University of Pune
Board of Studies in Mathematics
Syllabus for T. Y. B. Sc.(Mathematics)

	Semester- III		Semester-IV
MT 331 :	Set Theory and Logic	MT 341	Metric Spaces
MT 332 :	Real Analysis	MT 342	Complex Analysis
MT 333 :	Problem Course on MT 331 and MT 332	MT 343	Problem Course on MT 341 and MT 342
MT 334 :	Group Theory	MT 344	Ring Theory
MT 335 :	Ordinary Differential Equations	MT 345	Partial Differential Equations
MT 336 :	Problem Course on MT 334 and MT 335	MT 346	Problem Course on MT 344 and MT 345
	Any Two out of six courses		**Any Two out of six courses**
MT 337 A.	Operations Research	MT 347 A.	Optimization Techniques
MT 337 B.	Lattice Theory	MT 347 B.	Improper Integrals and Laplace Transforms
MT 337 C.	C - Programming-I	MT 347 C.	C - Programming-II
MT 337 D.	Differential Geometry	MT 347 D.	Dynamics
MT 337 E.	Combinatorics	MT 347 E.	Lebesgue Integration
MT 337 F.	Number Theory	MT 347 F.	Computational Geometry
MT 338:	Practical based on papers selected from 337 A to 337 F	MT 348	Practical based on papers selected from 347 A to 347 F

MT 331: Set Theory and Logic

Sets and Relations : **[8 Lectures]**
Cantor's concept of a set, Intuitive set theory, Inclusion, Operations for sets, Algebra of sets, Equivalence relations, Functions, Composition and Inversion of Functions, Operations for collections of sets, Ordering relations, Power sets, Numerical Equivalence of sets.

Natural Number sequence : **[12 Lectures]**
Induction and Recursion, Cardinal numbers and Cardinality, Cardinal arithmetic, Countable and Uncountable sets, Schroeder-Bernstein Theorem (without proof), Paradoxes of Intuitive set theory, Russell's Paradox.

Logic : **[4 Lectures]**
Statement calculus (Sentential connectivities, Truth tables, Validity, Consequence, Applications), Predicate Calculus (Symbolizing every day language, Formulation, Validity, Consequence).

Basic Logic : **[6 Lectures]**
(Revision) Introduction, proposition, truth table, negation, conjunction and disjunction, Implications, biconditional propositions, converse, contra positive and inverse propositions and precedence of logical operators.

Propositional equivalence : **[6 Lectures]**
Logical equivalences, Predicates and quantifiers : Introduction, Quantifiers, Binding variables and Negations.

Methods of Proof: **[12 Lectures]**
Rules of inference, valid arguments, methods of proving theorems; direct proof, proof by contradiction, proof by cases, proofs by equivalence, existence proofs, Uniqueness proofs and counter examples.

Text Books:

1. Set Theory and Logic, Robert R. Stoll, Errasia publishers, New Delhi. Sections 1.1 to 1.10, 2.3, 2.4, 2.5
2. Discrete Mathematics and its Applications, K.H. Rosen, Tata McGraw, New Delhi. Chapter 4

Reference Books :

1. Symbolic Logic, I.M. Copi, Fifth Edition, Prentice Hall of India, 1995.
2. Naive Set Theory, P.R. Halmos, 1974.

MT 332: Real Analysis

1. **S**equences of real numbers : **[10 Lectures]**
   Definition of sequence and subsequence, Limit of a sequence, convergent sequences, Limit superior and Limit inferior, Cauchy sequences.

2. **S**eries of Real numbers : **[10 Lectures]**
   Convergence and divergence of series of real numbers, alternating series, Conditional and absolute convergence of series, test of absolute convergence (Ratio test and Root test), series whose terms form a non-increasing sequence.

3. **R**iemann integral : **[14 Lectures]**
   Sets of measure zero, Definition and existence of a Riemann integral, properties of Riemann integral, Fundamental theorem of integral calculus, Mean value theorems of integral calculus.

4. **S**equence and series of functions : **[14 Lectures]**
   Pointwise and uniform convergence, sequence of functions, consequences of uniform convergence, convergence and uniform convergence of series of functions, integration and differentiation of series of functions.

