M. Sc (Mathematics)

III – Semester

1. Name of the Department: Mathematics and Statistics						
2. Course Name	**Differential Geometry II**			**L**	**T**	**P**
3. Course Code	**MT504**			3	1	0
4. Type of Course (use tick mark)		**Core (□)**	**DSE ()**	**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite	**B. Sc.** with Mathematics	6 . **Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()	Every Sem ()
7. Total Number of Lectures, Tutorials, Practical						
Lectures = 30		**Tutorials = 10**		**Practical = Nil**		

8. COURSE OBJECTIVES: 1. This is an introductory course on Differentiable manifolds. The aim of this course is to introduce and develop basic theoretical concepts of almost contact manifolds and almost complex manifolds for n-dimensional spaces.

2. This course is aimed to provide an understanding of the affine connections, curvature tensors, linear connexion, Nijenhuis tensor, contravariant & covariant almost analytic vectors.

3. This course is aimed to provide the concept of semi-invariant and CR-submanifolds of differentiable manifolds.

9. COURSE OUTCOMES (CO):

After the successful course completion, learners will develop following attributes:

COURSE OUTCOME (CO)	**ATTRIBUTES**
CO1	Understand the concept of various kinds of almost contact manifolds with examples.
CO2	Able to define almost complex manifolds and calculate the curvature tensors, Nijenhuis tensor, contravariant & covariant almost analytic vectors.
CO3	Make logical arguments on Kahler & nearly Kahler manifolds and CR-submanifolds of Kahlerian manifolds.
CO4	Characterize Almost contact manifold to Sasakian manifold, quasi Sasakian manifold, k-contact Riemannian manifolds and find semi-invariant submanifolds of Sasakian manifolds.
CO5	Develop the understanding of the basic concepts of Almost Hermite manifolds, submanifolds of almost Hermite manifold, almost Grayan submanifold, F-structure manifolds.

10. Unit wise detailed content

Unit-1	**Number of lectures = 08**	**Title of the unit: Tensor Analysis**
Almost contact manifold, affinely almost co-symplectic manifold, contact metric structures, para-contact structures.		
Unit-2	**Number of lectures =08**	**Title of the unit: Space curves**
Almost complex manifold, Nijenhuis tensor, contravariant & covariant almost analytic vector, F-connection, linear connexion.		
Unit-3	**Number of lectures = 08**	**Title of the unit: Surface Theory**
Kahler & nearly Kahler manifolds, affine connections, curvature tensors, CR-submanifolds of Kahlerian manifolds.		
Unit-4	**Number of lectures = 08**	**Title of the unit: Fundamental Equations**
Sasakian manifold, quasi Sasakian manifold, k-contact Riemannian manifold, semi-invariant submanifolds of Sasakian manifold.		
Unit-5	**Number of lectures = 08**	**Title of the unit: Riemannian Manifolds**
Almost Hermite manifolds, submanifolds of almost Hermite manifold, almost Grayan submanifold, F-structure manifolds.		

11. CO-PO mapping

COs	**Attributes**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	Understand the concept of various kinds of almost contact manifolds with examples.	**3**	**1**	**1**	**1**	**2**	**1**	**1**	**3**
CO2	Able to define almost complex manifolds and calculate the curvature tensors, Nijenhuis tensor, contravariant & covariant almost analytic vectors.	**3**	**1**	**2**	**1**	**3**	**1**	**2**	**3**
CO3	Make logical arguments on Kahler & nearly Kahler manifolds and CR-submanifolds of Kahlerian manifolds.	**3**	**1**	**2**	**1**	**3**	**1**	**1**	**2**
CO4	Characterize Almost contact manifold to Sasakian manifold, quasi Sasakian manifold, k-contact Riemannian manifolds and find semi-invariant submanifolds of Sasakian manifolds.	**3**	**1**	**1**	**1**	**2**	**1**	**2**	**3**

