Faculty of Natural Science and Engineering
Department of Mathematics and Informatics

Syllabus for M.Sc. in Mathematics

The Department of Mathematics and Informatics offers a program of study leading to the degree of Master of Science (M.Sc.) in Mathematics for four categories of students. The M.Sc. Final Program consists of 40 credits to be completed in three semesters (1 year).

A student who has been graduated on completion of 4 years B.Sc.(Hons.) program in Mathematics from this university, Bangladesh National University or any Public or recognized Private University of Bangladesh will be eligible directly for admission to the program.

A student who has been graduated on completion of 3 years B.Sc.(Hons.) program in Mathematics or 3 years B.Sc. (Pass) program with Mathematics as a subject from Bangladesh National University or any Public or recognized Private University of Bangladesh has to complete a Preliminary Master of Science in Mathematics non-degree program of 37 credits (minimum) in 3 semesters (1 year) for getting eligible for admission to the M.Sc. Final program.

A student who has been graduated on completion of 2 years B.Sc. (Pass) program with Mathematics as a subject from Bangladesh National University or any Public or recognized Private University of Bangladesh has to complete Graduate Diploma Program of 28 credits followed by a Preliminary Master of Science in Mathematics program as mentioned above to become eligible for admission to the M.Sc. Final program. A student on successful completion of a Gradate Diploma Program will be awarded a Graduate Diploma Certificate (GDC).

A student graduated from an overseas university will be judged for an equivalent qualification for admission into the M.Sc. Final program.

A student having a minimum of 60% class attendance will be eligible to appear in a Semester Final Examination. There will be an allocation of marks for Class Participation, Assignment, Mid-Semester Examination and Semester Final Examination. The distribution of marks in a course is as follows:

Class Participation	: 10%
Assignment / Tutorial Exam	: 10%
Presentation / Viva	: 10%
Mid-Semester Examination	: 30%
Semester Final Examination	: 40%

The grading system consists of letter grading, corresponding to Grade Point Average (GPA) as follows:

Numerical Grade	Letter Grade	Grade Point
80% and above	A+	4.00
75% to less than 80%	A	3.75
70% to less than 75%	A-	3.50
65% to less than 70%	B+	3.25
60% to less than 65%	B	3.00
55% to less than 60%	B-	2.75
50% to less than 55%	C+	2.50
45% to less than 50%	C	2.25
40% to less than 45%	C-	2.00
36% to less than 40%	D	1.00
Below 36%	F	0.00
Incomplete	I	Incomplete

Absence from any course or the final examination will be considered incompletion of the program. The distribution of courses for the different programs in gradual order is given below along with the detailed courses.

Syllabus for Graduate Diploma Certificate in Mathematics (3 Semesters)

First Semester

Course Code No.	Course Title	Hours/Week Theory	Credits
MAI 101	Fundamentals of Mathematics (Algebra)	3+0	3.0
MAI 102	Fundamentals of Mathematics (Geometry)	3+0	3.0
MAI 103	Differential Calculus	3+0	3.0
	Total	9+0	9.0

Second Semester

Course Code No.	Course Title	Hours/Week Theory+Lab	Credits
MAI 201	Integral Calculus	3+0	3.0
MAI 202	Ordinary Differential Equation	3+0	3.0
MAI 203	Vector Calculus and Mathematical Methods	3+0	3.0
	Total	9+0	9.0

Third Semester

Course Code No.	Course Title	Hours/Week Theory+Lab	Credits
MAI 301	Introduction to Computer Language	3+0	3.0
MAI 302	Introduction to Computer Language Lab	0+2	2.0
MAI 303	Numerical Analysis	3+0	3.0
MAI 304	Viva Voice/Project presentation	0+0	2.0
	Total	6+2	10.0

Detailed Syllabus

MAI 101 FUNDAMENTALS OF MATHEMATICS (ALGEBRA)
3 Hours/Week, 3 Credits

Introduction: Definitions and identities of trigonometric and hyperbolic functions with their inverses; De Moivre's Theorem and its application. **Summation of series** (algebraic and trigonometric)**:** Arithmetic and geometric series; method of difference and C+iS method (for trigonometric series). **Inequalities:** Inequalities involving mean; inequalities of Weierstrass, Cauchy, Tchebyshev, Holder and Minskowski. **Theory of equations:** Polynomials and division algorithms; fundamental theorem of algebra; multiple roots; transformation of equations; relations between roots and coefficients; Descarte's rule of signs; symmetric functions of the roots; solutions of cubic and biquadratic equations; Sturm's theorem.

Books Recommended:

1. *Lipschutz, S:* Set Theory and Related Topics
2. *Bernard and Child:* Higher Algebra
3. *Hall and Knight:* Higher Algebra
4. *Shahidullah and Bhattacherjee:* Higher Algebra

MAI 102 FUNDAMENTALS OF MATHEMATICS (GEOMETRY)
3 Hours/Week, 3 Credits

Two dimensional geometry: Coordinate system, straight line in a plane; distance of two lines; slope of a line; tangent and normal on a curve; pair of straight lines; basic properties of circle, parabola, ellipse and hyperbola; change of coordinatesand axes; general equation of second degree; reduction of general equation of second degree to standard form and identification of conic; polar and parametric equations of conic; poles, polar and chords in terms of middle points.

Coordinates in three dimensions: Different systems of coordinates and transformations of coordinates; direction cosines; direction ratios; planes and straight lines in three dimensions; general equation of second degree in three variables, reduction to standard forms and identification of conicoids; sphere, cylinder, cone, ellipsoid, paraboloid and hyperboloid.

Books Recommended:

1. *Smith, C.:* An Elementary Treatise on Solid Geometry.
2. *Thomas and Finney:* Calculus and Analytic Geometry
3. *Bell, R. J. T.:* An Elementary Treatise on Coordinate Geometry of Three Dimension
4. *Rahman and Bhattacharjee:* Two and Three Dimensional Geometry

MAI 103 DIFFRENTIAL CALCULAS
3 Hours/Week, 3 Credits

Functions: Functions of single variable, domain and range of a function, graph of simple functions such as polynomials, exponential functions, logarithmic function and trigonometric functions, inverse function. **Limit and continuity** of single variable functions,**Differentiation:** Derivative of a function, derivative of algebraic, trigonometric and hyperbolic functions, parametric functions, implicit functions, Intermediate forms and L'Hospital rules; successive differentiations and Leibnitz's Theorem. **Applications of derivatives:** The significance of the first derivative; Rolle's theorem; mean value theorem; Taylor's theorem in different forms; Maclaurin's series and their application for the expansion of functions; increasing and decreasing functions; concavity and point of inflection; asymptotes and symmetry; maxima and minima.

