Rashtrasant Tukadoji Maharaj Nagpur University

Post Graduate Teaching Department of Mathematics

Syllabus for M.Sc. (Mathematics) Program
Choice Based Credit System (CBCS)

From the Session 2021-22

Rashtrasant Tukadoji Maharaj Nagpur University

Post Graduate Teaching Department of Mathematics

Syllabus for Two Years (Four Semesters) M.Sc. (Mathematics) Program
(Choice Based Credit System)

Introduction:

The department has academic autonomy, which aimed to provide an opportunity to the department to add new, innovative, and need-based courses in the syllabus. So that, it can widen the mathematical knowledge of the students as well as the awareness of applications of Mathematics in various fields. The M.Sc. (Mathematics) program includes four semesters for the duration of two years the program contains theory as well as applied courses. M.Sc. Mathematics is the program, which laid the foundation of the career of a student. Hence, it is necessary to include the topics (courses) in this program, which can open the entry of students to various career options. Due to which the present syllabus is framed with consideration of this aspect. The framework of this syllabus includes core courses, elective courses, and one computer skill course per semester. The elective courses are framed to fulfill the demand of various fields such as data handling, data analysis, industry-based mathematics, system solutions etc., and skill-based courses provide an opportunity to develop a computer platform. Accordingly, one can look for opportunities in the industrial sectors, government sectors, and academic organizations after completion of this program. This syllabus provides an opportunity for the students to gain advanced knowledge of core mathematics, understand the applications of mathematics in different fields, and achieve computer skills to handle mathematical software. The combination of core mathematics and computer skills will provide a platform to open windows of employment. In semesters III and IV the students are allowed to choose one course/semester from other departments as per their interest. The Course Study and Scheme of Examination are given in Table I.

Eligibility:

For admission to the M. Sc. Semester I in Mathematics, a candidate shall have offered Mathematics as one of the subjects at the qualifying B.Sc. Examination. The department may conduct an entrance examination to admit the candidates to this program if needed.

Credits:

The total credits of the program are 100 (2500 marks). One credit of 25 marks for theory/tutorial will be of 1 hr and that of practical will be of 2 hrs per week, running for 15 weeks. One credit will be equivalent to 15 clock hours of teacher-student contact in a semester. For detail, please see Table I-IV.

Evaluation:

The evaluation of the student will be done according to the performance of components End Semester Examination (ESE) and Continuous Internal Assessment (CIA) where the weightage distribution for each course is 60% and 40% respectively. For detail, please see Table I-IV. Successful examinees at the end of M. Sc. Sem-IV Examination who obtained CGPA above 7.51 shall be placed in First Division with distinction, those obtaining CGPA from 6.00 to 7.50 shall be placed in First Division, those obtaining CGPA from 4.50 to 5.99 shall be placed in Second Division and those obtaining CGPA from 4.00 to 4.49 shall be placed in Third Division. In general, the percentage marks = CGPA x 10. Grades will be awarded as per university rules.

Internal Assessment:

The concerned teacher will award the internal assessment marks. Immediately after the assessment, the marks will be sent to the university in the prescribed format. The internal assessment marks will be awarded based on home assignments, unit test performance, seminars, practical performance, participation in the departmental activities (Popularization

of Mathematics, study tour, industrial visits, visit to educational institutions and research organizations, fieldwork, group discussions or any other innovative practice) and attendance of the student throughout the session.

General guidelines for Internal Assessment:

a) The internal assessment marks assigned to each theory paper as mentioned in the examination scheme.
b) There shall be one to three assignments per theory paper.
c) There shall be no separate/extra allotment of workload to the teacher concerned. He/She shall conduct the internal assessment activity during the regular teaching days/periods as a part of regular teaching activity.
d) The concerned teacher/the department shall keep the record of all the above activities until six months after the declaration of the results of that semester.
e) At the beginning of each semester, every teacher shall inform his/her students unambiguously the method he/she propose to adopt and the scheme of marking for internal assessment.
f) Teacher shall announce the schedule of activity for internal assessment in advance in consultation with Head of the Department.
g) Final submission of internal marks to the University shall be done with the marks of End Semester Examination (Theory).
h) Practical Examination for Computer based papers
    1. Practical performance shall be the part of internal assessment evaluated by the subject teacher as an Internal Examiner.
    2. Practical exam shall be of 2 hours duration for one or two days, depending on number of students.
    3. The Practical Record of every student shall carry a certificate as shown in the template, duly signed by the teacher-in-charge and the Head of the Department.
    4. If the student fails to submit his/her certified Practical Record duly signed by the Teacher-In Charge and the Head of the Department, he/she shall not be allowed to appear for the Practical Examination and no Marks shall be allotted to the student.
    5. The certificate template is given in Appendix.

Seminar:

In each semester, the student will have to deliver a seminar on any topic relevant to the Mathematical Sciences encompassing the recent trends and development in Mathematical Sciences. The topic of the seminar is to decide at the beginning of each semester in consultation with the supervising teachers. The student has to deliver the seminar, which is followed by the discussion. The seminar will be open to all the teachers of the department, invitees, and students.

The students should submit the seminar report typed and properly bound in two copies to the Head of the Department. The seminar report shall be evaluated by the concerned Supervisor/Head of the Department. The marks of the seminar shall be forwarded to the university within due period through Head of the Department. The record of the seminar shall be preserved until the declaration of the result.

Offering Elective Papers:

An elective course shall run through classes only if minimum 10 students register for it in a regular semester. However, students will have choice to opt the subject of his/her own interest from the list of core/open electives through MOOCs platform. Students have to inform HOD for the opted elective course at the commencement of the semester.

The vision statement of the Department:

To endeavor for Excellence Innovation and Professionalism Along with Sensibility, Kindness and Compassion.

The Mission of the Department

- To promote academic excellence in professional qualifications laced with technical skills.
- To achieve innovations in teaching, learning, research and extension.
- To develop decision-making capacity and to enable the youngsters to explore their own capabilities.
- To preserve our own cultural & humanistic values with the same ease as to adopt new technological expertise.
- To produce committed and better citizens and professionals, rich in values and excellence, with a promising future.
- To infuse a competitive and fighting spirit among the students.
- To inculcate creative, critical, and analytical thinking.
- To equip and empower students with relevant knowledge and competence to face global challenges.
- To develop personal human qualities like responsibility, sociability, self-management, self-esteem & integrity.

Program Specific Outcomes (PSO)

PSO1 Disciplinary Knowledge: *Understand the basic and advanced knowledge in the field of Mathematics*

PSO2 Critical Thinking: *Identify, analyze, formulate various problems with scientific approach*

PSO3 Problem Solving: *Identify and apply the most effective method to solve and evaluate the appropriate solution within a stipulated time*

PSO4 Research related skills: *Pursue research in challenging areas of pure/applied Mathematics.*

PSO5 Analytical Reasoning: *Think logically and analytically over the information to evaluate solution for the mathematical theorems or problems*

PSO6 Scientific Reasoning: *Solve mathematical problems systematically with scientific approach*

Program Outcomes (PO)

PO1 Communication Skills: *Effectively communicate and explore ideas of mathematics for propagation of knowledge and popularization of mathematics in society*

PO2 Professional Skills: *Explain/ demonstrate accurate and efficient use of advanced Mathematical techniques*

PO3 Team Work: *Participate constructively in classroom discussion*

PO4 Digitally literacy: *Have sound knowledge of mathematical modelling, programming and computational techniques as required for research or employment in industry*

PO5 Ethical and Social awareness: *Capable of demonstrating the ethical issues related with the Intellectual Property Rights, copyright etc. and demonstrate highest standards of ethical issues in mathematics*

PO6 Lifelong learning: *Continue to acquire mathematical knowledge and skills appropriate to professional activities*

PO7 Self-Directed Learning: *Work independently to explore new ideas and solutions to mathematical problems*

PO8 Leadership Quality: *Listen and understand the ideas and suggestions of others to improve quality of learning*

PO9 Reflective Thinking: *Identify the importance of the information provided in theorems, axioms and problems for further justification and application*

C E R T I F I C A T E

Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur
Post Graduate Teaching Department of Mathematics

This is to certify that this Practical Record contains the bonafide record of the Practical work of Shri / Shrimati / Kumari _ of M. Sc. Mathematics Semester _ _ _ _ _ _ _ _ during the academic year _ _ _ _ _ _ _.