CO5	Develop the understanding of the basic concepts of Almost Hermite manifolds, submanifolds of almost Hermite manifold, almost Grayan submanifold, F-structure manifolds.	**3**	**1**	**1**	**1**	**2**	**1**	**1**	**2**

3 Strong contribution, 2 Average contribution , 1 Low contribution

12. Brief description of self learning / E-learning component

1. https://www.youtube.com/watch?v=klks723on3k
2. https://www.youtube.com/watch?v=klks723on3k
3. https://www.youtube.com/watch?v=KwHfz5BegoU

13. Books recommended:

1. David E. Blair, Contact manifolds in Riemannian Geometry, Springer-Verlag. Structures of manifolds,
2. K. Yano & M. Kon, Structures of manifolds World Scientific Publishing Co. Pvt. Ltd.
3. S.I. Hussain. Lecture notes on differentiable manifolds
4. B.Y. Chen , Geometry of Submanifolds, Marcel Dekker, New York.

1. Name of the Department: Mathematics and Statistics						
2. Course Name	**APPLIED FUNCTIONAL ANALYSIS**			**L**	**T**	**P**
3. Course Code	**MT505**			3	1	0
4. Type of Course (use tick mark)		**Core (✓)**	**DE ()**	**FC ()**		**OE ()**
5. Pre-requisite (if any)	B.Sc.	**6. Frequency (use tick**	Even ()	Odd (✓)		Every Sem ()
7. Total Number of Lectures, Tutorials						
Lectures = 30		**Tutorials = 10**		**Practical = Nil**		

8. COURSE OBJECTIVES: The course gives an introduction to Applied functional analysis, which is a branch of analysis in which one develops analysis in infinite dimensional vector spaces. The central concepts which are studied are normed spaces with emphasis on Banach and Hilbert spaces, and continuous linear maps (often called operators) between such spaces. After successfully completion of course, the student will able to explore subject into their respective dimensions.

9. COURSE OUTCOMES (CO):

After the successful course completion, learners will develop following attributes:

COURSE OUTCOME	ATTRIBUTES
CO1	Define and describe Metric spaces, examples of metric spaces, interior point, limit point, open set, closed set, neighborhood, convergence, Cauchy sequence, continuity, complete metric spaces, compact metric spaces.
CO2	Define and describe Normed linear Space, Banach spaces, incomplete normed spaces, finite dimensional normed spaces and subspaces, equivalent norms, compactness, Riesz's lemma, linear operators, bounded and continuous linear operators, continuity of linear operators, linear functional, linear operators and functional on finite dimensional spaces.
CO3	Define and describe Inner product spaces, Hilbert spaces, properties of Inner product spaces, polarization identity, orthogonal complements and direct sums, orthogonal sets and sequences, series related to orthogonal sequences and sets, representation of functional on Hilbert space.
CO4	Describe Zorn's lemma, Hahn–Banach theorem, Hahn Banach theorem for complex vector spaces and normed spaces, Application to bounded linear functionals on C$[a, b]$, uniform boundedness theorem, Open mappings, open mapping theorem, Closed linear operators, closed graph theorem.
CO5	Define and describe Contraction mappings, Picard's iterates, Banach fixed point theorem, Application of Banach theorem to linear equations, Application of Banach theorem to differential equations.

10. Unit wise detailed content

Unit-1	**Number of lectures = 07**	**Title of the unit: Metric Spaces**

Metric spaces, examples of metric spaces, interior point, limit point, open set, closed set, neighborhood, convergence, Cauchy sequence, continuity, complete metric spaces, compact metric spaces.

Unit-2	**Number of lectures =08**	**Title of the unit: Normed Spaces & Banach spaces**

Normed linear Space, Banach spaces, incomplete normed spaces, finite dimensional normed spaces and subspaces, equivalent norms, compactness, Riesz's lemma, linear operators, bounded and continuous linear operators, continuity of linear operators, linear functional, linear operators and functional on finite dimensional spaces.

