M.Sc. Mathematics with Computer Science

Syllabus

Department of Mathematics
Jamia Millia Islamia
COURSE STRUCTURE

Semester-wise course structure is described in the following tables:

First Semester

<table>
<thead>
<tr>
<th>Paper No.</th>
<th>Title of the Paper</th>
<th>Total Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTM101</td>
<td>Real Analysis</td>
<td>100</td>
</tr>
<tr>
<td>MTM102</td>
<td>Abstract Algebra</td>
<td>100</td>
</tr>
<tr>
<td>MTM103</td>
<td>Discrete Mathematical Structures</td>
<td>100</td>
</tr>
<tr>
<td>MTM104</td>
<td>Computing Fundamentals &amp; Programming</td>
<td>100</td>
</tr>
<tr>
<td>MTM105</td>
<td>Computer Based Numerical Methods</td>
<td>100</td>
</tr>
<tr>
<td>Lab-I</td>
<td>Programming in C</td>
<td>50</td>
</tr>
<tr>
<td>Lab-II</td>
<td>Numerical Methods</td>
<td>50</td>
</tr>
<tr>
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<td><strong>Total</strong></td>
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Second Semester

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<thead>
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<th>Title of the Paper</th>
<th>Total Marks</th>
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<tbody>
<tr>
<td>MTM201</td>
<td>Topology</td>
<td>100</td>
</tr>
<tr>
<td>MTM202</td>
<td>Linear Algebra</td>
<td>100</td>
</tr>
<tr>
<td>MTM203</td>
<td>Differential Equations &amp; Applications</td>
<td>100</td>
</tr>
<tr>
<td>MTM204</td>
<td>Data Structure</td>
<td>100</td>
</tr>
<tr>
<td>MTM205</td>
<td>Operating Systems</td>
<td>100</td>
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<tr>
<td>Lab-III</td>
<td>Data Structure using C</td>
<td>50</td>
</tr>
<tr>
<td>Lab-IV</td>
<td>UNIX / LINUX Shell Programming</td>
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<td></td>
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<tbody>
<tr>
<td>MTM301</td>
<td>Functional Analysis</td>
<td>100</td>
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<tr>
<td>MTM302</td>
<td>Mechanics</td>
<td>100</td>
</tr>
<tr>
<td>MTM303</td>
<td>Differential Geometry</td>
<td>100</td>
</tr>
<tr>
<td>MTM304</td>
<td>Object Oriented Programming</td>
<td>100</td>
</tr>
<tr>
<td>MTM305</td>
<td>Database Management System</td>
<td>100</td>
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<tr>
<td>Lab-V</td>
<td>Programming in Java</td>
<td>50</td>
</tr>
<tr>
<td>Lab-VI</td>
<td>Oracle</td>
<td>50</td>
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### Fourth Semester

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<th>Paper No.</th>
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<tr>
<td>MTM401</td>
<td>Complex Analysis</td>
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<tr>
<td>MTM402</td>
<td>Fluid Dynamics</td>
<td>100</td>
</tr>
<tr>
<td>MTM403</td>
<td>Differentiable Manifolds</td>
<td>100</td>
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<tr>
<td>MTM404</td>
<td>Wavelet Analysis</td>
<td>100</td>
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<tr>
<td>MTM405</td>
<td>Software Engineering</td>
<td>100</td>
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<td>Lab-VII</td>
<td>Mini Project</td>
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<tr>
<td></td>
<td>Viva Voce</td>
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<td><strong>Total</strong></td>
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DETAILED SYLLABUS

<table>
<thead>
<tr>
<th>Code</th>
<th>Name</th>
<th>Lecture</th>
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<tbody>
<tr>
<td>MTM101</td>
<td>Real Analysis</td>
<td>4</td>
</tr>
</tbody>
</table>

**Unit 1.** Countability of sets. Outer and inner Lebesgue measure, Lebesgue measurable sets, Properties of measurable sets, Borel sets and their measurability, Non-measurable sets, Cantor’s ternary sets and their properties.

**Unit 2.** Measurable function, Characteristic function, Step function, Continuous function, Set of measure zero, Borel measurable function, The structure of measurable function.