The candidate has satisfactorily completed the experiments prescribed by the department for the course _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Dated _ _ _ / _ _ _ / _ _ _ _ _

Signature of the concerned teacher

Head of the Department

Table I: Scheme of Teaching and Examination for First Semester M.Sc. Mathematics Program (CBCS)

Paper	Paper Code	Title of Paper	Teaching		Examination Scheme						
						Maximum Marks					
			Mode	Hrs/Week	Exam Duration (hrs)	Theory	Practical	Internal Assessment	Minimum Passing Marks	Maximum Total Marks	Credits
Core 1	MMT1T01	Algebra-I	L/T	4	3	60	--	40	40	100	4
Core 2	MMT1T02	Real Analysis-I	L/T	4	3	60	--	40	40	100	4
Core 3	MMT1T03	Topology-I	L/T	4	3	60	--	40	40	100	4
Core 4	MMT1T04	Ordinary Differential Equations	L/T	4	3	60	--	40	40	100	4
Select any one											
Elective 1	MMT1E05	Integral Equations	L/T	4	3	60	--	40	40	100	4
	MMT1E06	Operations Research-I	L/T	4	3	60	--	40	40		
	MMT1E07	Probability and Distributions	L/T	4	3	60	--	40	40		
	MMT1E08	Linear Algebra and Differential Equations	L/T	4	3	60	--	40	40		
	MMT1E09	Representation Theory of Finite Group	L/T	4	3	60	--	40	40		
	MMT1E10	Applied Combinatorics	L/T	4	3	60	--	40	40		
Computer based Compulsory Paper (CBCP)											
Skill 1	MMT1T11	Fundamentals of Computer and C-Programming	L/T	2	3	60	--		40	100	4
	MMT1L11		L/P	4	2	--	40				
Seminar 1	MMT1S12	Seminar-I		2				25	10	25	1

Table II: Scheme of Teaching and Examination for Second Semester M.Sc. Mathematics Program (CBCS)

Paper	Paper Code	Title of Paper	Teaching		Examination Scheme						
						Maximum Marks					
			Mode	Hrs/Week	Exam Duration (hrs)	Theory	Practical	Internal Assessment	Minimum Passing Marks	Maximum Total Marks	Credits
Core 5	MMT2T01	Algebra-II	L/T	4	3	60	--	40	40	100	4
Core 6	MMT2T02	Real Analysis-II	L/T	4	3	60	--	40	40	100	4
Core 7	MMT2T03	Topology-II	L/T	4	3	60	--	40	40	100	4
Core 8	MMT2T04	Classical Mechanics	L/T	4	3	60	--	40	40	100	4
Select any one											
Elective 2	MMT2E05	Mathematical Modelling	L/T	4	3	60	--	40	40	100	4
	MMT2E06	Operations Research-II	L/T	4	3	60	--	40	40		
	MMT2E07	Design of Experiments	L/T	4	3	60	--	40	40		
	MMT2E08	Number Theory	L/T	4	3	60	--	40	40		
	MMT2E09	Coding Theory	L/T	4	3	60	--	40	40		
	MMT2E10	Differential Geometry	L/T	4	3	60	--	40	40		
Computer based Compulsory Paper (CBCP)											
Skill 2	MMT2T11	R-Softwre and Programming	L/T	2	3	60	--		40	100	4
	MMT2L11		L/P	4	2	--	40				
Seminar 2	MMT2S12	Seminar-II		2				25	10	25	1

Table III: Scheme of Teaching and Examination for Third Semester M.Sc. Mathematics Program (CBCS)

Paper	Paper Code	Title of Paper	Teaching		Examination Scheme						
						Maximum Marks					
			Mode	Hrs/Week	Exam Duration (hrs)	Theory	Practical	Internal Assessment	Minimum Passing Marks	Maximum Total Marks	Credits
Core 9	MMT3T01	Complex Analysis	L/T	4	3	60	--	40	40	100	4
Core 10	MMT3T02	Functional Analysis	L/T	4	3	60	--	40	40	100	4
Core 11	MMT3T03	Partial Differential Equations	L/T	4	3	60	--	40	40	100	4
Select any one											
Elective 3	MMT3E04	Differential Manifolds	L/T	4	3	60	--	40	40	100	4
	MMT3E05	Fluid Dynamics-I	L/T	4	3	60	--	40	40		
	MMT3E06	General Relativity	L/T	4	3	60	--	40	40		
	MMT3E07	Decision Theory and Non-parametric Methods	L/T	4	3	60	--	40	40		
Select any one											
Elective 4	MMT3E08	Operations Research-III	L/T	4	3	60	--	40	40	100	4
	MMT3E09	Field Theory	L/T	4	3	60	--	40	40		
	MMT3E10	Measure and Integration Theory	L/T	4	3	60	--	40	40		
	MMT3O11	*Foundation Paper From other Department*									
Computer based Compulsory Paper (CBCP)											
Skill 3	MMT3T12	MATLAB-Programming	L/T	2	3	60	--		40	100	4
	MMT3L12		L/P	4	2	--	40				
Seminar 3	MMT3S13	Seminar III		2				25	10	25	1
For the students other than M.Sc. Mathematics											
Foundation 1	MMT3O14	Elementary Mathematics-I	L/T	4	3	60	--	40	40	100	4

Table IV: Scheme of Teaching and Examination for Fourth Semester M.Sc. Mathematics Program (CBCS)

Paper	Paper Code	Title of Paper	Teaching		Examination Scheme						
						Maximum Marks					
			Mode	Hrs/Week	Exam Duration (hrs)	Theory	Practical	Internal Assessment	Minimum Passing Marks	Maximum Total Marks	Credits
Core 12	MMT4T01	Advanced Discrete Mathematics	L/T	4	3	60	--	40	40	100	4
Core 13	MMT4T02	Advance Numerical Methods	L/T	4	3	60	--	40	40	100	4
Core 14	MMT4T03	Use of Integral Transforms	L/T	4	3	60	--	40	40	100	4
Select any one											
Elective 5	MMT4E04	Operator Theory	L/T	4	3	60	--	40	40	100	4
	MMT4E05	Fluid Dynamics-II	L/T	4	3	60	--	40	40		
	MMT4E06	Cosmology	L/T	4	3	60	--	40	40		
	MMT4E07	Multivariate Analysis	L/T	4	3	60	--	40	40		
Select any one											
Elective 6	MMT4E08	Operations Research-IV	L/T	4	3	60	--	40	40	100	4
	MMT4E09	Dynamical Systems	L/T	4	3	60	--	40	40		
	MMT4E10	Cryptography	L/T	4	3	60	--	40	40		
	MMT4O11	*Foundation Paper From other Department*	L/T	4	3	60	--	40	40		
Computer based Compulsory Paper (CBCP)											
Skill 4	MMT4T12	Programming with Python	L/T	2	3	60	--		40	100	4
	MMT4L12		L/P	4	2	--	40				
Seminar 4	MMT4S13	Seminar IV		2				25	10	25	1
For the students other than M.Sc. Mathematics											
Foundation 2	MMT4O14	Elementary Mathematics-II	L/T	4	3	60	--	40	40	100	4

MMT1T01: ALGEBRA-I

Unit I:

1.1 Permutation Group
1.2 Normal subgroups
1.3 Quotient groups
1.4 Dihedral group
1.5 Commutator group
1.6 Isomorphism Theorems
1.7 Automorphisms
1.8 Characteristic subgroup
1.9 Conjugacy and G-Sets

Unit II:

2.1 Normal Series
2.2 Solvable groups
2.3 Nilpotent groups
2.4 Cyclic decomposition of a permutation group
2.5 Alternating groups
2.6 Simplicity of A_n

Unit III:

3.1 Direct product
3.2 Semi-direct product of groups,
3.3 Finitely generated abelian groups
3.4 Invariants of a finite abelian group
3.5 Sylow theorems
3.6 Groups of order p^2 and pq

Unit IV:

4.1 Definition and examples of Rings
4.2 Elementary properties of Rings
4.3 Types of Rings
4.4 Subrings and characteristic of a Ring
4.5 Additional Examples of Rings

Recommended Book:

1. Bhattacharya, Jain, and Nagpal, Basic Abstract Algebra, Second Edition, Cambridge University Press.

Reference Books:

1. Topics in Algebra, I. N. Herstein, Second Edition, John Wiley.
2. Abstract Algebra: David S. Dummit and Richard M. Foote, John Wiley
3. Michael Artin, Algebra, Prentice-Hall India.

