamic laws, and understand the behavior of materials under stress. By the end of the course, students will be prepared to approach advanced topics in mechanical and civil engineering fields with a solid theoretical foundation.</td></tr>
</table>

Course Outcomes

By the end of this course, students will be able to:

1. **Understand and apply the law of conservation of mass** and the Eulerian continuity equation, as well as utilize the Reynolds transport theorem and momentum integral theorem in various engineering applications.
2. **Comprehend the kinetic equation of state** and the first and second laws of thermodynamics, including their applications to both linear elasticity and fluid mechanics. Students will learn to apply the generalized Hooke's law for isotropic homogeneous solids.
3. **Analyze and solve problems related to linear elasticity**, including understanding and applying compatibility equations (Beltrami-Michell equations), strain energy functions, and the uniqueness theorem. Students will also be familiar with the principles of superposition and the relationship between pressure and density in fluid dynamics.
4. **Apply fundamental fluid dynamics principles**, including the kinetic equation of state, equations of motion, vorticity-stream surfaces for inviscid flow, and Bernoulli's equations. Students will also learn to identify and utilize similarity parameters of fluid flow.
5. **Understand irrotational flow and velocity potential concepts** and their applications in fluid dynamics, enabling them to analyze and solve complex fluid flow problems.
6. **Integrate the knowledge of thermodynamics and fluid dynamics** to solve practical engineering problems, preparing them for more advanced studies and professional applications in fields such as mechanical, civil, and aerospace engineering.

Unit – 1

Law of conservation of mass and Eulerian continuity equation. Reynolds transport theorem. Momentum integral theorem and equation of motion.

Unit – 2

Kinetic equation of state. First and the second law of thermodynamics and dissipation function. Applications (Linear elasticity and Fluids) – Assumptions and basic equations. Generalized Hook's law for an isotropic homogeneous solid.

Unit – 3

Compatibility equations (Beltrami-Michell equations). Classification of types of problems in linear elasticity. Principle of superposition, Strain energy function, Uniqueness theorem, p-ρ relationship and work kinetic energy equation, Irrotational flow and Velocity potential.

Unit – 4

Kinetic equation of state and first law of Thermodynamics. Equation of continuity. Equations of motion. Vorticity-stream surfaces for inviscid flow, Bernoullis equations. Irrotational flow and velocity potential. Similarity parameters of fluid flow.

Reference Books:

4. W. Prager, Introduction to Mechanics of Continua, Lexinton Mass, Ginn, 1961.
5. A.C. Eringen, Mechanics of Continua, Wiley, 1967.
6. T.J. Chung, Continuum Mechanics, Prentice- Hall, 1988.

Paper – 5: MAT B02: Boundary Layer Theory – II
(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	**MAT B02 : Boundary Layer Theory – II**	**3 Hrs**	**100**	**40**

<table>
<tr><th>Semester</th><th>Code of the Course</th><th colspan="4">Title of the Course/Paper</th><th>NHEQF Level</th><th>Credits</th></tr>
<tr><td>I</td><td>MAT B02</td><td colspan="4">Boundary Layer Theory – II</td><td></td><td>6</td></tr>
<tr><th rowspan="2">Level of Course</th><th rowspan="2">Type of the Course</th><th colspan="3">Credit Distribution</th><th rowspan="2">Offered to NC Student</th><th rowspan="2" colspan="2">Course Delivery Method</th></tr>
<tr><th>Theory</th><th>Practical</th><th>Total</th></tr>
<tr><td>Advance</td><td>Major</td><td>6</td><td>0</td><td>6</td><td>Yes</td><td colspan="2">Lecture, Ninety lectures</td></tr>
<tr><td colspan="2">Prerequisites</td><td colspan="6">Mathematics course at UG Level.</td></tr>
<tr><td colspan="2">Objectives of the Course:</td><td colspan="6">The objective of this course is to provide students with an in-depth understanding of unsteady boundary layer theory, thermal boundary layers, and convective heat transfer. The course aims to equip students with the skills to analyze and solve complex fluid flow problems involving boundary layers, using both exact and approximate methods. It covers the growth of boundary layers under various conditions, methods for solving boundary layer equations, and the thermal effects in convective flows. By integrating theoretical concepts with practical applications, students will be prepared for advanced studies and research in fluid dynamics and heat transfer.</td></tr>
</table>

Course Outcomes

By the end of this course, students will be able to:

