SYLLABUS
M. Sc. (Mathematics) (CBCS)
With effect from June – 2017 (Sem – 3 and Sem – 4)
**DEPARTMENT OF MATHEMATICS**

**Course Structure and Scheme of Examination**  
**For Choice based Credit System (CBCS)**  
(With effect from June – 2017 (Sem – 3 and Sem – 4))

### Semester 3

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Title of the Course</th>
<th>Course Credits</th>
<th>No. of Hrs. Per Week</th>
<th>Weightage For Internal Examination</th>
<th>Weightage For Semester End Examination</th>
<th>Total Marks</th>
<th>Duration Of Semester end Exam in hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMT – 3001</td>
<td>Prog. In C &amp; Numerical Methods</td>
<td>4</td>
<td>4</td>
<td>30</td>
<td>70</td>
<td>100</td>
<td>3</td>
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<tr>
<td>CMT – 3002</td>
<td>Functional Analysis</td>
<td>4</td>
<td>4</td>
<td>30</td>
<td>70</td>
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<tr>
<td>CMT – 3003</td>
<td>Number Theory 1</td>
<td>4</td>
<td>4</td>
<td>30</td>
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<td>100</td>
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<tr>
<td>CMT – 3004</td>
<td>Discrete Mathematics</td>
<td>4</td>
<td>4</td>
<td>30</td>
<td>70</td>
<td>100</td>
<td>3</td>
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<tr>
<td>EMT – 3011 OR EMT – 3021</td>
<td>Differential Geometry OR Sp. Theory of Relativity and Tensor Analysis</td>
<td>4</td>
<td>4</td>
<td>30</td>
<td>70</td>
<td>100</td>
<td>3</td>
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<tr>
<td>PMT – 3001</td>
<td>Practical ( Comp. Applications )</td>
<td>4</td>
<td>8</td>
<td>-</td>
<td>100</td>
<td>100</td>
<td>3</td>
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<td><strong>Total</strong></td>
<td></td>
<td><strong>24</strong></td>
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<td></td>
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<td><strong>600</strong></td>
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## Semester 4

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Title of the Course</th>
<th>Course Credits</th>
<th>No. of Hrs. Per Week</th>
<th>Weightage For Internal Examination</th>
<th>Weightage For Semester end Examination</th>
<th>Total Marks</th>
<th>Duration Of Semester end Exam in hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMT – 4001</td>
<td>Linear Algebra</td>
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<td>4</td>
<td>30</td>
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<tr>
<td>CMT – 4002</td>
<td>Integration Theory</td>
<td>4</td>
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<tr>
<td>CMT – 4003</td>
<td>Number Theory 2</td>
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<td>4</td>
<td>30</td>
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<td>CMT – 4004</td>
<td>Graph Theory</td>
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<td>EMT – 4011</td>
<td>Financial Mathematics</td>
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<td>OR EMT – 4021</td>
<td>General Theory of Relativity &amp; Cosmology</td>
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<tr>
<td>OR EMT – 4031</td>
<td>Commutative Ring Theory</td>
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<td>30</td>
<td>70</td>
<td>100</td>
<td>3</td>
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<tr>
<td>OR EMT – 4041</td>
<td>Introduction to Mathematical Cryptography</td>
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<tr>
<td>EMT – 4011</td>
<td>Practical (Numerical Methods with Programming)</td>
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<td>8</td>
<td>-</td>
<td>100</td>
<td>100</td>
<td>3</td>
</tr>
<tr>
<td>PMT – 4001</td>
<td>Practical (Numerical Methods with Programming)</td>
<td>4</td>
<td>8</td>
<td>-</td>
<td>100</td>
<td>100</td>
<td>3</td>
</tr>
</tbody>
</table>

**Total** | **24** | **600** |

* CMT – Core Subject, EMT – Elective Subject, PMT - Practical

- Passing Standard is 40% in Internal as well as in external examinations for all the courses.
- Student will have to clear internal as well as external examinations. (i.e. internal examination with minimum 40% and external examination with minimum 40% is compulsory) and student can earn credits mentioned against each course.
- There will be two internal examinations in each course and average of both the examinations will be considered.
M.Sc. SEMESTER 3
Sub. Code: CMT-3001
Core Sub. 1: Prog. In C & Numerical Methods

Unit 1
Constants, variables, C tokens, keywords, identifiers, declaration of variables, operations and expressions, managing input and output operations and formatted output.

Unit 2
Decision making and branching statements like – if then else, if then switch, go to and loops, jump in loops

Unit 3
One or two dimensional array and their initialization, handling of character strings, User defined functions, structure, unions, pointers and file management in C.