Text Books:

1. R.R. Goldberg - Methods of Real Analysis (Oxford and IBH Publications (1970)).
   Ch. 2 Art. 2.1, 2.9, 2.10.
   Ch. 3 to 3.3, 3.4A, 3.4B, 3.6F, 3.6G, 3.7.
   Ch. 7 Art. 7.1 to 7.4, 7.8 to 7.10.
   Ch. 9 Art. 9.1 to 9.5

Reference Books:

1. D. Somasundaram, B. Choudhary - A first course in Mathematical Analysis, Narosa Publishing House, 1997.

2. Robert, G. Bartle, Donald Sherbert - Introduction to real analysis, Third edition, John Wiley and Sons.

3. Shantinarayan and Mittal - A course of Mathematical Analysis, Revised edition, S. Chand and Co.(2002).

4. S.C. Malik and Savita Arora - Mathematical Analysis , New Age International Publications,Third Edition,(2008).

MT 334: Group Theory

Groups **[12 Lectures]**

1. Groups : definition and examples.
2. Abelian group, finite group, infinite group.
3. Properties of groups.
4. Order of an element - definition, examples, properties.
5. Examples of groups including $\mathbb{Z}, \mathbb{Q}, \mathbb{R}, \mathbb{C}$, Klein 4-group, Group of quaternions, S^1(= the unit circle in $\mathbb{C}$), $GL_n(\mathbb{R}), SL_n(\mathbb{R}), O_n$(=the group of $n \times n$ real orthogonal matrices), B_n(= the group of $n \times n$ nonsingular upper triangular matrices), and groups of symmetries of plane figures such as D_4 and S_3.

Subgroups **[10 Lectures]**

1. Subgroups : definition, necessary and sufficient conditions, examples on finding subgroups of finite groups, union and intersection of subgroups.
2. Subgroup generated by a subset of the group.
3. Cyclic groups : definition, examples of cyclic groups such as $\mathbb{Z}$ and the group μ_n of the n-th roots of unity, properties :
   (a) Every cyclic group is abelian.
   (b) If $G = (a)$, then $G = (a^{-1})$.
   (c) Every subgroup of a cyclic group is cyclic.
   (d) Let G be a cyclic group of order n. Let $G = (a)$. The element $a^s \in G$ generates a cyclic group of order $\dfrac{n}{\gcd(n, s)}$.
   (e) Let $G = (a)$ and $o(G) = n$. Then $(a^m) = G$ if and only if $(m, n) = 1$.
4. Cosets : definition and properties.
5. Lagrange's theorem and corollaries.

Permutation Groups **[6 Lectures]**

1. Definition of S_n and detail discussion of the group S_3.
2. Cycles and transpositions, even and odd permutations.
3. Order of permutation.
4. Properties : (i) $o(S_n) = n!$ (ii) A_n is a subgroup of S_n.
5. Discussion of the group A_4 including converse of Lagrange's theorem does not hold in A_4.

Normal Subgroups **[8 Lectures]**

1. Definition.

2. Properties with examples:

   (a) If G is an abelian group, then every subgroup of G is a normal subgroup.
   (b) N is a normal subgroup of G if and only if $gNg^{-1} = N$ for every $g \in G$.
   (c) The subgroup N of G is a normal subgroup of G if and only if every left coset of M in G is a right coset of N in G.
   (d) A subgroup N of G is a normal subgroup of G if and only if the product of two right cosets of N in G is again a right coset of N in G,.
   (e) If H is a subgroup of index 2 in G then H is a normal subgroup of G.
   (f) If H is the only subgroup of G of a fixed finite order then H is a normal subgroup of G.

3. Quotient groups and examples.

Homomorphism and Isomorphism **[12 Lectures]**

1. Homomorphism.

2. Isomorphism : definition, examples, establish isomorphism of two finite groups.

3. Fundamental Theorem of homomorphisms of groups.

4. The group $\mathbb{Z}/n\mathbb{Z}$ of residue classes (mod n). Characterization of cyclic groups (as being isomorphic to $\mathbb{Z}$ or $\mathbb{Z}/n\mathbb{Z}$ for some $n \in \mathbb{N}$).

5. Cayley's Theorem for finite groups.

6. Classification of groups of order ≤ 5.

7. Cauchy's theorem for Abelian Groups.

Text book:
I.N. Herstein, Topics in Algebra, Wiley, 1990.

Reference Books :

1. M. Artin, Algebra, Prentice Hall of India, New Delhi, 1994.

2. P.B. Bhattacharya, S.K. Jain and S.R. Nagpal, Basic Abstract Algebra, Second Ed., Foundation Books, New Delhi, 1995.

3. J.B. Fraleigh, A. First Course in Abstract Algebra, Third Ed., Narosa, New Delhi, 1990.

4. N.S. Gopalakrishnan, University Algebra, Second Ed., New Age International, New Delhi, 1986.
5. D.A.R. Wallace, Groups, Rings and Fields, Springer-Verlag, London, 1998.
6. I.N. Herstein, Abstract Algebra.
7. I. H. Sheth, Abstract Algebra, Second Revised Edition, 2009, PHL,India.