**Unit 4.** Point wise convergence, Convergence almost everywhere, Uniform convergence almost everywhere, Convergence in measure, F. Reisz’s theorem on convergence a.e., D.F. Egoroff’s theorem, Lebesgue bounded convergence theorem, Lebesgue domainated convergence theorem, Fatou’s lemma, Monotone convergence theorem.

L^p-space, Properties of L^p-space, Holder’s inequality, Minkowski’s inequality and Schwartz’s inequality, Convergence in the mean, Riesz-Fischer theorem.

**References**

1. Royden, H.L.,
   Real Analysis (2nd ed.)
   The Macmillan Co., new York (1968)

2. Jain, P.K. & Gupta V.P.,
   Lebesgue measure and Integration
   Willey Eastern Ltd., New Age Int. Ltd., New Delhi, (1994)

3. Inder K. Rana,
   An Introduction to measure and integration, Narosa Publishing House, Delhi, (1997)

4. D.Somasundaran
   A Second Course in Mathematical Analysis
<table>
<thead>
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<th>Lecture</th>
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<tbody>
<tr>
<td>MTM102</td>
<td>Abstract Algebra</td>
<td>4</td>
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</table>

1. **Group Theory**

**Unit-I:** Groups, Subgroups, Normal Subgroups, Quotient Groups, Right Cosets, Homomorphism, Kernel of Homomorphism, Isomorphism, Fundamental theorem of Homomorphism.

**Unit-II:** Order of an element of a group, Lagrange’s Theorem for finite groups, Normalization of an element, Centre of a group, Conjugate class, Class Equation and its applications, Sylow Theorem.

2. **Ring Theory**

**Unit-III:** Ring, Subring, Ideal, Integral domain and their Properties, Ring Homomorphism, Isomorphism, Quotient Ring, Euclidian Ring, Rings of Polynomial and their properties.

**Unit-IV:** Unique Factorization Domain, Unique Factorization Theorem, Primitive Polynomials, Gauss lemma, Eienstein Criteria for Irreducibility.

**References**

- I. N. Herstein, Topics in Algebra.
- Surjeet Singh & Q Zameeruddin, Modern Algebra.
- D.A.R. Wallace, Group, Rings and Fields.
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<tr>
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<th>Lecture</th>
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<tr>
<td>MTM103</td>
<td>Discrete Mathematical Structures</td>
<td>4</td>
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Unit 1. Relations and Functions, Equivalence Relations, Partial Order, Recurrence Relations, Solutions of Linear homogeneous Recurrence Relations, Introduction to Mathematical Logic, Propositional Calculus.

Unit 2. Lattices and Boolean algebra, Boolean Functions, Conoonical Form (Disjunctive Normal Form) of a Boolean function, Karnaugh Maps.


Unit 4. Linear codes, Hamming Code, Generator and parity check matrix, Hamming distance standard array and Syndrome decoding, introduction to cyclic codes.

References

1. Discrete Mathematics  
   K.A. Ross, Charles R.W. Wright,  
   Prentice Hall Inc.

2. Discrete Mathematical Structure for Computer Sciences  
   Bernard Kolman / Robert C. Busby  
   Prentice Hall of India.

3. Theory of Error Correcting Codes  
   F.J. Mac. Williams / N.J.A.Sloane,  

4. Graph Theory with Applications to Engineering and Computer Science  
   Narsingh Deo,  
   Prentice Hall of India.
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<tr>
<td>MTM104</td>
<td>Computing Fundamentals &amp; Programming</td>
<td>4</td>
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</table>


**Functions**: Introduction, Need for User-Defined Function, A Multi-function Program, Definition of Function, Arguments & local variables, Returning and Calling Function by reference & Call by value, Passing Arrays & Strings to Function, Returning Multiple Values, Recursion, Recursive Functions, Storage Class & Scope.


**Reference**:

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<tbody>
<tr>
<td>MTM105</td>
<td>Computer Based Numerical Methods</td>
<td>4</td>
</tr>
</tbody>
</table>

**Unit-1 (6+6):**


**Unit-2 (10)**

Least square approximation: Weighted least square approximation. Method of least square for continuous functions, orthogonal polynomials, Gram-Schmidt orthogonalization process and approximation of functions using Chebyshev polynomials.

