Department of Mathematics
Faculty of Natural Science, Jamia Millia Islamia, New Delhi-25
Course Structure of M.Sc. Mathematics with Computer Science

Semester – I

S. No.	Code	Title of paper	Unit	Credit	Internal Assessment	Semester Examination	Total Marks
1	MTM-1.1	Real Analysis	4	4	25	75	100
2	MTM-1.2	Abstract Algebra	4	4	25	75	100
3	MTM-1.3C_1*	Discrete Mathematical Structures	4	4	25	75	100
	MTM-1.3C_2*	Computer Organization and Architecture					
4	MTM-1.4	Computer Fundamentals & C Programming	4	4	25	75	100
5	MTM-1.5	Numerical Analysis	4	4	25	75	100
	Lab-I	*Programming in C*	-	2	25	25	50

Semester – II

S. No.	Code	Title of paper	Unit	Credit	Internal Assessment	Semester Examination	Total Marks
1	MTM-2.1	Topology	4	4	25	75	100
2	MTM-2.2	Linear Algebra	4	4	25	75	100
3	MTM-2.3	Differential Equations and Applications	4	4	25	75	100
4	MTM-2.4C_1*	Data Structures in C	4	4	25	75	100
	MTM-2.4C_2*	Data Structures in Java					
5	MTM-2.5SE#	Object Oriented Programming using Java	4	3+1	25	75	100
6	*Lab-II*	*Data Structures using C/Java*	-	2	25	25	50

Semester – III

S. No.	Code	Title of paper	Unit	Credit	Internal Assessment	Semester Examination	Total Marks
1	MTM-3.1	Functional Analysis	4	4	25	75	100
2	MTM-3.2	Mechanics	4	4	25	75	100
3	MTM-3.3	Differential Geometry	4	4	25	75	100
4	MTM-3.4	Operating Systems	4	4	25	75	100
5	MTM-3.5C_1*	Software Engineering	4	4	25	75	100
	MTM-3.5C_2*	Object Oriented Analysis & Design					
6	MTM-3.6AE#	Web Designing	4	3+1	25	75	100
7	*Lab-III*	*Operating Systems*	-	2	25	25	50

Semester – IV

S. No.	Code	Title of paper	Unit	Credit	Internal Assessment	Semester Examination	Total Marks
1	MTM-4.1	Complex Analysis	4	4	25	75	100
2	MTM-4.2	Differentiable Manifolds	4	4	25	75	100
3	MTM-4.3	Wavelet Analysis	4	4	25	75	100
4	MTM-4.4	Database Management System	4	4	25	75	100
5	MTM-4.5C_1*	Fluid Dynamics	4	4	25	75	100
	MTM-4.5C_2*	Operations Research					
	MTM-4.5C_3*	Lattice Theory					
6	*Lab-IV*	*DBMS*	-	2	25	25	50
7	MTM-4.6MP	*Minor Project (Lab based)*	-	4	-	-	100

***CBCS papers subject to the availability of the teacher**
***C: Choice Based**
#AE: Ability Enhancement
#SE: Skill Enhancement

M.Sc. Mathematics with Computer Science, Semester – I

MTM-1.1	Real Analysis	Unit	Credit	Lecture/ week
Internal Assessment: 25 Marks End Semester Examination: 75 Marks Duration of Examination: 2 Hrs.		4	4	4

Unit-I Outer and inner Lebesgue measure, Lebesgue measurable sets, Properties of measurable sets, Borel sets and their measurability, Non-measurable sets, Cantorôs ternary sets and their properties.

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

Unit-III Riemann integral and its deficiency, Lebesgue integral of bounded functions, Comparison of Riemann and Lebesgue integrals, Properties of Lebesgue integral for bounded measurable functions, The Lebesgue integral for unbounded functions, Integral of non-negative measurable functions, General Lebesgue integral, Improper integrals.

Unit-IV Point wise convergence, Convergence almost everywhere, Uniform convergence almost everywhere, Convergence in measure, F. Reiszôs theorem on convergence a.e., D.F. Egoroffôs theorem, Lebesgue bounded convergence theorem, Lebesgue dominated convergence theorem, Fatouôs lemma, Monotone convergence theorem.

L^P-spaces, Properties of L^P-spaces, Holderôs inequality, Minkowskiôs inequality and Schwartzôs inequality, Convergence in the mean, Riesz-Fischer theorem.

Books Recommended

1. H. L. Royden, *Real Analysis* (2^{nd}edition) The Macmillan Co., 1968.
2. P. K. Jain & V. P. Gupta, *Lebesgue measure and Integration*, Willey Eastern Ltd., New Age Int. Ltd., 1994.
3. Inder K. Rana, *An Introduction to measure and integration*, Narosa Publishing House, 1997.
4. D. Somasundaran, *A Second Course in Mathematical Analysis*, Narosa Publishing House, 2010.

M.Sc. Mathematics with Computer Science, Semester – I

MTM-1.2	Abstract Algebra	Unit	Credit	Lecture/ week
Internal Assessment: 25 Marks End Semester Examination: 75 Marks Duration of Examination: 2 Hrs.		4	4	4

Unit-I Groups, Order of an element of a group, Subgroups, Cyclic groups, Cosets, Normal subgroups, Quotient groups, Homomorphisms, Isomorphisms, Permutation groups.

Unit-II Cayleyôs Theorem, Automorphisms, Normalizer and centre, Conjugate classes, Class equation and its applications, Direct products, Sylowôs theorems, Finite abelian groups, Normal series and Solvable groups.

Unit-III Rings, Subrings, Ideals, Integral Domain and their properties, Quotient Rings, Ring Homomorphisms, Isomorphisms, Ring of polynomials and their properties.

Unit-IV Principal ideal domain, Euclidean domain, Unique factorization domain, Primitive polynomials, Gauss lemma, Eisensteinôs criterion for irreducibility.

Books Recommended

1. I. N. Herstein, *Topics in Algebra*, John Wiley & Sons., 2006.
2. Surjeet Singh and Qazi Zameeruddin, *Modern Algebra*, Vikas Publications, 2003.
3. N. Jacobson, *Basic Algebra*, Vol. I & II (2^{nd} Edition), Dover Books on Mathematics, 1984.
4. D. A. R. Wallace, *Groups, Rings and Fields, Series*, Springer Undergraduate Mathematics Series, 2001.
5. N. H. McCoy, *Theory of Rings*, Chelsea Pub. Co., 1973.