1. **Analyze unsteady boundary layers using methods** of successive approximations, understanding boundary layer growth after impulsive and accelerated starts, and for periodic flows driven by pulsatile pressure gradients.
2. **Apply approximate methods to solve boundary layer equations**, including the Karman momentum integral equation, the Karman-Pohlhausen method, the Waltz-Thwaites method, and the energy integral equation, to solve complex fluid flow problems.
3. **Derive and understand the two-dimensional thermal boundary layer equation** for flow over a plane wall, and analyze forced convection in a laminar boundary layer on a flat plate, utilizing Crocco's integrals and Reynolds analogy for heat and momentum transfer.
4. **Analyze temperature distribution in different jet flows**, including plane free jets, circular jets, and plane wall jets, and understand the principles of free convection from heated vertical plates. Apply thermal-energy integral equations and approximate solutions, such as the Pohlhausen method, to problems of free convection.
5. **Integrate knowledge of boundary layer theory and thermal analysis to address** complex fluid dynamics and heat transfer problems in engineering, preparing for further study or professional work in fields such as aerospace, mechanical, and chemical engineering.
6. **Demonstrate proficiency in using theoretical models** and numerical methods to solve practical problems in unsteady and thermal boundary layers, contributing to the development of innovative solutions in fluid mechanics and heat transfer applications.

Unit-1

Unsteady boundary layers – Method of successive approximations, Boundary layer growth after impulsive start of motion and in accelerated motion, Boundary layer for periodic flow (Pulsatile pressure gradient).

Unit - 2

Approximate methods for the solution of the boundary layer equations. Karman momentum integral equation. Karman-Pohlhausen method and its application. Waltz-Thwaites method. Energy integral equation.

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Unit - 3

Derivation of two-dimensional thermal boundary layer equation for flow over a plane wall. Forced convection in a laminar boundary layer on a flat plate, Crocco's first and second integrals. Reynolds analogy.

Unit - 4

Temprature distribution in the spread of a jet – (i) Plane free jet, (ii) Circular jet (iii) Plane wall jet. Free convection from a heated vertical plate. Thermal-energy integral equation. Approximate solution of the Pohlhausan's problem of free convection from a heated vertical plate.

Reference Books:

1. J.L. Bansal, Viscous Fluid dynamics, JPH, Jaipur, 2008.
2. M.D. Raisinghania, Fluid Dynamics, S. Chand, 2003.
3. F. Chorlton, A Text Book of Fluid Dynamics, CBC, 1985.
4. S. W. Yuan, Foundations of Fluid Mechanics, Prentice-Hall, 1976.
5. S. I. Pai, Viscous Flow Theory I- Laminar Flow, D. Van Nostrand Co., Ing., Princeton, New Jersey, N.Y., Landon, Toronto, 1956.
6. F.M. White, Viscous Fluid Flow, McGraw-Hill, N.Y., 1974.

Paper – 6: MAT C02: Mathematical Programming - II
(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	MAT C02 : Mathematical Programming - II	3 Hrs	100	40

<table>
<tr><th>Semester</th><th>Code of the Course</th><th colspan="3">Title of the Course/Paper</th><th>NHEQF Level</th><th>Credits</th></tr>
<tr><td>I</td><td>MAT C02</td><td colspan="3">Mathematical Programming - II</td><td></td><td>6</td></tr>
<tr><th rowspan="2">Level of Course</th><th rowspan="2">Type of the Course</th><th colspan="3">Credit Distribution</th><th rowspan="2">Offered to NC Student</th><th rowspan="2">Course Delivery Method</th></tr>
<tr><th>Theory</th><th>Practical</th><th>Total</th></tr>
<tr><td>Advance</td><td>Major</td><td>6</td><td>0</td><td>6</td><td>Yes</td><td>Lecture, Ninety lectures</td></tr>
<tr><td colspan="2">Prerequisites</td><td colspan="5">Mathematics course at UG Level.</td></tr>
<tr><td colspan="2">Objectives of the Course:</td><td colspan="5">The objective of this course is to provide students with a comprehensive understanding of nonlinear programming and optimization techniques. The course focuses on the theoretical foundations and practical applications of various optimization methods, including convex functions, quadratic programming, and geometric programming. Students will learn</td></tr>
</table>

	to formulate and solve constrained optimization problems, apply the Kuhn-Tucker conditions, and understand duality in quadratic programming. The course aims to equip students with the skills needed to tackle complex optimization problems in engineering, economics, and other fields.

Course Outcomes

By the end of this course, students will be able to:

1. **Understand and apply the concepts of convex functions and quadratic forms** to solve constrained problems of maxima and minima using the Lagrangian method.
2. **Formulate and solve nonlinear programming problems** using graphical methods and understand the fundamental ingredients of nonlinear optimization.
3. **Apply the Kuhn-Tucker necessary and sufficient conditions** for optimality and analyze saddle points and saddle-point theorems in the context of nonlinear programming.
4. **Solve quadratic programming problems using the Kuhn-Tucker** conditions and Wolfe method, and understand the concept of duality in quadratic programming.
5. **Apply Beale's method to solve quadratic programming problems** (QPP) and understand the formulation and solution of geometric programming problems using geometric-arithmetic inequalities and necessary conditions of optimality.
6. **Integrate the knowledge of optimization techniques to address** complex real-world problems, preparing for advanced studies or professional applications in areas such as operations research, finance, engineering, and data science.
7. **Demonstrate proficiency in theoretical and practical optimization** techniques, contributing to innovative solutions in various fields that require optimal decision-making and resource allocation.