Books Recommended:

1. *Thomas and Finney:* Calculus and Analytic Geometry
2. *Swokowski, E. W.:* Calculus with Analytic Geometry

3. *Das and Mukherjee*: Differential Calculus
4. *J. Stewart:* Calculus.

MAI 201 INTEGRAL CALCULAS
3 Hours/Week, 3 Credits

Integration: Introduction; indefinite integrals; basic integration formulas; integration by parts; products and powers of trigonometric functions; even powers of sine's and cosines trigonometric substitutions; partial fractions; definite integrals; calculating areas as limits; the fundamental theorems of integral calculus; integration by substitution; rules for approximating definite integrals, improper integrals; reduction formulae; Gamma and Beta functions.**Applications of definite integrals**: Area between two curves; calculating volumes by slicing; volumes modeled with shells and washers; length of a plane curve; area of a surface of revolution; average value of a function.

Books Recommended:

1. *Thomas and Finney:* Calculus and Analytic Geometry
2. *Swokowski, E. W.:* Calculus with Analytic Geometry
3. *Das and Mukherjee:* Integral Calculus

MAI 202 ORDINARY DIFFRENTIAL EQUATIONS
3 Hours/Week, 3 Credits

Introduction to differential equations. **Ordinary differential equations and their solutions:** Ordinary differential equations of first order and first degree; ordinary differential equations of 1st order but of higher degree; initial value problem; orthogonal trajectories; general solution of linearordinary differential equations (homogeneous and non-homogeneous) with constant coefficients; methods of undetermined coefficients and variation of parameters; reduction of order; solution in series; simple cases of non-linear differential equations; system of linear ordinary differential equations.

Books Recommended:

1. *Ayres, F.:* Differential Equations
2. *Ross, L.:* Introduction to Differential Equations
3. *Ch. V. Ramana Murty & N.C. Srinivas:* Applied Mathematics

MAI 203 VECTOR CALCULUS AND MATHEMATICAL METHODS
3 Hours/Week, 3 Credits

Vector differentiation: Vector and scalar fields; vector operator, directional derivatives; gradient, divergence, curl.
Vector integration: Line, surface and volume integrals; theorems of Green, Gauss and Stokes with their applications.
Fourier series : Fourier sine and cosine series,Convergence of Fourier Application to physical problems Lagendre's differential equations: Lagendrepolynomeals, Generating functions,Recurrence relations, Orthogonality, Rodrigues formula.. Bessel's differential equations: Bessel functions of the first kind , Zeros and orthogonality, Recurrence relations, Integral representations, Bessel functions of the second kind Laplace transform and its applications in differential equation(initial value problem). Boundary value problems involving second order ordinary differential equations; eigenfunction, expansions and Green's functions.Ideas about Strum-Liouville problems.

Books Recommended:

1. *Stephenson: Mathematical Methods*
2. *Ross, S. L.: Introduction to Differential Equations*
3. *Spiegel, M. R.:Laplace Transform*
4. *Spiegel, M.R.: Vector Analysis*
5. *M. Abdur Rahman:* Mathematical Methods; Vol: 1&2

MAI 301 INTRODUCTION TO COMPUTER LANGUAGE
3 Hours/Week, 3 Credits

Programming Language: Basic concepts, overview of programming languages, problem solving techniques and data flow diagram. **C-Language:** preliminaries, program constructs, variables and data types in C, input and output, character and formatted I/O, arithmetic expressions and assignment statements, loops and nested loops, decision making, arrays, functions, arguments and local variables, calling functions and arrays, recursion and recursive functions, structures with in structure, files, file functions for sequential and random I/O.**Pointers:** pointers and structures, pointer and functions, pointer and arrays, operation and pointer, pointer and memory addresses.

Operations on Bits: Bit operation, bit field, advanced features, standard and library.

Books Recommended:

1. *Kernighn & Ritchie:* The C Programming Language
2. *H. Schildt:* Teach Yourself C
3. *Schaum's outline Series:* Programming with C
4. *H. Schieldt:* The Complete Reference, Turbo C/C++

MAI 302 INTRODUCTION TO COMPUTER LANGUAGE LAB
2 Hours/Week, 2 Credits

Syllabus will be designed by the course teacher on the basis of MIS 311.

MAI 303 NUMERICAL ANALYSIS
3 Hours/Week, 3 Credits

Errors in numerical calculations: Errors definitions, sources, examples; propagation error; a general error formula. **Root finding:** The bisection method; the iteration method; the method of false position; Newton-Raphson method. **Methods of interpolation theory:** Polynomial interpolation; error in polynomial interpolation; interpolation using Newton's forward and backward formulas and Newton's divided difference formula and central difference formula; Starling's interpolating polynomial; Lagrange's interpolating polynomial; idea of extrapolation. **Numerical integration:** Trapezoidal method; Simpson's method; Weddle's method; Romberg's method; error analysis. **Interpolation:** Quadratic and cubic spline interpolation methods. **Solutions of systems of linear equations:** Gaussian elimination with and without pivoting; iteration method; solution of tri-diagonal system of equations. **Numerical solution of ordinary differential equation (IVP):** Euler's method (including modified form); Runge-Kutta method; predictor and corrector method. **Boundary value problem:** explicit and implicit finite difference method for BVP involving ODE; explicit finite difference method for BVP involving PDE (elliptic, parabolic and hyperbolic).

Books Recommended:

1. *Hilderman,F. B.:* Introduction to Numerical Analysis
2. *Burden, R. L., and Faires, J. D.:* Numerical Analysis
3. *Gerald and Wheatley:* Applied Numerical Analysis
4. *Smith, G.D.:* Numerical solution of Partial Differential Equations
5. *Jain, M. K.:* Numerical Solution of Differential equations
6. *Dr. A. Singera Veld:* Numerical Methods

MAI 304 VIVA VOCIE/ PROJECT PRESENTATION
2 Credits

Faculty of Natural Science and Engineering

Department of Mathematics and Informatics

Syllabus for Preliminary Master of Science in Mathematics (3 Semesters)

First Semester

Course Code No.	Course Title	Hours/Week Theory	Credits
MAI 511	Set Theory and Elementary Logic	3+0	3.0
MAI 512	Linear Algebra	3+0	3.0
MAI 513	Real Analysis	3+0	3.0
MAI 514	Linear Programming	3+0	3.0
	Total	12+0	12.0