Unit-3	**Number of lectures = 08**	**Title of the unit: Inner Product spaces & Hilbert Spaces**

Inner product spaces, Hilbert spaces, properties of Inner product spaces, polarization identity, orthogonal complements and direct sums, orthogonal sets and sequences, series related to orthogonal sequences and sets, representation of functional on Hilbert space.

Unit-4	**Number of lectures = 09**	**Title of the unit: Fundamental Theorems of Normed and Banach**

Zorn's lemma, Hahn–Banach theorem, Hahn Banach theorem for complex vector spaces and normed spaces, Application to bounded linear functionals on C$[a, b]$, uniform boundedness theorem, Open mappings, open mapping theorem, Closed linear operators, closed graph theorem

Unit-5	**Number of lectures = 08**	**Title of the unit: Banach fixed point theorem**

Contraction mappings, Picard's iterates, Banach fixed point theorem, Application of Banach theorem to linear equations, Application of Banach theorem to differential equations

11. CO-PO mapping

COs	**Attributes**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	Define and describe Metric spaces, examples of metric spaces, interior point, limit point, open set, closed set, neighborhood, convergence, Cauchy sequence, continuity, complete metric spaces, compact metric spaces.	**3**	**1**	**1**	**1**	**2**	**2**	**2**	**3**
CO2	Define and describe Normed linear Space, Banach spaces, incomplete normed spaces, finite dimensional normed spaces and subspaces, equivalent norms, compactness, Riesz's lemma, linear operators, bounded and continuous.	**3**	**1**	**1**	**1**	**2**	**1**	**2**	**3**
CO3	Define and describe Inner product spaces, Hilbert spaces, properties of Inner product spaces, polarization identity, orthogonal complements and direct sums, orthogonal sets and sequences, series related to orthogonal sequences and sets, representation of functional on Hilbert space.	**2**	**1**	**1**	**1**	**2**	**1**	**2**	**3**
CO4	Describe Zorn's lemma, Hahn–Banach theorem, Hahn Banach theorem for complex vector spaces and normed spaces, Application to bounded linear functionals on C$[a, b]$, uniform boundedness theorem, Open mappings, open mapping theorem, Closed linear operators, closed graph theorem.	**3**	**1**	**2**	**1**	**1**	**1**	**2**	**3**
CO5	Define and describe Contraction mappings, Picard's iterates, Banach fixed point theorem, Application of Banach theorem to linear equations, Application of Banach theorem to differential equations.	**3**	**1**	**1**	**1**	**2**	**1**	**2**	**3**

3 Strong contribution, 2 Average contribution , 1 Low contribution

12. Brief description of self learning / E-learning component

1. https://nptel.ac.in/courses/111105037/
2. https://www.youtube.com/watch?v=7IIw_U8rv4Q
3. https://freevideolectures.com/course/3145/functional-analysis

13. Books recommended:

1. Introductory Functional Analysis with Applications by Erwin Kreyszig(1989).
2. Introduction to Functional Analysis with Applications by A.H. Siddiqui, Khalil Ahmad and P. Manchanda, Real World Education Publishers, New Delhi(2015).
3. Applied Functional Analysis by A.H. Siddiqui, Real World Education Publishers, New Delhi (2015).
4. Elements of the Theory of Functions and Functional Analysis by W. Rudin.

1. Name of the Department: Mathematics and Statistics						
2. Course Name	**INTEGRAL EQUATIONS**			**L**	**T**	**P**
3. Course Code	**MT506**			3	1	0
4. Type of Course (use tick mark)		**Core (✓)**	**DE ()**	**FC ()**		**OE ()**
5. Pre-requisite (if any)	B.Sc.	**6. Frequency (use tick marks)**	Even ()	Odd (✓)		Every Sem ()

7. Total Number of Lectures, Tutorials		
Lectures = 30	**Tutorials = 10**	**Practical = Nil**

8. COURSE OBJECTIVES The course is aimed to develop the skills in mathematics for grooming them into successful science graduate. The topics introduced will serve as basic tools for specialized studies in science field.