Unit – 1

Convex function, Quadratic forms, constrained problem of maxima and minima, Lagrangian method, Non-linear programming: Formulation and Graphical method.

Unit – 2

Non-linear programming and its fundamental ingradients, Khun-Tucker necessary and sufficient conditions; Saddle point, Saddle-point theorems.

Unit – 3

Quadratic Programming: Kuhn-Tueker conditions, Wolfe method, Duality in Quadratic Programming.

Unit - 4

Beals method to solve QPP, Geometric Programming: Formulation, geometric arithmetic inequality, necessary conditions of optimality.

Reference Books:

1. Kanti Swaroop, P.K. Gupta and Manmohan, Operation Research, Sultan Chand & Sons., N. Delhi, 2007.
2. S.D. Sharma, Operations Research, Kedar Nath Ram Nath and co. Meerut, 2005.
3. F. S. Hillier and G. J. Lieberman, Introduction to Operations Research Concepts and Cases (9th Edition), Tata McGraw Hill, 2010.
4. Hamdy A. Taha, Operations Research, An Introduction (9th edition), Prentice-Hall, 2010.
5. G. Hadley, Linear Programming, Narosa Publishing House, New Delhi, 2002.

Paper – 7: MAT D02: Graph Theory – II
(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	MAT D02: Graph Theory – II	3 Hrs	100	40

<table>
<tr><th>Semester</th><th>Code of the Course</th><th colspan="4">Title of the Course/Paper</th><th>NHEQF Level</th><th>Credits</th></tr>
<tr><td>I</td><td>MAT D02</td><td colspan="4">Graph Theory – II</td><td></td><td>6</td></tr>
<tr><td rowspan="2">Level of Course</td><td rowspan="2">Type of the Course</td><td colspan="3">Credit Distribution</td><td rowspan="2">Offered to NC Student</td><td colspan="2" rowspan="2">Course Delivery Method</td></tr>
<tr><td>Theory</td><td>Practical</td><td>Total</td></tr>
<tr><td>Advance</td><td>Major</td><td>6</td><td>0</td><td>6</td><td>Yes</td><td colspan="2">Lecture, Ninety lectures</td></tr>
<tr><td colspan="2">Prerequisites</td><td colspan="6">Mathematics course at UG Level.</td></tr>
<tr><td colspan="2">Objectives of the Course:</td><td colspan="6">The objective of this course is to provide students with a comprehensive understanding of advanced graph theory concepts and their applications. The course covers various topics including cut sets, network flows, planarity in graphs, graph coloring, and directed graphs. Students will explore foundational theorems, such as the max-flow min-cut theorem, Euler’s formula, and Cayley’s theorem, as well as advanced topics like graph coloring and counting labeled trees. The course aims to develop students' abilities to analyze and solve complex problems in graph theory,</td></tr>
</table>

	which are applicable in computer science, engineering, operations research, and other related fields.

Course Outcomes

By the end of this course, students will be able to:

1. **Understand and apply concepts of cut sets**, cut vertices, and network flows to analyze the connectivity and separativity of graphs, and utilize the max-flow min-cut theorem to solve flow problems in networks.
2. **Analyze and determine the planarity of graphs using** combinatorial and geometric approaches, understand Kuratowski's graphs, apply Euler's formula, and calculate the thickness and crossing number of planar graphs.
3. **Apply graph coloring techniques, including vertex coloring**, edge coloring, and map coloring, to solve problems related to chromatic numbers and chromatic polynomials, and understand the four-color and five-color theorems.
4. **Understand the properties and applications of digraphs**, including binary relations, directed graphs, directed trees, and tournaments. Apply methods such as the Polish notation method and analyze tournaments using graph theory principles.
5. **Count labeled trees using various combinatorial methods,** including Cayley's theorem and Polya's theory, to solve problems in graph enumeration and understand the principles of counting in graph theory.
6. **Integrate knowledge of graph theory concepts to address practical** problems in various fields, preparing for advanced studies or professional applications in areas such as computer science, network design, and operations research.
7. **Demonstrate proficiency in theoretical and practical aspects** of graph theory, contributing to innovative solutions in fields that require complex network analysis, optimization, and algorithm development.

Unit-1

Cut set and Cut vertices, Cut set and bridge, fundamental cut set, Connectivity and Severability, Vector spaces of graphs.

Unit-2

Coloring: Graph Coloring, vertex coloring, Edge coloring, Properly coloring of a graph, Chromatic polynomial, Decomposition theorem, Four colour theorem, The five colour theorem.

Unit-3

Enumeration of graphs: Types of enumeration, Labeled graphs, Counting labeled tress, Rooted labled trees, Enumeration of graphs, Partitions, Generating functions, Counting unlabeled trees, Rooted unlabeled trees, Permutation, Composition of Permutation, P6lya's theorem, Burnside's lemma, P6lya's enumeration theorem.