Second Semester

Course Code No.	Course Title	Hours/Week Theory+Lab	Credits
MAI 521	Complex Analysis	3+0	3.0
MAI 522	Theory of Numbers	3+0	3.0
MAI 523	Hydrodynamics	3+0	3.0
MAI 524	Fundamental of Computer Techniques	3+0	3.0
	Total	12+0	12.0

Third Semester

Course Code No.	Course Title	Hours/Week Theory+Lab	Credits
MAI 531	General Topology	3+0	3.0
MAI 532	Tensor Analysis	3+0	3.0
MAI 533	Object Oriental Programming	3+0	3.0
MAI 534	Object Oriental Programming Lab	0+2	2.0
MAI 535	Dynamics	3+0	3.0
MAI 536	Computational Biology	3+0	3.0
MAI 537	Viva Voce/Project Presentation	0+0	2.0
	Total	15+2	19.0*

** A student has to complete a* minimum ***13.0*** *credits. Course MAI-537 is compulsory. Courses will be selected by the department.*

Total Credits for the program: 12.0 + 12.0 + 13.0 = 37.0

Detailed Syllabus

MAI 511 SET THEORYAND ELEMENTARY LOGIC
3 Hours/Week, 3 Credits

Sets: Elementary idea of set; subsets; power set of a set; product set; basic set operations and related theorems on sets; Venn diagrams; countable and uncountable sets; cardinality of a set. **Real number system:** Set of natural numbers; rational numbers, irrational numbers and real numbers along with their geometrical representation; idea of open and closed interval; product set of real numbers and their geometric representation; idea of absolute value of real number; axioms of real number system and their applications in solving algebraic equations. **Relations and Functions:** Binary relations; reflexive, symmetry anti-symmetry and transitive relations; pictorial representations of relations; properties of relation; variable of a set; functions of a variable; domain and range of a function; polynomial; graph of single polynomial functions; exponential, logarithmic, trigonometric functions and their graphs; algebra of functions; inverse of functions and its graph; vertical line test for a function and test for symmetry of functions; test for continuity of a function from its graph.**Logic:** Introduction to logic;elements of logic; conditional propositions and logical equivalence; quantifiers; method of proofs; mathematical induction; recursion and iteration.

Books Recommended:

1. *Seymour Lipschutz:* Set Theory
2. *R. David Gustafson and Peter D. Frisk:* Functions and Graphs
3. *Rosen, K.H.:* Discrete Mathematics and its application, *McGraw-Hill International edition (4th edition) 1999*

MAI 512 LINEAR ALGEBRA
3 Hours/Week, 3 Credits

Introduction tomatrices; addition and multiplication of matrices; determinant of matrix; types of matrices; adjoint and inverse of a matrix; elementary row operations and echelon forms of matrix; rank of a matrix; row rank and column rank of a matrix and their equivalence; use of rank and echelon form in solving system of homogeneous and non-homogeneous equations. **Vector space** and subspace over real numbers, direct sum; linear combination; linear dependence and independence of vectors; basis and dimension of vector space; quotient space; isomorphism theorems. **Linear transformations**; kernel, rank and nullity; matrix representation; change of basis; eigenvalues and eigenvectors; characteristic equations; Cayley-Hamilton theorem; diagonalization of matrices; similar matrices; canonical forms; orthogonal and Hermitian matrices. **Inner product**: inner product space, orthogonal vectors and orthonormal basis, Gram-Schmidt orthogonalization process, Bilinear and quadratic forms.

Books Recommended:

1. *Hamilton, A. G.:* Linear Algebra
2. *Anton, H. and Rorres, C.:* Elementary Linear algebra with Applications.
3. *Kolman, B.:* Elementary Linear Algebra
4. *Nering, E. D.:* Linear Algebra and Matrix Theory
5. *Lipschutz, S.:* Linear Algebra
6. *Otto Bretchjee:* Liner Algebra

MAI 513 REAL ANALYSIS
3 Hours/Week, 3 Credits

Real number system: Bounded sets of real numbers; supremum and infimum; the completeness axiom and Dedekind's axiom; neighborhoods; open and closed sets of real numbers; limit/cluster points of a set of real numbers; Media State Bolzano-Weierstrass theorem; derived set and closure of a set. **Sequence of real numbers:** Definition of a sequence; convergence of a sequence; subsequence; monotonic sequence; bounded sequence; Cauchy sequence; Cauchy criteria for convergence of sequences. **Infinite series:** Concept of sum and convergence; series of positive terms; alternating series; absolute and conditional convergence; various tests for convergence. **Limit, continuity and differentiabilityof functions:** Limit and continuity of functions with their properties; uniform continuity; Heine-Borel theorem; differentiability of functions; Rolle's theorem; mean value theorem; Darboux theorem; intermediate value theorem for derivatives; Taylor's theorem with remainder in Lagrange's and Cauchy's forms; Maclaurin's series; expansions of functions. **Power series:** Interval and radius of convergence; differentiation and integration of power series; identity theorem; Abel's continuity theorem. **Riemann integrals:** Riemann sum and Riemann integral; Darboux sums and Darboux integrals, Darbouxintegrability and Riemannintegrability; properties of integrals; fundamental theorem of integral calculus.

Books Recommended:

1. *Rudin, W.:* Principle of mathematical analysis
2. *Apostol, I.:* Mathematical Analysis
3. *Bartle:* Real Analysis
4. *Marsden, J.E. and Hoffman, M.J.:* Elementary Classical Analysis
5. *Burkill, J. G.:* A First Course in Mathematical Analysis
6. *Chowdhury, F. and Chowdhury, M.R.:* Essentials of Real Analysis

MAI 514 LINEAR PROGRAMMING
3 Hours/Week, 3 Credits

Linear programming: Linear programs; convex set; graphical solution of systems of linear inequalities and linear program; solution of linear program by simplex method; algebraic basis and computational set up; duality problem-duality theorem; transportation set problems; assignment problem and simple applications; connection between linear programming and two-person zero-sum matrix game; simple inventory problems.

Books Recommended:

1. *Haldey, G.:* Linear Programming
2. *Gass, S.I.:* Mathematical Programming
3. *Luenberger:* Linear and Nonlinear Programming

MAI 521 COMPLEX ANALYSIS
3 Hours/Week, 3 Credits

Complex variables: Geometry of the complex plane; elementary functions of a complex variable (including the general power and the logarithm). **Limit, continuity and differentiability** of functions of a complex variable; analytic functions and their properties; harmonic functions; meromorphic function and entire function. **Complex integrals:** Line integralover rectifiable curves; Cauchy's theorem for simple contours; Cauchy's integral formula; theorems of Liouville and Morera; fundamental theorem of algebra. **Zeros, singularities, poles and residues**; Taylor's and Laurent's series; expansion of functions; Cauchy's residue theorem; Rouche's theorem; the maximum modulus principle; evaluation of real integrals by contour integrations. **Conformal mappings,** bilinear transformations and their properties.

