MAHARAJA SURAJMAL BRIJ UNIVERSITY
BHARATPUR

SYLLABUS

(2025-2026 onwards)

M.A / M.Sc. (Mathematics)

(Semester I & II)

Semester Scheme

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Content

1. Eligibility
2. Scheme of Examination
3. Course Detail
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1. Eligibility

As per the rules formed/framed by the Commissionerate Higher Education Rajasthan, Jaipur.

2. Scheme of Examination

(i) As per University notifications issued time to time.

(ii) 1 credit = 25 marks for examinations/evaluation. Each course in Semester Grade Point Average (SGPA) has two components-

(a) Continuous Assignment(CA). (20% weightage)

(b) End of the Semester Examination (EoSE) (80% weightage)

(iii) **Continuous Assessment (CA):**

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

(iv) **End of Semester Examination (EOSE):**

Each Paper of EoSE shall carry 80% of the total marks of the course/subject. The EoSE will be of 3 hours duration. 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 8 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 (16 Marks of each question). Candidates are required to attempt all five questions.

(v) 75% Attendance is mandatory for appearing in EOSE.

3. Course Detail

The details of the courses with code, title and credits are as given below –

Abbreviation Used –

Course Category

CCC: Compulsory Core Course

ECC: Elective Core Course

SEC: Skill Enhancement Course

IEC: Interdisciplinary Elective Course

Contact Hours

L: Lecture

T: Tutorial

P: Practical or Other

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4. Semester Structure

First Semester

S. No.	Subject Code	Course Title	Course Category	Credit	Contact Hours per week			EoSE Duration (Hrs.)	
					L	T	P	Thy	P
1.	MAT.20101T	Advance Abstract Algebra	CCC	4	4	0	0	3	0
2.	MAT.20102T	Real Analysis	CCC	4	4	0	0	3	0
3 &4	MAT.20103T	Differential Equations	ECC	4+4=8	4	0	0	3	0
	MAT.20104T	Differential Geometry			4	0	0	3	0
	MAT.20105T	Continuum Mechanics			4	0	0	3	0
	MAT.20106T	Dynamics of Rigid Bodies			4	0	0	3	0
	MAT.20107T	Statistics-I			4	0	0	3	0
5.	SEC-509-P	Skill Enhancement Course (Numerical Techniques) Laboratory work	SEC	4	0	0	8	0	3
6.	MAT.20108P	Mathematics Laboratory work-1	Practical	4	0	0	8	0	3
7.		**Total Credits**		**24**					

Candidate are required to opt any two ECC (4 Credits each) from MAT.20103T, MAT.20104T, MAT.20105T, MAT.20106T&MAT.20107T. The medium of instruction and Examination shall be English Only.

Second Semester

S. No.	Subject Code	Course Title	Course Category	Credit	Contact Hours per week			EoSE Duration (Hrs.)	
					L	T	P	Thy	P
1.	MAT.20201T	Advance Linear Algebra	CCC	4	4	0	0	3	0
2.	MAT.20202T	Topology	CCC	4	4	0	0	3	0
3.	MAT.20203T	Special Function	ECC	4	4	0	0	3	0
	MAT.20204T	Riemannian Geometry and Tensor Analysis			4	0	0	3	0
	MAT.20205T	Operation Research			4	0	0	3	0
	MAT.20206T	Statistics-II			4	0	0	3	0
4.	IEC P	Interdisciplinary Elective Course (Computational Techniques) Laboratory work	IEC	4	0	0	8	0	3
5.	MAT20207P	Mathematics Laboratory work-2	Practical	4	0	0	8	0	3
6.		Introduction to Research Methodology		4	4	0	0	3	0
7.		**Total Credits**		**24**					

Candidate are required to opt any one ECC(4 Credit) from MAT.20203T, MAT.20204T, MAT.20205T &. MAT.20206T The medium of instruction and Examination shall be English Only.

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SEMESTER-1

Advance Abstract Algebra

Semester	Code of the Course	Title of the Course / Paper	NHEQF Level	Credits
I	MAT.20101T	Advanced Abstract Algebra	6.5	4
Level of Course	**Type of Course**	**Delivery of the Course**		
Advance	CCC	Lectures (4 hrs a week), Sixty lectures including diagnostic and formative assessment during lecture hours.		
Prerequisites	Mathematics course at the Undergraduate 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 learning outcomes:

The student will be able to learn after completion of the course:

1. Remembering: Recall the definitions and key properties of algebraic structures like groups, rings, and fields, as well as important theorems such as Sylow's, Cauchy's, and Jordan-Hölder's theorems.
2. Understanding: Explain the significance and basic concepts behind these structures, including their isomorphisms and theorems that govern their behavior.
3. Applying: Use core theorems to solve problems and analyze the structure of finite groups and algebraic systems.
4. Analyzing: Break down the structure of finite groups by exploring normal subgroups, solvability, and composition series, applying relevant theorems to determine group properties.
5. Evaluating: Assess the properties of algebraic systems like quotient rings and factorization domains to solve algebraic equations, using tools such as Eisenstein's criterion.
6. Creating: Construct examples of advanced algebraic structures like field extensions, normal and perfect fields, and use Galois theory to analyze their properties and solvability.
7. 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.

Contents:

Unit-1

Commutators, Derived subgroups, Higher derived subgroups, Homeomorphism and Isomorphism, Theorems related to Homeomorphism, Isomorphism and Automorphism, Main theorem on Quotient groups, First theorem on isomorphism, The double quotient isomorphism theorem, Diamond isomorphism theorem, Zassenhaus Leema (Butterfly Lemma), Direct product of groups (External and Internal).

(15 Lectures)

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Unit-2

Subnormal and normal series, Refinement of subnormal series, Solvable groups, Characteristic property of solvable group, Properties of solvable groups, Composition series, Maximal Normal Subgroup, Refinement theorem, Jordan-Holder theorem, Conjugate class, Conjugate subgroup, Class Equation, Cauchy`s Theorem, p-groups, Burnside theorem, Nilpotent group, Sylow's theorems.

(15 Lectures)

Unit-3

Factorization of Integral Domain-Prime element, Composite element, Euclidean Algorithm for polynomials, Einstein`s Theorem, Euclidean rings, Euclidean domains, Unique Factorization Theorem. Field theory – Extension fields, Algebraic and Transcendental extensions, Separable and inseparable extensions, Normal extensions. Splitting fields.

(15 Lectures)

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. Modules-Sub modules, Quotient modules, Cyclic modules, Semi simple modules, Schler`s Lemma, Free modules.

(15 Lectures)

Text Books:

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

Reference Books:

1. I.S. Luthar and B.S. Passi, Algebra Vol-I Groups, Vol-II Rings, Narosa Publishing House.
2. N. S. Gopalkrishnan, University Algebra, New Age International, 1986.
3. Qazi Zameeruddin and Surjeet Singh, Modern Algebra, Vikas Publishing, 2006
4. J.K. Goyal and K.P.Gupta, Advanced Course in Modern Algebra, Pragati Prakashan Meerut
5. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra (4th Edition), Prentice-Hall of India Pvt. Ltd., New Delhi, 2004.
6. I.N. Herstein, Topics in Algebra (2nd edition), John Wiley & Sons, 2006
7. Fraleigh, J. B., A First Course in Abstract Algebra, Narosa Publishing House, New Delhi.
8. D. S. Chauhan and K. N. Singh, Studies in Algebra, JPH, 2006
9. Frank Ayres, Jr. and Lloyd R., Theory and problems in Abstract Algebra (2nd Ed.), Tata McGraw-Hill Pub. Co. Ltd., 2004.

E-resources:

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

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Real Analysis

Semester	Code of the Course	Title of the Course / Paper	NHEQF Level	Credits
I	MAT.20102T	Real Analysis	6.5	4
Level of Course	Type of Course	Delivery of the Course		
Advance	CCC	Lectures (4 hrs a week), Sixty lectures including diagnostic and formative assessment during lecture hours.		
Prerequisites	Mathematics course at the Undergraduate Level.			
Objectives of the Course	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.			

Course Learning Outcomes:

On successful completion of the course, the students will be able to:

1. Remembering: Recall the definitions of measure, Lebesgue outer measure, measurable sets, and non-measurable sets, along with the concepts of exterior and interior measure and measurable functions.
2. Understanding: Explain the Lebesgue integral, comparing it with the Riemann integral, and understand the properties and application of the First Mean Value Theorem and the Lebesgue integral of unbounded functions.
3. Applying: Apply key theorems such as the Monotone Convergence Theorem, Dominated Convergence Theorem, and Lebesgue's Theorem on Bounded Convergence to evaluate integrals and convergence of measurable functions.
4. Analyzing: Analyze the properties of functions of bounded variation, absolutely continuous functions, and the Lebesgue set, applying Vitali's covering theorem and Dini's four derivatives in problem-solving.
5. Evaluating: Evaluate inequalities such as Schwarz's, Hölder's, and Minkowski's inequalities in the context of the Lebesgue class Lp spaces, and assess mean convergence for functions within L^p .
6. Creating: Develop solutions to complex integration problems involving Lebesgue integrals, theorems on convergence, and functions of bounded variation, demonstrating mastery in handling L^p spaces and related inequalities
7. 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.

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Contents:

Unit-I

Algebra and algebras of sets, Algebras generated by a class of subsets, Borel sets, Concept of Lebesgue outer measure, inner measure, Countable sub additivity of outer measure, Measurable sets, Properties of measurable sets, Existence of Non- measurable sets.

(15 Lectures)

Unit-II

Measurable functions- Definition, properties of measurable functions, operations of measurable functions., pointwise and uniform convergence of the sequence of measurable functions, Fgorov's theorem, Lebesgue theorem, Convergence in measure, F Reisz theorem, Structure of measurable functions, Weierstrass's theorem on the approximation *or* continuous functions by polynomials.