Unit-4

Graph and Algorithms: Applications Shortest path algorithms, Dijkstra's algorithm, Algorithm for minimal spanning tree, Kruskal's algorithm, Prim's algorithm, the labeling algorithms.

Reference Books:

1. N. Deo, Graph Theory with Applications to Computer Science, Prentice-Hall of India, 1979.
2. C.L. Liu, Elements of Discrete Mathematics, (Second Edition), McGraw Hill, International Edition, 1986.
3. J.P. Tremblay and R. Manohar, Discrete Mathematical Structures with Applications to Computer Science, McGraw-Hill Book Co., 1995.
4. S. Wiitala, Discrete Mathematics: A Unified Approach, McGraw-Hill Book Co., 1987.
5. Ian Anderson, A First course in Combinatorial Mathematics, Springer, 1989.

Paper – 8 : MAT F02 : General Relativity & Cosmology
(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	MAT F02 : General Relativity & Cosmology	3 Hrs	100	40

<table>
<tr><th>Semester</th><th>Code of the Course</th><th colspan="4">Title of the Course/Paper</th><th>NHEQF Level</th><th>Credits</th></tr>
<tr><td>I</td><td>MAT F02</td><td colspan="4">General Relativity & Cosmology</td><td></td><td>6</td></tr>
<tr><td rowspan="2">Level of Course</td><td rowspan="2">Type of the Course</td><td colspan="3">Credit Distribution</td><td rowspan="2">Offered to NC Student</td><td colspan="2" rowspan="2">Course Delivery Method</td></tr>
<tr><td>Theory</td><td>Practical</td><td>Total</td></tr>
<tr><td>Advance</td><td>Major</td><td>6</td><td>0</td><td>6</td><td>Yes</td><td colspan="2">Lecture, Ninety lectures</td></tr>
<tr><td colspan="2">Prerequisites</td><td colspan="6">Mathematics course at UG Level.</td></tr>
<tr><td colspan="2">Objectives of the Course:</td><td colspan="6">The objective of this course is to provide students with a deep understanding of the fundamental concepts and mathematical frameworks</td></tr>
</table>

	of General Relativity. The course covers the theoretical underpinnings of Einstein's field equations, the Schwarzschild metric, and the relationship between gravity and spacetime. Students will explore key topics such as Mach's principle, the nature of singularities, relativistic orbits, tests of General Relativity, and cosmological models. By the end of the course, students will be equipped with the knowledge and skills necessary to analyze complex problems in gravitational physics and cosmology.

Course Outcomes

By the end of this course, students will be able to:

1. **Understand and apply Mach's principle and the Newtonian approximation** of the equation of motion. Derive and analyze Einstein's field equations for both matter and empty space, and understand their reduction to Poisson's equation. Explain the resolution of the clock paradox within the framework of General Relativity.
2. **Analyze the Schwarzschild exterior metric and its isotropic form**, including the identification and implications of singularities. Derive key relationships such as GM=c2mGM = c^2mGM=c2m and calculate the mass of the sun in gravitational units. Formulate and solve the relativistic differential equations governing the orbits of planets.
3. **Describe and analyze the three crucial tests of General Relativity** and understand their significance. Explore the analogues of Kepler's laws in the context of General Relativity, and calculate the trace of the Einstein tensor and the energy-momentum tensor for a perfect fluid. Understand the Schwarzschild interior metric and the corresponding boundary conditions.
4. **Demonstrate the Lorentz invariance of Maxwell's equations in empty** space and calculate the Lorentz force on a charged particle. Derive the energy-momentum tensor for electromagnetic fields and understand its role in Einstein's field equations with a cosmological term. Analyze static cosmological models, including the Einstein and de-Sitter models, and understand their physical and geometrical properties. Explore non-static forms of de-Sitter line-elements and their relation to redshift, Einstein spaces, Hubble's law, and Weyl's postulate.
5. **Integrate knowledge of General Relativity and cosmology** to solve complex theoretical and practical problems in gravitational physics, providing a solid foundation for advanced studies or research in these fields.

6. **Demonstrate proficiency in theoretical physics by applying** advanced mathematical techniques to analyze and solve problems related to the curvature of spacetime, the behavior of objects in strong gravitational fields, and the dynamics of the universe.

Unit - 1

Mach's principle, Newtonian approximation of equation of motion, Einstein's field equation for matter and empty space, Reduction of Einstein's field equation to Poisson's equation, Removal of clock paradox in General Relativity.

Unit - 2

Schwarzschild exterior metric, its isotropic form, Singularity and singularities in Schwarzschild exterior metric, Derivation of the formula $GM = c^2m$, Mass of sun in gravitational unit, Relativistic differential equation for the orbit of the planet.

Unit – 3

Three crucial tests in General Relativity and their detailed descriptions, Analogues of Kepler's laws in General Relativity, Trace of Einstein tensor, Energy-momentum tensor and its expression for perfect fluid, Schwarzschild interior metric and boundary condition.