Books Recommended:

1. *Churchill and Brown:* Complex variables and Applications
2. *Stewart and Tall:* Complex Analysis
3. *Spiegel, M. R.:* Complex Variable
4. *Copson, E. I.: Theory of Function of Complex Variables*

MAI 522 THEORY OF NUMBERS
3 Hours/Week, 3 Credits

Divisibility and greatest common divisors; arithmetic in Z; prime numbers and perfect numbers; fundamental theorem of arithmetic and its consequences; division algorithm; congruence; least residue theorem; Fermat's theorem, Euler's theorem and Wilson's theorem; solutions of congruence; Lagrange's theorem of congruence; Chinese remainder theorem; arithmetic functions and their properties; multiplicative functions; Zeta function and its relation with arithmetic functions; quadratic residues and non-residues; law of quadratic reciprocity; Legendre symbol; some Diophantine equations and their solutions; representation of integers by sum of two squares or four sum squares; solution of the equation $z^2 = x^2 + y^2$; Selberg's proof of the prime number theorems.

Books Recommended:

1. *Apostol:* Theory of Numbers
2. *Chowdhury, F. and Chowdhury, M.R.:* Essentials of Number Theory
3. *Niven and Zucherman:* Theory of Numbers
4. *Hunter, J..:* Number Theory
5. *Hardy, G. H. and Wright, E. M.:* Theory of Numbers
6. *S.G.. Telang:* Theory of Numbers

MAI 523 HYDRODYNAMICS
3 Hours/Week, 3 Credits

Introductory motion: Physical dimension; stream lines and path lines; hydrodynamic pressure; Bernoulli's theorem; adiabatic expansion. Equation of motion: Equation of continuity; equation of motion of inviscid liquid and Bernoulli's equation; steady motion and conservative forces; circulation and Kelvin's theorem; vorticity; irrotational motion and velocity potential; the energy equation; kinetic energy and Kelvin's minimum energy theorem. Two dimensional motions: Rate of change of vorticity; stream function and pressure equation; streaming motions; complex potential and complex velocity; stagnation points; circle theorem; motion past a cylinder; Joukowaski transformation; Blasius theorem. source and sink: Doublets; complex potentials due to sourses sinks and doublets ; source and sink of equal strength; source and sink in a stream; method of images calculation of pressure on boundary walls due to sourses ;

Books Recommended:

1. *Milne-Thompson, L. M.:* Theoretical Hydrodynamics
2. *Lamb, H.:* Hydrodynamics
3. *Ramsey:* Hydrodynamics
4. *Shanti Swarup:* Hydrodynamics

MAI 524 FUNDAMENTAL OF COMPUTER TECHNIQUE
3 Hours/Week, 3 Credits

Introduction: Generation and Classification of Computers- Basic Organization of a Computer –Number System - Binary - Decimal - Conversion - Problems. Need for logical analysis and thinking - Algorithm - Pseudo code - Flow Chart.**Problem-solving Techniques using computer:** Flowcharts, Algorithms, Pseudo codes.**Introduction to Mathematica/Maple:** Running the package Manipulating Notebooks/worksheets. Numerical Computation.Algebraic computation. Mathematical functions. Manipulating equations Derivatives and integrals, Limits and Series.Lists and Matrices Graphics.Standard Package.**Programming in C:** Syntax and Semantics, data types and structures, input/output, loops, decision statements, arrays, user-defined functions, subroutines and recursion.

1. *R.G. Dromey, "How to Solve it by Computer", Pearson Education, Fourth Reprint, 2007*
2. *Ashok N. Kamthane, "Computer programming", Pearson Education, 2007.*
3. *PradipDey, ManasGhosh, "Fundamentals of Computing and Programming in C", First Edition, Oxford University Press, 2009*
4. Fundamental of Computer

MAI 531 GENERAL TOPOLOGY
3 Hours/Week, 3 Credits

Topology and topological space; open sets and closed sets; closure of a set; interior, exterior and boundary; neighborhoods and neighborhoods systems; weak and strong topology; topology of the real line and plane; cofinite and cocountable topology; subspaces; relative topology; bases and subbases for a topology; continuity and topological equivalence; homeomorphic spaces.**Metric and normed spaces:** Metric topologies; properties of metric spaces; metrizable space; Hilbert space; convergence and continuity in metric space; normed spaces. **Countability:** First countable spaces; second countable spaces and related theorems. **Compactness:** Covers; compact sets; subset of a compact space; finite intersection property; Bolzano-Weierstrass theorem; locally compact spaces. **Connectedness:** Separated sets; connected sets; connected spaces; components; locally connected spaces and simply connected spaces. **Separation axioms:** T_1-spaces; Hausdorff spaces; regular spaces; normal spaces; completely normal spaces and completely regular spaces.

Books Recommended:

1. *Simmons, G.F.:* Introduction to Topology and Modern Analysis
2. *Gal, S.:* Point Set Topology
3. *Lipschutz, S.:* General Topology
4. *Kelley, J.L.:* General Topology
5. *Hockling and Young:* Topology

MAI 532 TENSOR ANALYSIS
3 Hours/Week, 3 Credits

N dimensional spaces, Summation convention, ,Transformation of coordinates; covariant and contravariant tensor; mixed tensors, conjugate tensor; associated tensor;Algebra of tensors, Relative tensors, Metric tensors, fundamental operations on tensor s; Christoffel symbols and their transformations , ; covariant differentiation; parallelism and geodesics; Riemann-Christoffel tensor; curvature tensor; Ricci tensor and Bianchi identity and Einstein tensor.