(15 Lectures)

Unit-III

Lebesgue integration - Lebesgue integral and its comparison with Reimann integral, properties of Lebesgue integral of bounded measurable functions, Lebesgue theorem on the passage to the limit under the sign of integral for bounded measurable functions. Lebesgue integral of non-negative measurable functions, Fatou's lemma, Lebesgue monotone convergence theorem, Countable additivity of Lebesgue integral, Lebesgue Integra of an arbitrary function and sumnability of Lebesgue integral, Lebesgue dominated convergence theorem.

(15 Lectures)

Unit-IV

Summabilitv of Lebesgue integral- Space of summable Functions, Space of square summable functions, Orthonormal system, Fourier series, Reisz-Fischer theorem. L^p Space- Space of p-summable functions, Reisz-Holder's inequality, Reisz-Minkowsky inequality, convergence in norm in L^p space, Summable series.

(15 Lectures)

Text Books:

1. P.K. Jain and V.P Gupta, Lebesgue Measure and Integration, New Age Int. (P) Ltd., New Delhi
2. S.C. Malik and S. Arora, Mathematical Analysis. New Age India Int. (P) Ltd., New Delhi
3. G.N. Purohit, Lebesgue Measure and Integration, Jaipur Publishing House, Jaipur
4. H.L. Royden, Real Analysis, Prentice Hall of India Pvt Ltd, New Delhi

Reference Books:

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

E-resources:

nptel.ac.in/courses/111101100

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Differential Equations

Semester	Code of the Course	Title of the Course / Paper	NHEQF Level	Credits
I	MAT.20103T	Differential Equations	6.5	4

Level of Course	Type of Course	Delivery of the Course
Advance	ECC	Lectures (4 hrs a week), Sixty lectures including diagnostic and formative assessment during lecture hours.
Prerequisites	Mathematics course at the Undergraduate Level. Solution methods of ODE differential calculus	
Objectives of the Course	The objective of this course is to provide students with a comprehensive understanding of non-linear ordinary differential equations (ODEs), linear partial differential equations (PDEs) and boundary value problems. 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, classification and canonical forms of second-order linear PDEs, the theory of Sturm-Liouville problems and methods for solving both homogeneous and nonhomogeneous 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.	

Course Outcomes

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

1. Remembering: Recall the definitions and key concepts related to non-linear ordinary differential equations (ODEs) such as Riccati's equation, and total differential equations, as well as series solutions and methods applicable to second-order PDEs.
2. Understanding: Explain the structure of second-order linear partial differential equations (PDEs), and describe the process of reducing them to canonical forms for solving boundary value problems. Define and analyze functionals, variations, and their properties. Formulate and solve variational problems with fixed boundaries using Euler's equation. 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.
3. Applying: Use the method of separation of variables to solve classical PDEs like Laplace's, wave, and heat conduction equations, and apply D'Alembert's solution to the wave equation to understand physical phenomena. Construct and utilize Green's functions to solve non-homogeneous PDEs, understand their bilinear form, and apply them to Cauchy's problems and other initial boundary value problems. 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. Analyzing: Analyze linear homogeneous and non-homogeneous boundary value problems using Sturm-Liouville theory, compute eigenvalues and eigenfunctions, and apply these to expand solutions with normalized eigenfunctions.

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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.

Contents: -

Unit-I

Non-linear differential equations of particular forms, Riccati's equation- general solution and the solution when one, two and particular solutions are known. Total differential equations- necessary and sufficient conditions, methods of solution, geometric meaning of total differential equation.: Series solution- ordinary and singular point, radius of convergence, series solution near a singular point, method of differentiation, Cauchy-Euler equation, solution near a regular singular point (method of Frobenius), solution of Gauss-Hypergeometric equation.

Unit-I **(15 Lectures)**

Partial differential equations of second order with variable coefficient -Monge's method, Canonical forms. Classification of second order linear partial differential equations, Canonical forms, Cauchy's problem.

Unit-III **(15 Lectures)**

Boundary value problem- eigen values and eigen functions, Sturm-Liouville boundary value problems, orthogonality of eigen functions, normalized eigen functions, Non-homogeneous boundary value problems. Method of separation of variables-Laplace, Wave, and diffusion equations.

Unit-IV **(15 Lectures)**

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.

Text Books: **(15 Lectures)**

1. S. L. Ross, Differential Equations, Wiley, 2007.
2. A.K. Nandakumaran, P.S. Dutti and George R.K., Ordinary Differential Equations: Principles and Applications, Cambridge University Press,2017.
3. J.L.Bansal and H . S . Dharmi, Differential Equations Vol. II, Jaipur Publishing House, Jaipur
4. M.D. Rai Singhania, Ordinary and Partial Differential Equations, S. Chand & Co., New Delhi.
5. S.K. Rao, Introduction to Partial Differential Equations, PHI Learning.
6. Sneddon, I.N., Elements of Partial Differential Equations, Dover Publications.
7. G. Birkhoff and G.C. Rota, Ordinary Differential Equations, Wiley.

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Reference Books:

1. E.A. Codington, An Introduction to Ordinary Differential Equations, Prentice Hall of India, 1961.
2. Frank Ayres, Theory and Problems of Differential equations, TMH, 1990.
3. A.R.Forsyth, A Treatise on Differential Equations, Macmillan & Co. Ltd., London, 1956.
4. E.R.Coddington and N. Levinson 2010, Theory of Ordinary Differential Equations, McGraw Hill Education.
5. V.I.Arnold,.: Ordinary Differential Equations, MIT Press, Cambridge, 1981

E-resources:

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

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

Differential Geometry

Semester	Code of the Course	Title of the Course / Paper	NHEQF Level	Credits
I	MAT.20104T	**Differential Geometry**	6.5	4
Level of Course	**Type of Course**	**Delivery of the Course**		
Advance	ECC	Lectures (4 hrs a week), Sixty lectures including diagnostic and formative assessment during lecture hours.		
Prerequisites	Mathematics course at the Undergraduate Level.			
Objectives of the Course	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.			

Course Outcomes:-

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

1. Remembering: Recall the definitions of unit tangent vectors, normal lines, and normal planes, and understand the concepts of osculating planes, fundamental unit vectors, and fundamental planes in the context of curves in space.
2. Understanding: Explain the concepts of curvature, torsion, skew curvature vectors, and the Serret-Frenet formulae, as well as their applications in analyzing space curves.
3. Applying: Apply the principles of osculating circles, osculating spheres, and Bertrand curves to solve problems related to the geometry of space curves.
4. Analyzing: Analyze the relationship between involutes and evolutes of space curves, and investigate the properties of ruled surfaces, including developable and skew surfaces.
5. Evaluating: Evaluate the parametric representation of surfaces, applying the first and second fundamental forms, and solving for the lines of curvature through differential equations.
6. Creating: Develop mathematical models and solutions involving the curvature and torsion of asymptotic lines, applying various theorems such as the Beltrami-Enneper theorem to study the properties of surfaces in space.

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7. 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.

Contents:-

Unit-1

Curves in Space- class of a curve, tangent line, length of space curve, order of contact of a curve and surface, inflexional tangent, osculating plane, principal normal and binormal, Curvature and torsion, Frenet-Serret's formulae, osculating circle and sphere, Involutes and Evolutes, Bertrand curves, Spherical indicatrix, Fundamental theorem of space curve.

Unit-11 **(15 Lectures)**

Envelops and Developable Surfaces- Envelope of one and two parameter family of surfaces, edge of regression, ruled surfaces, necessary and sufficient condition that a surface z=f(x, y) should represent a developable surface; tangent, principal normal and binormal surfaces, Central point and line of Striction. Metric of a surface- first, second and third fundamental forms, Fundamental magnitudes of some important surfaces.

Unit-III **(15 Lectures)**

Curves on surfaces- parametric curves on surfaces, direction coefficient, angle between two tangential directions, orthogonal trajectory, condition that $Pdu^2 + 2Qdudv + Rdv^2=0$ may represent orthogonal family of curves. Normal curvature and curvature of normal section, Meunier's theorem, principal directions and principal curvatures, mean curvature, Gaussian curvature, minimal surface, Lines of curvatures, Euler's theorem, Dapin's theorem, Rodrigues formula, Joachimsthal's theorem, Relation between fundamental forms.

Unit-IV **(15 Lectures)**

Conjugate directions, Asymptotic lines, differential equation and theorems of asymptotic lines, curvature and torsion of asymptotic lines, Beltrami-Enneper's theorem,. Gauss's formulae, Gauss characteristic equation, Wiengarten formulae, Mainardi-Codazzi equations, Fundamental existence theorem for surfaces, Parallel surfaces and Bonnet's theorem. Gaussian curvature and mean curvature for a parallel surface.

Text Books: **(15 Lectures)**

1. R.J.T. Bell, Elementary Treatise on Co-ordinate geometry of three dimensions, Macmillan India Ltd., 1994.
2. J.L. Bansal and P.R.Sharma, Differential Geometry, Jaipur Publishing House (2004).
3. P.P. Gupta, G.S. Malik and S.K. Pundir, Differential Geometry, Pragati Prakashan, Meerut.
4. S. C. Mittal and D.C.Agarwal, Differential Geometry, Krishna publication Media(P) Ltd, Meerut

Reference Books:

1. J.N.Sharma and A.R. Vasistha, Differential Geometry, Kedar Nath Ram Nath, Meerut
2. J.A. Thorpe, Introduction to Differential Geometry, Springer-Verlog, 2013.
3. T.J. Willmore, An Introduction to Differential Geometry. Oxford University Press.1972.
4. Thorpe, Elementary Topics in Differential Geometry, Springer Verlag, N.Y. (1985).
5. R.S. Millman and G.D. Parker, Elements of Differential Geometry, Prentice Hall, 1977.