MMT1T02: REAL ANALYSIS-I

Unit I:
1.1 Uniform convergence
1.2 Uniform convergence and continuity
1.3 Uniform convergence and integration
1.4 Uniform convergence and differentiation
1.5 Equicontinuous families of functions
1.6 The Stone-Weierstrass theorem.

Unit II:
2.1 Differentiation
2.2 The Contraction Principle
2.3 The Inverse Function Theorem
2.4 The Implicit Function Theorem
2.5 The Rank Theorem
2.6 Partitions of unity.

Unit III:
3.1 The space of tangent vectors at a point of Rn
3.2 Another definition of Ta (Rn)
3.3 Vector fields on open subsets of Rn
3.4 Topological manifolds
3.5 Differentiable manifolds
3.6 Real Projective space
3.7 Grassman manifolds
3.8 Differentiable functions and mappings.

Unit IV:
4.1 Rank of a mapping
4.2 Immersion
4.3 Sub-manifolds
4.4 Lie groups
4.5 Examples of Lie groups

Recommended Books:
1. Walter Rudin, Principles of Mathematical Analysis (Third Edition), Mc GRAW-HILL Book Company.
2. W. Boothby, An Introduction to Differentiable Manifolds and Riemannian Geometry, Academic Press, 1975.

Reference Books:
1. R. R. Goldberg, Methods of Real Analysis, John Wiley.
2. C Goffman, Calculus of Several Variables, Harper and Row.

MMT1T03: TOPOLOGY-I

Unit I:

1.1 Countable and Uncountable sets
1.2 Examples and related Theorems
1.3 Cardinal Numbers and related Theorems
1.4 Topological Spaces and Examples

Unit II:

2.1 Open sets and Limit points
2.2 Derived Sets
2.3 Closed sets and closure operators
2.4 Interior, Exterior, and boundary operators
2.5 Neighbourhoods, bases, and relative topologies

Unit III:

3.1 Connected sets and components
3.2 Compact and countably compact spaces
3.3 Continuous functions and homeomorphisms
3.4 Arc-wise connectivity

Unit IV:

4.1 T_0 and T_1-spaces
4.2 T_2-spaces and sequences
4.3 Axioms of countability
4.4 Separability
4.5 Regular and normal spaces

Recommended Book:

1. Foundations of General Topology: W.J. Pervin, Academic press, 1964.

Reference Books:

1. J.R. Munkres, Topology (second edition), Prentice-Hall of India, 2002.
2. G.F. Simmons, Introduction to Topology and Modern Analysis, Mc Graw Hill 1963.
3. J.L. Kelley, General Topology, Van Nostrand, 1995.
4. K.D. Joshi, Introduction to general Topology, Wiley Eastern Ltd. 1983

MMT1T04: ORDINARY DIFFERENTIAL EQUATIONS

Unit I: Linear Equations with variable coefficients

1.1 Initial value problems for the homogeneous equations
1.2 Solutions of the homogeneous equations
1.3 The Wronskian and linear independence
1.4 Reduction of the order of a homogeneous equation
1.5 The non-homogenous equations
1.6 Homogeneous equations with analytic coefficients
1.7 The Legendre equations

Unit - II: Linear Equations with regular singular points

2.1 The Euler equations
2.2 Second order equations with regular singular points
2.3 The Bessel equation
2.4 Regular singular points at infinity.

Unit III: Existence and uniqueness of solutions to first-order equations

3.1 The method of successive approximations
3.2 The Lipschitz condition of the successive approximation
3.3 Convergence of the successive approximation
3.4 Non-local existence of solutions
3.5 Approximations to solutions and uniqueness of solutions.

Unit IV: Existence and Uniqueness of Solutions to System of first-order ordinary differential equations

4.1 An example- Central forces and planetary motion
4.2 Some special equations, Systems as vector equations
4.3 Existence and uniqueness of solutions to systems
4.4 Existence and uniqueness for linear systems

Recommended Book:

1. E.A. Coddington, An introduction to ordinary differential equations, Prentice-Hall of India Pvt. Ltd. New Delhi (2012)

Reference Books:

1. G.F. Simmons Differential Equations with Applications and Historical note, McGraw Hill, Inc. New York. (1972)
2. G. Birkoff and G.G. Rota, Ordinary Differential equations, John Willey and Sons
3. E.A. Coddington and N. Levinson, Theory of ordinary differential equations, Tata McGraw Hill, India.

MMT1E05: INTEGRAL EQUATIONS

Unit I:

1.1 Preliminary concepts of integral equations
1.2 Some problems which give rise to integral equations
1.3 Conversion of ordinary differential equations into integral equations
1.4 Classification of linear integral equations
1.5 Integro-differential equations.

Unit II:

2.1 Fredholm equations
2.2 Degenerate kernels
2.3 Hermitian and symmetric kernels
2.4 The Hilbert- Schmidt theorem
2.5 Hermitization and symmetrization of kernels
2.6 Solutions of integral equations with Green's function type kernels.

Unit III:

3.1 Types of Voltera equations
3.2 Resolvent kernel of Voltera equations, Convolution type kernels
3.3 Some miscellaneous types of Voltera equations
3.4 Non-linear Volterra equations
3.5 Fourier integral equations
3.6 Laplace integral equations.

Unit IV

4.1 Hilbert transforms, Finite Hilbert transforms
4.2 Miscellaneous integral transforms.
4.3 Approximate methods of solutions for linear integral equations.
4.4 Approximate evaluation of Eigenvalues and Eigenfunctions.

Recommended Book:

1. L.G. Chambers, Integral Equations, A short course, International textbook company Ltd, (1976).

Reference Books:

1. R.P. Kanwal, Linear Integral Equation, Theory and Techniques, Academic Press, N.Y. (1971)
2. S.G. Mikhlin, Linear Integral Equations, Hindustan Book Agency, (1960)
3. A.M. Viazwaz, A First Course in Integral Equations, World Scientific (1997)
4. Larry Andrews, Bhimsen Shiramoggo, Integral Transform for Engineers, Prentice Hall of India (2003)
5. M. D. Raisinghania, Integral equations and boundary value problems by, S. Chand publication.