MT 335: Ordinary Differential Equations

1. What is a Differential Equation?: **[14 Lectures]**
   Introductory Remarks, the nature of solutions, separable equations, first-order linear equations, exact equations, orthogonal trajectories and families of curves, homogeneous equations, integrating factors,
   reduction of order:(1) dependent variable missing, (2) independent variable missing, electrical circuits.

2. Second-Order Linear Equations: **[12 Lectures]**
   Second-order linear equations with constant coefficients, the method of undetermined coefficients, the method of variation of parameters, the use of a known solution to find another, vibrations and oscillations : (1) undamped simple harmonic motion (2) damped vibrations (3) forced vibrations.

3. Power Series Solutions and Special Functions: **[12 Lectures]**
   Introduction and review of power series, series solutions of first-order differential equations, second-order linear equations, ordinary points, regular singular points, more on regular singular points.

4. System of First-Order Equations: **[10 Lectures]**
   Introductory remarks, linear systems, homogeneous linear systems with constant coefficients.

Text Book: Differential Equations by George F. Simmons, Steven G. Krantz, Tata McGraw-Hill.
Reference Book:
1. W.R. Derrick and S.I. Grossman, A First Course in Differential Equations with Applications. CBS Publishers and distributors, Delhi-110 032. Third Edition.
2. Rainville, Bedient: Differential Equations

MT 337 A: Operation Research

1. **Modeling with Linear Programming** **[8 Lectures]**
   Two variable LP Model, Graphical LP solution, Selected LP Applications

2. **The Simplex Method** **[16 Lectures]**
   LP Model in equation form, Transition from graphical to algebraic solutions, The simplex method, Artificial starting solutions,Sensitivity analysis.

3. **Duality** **[6 Lectures]**
   Definition of the dual problem, Primal dual relationship

4. **Transportation Model** **[12 Lectures]**
   Definition of the Transportation model, The Transportation algorithm.

5. **The Assignment Model** **[6 Lectures]**
   The Hungarian method, Simplex explanation of the Hungarian method.

Text Book: Hamdy A. Taha, Operation Research (Eighth Edition, 2009), Prentice Hall of India Pvt. Ltd, New Delhi.
Ch.2: 2.1,2.2,2.3(2.3.4, 2.3.5, 2.3.6).
Ch.3: 3.1, 3.2, 3.3, 3.4, 3.5, 3.6 (3.6.1).
Ch.4: 4.1, 4.2.
Ch.5: 5.1,5.3 (5.3.1, 5.3.2, 5.3.3), 5.4(5.4.1, 5.4.2).
Reference Books:

1. Frederick S. Hillier, Gerald J. Lieberman, Introduction to Operation Research (Eighth Edition) Tata McGraw Hill.

2. J K Sharma, Operations Research (Theory and Applications, second edition, 2006), Macmilan India Ltd.

3. Hira and Gupta, Operation Research.

MT 337 B: Lattice Theory

1. **Ordered Sets** **[12 Lectures]**
   a. Ordered sets.
   b. Examples from social science and computer science.
   c. Diagrams : the art of drawing ordered sets.
   d. Constructing and de-constructing ordered sets.
   e. Down-sets and up-sets.
   f. Maps between ordered sets.

2. **Lattices and Complete Lattices** **[18 Lectures]**
   a. Lattice as ordered sets.
   b. Lattices as algebraic structures.
   c. Sublattices, products and homomorphisms.
   d. Ideals and Filters.
   e. Complete lattices and Intersection-structures.
   f. Chain conditions and completeness.
   g. Join-irreducible elements.

3. **Modular, distributive and Boolean Lattices** **[18 Lectures]**
   a. Lattices satisfying additional identities.
   b. The characterization Theorems of Modular and Distributive lattices.
   c. Boolean lattices and Boolean algebras.
   d. Boolean terms and disjunctive normal form.

Test-book:
B.V. Davey and H.A. Priestley : *Introduction to Lattices and Order,* Cambridge University Press, Second edition, 2002.
(Chapters 1,2 and 4).

Reference Book S. Greitzer, General Lattice Theory, Academic Press.