E-resources:

nptel.ac.in/courses/111104765

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Continuum Mechanics

Semester	Code of the Course	Title of the Course / Paper	NHEQF Level	Credits
I	MAT.20105T	Continuum Mechanics	6.5	4
Level of Course	**Type of Course**	**Delivery of the Course**		
Advance	ECC	Lectures (4 hrs a week), Sixty lectures including diagnostic and formative assessment during lecture hours.		
Prerequisites	Mathematics course at the Undergraduate Level.			
Objectives of the Course	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. Students will be equipped to apply these concepts to complex problems in solid and fluid mechanics. This course provides 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 behaviour 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			

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.
6. **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.
7. **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

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8. **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.
9. **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.
10. **Understand irrotational flow and velocity potential concepts** and their applications in fluid dynamics, enabling them to analyze and solve complex fluid flow problems.
11. **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.

Contents:-

Unit-1

Cartesian Tensors, Indes notation and transformation laws of Cartesian tensors, Addition, Subtraction and Multiplication of Cartesian tensors, Gradient of a scaler function, Divergence of a vector function and Curl of a vector function using index notation, $\varepsilon - \delta$ identity, Conservative vector field and concept of a scalar potential function, Stocke's, Gauss's and Green's theorems. Continuum approach.

Unit-1I **(15 Lectures)**

Classification of continuous media, Body forces and surface forces, Components of stress tensor, Force and Moment equations of equilibrium, transformation of laws of stress tensor, Stress quadric, Principal stress and principal axes, Stress invariants and stress deviator, maximum shearing stress, Lagrangian and Eulerian description of deformation of flow, Comoving derivative.

Unit-1II **(15 Lectures)**

Velocity and Acceleration, Continuity equation, Strain tensors, Linear rotation tensor and rotation vector, Analysis of relative displacements, Geometric meaning of the components of the linear stress tensor, properties of linear strain tensors, Principal axes, Theory of linear strain, Linear strain components, Rate of strain tensors, The verticity tensor, rate of rotation vector and vorticity, properties of rate strain tensor, rate of cubical dilation, Law of conservation of mass and Eulerian continuity equation.

Unit-1V **(15 Lectures)**

Reynold's transport theorem, Momentum integral equation and equation of motion, Kinetic equation of state, First and second law of thermodynamics and dissipation function, Applications (Linear elasticity and Fluids)- Assumptions and basic equation, Generalized Hooks law for an isotropic homogeneous solid, Compatibility equations (Beltrami -Michell equation), Classification of types of problems in linear elasticity, Principle of superposition, Strain energy function, work kinetic energy equation, irrotational flow and velocity potential, Kinetic equation of state and first law of thermodynamics, Equation of continuity, Equation of motion.

(15 Lectures)

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Text Books:

1. George E. Mase: Schaum's Outline of Continuum Mechanics
2. D. Frederic and T.S. Chang : Continuum Mechanics, Ally and Bacon. Inc. Boston
3. K.D.Sharma: Continuum Mechanics, Navkar Prakashan, AJMER
4. Mortone E. Gurtin : An Introduction to Continuum Mechanics, (Academic Press)

Reference Books:

1. T.J. Chung, Continuum Mechanics, Prentice- Hall, 1988.
2. W. Prager, Introduction to Mechanics of Continua, Boston, Ginn, 1961
3. A.C. Eringen, Mechanics of Continua, John Wiley & Sons, INC, 1967.
4. John W. Rudnicki: Fundamentals of Continuum Mechanics, John Wiley & Sons Inc;2014
5. P. Chadwick: Continuum Mechanics ;Concise Theory and Problems, Dover Books,1998
6. J. N. Reddy: An Introduction to Continuum Mechanics, Cambridge University Press, 2013
7. J. N. Reddy: Principles of Continuum Mechanics (South Asia Edition), Cambridge University Press, 2017
8. C. S. Jog : Continuum Mechanics, Cambridge University Press, 2015

E-resources:

nptel.ac.in/courses/112103167

nptel.ac.in/courses/112106912

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Dynamics of Rigid Bodies

Semester	Code of the Course	Title of the Course / Paper	NHEQF Level	Credits
I	MAT.20106T	Dynamics of Rigid Bodies	6.5	4
Level of Course	Type of Course	Delivery of the Course		
Advance	ECC	Lectures (4 hrs a week), Sixty lectures including diagnostic and formative assessment during lecture hours.		
Prerequisites	Mathematics course at the Undergraduate 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, Motion about a fixed axis, conservation of momentum 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. Remembering: concept of Rigid dynamics, moment of inertia, product of inertia, Momental Ellipsoid and principal axes. Recall the principles governing the motion of rigid bodies under finite forces, including rolling, slipping of rods, motion when one of the body is fixed, motion on a horizontal plane, motion when both the bodies are movable.
2. Analyzing: Analyze the conservation of linear and angular momentum and apply them to understand the behavior of objects under impulsive forces, distinguishing between different types of motion and interactions.
3. 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.
4. 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.
5. 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.
6. 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.
7. 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.

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Contents:-

Unit-I

D'Alembert's Principle- General equations of motion of a rigid body, motion of centre of inertia, motion relative to centre of inertia. Motion about a fixed axis- Moment of momentum of a body about the fixed axis, moment of effective force about the axis, equation of motion, Compound Pendulum, Centre of Percussion.

(15 Lectures)

Unit-II

Motion of a rigid body in two dimensions under finite forces- equation of motion, friction, pure rolling, slipping of rods, motion when one of the body is fixed, motion when both the bodies are movable. Conservation of momentum-principle of conservation of linear momentum, principle of conservation of angular momentum, Sudden fixtures, principal of conservation of energy.

(15 Lectures)

Unit-III

Lagrange's Equations of Motion- generalised coordinates, degree of freedom, holonomic system, Lagrange's equations of motion for finite forces, Lagrange's function, small oscillations, normal coordinates, Lagrange's equations of motion for impulsive forces. Hamilton's equations of motion, Hamilton's Principle and Principle of Least action.

(15 Lectures)

Unit-IV

Motion in three dimensions- Rigid body moving with one fixed point, moving axes and fixed axes, Euler's dynamical equations of motion, instantaneous axis, Eulerian angles, Euler's geometrical equations of motion, motion under no forces, motion under impulsive forces. Motion of top.

(15 Lectures)

Text Books:

1. S.L Loney, An Elementary Treatise on the Dynamics of a Particle and Rigid Bodies, Cambridge University Press.
2. M. Ray and H.S. Sharma, A Text Book of Dynamics of a Rigid Body, Students' Friends & Co., Agra, 1984
3. Bansal, Sharma & Goyal, Dynamics of a Rigid Body, Jaipur Publishing House, Jaipur

Reference Books:

1. N. C. Rana and P.S. Joag, Classical Mechanics, Tata McGraw-Hill, 1991.
2. H. Goldstein, Classical Mechanics, Narosa, 1990.
3. J. L. Synge and B. A. Griffith, Principles of Mechanics, McGraw-Hill, 1991.
4. L. N. Hand and J. D. Finch, Analytical Mechanics, Cambridge University Press, 1998.
5. P.P. Gupta.: Rigid Bodies analytic Dynamics I, II, Krishna Prakashan media (P)Ltd.

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Statistics -I

Semester	Code of the Course	Title of the Course / Paper	NHEQF Level	Credits
I	MAT.20107T	Statistics -I	6.5	4
Level of Course	Type of Course	Delivery of the Course		
Advance	ECC	Lectures (4 hrs a week), Sixty lectures including diagnostic and formative assessment during lecture hours.		
Prerequisites	Mathematics course at the Undergraduate Level.			
Objectives of the Course	The objective of the course is to studding probability theory, discrete and continuous distribution with applications which will be foundation for further study in statistics.			

Course Outcomes

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

1. Understand concepts of probability, Baye's theorem and its applications.
2. Finding mathematical expectations, moments generating function.
3. Apply Binomial, Poisson distribution.
4. Study Normal, Gamma and Beta distributions and apply real life problem.

Contents:

Unit I

Sample space, combination of events, Statistical independence, Conditional probability, Bay's repeated trials, Random variable, Distribution function, Probability function, Density function.

Unit-II **(15 Lectures)**

Mathematical expectation, Generating function, Continuous probability distribution, Characteristic function, Fourier's inversion, Chebyshev and Kolmogorovea,s inequality, Weak and strong laws of large numbers. Normal distribution, Hypergeometric distribution.

Unit- III **(15 Lectures)**

Rectangular, Negative, Binomial, Beta, Gamma and Chauchy's distributions. Method of least squares and curve fitting.

Unit-IV **(15 Lectures)**

Correlation and regression coefficients, Association of attributes. Interpolation: Introduction, Newton-Gregory theorem, Newton, Lagrange, Gauss and Stirling formulae.

Text Books: **(15 Lectures)**

1. Gupta and Kapoor: Fundamentals of Mathematical Statistics, Sultan Chand & Sons., New Delhi
2. J.N.Kapur and H.C.Sexena: Mathematical Statistics, S. Chand Publishing, New Delhi
3. M.R.Spiegel and L.J. Stephens: Theory and Problems of Statistics, TMH

Reference Books:

1. Mood A.M., Graybill F.A. and Boes D.C. (1974) : Introduction to the theory of Statistics,
2. S.P. Gupta : Statistical Methods, Sultan Chand & Sons. First edition.