Books Recommended:

1. *Spiegel, M.R.:* Vector and tensor Analysis
2. *Lass, H.:*Vector and Tensor Analysis
3. *Spain, B.:*Tensor Calculus

MAI 533 OBJECT ORIENTAL PROGRAMMING
3 Hours/Week, 3 Credits

Introduction to Java: History of Java**,** Java Class Libraries**,** Introduction to Java Programming**,** A simple Program**. Developing Java Application:** Introduction, Algorithms, Pseudo code, Control Structure, The If /Else Selection Structure, The While Repetition Structure, Assignment Operators, Increment and Decrement Operators, Primitive Data Types, Common Escape Sequence, Logical Operator.**Control Structure:** Introduction, The For Structure, The Switch Structure, The Do/While Structure, The Break and Continue Structure**. Methods:** Introduction, Program Module in Java, Math Class Methods, Method Definitions, Java API Packages, Automatic Variables, Recursion, Method Overloading, Method of the Applet Class**. Arrays :**Introduction, Arrays, Declaring and Allocating Arrays, Passing Arrays to Methods, Sorting Arrays, Searching Arrays, Multiple-Subscripted Arrays.**Object-Based Programming:** Introduction, Implementing a Time Abstract DataType with a Class, Class Scope, Controlling Access to Members, Utility Methods, Constructors, Using Overload Constructor, Using Set and Get Method, Software Reusability, Friendly Members, Finalizers, Static Class Members, Data Abstraction and Information Hiding. **Object-Oriented Programming:** Introduction, Superclasses and Subclasses, Protected Members, Using Constructor and Finalizers in Subclasses, Composition vs. Inheritance, Introduction to polymorphism, Dynamic method building, Final Methods and Classes, Abstract Superclasses and Concrete Classes**. String and Characters, Graphics, Exception Handling, Files and Stream, Java API, Utility Classes, 2D Graphics, GUI, Swing, Events.**

MAI 534 OBJECT ORIENTAL PROGRAMMING LAB
2 Hours/Week, 2 Credits

Object-Oriented Programming: Classes and objects, Constructors and destructor, Encapsulation of class members and methods, Manipulating objects. **Dynamic Memory Allocation:** Pointers to objects, Pointers and arrays, Call-by-reference and call-by-value. **Concept of Inheritance, Interface and Polymorphism:** Direct and indirect inheritance, Private and protected members of inherited class, Constructors and destructors under inheritance, Polymorphism, Abstract base classes. **Exceptions:** Error handing in program, Creating own exception. **Handing Files:**Input/Output streams, Processing files, Random access files.**Thread Programming:** Introduction to threads, Using threads to solve multi-tasking problems, Thread synchronization. **Client-Server programming:** Applet and Servlets, Introduction to JSP, Socket programming. GUI: Basic user interface design using Java swing.
Understanding Java Enterprise Level Works.

MAI 535 DYNAMICS
3 Hours/Week, 3 Credits

Kinematics of particles:Mechanical vibrations: Simple harmonic motion; application of the principle of conservation of energy; motion under a central force and conservative central force; principle of impulse and momentum; impulsive motion. **System of particles:** Applications of Newton's laws to the motion of a system of particles; effective forces; linear and angular momentum of a system of particles; conservation of momentum and energy for a system of particles; work energy principles. **Kinematics of rigid bodies:** Translation, rotation, velocity, acceleration and plane motion of a particle relative to a rotating frame; Corilis acceleration. **Plane motion of rigid bodies:** Equations of motion for a rigid body; motion of a rigid body in two dimensions; Euler's equation of motion of a rigid body about a fixed point.

Books Recommended:

1. *Synge and Griffiths:* Principle of Mechanics
2. *Beer, F. P. and Johnston, E. R.:* Vector Mechanics for Engineers
3. *Synge and Griffiths:* Principle of Mechanics
4. *Beer, F. P. and Johnston, E. R.:* Vector Mechanics for Engineers*:* Dynamics
5. *Khanna, M.L:* Dynamics
6. *Chorlton, F.:* Text Book of Dynamics

MAI 536 COMPUTATIONAL BIOLOGY
3 Hours/Week, 3 Credits

Understand basic concepts in bioinformatics; Understand bioinformatics is an interdisciplinary field that needs computer science, biology and other majors to collaborate; Receive an introduction and historical perspective to the field of bioinformatics; Learn the key methods and tools used in bioinformatics (a) Learn to use bioinformatics resources, including software, database search engines, and other Internet tools; (b) Learn to use data visualization tools in bioinformatics research; (c) Learn key computational procedures and algorithms to analyze structures and functions of biological systems; (d) Learn basic methods for digitizing, storing, processing and displaying information related to informatics applications. Be prepared to use bioinformatics in your own work. Build a solid foundation and ability to collaborate with others to solve bioinformatics problems.

Books Recommended:

1. *Durbin et al*: Biological Sequence Analysis
2. *Neil C. Jones and Pavel A. Pevzner:*An Introduction to Bioinformatics Algorithms
3. *Richard Durbin, Sean R. Eddy, Anders Krogh, Graeme Mitchison:*Biological Sequence Analysis
4. *Warren J. Ewens, Gregory R. Grant:*Statistical Methods in Bioinformatics: An Introduction
5. *John A. Jacquez*: Compartmental Analysis in Biology and Medicine, Second Edition
6. *E.K. Yeargers, R.W. Shonkwiler, and J.V. Herod:*An Introduction to the Mathematics of Biology

MAI 537 VIVA VOCE/PROJECT PRESENTATION
2 Credits

Faculty of Natural Science and Engineering
Department of Mathematics and Informatics

Syllabus for Final Master of Science in Mathematics (3 Semesters)

First Semester

Course Code No.	Course Title	Hours/Week Theory +Lab	Credits
MAI 611	Theory of Groups	3+0	3.0
MAI 612	Functional Analysis	3+0	3.0
MAI 613	Analytical Dynamics	3+0	3.0
MAI 614	Fluid Dynamics	3+0	3.0
	Total	12+0	12.0

Second Semester

Course Code No.	Course Title	Hours/Week Theory +Lab	Credits
MAI 621	Theory of Ring and Modules	3+0	3.0
MAI 622	Differential and Integral Equations	3+0	3.0
MAI 623	Discrete Mathematics	3+0	3.0
MAI 624	Operation Research	3+0	3.0
	Total	12+0	12.0

Third Semester

Course Code No.	Course Title	Hours/Week Theory +Lab	Credits
MAI 631	Lattice Theory and Boolean Algebra	4+0	4.0
MAI 632	Quantum Mechanics	4+0	4.0
MAI 633	Theory of Relativity	4+0	4.0
MAI 634	Differential Geometry	4+0	4.0
MAI 635	Metrology and Physical Oceanography	4+0	4.0
MAI 636	Computer Network	3+0	3.0
MAI 637	Computer Networks Lab	0+1	1.0
MAI 638	Project and Presentation	0+0	2.0
MAI 639	Viva Voce	0+0	2.0
	Total	23+1	28.0*

** A student has to complete a* minimum of ***16.0*** *credits. Course MAT 638 & MAT 639 are compulsory. Courses will be selected by the department*

Total Credits: 12.0 + 12.0 + 16.0 =40.0

Detailed Syllabus

MAI 611THEORY OF GROUPS
3 Hours/Week, 3 Credits

The class equation of a group;p-group and related theorems; Cauchy's theorem; commutator subgroup; characteristic subgroup; maximal subgroup. **Group action** on a set;doublecosets; Sylow's theorems with applications; groups of order pq; classification of groups of small orders (up to 15). **Normal/ subnormal series**;composition series; Jordan-Hölder theorem; Zassenhans's Butterfly Lemma. Solvable groups and nilpotent groups with related theorems.Direct products of groups with application. **Group extension**;splitting extension of groups; non-abelian group of order p^3. **Representaion of groups**; generalization of Cayley's theorem; permutational and matrix representation of finite groups; Maschke's theorem; Schur's lemma; Galois Theory.