**Unit-3 (6+6)**


**Unit-4 (10)**


Elliptic equations- Standard five point formula, Jacobi’s iteration method and Leibmann’s method. Hyperbolic equations: Explicit finite difference method.

**Reference:**

1. S.D. Conte & Carl D. Boor, Elementary Numerical Analysis
2. Iyengar and Jain: Numerical methods for Scientific and Engineering Computations
3. G.D. Smith, Numerical Solution of Partial Differential Equations
5. Naseem Ahmad, Fundamentals Numerical Analysis with error estimation
Unit – 1:

Unit – 2:
First and Second countable spaces, Separable spaces, Second countability and Separability, Separation Axioms, T$_i$ (i = 0,1,2) spaces and their characterizations and basic properties, Regular and Normal Spaces, Urysohn’s lemma, Tietze extension theorem.

Unit – 3:
Open covering and Compact spaces, Continuous functions and Compact sets, Finite intersection property, Locally compact spaces, Countable compactness and Sequential compactness, Bolzano Weierstrass property, Lebesgue covering lemma, Total boundedness, Equivalence of compactness.

Unit – 4:
Separation of a space, Connected spaces, Connected sets in the real line, Totally disconnected spaces, Intermediate value theorem, Path connected, Components, Local connectedness, Locally path connected spaces, Continuous functions and connected sets.

Books Recommended
1. J.R. Munkres: Topology (Relevant portions only)
2. Benjamin T. Sims:
   Fundamentals of Topology (Relevant portions only)
   Macmillan Publishing Co. Inc. N.Y.

Help Books
1. Colin Adams and Robert Franzosa:
   Introduction to Topology Pure and Applied
2. G.F. Simmons:
   Introduction to Topology and Modern Analysis

3. B.K. Tyagi:
   Metric Spaces
   Cambridge University Press India Pvt. Ltd., 2010
### Unit-I

Vector Space, Subspaces and properties, Quotient Space, Basis and Dimension, Linear Transformation, Rank And Nullity of a Linear Transformation, Sylvester’s Law of Nullity.

### Unit-II

Algebra of Linear Transformations, Hom(u,v), Dual Space, Bidual, Matrix of Linear Transformations, Change of Basis Equivalent and Similar Matrices, Dimension of Hom(u,v), Isomorphism between link of all linear Transformation on a Vector space and ring of all n x n matrices over F.

### Unit-III

Minimal Polynomials, Invertible linear Transformation, Eigen Values, Eigen Vectors, Result on Minimal Polynomial related to Eigen Values and Eigen Vectors.

### Unit-IV

More on Minimal Polynomials, Cyclic Space, Companion matrix, Jordan Blocks, Inner Product Space, Unitary, Adjoint, Hermitian Adjoint, Skew Hermitian, Normal Linear Operators.

### References

- I. N. Herstein, Topics in Algebra.
- P. R. Halmos, Linear Algebra with Problems.
- Hoffman & Kunze, Linear Algebra.
- Surjeet Singh & Q Zameeruddin, Modern Algebra.
<table>
<thead>
<tr>
<th>Code</th>
<th>Name</th>
<th>Lecture</th>
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<tbody>
<tr>
<td>MTM203</td>
<td>Differential Equations and Applications</td>
<td>4</td>
</tr>
</tbody>
</table>

**Unit 1.** Existence & uniqueness theorem, General theory of Homogenous and nonhomogeneous equations with constant coefficients, Theory of equations with variable coefficients, Method of variation parameter and the formula for particular integral in terms of Wronskian.

**Unit 2.** Series Solution of second order linear differential equations near ordinary point, Singularity and the solution in the neighborhood of regular singular point, Euler equation and Frobenious method, Solution of Legendre, Bessel, Hypergeometric, Hermite and Lagurre differential equations.

**Unit 3.** Formulation of heat conduction equation and its solution by variable sepration method, Steadystate condition and the solution of heat conduction problem with non-zero end conditions, Formation of wave equation and the solution of wave equation.