Unit – 4

Lorentz invariance of Maxwell's equations in empty space, Lorentz force on charged particle, Energy-momentum tensor for electro-magnetic field. Einstein's field equation with cosmological term, Static cosmological models (Einstein & de-Sitter models) with physical and geometrical properties, Non-static form of de-Sitter line-element and Red shift in this metric, Einstein space, Hubble's law, Weyl's postulate.

Reference Books:

1. J.V. Narlikar, Lectures on General Relativity and Cosmology, Macmillan Co. Ltd. India, N. Delhi, 1978.
2. C. Moller, The Theory of Relativity, Oxford Clarendon Press, 1952.
3. P.G. Bergmann, Introduction to the Theory of Relativity, Prentice Hall of India, 1969.
4. J.L. Anderson, Principles of Relativity Physics, Academic Press, 1967.
5. W. Rindler, Essential Relativity, Van Nostrand Reinhold Company, 1969.
6. V. A. Ugarov, Special Theory of Relativity, Mir Publishers, 1979.

Paper – 9: MAT G02: Industrial Mathematics – II
(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	MAT G02 : Industrial Mathematics – II	3 Hrs	100	40

Semester	Code of the Course	Title of the Course/Paper			NHEQF Level	Credits
I	MAT G02	Industrial Mathematics – II				6
Level of Course	Type of the Course	Credit Distribution			Offered to NC Student	Course Delivery Method
		Theory	Practical	Total		
Advance	Major	6	0	6	Yes	Lecture, Ninety lectures
Prerequisites		Mathematics course at UG Level.				
Objectives of the Course:		The objective of this course is to introduce students to the fundamental concepts and mathematical models of inventory management, replacement, and reliability theory. The course covers various Economic Order Quantity (EOQ) models, including those with constraints and shortages, as well as replacement strategies for items that deteriorate or fail completely. Additionally, the course provides an in-depth understanding of reliability theory, including the analysis of system reliability, aging, and failure rates. Students will learn to apply these models to optimize inventory management, maintenance strategies, and reliability of systems in various practical contexts.				

Course Objective

The objective of this course is to introduce students to the fundamental concepts and mathematical models of inventory management, replacement, and reliability theory. The course covers various Economic Order Quantity (EOQ) models, including those with constraints and shortages, as well as replacement strategies for items that deteriorate or fail completely. Additionally, the course provides an in-depth understanding of reliability theory, including the analysis of system reliability, aging, and failure rates. Students will learn to apply these models to optimize inventory management, maintenance strategies, and reliability of systems in various practical contexts.

Course Outcomes

By the end of this course, students will be able to:

1. **Understand and apply inventory management models**, specifically Economic Order Quantity (EOQ) models, with and without shortages. Analyze these models to determine optimal inventory levels and reorder points.
2. **Develop and apply EOQ models with constraints**, understanding how to incorporate real-world limitations such as budget, space, and supplier constraints into inventory management decisions.
3. **Analyze replacement and reliability models**, including strategies for replacing items that deteriorate over time or fail completely. Determine optimal replacement schedules to minimize costs and maximize operational efficiency.
4. **Apply reliability theory to assess system reliability**, including the study of coherent structures and the reliability of systems composed of independent components. Calculate bounds on system reliability and understand the shapes of reliability functions.
5. **Understand concepts related to the aging and failure rates** of systems, including parametric families of life distributions with monotone failure rates. Apply these concepts to predict system performance and lifespan.
6. **Integrate knowledge of inventory, replacement, and reliability** models to optimize decision-making in various industrial and engineering contexts, preparing for advanced study or professional applications in operations management, logistics, and reliability engineering.
7. **Demonstrate proficiency in mathematical modeling** and analysis by effectively applying inventory, replacement, and reliability theories to solve complex, real-world problems in management and engineering.

Unit - 1

Inventory Models. EOQ models with and without shortages.

Unit - 2

EOQ models with constraints.

Unit - 3

Replacement and Reliability models. Replacement of items that deteriorate, Replacement of items that fail completely.

Unit - 4

Reliability Theory – Coherent structure, Reliability of systems of independent components, Bounds on system reliability, Shapes of the system reliability function, Motion of aging, Parametric families of life distribute with Monotone failure rate.

Reference Books:

1. Kanti Swaroop, P.K. Gupta and Manmohan, Operation Research, Sultan Chand & Sons., N. Delhi, 2007.
2. S.D. Sharma, Operations Research, Kedar Nath Ram Nath and co. Meerut, 2005.
3. H.A. Taha, Operations Research: An Introduction; MacMillan Publishing Company, New York, 1982.
4. F.S. Hillier and G.J. Leiberman, Introduction to Operations Research; Holden Day, 1962.
5. I.N. Sneddon, Elements of Partial Differential Equations, McGraw-Hill, 1988.