M.Sc. Mathematics with Computer Science, Semester – I

MTM-1.3C$_1$	**Discrete Mathematical Structures**	**Unit**	**Credit**	**Lecture/ week**
Internal Assessment: 25 Marks End Semester Examination: 75 Marks Duration of Examination: 2 Hrs.		4	4	4

Unit-I Relations and Functions, Equivalence Relations, Partial Order, Recurrence Relations, Solutions of Linear homogeneous Recurrence Relations, Introduction to Mathematical Logic, Propositional Calculus.

Unit-II Lattices and Boolean algebra, Boolean functions, Connonical form (Disjunctive Normal form) of a Boolean function, Karnaugh Maps.

Unit-III Graphs and their representations, Walk, Path, Cycle, Circuit, Eulerian Graphs, Connected Graphs, Planar Graphs, Trees, Spanning trees, Binary Tree Traversals.

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

Books Recommended

1. K.A. Ross, Charles R.W. Wright, *Discrete Mathematics*, 5th edition, PHI, 2002.
2. Bernard Kolman, Robert C. Busby, *Discrete Mathematical Structure for Computer Sciences*, Prentice Hall of India, 1987.
3. F.J. Mac. Williams, N. J. A. Sloane, *Theory of Error Correcting Codes*, North Holland Pub. Co., 1978.
4. Narsingh Deo, *Graph Theory with Applications to Engineering and Computer Science*, Prentice Hall of India, 1979.

M.Sc. Mathematics with Computer Science, Semester – I

MTM-1.3C_2	Computer Organization and Architecture	Unit	Credit	Lecture/ week
Internal Assessment: 25 Marks End Semester Examination: 75 Marks Duration of Examination: 2 Hrs.		4	4	4

Unit-I Number Systems, Binary Arithmetic, Fixed-point and Floating-point representation of numbers, Codes, Complements, Character Representation ï ASCII, EBCDIC. Boolean Algebra: Basic Definitions, Axiomatic definition of Boolean Algebra, Basic theorems and Properties of Boolean Algebra, Boolean functions, Canonical and Standard Forms.

Unit-II Basic Gates ï AND, OR, NOT, Universal Gates ï NAND, NOR, Other Gates ï XOR, XNOR etc. NAND, NOR implementations of digital circuits, Simplification of Boolean Expressions: Formulation of simplification problem, Karnaugh Maps, Minimal, Combinational Logic Design Procedure, Adders, Subtractors, Code Conversion, Decimal Adder, Magnitude Comparator, Decoders, Encoder, Multiplexers, De-multiplexer.

Unit-III Flip-Flops, Clocked RS, D type, JK, T type, State table, State diagram and State equations. Flip-flop excitation tables. Design Procedure, Design of sequential circuit and Counters, Shift registers, Synchronous Counters.

Unit-IV Primary Memory, Secondary memory, Cache memory, Memory Hierarchy, Basic architecture of computer, Bus structures, Von Neumann concept. Overview of Microprogramming, Addressing modes, Pipelining, Synchronous and Asynchronous Data transfer, DMA data transfer.

Books Recommended

1. M. Morris Mano, *Computer System Architecture*, Prentice Hall of India, 1982.
2. William Stalling, *Computer Organization and Architecture*, Pearson Education, 2015.
3. Andrew S. Tanenbaum, *Structured Computer Organization*, PHI, 2006.
4. J. P. Hayes, *Computer Architecture and Organization*, McGraw Hill Education India, 2012.
5. M. Morris Mano, *Computer Engineering Hardware Design*, PHI, 1988.
6. V. Rajaraman & T. Radhakrishnan, *An Introduction to Digital Computer Design*, PHI, 2004.
7. Nicholas Carter, *Schaum's Outlines Computer Architecture*, McGraw-Hill Education, 2002.
8. Carl Hamacher, ZvonkoVranesic, Safwat Zaky, *Computer Organization*, 5th Edition, McGraw-Hill Education India, 2001.
9. M. Morris Mano, *Digital Logic and Computer Design*, PHI, 2004.
10. Donald Givone, *Digital Principles and Design*, TMH (Unit II and V), 2002.

M.Sc. Mathematics with Computer Science, Semester – I

MTM-1.4	Computer Fundamentals & C Programming	Unit	Credit	Lecture/ week
Internal Assessment: 25 Marks End Semester Examination: 75 Marks Duration of Examination: 2 Hrs.		4	4	4

Unit-I Introduction to Computers, Program, Software, Algorithms, Flow Charts, Introduction to C, Character Set, C Token, Identifier & Keyword, Constants, Variables, Data Types, Data Declaration & Definition, Operators & Expression - Arithmetic, Relational, Logical, Increment & Decrement, Bit wise, Assignment, Conditional.

Unit-II Precedence & Associativity of Operators, Type Conversions - Implicit and Explicit, Console I/O, Control and Selection Statements - If, Nested if, if-else-if, The Alternative -Conditional Expression, Switch, Nested Switch, Iteration Statements for loop, while loop, do-while loop, break, continue, goto statements, Single dimensional and Multi-dimensional Arrays - Accessing array elements, Initializing an array, Strings using arrays.

Unit-III Pointers ï Introduction, Declaration of Pointer, Initializing Pointer, De-referencing Pointer, Pointer to Pointer, Array of Pointers, Strings using pointers.

User-Defined Function, Function Prototype, Definition of Function, Arguments & local variables, Returning and Calling Function by reference & Call by value, Passing Arrays & Strings to Function, Returning Multiple Values, Recursive Functions.

Unit-IV Storage Class & Scope, Structures, Declaration and Initializing Structure, Accessing Structure members, Structure, Assignments, Arrays of Structure, Passing Structure to function, Structure Pointer, Unions, Enumeration, File handling: Introduction, Opening a File, Closing a File, Input/Output Operations on Files, Command Line Arguments.

Books Recommended:

1. P. K Sinha & Sinha, Priti, *Computer Fundamentals*, BPB, 2007.
2. V., Rajaraman, *Fundamentals of Computers*, PHI, 2010.
3. E. Balagruswamy, *Programming in ANSI C*, Tata McGraw Hill, 2011.
4. Gottfried, Byron S., *Programming with C*, Tata McGraw Hill, 2011.
5. Yashwant Kanetker, *Let us C*, BPB, 2007.
6. Yashwant Kanetker, *Pointers in C*, BPB, 2007.
7. R. G. Dromey, *How to Solve by Computer*, Pearson Education, 2007.
8. Deitel & Deitel, *C: How to Program*, Pearson Education, 2003.