**Unit 4.** Linear homogeneous boundary value problems, Eigen values and Eigen functions, Sturm Liouville boundary value problems, Non-homogeneous boundary value problems, Green’s functions and the solution of boundary value problems in terms of Green’s functions.

**References**

1. Earl A. Coddington,  
   An Introduction to Ordinary Differential Equation.

2. Boyce and Diprime.,  
   Elementary Differential Equations and Boundary Value Problems.

3. E. Weinberger,  
   A first course in partial differential equations
Introduction to Data Structure: Definition of Data Structure, Types & Characteristics of Data Structures, Abstract Data Type (ADT), Algorithms: Algorithm Concepts, Definition of Algorithm, Objectives of Algorithms, Quality of an Algorithm, Space Complexity and Time Complexity of an Algorithm.


Sorting and Searching: Bubble Sort, Sequential Sort, Selection Sort, Insertion Sort, Merge Sort, Quick Sort, Heap Sort. Linear Search and Binary Search

References:

- Classic Data Structures by D. Samanta, PHI
- Data Structures by S. Lipshutz, Schaum outline series, Tata Mc-graw Hill
- Data Structures Using C & C++ by Tananbaum
- Introduction to Algorithms Cormen, Leiserson, Rivest.
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<th>Code</th>
<th>Name</th>
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<tr>
<td>MTM205</td>
<td>Operating Systems</td>
<td>4</td>
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**Memory Management:** Classical Memory Management Techniques, Paging, Segmentation, Virtual Memory - Demand Paging, Page Replacement Policies, Allocation of Frames, Thrashing.


**References**

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<th>Code</th>
<th>Name</th>
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<tbody>
<tr>
<td>MTM301</td>
<td>Functional Analysis</td>
<td>4</td>
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</table>

Unit 1. Normed Spaces, Banach Spaces and Bounded Linear Operators:

Definition and examples, subspaces, some concrete examples of Banach spaces, bounded linear operators, spaces of bounded linear operators, equivalent norms, open mapping and closed graph theorems and their consequences, uniform boundedness principle.

Unit 2. Bounded Linear Functionals:

Examples and basic properties, Forms of dual spaces, Hahn-Banach theorem and its consequences, embedding and reflexivity, adjoint of bounded linear operators, weak convergence.

Unit 3. Inner Product and Hilbert Spaces:

Definitions and examples, orthogonality of vectors, orthogonal complements and projection theorem, orthonormal sets, complete orthonormal sets.

Unit 4. Functionals and Operators on Hilbert Spaces:

Bounded linear functionals, Riesz-Frechet theorem, Hilbert-adjoint operators, self-adjoint operators, normal operators and unitary operators.

Books Recommended:

1. Introductory Functional Analysis and Applications
   E. Kreyszig,
   John-Wiley & Sons.

2. Introduction to Functional Analysis with Applications
   A.H.Siddiqi, Khalil Ahmad and P. Manchanda,
<table>
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<th>Code</th>
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<tr>
<td>MTM302</td>
<td>Mechanics</td>
<td>4</td>
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</table>

**Unit-I.** Kinematics of a rigid body motion, Moments and Products of inertia, Perpendicular and Parallel axis theorem, Momental ellipsoid, Kinetic energy, Theorem of König, Angular momentum.

**Unit-II.** Euler’s dynamical equations, Euler’s angles, motion of symmetrical top, compound pendulum.

**Unit-III.** Generalized coordinates, Lagrange’s equations of motion, Lagrange function, Techniques of calculus of variations

**Unit-IV.** Hamilton’s principles. Hamilton’s equations of motion, Canonical transformation, Lagrange’s and Poison brackets Integral in variances, Hamilton-Jacobi Poisson equations.

**References**

1. Synge and Griffith, Principle of Mechanics, McGraw Hill Company
3. K. Sankara Rao, Classical Mechanics, PHI India
5. C. Fox, An introduction to the Calculus of Variation, Dover Publication
<table>
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<th>Name</th>
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<tbody>
<tr>
<td>MTM303</td>
<td>Differential Geometry</td>
<td>4</td>
</tr>
</tbody>
</table>

**Unit-I:**

Co-ordinate transformation, Covariant, Contravariant and Mixed tensors, Tensors of higher rank, Symmetric and Skew-symmetric tensors, Tensor algebra, Contraction, Inner product, Riemannian metric tensor, Christoffel symbols, Covariant derivatives of tensors.