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Skill Enhancement Course

Numerical Techniques- Laboratory work (Practical)

Semester	Code of the Course	Title of the Course / Paper	NHEQF Level	Credits
I	SEC-509-P	Numerical Techniques Laboratory work(Practical)	6.5	4
Level of Course	Type of Course	Delivery of the Course		
Advance	Skill Enhancement Course	Practical (8 hrs. a week), One hundred twenty practical hours, including diagnostic and formative assessment during practical hours.		
Prerequisites	Mathematics course at the Undergraduate Level.			
Objectives of the Course	The purpose of practical is to provide hands-on experience in applying statistical concepts and techniques to real-world data, enabling individuals to describe data, make inferences about populations, identify relationships and patterns, predict future trends, and ultimately make informed decisions and support research across various fields. The course provides students to gain insight into scientific phenomena, model complex systems, and predict future behavior using experimental data. By fitting a parameterized function (the empirical law) to a set of observed data points, students learn to identify relationships between variables, smooth noisy data, perform calculations like differentiation and integration, and visualize trends. The practical in the Numerical Solution of Partial Differential Equations (PDEs) is to apply numerical methods to find approximate solutions to complex PDEs that lack analytical solutions. The purpose of a matrix inversion practical is to find the inverse of a matrix, which allows for the solution of linear systems and understanding the original matrix's properties, such as its determinant or condition number.			

Duration of Examination	Maximum Marks	Minimum Marks
1 Hours	Midterm (MT) - 20 Marks	Midterm (MT) - 08 Marks
3 Hours	EoSE- 80 Marks	EoSE- 32 Marks

Practical – Each candidate is required to appear in the practical examination to be conducted by internal and external examiners. External examiner will be appointed by university and internal examiner will be appointed by the principal consultation with Head, department of Mathematics in the college. An internal/External examiner can conduct practical examination of not more than 60 candidate (20 candidate in each batch).

Distribution of Marks:

S.No.	Exercise	Marks
1.	Four Exercises one from each Group	15+15+15+15=60
2.	Practical record	10
3.	Viva-Voce	10
4.	**Total**	**80 Marks**

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Course Outcomes

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

1. Organize, manage and present data. Analyze statistical data graphically using frequency distributions and cummulative frequency distributions. Analyze statistical data using measures of central tendency, dispersion and location.
2. construct mathematical equations to represent data, learn to apply numerical methods like least squares, understand the limits of analytical solutions, and gain experience in using software tools for data analysis, thereby connecting theoretical concepts to real-world problem-solving in science and engineering.
3. apply the numerical techniques to solve research problems of fluid dynamics, mathematical modeling.
4. apply computational methods to solve PDEs, enabling them to develop and validate numerical codes, model physical phenomena like heat and wave propagation, and interpret their results for real-world problems, often using software tools. Key skills gained include proficiency in finite difference and finite element methods for various PDE types and the ability to select and apply appropriate computational techniques.
5. solve for eigenvalues and eigenvectors, compute the inverse of a matrix, apply these concepts to real-world problems, use computational tools, and analyze the stability and characteristics of systems based on their eigenvalues and eigenvectors. They should also be able to understand the theoretical underpinnings and limitations of these techniques.

Contents:-

Group-I

Statistical Method-Measures of central tendency, Measures of dispersion, Standard deviation of combination of two groups, Correlation, Lines of Regression, Standard error of estimate, Rank of Correlation.

Group -II **(30 Lectures)**

Empirical Laws and Curve Fitting- Graphical method, Laws reducible to the linear law, Principle of least square, Fitting of curves, Method of group averages, Method of moments.

Group -III **(30 Lectures)**

Numerical Solution of Partial Differential Equations- Classification of second order equations, Finite difference approximations to derivatives, Jacobi`s Iteration formula, Gauss- Seidel Method, Solution of Laplace equation, Posson`s equations, Parabolic equations, Heat equations, Hyperbolic Equations, and wave equation.

Group -IV **(30 Lectures)**

Matrix inversion and eigenvalue problem-Gauss Jorden method, Gauss elimination method, Factorization method, Partition method, Iterative method, numerically largest eigenvalue and the corresponding eigenvector, Power method, Jacobi's method, Given's method, House-Holder's method.

Text Books: **(30 Lectures)**

1. Gupta and Kapoor: Fundamentals of Mathematical Statistics
2. Kapur and Sexena: Mathematical Statistics
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. Atkinson K. E., *An Introduction to Numerical Analysis* (2nd Ed.), Wiley-India, 1989.
5. Sastry S. S., Introductory Methods of Numerical Analysis, PHI,2019.

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Reference Books:

1. V.Rajaraman, Computer Oriented Numerical Methods, PHI, 1993.
2. C. F. Gerald and P. O. Wheatley, Applied Numerical Analysis, Pearson Education, India,7th edition, 2008.
3. C.F. Gerald, P.O. Wheatley, Applied Numerical Analysis, Addison-Wesley, 1998.
4. S. D. Conte, C de Boor, Elementary Numerical Analysis, McGraw-Hill, 1980.
5. C.E. Froberg, Introduction to Numerical Analysis, (Second Edition), Addition-Wesley, 1979.
6. Buchaman J.I., Turner P. R., *Numerical Methods and Analysis*, McGraw-Hill,1992.

E-resources:

nptel.ac.in/courses/111106415
nptel.ac.in/courses/111107062

Mathematics Laboratory work -1

Semester	Code of the Course	Title of the Course / Paper	NHEQF Level	Credits
I	MAT.20108P	Mathematics Laboratory work -1	6.5	4
Level of Course	**Type of Course**	**Delivery of the Course**		
Advance	**Skill Enhancement Course**	Practical (8 hrs. a week), One hundred twenty practical hours, including diagnostic and formative assessment during practical hours.		
Prerequisites	Mathematics course at the Undergraduate Level.			
Objectives of the Course	The objective of this course is to provide a comprehensive understanding of numerical methods for solving algebraic, transcendental and ordinary differential equations. The main objective of a course is to equip students with the knowledge and skills to approximate solutions to mathematical problems that are impossible or difficult to solve analytically. The practical aspect emphasizes implementing these methods, often using computer software. Students learn the theoretical background of various numerical methods and the associated concepts of error analysis (truncation and round-off errors), convergence, and stability. The course aims to develop students' proficiency in using PDEs as powerful tools for analysing, predicting, and optimizing the performance and design of complex systems in various professional fields The objective of this is to teach students how to find functions (paths, shapes, etc.) that optimize (minimize or maximize) a given quantity (like time, distance, energy) by solving problems involving functionals, using tools like the Euler-Lagrange equation, and applying these methods to real-world physics, engineering, and geometry problems, such as finding geodesics, least-action paths, and minimal surfaces.			

Duration of Examination	Maximum Marks	Minimum Marks
1 Hours	Midterm (MT) - 20 Marks	Midterm (MT) - 08 Marks
3 Hours	EoSE- 80 Marks	EoSE- 32 Marks

Practical – Each candidate is required to appear in the practical examination to be conducted by internal and external examiners. External examiner will be appointed by university and internal examiner will be appointed by the principal consultation with Head, department of Mathematics in the college. An internal/External examiner can conduct practical examination of not more than 60 candidate (20 candidate in each batch).

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Distribution of Marks:

S.No.	Exercise	Marks
1.	Four Exercises one from each Group	15+15+15+15=60
2.	Practical record	10
3.	Viva-Voce	10
4.	**Total**	**80 Marks**

Course Outcomes

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

1. Remembering: Recall the various numerical methods for solving polynomial equations, such as Synthetic Division, Birge-Vieta, Bairstow, and Graeffe's root squaring methods.
2. Understanding algorithms, programming these methods, analyzing convergence, and solving real-world problems where exact solutions are difficult, demonstrating computational skills for engineering/science.
3. **Evaluating**: Evaluate the effectiveness of different numerical methods for solving ordinary differential equations, such as Euler's, Modified Euler's, Taylor Series, Picard, Runge-Kutta, and Milne methods, based on accuracy and computational efficiency.
4. Model real-world problems, choose appropriate numerical methods (like Euler, Runge-Kutta), implement them (often with software like MATLAB/Python), understand error analysis, analyze stability, and solve initial value (IVP) and boundary value problems (BVP) for ODEs, bridging theory with computational application in science and engineering.
5. Applying: Use the method of separation of variables to solve classical PDEs like Laplace's, wave, and heat conduction equations, and apply D'Alembert's solution to the wave equation to understand physical phenomena.
6. Model real-world phenomena (heat flow, waves, fluids) using PDEs, solve them with analytical methods (separation of variables, Fourier series) or numerical techniques (finite differences), interpret solutions physically (visualizing waves), and use software (MATLAB, Mathematica) for simulations, linking math to physics/engineering applications.
7. Use variational methods to solve optimization problems involving functionals, particularly those found in science and engineering, and to understand the theoretical underpinnings of these methods.
8. Find solutions to well- known problems like the brachistochrone problem (fastest path between two points), finding geodesics (shortest path on a curved surface), and minimal surfaces.
9. Derive and apply the Euler-Lagrange equation, which is a necessary condition for a function to be an extremum of a functional.

Contents:-

Group-I

Numerical solution of Algebraic and transcendental equations: iteration methods, Acceleration of convergence, Chebyshev method, Muller's method, methods for multiple and complex roots, Newton-Raphson method for simultaneous equations, Convergence of iteration process in the case of several unknowns, Polynomial equation, Real and complex roots, synthetic division, Birge-Vieta method, Bairstow method, Graeffe's root squaring method.

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(30 Lectures)

Group -II

Numerical solution of ordinary differential equations. truncation error, Convergence and Stability, Taylor Series method, Picard's Method of successive approximation, Euler's and modified Euler's methods, Runge-Kutta method up-to fourth order. Multistep method, Predictor-corrector method Adams- Bashforth method, Stability analysis-single and multistep methods.

Group -III

(30 Lectures)

Applications of Partial Differential Equations; Method of separation of variables, Partial differential equations of engineering, Vibrations of a stretched string-Wave equation, One dimensional heat flow, Two dimensional heat flow, Solution of Laplace's equation, Laplace's equation in polar coordinates, Vibrating Membrane-Two dimensional wave equation, Transmission line, Laplace's equation in three dimensions, Solution of three-dimensional Laplace's equation.