MT 337 C: C Programming-I

1. Introductory Concepts: Introduction to computer. Computer Characteristics. Types of Programming Languages. Introduction to C. **[2 Lectures]**
2. C Fundamentals: The character set. Identifier and keywords. Data types. Constants. Variables and arrays. Declarations. Expressions. Statements. Symbolic constants. **[4 Lectures]**
3. Operators and Expressions: Arithmetic operators. Unary operators. Relational and Logical operators. Assignment operators. Conditional Operator. Library functions. **[6 Lectures]**
4. Data Input and Outputs: Preliminaries. Single character input-getchar() function. Single character output-putchar() function. Writing output data-printf function. Formatted input-output. Get and put functions. **[8 Lectures]**
5. Preparing and Running a Program: Planning and writing a C Program. Compiling and Executing the Program. **[2 Lectures]**
6. Control Statements: Preliminaries. The while statement. The do-while statement. The for statement. Nested loops. The if-else statement. The switch statement. The break statement. The continue statement. The comma operator. **[8 Lectures]**
7. Functions: A brief overview. Defining a function. Accessing a function. Passing arguments to a function. Specifying argument data types. Function prototypes. Recursion. **[8 Lectures]**
8. Arrays: Defining an array. Processing an array. Passing arrays to a function. Multidimensional arrays. Arrays and strings. **[10 Lectures]**
Text Book: Programming with C. By Byron S. Gottfried. Schaum's Outline series. Chapters:1,2,3,4,5,6,7,9.
Reference Book: The C Programming Language. By Brian W. Kernighan, Dennis M. Ritchie.

MT 337 D: Differential Geometry

1. Curves in the plane and in space. **[4 Lectures]**
2. How much does a curve curve? **[8 Lectures]**
3. Global Properties of curves. **[8 Lectures]**
4. Surfaces in three dimensions. **[8 Lectures]**
5. The first fundamental form. **[10 Lectures]**
6. Curvature of surfaces. **[10 Lectures]**

Text Book : Andrew Pressley : Elementary Differential Geometry, Springer International Edition, Indian Reprint 2004.

Chapters : 1 to 6.

Reference Book : John A. Thorpe : Differential Geometry, Springer International Edition, Indian Reprint 2004.

MT 337 E: Combinatorics

1. (a) Two basic Counting Principles: addition Principle and Multiplication Principle

   (b) Simple Arrangements and Selections

   (c) Arrangements and Selections with repetition

   (d) Distributions

   - Number of distributions of r distinct objects into n distinct boxes is n^r.
   - Number of distributions of r identical objects into n distinct boxes is $C(n+r-1, r)$ = the number of non-negative integer solutions to $x_1 + x_2 + \cdots + x_n = r$.
   - Binomial Identities: Binomial identities and Multinomial theorem.

   (20 Lectures)

2. Inclusion-Exclusion Principle, Counting with Venn diagrams, Inclusion Exclusion formula, Derangements, Simple Examples. **(10 Lectures)**

3. Pigeonhole principle **(8 Lectures)**

4. Recurrence Relations: Recurrence relation models, Solution of Linear Homogeneous and non-homogeneous recurrence relations (methods without proof). . **(10 Lectures)**

Text Book:
Alan Tucker, Applied Combinatorics, Wiley, 1995.
§ 5.1 *to* § 5.5, § 7.1 *to* § 7.4, § 8.1 *to* § 8.2, A.4

Reference Book:

1. Richard A. Brualdi, Introductory Combinatorics, Elsevier, North-Holland, New York, 1977.
2. V. K. Balakrishnan, Combinatorics, Schuam Series, 1995.

MT 337 F: Number Theory

Divisibility **[8 Lectures]**

Divisibility in integers, Division Algorithm, GCD, LCM, Fundamental theorem of Arithmetic, Infinitude of primes, Mersene Numbers and Fermat Numbers.

Congruences **[12 Lectures]**

Properties of congruences, Residue classes, complete and reduced residue system, their properties, Fermat's theorem. Euler's theorem, Wilson's theorem, $x^2 \equiv -1 \pmod{p}$ has a solution if and only if $p = 2$ or $p \equiv 1 \pmod{4}$, where p is a prime. Linear congruences of degree 1, chinese remainder theorem.

Greatest integer function, Arithmetic functions **[10 Lectures]**

Euler's Φ function, the number of divisors $d(n)$ sum of divisors $\sigma(n)$, $\sigma_k(n)$, $\omega(n)$, and $\Omega(n)$. Multiplicative functions, Totally Multiplicative Functions, Möbius function, Möbius inversion formula.

Quadratic Reciprocity **[10 Lectures]**

Quadratic residues, Legendre's symbol. Its properties, Law of quadratic reciprocity.

Diophantine Equations **[8 Lectures]**

$ax + by = c$ and Pythagorean triplets.