MMT1E06: OPERATIONS RESEARCH-I

Unit I: Linear Programming - Simplex Method

1.1 Fundamental properties of solutions
1.2 The computational procedure
1.3 Use of Artificial variables
1.4 Degeneracy in linear programming
1.5 Solution of simultaneous linear equation
1.6 Inverting a matrix using simplex method
1.7 Applications of simplex method

Unit II: Duality in Linear Programming

2.1 General Primal-dual pair
2.2 Formulating a dual problem
2.3 Primal-dual pair in matrix form
2.4 Duality theorems
2.5 Complementary slackness theorem
2.6 Duality and simplex method
2.7 Economic interpretation of duality
2.8 Dual simplex method

Unit III: Post-optimal analysis

3.1 Changes in objective function coefficients c_j's
3.2 Changes in the b_i values
3.3 Changes in the coefficients a_{ij}'s
3.4 Structural changes
3.5 Applications of post-optimal analysis

Unit IV: Goal Programming

4.1 Categorisation of goal programming
4.2 Formulation of linear goal programing problem
4.3 Graphical goal attainment method
4.4 Simplex method for goal programming problem

Recommended book:

1. Kanti Swarup, P.K. Gupta and Man Mohan, Operations Research, Sultan Chand and Sons New Delhi.

Reference Books:

1. H. A. Taha, Operations Research – An Introduction, Prentice-Hall, 1997.
2. J. K. Sharma, Operations Research: Theory and Applications, Macmillan, 1997
3. F. S. Hillier and G. J. Lieberman, Introduction to Operations Research, McGraw-Hill, 2001

MMT1E07: PROBABILITY AND DISTRIBUTIONS

Unit I:

1.1 Sample space, discrete probability independent events
1.2 Bayes theorem
1.3 Axiomatic definition of probability, independence of two events and more than two events,
1.4 Pairwise and mutual independence of events
1.5 Sequence of independent events, independent classes of events
1.6 Borel-Cantelli lemma, Borel zero-one law
1.7 Random variables (discrete and continuous), independence of random variables.

Unit II:

2.1 Basic distribution theory, joint marginal and conditional pmfs and pdfs, conditional expectation.
2.2 Discrete distributions: Bernoulli, Binomial, Poisson, Negative binomial, geometric, uniform, multinomial and hypergeometric distributions.

Unit III:

3.1 Continuous distributions- Normal, bivariate normal, exponential.
3.2 Function of Random variables and their distributions.
3.3 Joint distribution of sample and induced sampling distribution of the statistic.
3.4 Beta, gamma, Cauchy, log-normal distributions, chi-square distribution and its properties.

Unit IV:

4.1 t and F distributions as sampling distribution and their properties
4.2 Parametric test using Chi-square, t, and F distribution
4.3 Order statistics, their distribution,
4.4 Range and their properties
4.5 Joint and marginal distribution of order statistics.

Recommended Books:

1. Rohatgi V.K, An introduction to probability theory and mathematical statistics
2. Basu A.K, Measure and Probability Theory.

Reference Books:

1. Bhat B.R., Modern probability theory
2. Johnson Sand Kotz: Distributions in Statistics Vol. I ,II and III
3. M. Capinski and Tomasz Zastawniak, Probability Through Problems, Springer.

MMT1E08: LINEAR ALGEBRA AND DIFFERENTIAL EQUATIONS

Unit I: Linear System with Constant Coefficient and Real Eigenvalues

1.1 Basic Linear Algebra
1.2 Real Eigen Values
1.3 Differential equations with Real Distinct Eigen values

Unit - II: Linear System with Constant Coefficient and Real Eigenvalues

2.1 Complex Eigen values.
2.2 Complex vector spaces
2.3 Real operators with Complex Eigen values
2.4 Application of complex linear algebra to differential equations.

Unit III: Linear System and Exponentials of Operators

3.1 Review of topology in R^n.
3.2 New norms for old
3.3 Exponential of operators.
3.4 Homogeneous linear systems
3.5 A non-homogeneous equation
3.6 Higher order systems.

Unit IV: Linear System and Canonical Forms of Operators

4.1 The primary decomposition
4.2 The S+N decomposition
4.3 Nilpotent canonical forms
4.4 Jordan and real canonical forms
4.5 Canonical forms and differential equations
4.6 Higher order linear equations
4.7 Operators on function spaces.

Recommended Book:

1. M.W. Hirsch and S. Smale, Differential Equations, Dynamical Systems and Linear Algebra, Academic Press, 1975.

Reference Book:

1. V.I. Arnold, Dynamical systems, Springer Verlag, 1992.

MMT1E09: REPRESENTATION THEORY OF FINITE GROUPS

Unit I: Basics of Group Theory and Linear Algebra

1.1 Group actions, General linear group, basic definitions and examples of group actions and orbits under group actions,
1.2 General linear group

Unit II: Group Representations

2.1 Irreducible and Indecomposable representations,
2.2 Maschke‟s theorem and complete, reducibility, Schur‟s lemma

Unit III: Character Theory and Orthogonality relations

3.1 Orthogonality relations, characters and class functions,
3.2 The regular representation, permutation representation, representations of Abelian groups.

Unit IV: Fourier Analysis on Finite Groups

4.1 Periodic functions and Fourier transform,
4.2 Convolutions, Fourier Inversion,
4.3 Dual group.

Recommended Book:

1. Benjamin Steinberg, Representation Theory of Finite Groups
   Unit-I 2.1 to 2.3; Unit-II 3.1, 3.2; Unit-III 4.1to 4.5; Unit-IV 5.1 to 5.3.

Reference Books:

1. J. P. Serre, Linear Representations of Groups
2. James Leibeck, Representation Theory Michael Artin, Algebra.

MMT1E10: APPLIED COMBINATORICS

Unit I: Basic Counting Principles

1.1 Two Basic Counting Principles
1.2 Simple Arrangements and Selections
1.3 Arrangements and Selections with Repetitions
1.4 Distributions
1.5 Binomial Identities

Unit II: Generating Functions

2.1 Generating Functions Models.
2.2 Calculating Coefficients of Generating Functions.
2.3 Partitions
2.4 Exponential Generating Functions.
2.5 A Summation Method

Unit III: Recurrence Relations

3.1 Recurrence Relations Models
3.2 Divide-and-Conquer Relations
3.3 Solutions of Linear Recurrence Relations
3.4 Solutions of Non-Homogeneous Recurrence Relations
3.5 Solutions of Generating Functions

Unit IV: Inclusion-Exclusion

4.1 Counting with Venn Diagrams.
4.2 Inclusion-Exclusion Formula.
4.3 Restricted Positions and Rook Polynomials

Recommended Book:

1. Alan Tucker: Applied Combinatorics 6th Edn; Wiley India.
Sections 5.1 to 5.5; 6.1 to 6.4; 7.1, 7.3; 8.1 to 8.2.

Reference Book:

1. B. Kolman, R. Busby, S.C. Ross: Discrete Mathematical Structures, 6th Edn, Pearson Edn.
2. Richer A. Brualdi, Introductory Combinatorics, Pearson.

MMT1T11: FUNDAMENTALS OF COMPUTER AND C-PROGRAMMING

Unit I:

1.1 Introduction of Computers
1.2 Block Diagram of Computers
1.3 Generation of Computers
1.4 Memory and Types of Memory
1.5 Computer programming language
1.6 Machine and assembly languages
1.7 Algorithmic languages
1.8 Business-oriented language

Unit II:

2.1 Program Logic development using algorithm and flowchart,
2.2 Introduction to C programming structure, Constants, variables and keywords,
2.3 'C' instructions.
2.4 Data representation: Simple data types like real, integer, character, etc.
2.5 Program statements and header files,
2.6 Use of input and output statements in running simple C programs.

Unit III:

3.1 Operators and expressions,
3.2 Decision control: 'if' statement, 'if-else' statement, nested if and conditional operators, switch statement, Arrays,
3.3 Loop Control Structures: for loop while loop and do-while loop.

Unit IV:

4.1 Introduction to MS- Office
4.2 Working with MS-Word
4.3 Working with MS- Excel
4.4 Working with MS- Power-Point

Reference Books:

1. P.K. Sinha, Computer Fundamentals
2. Microsoft Office: Rom Mansfield.
3. Samuel P. Harkison and GlyL Steele Jr. C; A Reference manual 2nd Edition Prentice hall 1984.
4. Brain W. Kernigham & Dennis M. Ritchie the C programmed Language 2nd Edition (ANSI features) Prentice Hall 1989.