Group -IV

(30 Lectures)

Calculus of variation –Functionals, Euler-Lagrange differential equation for an extremal, variational problems with several dependent variables, variational problems involving several independent variables, isoperimetric problems and isoperimetric conditions, geodesic problems, variational problems involving constraints, Variational problems with moving boundaries, applications of calculus of variation to the problems of mechanics.

Text Books:

.(30 Lectures)

1. J.L.Bansal and H . S . Dharmi, Differential Equations Vol. II, Jaipur Publishing House, Jaipur
2. M.D. Rai Singhania, Ordinary and Partial Differential Equations, S. Chand & Co.,New Delhi.
3. S. K. Rao, Introduction to Partial Differential Equations, PHI Learning.
4. I. N. Sneddon, Elements of Partial Differential Equations, Dover Publications.
5. M.K. Jain, S.R.K. Eyenger and R.K. Jain, Numerical Methods for Mathematics and Applied Physicists, Wiley-Eastern Pub., N. Delhi, 2005.
6. Atkinson K. E., An Introduction to Numerical Analysis (2^{nd} Ed.), Wiley-India, 1989.
7. Sastry S. S., Introductory Methods of Numerical Analysis, PHI,2019.
8. D. S. Chauhan, Paresh Vyas and Vimlesh Soni, Studies in Numerical Analysis, JPH
9. M.K. Singh, Calculus of Variations, Krishna Prakashan Media (P) Ltd, 2014.

Reference Books:

1. V.Rajaraman, Computer Oriented Numerical Methods, PHI, 1993.
2. C. F. Gerald and P. O. Wheatley, Applied Numerical Analysis, Pearson Education, India,
3. C.F. Gerald, P.O. Wheatley, Applied Numerical Analysis, Addison-Wesley, 1998.
4. S. D. Conte, C de Boor, Elementary Numerical Analysis, McGraw-Hill, 1980.
5. C.E. Froberg, Introduction to Numerical Analysis, Addition-Wesley, 1979.
6. Buchaman J.I., Turner P. R., *Numerical Methods and Analysis*, McGraw-Hill,1992.
7. Frank Ayres, Theory and Problems of Differential equations, TMH, 1990.
8. A.S. Gupta, Calculus of Variations with Applications, Prentice Hall India Learning Private Limited
9. I. M. Gelfand & S. V. Fomin, Calculus of Variations, Dover Publications, 1963.

E-resources:

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

nptel.ac.in/courses/111106101

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प्रभारी अकादमिक प्रभा.

SEMESTER - II

Advanced Linear Algebra

Semester	Code of the Course	Title of the Course / Paper	NHEQF Level	Credits
II	MAT.20201T	Advanced Linear Algebra	6.5	4
Level of Course	Type of Course	Delivery of the Course		
Advance	CCC	Lectures (4 hrs a week), Sixty lectures including diagnostic and formative assessment during lecture hours.		
Prerequisites	Mathematics course at the Undergraduate Level.			
Objectives of the Course	The objectives of this course are to develop a conceptual and computational understanding of vector spaces, matrices and linear transformations, dual spaces, inner product spaces and orthogonal basis enabling students to solve systems of linear equations, understand geometric concepts like distance and angle, and apply these principles in fields like computer science and engineering through concepts such as eigenvalues and eigenvectors. Key goals include mastering matrix algebra, vector space properties, and the relationship between matrices and linear maps, preparing students to analyze and manipulate abstract mathematical structures.			

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.
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, implementing the Gram-Schmidt orthogonalization process.
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.
6. use different concepts associated with vector spaces, linear transformations, diagonalization and inner product spaces in other courses like functional analysis, differential equations.
7. Students should be able to analyze and solve systems of linear equations, determine eigenvalues eigenvectors, and utilize software to solve applied problems in fields like engineering, computer science, and economics.

Contents:

Unit-I:

Linear Transformations on Vector Spaces- Rank and Nullity of linear transformation, Sylvester's theorem, algebra of linear transformations, Linear functionals, Dual Spaces, Dual basis and their properties, Dual maps, Annihilator.

(15 Lectures)

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Unit-II:

Matrices- Matrices of linear transformations, Matrices of composition maps, Matrices of Dual maps, change of basis, similarity of matrices, trace of matrix, invertible matrices, invariance, reducibility, projections, adjoint or transpose of linear transformations, adjoint of projections.

(15 Lectures)

Unit-III:

Determinants- Determinants of matrices and its computations, existence and uniqueness of determinants, Cramer rule, cofactor expansion formula, characteristic polynomial, eigen values and eigen vectors, Cayley-Hamilton theorem, diagonalisable operator and matrices, minimal polynomial, minimal equation.

(15 Lectures)

Unit-IV:

Inner product spaces- Schwarz inequality, normed vector space, matrix of inner product, conjugate transpose of matrix, Hermitian matrix, orthogonality, Pythagoras theorem, complete orthonormal set, Gram-Schmdt orthogonalization theorem, Bessel's inequality, orthogonal complements, linear maps on inner product spaces, adjoint of a linear transformation, principal axis theorem, normal operators, Spectral theorem. Quadratic forms, reduction and classification of quadratic forms

(15 Lectures)

Text Books:

1. Bhattacharya, P. B. Jain, S. K. and Nagpal, S. R., First Course in Linear Algebra, Wiley Eastern Ltd., New Delhi.
2. Hoffman, K. and Kunze, R.,Linear Algebra. 2nd edition, Pearson India, 2015
3. Axler, S.,Linear Algebra Done Right. 2nd edition, Springer-Verlag, 2014.
4. Lang, S., Linear Algebra. 3rd edition, Springer-Verlag, New York, 2013.
5. Lipschutz, S. and Lipson, M., Linear Algebra. 3rd edition, Tata McGraw-Hill, 2005.
6. Friedberg, S. H., Insel, A. J. and Spence, L. E., Linear Algebra. 4th edition, Prentice-Hall of India Pvt. Ltd., New Delhi, 2004.

Reference Books:

1. Qazi Zameeruddin and Surjeet Singh, Modern Algebra, Vikas Publishing,2006
2. D. S. Chauhan and K. N. Singh, Studies in Algebra, JPH, 2006
3. Joseph A. Gallian, Contemporary Abstract Algebra (4th Ed.), Narosa Publishing House, 1999.
4. David S. Dummit and Richard M. Foote, Abstract Algebra (3rd Edition), John Wiley and Sons (Asia) Pvt. Ltd, Singapore, 2004.
5. I.N. Herstein, Topics in Algebra (2nd edition), John Wiley & Sons, 2006.
6. Michael Artin, Algebra (2nd edition), Pearson Prentice Hall, 2011.
7. Halmos, P. R., Finite Dimensional Vector Spaces, D. Van Nostrand Company Inc.
8. Finkbeiner, D.T., Introduction to Matrices and Linear Transformations (3rd edition) Dover Publications.
9. Kumaresan,S., Linear Algebra: A Geometric Approach, Prentice-Hall of India Pvt. Ltd., New Delhi.
10. B.Cooperstein, Advanced Linear Algebra, CRC Press.

E-resources:

nptel.ac.in/courses/111104137
nptel.ac.in/courses/111108066

Topology

Semester	Code of the Course	Title of the Course / Paper	NHEQF Level	Credits
II	MAT.20202T	Topology	6.5	4
Level of Course	Type of Course	Delivery of the Course		
Advance	CCC	Lectures (4 hrs a week), Sixty lectures including diagnostic and formative assessment during lecture hours.		
Prerequisites	Mathematics course at the Undergraduate Level.			
Objectives of the Course	To introduce basic concepts of point set topology, basis and sub-basis for a topology and order topology. Further, to study continuity, homeomorphisms, open and closed maps, product and introduce notions of connectedness, path connectedness, local connectedness, local path connectedness, convergence, nets, Filters, and compactness of spaces.			

Course Outcome: On successful completion of the course, the students will be able to:

1. Understand the fundamental concepts of topological spaces, including the definition of open and closed sets, and how interior, closure, and neighborhood operators characterize these spaces.
2. Characterize frontier sets, subspaces, and dense subsets, and apply the concept of relative topology to analyze the properties of subsets in a given topological space.
3. Analyze continuous functions, closed and open functions, and homomorphisms, developing a clear understanding of their behaviour within topological spaces.
4. Apply the concepts of compactness, including the finite intersection property, Heine-Borel theorem, and Bolzano-Weierstrass property, to analyze compact spaces and sets.
5. Understand and prove basic theorems on connected and disconnected spaces.
6. Evaluate spaces based on the first and second axioms of countability, and differentiate between separable and Lindelöf spaces. Recognize the significance of T_0, T_1, T_2, regular, and normal spaces, and understand their relationship with compactness and separation properties in topological spaces.

Contents:

Unit-I:

Topological spaces: Topology, T-open sets, sub spaces, open sets and closed sets, neighbourhood system, closure, interior, limit point, relative topology, co-finite topology, upper limit topology, intersection of topological spaces, Kuratowsky theorem, metric spaces, Bases, sub-bases and countability.

(15 Lectures)

Unit-II:

Continuous mappings: Continuity, Sequentially continuous functions, Homeomorphism. Topological properties, Open and Closed maps, Uniform continuity, product invariant, restriction maps, isometry, Nets and Convergence: directed sets, Residual subsets, Co-final subsets, Sequence convergence of a set, Cluster point, subnet, Isotone mapping. Filters and Ultra filters: Co-finite filters, Convergent filters, Zorn's lemma.

(15 Lectures)

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Unit-III:

Separation axioms$(T_0, T_1, T_2, T_3, T_4)$, normal spaces, regular spaces, Tychonoff space, Completely normal, Huasdorff space, Problems related to hereditary property, Problems related to topological property, Urysohn's lemma, Tietze extension theorem. Compact and locally compact spaces, continuity and compactness.