Text Book:

1. I. Niven, H. Zuckerman and H.L. Montgomery, An Introduction to Theory of Numbers, 5th Edition, John Wiley and Sons.

§ 1.1, § 1.2, § 1.3, § 2.1, § 2.2, § 2.3, § 3.1, § 3.2,
§ 3.3, § 4.1, § 4.2, § 4.3, § 5.1, and § 5.3.

Reference Book:

1. David M. Burton, Elementary Number Theory (Second Ed.), Universal Book Stall, New Delhi, 1991.

MT 341: Metric Spaces

1. Chapter 1 : Basic Notions. **[8 Lectures]**
2. Chapter 2: Convergence. **[8 Lectures]**
3. Chapter 3 : Continuity. **[8 Lectures]**
4. Chapter 4 : Compactness. **[10 Lectures]**
5. Chapter 5 : Connectedness. **[6 Lectures]**
6. Chapter 6 : Complete Metric Spaces. **[8 Lectures]**

Text Book:
Topology of Metric Spaces' by S. Kumaresan, Narosa Publishing House, 2005.

Sections : 1.1, 1.2 (except the Sections 1.2.51 to 1.2.65), 2.1, 2.2, 2.3, 2.4, 2.5 and 2.7, 3.1, 3.2 (up to 3.2.32 only), 3.3, 3.4,3.5.(Uniform Continuity to be dropped), 4.1, 4.2, (Proposition 4.2.13 without proof) and 4.3 (Theorem 4.3.24 without proof), 5.1 and 6.1 (Theorems 6.1.1, 6.1.3, 6.1.11, without proofs).

Note: All the problems which are based on normed linear spaces and matrices be dropped.

Reference books :

1. Real Analysis, Carothers, Cambridge University Press, 2000.
2. Methods of Real Analysis, R.R. Goldberg, Oxford and IBH Publishing Company.
3. Metric Spaces, E.T. Copson, University Press, Cambridge, 2nd edition, Mumbai, 1978.
4. Introduction to Topology and Modern Analysis, G.F. Simmons. McGraw Hill International Book Company, International Student Edition.

MT 342: Complex Analysis

1. **Analytic function** **[10 Lectures]**
   Functions of Complex Variables,Limits, theorems on limits, Limits involving the point at infinity, continuity, derivatives, differentiation formulas, Cauchy-Riemann Equations, Sufficient Conditions for differentiability, polar coordinates, Harmonic functions.

2. **Elementary Functions** **[8 Lectures]**
   Elementary Functions, Exponential functions, Logarithmic function and its branches and derivatives of logarithms, sum identities involving logarithms, complex exponents,. Trigonometric functions, Hyperbolic functions,inverse trigonometric and hyperbolic functions.

3. **Definite Integrals** **[12 Lectures]**
   Derivatives of functions, definite integrals of functions, contours, contour integrals, examples, upper bounds for moduli of contour integrals, anti-derivatives, examples, Cauchy-Groursat's Theorem, Simply and multiply connected domains. Cauchy integral formula. Derivatives of analytic functions. Liouville's Theorem. Fundamental Theorem of Algebra.

4. **Series** **[8 Lectures]**
   Convergence of sequences, convergence of series, Taylor Series, examples, Laurent Series, examples. Absolute and uniform convergence of power series, continuity of sums of power series, Integration and Differentiation of power series.

5. **Residues** Residues, Cauchy residue theorem, using a single residue, three types of isolated singular points, residues at poles, zeros of analytic functions, zeros and poles. **[6 Lectures]**

6. **Applications of Residues** **[4 Lectures]**

   Evaluation of improper integrals, examples.

Text Book:

R.V. Churchill and I.W. Brown, Complex Variables and Applications, International Student Edition, 2003. (Seventh Edition).

Chapter 2 : Section 18 to 25, **Chapter 3 :** Section 28 to 34, **Chapter 4 :** Section 36 to 44 and Section 46 to 50; (except 45), **Chapter 5 :** Section 53 to 56, **Chapter 6 :** Section 62 to 69, **Chapter 7 :** Section 72, **Chapter 8 :** Section 84 to 87.