9. COURSE OUTCOMES (CO):
After the successful course completion, learners will develop following attributes:

COURSE OUTCOME	ATTRIBUTES
CO1	Familiar with the concepts of integral operator and functional.
CO2	Recognize difference between Volterra and Fredholm Integral Equations, First kind and Second kind, homogeneous and inhomogeneous etc.
CO3	Acquired sound knowledge of Green's functions, Fredholm and Volterra integral equations and of the calculus of variations.
CO4	Ordinary and partial differential equations using Green's functions.
CO5	They apply different methods to solve Integral Equations.

10. Unit wise detailed content

Unit-1	**Number of lectures = 07**	**Title of the unit: Metric Spaces**

Regularity conditions, special kinds of kernels, Eigen values and Eigen functions, Convolution integral, reduction to a system of algebraic equations , Fredholm alternative, an approximate method , examples, iterative scheme, Volterra integral equation, Some results about the resolvent Kernel, Examples.

Unit-2	**Number of lectures =08**	**Title of the unit: Normed Spaces & Banach spaces**

The method of solution of Fredholm, Fredholm first theory, Examples.

Unit-3	**Number of lectures = 08**	**Title of the unit: Inner Product spaces & Hilbert Spaces**

Initial value problems, boundary value problems, Dirac delta Function, Green's Function approach, Green's function for nth order ordinary differential equations, Modified Green's function, Examples.

Unit-4	**Number of lectures = 09**	**Title of the unit: Fundamental Theorems of Normed and Banach**

Introduction, Fundamental properties of Eigen values and Eigen functions for symmetric Kernels, Expansion in Eigen functions and Bilinear forms, Hilbert-Schmidt theorem and some immediate consequences, solutions of a symmetric integral equation, Examples.

Unit-5	**Number of lectures = 08**	**Title of the unit: Banach fixed point theorem**

Abel's Equations, Inversion formula for singular integral equations, Laplace transform, Application to Volterra integral and integral differential equations with convolution type Kernels, Abel's Integral equations, Fourier Transform, Solution by Fourier Transform Method.

11. CO-PO mapping

COs	Attributes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	Familiar with the concepts of integral operator and functional.	**3**	**2**	**2**	**1**	**1**	**3**	**1**	**1**
CO2	Recognize difference between Volterra and Fredholm Integral Equations, First kind and Second kind, homogeneous and inhomogeneous etc.	**2**	**2**	**2**	**1**	**1**	**2**	**2**	**1**
CO3	Acquired sound knowledge of Green's functions, Fredholm and Volterra integral equations and of the calculus of variations.	**2**	**2**	**2**	**1**	**1**	**2**	**3**	**3**
CO4	Ordinary and partial differential equations using Green's functions.	**3**	**2**	**3**	**1**	**1**	**3**	**2**	**3**
CO5	They apply different methods to solve Integral Equations.	**3**	**2**	**1**	**1**	**1**	**2**	**1**	**1**

3 Strong contribution, 2 Average contribution , 1 Low contribution
12. Brief description of self learning / E-learning component
1. https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/115104096/lec47.pdf 2. https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/111107103/lec13.pdf 3. http://hitoshi.berkeley.edu/221A/delta.pdf 4. https://nptel.ac.in/courses/111107103/ https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/111106100/lec11.pdf
13. Books recommended: 1. 1. Numerical Methods for Scientific and Engineering computation by M.K. 2. Jain, S.R.K. Iyengar, R.K. Jain, New Age Int. Ltd., New Delhi. 3. Numerical Methods by P. Kandasamy, S. Chand Publ. New Delhi. 4. Introduction to Numerical Analysis, by S.S. Sastry Prentice Hall Flied 5. S.D. Conte & C.D. Boor, Elementary Numerical Analysis Lothar Collatz, Numerical treatment of differential equations, Springer Ver. Publications.