Books Recommended:

1. *Hall, M.:* The Theory of Groups
2. *B. Bhattacharya, S.K. Jain and S.R. Paul:* Basic Abstract Algebra
3. *B. Baumslag and B. Chandler:* Theory and Problems of Group Theory
4. *Martin Burrow:* Representation Theory of Finite Groups

MAI 612 FUNCTIONAL ANALYSIS
3 Hours/Week, 3 Credits

Normed linear spaces.Banach spaces and examples.Quotient space of normedlinear spaces and its completeness, equivalent norms.Riesz Lemma. Basicproperties of finite dimensional normed linear spaces and compactness. Weakconvergence and founded linear transformation normed liner spaces of boundedlinear transformations, dual spaces with examples. Uniform boundedness theoremand some of its consequences. Open mapping and closed graph theorems.Hahn-Banach theorem for real linear spaces.Complex linear spacesand normed linear spaces.Reflexive spaces.Weak Sequential compactness.Compact Operators.Solvability of linear equations in Banach spaces. Theclosed Range Theorem.Inner product spaces.Hilbert spaces. Orthonormal sets. Bessel's inequality.
Complete orthonormal sets and Parseval's identity. Structure of Hilbert spaces.Projection theorem.Rieszrepresentation theorem.Adjoint of an operator on aHilbert space, Reflexivity of Hilbert spaces.Self-adjoint operators.Positiveprojection normal and unitary operators.Abstract variational boundary-valuebproblem.The generalized Lax-Milgram theorem.

Books Recommended

1. *A.E. Taylor:* Introduction to Functional Analysis
2. *I.J. Maddox:* Elements of Functional Analysis
3. *H.G. Heuser:* Functional Analysis
4. *W. Rudin:* Functional Analysis
5. *C.L. Devito:* Functional Analysis & Linear Operator Theory
6. *S.K. Berberian:* Measure and integration.Chelsea Publishing Company, NY. 1965.
7. *G.de Barra:*Measure Theory and integration. Wiley Eastern Ltd. 1981.

MAI 613 ANALYTICAL DYNAMICS
3 Hours/Week, 3 Credits

Kinematics of particles: Mechanical vibrations: Simple harmonic motion; application of the principle of conservation of energy; motion under a central force and conservative central force; principle of impulse and momentum; impulsive motion. System of particles: Applications of Newton's laws to the motion of a system of particles; effective forces; linear and angular momentum of a system of particles; conservation of momentum and energy for a system of particles; work energy principles. Kinematics of rigid bodies: Translation, rotation, velocity, acceleration and plane motion of a particle relative to a rotating frame; Coriolis acceleration. Plane motion of rigid bodies: Equations of motion for a rigid body; motion of a rigid body in two dimensions; Euler's equation of motion of a rigid body about a fixed point.

Books Recommended:

1. *Loney, S.L.*: Dynamics of a particle and Rigid bodies.
2. *Khanna, M.L*: Dynamics
3. *Beer, F. P. and Johnston, E. R.*: Vector Mechanics for Engineers: Dynamics
4. *Chorlton, F.*: Text Book of Dynamics

MAI 614 FLUID DYNAMICS
3 Hours/Week, 3 Credits

Viscous flow: Viscosity, stress analysis, relations between stress & strain, Navier-Stokes equations, dimensional analysis, Reynold's number, Reynold's principle of similarity, diffusion of vorticity & energy dissipation. Exact solution of Navier-Stokes equation: Steady flow between parallel planes, Couette flow, Hagen-Poiseuille flow, flow between two concentric rotating cylinders. Slow motion: Differential equations for slow motion, Stokes flow past a sphere, Lubrication. Laminar boundary layer theory: Boundary layer concepts & equations, boundary layer along a flat plate, skin friction, boundary layer thickness & separation, momentum & energy integral equations. Solutions of boundary layer equations: (a) Similar solutions & series solutions, (b) Exact solutions of the steady two dimensional equations for flow (i) past a flat plate, a cylinder & a wedge, (ii) in a convergent channel, (iii) in the wake of a flat plate at zero incidence. (c) Approximate solutions of Von-Karman & Polhausen method. Hydrodynamic stability: The general problem, method of small perturbations, Orr-Sommerfeld equations. Turbulent flow: Fundamentals- mean motion & fluctuations, turbulent stresses & Reynold's equations.

Books Recommended:

1. *H. Schlichting*: Boundary Layer Theory
2. *J. N. Hunt*: Incompressible Fluid Dynamics
3. *L. Rosenhead* : Laminar Boundary Layers
4. *Curle & Davies*: Modern Fluid Dynamics, Vol. I & II
5. *L.M. Milne-Thomson*: Theoretical Hydrodynamics
6. *F. Chorlton*: A Text Book of Fluid Dynamics
7. *G.K. Batchclor*: The Theory of Homogeneous Turbulence
8. *D. Meksyn*: New Methods in Laminar Boundary Layer Theory
9. *C.C. Lin*: The Theory of Hydrodynamics Stability
10. *M. D. Rai Singhania:* Fluid Dynamics

MAI 621 THEORY OF RINGS AND MODULES
3 Hours/Week, 3 Credits

Embedding of Rings**,** local rings, Artinian&Noetherianrings,Zorn's Lemma. Principal ideal domain (PID), unique factorization domain (UFD), Euclidean domains, polynomial rings over UFD, Divisibility in integral domain, Factorization theory for polynomial domains.Homomorphism of rings, isomorphism theorems of rings, quotient rings, rings of fractions & embedding theorems. Sum & direct sum of ideals, maximal & prime ideals, nilpotent ideals.**Integral domain and field** with related theorems; characteristic of a field. Module and Module homeomorphisms, Sequences and exact Sequences; Projection and injective modules.