M.Sc. Mathematics with Computer Science, Semester – I

MTM-1.5	Numerical Analysis	Unit	Credit	Lecture/ week
Internal Assessment: 25 Marks End Semester Examination: 75 Marks Duration of Examination: 2 Hrs.		4	4	4

Unit-I Newton-Raphson method for complex roots, Solution of system of nonlinear equations by Seidal iteration method, Newton-Raphson method, Lagrangeôs form of interpolating polynomial, Existence and uniqueness of interpolating polynomial, Hermite, Piecewise and Cubic spline interpolation.

Unit-II **Approximation:** Weighted least squares approximation, Method of least squares for continuous functions, Gram-Schmidt orthogonalization process, Approximation of functions using Chebyshev polynomials, Numerical integration: Rombergôs method, Guass Quadrature formula and error estimation.

Unit-III **Numerical solution of initial value problems:** Runge-Kutta method of order four for system of equations, second and higher order differential equations, Boundary value problems by shooting method, Finite difference method, Convergence of finite difference scheme, Stability analysis.

Unit-IV **Numerical solution of partial differential equations:** Parabolic equations- explicit methods and Crank-Nicolson method with stability analysis, Elliptic equations- Standard five point formula, Jacobiôs iteration method and Leibmannôs method, Hyperbolic equations: Explicit finite difference method.

Books Recommended

1. Gerald & Wheatlay, *Applied Numerical Analysis*, Pearson, 2004.
2. M. K. Jain, S.R.K Iyengar and R. K. Jain, *Numerical Methods for Scientific and Engineering Computations*, New Age Int., New Delhi, 2010.
3. G.D. Smith, *Numerical Solutions of Partial Differential Equations*, Clarendon Press Oxford, 1985.
4. S.D. Conte & Carl De Boor, *Elementary Numerical Analysis*, McGraw Hill, 2005.
5. Naseem Ahmad, *Fundamentals Numerical Analysis with error estimation*, Anamaya Publishers, 2010.

M.Sc. Mathematics with Computer Science, Semester – II

MTM-2.1	Topology	Unit	Credit	Lecture/ week
Internal Assessment: 25 Marks End Semester Examination: 75 Marks Duration of Examination: 2 Hrs.		4	4	4

Unit-I Definition and examples of topological spaces, Neighbourhood of a point, Open and Closed sets, Closure, Interior, Exterior and Boundary, Limit points, Derived sets, Bases and subbases, I and II countable space, Lindelof space, Separable space, Continuity, Homeomorphism, Subspaces, product spaces and quotient spaces.

Unit-II Compactness, Continuous functions and compact sets. Finite intersection property, Heine Borel theorem, Locally compact spaces, Bolzano Weierstrass property.

Unit-III Separation Axioms, T_i (i = 0,1,2,3,4) spaces, Regular and completely regular spaces, Normal and completely normal spaces, Urysohnôs lemma, Tietze extension theorem.

Unit-IV Connected and Disconnected space, Examples, Components, Locally connected spaces, Closure of a connected space, Totally disconnected spaces.

Books Recommended

1. G.F. Simmons, *Introduction to Topology and Modern Analysis*, McGraw Hill Book Company, 1963.
2. J. R. Munkres, *Topology, A First course*, Prentice Hall of India Pvt. Ltd., New Delhi, 2000.
3. C. Adams and R. Franzosa, *Introduction to Topology, Pure and Applied*, Pearson Prentice Hall, 2008.

M.Sc. Mathematics with Computer Science, Semester – II

MTM-2.2	Linear Algebra	Unit	Credit	Lecture/ week
Internal Assessment: 25 Marks End Semester Examination: 75 Marks Duration of Examination: 2 Hrs.		4	4	4

Unit-I Vector space, Subspaces and properties, Basis and Dimensions, Sum and direct sum of subspaces, Independent subspaces, Quotient space, Linear transformations, Rank and Nullity of a linear transformation, Sylvesterôs law of nullity.

Unit-II Algebra of linear transformations, $\mathrm{Hom}(U,V)$, Singular and Non-singular linear transformations, Invertible linear transformations, Dual spaces, Principle of duality, Bidual, Annihilators.

Unit-III Matrix of a linear transformation, Change of Basis, Equivalent and Similar matrices, Relationship between $\mathrm{Hom}(U,V)$ and $M_{m,n}(F)$, Minimal polynomials of a linear transformation and its properties, Cyclic space.

Unit-IV Eigen values and Eigen vectors, Inner product spaces, Orthogonality and Orthonormality, Schwarz inequality, Gram-Schmidt orthogonalization process, Adjoint, Hermitian, Unitary and Normal linear operators.

Books Recommended

1. I. N. Herstein, *Topics in Algebra*, John Wiley & Sons. 2006.
2. P. R. Halmos, *Linear Algebra Problem Book (Dolciani Mathematical Expositions)*, Number 16, The Mathematical Association of America, 1995.
3. Hoffman & Kunze, *Linear Algebra*, PHI, 1971.
4. Surjeet Singh & Qazi Zameeruddin, *Modern Algebra*, Vikas Publications., 2003.

M.Sc. Mathematics with Computer Science, Semester – II

MTM-2.3	Differential Equations and Applications	Unit	Credit	Lecture/ week
Internal Assessment: 25 Marks End Semester Examination: 75 Marks Duration of Examination: 2 Hrs.		4	4	4

Unit-I 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-II Series solution of second order linear differential equations near ordinary point, Singularity and the solution in the neighbourhood of regular singular point, Euler equation and Frobenious method, Solution of Legendre, Bessel, Hermite and Lagurre differential equations.

Unit-III Formulation of heat conduction equation and its solution by the method of separation of variables, Steady state condition and the solution of heat conduction problem with non-zero end conditions, Formation of wave equation and its solution by the method of separation of variables.

Unit-IV Linear homogeneous boundary value problems, Eigen values and Eigen functions, Sturm Liouville boundary value problems, Non-homogeneous boundary value problems, Greenôs functions and the solution of boundary value problems in terms of Greenôs functions.

Books Recommended

1. Earl A. Coddington, *An Introduction to Ordinary Differential Equation*, Dover Publications, INC., 2012.
2. Boyce and Diprime, *Elementary Differential Equations and Boundary Value Problems*, Wiley, 2008.
3. H. F. Weinberger, *A First Course in Partial Differential Equations: with Complex Variables and Transform Methods (Dover Books on Mathematics),* Dover Publications, 1995.

M.Sc. Mathematics with Computer Science, Semester – II

MTM-2.4C$_1$ Data Structures in C	Unit	Credit	Lecture/ week
Internal Assessment: 25 Marks End Semester Examination: 75 Marks Duration of Examination: 2 Hrs.	4	4	4

Unit-I Definition of Data Structure, Types 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, Introduction to Arrays, Row and Column Major Implementations of 1 - D, 2-D, 3-D Arrays, Searching in Arrays - Linear Search, Binary Search, Hash Tables.