1. Name of the Department: Mathematics and Statistics						
2. Course Name	**Optimization Techniques**			**L**	**T**	**P**
3. Course Code	**MT507**			2	1	0
4. Type of Course (use tick mark)		**Core (✓)**	**DE ()**	**FC ()**		**OE ()**
5. Pre-requisite (if any)		**6. Frequency (use tick**	Even ()	Odd (✓)		Every Sem ()
7. Total Number of Lectures, Tutorials						
Lectures = 30		**Tutorials = 10**		**Practical = Nil**		

8. COURSE OBJECTIVES: understand the definitions and Formulation of linear programming problem and different optimization techniques

9. COURSE OUTCOMES (CO):
After the successful course completion, learners will develop following attributes:

COURSE OUTCOME (CO)	ATTRIBUTES
CO1	To understand the definitions and Formulation of linear programming problem (LPP) Graphical method, Simplex method, Big-M method, Two Phase method, Primal & Dual problem.
CO2	Able to explain the Various method of finding initial basic feasible solution of transportation problem, Optimality criterion in transportation problem. Solution of assignment problem using Hungarian method.
CO3	Able to understand the basic definitions, Two-person Zero-sum games, Pure and mixed strategy, Principle of Dominance, Graphical method, Solution of games by linear programming method. **Decision Theory:** Introduction, Elements of decision problem, Types of decision making environment, Decision tree.
CO4	Able to explain Sequencing: Basic assumptions, Processing of n-Jobs on 2-Machines, n-Jobs on 3-Machines and 2-Jobs on k-Machines. **Replacement Problems:** Replacement of items that deteriorate with time, Replacement of items that fails suddenly - Individual replacement policy and Group replacement policy
CO5	Able to explain Inventory Models**,**Types of inventory models, Various inventory costs, Deterministic inventory models, Economic order quantity, Price breaks- one, two, n-price breaks, Single period probabilistic inventory models.

10. Unit wise detailed content

Unit-1	**Number of lectures = 08**	**Title of the unit:**
Linear Programming: Linear programming problem (LPP), Formulation of linear programming problem, Graphical method, Simplex method, Big-M method, Two Phase method, Primal & Dual problem.		
Unit-2	**Number of lectures =08**	**Title of the unit:**

Transportation and Assignment Problem: Various method of finding initial basic feasible solution of transportation problem, Optimality criterion in transportation problem, Variations in transportation problem, Solution of assignment problem using Hungarian method and Variations in assignment problem

Unit-3	Number of lectures = 08	Title of the unit:

Game Theory: Basic definitions, Two-person Zero-sum games, Pure and mixed strategy, Principle of Dominance, Graphical method, Solution of games by linear programming method. **Decision Theory:** Introduction, Elements of decision problem, Types of decision making environment, Decision tree.

Unit-4	Number of lectures = 08	Title of the unit:

Sequencing: Basic assumptions, Processing of n-Jobs on 2-Machines, n-Jobs on 3-Machines and 2-Jobs on k-Machines. **Replacement Problems:** Replacement of items that deteriorate with time, Replacement of items that fails suddenly - Individual replacement policy and Group replacement policy.

Unit-5	Number of lectures = 08	Title of the unit:

Inventory Models: Types of inventory models, Various inventory costs, Deterministic inventory models, Economic order quantity, Price breaks- one, two, n-price breaks, Single period probabilistic inventory models.