**Unit-II:**

Differentiable curves in R3 and their parametric representations, Vector fields, Tangent vector, Principal normal, Binormal, Curvature and torsion, Serret-Frenet formula, Frame fields, Covariant differentiation, Connection forms, The structural equations.

**Unit-III:**

Surfaces, Differentiable functions on surfaces, Differential of a differentiable map, Differential forms, Normal vector fields, First fundamental form, Shape operator, Normal curvature, Principal curvatures, Gaussian curvature, Mean curvature, Second fundamental form.

**Unit-IV:**

Gauss equations, Weingarten equation, Codazzi-Mainardi equations, Totally umbilical surfaces, Minimal surfaces, Variations, First and second variations of arc length, Geodesic, Exponential map, Jacobi vector field, Index form of a geodesic.

**References**

1. Elementary Differential Geometry

2. Differential Geometry of Curves and Surfaces

3. Curves and Surfaces

4. Differential Geometry, A first course
   Somasundaram, Narosa Publication.

5. Tensor Calculus
   Zafar Ahsan, Anamaya Publications, New Delhi.
6. Tensor Calculus  
   U. C. De, Narosa Publications, New Delhi.


Multithreading, I/O and String Handling: Thread Models, Main Thread, Creating Threads, Thread Priorities, Life Cycle of Thread, Synchronization in Java, Thread Exceptions, Inter-Thread Communications. I/O Basics, Byte Stream and Character Stream Classes, Reading from and Writing to Console, Reading and Writing Files, Transient and Volatile Modifiers, Stream Tokenizer, Serialization. String – Fundamental of Characters and Strings, String Class, String Operations, String Buffer Class and Methods.


References

<table>
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<th>Code</th>
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<tr>
<td>MTM305</td>
<td>Database Management Systems</td>
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</table>

**Unit 1.** Databases, DBMS, Advantages of DBMS, Role of DBA, data integrity, data independence.

**Unit 2.** Architecture of Database Management System: External level, conceptual level and internal level, Schemas, Distributed databases.

**Unit 3.** Three approaches to DBMS, Characteristics of Hierarchical model, DBTG Network Model, Introduction to Relational model, Security and Reliability, Audit trail.

**Unit 4.** Normalization, First Normal Form, Second Normal Form, Third Normal Form, BCNF, Relational Algebra and Relational Calculus, Well formed formula, SQL Language.

**References:-**
1. An Introduction to Database System  
   C.J. Date, Sixth Ed.,  
   Addison-Wesley Publishing Co.
2. Principles of Database System  
   Ullman, Jeffery D.,  
   Galgotia Publications (P) Ltd.
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<tr>
<td>MTM401</td>
<td>Complex Analysis</td>
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**Unit-I**

Representation of Complex Numbers, Analytic Function, Cauchy Riemann Equations, Power Series, Some Elementary Functions, Harmonic Functions.

**Unit-II**

Properties of Line Integrals, Zeros of an Analytic Function, Cauchy’s Theorem, Morera’s Theorem, Cauchy’s Integral Formula, Cauchy’s Inequality, Fundamental Theorem of Algebra, Poisson’s Formula, Liouville’s Theorem, Rouche’s Theorem, The Argument Principle.

**Unit-III**

Zeros and Poles, Classification of Isolated Singularities, Taylor’s and Laurent’s Series, Winding Numbers and Residues, Cauchy Residue Theorem and Application in Evaluation of Improper Real Integrals and Evaluation of Sum.

**Unit-IV**

Conformal Mapping Properties, Schwarg Lemma, Riemann Mapping Theorem (Without Proof), Maximum Modulus Theorem, Analytical Continuation.