Unit-II Sorting in arrays - Bubble Sort, Selection Sort, Insertion Sort, Merge Sort, Quick Sort, Concept of a Linked List, Linear Single and Double Linked Lists, Circular linked List, Operations on Linked Lists and implementation in C, Applications of Linked List. Introduction to Stacks, Operations on Stack, Stack Implementation in C, Applications of Stack.

Unit-III Introduction to Queues, Types of Queues: Linear Queue, Circular Queue, Priority Queue, Double Ended Queue, Operations on Queues, Queue Implementation in C, Concept of a Tree, Definitions and Examples of n-ary Tree, Binary Tree, Strictly Binary Tree, Complete Binary Tree, Almost Complete Binary Tree. Level of a Node, Height and Depth of a Tree, Binary Search Tree, Operation on Trees, Tree Traversal and Search Algorithm with Implementation in C, AVL Tree, B Tree, B+ Tree, Heap Tree.

Unit-IV Huffman Algorithm. Definitions of Vertex, Edge and Graph, Types of Graphs ï Directed and Undirected, Connected and Disconnected, Cyclic and Acyclic, Isomorphic Graphs. Representation of Graphs: Adjacency Matrix, Linked List. Incidence Matrix, Path Matrix. Graph Algorithms ï Breadth First Search (BFS), Depth First Search (DFS), Spanning Tree, Minimum Spanning Tree (MST), Kruskalôs Algorithm, Primôs Algorithm and Shortest Path Algorithms.

Books Recommended:

1. S. Lipshutz, Data Structures, *Schaum outline series*, McGraw-Hill, 2011.
2. D. Samanta, *Classic Data Structures*, PHI, 2006.
3. Yashavant P. Kanetkar, *Data Structures through C*, Second Edition, BPB, 2003.
4. A.M. Tanenbaum, *Data Structures Using C and C++*, Prentice-Hall, Inc., New Jersey, 1998.
5. Cormen, Leiserson, Rivest and Stein, *Introduction to Algorithms*, 2nd Edition, McGraw-Hill, 2009.

M.Sc. Mathematics with Computer Science, Semester – II

MTM-2.4C_2 Data Structures in Java	Unit	Credit	Lecture/ week
Internal Assessment: 25 Marks End Semester Examination: 75 Marks Duration of Examination: 2 Hrs.	4	4	4

Unit-I Definition and Types of Data Structure, 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, Introduction to Arrays, Row and Column Major Implementation of Multi-Dimensional Arrays, Searching in Arrays - Linear Search, Binary Search.

Unit-II Sorting in Arrays - Bubble Sort, Selection Sort, Insertion Sort, Merge Sort, Quick Sort. Introduction to Java Collections Framework: Interfaces (Set, List, Queue, Deque etc.) and Classes (ArrayList, Vector, LinkedList, HashSet, LinkedHashSet etc.). Ordered and Unordered Implementations of Lists and their Applications. Introduction to Stacks, Operations on Stack, Stack Implementations In Java, Applications of Stack.

Unit-III Introduction to Queues, Types of Queues - Linear Queue, Circular Queue, Priority Queue, Double Ended Queue, Operations on Queues, Queue Implementations in Java. Concept of a Tree, Definitions and Examples of n-ary Tree, Binary Trees, Strictly Binary Tree, Complete Binary Tree, Full Binary Tree, Level of a Node, Height and Depth of a Tree, Binary Search Trees, Operation on Trees, Tree Traversals and Search Algorithm with Implementation in Java, AVL Tree, B-Tree, B+ Tree, Heap Tree.

Unit-IV Huffman Algorithm. Definitions of Vertex, Edge and Graph, Types of Graphs ï Directed and Undirected, Connected and Disconnected, Cyclic and Acyclic, Isomorphic Graph, Representation of Graphs: Adjacency Matrix, Linked List. Incidence Matrix, Path Matrix. Graph Algorithms ï Breadth First Search (BFS), Depth First Search (DFS), Spanning Tree, Minimum Spanning Tree (MST), Kruskalôs Algorithm, Primôs Algorithm, and Shortest Path Algorithms.

Books Recommended:

1. S. Lipshutz, *Data Structures*, Schaum outline series, McGraw-Hill, 2011.
2. D. Samanta, *Classic Data Structures*, PHI, 2006.
3. Robert Lafore, *Data Structures & Algorithms in Java*, 2nd Edition, Pearson, 2009.
4. John R. Hubbard and Huray Anita, *Data Structures with Java*, Pearson Prentice Hall, 2004.
5. Mark Allen Weiss, *Data Structures and Algorithms Analysis in Java*, 3rd Edition, Pearson Education, 2011.
6. Cormen, Leiserson, Rivest and Stein, *Introduction to Algorithms*, 2nd Edition, McGraw-Hill, 2009.

M.Sc. Mathematics with Computer Science, Semester – II

MTM-2.5SE	Object Oriented Programming using Java (Skill Enhancement)	Unit	Credit	Lecture/ week
Internal Assessment: 25 Marks End Semester Examination: 75 Marks Duration of Examination: 2 Hrs.		4	3+1	3L + 2P

Unit-I Paradigms of Programming Languages, Basic Concepts of Object Oriented Approach, Comparison of Object Oriented and Procedure Oriented Approach, Benefits and Applications of Object Oriented Programming. Introduction to Java, Basic Features of Java, Java Virtual Machine, Java Runtime Environment, Primitive Data Type and Variables, Expressions, Statements and Arrays, Operators, Control Statements.

Unit-II Encapsulation, Classes and Objects, Class Members: Data Members and Member Functions. Class Member Visibility, Understanding Static, Constructors, Argument Passing, Object Initialisation, Garbage Collection. Polymorphism: Ad hoc and Universal Polymorphism. Inheritance Basics: Access Control, Use of Super, Types of Inheritance, Method Overriding, Dynamic Method Dispatching, Preventing Inheritance and Overriding.

Unit-III Defining and Implementing an Interface, Applying Interface, Accession of Interface Variable, Abstract Class. Java API Packages, Using System Packages, Naming Conventions, Creating Packages, Accessing a Package, Adding a Class to a Package. Exception Types, Exception Handling, Catching Multiple Exceptions, Java Built-in Exception, Creating Exception Subclasses.