11. CO-PO mapping

COs	Attributes	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	To understand the definitions and Formulation of linear programming problem (LPP) Graphical method, Simplex method, Big-M method, Two Phase method, Primal & Dual problem.	3	3	2	2	2	2	2
CO2	Able to explain the Various method of finding initial basic feasible solution of transportation problem, Optimality criterion in transportation problem. Solution of assignment problem using Hungarian method.	2	3	3	2	2	3	2
CO3	Able to understand the basic definitions, Two-person Zero-sum games, Pure and mixed strategy, Principle of Dominance, Graphical method, Solution of games by linear programming method. **Decision Theory:** Introduction, Elements of decision problem, Types of decision making environment, Decision tree.	2	2	2	2	3	2	3
CO4	Able to explain Sequencing: Basic assumptions, Processing of n-Jobs on 2-Machines, n-Jobs on 3-Machines and 2-Jobs on k-Machines. **Replacement Problems:** Replacement of items that deteriorate with time, Replacement of items that fails suddenly - Individual replacement policy and Group replacement policy	2	3	3	3	2	2	2
CO5	Able to explain Inventory Models,Types of inventory models, Various inventory costs, Deterministic inventory models, Economic order quantity, Price breaks- one, two, n-price breaks, Single period probabilistic inventory models.	2	2	3	2	2	2	2

3 Strong contribution, 2 Average contribution , 1 Low contribution

12. Brief description of self learning / E-learning component

1. https://www.youtube.com/watch?v=be9e-Q-jC-0
2. https://www.youtube.com/watch?v=bQ5_PPRPjG4
3. https://www.youtube.com/watch?v=jauhoR7w1YM

13. Books recommended:

1 H.A. TAHA "Operations Research- An Introduction" Pearson.
2. K.Swarup, P.K.Gupta and A. Manmohan, "Operations Research", S. Chand.
3. Hiller And Liebarman, "Introduction to Operations Research", McGraw Hill Company.
4. J.K.Sharma, "Operations Research ", Pearson.

	1. Name of the Department: Mathematics and Statistics						
2. Course Name	**Fluid Dynamics**				**L**	**T**	**P**
3. Course Code	**MT508**				3	1	0
4. Type of Course (use tick mark)		**Core (□)**	**DSE ()**		**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite (if any)	B. Sc. with Mathematics	**6. Frequency (use tick marks)**			Odd (□)		
	7. Total Number of Lectures, Tutorials, Practicals						
Lectures = 30		**Tutorials = 10**			**Practical = Nil**		
	8. COURSE OBJECTIVES: Students will be able to learn the concepts and mathematical understanding of Fluid Dynamics. They will understand the physical and mathematical formulation of non viscous fluids and their solutions and can develop the idea of source, sink and doublet and obtain complex potentials. Also Understand, formulate and solve the equations of motion under different conditions. Students will be able to understand the similarity of the fluids, obtain and solve the differential equations of viscous incompressible fluid under specified boundary conditions.						
	9. COURSE OUTCOMES (CO): ***After the successful course completion, learners will develop following attributes:***						

COURSE OUTCOME (CO)	**ATTRIBUTES**
CO1	Develop mathematical understanding of fluid Dynamics problems.
CO2	Understand the various concepts and relations of fluid and understand the physical and mathematical formulation of non viscous fluids and their solutions.
CO3	Understand and develop the idea of source, sink and doublet and obtain complex potentials
CO4	Able to understand, derive and solve the two dimensional equations of fluid motion of circular, elliptic and coaxial cylinders. Derive and solve the equation of motion of viscous fluid and obtain the energy equation, vorticity and circulation.
CO5	Apply the dimensional analysis to obtain the dimensionless numbers to express the fluid motion independently. Obtain, solve and analyze Navier-Stoke equation of motion of viscous fluid between parallel plates and of concentric rotating cylinders to find the velocity and temperature distribution function of the fluid.

	10. Unit wise detailed content		
Unit-1	**Number of lectures = 08**		**Title of the unit:**
	Equation of motion - Lagrange's and Euler's equation of motion-Bernoulli's theorem - Stream functions - Irrotational motion in two-dimensions-Complex velocity potential sources–Sinks, doublets and their images-Milne-Thompson Circle theorem.		
Unit-2	**Number of lectures =08**		**Title of the unit:**
	Two dimensional irrotational motion produced by motion of Circular, Co-axial and elliptic cylinders in an infinite mass of liquid-Theorem of Blasius motion of a sphere through a liquid at rest at infinity-Liquid streaming past a fixed sphere.		
Unit-3	**Number of lectures = 08**		**Title of the unit:**
	Fundamental Equations of Motion of Viscous Fluid; Equation of State, Equation of Continuity, Navier–Stokes (NS) Equations (equation of Motion, Equation of Energy, Streamlines & Pathlines, Vorticity and Circulation (Kelvin's Circulation Theorem).		
Unit-4	**Number of lectures = 08**		**Title of the unit:**
	Dynamical Similarity (Reynold's Law), Inspection Analysis-Dimensional Analysis, Buckingham–π-Theorem, and its Applications π–products and coefficients, Non-dimensional parameters and their physical importance. Exact Solutions of the N S Equations.		
Unit-5	**Number of lectures = 08**		**Title of the unit:**