Practical list:

1. Program to find roots of quadratic equation.
2. Program to rules x to the Power N.
3. Program to add digits of a number.
4. Program to check whether a number is prime or not prime.
5. Program to print given number in reverse order.
6. Program to print GCD of two numbers.
7. Program to generate Fibonacci series.
8. Program for reversing an array using function.
9. Program to calculate factorial of a given number.
10. Program to find the sum of first n natural numbers.
11. Create PPT presentation using MS power point.
12. Create a document and insert header and footer, page title using MS-Word.

MMT2T01: ALGEBRA-II

Unit I:

1.1 Ideals and Homomorphisms
1.2 Sum and direct sum of ideals
1.3 Maximal and prime ideals
1.4 Nilpotent and Nil ideals
1.5 Zorn's Lemma

Unit II:

2.1 Unique factorization domains
2.2 Principal Ideal domains
2.3 Euclidean domains
2.4 Polynomial rings over unique factorization domains

Unit III:

2.1 Rings of fractions
2.2 Rings with Ore condition
2.3 Peano's Axioms
2.4 Integers

Unit IV:

3.1 Definition and examples of Modules
3.2 Submodules and direct sums
3.3 R-homomorphisms and quotient modules
3.4 Completely reducible modules
3.5 Free modules
3.6 Representation of linear mappings
3.7 Rank of a linear mapping

Recommended Book:

1. Bhattacharya, Jain, and Nagpal, Basic Abstract Algebra, Second Edition, Cambridge University Press.

Reference Books:

1. Topics in Algebra, I. N. Herstein, Second Edition, John Wiley.
2. Abstract Algebra: David S. Dummit and Richard M. Foote, John Wiley.

MMT2T02: REAL ANALYSIS-II

Unit I:

1.1 Outer measure
1.2 Measurable sets and Lebesgue measure
1.3 Anon-measurable set
1.4 Measurable functions
1.5 Littlewood's three principles.

Unit II:

2.1 The Riemann integral
2.2 Lebesgue integral of a bounded function over a set of finite measures. Integral of a non-negative function
2.3 General Lebesgue integral
2.4 Convergence in measure
2.5 Differentiation of monotone functions
2.6 Functions of bounded variation
2.7 Differentiation of an integral.

Unit III:

3.1 Absolute continuity. Convex functions
3.2 L_p-spaces
3.3 Holder and Minkowski inequality
3.4 Riesz-Fischer theorem. Approximation in L_p-spaces
3.5 Bounded linear functionals on L_p-spaces.

Unit IV:

4.1 Compact metric spaces
4.2 Baire category theorem
4.3 Arzela Ascoli theorem
4.4 Locally compact spaces
4.5 Sigma compact spaces.

Recommended Book:

1. H.L. Royden, Real Analysis, Third edition, Prentice Hall, 1988.

Reference Books:

1. Andrew Browder, Mathematical Analysis, An Introduction, Springer
2. G. de Barra, Measure theory and Integration, Wiley Eastern Limited, 1981.
3. Inder K. Rana, An introduction to Measure & Integration, Narosa Publishing House

MMT2T03: TOPOLOGY-II

Unit I:

1.1 Continuous Functions
1.2 The product topology
1.3 The metric topology
Chapter 2: Sections 18 to 21 [Omit Section 22]

Unit II:

2.1 Connected spaces
2.2 Connected subspaces of the Real line
2.3 Components and local connectedness.
Chapter 3: Sections 23 to 25

Unit III:

3.1 Compact spaces
3.2 Compact subspaces of the Real line
3.3 Limit Point Compactness
3.4 Local Compactness
Chapter 3: Sections 26 to 29

Unit IV:

4.1 The Countability Axioms
4.2 The separation Axioms
4.3 Normal spaces
4.4 The Urysohn Lemma
4.5 The Urysohn metrization Theorem
4.6 The Tietz extension theorem
Chapter 4: Sections 30 to 35

Recommended Book:

1. James R. Munkres, Topology (2nd Edition) Pearson Education Pve. Ltd., Delhi-2002.

Reference Books:

1. J. Dugundji, Topology, Prentice Hall of India, New Delhi, 1975.
2. G.F. Sinmons, Introduction to Topology and Modern Analysis, McGraw Hill Book Co., 1963
3. J.L. Kelly, General Topology, Van Nostrand, Reinhold Co., New York
4. L. Steen and J. Subhash, Counter Examples in Topology, Holt, Rinehart and Winston, New York, 1970.
5. S. Willard, General Topology, Addison - Wesley, Mass., 1970

MMT2T04: CLASSICAL MECHANICS

Unit I: Variational principle and Lagrange's Equations:

1.1 Hamilton's principle, some techniques of the calculus of variations
1.2 Derivation of Lagrange's Equations from Hamilton's Principle
1.3 Extension of principle to nonholonomic systems
1.4 Conservation theorems and symmetry properties.

Unit II:

2.1 Legendre transformations and the Hamilton equations of motion
2.2 Cyclic coordinates and conservation theorems, Routh's equations
2.3 Derivation of Hamilton's equations from a variational principle
2.4 The principle of least action.

Unit III: **Canonical transformations**

3.1 The equations of Canonical transformation, examples of canonical transformations.
3.2 Symmetric approach to Canonical Transformation
3.3 Poisson's bracket & other canonical invariants.

Unit IV:

4.1 Equations of motion.
4.2 Infinitesimal canonical transformations and conservation theorems in the Poisson bracket formulation,
4.3 The angular momentum poisson bracket relations
4.4 Hamilton-Jacobi theory for Hamilton's principle, and characteristic functions.

Recommended Book:

1. H. Goldstein, Classical Mechanics, Second edition, Narosa Publishing House, New Delhi

Reference Books:

1. T.M. Karade, G.S. Khadekar, Lectures on Advanced Mechanics, Sonu-Nilu publication
2. A.S. Ramsey Dynamics Part-II, the English Language Book Society, and Cambridge University Press.
3. Gupta, Kumar and Sharma, Classical Mechanics
4. I.D. Landau and E.M. Lifchitz, Vol. I third edition, Perguman press, New Delhi
5. N.C. Rana & P.S. Joag, Classical Mechanics, Tata Mc Graw Hill
6. L.M. Katkar, Classical Mechanics (Mathematics), Shivaji University Kolhapur, 2007

MMT2E05: MATHEMATICAL MODELLING

Unit I: Mathematical Modelling through Ordinary Differential Equations (ODE)

1.1 Mathematical modeling through differential equations
1.2 Linear, Non-linear Growth and Decay models
1.3 Compartment Models
1.4 Mathematical Modelling in Dynamics through first order ODE
1.5 Mathematical Modelling of Geometrical problems through first order ODE

Unit II: **Mathematical Modelling through Systems of First order ODE**

2.1 Mathematical Modelling in Population Dynamics
2.2 Mathematical Modelling of Epidemics
2.3 Compartment Models
2.4 Mathematical Modelling in Economics
2.5 Mathematical Modelling in Medicine, Arms race, Battles and International trade
2.6 Mathematical Modelling in Dynamics

Unit III: **Mathematical Modelling through Systems of Second order ODE**

3.1 Mathematical Modelling of Planetary Motions
3.2 Mathematical Modelling of Circular Motions and Motion of Satellites
3.3 Mathematical Modelling through linear Second order ODE
3.4 Miscellaneous Mathematical models through Second order ODE

Unit IV: Mathematical Modelling through Difference Equations

4.1 The need for Mathematical Modelling through difference equations
4.2 Basic theory of linear difference equations with constant coefficients
4.3 Mathematical modelling in Economics, finance, Population Dynamics and Genetics, and Probability theory
4.4 Miscellaneous examples of Mathematical Modelling through Difference equations

Recommended Book:

1. Mathematical Modelling by J. N. Kapur: New Age International (P) Limited Publishers, New Delhi, 1988, Reprinted 2005.

Reference Books:

1. Shepley L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, 1984.
2. Sandip Banerjee, Mathematical Modeling, models, analysis and applications, IIT Roorkee, Publication: CRS Press, Taylor and Francis Group, London.
3. Seyed M. Moghdas, Majid Jaberi-Douraki, Mathematical Modelling, Wiley publications.