Unit 4

Unit 5
Solution of simultaneous algebraic equations introduction, Gauss elimination method, ill conditioned equations, refinement of the solution obtained by Gaussian elimination, Gauss-Seidel iterative method, comparison of direct and iterative methods. Interpolation introduction, Lagrange interpolation, difference tables.

Reference Books:-
M.Sc. SEMESTER 3

Sub. Code: CMT-3002
Core Sub. 2: Functional Analysis

Unit 1
Normed linear spaces, Banach spaces, Quotient space of a normed linear spaces and its completeness, bounded linear transformations, normed linear spaces of bounded linear transformations, dual spaces with examples.

Unit 2
Weak convergence in normed linear spaces, equivalent norms, Riesz lemma, Basic properties of finite dimensional normed linear spaces and compactness, weak convergence in normed linear spaces, reflexive spaces.

Unit 3
Uniform Boundedness theorem and its consequences, open mapping theorem, closed graph theorem, Hahn-Banach theorem for normed linear spaces, compact operations, solvability of linear equations in Banach spaces, the closed range theorem.

Unit 4
Inner product space, Hilbert space, orthonormal sets, Bessel’s inequality, complete orthonormal sets, Parseval’s identity, structure of Hilbert spaces, projection theorem, Riesz representation theorem for bounded linear functional on Hilbert spaces, reflexivity of Hilbert spaces.

Unit 5

This course is covered by relevant portions from the text “Introductory Functional Analysis with Applications”, John Wiley and Sons, Newyork, 1978.

Reference Books:-

M.Sc. SEMESTER 3
Sub. Code: CMT-3003
Core Sub. 3: Number Theory - 1

Unit 1
Divisibility, Prime Numbers.

Unit 2
Congruences, Linear Congruences and their solutions, Chinese Remainder Theorem, Degree of a Congruence relation and related theorems.

Unit 3
Primitive rules and related Theorems and Examples, Related Congruences and their solutions.

Unit 4
Largest Integer functions and related results, Arithmetic Functions.

Reference Books:-

1. THE THEORY OF NUMBERS (Authors: Ivan Niven, Herbert S. Zuckerman, Hugh L. Montgomery)
2. NUMBER THEORY (Authors: Z. I. Borevich and I. R. Shafarevich)
3. AN INTRODUCTION TO THE GEOMETRY OF NUMBERS (Authors: J. W. S. Cassels)
4. HISTORY OF THE THEORY OF NUMBERS (Authors: L. E. Dickson)
M.Sc. SEMESTER 3

Sub. Code: CMT-3004
Core Sub. 3: Discrete Mathematics

Unit 1
Semigroups and Monoids, Homomorphism of Semigroups and Monoids, Products and Quotients of semigroups, Fundamental theorem of Homomorphism of Semigroups, Subsemigroups and submonoids. Relations, Transitive Closure and Warshall's Algorithm

Unit 2
Lattices as partially ordered sets, Properties of Lattices, Lattices as algebraic systems, Sublattices, Direct product and Homomorphisms of Lattices, Some Special Lattices, Finite Boolean Algebras, Functions on Boolean Algebras, Karnaugh Map Method.

Unit 3
Languages and Grammars, Finite State Machines, Semigroups, Machines and Languages, Moore Machines, Simplification of Machines, Moore Machines and Regular Languages, Kleene's Theorem, Pumping Lemma, Nondeterministic Finite State Automata.

Unit 4
Propositions and Logical operations, Truth tables, Conditional statements and Logical Equivalence, Quantifiers, Rules of Inference.

Unit 5
Elements of Coding Theory, The Hamming Metric, The Parity-Check and Generator Matrices, Group Codes: Decoding with Coset Leaders, Hamming Matrices.

Reference Books:-

M.Sc. SEMESTER 3  
Sub. Code: EMT-3011  
Elective Sub. 1: Differential Geometry

Unit 1  

Unit 2  
Local theory of surfaces – parametric patches on surface. First Fundamental form and arc length.

Unit 3  
Normal curvature, Geodesic curvature and Gauss formulae, Shape operator $L^p$ of a surface at a point, vector field a curve.

Unit 4  
Second and third fundamental forms of a surface, Weingarten map, principal curvatures, Gaussian curvature, mean and normal curvatures.

Unit 5  
Riemannian curvatures, Gauss theorem of Egregium, isometry groups and fundamental existence theorem for surfaces.