(15 Lectures)

Unit IV:

Product and Quotient spaces: Product topology, Projection maps, Tychonoff topology. Embedding, Tychonoff cube, Hausdorff maximal principle, Alexander sub base lemma, Tychonoff's one point Compactification, Stone-Cesh Compactificatiopn theorem Connected and Locally connected spaces, Continuity and Connectedness.

(15 Lectures)

Text Books:

1. Simmons G.F., 1963, *Topology and Modern Analysis*, McGraw Hill.
2. Vicker, 1996, *Topology via Logic*, Cambridge University Press.
3. Munkers, J.R., 2015, *Topology- A First Course*, Pearson Education India.
4. Joshi, K.D., 2017, *Introduction To General Topology,* New Age International Private Limited.
5. Lipschutz, S. General Topology. Tata McGraw-Hill, 1965.

Reference Books:

1. Kell, J.L., 2017, General Topology, Dover Publications.
2. J. Dugundji, Topology, Prentice-Hall of India, 1975.
3. K.P. Gupta: Topology, Pragati Prakashan, Meerut.
4. B.D. Gupta: Topology; Kedar Nath Ram Nath; Delhi; Meerut.

E-resources:

nptel.ac.in/courses/111106054

Special Functions

Semester	Code of the Course	Title of the Course / Paper	NHEQF Level	Credits
II	MAT.20203T	Special Functions	6.5	4

Level of Course	Type of Course	Delivery of the Course
Advance	ECC	Lectures (4 hrs a week), Sixty lectures including diagnostic and formative assessment during lecture hours.
Prerequisites	Mathematics course at the Undergraduate Level.	
Objectives of the Course	The objective of this course is to provide students with a thorough understanding of special functions, focusing on Legendre polynomials, Bessel functions, Hermite polynomials, Laguerre polynomials , Jacobi polynomials, and Elliptic functions. 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. Students will explore the properties of the Gauss hypergeometric function, Kummer's confluent hypergeometric function, equipping them with the analytical tools necessary for solving complex mathematical problems in applied mathematics and physics.	

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Course Outcome:

After completion of this course, students will be able to

1. Find solutions of various differential equations using series solution.
2. **Remembering:** Recall the definition of hypergeometric functions and series, and identify their properties and integral formulas.
3. **Understanding**: Explain the concepts of linear transformations of hypergeometric functions and the significance of contiguous function relations in hypergeometric differential equations.
4. **Applying**: Use the definition and integral representation of generalized hypergeometric functions to solve problems,.
5. **Analyzing**: Analyze the properties of Legendre polynomials, including their generating function, orthogonality, and solutions to Legendre's differential equation, and apply Rodrigue's formula and recurrence relations to solve related problems.
6. **Evaluating**: Assess the use of Bessel's equation and Bessel functions, evaluating their recurrence relations, generating functions, and integral representations to solve physical and engineering problems.
7. Apply special functions in various problems.
8. **Applying**: Use the definition of Elliptic functions, Jacobian theta function and Jacobian elliptic functions derive differential equation satisfied by these functions.

Contents:

Unit-I:

Gauss-Hypergeometric equation and its solution- hypergeometric function, integral representation, Guass's theorem, Vandermonde's theorem, Kumar's theorem, confluent hypergeometric equation and its solution, confluent hypergeometric function. Hermite differential equation and its solution, Hermite polynomials, generating function, orthogonal property, recurrence relations.

(15 Lectures)

Unit-II:

Legendre's Function of first and second kind Legendre equation and its solution, Legendre functions P(x) and Q(x), generating function, Laplace's integrals for P(x). Rodrigue's formula, orthogonal properties of Legendre's polynomial, recurrence relations. Christoffel's expansion, Christoffel's summation formula, Beltrami's result, Zeros of P(x). Legendre polynomial Q(x), recurrence relations, relation between P(x) and Q(x), properties of Q(x), Christoffel's second summation formula, Newman's Integral.

(15 Lectures)

Unit-III:

Bessel's Function- Bessel's equation and its solution, Bessel's function J(x), recurrence formulae, generating function, integral expression for Bessel's function, addition formula for Bessel's function, orthogonal property, Fourier-Bessel expansion, Leguerre's Function- Leguerre's differential equation and its solution, Leguerre's polynomials, generating function, orthogonal property, recurrence relations.

(15 Lectures)

Unit-IV:

Jacobi Polynomial: Definition and its special cases, Bateman's generating function, Rodrigue's formula, orthogonality, recurrence relations, expansion in series of polynomials. Elliptic functions- Weistrass` Elliptic function *P(z)*, differential equation satisfied by *P(z)*, Jacobian theta function, zeros of theta function, differential equation satisfied by theta function,, Jacobian elliptic functions, theta functions as infinite products.

(15 Lectures)

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Text Books:

1. E.D. Rainville, 1960, *Special Functions, The MacMillan Comp.*
2. I.N. Sneddon, Special Functions of Mathematical Physics and Chemistry, Oliver and Byod,
3. Saran, Sharma & Trivedi, Special Functions, Pragati Prakashan, Meerut

Reference Books:

1. G.N.Watson, A Treatise on the Theory of Bessel Functions, Cambridge University Press.
2. N.N. Labedye, Special Functions and their Applications, Dover.
3. J.L.Bansal and H . S . Dharmi., Differential Equations Vol. II, Jaipur Publishing House, Jaipur
4. M.D. Rai Singhania, Ordinary and Partial Differential Equations, S. Chand & Co., New Delhi 2003.

Riemannian geometry and Tensor Analysis

Semester	Code of the Course	Title of the Course / Paper	NHEQF Level	Credits
II	MAT.20204T	Riemannian geometry and Tensor Analysis	6.5	4
Level of Course	**Type of Course**	**Delivery of the Course**		
Advance	ECC	Lectures (4 hrs a week), Sixty lectures including diagnostic and formative assessment during lecture hours.		
Prerequisites	Mathematics course at the Undergraduate 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 Outcome: After 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. Apply the general equation of geodesics on various surfaces, such as r=r(u,v) and F(x,y,z)=0, and solve for geodesics on specific surfaces like surface of revolution, conoidal surfaces, developable surfaces, and conicoids.
3. **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.
4. **Utilize Christoffel Symbols:** Understand the properties and transformation laws of Christoffel's symbols, and compute covariant derivatives of contravariant and covariant tensors. Apply these concepts to derive results in differential geometry, and apply Ricci's theorem in relevant contexts.
5. **Explore Riemannian Curvature:** Explore the Riemann-Christoffel tensor and covariant curvature tensor, understanding their properties and applications. Study the contraction of the Riemann-Christoffel tensor into the Ricci curvature tensor, and explore key concepts like flat space and Bianchi's identity in Riemannian geometry.

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6. **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.

Contents:

Unit-I

Geodesics- Introduction, differential equation of geodesic, canonical equation, Geodesic on a surface of revolution, Geodesic on conoidal surface, geodesic on conicoids, Geodesic Bonnet's formula for geodesic, Torsion of a geodesic, Bonnet's formula for torsion, Gauss-Bonnet's theorem, Joachimsthal Theorem, Geodesic coordinates and geodesic parallels, Existence theorem, isometric lines.

(15 Lectures)

Unit-II:

Tensors-Introduction, Kronecker delta, Contravariant and Covariant tensors, symmetric tensors, algebraic operations with tensors, contraction of tensors, quotient law of tensors, relative tensor, Riemannian space, Metric tensor, indicator, angle between two vectors, Permutation symbols and Permutation tensors.

(15 Lectures)

Unit-III:

Christoffel's Symbols and Covariant Differentiation- Christoffel symbols and their properties, Covariant differentiation of tensors, intrinsic derivative, Ricci's theorem, divergence of a vector. Curvature of a curve, Geodesic, Euler's condition, differential equation of geodesic, geodesic coordinates.

(15 Lectures)

Unit-IV:

Parallelism of vectors- parallelism in subspace, Fundamental theorem of local Riemannian Geometry, Riemann-Christoffel tensor and its properties, Ricci's Tensor, Covariant curvature tensor, Bianchi Identity, Flat space, Einstein Space, Schur's theorem.

(15 Lectures)

Text Books:

1. R.J.T. Bell, Elementary Treatise on Co-ordinate geometry of three dimensions, Macmillan India Ltd., 1994.
2. J.L. Bansal and P.R.Sharma., Differential Geometry: Jaipur Publishing House (2004).
3. J.L. Bansal, Tensor Analysis, Jaipur Publishing House
4. J.K. Goyal and K.P.Gupta, Tensor Calculus and Riemannian Geometry, Pragati Prakashan Meerut

Reference Books:

1. P.P. Gupta, G.S. Malik and S.K. Pundir., Differential Geometry, Pragati Prakashan, Meerut.
2. S. C. Mittal and D. C.Agarwal, Differential Geometry, Krishna publication Media(P) Ltd, Meerut
3. J.A. Thorpe, Introduction to Differential Geometry, Springer-Verlag, 2013.
4. T.J. Willmore, An Introduction to Differential Geometry. Oxford University Press.1972.
5. C.E. Weatherburn`s, Riemannian Geometry and Tensor Calculus, Cambridge Univ. Press, 2008.
6. Thorpe, Elementary Topics in Differential Geometry, Springer Verlag, N.Y. (1985).
7. R.S. Millman and G.D. Parker, Elements of Differential Geometry, Prentice Hall, 1977.
8. David C Kay, Theory and Problems of Tensor Calculus, TMH

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Operation Research

Semester	Code of the Course	Title of the Course / Paper		NHEQF Level	Credits
II	MAT.20205T	Operation Research		6.5	4
Level of Course	Type of Course	Delivery of the Course			
Advance	ECC	Lectures (4 hrs a week), Sixty lectures including diagnostic and formative assessment during lecture hours.			
Prerequisites	Mathematics course at the Undergraduate Level.				
Objectives of the Course	The objective of Operations Research is to provide a scientific basis to the decision maker for solving the problems involving the interaction of various components of an organization by employing a team of scientists from various disciplines, all working together for finding a solution which is in the best interest of the organization as a whole.				