MMT2E06: OPERATIONS RESEARCH-II

Unit I: Integer Programming Problems

1.1 Gomory's cutting plane algorithm (All integer and mixed integer algorithms),
1.2 Branch and Bound method.

Unit II: Linear Programming Problem–Advanced Techniques

2.1 Revised simplex method
2.2 Bounded Variable
2.3 Parametric Linear Programming
2.4 Linear Fractional Programming
2.5 Karmarkar Algorithm

Unit III: Non-Linear Programming

3.1 Formulating a nonlinear programming problem
3.2 Constrained optimization with equality constraints
3.3 Constrained optimization with inequality constraints
3.4 Saddle Point Problem
3.5 Saddle point and NLPP

Unit IV: Decision Analysis

4.1 Decision making problem
4.2 Decision-making process
4.3 Decision-making environment
4.4 Decision under uncertainty
4.5 Decision under risk
4.6 Decision tree analysis
4.7 Decision-making with utilities

Recommended book:

1. Kanti Swarup, P.K. Gupta and Man Mohan, Operations Research, Sultan Chand and Sons New Delhi.

Reference Books:

1. H. A. Taha, Operations Research – An Introduction, Prentice-Hall, 1997.
2. J. K. Sharma, Operations Research: Theory and Applications, Macmillan, 1997
3. F. S. Hillier and G. J. Lieberman, Introduction to Operations Research, McGraw-Hill, 2001

MMT2E07: DESIGN OF EXPERIMENTS

Unit I:

1.1 Basic principles of experimental design
1.2 Analysis of variance, one way and two-way classified data
1.3 Randomization structure and analysis of completely randomized design (CRD), randomized block design (RBD) and Latin square design (LSD).
1.4 Missing plot technique in RBD and LSD with one and two missing values (only estimation).

Unit II:

2.1 Incomplete block designs, balanced incomplete block design (BIBD)
2.2 Parametric relations and analysis of BIBD
2.3 Connectedness and orthogonality
2.4 BIBD with recovery of inter-block information PBIBD with two associate classes
2.5 Definitions and parametric relations of SBIBD, RBIBD, ARBIBD, PBIBD
2.6 Youden Square Design-definition and analysis

Unit III:

3.1 Factorial experiments
3.2 Factorial effects, best estimates and testing the significance of factorial effects.
3.3 Analysis of 2^n (2^3 and 2^4) factorial experiments in randomized blocks. Split plot designs-construction and analysis.
3.4 Analysis of covariance for one way and two way classified data.

Unit IV:

4.1 Confounding and fractional replication in factorial experiments, complete and partial confounding.
4.2 Simultaneous confounding, double confounding.
4.3 Concept of generalized interaction.
4.4 Design for study of response surfaces

Recommended Books:

1. Das M.N. and Giri N., Design and Analysis of experiments, Wiley Eastern (1997)
2. Alok Dey Theory of Block design. Wiley Eastern

Reference Books:

1. Montgomery C.D. Design and Analysis of experiments. Wiley, New York (1976)

MMT2E08: NUMBER THEORY

Unit I:

1.1 The Mobius function u(n)
1.2 The Euler totient function φ(n)
1.3 A relation connecting φ and μ. A product formula for φ (n)
1.4 The Dirichlet product of arithmetical functions
1.5 Dirichlet inverses and Mobius Inversions formula.
1.6 The Mangoldt function π(n),
1.7 Multiplicative functions and Dirichlet multiplication,
1.8 The inverse of a completely multiplicative function
1.9 Liouville's function (n), The divisor function (n). Generalised convolutions.

Unit II:

2.1 The big O notation Asymptotic equality of functions
2.2 Euler's summation formula, some elementary asymptotic formulas
2.3 The average order of d(n), the average order of divisor functions (n), the average order of φ(n)
2.4 An application to the distribution of lattice points visible from the origin.
2.5 The average order of μ(n) and π(n), The partial sums of a Dirichlet product, Applications to μ(n) and π(n),
2.6 Another identity for the partial sums of a Dirichlet product.

Unit III: Galois Theory

3.1 Chebyshev's functions Ψ(x)and v(x).
3.2 Relations connecting Ψ (x)and v(x)
3.3 Some equivalent forms of the prime number theorem
3.4 Inequlities of π(n) and P_n Shapiro's Tauberian theorem
3.5 Application of Shapiro's theorem
3.6 An asymptotic formulae for the partial sums $\sum (1/p)$.

Unit IV: Applications of Galois theory to classical problems

4.1 Definition and basic properties of congruences.
4.2 Residue classes and complete residue systems.
4.3 Linear congruences. Reduced residue systems and Euler - Format theorem,
4.4 Polynomial congruences modulo p, Lagrange's theorem.
4.5 Simultaneous linear congruences, the Chinese remainder theorem.
4.6 Applications of the Chinese remainder theorem.
4.7 Polynomial congruences with prime power moduli

Recommended Book:

1. Introduction to analytic number theory - by Tom M-Apostol, Narosa Publishing House, New Delhi.

Reference Books:

1. D.M. Burton, Introduction to Number Theory, McGraw-Hill.

MMT2E09: CODING THEORY

Unit I: Error detection

1.1 Correction and decoding: Communication channels, Maximum likelihood decoding,
1.2 Hamming distance, nearest neighbor / minimum distance decoding, Distance of a code.

Unit II: Linear Codes

2.1 Vector spaces over finite fields, Linear codes, Hamming weight, Bases of linear codes
2.2 Generator matrix and parity check matrix, Equivalence of linear codes, Encoding with a linear code, Decoding of linear codes
2.3 Cossets, nearest neighbor decoding for linear codes, Syndrome decoding.

Unit III: Bounds in Coding Theory

3.1 Main coding theory problem, lower bounds, sphere covering bounds, Gilbert Varshamov bound, Hamming Codes
3.2 Hamming bound and Perfect codes Singleton bound and MDS codes

Unit IV: Cyclic Codes

4.1 Definitions, Generator polynomials
4.2 Generator and parity check matrices
4.3 Decoding of cyclic codes, Burst-error-correcting codes
4.4 Some special cyclic codes: BCH codes, Definitions, Parameters of BCH codes

Recommended Book:

1. San Ling and Chaoing xing, Coding Theory- A First Course (Cambridge University Press, 2004)
   (Sections 2.1, to 2.5); (Sections 3.1. to 3.4 and Sections 4.1, to 4.8); (Sections 5.1, to 5.4), (7.1, to 7.4); (8.1, 8.1.1 and 8.1.2)

Reference Books:

1. San Ling and Chaoing xing, Coding Theory- A First Course
2. Raymod Hill, A First Course in Coding Theory (Oxford)
3. Lid and Pilz, Applied Abstract Algebra Second Edition.

MMT2E10: DIFFERENTIAL GEOMETRY

Unit I:

1.1 Definition of surface, Curves on a surface
1.2 Surfaces of revolution
1.3 Helicoids
1.4 Metric, Direction coefficients
1.5 Families of curves
1.6 Isometric correspondence
1.7 Intrinsic properties.

Unit II:

2.1 Geodesics
2.2 Canonical geodesic equations
2.3 Normal property of geodesics
2.4 Existence theorems
2.5 Geodesic parallels
2.6 Geodesic curvature
2.7 Gauss-Bonnet theorem and Gaussian curvature
2.8 Surfaces of constant curvature
2.9 Conformal mapping and Geodesic mapping.