Reference Books:-
M.Sc. SEMESTER 3

Sub. Code: EMT-3021
Elective Sub. 2: Special Theory of Relativity and Tensor Analysis

Unit 1
- Newtonian Relativity (Galilean Transformation)
- Lorentz transformation
- Michelson – Morley experiment

Unit 2
- Length Contraction
- Time dilation
- Relativistic law of addition of velocities
- Equivalence of mass and energy
- Problems related to above topic

Unit 3
- Tensor Algebra
- Vector field in affine and Riemann space

Unit 4
- Christoffel Symbols
- Tensor Analysis

Books:-
1. Related topics of Unit 1 and Unit 2 will be covered from the book “Special Relativity” by W. Rindler. Pub.: Oliver and Bosed.

Reference Books:-
1. The Special theory of Relativity – Benerji and Benarjee. Pub.: Prentice Hall India Ltd.
M.Sc. SEMESTER 4

Sub. Code: CMT – 4001
Core Sub. 1: Linear Algebra

Unit 1
The Algebra of linear transformations, Characteristic roots, Matrices.

Unit 2
Canonical Forms: Triangular Form, Nilpotent linear transformations, Invariants of a nilpotent linear transformation.

Unit 3
Canonical Forms: The primary decomposition theorem, Jordan Form, Rational canonical Form.

Unit 4
Trace and Transpose, Determinants, Cramer's rule, Cayley-Hamilton theorem, a quick review of inner product spaces, Hermitian, Unitary and Normal transformations.

Unit 5
Real Quadratic Forms, Sylvester's law of inertia, Bilinear Forms, Symmetric Bilinear Forms, Skew-Symmetric Bilinear Forms, Groups preserving Bilinear Forms.

Reference Books:-

1. N. Herstein, Topics in Algebra, 2/e, Wiley Publication, 1975. (For Unit 1 to Unit 4)
2. K. Hoffman & R. Kunze, Linear Algebra, 2/e, Prentice Hall of India, New Delhi, 1992. (For Unit 5)
M.Sc. SEMESTER 4

Sub. Code: CMT-4002
Core Sub. 2: Integration Theory

Unit 1
Measures spaces, Measurable functions, integration, general convergence theorems.

Unit 2
Signed measures, Positive sets, negative sets, null sets and their properties, Hahn-Decomposition Theorem, mutually singular measures, Jordan-Decomposition for a signed measure.

Unit 3
Measure absolutely continuous with respect to another measure, Radon-Nikodym theorem for measure and for signed measure, Lebesgue decomposition theorem, outer measure on a set, algebra of sets, Caratheodary extension theorem.

Unit 4
Product measure, structure of measurable sets in the product measure space, Fubini’s theorem, Fonelli’s theorem, $L^p(k)$ and Riesz Representation theorem for bounded linear functional on $L^p(k)$, Baire measure on the real line, Lebesgue Stieltjes integral of Borel measurable function with respect to monotonically increasing function.

Unit 5
Locally compact Hausdorff spaces, Baire and Boral measures, continuous functions with compact support, regularity of measures on locally compact Hausdorff spaces, integration of continuous functions with compact support, Riesz Markov-theorem.

Reference Books:-

M.Sc. SEMESTER 4

Sub. Code: CMT-4003
Core Sub. 3: Number Theory - 2

Unit 1
Farey Fractions, Irrational numbers, Farey Fractions and Approximation of Irrationals by Rationals.

Unit 2
Continued Fractions (Finite and Infinite), Approximations of Irrationals by Rationals, Hurwitz’s Theorem.

Unit 3
Periodic Continued Fractions, Pell’s Equations.

Unit 4
Diophantine Equations, Pythagorean Triples, Some other Examples.

Reference Books:-

1. THE THEORY OF NUMBERS (Authors: Ivan Niven, Herbert S. Zuckerman, Hugh L. Montgomery)
2. NUMBER THEORY (Authors: Z. I. Borevich and I. R. Shafarevich)
3. AN INTRODUCTION TO THE GEOMETRY OF NUMBERS (Authors: J. W. S. Cassels)
4. HISTORY OF THE THEORY OF NUMBERS (Authors: L. E. Dickson)
M.Sc. SEMESTER 4
Sub. Code: CMT-4004
Core Sub. 4: Graph Theory

Unit 1
Graph, degree of a vertex, path, circuit, connected and disconnected graphs, components, adjacency and incidence matrix.

Unit 2
Euler circuits, Euler graph, Hamiltonian Paths and circuits.