Reference Books:

1. S. Ponnusamy, Complex Analysis , Second Edition (Narosa).

2. J.M. Howie, Complex Analysis, (Springer, 2003).

3. S. Lang, Complex Analysis, (Springer Verlag).

4. A.R. Shastri, An Introduction to Complex Analysis, (MacMillan).

MT 344: Ring Theory

1. Definition and properties of Ring, Subring. **[5 Lectures]**
2. **Integral Domains** : Zero devisiors, Cancellation Law, Field, Characteristics of Ring. **[5 Lectures]**
3. **Ideals and Factor Rings** : Existence of Factor Ring, Prime Ideals, Maximal Ideals. : **[6 Lectures]**
4. **Homomorphism of Rings** : Properties of Ring Homomorphism, Kernel, First isomorphism Theorem for Ring, Prime Fields. The field of Quotients. **[8 Lectures]**
5. **Polynomial Ring** : Definition. The division Algorithm, Principle Ideal Domain. **[6 Lectures]**
6. **Factorization of Polynomial** : Reducibility and Irreducibility Tests, Eisenstein criterion. Ideals in $F[x]$. Unique Factorization in $Z[x]$. **[8 Lectures]**
7. **Divisibility in Integral Domain**: Associates, Irreducible and Primes, Unique Factorization Domains, Ascending chain Condition for PID, PID implies UFD, Euclidean Domains. ED Implies PID,
   D is UFD implies $D[x]$ is UFD. **[10 Lectures]**

Text Book:
Joseph, A. Gallian, Contemporary Abstract Algebra,(4th Edition), Narosa Publishing House.
Chapter Numbers : 12,13,14,15,16,17 and 18.

Reference Books:

1. J.B. Fraleigh, First course in Abstract Algebra (4rd Edition). Narosa Publishing House.
2. I.N. Herstein. Abstract Algebra, (3rd Edition), Prentitice Hall of India, 1996.
3. N.S. Gopalkrishnan, University of Algebra, Wiley Eastern 1986.
4. C. Musili, Rings and Modules, Narosa Publishing House, 1992.

MT 345: Partial Differential Equations

1. **Ordinary Differential Equations in More Than Two Variables**

   (a) Surface and Curves in Three Dimensions **[20 Lectures]**

   (b) Simultaneous Differential Equations of the First Order and the First Degree in Three Variables.

   (c) Methods of solution of $\frac{dx}{P} = \frac{dy}{Q} = \frac{dz}{R}$.

   (d) Orhogonal Trajectories of a System of curves on a Surface.

   (e) Pfaffian Differential Forms and Equations.

   (f) Solution of Pfaffian Differential Equations in Three Variables.

   First Order Partial Differential Equations : **[28 Lectures]**

   (a) Curves and surfaces.

   (b) Genesis of First Order Partial Differential Equations.

   (c) Classification of Integrals.

   (d) Linear Equations of the First Order.

   (e) Pfaffian Differential Equations.

   (f) Compatible Systems.

   (g) Charpit's Method.

   (h) Jacobi's Method.

   (i) Integral Surfaces through a given curve.

   (j) Quasi-Linear Equations.

Text Book:

1. Ian Sneddon, Element of Partial Differential Equations, McGraw-Hill Book Company, McGraw-Hill Book Company. Chapter 1 §1 to §6.

2. T. Amaranath, An Elementary Course in Partial Differential Equations, Narosa Publishing, House 2nd Edition, 2003 (Reprint, 2006). Chapter 1 §1 to §10.

Reference Book:

1. Frank Ayres Jr., Differential Equations, McGraw-Hill Book Company, SI Edition (International Edition, 1972)

2. Ravi P. Agarwal and Donal O'Regan, Ordinary and Partial Differential Equations, Springer, First Edition (2009).

3. W.E. Williams, Partial Differential Equations, Clarendon Press, Oxford,(1980).

MT 347 A: Optimization Techniques

1. **Network Models** **[12 Lectures]**
   CPM and PERT, Network representation, Critical Path Computations, Construction of the time schedule, Linear programming formulation of CPM, PERT calculations

2. **Decision Analysis and Games** **[12 Lectures]**
   Decision under uncertainty, Game theory, Some basic terminologies, Optimal solution of two person zero sum game, Solution of mixed strategy games, graphical solution of games, linear programming solution of games.

3. **Replacement and Maintainance Models** **[6 Lectures]**
   Introduction, Types of failure, Replacement of items whose efficiency deteriorates with time.

4. **Sequencing Problems** **[6 Lectures]**
   Introduction, Notation, terminology and assumptions, Processing n jobs through two machines, Processing n jobs through three machines.

5. **Classical Optimization Theory** **[12 Lectures]**
   Unconstrained problems, Necessary and sufficient conditions, Newton Raphson method, Constrained problems, Equality constraints.

Text Book:

1. Hamdy A. Taha, Operation Research (Eighth Edition, 2009), Prentice Hall of India Pvt. Ltd, New Delhi.
   Ch.6: 6.5 (6.5.1,6.5.2,6.5.3,6.5.4,6.5.5).
   Ch.13: 13.3, 13.4(13.4.1,13.4.2,13.4.3).
   Ch.18: 18.1(18.1.1, 18.1.2), 18.2 (18.2.1).