Paper – 10: MAT H02: Magnetohydrodynamics - II
(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	**MAT H02: Magnetohydrodynamics - II**	3 Hrs	100	40

<table>
<tr><th>Semester</th><th>Code of the Course</th><th colspan="3">Title of the Course/Paper</th><th>NHEQF Level</th><th>Credits</th></tr>
<tr><td>I</td><td>MAT H02</td><td colspan="3">Magnetohydrodynamics - II</td><td></td><td>6</td></tr>
<tr><th rowspan="2">Level of Course</th><th rowspan="2">Type of the Course</th><th colspan="3">Credit Distribution</th><th rowspan="2">Offered to NC Student</th><th rowspan="2">Course Delivery Method</th></tr>
<tr><th>Theory</th><th>Practical</th><th>Total</th></tr>
<tr><td>Advance</td><td>Major</td><td>6</td><td>0</td><td>6</td><td>Yes</td><td>Lecture, Ninety lectures</td></tr>
<tr><td colspan="2">Prerequisites</td><td colspan="5">Mathematics course at UG Level.</td></tr>
<tr><td colspan="2">Objectives of the Course:</td><td colspan="5">The objective of this course is to provide students with a comprehensive understanding of Magnetohydrodynamics (MHD) and its applications in fluid dynamics. The course covers various types of MHD flows, including stagnation point flows, boundary layer flows, jet flows, and shock waves. It focuses on the mathematical modeling, analysis, and numerical techniques used to solve MHD problems, as well as the physical interpretations of these solutions. By the end of the course, students will be able to analyze and solve complex MHD flow problems and understand the behavior of conducting fluids in magnetic fields, preparing them for</td></tr>
</table>

	advanced studies and research in fluid dynamics and engineering.

Course Outcomes

By the end of this course, students will be able to:

1. **Understand and analyze MHD flows near stagnation points and different** types of MHD flows such as Rayleigh's flow, Stokes' flow past a sphere, and Oseen's flow past a sphere. Apply mathematical techniques to solve these flows and interpret the physical phenomena associated with them.
2. **Solve MHD boundary layer flow problems past flat** plates in both aligned and transverse magnetic fields. Utilize Wilson's numerical solution technique and modified Rossow's method to analyze these flows, understanding the effects of magnetic fields on boundary layer behavior.
3. **Analyze MHD plane free jet flows and MHD waves** using the theory of characteristics. Understand and derive equations of characteristics and characteristic surfaces, and solve MHD characteristic equations to analyze wave propagation in conducting fluids.
4. **Understand and analyze MHD shock waves**, including the derivation and interpretation of Friedriches diagrams, dispersion relations, and the generalized Hugoniot condition. Classify MHD shock waves, evaluate their compressive nature, and assess their stability under different conditions.
5. **Apply theoretical and numerical methods to solve MHD flow problems**, integrating knowledge of fluid dynamics and electromagnetism to address complex real-world scenarios involving conducting fluids and magnetic fields.
6. **Demonstrate proficiency in MHD theory and application**, preparing for advanced research or professional practice in fields such as aerospace engineering, astrophysics, and industrial applications involving magnetic fields and conducting fluids.

Unit - 1

MHD flow near a stagnation point. MHD Reyleigh's flow. MHD Stoke's flow past a sphere, MHD Oseen's flow past a sphere.

Unit - 2

MHD boundary layer flow past a flat plate in an aligned magnetic flow. Wilson's numerical solution technique. MHD boundary layer flow past a flat plate in a transverse magnetic field. modified Rossow's method of solution.

Unit - 3

MHD plane free jet flow. Wave and theory of characteristics, Equation of the characteristics, Characteristic surfaces, MHD characteristic equations. MHD waves.

Unit - 4

Friedriches diagrams. Dispersion relation. MHD shock waves. Generalized Hugoniot condition. Compressive nature of MHD shocks. MHD shock wave classification. MHD shock stability.

Reference Books:

1. J.L. Bansal, Magnetofluiddynamics of Viscous Fluids, JPH, Jaipur, 1994.
2. K.R. Cramer and S.I. Pai, Magnetofluiddynamics for Enginners and Applied Physicists, McGraw-Hill, N.Y., 1973.
3. P.A. Davidson, An Introduction to Magnetohydrodynamics, Cambridge Univ. Press, U.K., 2001.
4. J.A. Shercliff, A Textbook of Magnetohydrodynamics, Pergamon Press., 1965.
5. K.R. Cramer and S.I. Pai, Magnetofluid Dynamics for Engineers and Applied Physicists, McGraw- Hill Book Co., 1973.