Unit 3
Trees and their characterizations, Cut-Sets and Cut-Vertices

Unit 4
Planar Graphs, Kuratowski’s two graphs, Different representation of planarity, Detection of Planarity.

Unit 5
Coloring of graphs, chromatic number, chromatic polynomial, the four color problem matching

Unit 6
Graph theory in Operation Research: transport networks, extension of Max-Flow, Min-Cut theorem, minimal cost flows.

The syllabus is a covered from chapters 1 & 2 ( for quick review ), Chapter 3 (3.1 to 3.6), 4 (4.1 to 4.6), 5 (5.1 to 5.5), 8 (8.1 to 8.4) and 14(14.1 to 14.3) from “Graph theory with application to Engineering & computer science” by Narsingh Deo, Prentice – Hall of India New Delhi.

Reference Books:-
M.Sc. SEMESTER 4

Sub. Code: EMT-4011
Elective Sub. 1: Financial Mathematics

Unit 1
Basic option theory, Types of options, interest rates and present value, Asset price

Unit 2
Random walk, Ito’s lemma, Black-Sholes model, arbitrage theorem, option values

Unit 3
The Black – Sholes formulae, hedging the practice, partial differential equations and Black – Sholes formulae.

Unit 4
Variations in Black – Sholes model to include dividends as well as forward and future contracts, American Options.

Reference Books:-
M.Sc. SEMESTER 4

Sub. Code: EMT-4021
Elective Sub. 2: General Theory of Relativity & Cosmology

**Unit 1: The Gravitational Field Equation in Empty Space**
- Criteria for the field equations.
- The Riemann curvature tensor and its properties.
- The Bianchi identities.

**Unit 2: The Schwarzschild solution and its consequences, experimental tests of General Relativity**
- The Schwarzschild solution
- The Schwarzschild solution in isotropic co-ordinates
- The General Relativistic Kepler problem and the perihilc shift of Mercury.
- The trajectory of light ray in Schwarzschild field.
- The Schwarzschild radius, Kruskal co-ordinates and the Black hole.

**Unit 3: The Kerr Solution**
- The Schwarzschild and Kerr solution
- The Kerr solution and Rotation.

Relevant topics will be covered from “Introduction to General Relativity”. – By R. Adees, M. Bazin & M. Schiffer.

**Reference Books:-**
M.Sc. SEMESTER 4
Sub. Code: EMT – 4031
Elective Sub. 3: Commutative Ring Theory

Unit 1
Rings and ring homomorphisms, Ideals, Quotient rings, Zero-divisors, Nilpotent elements, Units, Prime ideals and Maximal ideals, Nilradical and Jacobson radical, Operations on ideals, Extension and contraction.

Unit 2
Modules and module homomorphisms, Submodules and quotient modules, Operation on Submodules, Direct sum and product, Finitely generated modules, Exact sequences, Rings and modules of fractions, Local properties, Extended and contracted ideals in rings of fractions.

Unit 3

Unit 4
Noetherian modules, Artinian modules, Composition series of a module, Noetherian rings, Hilbert's basis theorem, Primary decomposition in Noetherian rings.

Unit 5
Artin rings, Structure theorem for Artin rings, Discrete Valuation rings, Dedekind domains, fractional ideals.

Text Book:-

Introduction to Commutative Algebra by M. F. Atiyah and I. G. Macdonald, Addison-Wesley Publishing Company, 1969. (Chapter 1 to Chapter 9)

Reference Books:-
M.Sc. SEMESTER 4
Sub. Code: EMT – 4041
Elective Sub. 4: *Introduction to Mathematical Cryptography*

**Unit 1**
Modular arithmetic, the language of rings and fields, finding multiplicative inverses in $\mathbb{Z}/n$, Fermat’s little theorem, the primitive root theorem for $\mathbb{F}_p$.

**Unit 2**

**Unit 3**
Euler's formula for powers in $\mathbb{Z}/(pq)$, and the RSA cryptosystem. How to find large primes: the Prime Number Theorem and some Monte Carlo Methods (e.g. the Miller-Rabin test). Algorithms for factoring large integers: Pollard's $p - 1$ algorithm.

**Unit 4**
Elliptic curves. Smoothness, the point at infinity, the group law. Using elliptic curves for cryptography. Classification of finite abelian groups. Integer factorization using elliptic curves (Lenstra's method).

**Text Book:-**
*An Introduction to Mathematical Cryptography* by Jeffrey Hoffstein, Jill Pipher & Joseph H. Silverman, Springer – Verlag, 2008. (Chapters 1, 2, 3 & 5)

**Reference Books:-**