**References**

- Rudin, Real and Complex Analysis
- J. B. Conway, Complex Analysis.
- Alfors, Complex Analysis.
- E. C. Titchmarsh, Complex Analysis.
- B. Choudhary, Complex Analysis.
- Anant R. Shastri – Complex analysis
- Zill Dennis G. & Shanahan Patrick D. – A first course in Complex Analysis with Applications.
- Fundamentals of Complex Analysis with Applications to Engineering and Science, E-B Saff and A-D Snider.
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<tr>
<td>MTM402</td>
<td>Fluid Dynamics</td>
<td>4</td>
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</table>

**Unit - 1.** Ideal and Real fluids, Pressure, Density, Viscosity, Description of Fluid motion, o-Lagrangian method, Eulerian method. Steady and unsteady flows, Uniform and nonuniform flows, One dimensional, two dimensional and axisymmetric flows, Line of flows, Stream line Path line, Stream surface, Stream tube, Streak lines, Local and Material delivative, Equation of Continuity.

**Unit-2.** Euler’s equation of Motion along a stream line, Equation of motion of an inviscid fluid, conservative field of force, Integral of Uelers equation, Bernoullis equation and its applications, flow from a tank through a small orifice, Cauchys integral, Symmetric forms of the equation of continuity, Impulsive motion of a fluid, Energy equation.

**Unit -3.** Dimenssional Analysis, Buckingham’s pi theorem, Variable in fluid mechanics, Procudures of dimensional Analysis, Similitude, Important dimension less perameter (Reynold’s no., Mech No., Prandtl, Pradtl No.etc.)

**Unit – 4.** Boundary layer definition and it’s characteristics, Leminar boundary layer, Separation and it’s control, Similarity solution of boundary layer equation, Boundary layer flow over flat plate, Stagnation point and boundary layer flow near this.

**Books Recommended:**

1. Introduction to Fluid Dynamics by Fay
2. Boundary Layer Theory by H. Schlichting
3. Introduction to Fluid Dynamics by R. K. Rathy
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<th>Code</th>
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<tr>
<td>MTM403</td>
<td>Differentiable Manifolds</td>
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**Unit-1.** Differentiable manifolds, examples, smooth maps, tangent vector and tangent space at a point on a manifold, tangent bundle of manifold.

**Unit-2.** Vector fields, Lie bracket, Jacobian of a smooth map, Lie derivatives, integral curves on manifolds, one parameter group of transformation and flows, Involutive distribution.

**Unit-3.** Cotangent space, differential forms, pullback of 1-form, tensor fields, exterior derivatives.

**Unit-4.** Connections, Geodesics, Covariant differentiations, Torsion, curvature, structure equations of Cartan, Bianchi identities.

**Books Recommended:**

5. An Introduction to Differentiable Manifolds and Riemannian Geometry, Boothby, Academic Press.
6. Differentiable Manifolds, Gerardo F. Torres del Castillo, Birkhauser
Unit I. Fourier Transform: Fourier transform in $L^1(\mathbb{R})$, properties of Fourier transforms Fourier transform in $L^2(\mathbb{R})$, Parseval Identities, Change of roof, Inversion formula, Plancherel Theorem, Duality Theorem, Poission summation formula, Sampling theorem, Heisenberg’s uncertainty principle, Heisenberg’s inequality, Discrete Fourier transform, Fast Fourier transform

Unit II. Wavelet Transform: Gabor transform, Parseval formula, Inversion formula, Continuous wavelet transform, Maxican hat wavelet, Properties of wavelet transforms, Discrete wavelet transform

Unit III. Multiresolution Analysis and Construction of Wavelets: Multiresolution Analysis, Mother wavelet, Haar wavelet, Shannon wavelet, Meyer wavelet, Franklin wavelet, Orthonormal spline wavelets, Compactly supported wavelets

Unit IV. Wavelets and Applications: Biorthogonal wavelets, Wavelets in several variables, Wavelet packets, Multiwavelets, Wavelet frames, Applications in Neural Networks, Turbulance and Medicine

Books Recommended

1. Khalil Ahmad and F. A. Shah: Introduction to Wavelets with Applications
   World Education Publishers, 2012

2. D. F. Walnut: An Introduction to Wavelet Analysis
   Birkhauser, Boston, 2002

   Academic Press, Boston, MA.


References

- Prof. K.K. Aggarwal & Yogesh Singh: SOFTWARE ENGG:
- Pressman “Priciples of Software Engg” TMC, 5th Ed. 2005