Unit-IV Multithreading, Main Thread, Creating Threads, Thread Priorities, Life Cycle of Thread, Synchronization in Java, Thread Exceptions, String: Fundamental of Characters and Strings, String and StringBuffer Classes, Introduction to Applet Programming.

Books Recommended:

1. Cay Horstmann, *Computing Concepts with Java Essentials*, 2nd Edition, Wiley India, 2006.
2. Bruce Eckel, *Thinking in Java*, Pearson Education, 2006.
3. H. Schildt, *Java 2: The Complete Reference* (5th ed.), Tata McGraw Hill, 2002.
4. Richard Johnson, *An Introduction to Java Programming and Object-Oriented Application Development*, Thomson Learning, 2006.
5. Deitel & Deitel, *Java-How to Program* (7th ed.), Prentice Hall, 2007.
6. Daniel Liang, *Introduction to Java Programming* (5th ed.), Prentice Hall, 2011.

M.Sc. Mathematics with Computer Science, Semester – III

MTM-3.1	Functional Analysis	Unit	Credit	Lecture/ week
Internal Assessment: 25 Marks End Semester Examination: 75 Marks Duration of Examination: 2 Hrs.		4	4	4

Unit-I 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-II Examples and basic properties, Forms of dual spaces, Hahm-Banach theorem and its consequences, Embedding and reflexivity, Adjoint of bounded linear operators, Weak convergence.

Unit-III Definitions and examples, Orthogonality of vectors, Orthogonal complements and projection theorem, Orthonormal sets, Complete orthonormal sets.

Unit-IV Bounded linear functionals, Riesz-Frechet theorem, Hilbert-adjoint operators, Self-adjoint operators, Normal operators and unitary operators.

Books Recommended:

1. E. Kreyszig, *Introductory Functional Analysis and Applications*, John-Wiley & Sons, 2006.
2. A.H.Siddiqi, Khalil Ahmad and P. Manchanda, *Introduction to Functional Analysis with Applications*, Anamaya Publishers, New Delhi and Anshan Ltd., U.K., 2006.

M.Sc. Mathematics with Computer Science, Semester – III

MTM-3.2	Mechanics	Unit	Credit	Lecture/ week
Internal Assessment: 25 Marks End Semester Examination: 75 Marks Duration of Examination: 2 Hrs.		4	4	4

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

Unit-II Generalized coordinates, Constraints, Basic problem of mechanics, Degree of freedom, Ideal constraints, Dô Alembertôs principle, Necessary and sufficient condition for a holonomic system to be in equilibrium, Generalized forces for a holonomic system.

Unit-III Lagrangeôs equations of motion. Lagrange function, Techniques of calculus of variations, Hamiltonôs equation of motion.

Unit-IV Hamiltonôs principles, Canonical transformation, Lagrangeôs and Poison brackets, Integral in variances, Hamilton-Jacobi Poisson equations.

Books Recommended:

1. Synge and Griffith, *Principle of Mechanics*, McGraw Hill Company, 1959.
2. Chorlton, F., *Textbook of Dynamics*, John Wiley & Sons, 2004.
3. K. SankaraRao, *Classical Mechanics*, PHI India, 2005.
4. Madhumagal Pal, *A Course on Classical Mechanics*, Narosa Publication, 2008.
5. C. Fox, *An introduction to the Calculus of Variation*, Dover Publication, 1988.
6. S.L. Loney, *Ele. Treatise on the dynamics of particle and of rigid bodies*, Forgotten Books, 2012

M.Sc. Mathematics with Computer Science, Semester – III

MTM-3.3	Differential Geometry	Unit	Credit	Lecture/ week
Internal Assessment: 25 Marks End Semester Examination: 75 Marks Duration of Examination: 2 Hrs.		4	4	4

Unit-I Tensors: co-ordinate transformation, Contravariant, Covariant vectors and tensors of higher rank, Contraction, Quotient law of tensor, Metric tensor and 3-index christofell symbols and their properties, Transformation law for christofell symbols, Covariant derivative of a vector and tensor, Riemannian curvature tensor and its properties, Ricci tensors and scalar curvature.

Unit-II Curves in R^3: Representation of curves, Unit and arbitrary speed curves, Frenet-frame, curvature and torsion, Serret - Frenet formula, Helix, Minkowski 3-space □, Slant helix, Minkowski space time □, k-type slant helix, Directional derivative and covariant derivative, Frame field, Altitude matrix and connection Forms, Curve frame rotation matrix, Offset curves.

Unit-III Surface in R^3: Definition and examples of a smooth surface, Differentiable functions on surfaces, Tangent plane and unit surface normal, Surface of revolution, First fundamental form and its properties, Second fundamental form, Tangential intersection of two surfaces, Normal curvature, Principal curvature.

Unit-IV Meusnierôs theorem, Eulerôs theorem, Umbilical surface, Helicoidal surface, Shape operator and its properties, Gaussian and mean curvature, Minimal surface, Ruled surface, Line of curvature, Rodriguez formula, Geodesic of a surface and geodesic equation, Gauss and Weingarten equations, Mainardi-Codazzi equations, Geodesic curvature, Liouvilleôs formula, Gauss-Bonnet theorem.

Books Recommended:

1. B.O. Neill, *Elementary Differential Geometry*, Academic Publishers, 2006.
2. Andrew Pressley, *Elementary Differential Geometry*, Springer, 2010.
3. M. P. doCarmo, *Differential Geometry of Curves and Surfaces*, Prentice Hall, 1976.
4. Zafar Ahsan, *Tensors: Mathematics of Differential Geometry and Relativity*, PHI, 2015.
5. D. Somasundaram, *Differential Geometry*, Narosa Publishing House, 2005.
6. Anthony W. Nutbourne, Ralph R. Martin, *Differential geometry Applied to Curve and Surface Design*, Volume I, John Wiley & Sons, 1988.

M.Sc. Mathematics with Computer Science, Semester – III

MTM-3.4	Operating Systems	Unit	Credit	Lecture/ week
Internal Assessment: 25 Marks End Semester Examination: 75 Marks Duration of Examination: 2 Hrs.		4	4	4

Unit-I Introduction, Evolution of Operating System, Role and Functions of Operating Systems, Operating System Classification, Operating System Structure, Definition of Multiprogramming, Multitasking, Multiprocessing, Multi-user, Timesharing, Multithreading.

Unit-II Process Overview, Process States and State Transitions, Levels of Schedulers and Scheduling Algorithms, Process Communication, Process Synchronization, Semaphores, Critical Section and Mutual Exclusion Problem, Classical Synchronization Problems, Multithreading, Introduction to Deadlock, Coffmanôs Conditions for deadlock, Deadlock Detection and Recovery, Deadlock Prevention, Deadlock Avoidance.