Course Outcomes: On successful completion of the course, the students will be able to:

1. Understand the need of using operations research – a quantitative approach for effective decision making.
2. Know the historical perspective of operations research approach. know various definitions of operations research, its characteristics, and various phases of scientific study.
3. Recognize, classify and use of various models for solving a problem under consideration.
4. Be familiar with several computer software available for solving an operations research model.
5. Realize the need to study replacement and maintenance analysis techniques.
6. Appreciate the use of replacement analysis in handling problems like, 'staffing problem' and 'equipment renewal problem', etc.
7. Understand the meaning of inventory control as well as various forms and functional role of inventory.
8. Use various selective inventory control techniques to classify inventory items into broad categories.
9. Identify and examine situations that generate queuing problems.
10. Describe the trade-off between cost of service and cost of waiting time.
11. Understand various components (or parts) of a queuing system and description of each of them.
12. Understand the principles of two-person zero-sum games.
13. Apply various methods to select and execute various optimal strategies to win the game.
14. Use dominance rules to reduce the size of a game payoff matrix and compute value of the game with mixed strategies.
15. Apply minimax and maximin principle to compute the value of the game, when there is a saddle point.
16. Make distinction between pure and mixed strategies.
17. Use linear programming approach to compute the value of the game when dominance rules do not apply.

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Contents:

Unit-I:

Introduction to O. R., Modelling and applications. Problems of Replacement-Introduction, concept of present value, replacement models and their solutions, mortality tables, group replacement method, staffing problems.

(15 Lectures)

Unit-II:

Inventory Control- Introduction, Classification of inventory models, Deterministic models, Economic lot-size models, production lot-size models, quantity discount, deterministic models with shortages, fixed time model, lost sales shortages, Multi-item deterministic models.

(15 Lectures)

Unit-III:

Queueing Theory- Introduction, Components of queueing system, Classification of queues and their problems, Steady, transient, and explosive states, distribution of arrivals and service times, queue models, M/M/1 :(infinite/ FIFO), M/M/1(N/FIFO), M/M/e (infinity/FIFO), M/M/c:(N/FIFO), M/E/1:(infinity/FIFO).

(15 Lectures)

Unit-IV:

Game Theory- Introduction, Description of games, Maximin and minimax principles, Saddle point, Dominance in games, Solution of rectangular games, Solution of 2x2 game without saddle point, Solution of two person zero sum 2xn game, graphical method, algebraic method, Solution of two person zero-sum game by transforming into L. p. p. using Simplex method. Iterative method for approximate solution of game, Fundamental theorem of game theory. Method of oddments to solve game.

(15 Lectures)

Text Books:

1. Hillier F. S., Lieberman G. J., Nag B., Basu P., 2012, Introduction to Operations Research, Tata McGraw Hill Education Pvt. Ltd.
2. Taha H. A., Operations Research-An Introduction, Prentice Hall of India Pvt. Ltd,2007.
3. S.D. Sharma: Operations Research, Kedar Nath Ram Nath, Meerut, India.
4. P.K.Gupta and D.S. Hira: Introduction to Operations Research, S. Chand & Company Ltd.
5. Kapur J.N., *Mathematical Modelling*, New Age Int. Publication, New Delhi

Reference Books:

1. B.S. Goel, S.K. Mittal and Sudhir K. Pundir: Operations Research, Pragati Prakashan Meerut.
2. K.V. Mittal and C. Mohan: Engineering Optimization Methods, New Age International Publisher.
3. N. Paul Loomba: Linear Programming, Mc Grow Hill Company.
4. Thomas L. Satty: Mathematical Methods of Operations Research, DoverPublications.
5. K.V. Mittal: Optimization Methods in Operations Research and System Analysis. Wiley, New York.

E-resources:

nptel.ac.in/courses/111107128

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

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Statistics –II

Semester	Code of the Course	Title of the Course / Paper	NHEQF Level	Credits
II	MAT.20206T		6.5	4
Level of Course	Type of Course	Delivery of the Course		
Advance	ECC	Lectures (4 hrs a week), Sixty lectures including diagnostic and formative assessment during lecture hours.		
Prerequisites	Mathematics course at the Undergraduate Level.			
Objectives of the Course	The objective of this course is to enhanced the knowledge of students with basic concepts of statistical theory of estimation and testing hypothesis with real life applications.			

Course Outcomes: On successful completion of the course, the students will be able to:

1. Understand basic concepts of sampling theory, Distribution of means of samples for binomial, Chauchy, rectangular, and normal population.
2. Describe Chi square with properties and applications.
3. Exact distributions of x^2, t, z and F with properties and applications.
4. Discuss the method of maximum Likelihood estimator and its properties and find maximum likelihood estimator for binomial, Poisson and Normal populations
5. Understand Analysis of variance, simple (one criteria and two criteria of classification).

Contents:

UnitI:

Index number: Introduction, Price relatives, Quantity relatives, Value relatives, Link and Chain relatives. Aggregate methods, Fisher's ideal index, Change of the base of the index numbers. Elementary sampling theory, Distribution of means of samples for binomial, Chauchy, rectangular, and normal population.

(15 Lectures)

Unit-II:

Exact distributions of x^2, t, z and F. Statistics in samples from a normal population, their simple properties and applications. Elementary statistical theory of estimation, Fisher criterion for the estimator

(15 Lectures)

Unit-III:

Consistent, Efficient and Sufficient estimators, method of maximum likelihood, maximum likelihood estimator, other methods of estimation. Methods of moments, minimum variance, Minimum Chi-square and least squares.

(15 Lectures)

Unit-IV:

Test of significance and difference between two means and two standard deviations for the large samples with modification of small samples and taken from normal population. Analysis of variance, simple cases (one criteria and two criteria of classification).

(15 Lectures)

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Text Books:

1. Gupta and Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand & Sons., New Delhi
2. J.N.Kapur and H.C.Sexena, Mathematical Statistics, S. Chand Publishing, New Delhi
3. M.R.Spiegel and L.J. Stephens, Theory and Problems of Statistics, TMH

Reference Books:

1. Mood A.M., Graybill F.A. and Boes D.C. (1974), Introduction to the theory of Statistics,
2. S.P. Gupta, Statistical Methods, Sultan Chand & Sons. First edition.

Interdisciplinary Elective Course

Computational techniques - Laboratory work (Practical)

Semester	Code of the Course	Title of the Course / Paper	NHEQF Level	Credits
II	IEC P	Computational Techniques Laboratory work (Practical)	6.5	4
Level of Course	**Type of Course**	**Delivery of the Course**		
Advance	**Interdisciplinary Elective Course**	Practical (8 hrs a week), One hundred twenty practical hours,including diagnostic and formative assessment during practical hours.		
Prerequisites	Mathematics course at the Undergraduate Level.			
Objectives of the Course	The main objective of studying approximations and errors in computation is to understand, quantify, and manage the inevitable differences between exact mathematical values and practical, computed results, enabling simpler, feasible calculations for real-world problems (like GPS, engineering) while ensuring the final answer remains sufficiently accurate for its purpose, thus balancing complexity with reliability. Interpolation formulae determine unknown data points that fall within the range of a discrete set of known data points. These formulae effectively "connect the dots" between existing data points to create a continuous function or curve, which has several key applications. The primary objective of practical is to find a mathematical function that best represents a given set of data points. This function serves various practical purposes across scientific, engineering, and economic fields. Boundary Value Problems (BVPs) in ODEs is to find solutions for physical systems (like heat flow, vibrations, or fluid dynamics) where conditions are specified at the edges or boundaries, not just the start (like Initial Value Problems). Practically, this involves modeling real-world scenarios, transforming them into mathematical equations with boundary conditions (e.g., fixed temperatures at walls, zero displacement at supports), and then using numerical methods (like finite differences or shooting methods) to find the specific, unique, and stable solution that fits those physical constraints, enabling accurate prediction and engineering design. Probability and distribution provide a mathematical framework for quantifying uncertainty and randomness in real-world situations, which allows for informed decision-making, prediction, and analysis of data across various fields.			

Duration of Examination	Maximum Marks	Minimum Marks
1 Hours	Midterm (MT) - 20 Marks	Midterm (MT) - 08 Marks
3 Hours	EoSE- 80 Marks	EoSE- 32 Marks

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Practical – Each candidate is required to appear in the practical examination to be conducted by internal and external examiners. External examiner will be appointed by university and internal examiner will be appointed by the principal consultation with Head, Department of Mathematics in the college. An internal/External examiner can conduct practical examination of not more than 60 candidate (20 candidate in each batch).

Distribution of Marks:

S.No.	Exercise	Marks
1.	Four Exercises one from each Group	15+15+15+15=60
2.	Practical record	10
3.	Viva-Voce	10
4.	**Total**	**80 Marks**

Course Outcomes: The students will be able to

1. Understand Error Types: Define, identify, and differentiate between various sources of error in computation, including inherent errors (from input data), round-off errors (due to finite computer precision), and truncation errors (from using approximations like Taylor series instead of exact formulas).
2. Quantify Errors: Calculate and interpret different measures of error, such as absolute error, relative error, and percentage error, to evaluate the accuracy and precision of an approximate solution compared to the true value.
3. Apply Approximation Techniques: Select and apply appropriate approximation techniques and numerical methods (e.g., Taylor series expansion, specific algorithms for integration or solving equations) to solve complex mathematical and real-world problems when exact analytical solutions are unavailable or impractical.
4. Enables students to approximate a function whose explicit form is unknown using simpler interpolating polynomials (like Lagrange, Newton, or spline polynomials), making it easier to analyze, differentiate, or integrate the function. Apply these methods in various multidisciplinary fields such as machine learning, computer graphics, image processing, and mechanical/civil engineering to solve practical problems.
5. equipping students with the skills to model data, analyze relationships between variables, and apply numerical methods to solve real-world engineering and scientific problems.
6. understand the underlying mathematics, particularly the principle of least squares, which minimizes the sum of the squared errors between observed data and the fitted function.
7. equip students with the skills to formulate, solve, and interpret solutions for real-world problems using both analytical and numerical methods.
8. Distinguish between initial value problems (IVPs) and BVPs, and understand the physical significance of boundary conditions.