Unit III:

3.1 Second fundamental form
3.2 Principal curvatures
3.3 Lines of curvature
3.4 Developable, Developable associated with space curves
3.5 Developable associated with curves on surfaces
3.6 Minimal surfaces and ruled surfaces

Unit IV:

4.1 Tensor notations
4.2 Gauss equations
4.3 Weingarten equations
4.4 Mainardi-Codazzi equations
4.5 Parallel surfaces.
4.6 Fundamental existence theorem for surfaces

Recommended Book:

1. D. Somasundaram, Differential Geometry a first course, Narosa Publishing House, 2008

Reference Books:

1. T.J. Wilmore, An introduction to Differential Geometry, Oxford University Press
2. do Carmo, Geometry of curves and surfaces, Academic Press.
3. A. Pressley, Elementry Differential Geometry, Springer UTM.

MMT2T11: R-SOFTWARE AND PROGRAMMING

Unit I:

1.1 Basic fundamentals, installation and use of software
1.2 Data editing
1.3 Use of R as a calculator, functions and Assignments
1.4 Use of R as a calculator, functions and matrix operations, logical operators.

Unit II:

2.1 Variables and Types of Data, Conditional executions and loops,
2.2 Data management with sequences.
2.3 Data management with repeats, sorting, ordering, and lists.
2.4 Vector indexing
2.5 Data management with strings, display and formatting.

Unit III:

3.1 Data frames, statistical functions, Absolute Frequency, Relative Frequency and Frequency Distribution
3.2 Arithmetic Mean, Median, Quantiles, Mode, Geometric Mean and Harmonic Mean
3.3 Range, Interquartile Range and Quartile Deviation

Unit IV:

4.1 Statistical functions for central tendency, variation, Skewness and kurtosis,
4.2 Handling of bivariate data through graphics, correlations, Graphics and plots.

Recommended Books:

1. Prof. Shalabh, Introduction to R Software, Mathematics, IIT Kanpur.
2. Prof. Shalabh, Descriptive Statistics with R Software, Mathematics, IIT Kanpur.

Practical list:

1. Arithmetic Operation and Array
2. Basic Matrices operation and Element-by-Element matrix operation.
3. Find determinant of matrix, Inverse of matrix, Find Eigen value, Eigen Vector, Rank of Matrix,
4. Calculate Absolute Frequency, Relative Frequency and Frequency Distribution,
5. Find Arithmetic Mean, Median, Mode, Geometric Mean and Harmonic Mean,
6. Calculate Quantiles, Range, Interquartile Range and Quartile Deviation.
7. Calculate central tendency, variation, Skewness and kurtosis.

MMT3T01: COMPLEX ANALYSIS

Unit I:

1.1 Impossibility of ordering Complex numbers
1.2 Extended complex plane and stereographic projection
1.3 Elementary properties and examples of analytic Functions, Power series, analytic functions.

Unit II:

2.1 Analytic functions as mappings
2.2 Mobius transformations
2.3 Power series representation of analytic functions
2.4 Zeros of an analytic function, index of a closed curve.

Unit III:

3.1 Cauchy's theorem and integral formula
3.2 The homotopic version of cauchy's theorem and simple connectivity
3.3 Counting zeros
3.4 The open mapping theorem, Goursat's theorem
3.5 Classification of singularities, residues, the argument principle.

Unit IV:

4.1 The maximum principle
4.2 Schwarz's lemma
4.3 Convex functions and Hadamards three circles theorem.
4.4 Phragmen-Lindel of theorem.

Recommended Book:

1. John B. Conway, Functions of one complex variable: Second edition, Springer international Student Edition.

Reference Books:

1. Complex Analysis, L.V. Ahlfors. Mc-Graw Hill, 1966

MMT3T02: FUNCTIONAL ANALYSIS

Unit I:
1.1 Normed spaces, Banach spaces
1.2 Further properties of normed spaces
1.3 Finite-dimensional normed spaces and subspaces
1.4 Compactness and finite dimension
1.5 Bounded and continuous linear operators

Unit II:
2.1 Linear functionals
2.2 Normed spaces of operators
2.3 Dual spaces
2.4 Inner product space
2.5 Hilbert space
2.6 Further properties of inner product spaces
2.7 Orthogonal complements and direct sums
2.8 Orthonormal sets and sequences
2.9 Total orthonormal sets and sequences.

Unit III:
3.1 Representation of functionals on Hilbert spaces
3.2 Hilbert adjoint operators, self-adjoint, unitary and normal operators.
3.3 Hahn-Banach Theorem
3.4 Hahn-Banach Theorem for complex vector spaces and normed spaces
3.5 Reflexive spaces.

Unit IV:
4.1 Category theorem
4.2 Uniform boundedness theorem, strong and weak convergence
4.3 Convergence of sequences of operators and functionals
4.4 Open mapping theorem
4.5 Closed linear operators and closed graph theorem.

Recommended Book:
1. E. Kreyszig, Introductory Functional Analysis with Applications by John Wiley and Sons.

Reference Books:
1. A.E. Taylor and D.C. Lay, Introduction to Functional Analysis by John Wiley and Sons.
2. Introduction to Topology and Modern Analysis: G.F. Simmons, McGraw Hill.

MMT3T03: PARTIAL DIFFERENTIAL EQUATIONS

Unit I: Partial Differential Equations of the First Order

1.1 Cauchy's problem for first-order equations
1.2 Linear equations of the first order
1.3 Integral surfaces passing through a given curve
1.4 Surfaces orthogonal to a given system of surfaces
1.5 Nonlinear partial differential equations of the first order
1.6 Cauchy's method of Characteristics
1.7 Compatible systems of first-order equations and Charpit's method
1.8 Special types of first-order equations
1.9 Solutions satisfying given conditions
1.10 Jacobi's method
1.11 Applications of first-order equations

Unit II: Partial Differential Equations of the Second Order

2.1 Linear partial differential equations with Constant coefficients
2.2 Equations with Variable coefficients
2.3 Characteristic curves of second-order equations
2.4 Characteristics of equations in three variables
2.5 The solution of linear hyperbolic equations
2.6 Separation of variables
2.7 Nonlinear equations of the second order

Unit III: Laplace's Equation

3.1 Elementary solutions of Laplace's equation
3.2 Boundary value problems
3.3 Separation of variables
3.4 Problems with axial symmetry
3.5 Kelvin's inversion theorem
3.6 The two dimensional Laplace equation
3.7 Green's function for Laplace equation

Unit IV: The Wave and Diffusion Equations

4.1 The occurrence of the wave equation in physics
4.2 Elementary solutions of the one-dimensional wave equation
4.3 Vibrating membranes: Application of the calculus of variations
4.4 General solutions of the wave equation
4.5 Green's function for the wave equation
4.6 The nonhomogeneous wave equation
4.7 The occurrence of the diffusion equation in physics
4.8 The resolution of boundary value problems for the diffusion equation
4.9 Elementary solutions of the diffusion equation
4.10 Separation of variables
4.11 Use of Green's function

Recommended Books:

1. I N. Sneddon, Elements of Partial Differential Equations, Tata Mc Graw Hill Int.
2. T. Amarnath, An Elementary Course in Partial Differential Equations, 2nd Ed., Narosa Publishing House

Reference Book:

1. G.B. Polland, Introduction to Partial Differential Equations, Overseas Press, 1995.

MMT3E04: DIFFERENTIAL MANIFOLDS

Unit I:

1.1 Multilinear Algebra
1.2 Alternating Tensors
1.3 The Wedge Product
1.4 Tangent Vectors and Differential Forms
1.5 The Differential Operator
1.6 The Action of a Differential Map

Unit II:

2.1 The Volume of a Parallelopiped
2.2 The Volume of a Parameterized-Manifold
2.3 Manifolds in Rn
2.4 The Boundary of a Manifold
2.5 Integrating a Scalar Function over a Manifold

Unit III:

3.1 Integrating Forms over Parameterized Manifolds
3.2 Orientable Manifolds
3.3 Integrating Forms over Oriented Manifolds
3.4 The Generalized Stokes' Theorem

Unit IV:

4.1 The Poincare Lemma
4.2 The deRham Groups of Punctured Euclidean Spacen

Recommended Book:

1. James R. Munkres, Analysis on Manifolds (Westview Press), ISBN 0-201-31596-3. Chapter 5. Chapter 6 (except section 31). Chapter 7 (except section 36 and 38).