Unit-III Classical Memory Management Techniques- Monoprogramming, Multiprogramming with fixed and variable partitions, Relocation & Protection, Swapping, Internal and External Fragmentation, Memory Compaction, Virtual Memory - Paging, Page Table, Page Replacement Policies, Segmentation, Thrashing.

Unit-IV File Concept, File Operations, Access Methods, Directory Structure, File-System Mounting, File Sharing, File-system Structure, File-System Implementation, Directory Implementation, Disk-block Allocation Methods, Free-Space Management, Disk structure, Disk Scheduling Algorithms- FCFS, SSTF, SCAN, C-SCAN, LOOK, C- LOOK.

Books Recommended:

1. A. S. Tanenbaum, *Modern Operating Systems*, Pearson Education, 3rd edition, 2015.
2. Silberschatz, P. B. Galvin and G. Gagne, *Operating System Concepts*, Wiley, 2009.
3. William Stallings, *Operating Systems: Internals and Design Principles*, PHI, 2009.
4. D.M. Dhamdhere, *Operating Systems: A Concept Based Approach*, Tata McGraw-Hill, 2007.
5. Deitel Deitel Choffnes, *Operating Systems*, Pearson, 2004.

M.Sc. Mathematics with Computer Science, Semester – III

MTM-3.5C$_1$	**Software Engineering**	**Unit**	**Credit**	**Lecture/ week**
Internal Assessment: 25 Marks End Semester Examination: 75 Marks Duration of Examination: 2 Hrs.		4	4	4

Unit-I Definition, Program Vs Software, Overview of S/W Engineering Process, Software life cycle Models: Build and Fix, Waterfall, Prototype, Iterative Enhancement Model, Evolutionary, Spiral Model, RAD Model.

Unit-II Requirements Engineering Process, Requirements Elicitation & Analysis Techniques, Problem Analysis, Data Flow Diagrams, Data Dictionaries, Software Requirement and Specifications (SRS), Characteristics of good quality SRS, Components of SRS - Functional & Non-Functional Requirements, Requirements Validation, Use Cases, Decision Table, Decision Tree.

Unit-III Software Project Planning Objectives, Project Size Estimation, Cost Estimation - COCOMO Estimation Model. Software Risks, Risk Identification, Risk Refinement, Risk Monitoring & Management. Introduction to Software Design, Principles, Abstraction, Modularity, Information Hiding, Functional Independence, Module Level Concepts: Cohesion, Coupling, Types of Cohesion and Coupling.

Unit-IV Design components - Data Design, Architectural Design, User Interface Design, Component Design, Activity Diagrams. Introduction to Software Testing, Error, Faults, Failure, Software Reliability, Functional and Structural Testing, Basis Path Testing, Cyclomatic complexity, Testing Levels: Unit, Integration, Validation and System Testing, Alpha and Beta Testing, Quality Assurance.

Books Recommended:

1. R.S. Pressman, *Software Engineering: A Practitioner's Approach*, McGraw-Hill, 2014.
2. Pankaj Jalote, *An Integrated Approach to Software Engineering*, Narosa Publishing, 2015.
3. K. K. Aggarwal and Yogesh Singh, *Software Engineering*, New Age International Publishers, 2008.
4. W. S. Jawadekar, *Software Engineering: Principles and Practice*, McGraw-Hill, 2004.
5. Douglas Bell, *Software Engineering for Students*, Addison-Wesley, 2007.

M.Sc. Mathematics with Computer Science, Semester – III

MTM-3.5C_2 Object Oriented Analysis & Design	Unit	Credit	Lecture/ week
Internal Assessment: 25 Marks End Semester Examination: 75 Marks Duration of Examination: 2 Hrs.	4	4	4

Unit-I Introduction to Object Oriented Modelling, Characteristics of Object Oriented Modelling, Differences between Structured Analysis and Object Oriented Analysis, Importance of Modelling, Introduction to UML, Conceptual Model of the UML.

Unit-II Object Modelling, Class and Object, Class Diagram, Object Diagram, Link and Association, Types and Roles, Aggregation, Generalization and Inheritance, Abstract Classes, Interfaces, Generalization as an Extension and Restriction, Multiple Inheritance, Metadata, Candidate keys, Constraints.

Unit-III Dynamic Modelling, Events and States, Signals, State Machine Diagram, Nested State Diagrams, Advanced Dynamic Modelling Concepts, Behaviour Analysis, Interaction Diagram, Use Cases, Activity and Interaction Diagrams.

Unit-IV Functional Modelling, Data Flow Diagrams, Features of a DFD, Architecture Modelling, Packages, Component and Deployment Diagram, Case Study ï Web Application, Vacation Tracking System.

Books Recommended:

1. Grady Booch, *The Unified Modeling Language User Guide*, 2nd Edition, Pearson Education, 2015.
2. Rumbaugh, Blaha, Premerlani, Eddy, Lorensen, *Object-Oriented Modelling and Design*, PHI, 2002.
3. Booch, Maksimchuk, Engle, Young, Conallen, Houston, *Object - Oriented Analysis and Design with Applications*, 3rd Edition, Pearson, 2012.
4. Atul Kahate, *Object Oriented Analysis & Design*, Tata McGraw-Hill, 2004.

M.Sc. Mathematics with Computer Science, Semester – III

MTM-3.6AE	Web Designing (Ability Enhancement)	Unit	Credit	Lecture/ week
Internal Assessment: 25 Marks End Semester Examination: 75 Marks Duration of Examination: 2 Hrs.		4	3+1	3L + 2P

Unit-I Brief History of Internet, World Wide Web, Communication on the Internet, Internet Domains, Internet Server Identities, Establishing Connectivity on the Internet, Protocol used in Internet ï TCP/IP, SMTP, PPP, HTTP, Services on the Internet - E-mail, Usenet, FTP, Search Engines, Web Browsers, Web Servers, Design Templates.

Unit-II Introduction to HTML, Basic Structure of a HTML Document, Document Head and Body, Titles and Footers, Working with Texts ï Texts Formatting, Text Styles, Text Effects, Ordered & Unordered Lists, Table ï TR & TD Tags, Cell Spacing, Cell Padding, Colspan, Rowspan, Frames ï FRAME and FRAMESET Tags, Hyperlinks, Forms ï FORM and INPUT Tags, Text Box, Radio Button, Checkbox, SELECT Tag and Pull Down Lists, Hidden, Submit and Reset.