	Steady Motion between parallel plates: Velocity distribution & Temperature Distribution. Plane Couette flow, generalized plane Couette flow. Flow between two concentric Rotating Cylinders: Velocity distribution & Temperature distribution.

11. CO-PO mapping

COs	Attributes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	Develop mathematical understanding of fluid Dynamics problems.	3	2	2	1	1	1	2	2
CO2	Understand the various concepts and relations of fluid and understand the physical and mathematical formulation of non viscous fluids and their solutions.	3	2	1	1	1	2	2	2
CO3	Understand and develop the idea of source, sink and doublet and obtain complex potentials	3	1	1	1	1	2	2	2
CO4	Able to understand, derive and solve the two dimensional equations of fluid motion of circular, elliptic and coaxial cylinders. Derive and solve the equation of motion of viscous fluid and obtain the energy equation, vorticity and circulation.	3	1	1	1	1	2	2	2
CO5	Apply the dimensional analysis to obtain the dimensionless numbers to express the fluid motion independently. Obtain, solve and analyze Navier-Stoke equation of motion of viscous fluid between parallel plates and of concentric rotating cylinders to find the velocity and temperature distribution function of the fluid.	3	2	1	1	1	2	2	2

3 Strong contribution, 2 Average contribution , 1 Low contribution

12. Brief description of self learning / E-learning component

1. https://nptel.ac.in/courses/112105171/
2. http://www3.dicca.unige.it/rrepetto/linked-files/fluid-dynamics-lecture-notes.pdf
3. http://web.engr.uky.edu/~acfd/me330-lctrs.pdf

13. Books recommended:

1.W.H. Besaint and A.S.Ramsay, A Treatise on Hydromechanics, Part-II. CBS Publishers, Delhi, 1988.
2. F. Chorlton, Text book of Fluid Dynamics, CBS Publishers, Delhi, 1985.
3. G.K. Batchelor, An Introduction to Fluid Dynamics, Cambridge University Press (1970).
4. C.S. Yih, Fluid Mechanics, McGraw-Hill Book, Company
5. T. E. Faber, Fluid Dynamics for Physicists, Cambridge University Press.
6. *M.D Raisinghania*, *Fluid Dynamics, S. Chand Publishing*
7. Z.U.A. Warsi, Fluid Dynamics, Theoretical and Computational approaches, C.R.C. Press.

1.Name of the Department: Mathematics and Statistics						
2.Course Name	**Special Functions**			**L**	**T**	**P**
3.Course Code	**MT509**			3	1	0
4.TypeofCourse(usetickmark)		**Core(□)**	**DSE()**	**AEC()**	**SEC()**	**OE()**
5.Pre-requisite (ifany)	M.Sc. (Mathematics)	**6.Frequency(usetickmarks)**	Even (□)	Odd (Yes)	EitherSem ()	EverySem()
7.TotalNumberofLectures,Tutorials,Practicals						
Lectures=30		**Tutorials=10**		**Practical=Nil**		

8. COURSE OBJECTIVES• The interplay between mathematical analysis and physical understanding. • To investigate and derive the properties of special functions, inter-relations between such functions and their representations in various forms. • Certain specific systems of orthogonal polynomials and their properties.