Paper 11: MAT I02: Numerical Analysis – II
(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	MAT I02: Numerical Analysis – II	3 Hrs	100	40

<table>
<tr><th>Semester</th><th>Code of the Course</th><th colspan="3">Title of the Course/Paper</th><th>NHEQF Level</th><th>Credits</th></tr>
<tr><td>I</td><td>MAT I02</td><td colspan="3">Numerical Analysis – II</td><td></td><td>6</td></tr>
<tr><th rowspan="2">Level of Course</th><th rowspan="2">Type of the Course</th><th colspan="3">Credit Distribution</th><th rowspan="2">Offered to NC Student</th><th rowspan="2">Course Delivery Method</th></tr>
<tr><th>Theory</th><th>Practical</th><th>Total</th></tr>
<tr><td>Advance</td><td>Major</td><td>6</td><td>0</td><td>6</td><td>Yes</td><td>Lecture, Ninety lectures</td></tr>
<tr><td colspan="2">Prerequisites</td><td colspan="5">Mathematics course at UG Level.</td></tr>
<tr><td colspan="2">Objectives of the Course:</td><td colspan="5">The objective of this course is to provide students with a thorough understanding of numerical methods for curve fitting, function approximation, and solving ordinary differential equations (ODEs). The course covers various techniques for approximating functions, including least squares, polynomial fitting, Taylor series, and Chebyshev polynomials. Additionally, students will learn numerical methods for</td></tr>
</table>

	solving ODEs, including Taylor series, Picard, and Runge-Kutta methods, and explore stability analysis and boundary value problems. Finite difference methods for solving linear boundary value problems are also introduced. By the end of the course, students will have the skills to apply these numerical techniques to solve complex mathematical problems encountered in engineering and applied sciences.

Course Outcomes

By the end of this course, students will be able to:

1. **Understand and apply curve fitting and function approximation techniques**, including least square error criterion, linear regression, polynomial fitting, and approximation of functions using Taylor series and Chebyshev polynomials. Analyze the accuracy and efficiency of different approximation methods.
2. **Solve ordinary differential equations (ODEs) numerically using** various methods such as Taylor series, Picard method, Runge-Kutta methods up to fourth order, and multistep methods, including predictor-corrector strategies.
3. **Perform stability analysis for numerical methods used in solving ODEs**, both single and multistep methods. Apply this understanding to ensure the reliability and accuracy of numerical solutions.
4. **Analyze and solve boundary value problems (BVPs) for ordinary differential equations** using methods such as the shooting method, and understand their application in various scientific and engineering problems.
5. **Implement finite difference methods to develop difference schemes for solving** linear boundary value problems, and apply these schemes to practical problems.
6. **Integrate knowledge of numerical methods to solve complex problems,** enabling advanced study or professional application in fields such as engineering, physics, and computational mathematics.
7. **Demonstrate proficiency in applying numerical techniques** for solving mathematical problems, contributing to innovative solutions in computational analysis and modeling in scientific and engineering contexts.

Unit – 1

Curve Fitting and Function Approximations – Least square error criterion. Linear regression. Polynomial fitting and other curve fittings, Approximation of functions by Taylor series and Chebyshev polynomials.

Unit – 2

Numerical solution of Ordinary Differential Equations – Taylor series Mathod, Picard method, Runge-Kutta methods upto fourth order, Multistep method (Predictor-corrector strategies).

Unit - 3

Stability analysis – Single and Multistep methods.BVP's of ordinary differential Equations – Boundary value problems (BVP's), Shooting methods.

Unit - 4

Finite difference methods. Difference schemes for linear boundary value problems of the type $y'' = f(x, y), y'' = f(x, y, y')$ and $y^{iv} = f(x, y)$.

Reference Books:

1. S.S. Sastry, Introductory Methods of Numerical Analysis, PHI, 1979.
2. V.Rajaraman, Computer Oriented Numerical Methods, PHI, 1993.
3. M.K. Jain, S.R.K. Eyenger and R.K. Jain, Numerical Methods for Mathematics and Applied Physicists, Wiley-Eastern Pub., N. Delhi, 2005.
4. B. Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, India, 2007.
5. C. F. Gerald and P. O. Wheatley, Applied Numerical Analysis, Pearson Education, India,7th edition, 2008.
6. C.F. Gerald, P.O. Wheatley, Applied Numerical Analysis, Addison-Wesley, 1998.
7. S. D. Conte, C de Boor, Elementary Numerical Analysis, McGraw-Hill, 1980.
8. C.E. Froberg, Introduction to Numerical Analysis, (Second Edition), Addition-Wesley, 1979.

Paper – 12: MAT J02: Computer Applications-II
(Teaching 6 hours per week)

Type	Paper code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Passing Marks
Theory	MAT J02: Computer Applications-II	3 Hrs	100	40

Semester	Code of the Course	Title of the Course/Paper			NHEQF Level	Credits
I	MAT J02	Computer Applications-II				6
Level of Course	Type of the Course	Credit Distribution			Offered to NC Student	Course Delivery Method
		Theory	Practical	Total		
Advance	Major	6	0	6	Yes	Lecture, Ninety lectures

Dy. Registrar (Academic) University of Rajasthan JAIPUR

Prerequisites	Mathematics course at UG Level.
Objectives of the Course:	The objective of this course is to introduce students to various numerical methods for solving mathematical problems and to develop proficiency in using computational tools such as MATLAB, Mathematica, and Maple. The course covers the numerical solution of systems of linear equations, computation of eigenvalues and eigenvectors, least squares approximation, numerical integration, and the numerical solution of differential equations. It also includes graphical representation of data and solutions in two and three dimensions. By the end of the course, students will be able to apply these numerical techniques to solve complex mathematical problems and utilize software tools to perform advanced computations and visualizations.