Unit-III Introduction to DHTML, Benefit of CSS, CSS Properties, CSS Styling ï Background, Text Format, Controlling Fonts, Working with Lists and Tables, CSS ID and Class, Web Page Layout and Editing with CSS, Writing JavaScript into HTML, Basic Programming using JavaScript, JavaScript Client Validations, Dialog Boxes, Overview of Document Object Model, Event Handling.

Unit-IV Introduction to Server-Side Programming, Overview of Server-Side Programming Languages, Introduction to Servlets, Servlet Life Cycle, Servlet Implementation and Configuration, Servlet Exception, Requests & Responses, Deployment Descriptor, Session Tracking, Introduction to JSP, JSP Tags, Implicit Objects, Working with Session Objects, Database Connection using JSP/Servlet, Overview of Tomcat Sever ï Configuration and Web Application Deployment.

Books Recommended:

1. Robert W. Sebesta, *Programming the World Wide Web*, (4th ed.), Addison Wesley, 2007.
2. Dick Oliver, Michael Morrison, *Sams Teach Yourself HTML and CSS in 24 Hours*, Pearson Education, 2005.
3. Danny Goodman, *JavaScript & DHTML Cookbook: Solutions and Example for Web Programmers*, O'Reilly Media, 2003.
4. Ivan Bayross, *HTML 5 and CSS 3 Made Simple*, BPB, 2012.
5. Jim Keogh, *J2EE: The Complete Reference*, TMH, 2015.
6. Wrox Press, *Professional JSP J2EE 1.3 Edition*, Shroff Publishers, 2005.

M.Sc. Mathematics with Computer Science, Semester – IV

MTM-4.1	Complex Analysis	Unit	Credit	Lecture/ week
Internal Assessment: 25 Marks End Semester Examination: 75 Marks Duration of Examination: 2 Hrs.		4	4	4

Unit-I Complex integration, Cauchy-Goursat Theorem, Cauchyôs integral formula. Higher order derivatives, Moreraôs theorem, Cauchy inequality and Liouvilleôs theorem, The fundamental theorem of algebra.

Unit-II Taylorôs theorem, Maximum modulus principle, Schwarz lemma, Laurentôs series, Isolated singularities, Residues, Cauchyôs residue theorem, Evaluation of integrals, Branches of many valued functions with arg z, log z, and z^a .

Unit-III Meromorphic functions, The argument principle, Roucheôs theorem, Inverse function theorem.

Unit-IV Bilinear transformations and their properties and classification, Definition and examples of conformal mappings.

Books Recommended:

1. B. Choudhary, *Elements of Complex Analysis*, Wiley Eastern Ltd., New Delhi, 1993.
2. J.B. Conway, *Functions of one Complex variable*, Springer-Verlag, International Student-Edition, Narosa Publishing House, 1980.

M.Sc. Mathematics with Computer Science, Semester – IV

MTM-4.2	Differentiable Manifolds	Unit	Credit	Lecture/ week
Internal Assessment: 25 Marks End Semester Examination: 75 Marks Duration of Examination: 2 Hrs.		4	4	4

Unit-I Differentiable manifolds, Definition and examples, Smooth maps between two smooth manifolds, Tangent vector and tangent space at a point on a manifold, Tangent bundle of manifold.

Unit-II Vector fields, Lie bracket, Jacobian of a smooth map, One parameter group of transformation, Integral curves on manifolds, Involutive distribution, Lie derivatives.

Unit-III Cotangent space, Differential forms, Pullback of 1-form, Tensor fields, Exterior derivatives, Immersions, Submersions and submanifolds examples.

Unit-IV Connections, Geodesics, Covariant differentiations, Torsion, curvature, Structure equations of Cartan, Bianchi identities, Riemannian metric, Riemannian manifold, Riemannian connection, Riemannian curvature, Sectional curvature, Ricci curvature and Scalar curvature.

Books Recommended:

1. B.O. Neill, *Elementary Differential Geometry*, Academic Publishers, 2006.
2. U.C. De and A. Shahikh, *Differentiable Manifolds*, Narosa Publications, 2007.
3. S. Kumaresan, *A Course in Differential Geometry and Lie Groups*, Hindustan Book Agency, 2002.
4. Boothby, *An Introduction to Differentiable Manifolds and Riemannian Geometry*, Academic Press, 2002.
5. Gerardo F. Torres del Castillo, *Differentiable Manifolds*, Birkhauser, 2012.
6. M. P. DoCarmo, *Riemannian Geometry*, Brikhauser, 2013.

M.Sc. Mathematics with Computer Science, Semester – IV

MTM-4.3	Wavelet Analysis	Unit	Credit	Lecture/ week
Internal Assessment: 25 Marks End Semester Examination: 75 Marks Duration of Examination: 2 Hrs.		4	4	4

Unit-I Fourier transform in $L^1(R)$, Properties of Fourier transforms, Fourier transform in $L^2(R)$, Parseval Identities, Change of root, Inversion formula, Plancherel Theorem, Duality Theorem, Poission summation formula, Sampling theorem, Heisenbergôs uncertainty principle, Heisenbergôs 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.
3. C. K. Chui, *Wavelets: A Tutorial in Theory and Applications*, Academic Press, 1992.

M.Sc. Mathematics with Computer Science, Semester – IV

MTM-4.4	Database Management System	Unit	Credit	Lecture/ week
Internal Assessment: 25 Marks End Semester Examination: 75 Marks Duration of Examination: 2 Hrs.		4	4	4

Unit-I Introduction to Databases and Database Management System (DBMS), Characteristics of DBMS Approach, Advantages, Disadvantages & Applications of DBMS, Role of DBA, Data Integrity, Entity Integrity, Domain Integrity, Referential Integrity, Keys: Super key, candidate key, alternate key, Introduction to Transactions and Serializability, ACID properties.

Unit-II Three Schema Architecture of DBMS, Data Independence, Classifications of DBMS. Data Model, Types, Data Modelling Using E-R Diagram, Entity Types, Relationship Types, Role names & Recursive relationship, relationship degree, Attributes, Key attributes, Weak Entity, Owner Entity, Identifying relationship, Partial Key, Cardinality and Participation constraint, Characteristics of Hierarchical & Network Model.

Unit-III Relational Model Concepts, Conversion of ER Diagram to Relational Model, Relational Algebra- Select, Project, Cartesian Product, Joins, Division & Set operations, Aggregate Functions, Introduction to Tuple and Domain Relational Calculus, Functional dependency.