9. COURSE OUTCOMES (CO):

After the successful course completion, learners will develop following attributes:

COURSE OUTCOME (CO)	ATTRIBUTES
CO1	Solve, expand and interpret solutions of many types of important differential equations by making use of special functions and orthogonal polynomials.
CO2	Derive the formulas and results of certain classical special functions and orthogonal polynomials by different methods.
CO3	Derive the generating relations involving special functions.
CO4	Understand purpose and functions of the gamma and beta functions, and Transformation.
CO5	Achieve the knowledge to analyse the problems using the methods of special functions and orthogonal polynomials, which helps in exploring the role of special functions and orthogonal polynomials in other areas of mathematics.

10.Unit wise detailed content

Unit-1	**Number of lectures=08**	**Title of the unit: Gamma and Beta functions**

The Euler or Macheroni Constant, Gamma function, A series for gamma function, Difference equation Gamma(Z+1) = ZGamma(Z), Euler's Integral for Gamma(z), Beta function, Value of Gamma(z)Gamma(1-z), Factorial function, Legender duplication formula, Gauss multiplication Theorem.

Unit-2	**Number of lectures=08**	**Title of the unit: Hypergemetric and Generalized hypergeometric function**

Definition and integral representation of Gauss hypergeomteric function 2F1 (a,b;c;z). Contagious function relation, Hypergeometric differential equations and its solutions, F(a,b;c;z) as function of its parameters, Elementary series manipulation, Simple transformations and reduction formulas.

Unit-3	**Number of lectures=08**	**Title of the unit: Bessel and Legendre polynomials**

Definition of Jn(Z), Bessel differentia equation, generating functions, recurrence relations and integral representation; Generating function Legendre polynomials, Rodrigue's formula, Recurrence relations and hypergeometric form of Legendre polynomials, First and second kind integral transforms, orthogonally.

Unit-4	**Number of lectures=08**	**Title of the unit: Hermite Polynomials**

Definition of Hermite Polynomials Hn(x), Pure and recuerrence relations, Rodrigue's formula, other generating functions, Orthogonally, Expansion polynomials.

Unit-5	**Number of lectures=08**	**Title of the unit: Laguerre Polynomials**

The Laguerre Polynomials Ln(x), generating function, pure and differential recurrence relations, Rodrigues formula, Orthogonally, Expansion of Polynomials

11. CO-PO mapping

COs	Attributes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8

CO1	Student will be able to understand special functions of various engineering problem and to known the application of some basic mathematical methods via all these special functions.	**3**	**1**	**1**		**1**	**1**	**1**	**3**
CO2	Students will be able to Use power series to solve second-order differential equations.	**3**	**1**	**2**		**3**	**1**	**1**	**3**
CO3	Students will use the gamma function, beta function and special functions to: evaluate different types of integral calculus problems and to solve differential equations.	**3**	**1**	**2**		**3**	**1**	**1**	**3**
CO4	Students gain importance of Certain specific systems of orthogonal polynomials and their properties	**3**	**1**	**1**		**3**	**1**	**1**	**3**
CO5	Students will gain an understanding of Stability of Special functions with applications	**3**	**1**	**1**		**2**	**2**	**1**	**3**

3 Strong contribution, 2 Average contribution , 1 Low contribution

12.Brief description of selflearning/E-learning component

1. https://meet.google.com/apj-ammk-bhp, https://web.mst.edu/~lmhall/SPFNS/spfns.pdf
2. https://meet.google.com/byc-ckzd-ghr, http://web.math.ku.dk/~henrikp/wosfa/book-of-abstracts.pdf
3. https://meet.google.com/apj-ammk-bhp

13.Books recommended:

1. E. D. Rainville: Special Functions, Chelsea Publishing Co., Bronx, New York, Reprint, 1971.
2. Saran, N., Sharma S.D., and Trivedi: Special functions with applications, PragatiPrakashan, 1986.
3. Lebdev, N.N: Special functions and Their Applications, Prentice Hall, Englewood Cliffs, New Jersey, USA, 1995

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