Course Outcomes

By the end of this course, students will be able to:

1. **Solve systems of linear equations using numerical methods such** as Gauss elimination and Gauss-Seidel methods. Analyze the efficiency and accuracy of these methods in various applications.
2. **Compute eigenvalues and eigenvectors using the power method** and inverse power method, and apply these techniques to problems in linear algebra and other areas requiring eigenvalue analysis.
3. **Perform least squares approximation to fit data to straight lines**, parabolas, and cubic equations, enabling accurate modeling of data and trends in scientific and engineering contexts.
4. **Apply numerical integration techniques,** including the trapezoidal and Simpson's methods, to approximate the definite integrals of functions, and perform double integration for more complex problems.
5. **Find roots of polynomials and create two-dimensional** and three-dimensional plots to visually represent mathematical functions and data, enhancing understanding of the underlying concepts.
6. **Solve initial value problems numerically using methods such as** Euler's method and the fourth-order Runge-Kutta method, and apply these techniques to practical problems involving differential equations.

7. **Utilize computational tools such as MATLAB**, Mathematica, and Maple to solve boundary value problems, perform numerical integrations, and create visualizations, effectively leveraging technology for advanced mathematical computations.
8. **Integrate numerical methods and computational tools** to solve complex problems across various disciplines, preparing for advanced study or professional work in fields such as engineering, physics, and applied mathematics.
9. **Demonstrate proficiency in the application of numerical methods** and software tools for solving mathematical problems, contributing to innovative solutions in research and industry.

Unit 1: Advanced LaTeX and Scientific Documentation

This unit prepares students for technical writing and professional presentation of research work. It covers LaTeX document structure, mathematical typesetting, tables, figures, equations, graphs and referencing using BibTeX. Students also learn to include algorithms, theorems, and code listings using packages like amsmath, algorithm2e, and listings. The unit ends with the preparation of a mini-project report or thesis template integrating code, equations, graphs, and references in LaTeX.

Unit 2: Scientific Computing using Scilab and MATLAB

Students explore the computational environments of Scilab and MATLAB. Topics include matrix operations, writing scripts and user-defined functions, data visualization through plots and surface graphs, and solving algebraic and differential equations. Applications in calculus, linear algebra, and graphical representation of mathematical models are emphasized to build intuition through simulation.

Unit 3: Symbolic Computation using Mathematica and Maple

This unit introduces symbolic computing tools for exact mathematical analysis. Students learn to perform symbolic differentiation, integration, series expansion, simplification, and algebraic equation solving. Advanced applications include symbolic solutions to ODEs and PDEs, and generating interactive plots and animations. Emphasis is given to modeling complex mathematical structures and symbolic manipulation of expressions.

Unit 4: R Programming for Mathematical and Statistical Applications

Introduction to the R programming environment; manipulation of data structures including vectors, matrices, lists, and data frames; development of reusable functions and implementation of control structures; generation of plots using base graphics and gplot2; applications involving statistical computations, graphical visualization of curves, and numerical solutions of differential and algebraic equations.

Reference Books:

1. Yashavant Kanetkar, Let Us C – BPB Publications
   (Comprehensive guide to C programming with examples and exercises.)
2. E. Balagurusamy, Programming in ANSI C – McGraw Hill
   (Essential for understanding C syntax, control structures, arrays, and functions.)
3. Steven C. Chapra, Applied Numerical Methods with MATLAB for Engineers and Scientists – McGraw Hill
   (Numerical computing techniques using MATLAB and Scilab.)
4. Garrett Grolemund & Hadley Wickham, R for Data Science – O'Reilly
   (An accessible introduction to R programming for data analysis and statistical computing.)
5. Norman Matloff, The Art of R Programming – No Starch Press
   (Deeper understanding of R language for advanced users.)
6. P.K. Sinha & P. Sinha, Computer Fundamentals – BPB Publications
   (Foundation in computing systems and logic for beginners.)
7. Paul Wellin, Programming with Mathematica®: An Introduction – Cambridge University Press
   (Practical guide to symbolic computation and mathematical modeling.)
8. Joe Habraken, Microsoft Office 2021 In Depth – Pearson
   (Covers MS Word, Excel, and PowerPoint usage for academic and professional tasks.)
9. Leslie Lamport, LaTeX: A Document Preparation System – Addison-Wesley
   (Classic manual for preparing professional documents, equations, and technical reports.)
10. R.G. Dromey, How to Solve It by Computer – Pearson
    (Fundamentals of algorithmic thinking and logical problem solving.)