Books Recommended:

1. *John R. Durbin:* Modern Algebra an introduction
2. *I.N. Herstein:* Topics in Algebra
3. *Dean, R.A.:* Elements of Abstract Algebra
4. *Hiran Paley and Paul M. Wrichsel:* A First Course in Abstract Algebra
5. *D.G. Northcott:* Ideal Theory

MAI 622 DIFFERENTIAL AND INTEGRAL EQUATIONS
3 Hours/Week, 3 Credits

General concepts: Linearity, well-posedness, initial and boundary value problems. **Diffusion:** The heat equation, existence and uniqueness of solutions, fundamental solutions, symmetric random walks, and Brownian

motion. **The Laplace/Poisson Equation:** Properties of harmonic functions; Representation formulae for solutions in terms of potential functions, including both single and double layer potentials. **First order equations and scalar conservation laws:** Traffic dynamics, the method of characteristics, integral (weak) solutions, the formation of shocks. **Waves and Vibrations:** Fundamentals of wave propagation; the classical formulae of d'Alembert, Kircho, and Poisson. **Nonlinear wave equations:** the KdV and non-linear Schrödinger equations, solutions, applications to water waves and nonlinear optics. **Weak solutions and regularity theory:** An introduction to distributions, Sobolev spaces, and weak solutions and regularity theory for elliptic equations.

Books recommended:

1. *L. Evans:* Partial Differential Equations, American Mathematical Society, 2010.
2. *S.Salsa:* Partial Differential Equations in Action: From Modeling to Theory".
3. *W. Strauss:* Partial Differential Equations, An Introduction".
4. *M. Gockenbach:* Partial Differential Equations", Analytical and Numerical Methods".
5. *Ockendon, Howison, Lacey, and Movchan:* Applied Partial Differential Equations".
6. *J. Duistermaat and J. Kolk, Birkhuser:* Distributions: Theory and Applications".

MAI 623 DISCRETE MATHEMATICS
3 Hours/Week, 3 Credits

Number systems: Numbers with different bases; their conversions and arithmetic operations; normalized scientific notation. **Application of Logic:** Logic gates; minimization of Boolean expressions; Karnaugh maps; Karnaugh map algorithm. **Graphs:** Introduction; the bridges of Königsberg; representing graphs and graph isomorphism; connected graph; planar graph; path and circuit; shortest path algorithm; Eulerian path; Euler's theorem; graph coloring. **Application of graphs:** Trees; tree traversal; trees and sorting; cryptology coding; decoding; encoding. Huffman code; error correcting codes; Hamming code; spanning tree; minimum spanning trees; Kruskal's algorithm. **Modeling computation:** Languages and grammars; finite state machine; language of finite state machine; accepted and non-accepted finite state machine; turing machine.

Books Recommended:

1. *Rosen, K.H.:* Discrete Mathematics and its application, *McGraw-Hill International edition (4th edition) 1999*
2. *Biggs, N. L.:* Discrete Mathematics, Clarendon press, Oxford (2nd Print.) 1987
3. *Cameron, P. J. and J. H. Van Kint:* Graph Theory, Coding Theory and Block Designs C.U.P 197
4. *Bose, R. C. and B. Manvel:* Introduction to Combinatorial Theory J. Willey 1984

MAI 624 OPERATION RESEARCH
3 Hours/Week, 3 Credits

Basics of Operations Research: Development, definition, characteristics, necessity, classification schemes of models. Linear Programming : Scope, advantage and limitations of Linear programming, application, general mathematical formulation, graphic solution of two variables Linear programming problems, canonical and standard forms, simplex method. Transportation model : Definition of transportation problem, mathematical formulation and solutions of transportation models, Least-time transportation problem.Assignment model : Definition of assignment model, mathematical formulation and solutions of assignment problems.Network Model: Network definitions, shortest route problem, minimal spanning tree problem, maximal-flow problem.Theory of Games : Competitive games, characteristics, zero-sum and non-zerosum game, maximin and minimax principle, solutions of 2x2, 2xn and mx2 games, matrix reduction by dominance.Dynamic Programming : Investment problem, production scheduling problem, cargo loading problem, equipment replacement problem. Non-linear programming : Unconstrained problem, Lagrange multipliers method, Khun-Tucker conditions, quadratic programming.

Books recommended:

1. *Hamdi A Taha:* Operations Research.
2. *P.K Gupta &D.S Hira:* Operations Research.
3. *Hillier & Lieberman*; Introduction to Operations Research.
4. *P.K Gupta &Manmohan:* Linear Programming & Theory of Games.

MAI 631 LATTICE THEORY AND BOOLEAN ALGEBRA
4 Hours/Week, 4 Credits

Ordered sets: Ordered sets; diagrams; constructing and deconstructing ordered sets; down-sets and up-sets; order preserving map. **Lattices and complete lattices:** Lattices as ordered sets; lattices as an algebra; sublattices and convex sublattice of a lattice; product lattice; ideals and filters; prime ideals and maximal ideals; Zorn's Lemma; complete lattice; chain conditions and completeness; join irreducible elements. **Modular, distributive and Boolean lattices:** Modular and distributive lattices and its characterizations; ideals; prime ideals and maximal ideals for modular and distributive lattices; Stone's separation theorem; Boolean lattice and Boolean algebra. **Congruences and lattice homomorphism:** Introducing congruence; congruences and diagrams; the congruences lattice; factor lattice; lattice homomorphism and related theorems. **Representation:** Finite Boolean algebras and power set algebras; finite distributive lattice and finite ordered sets in partnership; Stone's representation theorem for Boolean algebras; Priestley's representation theorem for distributive lattices; distributive lattices and Priestley spaces in partnership.

Books Recommended:

1. *Balbs, R. and Dwinger, P.:* Distributive lattices, *University of Missouri Press, 1974*
2. *Birkhoff, G.:* Lattice Theory, *3rd edition, Coll. Publ., XXV, American Mathematical Society, 1967.*
3. *Davey, B.A. and Priestley, H.A.:* Introduction to Lattices and Order, *2nd edition, Cambridge University Press, 2002.*
4. *Grätzer, G.:* GeneralLattice Theory, *2nd edition, BirkhäuserVerlag, 1998.*

MAI 632 QUANTUM MECHENICS
4 Hours/Week, 4 Credits

Physical basis of quantum mechanics: Blackbody Radiation, Planck's law. Einstein's photon theory. Compton effect, Principel of Uncertainty, Rutherford atom model &Bohrs theory, de-Broglie waves & wave packets. waves Mechanical Concepts: Schrödinger wave equation, physical interpretation & boundary Conditions of wave function. Expectation value &Ehven-feosts theorem, finit potential step, one dimensional square well potential energy eigenvalues & energy eigenfunctions, Box normalization, Closure property, liner harmonic oscillator, Spherically symmetry potential & three dimensional square well potential.