2. J K Sharma, Operations Research (Theory and Applications, second edition, 2006), Macmilan India Ltd. Ch.17: 17.1,17.2, 17.3.
   Ch.20: 20.1, 20.2, 20.3, 20.4.

Reference Books:

1. Frederick S. Hillier, Gerald J. Lieberman, Introduction to Operation Research (Eighth Edition) Tata McGraw Hill.

2. Hira and Gupta, Operation Research.

MT 347 B: Improper Integrals and Laplace Transforms

1. Improper Integrals: **[14 Lectures]**
   Definition of improper Integral of first kind, Comparison Test, - test, absolute and conditional convergence, Integral test for convergence of series, Improper integral of second kind, Comparison Test, Cauchy Principal Value.

2. The Laplace Transform: **[15 Lectures]**
   Definition, Laplace Transform of some elementary functions, Some important properties of Laplace Transform, Laplace Transform of derivatives, Laplace Transform of Integrals, Methods of finding Laplace Transform, Evaluation of Integrals, The Gamma function, Unit step function and Dirac delta function.

3. The Inverse Laplace Transform: **[15 Lectures]**
   Definition, Some inverse Laplace Transform, Some important properties of Inverse Laplace Transform, Inverse Laplace Transform of derivative, Inverse Laplace Transform of integrals, Convolution Theorem, Evaluation of Integrals.

4. Applications to Differential Equations: **[4 Lectures]**
   Ordinary Differential Equations with constant coefficients.

Text Books :

1. D. Somasundaram, B. Choudhary : A First Course in Mathematical Analysis, Narosa Publishing House 2009.(Corrected Edition) §8.5

2. Schaum's Outline Series - Theory and Problems of Laplace Transform by Murray R. Spiegel. Articles 1, 2, 3.

Reference Books :

1. R. R. Goldberg : Methods of Real Analysis, Oxford and IBH Publishing Corp. Ltd., 1970.

2. Robert Wrede, Murry R. Spiegel : Theory and Problems of Advanced Calculus, Schaums Outline Series, The McGraw-Hill Companies 2002.

3. Joel L. Schiff : The Laplace Transforms - Theory and Applications, Springer-Verlag New York 1999.

4. Dyke : An Introduction to Laplace Transforms and Fourier Series, Springer International Edition, Indian Reprint 2005.

Remarks :

1. William F. Trench : Introduction To Real Analysis, Free Edition 1, March 2009 : - available online with Instructors solution manual.

MT 347 C: C programming

1. Program Structures: Storage classes. Automatic variables. External variables. Static variables. **[4 Lectures]**

2. Pointers: Fundamentals. Pointer declarations. Passing pointer to a function. Pointer and one dimensional arrays. Dynamic memory allocation. Operations on pointers. Pointers and multidimensional arrays. Array of pointers. Pointer to function. Passing functions to other functions. More about pointer declarations.
. **[12 Lectures]**

3. Structures and Unions: Defining a structure. Processing a structure. User-defined data types (typedef). Structures and pointers. Passing structure to a function. Self-referential structures. Unions. **[12 Lectures]**

4. Data Files: Opening and closing a data file. Creating a data file. Processing a data file. Unformatted data files. **[10 Lectures]**

5. Low-Level Programming: Bitwise operators. Register variables. Enumerations. Macros. Command line arguments. The C processor. **[10 Lectures]**

Book: Programming with C. By Byron S. Gottfried. Schaum's Outline series. Chapters:8,10,11,12,13,14.

Reference Book: The C Programming Language. By Brian W. Kernighan, Dennis M. Ritchie.

MT 347 D: Dynamics

1. **Plane Kinematics** **[12 Lectures]**
   Motion and its description, Instantaneous speed, Displacement, Velocity, Composition and Resolution of Velocity. Acceleration, Rectilinear motion with uniform acceleration, Bodies falling under gravity, Cartesian rectangular components of velocity and acceleration, Radial and transverse components of velocity and acceleration, Tangential and normal components of velocity and acceleration.

2. **Work-Power-Energy** **[10 Lectures]**
   Kinetics of a particle, mass, momentum, force, Newton's Laws of Motion, Rectilinear motion under a constant force, constrained motion, Reaction of a supporting plane, motion on a smooth inclined plane, work and power, kinetic energy, work-energy principle, Potential energy.

3. **Projectile Motion** **[10 Lectures]**
   Motion of a projectile in a vertical plane, trajectory, velocity at a point of the tragectory, Target problems, Range on an inclined plane.