Unit-IV Design Guidelines for Relational Schemas, Normalisation, Types of Normal Forms, De-normalization. SQL: DDL, DML, DCL, Queries for Table Creation, Deletion and Modification in SQL, Defining Constraints, Select query for Data Extraction, group by, having, order by clauses, Insert, Delete & Update Statements in SQL, Views in SQL, types of Joins, Aggregate Functions, Nested Queries, Introduction of PL/SQL, Programming Constructs, Procedures, Functions, Exception handling, Cursors.

Books Recommended:

1. Elmasri, Navathe, *Fundamentals of Database Systems*, Pearson Education, 2008.
2. Henry F. Korth, Abraham Silberschatz, S. Sudurshan, *Database System Concepts*, McGraw-Hill, 2005.
3. C. J. Date, *An Introduction to Database Systems*, Pearson, 2006.
4. Ramakrishna, Gehrke, *Database Management Systems*, Mcgraw-Hill, 2014.
5. S.K. Singh, *Database Systems Concepts, Design and Applications*, Pearson, 2011.
6. Jeffrey D. Ullman, Jennifer Widom, *A first course in Database Systems*, Pearson, 2014.

M.Sc. Mathematics with Computer Science, Semester – IV

MTM-4.5C_1 Fluid Dynamics	Unit	Credit	Lecture/ week
Internal Assessment: 25 Marks End Semester Examination: 75 Marks Duration of Examination: 2 Hrs.	4	4	4

Unit-I **Kinematics:** Definition, Lagrangian and Eulerian Specifications, Stramline, Path line and Streak line, Linear strain rate, Shear strain rate, Vorticity and Circulation, Material derivative, Acceleration of fluid particle, Numerical problems on Lagrangian/Eulerian specifications, Stramline/pathe line/Streak line and Material derivative.

Unit-II **Conservation laws:** Conservation of mass in integral and differential forms, Origin of forces in fluid, Stress at a point, Conservation of Momentum, Constitutive equation for Newtonian fluid, Navier-Stokes equation, Euler equation, Bernoulliôs equation and its applications, Boussinesq approximation.

Unit-III **Laminar Flows:** Steady flow between parallel plates, Volume flow rate, Average velocity, Plane Couette flow, Magnitude of shear stress, Plane Poiseuille flow, Magnitude of shear stress, Steady flow in a pipe, Shear stress at any point, Volume flow rate, Impulsively started plate: Similarity solutions.

Unit-IV **Dynamic Similarity:** Dimensional analysis, Rayleighôs technique, Backinghamπ – theorem, Significance of Reynolds number, Definition of Reynoldôs number, Froude number, Euler number, Mach number, Prandtl number. Boundary Boundarylaer and boundary equation, Boundary layer thickness, Displacement thickness, Drag and lift, Blassius equation and its solution.

Books Recommended:

1. P. K. Kundu and I. M. Cohem, *Fluid Mechanics*, Elsevier Publication, 2010.
2. Fay, *Introduction to Fluid Mechanics*, Prentice Hall of India, 1996.
3. H. Schlichting, K. Gersten, *Boundary-Layer Theory*, 8th Edition, Springer; 2000.
4. M. D. Raishghania, *Fluid Dynamics*, S. Chand Publication, 2003.

M.Sc. Mathematics with Computer Science, Semester – IV

MTM-4.5C$_2$	**Operations Research**	**Unit**	**Credit**	**Lecture/ week**
Internal Assessment: 25 Marks End Semester Examination: 75 Marks Duration of Examination: 2 Hrs.		4	4	4

Unit-I Convex sets and their properties, Graphical method, Integer Programming, Branch and Bound Technique, Theory of Simplex method, Two-Phase Simplex Method, Big-M method.

Unit-II Duality in LP, Conversion of primal to dual, Dual Simplex method, Sensitivity analysis, Discrete change in price vector, requirement vector and coefficient matrix, adding a new variable and new constraints.

Unit-III Queuing Theory, Distribution of arrival and departure pattern, (M/M/1):(Đ/FCFS), (M/M/1):(N/FCFS) and (M/M/S):(Đ/FCFS) queuing models, Network analysis, Critical Path Method (CPM), Project Evaluation and Review Technique (PERT), Project management with CPM/PERT.

Unit-IV Dynamic programming, Bellmanôs Principle of Optimality, Nonlinear Programming (NLP), Graphical method for NLP, Kuhn-Tucker Conditions for Constrained Optimization, Quadratic Programming, Wolfeôs modified Simplex method, Separable Programming.

Books Recommended:

1. H. A. Taha, *Operations Research*, 9th edition, Pearson Education, 2014.
2. Hillier and Lieberman, *Introduction to Operations Research*, McGraw Hill, 1995.
3. S. D. Sharma, *Operations Research*, Kedar Nath Ram Nath Publishers.
4. J. K. Sharma, *Operations Research – Theory and Application*, Macmillian Publication, 2009.
5. S. M. Sinha, *Mathematical Programming*, Elsevier India Pvt. Ltd., 2005.

M.Sc. Mathematics with Computer Science, Semester – IV

MTM-4.5C$_3$ **Lattice Theory**	**Unit**	**Credit**	**Lecture/ week**
Internal Assessment: 25 Marks End Semester Examination: 75 Marks Duration of Examination: 2 Hrs.	4	4	4

Unit-I Partially ordered set, Least upper bound, Greatest lower bound, Lattice, Sublattice, their Characterizations, Ideals in a lattice, Properties of ideals, Interval, Homomorphism, Isomorphism and its characterization.

Unit-II Zero and all elements in a lattice, Complete lattice, Modular and distributive lattices, Characterization of a modular lattice, Isomorphic, Similar and projective intervals, Refinement of a chain, Schreierôs refinement theorem, Jordan-Holder theorem.

Unit-III A.C.C, and D.C.C., Fundamental dimensionality relation for modular lattice, Independent (join) elements in a lattice & their properties, Complemented modular lattices, Points, Properties of complemented modular lattices with chain condition, Boolean Algebra, Boolean rings, Conversion of a Boolean algebras into Boolean rings and vice-versa.

Unit-IV Algebras, Different types of algebras including Quarternions, Caley, Endomorphism, Derivation of a ring and algebra, Lie ring, Lie ring of endomorphism of an additive abelian group, Inner derivations, Inner derivation for associative and Lie rings.

Books Recommended:

1. N. Jacobson, *Lectures in Abstract Algebra*, Springer, 1951.
2. George Gratzer, *General Lattice Theory*, Springer, 2011.
3. Garrett Birkhoff, *Lattice Theory*, Colloquium Publications, 1940.
4. A. G. Kurosh, *Lectures on General Algebra*, Chelsea Pub. Co, 1963.