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9. Utilize various numerical techniques and software tools to approximate solutions for problems that do not have simple analytical solutions. Specific methods often include: Shooting methods, Finite difference methods, Iterative techniques.
10. apply linear algebra concepts and matrix operations to solve problems in diverse areas like computer science, physical sciences, and economics.
11. gain the ability to compile and interpret matrix properties, such as rank, to analyze data and understand underlying structures in various applications.
12. explain different concepts about linear transformations and inner product spaces,
13. learn different characterization of diagonalization and canonical forms of a given linear transformation
14. use different concepts associated with vector spaces, linear transformations, diagonalization and inner product spaces in other courses like functional analysis, differential equations.

Group-I

Approximations and Errors in Computation; Accuracy of Numbers, Errors, Useful Rules for Estimating Errors, Error Propagation, Error in the Approximation of a Function, Error in a Series Approximation, Order of Approximation, Growth of Error, Newton's interpolation formulae, Central difference interpolation formulas, Gaues's interpolation formulae: Stirling's formula: Bessel's formula: , Laplace-Everett's formula, Choice of an interpolation formula, interpolation with unequal intervals, Lagrange's formula, Divided differences, Newton's divided difference formula, Inverse interpolation.

(30 Lectures)

Group -II

Curve fitting and Function Approximation: Curve Fitting and Least square principal, polynomial fitting, and other curve fitting, least square approximation using orthogonal polynomial, Approximation using Legendre polynomials, Approximation using Chebyshev polynomials, Properties of Chebyshev polynomials.

(30 Lectures)

Group -III

Boundary value problems of Ordinary differential equations, Boundary value problems (BVP's), Finite difference methods, Shooting method, Difference schemes for linear boundary value problems of the type $y^{ii} = f(x, y^{i})$, $y^{ii} = f(x, y, y^{i})$ and $y^{iv} = f(x, y)$.

(30 Lectures)

Group -IV

Probability and set notations, Addition law of probability, independent events-Multiplication law of probability, Baye`s theorem, Random variable. Discrete probability distribution, Continuous probability distribution, Expectation, Variance, Moments, Moment generating function, Probability generating function, Repeated trials, Binomial distribution, Poisson distribution, Normal distribution.

(30 Lectures)

Text Books:

1. Gupta and Kapoor: Fundamentals of Mathematical Statistics
2. M.K. Jain, S.R.K. Eyenger and R.K. Jain, Numerical Methods for Mathematics and Applied Physicists, Wiley-Eastern Pub., N. Delhi, 2005.
3. Atkinson K. E., *An Introduction to Numerical Analysis* (2nd Ed.), Wiley-India, 1989.
4. Sastry S. S., Introductory Methods of Numerical Analysis, PHI,2019.
5. D. S. Chauhan, Paresh Vyas and Vimlesh Soni, Studies in Numerical Analysis, JPH
6. Sheldon Ross, A First Course in Probability, 10e, Pearson Education

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Reference Books:

1. V.Rajaraman, Computer Oriented Numerical Methods, PHI, 1993.
2. C. F. Gerald and P. O. Wheatley, Applied Numerical Analysis, Pearson Education, India,
3. C.F. Gerald, P.O. Wheatley, Applied Numerical Analysis, Addison-Wesley, 1998.
4. S. D. Conte, C de Boor, Elementary Numerical Analysis, McGraw-Hill, 1980.
5. C.E. Froberg, Introduction to Numerical Analysis, Addition-Wesley, 1979.
6. Buchaman J.I., Turner P. R., Numerical Methods and Analysis, McGraw-Hill,1992.
7. M.R. Spiegel, Schaum's Outline of Theory and Problems of Probability and Statistics, TMH
8. Seymour Lipschutz , Introduction to Probability and Statistics, TMH

E-resources:

nptel.ac.in/courses/111104137

nptel.ac.in/courses/111108066

Mathematics Laboratory work -2

Semester	Code of the Course	Title of the Course / Paper	NHEQF Level	Credits
II	MAT.20207P	Mathematics Laboratory work -2	6.5	4
Level of Course	**Type of Course**	**Delivery of the Course**		
Advance	Practical	Practical (8 hrs a week), One hundred twenty practical hours,including diagnostic and formative assessment during practical hours.		
Prerequisites	Mathematics course at the Undergraduate Level.			
Objectives of the Course	The objective of a practical is to apply theoretical concepts to solve problems, focusing on skills like performing matrix operations, solving systems of linear equations, and utilizing computational tools to understand and analyze multidimensional data relevant to fields like machine learning, engineering, and physics. Practical exercises reinforce concepts such as linear transformations, vector spaces, eigenvalues, and decomposition techniques, bridging theory with real-world applications. The objective is to learn how matrices represent linear transformations in vector spaces, which are fundamental for geometric manipulations and understanding function changes. Eigenvalues and eigenvectors are crucial for understanding the behavior of linear systems and are widely used in data analysis and physics. Practical exercises will involve defining linear transformations and finding their domain, range, kernel, rank, and nullity. The practical component emphasizes the development of computational skills, often involving the use of software like MAXIMA or other free and open-source software (FOSS) to perform matrix operations and solve complex problems.			

Duration of Examination	Maximum Marks	Minimum Marks
1 Hours	Midterm (MT) - 20 Marks	Midterm (MT) - 08 Marks
3 Hours	EoSE- 80 Marks	EoSE- 32 Marks

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Practical – Each candidate is required to appear in the practical examination to be conducted by internal and external examiners. External examiner will be appointed by university and internal examiner will be appointed by the principal consultation with Head, Department of Mathematics in the college. An internal/External examiner can conduct practical examination of not more than 60 candidate (20 candidate in each batch).

Distribution of Marks:

S.No.	Exercise	Marks
1.	Four Exercises one from each Group	15+15+15+15=60
2.	Practical record	10
3.	Viva-Voce	10
4.	**Total**	**80 Marks**

Course Outcomes: The students will be able to

1. learn algebra of linear transformations, significance, different characterization of diagonalization and canonical forms of a given linear transformation.
2. demonstrating an understanding of core concepts like vector spaces, linear transformations, and matrices, and then applying these to solve real-world problems using both theoretical knowledge and computational tools. Students should be able to analyze and solve systems of linear equations, determine eigenvalues and eigenvectors, and utilize software to solve applied problems in fields like engineering, computer science, and economics.
3. use mathematical software to solve systems of linear equations, find eigenvalues and eigenvectors, determine matrix ranks, and represent linear transformations or geometric transformations using matrices. They will gain hands-on experience applying these concepts to real-world applications in various fields, enhancing their analytical and computational skills.
4. use matrices to solve systems of linear equations and understand the relationship between matrix rank and the existence of solutions.
5. learn to compute eigenvalues and eigenvectors of matrices, a critical concept in many engineering and scientific applications.
6. gain experience working with vector spaces, implementing the Gram-Schmidt orthogonalization process, and understanding concepts like inner products and the Schwartz inequality.
7. apply linear algebra concepts and matrix operations to solve problems in diverse areas like computer science, physical sciences, and economics.
8. gain the ability to compile and interpret matrix properties, such as rank, to analyze data and understand underlying structures in various applications.
9. explain different concepts about linear transformations and inner product spaces,
10. learn different characterization of diagonalization and canonical forms of a given linear transformation
11. use different concepts associated with vector spaces, linear transformations, diagonalization, and inner product spaces in other courses like functional analysis, differential equations.

Group-I

Elementary matrices and LU factorization, Transition matrix, solving a linear system using LU factorization, Applications of System of Linear Equations-Balancing Chemical Equations, Network flow, Nutrition, Economic input-output Model. Eigen values and eigen vectors of a linear transformation, Diagonalizable matrix and operators, General solution of systems of linear differential Equations, Uncoupled systems, the phase plane, Diagonalization, Diagonalizing the Transition matrix

(30 Lectures)

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Group -II

Linear transformation, Null space and range, Rank and Nullity of linear transformation, isomorphisms, Matrix representation of linear transformation, Inverse of linear transformation, Transition matrix of linear transformation, Similarity of linear transformation,

(30 Lectures)

Group -III

Matrix of a bilinear form, bilinear form corresponding to a given matrix, Matrix of a quadratic form, quadratic form corresponding to a given matrix, Congruence of quadratic form, congruent reduction of a Symmetric matrix, reduction of a real quadratic form, Lagrange`s reduction of a real quadratic form, Value class of a real quadratic form.

(30 Lectures)

Group -IV

Inner product spaces, orthonormal bases, orthogonal projections, Gram- Schmidt orthogonalization process, orthogonal complements, Least square approximation by using the concepts of linear algebra, Diagonalization of a symmetric matrices, Singular value decomposition of matrix.

(30 Lectures)

Text Books:

1. Bhattacharya, P. B. Jain, S. K. and Nagpal, S. R.: First Course in Linear Algebra, Wiley Eastern Ltd., New Delhi.
2. Hoffman, K. and Kunze, R.: Linear Algebra. 2nd edition, Pearson India, 2015
3. Axler, S.: Linear Algebra Done Right. 2nd edition, Springer-Verlag, 2014.
4. Lang, S.: Linear Algebra. 3rd edition, Springer-Verlag, New York, 2013.
5. Lipschutz, S. and Lipson, M.: Linear Algebra. 3rd edition, Tata McGraw-Hill, 2005.
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