4. **E**quations of Plane Curves **[4 Lectures]**
   Polar coordinates, Angle between Radius Vector and Tangent, Perpendicular from pole on tangent, Angle of intersection of two curves, Pedal Equations.

5. **Central Orbits** **[12 Lectures]**
   Motion of a particle under a central force, the differential equation of a central orbit-Reciprocal polar form and pedal form. Energy equation, central orbit under inverse square law-polar form, planetary orbits - Keplers laws of planetary orbits.

Test Book:
J.N. Kapoor and J.D. Gupta , A text book of Dynamics. 5^{th} edition, Ramchand and Co. Delhi, 1999.
Articles : 1.1 to 1.11, 2.1 to 2.5, 2.7 to 2.9, 3.1 to 3.5, 8.1 to 8.4, 8.5-1A, 8.8-1.

Reference Books:

1. M. Ray, A text book of Dynamics, S. Chand and Company, Reprint, 1997.
2. P.N. Singhal and S. Sareen, Mechanics. Anmol Publications, New Delh, 2000.

MT 347 E: Lebesgue Integration

1. **Measurable Sets** **[12 Lectures]**
   (i) Length of open sets and closed sets.
   (ii) Inner and outer measure.
   (iii) Measurable sets.
   (iv) Properties of measurable sets.

2. **Measurable Functions** **[12 Lectures]**

3. **The Lebesgue integrals** **[16 Lectures]**
   (i) Definition and example of the Lebesgue integrals for bounded functions.
   (ii) Properties of Lebesgue integrals for bounded measurable functions.
   (iii) The Lebesgue integral for unbounded functions.
   (iv) Some fundamental theorems.

4. **Fourier Series** **[8 Lectures]**
   (i) Definition and examples of Fourier Series.
   (ii) Formulation of convergence problems.

Text-Book:
Richard R. Goldberg, Methods of Real Analysis, Oxford and IBH Publishing Co. Pvt. Ltd. (1970).
(Chapter No. 11, 11.1 to 11.8, 12.1, 12.2. Theorem No. 11.1B and 11.1C, 11.8D Statements only).

Reference Books:

1. Tom Apostol, Advanced Calculus, 2nd Edition, Prentice Hall of India, (1994).

2. D. Somasundaram and B. Choudhari, A first course in Mathematical Analysis, Narosa Publishing House, (1997).

3. R.G. Bartle and D.R. Scherbert, Introduction to real analysis 2nd Edition, John Wiley, (1992).

4. Inder K. Rana, Measure and Integration

MT 347 F: Computational Geometry

Two dimensional Transformations **[12 Lectures]**
Representation of Points, Transformations and Matrices, Transformation of Points, Transformation of Straight Lines, Midpoint Transformation, Transformation of Parallel Lines, Transformation of Intersecting Lines, Rotation, Reflection, Scaling, Combined Transformations, Transformation of the Unit Square, Solid Body Transformation, Translations and Homogeneous Coordinates, Rotation About an Arbitrary Point, Reflection Through an Arbitrary Line, Projection - A Geometric Interpretation of Homogeneous Coordinates, Overall Scaling, Points at Infinity, Transformation Conventions.

Three Dimensional Transformations **[12 Lectures]**
Three-Dimensional Scaling, Three-Dimensional Shearing, Three-Dimensional Rotation. Three-Dimensional Reflection. Three-Dimensional Translation. Multiple Transformations, Rotations about an Axis Parallel to a coordinate axis, Rotation about an Arbitrary Axis in Space, Reflection Through an Arbitrary Plane. Affine and Perspective Geometry, Orthographic Projections, Axonometric Projections, Oblique Projections, Perspective Transformations. Techniques for generating perspective views, Vanishing points, photography and the perspective transformation, stereographic projection, comparison of object fixed and center of projection , Fixed projections, reconstruction of three-dimensional images.

Plane Curves **[12 Lectures]**
Curve representation, non-parametric curves, parametric curves, parametric representation of a circle, parametric representation of an Ellipse, parametric representation of a parabola, parametric representation of a Hyperbola. A procedure for using conic sections. The general conic equations.

Space Curves **[12 Lectures]**
Bezier curves introduction, definition, properties (without proofs), curve fitting (up to $n = 3$), equation of the curve in matrix form (up to $n = 3$).
B-spline curves- introduction,definition,properties(without proof).

Text-Book:
D.F. Rogers, J. Alan Adams, Mathematical Elements of Computer Graphics, Second Edition, McGraw-Hill Publishing Company.