Books Recommended:

1. *Beiser, A.*, Concepts of Modern Physics.
2. *Dirac, P.M.*, Quantum Mechanics
3. *Sehig L.I*., Quantum Mechanics
4. *Powell &Crosemann*Quantum Mechanics

MAI 633 THEORY OF RELATIVITY
4 Hours/Week, 4 Credits

Introduction, Galilean transformations, Michelson-Morley experiment, the postulates of the theory of special relativity, the relativity of simultaneity, derivation of the Lorentz transformation equations, the transformation properties of velocity, acceleration, momentum, energy mass and force, the equivalence of mass and energy. Minkowski space-time 'continuum', relativity of electromagnetism, four dimensional expression of Maxwell's equations, the clock paradox.Introduction,Principle of equivalence, Principle of covariance, Einstein's field equation, Einstein's law of gravitation, Schwarzachild's solution of Einstein's equation, the ideal of unified field theory. The three crucial tests of the general theory of relativity, the black hole concept.The cosmological principle, The Robertson-walker metric, the Friedman models, the state cosmology, the standard model cosmology.

Books recommended:

1. *Moshe Carmeli: Classical fields*: General Relativity and Gauge Theory
2. *Sean M. Carrol*: Lecture notes on General Relativity
3. *Robert resnick:* Introduction to Special relativity
4. *J. V. Narlikar:* General relativity and cosmology
5. *Tolman*: Relativity, thermodynamics & cosmology
6. *Satyaprakash:* Relativistic mechanics
7. *S. Wsinberg*: Gravitation & Cosmology.

MAI 634 DIFFERENTIAL GEOMETRY
4 Hours/Week, 4 Credits

Curves in space: Concepts of space curves and their applications, tangent, normal and bi-normal, osculating plane, rectifying plane and normal plane, curvature and torsion, Serret-Frenet formulae, helices, evolutes and involutes.**Elementary theory of surfaces: First** fundamental form, second fundamental form, Euler's theorem, Gaussian curvature, mean curvature, the equation of Gauss–Weingarten, the theorem of Gauss and equation of Codazzi, developable surface, minimal surface, rulled surface.Mapping of surfaces: **Conformal mapping, geodesic mapping, isometric mapping.**

Books Recommended:

1. *T. J. Willmores*: Differential Geometry
2. *W. Klingenberg :* A course in Differential Geometry
3. *C. E. Weatherburn :* Differential Geometry in three dimension

MAI 635 METROLOGY AND PHYSICAL OCEANOGRAPHY
4 Hours/Week, 4 Credits

Struture of Atmoshere: Barotropic and Baroclinic atmosphere, earth's albedo, Green-house effect, adiabatic rates of cooling. International cloud types in the tropics, cloud genera. LCL, MCL, LFC and CCL.scale analysis, Fundamental forces (pressure gradient force, gravitational force, frictional or viscous force, centrifugal force, effective force, coriolis force). **Equations of motion**, Total differentiation following the fluid, total differentiation of a vector in rotating system, vectorial form of momentum equation in rotating coordinates, Continuity equation, continuity equation in isobaric coordinates, Equation of motion with viscosity, Geostropic approximation, Hydrostatic approximation.**Elementary application of the horizontal equation of motion** :Geostropic wind, Gradient wind, Thermal wind, Isentropiccoordinares , Cyclostropic flow. Local wnid systems : Land and breeze, mountain and velly wind, drainage winds, Foehn and chinook, worm winds and cold winds.**Circulation**: Thermohaline and wind driven circulation, effect of fronts and frontal waves on circulation, Influence on seasons on circulation , Influence of currents on weather, Cyclones and anticyclones, tropical cyclones (regional names), Roles or onset of convection (parcel method), stommel. Temperature, salinity and density.**Responce of upper ccean to winds**: Ekman layer at the sea surface, Ekman number, Influence of stability in Ekman layer, Ekman mass transport.

Field works:
Books recommended:

1. *J R Halton:* An introduction to dynamic meteorology.
2. *Petterssen:* Introduction to Meteorology.
3. *R. A. Browne:* Fluid mechanics of the atmosphere.
4. *RH. Stewart:* Introduction to Physical Oceanography.

MAI 636 COMPUTER NETWORS
3 Hours/Week, 3 Credits

Introduction: Introduction to Computer Networks, Network Goals, Applications of Networks, Network Structure, Network Architectures, The OSI Reference Model, Data Transmission in the OSI Model, OSI Terminology, The ARPANET. **Local Area Network :**LAN Technology - Architecture, Topology. **Wired LANs:** Ethernet and Fast-Ethernet, Token Ring, FDDI.**Wireless LANs:** IEEE 802.11, Bluetooth. Backbone Networks, Virtual LANs. **Wide Area Network:** SONET, Virtual Circuit Networks - Frame Relay, ATM and ATM LANs. **Network Layer:** Logical Addressing,**Internet Protocol:** Internetworking, Routing Protocol, IPv4 and IPv6. **Address Mapping, Error Reporting and Multicasting:** ICMP, IGMP, ICMv6. Delivery, Forwarding and Routing.**Transport Layer:** Process-to-Process delivery, Transport Services, Protocol mechanisms, TCP, UDP, SCTP, Congestion and QoS. **Application Layer:** Domain Name System, Abstract Syntax Notation One (ASN.1), Network Management - SNMPv2, Electronic mail - SMTP and MIME, Uniform Resource Locator (URL) and Universal Resource Identifier (URI), Hypertext Transfer Protocol (HTTP).**Wireless and Mobile Networking**: Wireless Networking: Issues and Trends, Wireless Physical Layer Concepts , Wireless Cellular Networks, Mobile IP - IPv4, IPv6, TCP over Wireless, Ad Hoc Networks: Issues and Routing, Wireless Sensor

Networks, Wireless Mesh and Multi-Hop Relay Networks, Wireless Network Security, Energy Management in Ad Hoc Wireless Networks.**Network Security:** Security requirements and attacks, Privacy with conventional encryption, Message Authentication and Hash functions, Public-key encryption and digital signatures, Ipv4 and Ipv6 security.

MAI 637 COMPUTER NETWORKS LAB
1 Hour/Week, 1 Credit

Sub netting and designing a network using Packet Tracer. Analysis of the TCP/IP behavior. Packet analysis. Server configuration: DHCP, SMTP, FTP, Web. Switch and Router Configuration, Socket Programming.

MAI 638 PROJECT AND PRESENTATION
2 Credits

MAI 639 VIVA VOCE
2 Credits