Reference Books:

1. Michael Spivak, Calculus on Manifolds, CRC Press (Taylor and Francis Group), Chapman and Hall Book, 1965.
2. Guillemin and Pollack, Differential Topology, AMS-Chelsea Publishing, 2010.

MMT3E05: FLUID DYNAMICS-I

Unit I:

1.1 Real fluids and ideal fluids
1.2 Velocity of a fluid at a point
1.3 Stream lines and path lines
1.4 Steady and unsteady flows
1.5 Velocity potential. Velocity vector
1.6 Local and particle rate of change
1.7 Equation of continuity. Acceleration of a fluid
1.8 Condition at a rigid boundary. General analysis of fluid motion.
1.9 Euler's equation of motion. Bernoulli's equation. Worked examples.
1.10 Discussion of the case of steady motion under conservative body forces. Some further aspects of vortex motion.

Unit II:

2.1 Sources, sinks and doublets.
2.2 Images in a rigid infinite plane and solid spheres.
2.3 Axisymmetric flows. Stokes' stream function.
2.4 The complex potential for two-dimensional irrotational, incompressible flow.
2.5 Complex velocity potential for standard two dimensional flow.
2.6 Uniform stream. Line source and line sink. Line doublets. Line vortices.
2.7 Two-dimensional image systems.
2.8 The Milne-Thomson circle theorem. Circle Theorem. Some applications of circle theorem. Extension of circle theorem.
2.9 The theorem of Blasius.

Unit III:

3.1 The equations of state of a substance, the first law of thermodynamics
3.2 Internal energy of a gas, functions of state, entropy
3.3 Maxwell's thermodynamic relation, Isothermal Adiabatic and Isentropic processes.
3.4 Compressibility effects in real fluids, the elements of wave motion
3.5 One-dimensional wave equation, wave equation in two and three dimensions, spherical waves, progressive and stationary waves.

Unit IV:

4.1 The speed of sound in a gas, equation of motion of a gas
4.2 Sonic, subsonic, supersonic flows; isentropic gas flow
4.3 Reservoir discharge through a channel of varying section, investigation of maximum mass flow through a nozzle, shock waves, formation of shock waves, elementary analysis of normal shock waves.

Recommended Book:

1. F. Chorlton, Text book of Fluid Dynamics, CBS Publishers, Delhi 1985.

Reference books:

1. G.K. Batchelor, An Introduction to fluid Mechanics, Foundation Books, New Delhi 1994.
2. M.D. Raisinghania, fluid Mechanics, S. Chand and Company, Delhi.

MMT3E06: GENERAL RELATIVITY

Unit I:

1.1 Tensor Algebra,
1.2 Riemannian geometry,
1.3 Curvature Tensor: Covariant Curvature tensor, Ricci tensor, Einstein Tensor
1.4 The Bianchi identity.

Unit II:

2.1 The principle of covariance, The principle of equivalence, Geodesic principle
2.2 Newton's equations of motion as an approximation of geodesic equations
2.3 Poisson's equations as an approximation to Einstein field equations.

Unit III:

3.1 Gravitational field equations in free space
3.2 Exterior Schwarzchild's solution and its isotropic form
3.3 Birkhoff's theorem, Schwarzchild singularity, planetary orbit
3.4 Advance of Perihelion of a planet
3.5 Bending of light rays in the gravitational field
3.6 Gravitational Redshift in the spectral lines

Unit IV:

4.1 Newtonian Incompressible star
4.2 The pressure contribution mass of static, spherically symmetric System
4.3 The Tolman-Oppenheimer-Volkoff Equation
4.4 Schwarzchild's Interior solution

Recommended Books:

1. Ronald Adler, Maurice Bezin and Manamen Schiffer, Introduction to General Relativity: McGraw-Hill Kogakusha Ltd.
2. Øyvind Gron, Lecture Notes on General Theory of Relativity, Springer publication Unit 4: Chapter 10, articles [10.1, 10.2,10.3, 10.4]

Reference Books:

1. Rosser W.G.V., Introduction to theory of relativity, ELBS(1972).
2. T M Karade, G S Khadekar and Maya S Bendre, Lecture on General Relativity, Sonu Nilu Publication (2004)
3. Rindler W., Relativity Special, General and Cosmology, Pub. Oxford University Press (2003).
4. Landau I.D. and Lifshitz E.M., The Classical Theory of Fields By Pub. Pergamon Press (1978)

MMT3E07: DECISION THEORY AND NON-PARAMETRIC METHODS

Unit I:

1.1 Decision problem, loss function, expected loss
1.2 Decision rules (non-randomized and randomized),
1.3 Decision principles (conditional Bayes, frequentist)
1.4 Inference and estimation problems as decision problems, criterion of optimal decision rules.
1.5 Concepts of admissibility and completeness, Bayes rules, minimax rules,
1.6 Admissibility of Bayes rules. Existence of Bayes decision rules

Unit II:

2.1 Definition of non-parametric test, Advantages and disadvantages of Nonparametric tests
2.2 Single sample problems: Test of randomness,
2.3 Test of good ness of fit: Empirical distribution function. Kolmogorov– Smirnov test, Chi-square test
2.4 Comparison of Chi square test & KS test.
2.5 One sample problem of location: Sign Test
2.6 Wilcoxon's signed rank test, Wilcoxon paired sample signed rank test

Unit III:

3.1 Two sample problems: Different types of alternatives, Sign test, Wilcoxon's two sample rank sum test, Wald-Wolfowitz run test, Mann-Whitney-Wilcoxon test, Median test, KS-two sample test. Klotz Normal score test
3.2 One sample U-statistic, Kernel and symmetric Kernel Variance of U-Statistic, two-sample U-statistic
3.3 Linear rank Statistics and their distributional properties under null hypothesis

Unit IV:

4.1 Concept of time order and random censoring, likelihood in these cases,
4.2 Survival function, hazard function.
4.3 Non-parametric Estimation of Survival function
4.4 Cox's proportional hazards model, the actuarial estimator

Recommended Books:

1. Ferguson T.S., Mathematical Statistics–A decision theoretic approach

Reference Books:

1. Gibbons J.D., Nonparametric Statistical inference

MMT3E08: OPERATIONS REASERCH-III

Unit I: Transportation Problem

1.1 LP formulation and existence of solution in transportation problem
1.2 Solution of transportation problem
1.3 Test for optimality
1.4 Transportation algorithm-MODI method
1.5 Stepping stone solution method
1.6 Some exceptional cases
1.7 Time-minimization transportation problem
1.8 Transhipment problem

Unit II: Assignment Problem

2.1 Mathematical formulation of the assignment problem
2.2 Solution methods
2.3 Special cases
2.4 A typical assignment problem
2.5 Dual of the assignment method
2.6 The traveling salesman problem

Unit III: Network Routing Problems

3.1 Network flow problems
3.2 Minimal spanning tree problem
3.3 Shortest route problems
3.4 Maximal flow problems
3.5 Minimum cost flow problems
3.6 More network flow problems
3.7 Insight into big networks

Unit IV: Network Scheduling by PERT/CPM

4.1 Network: Basic components
4.2 Logical sequencing
4.3 Rules of network construction
4.4 Concurrent activities
4.5 Critical path analysis
4.6 Probability considerations in PERT
4.7 Distinction between PERT and CPM

Recommended Book:

1. Kanti Swarup, P.K. Gupta and Man Mohan, Operations Research, Sultan Chand and Sons New Delhi.

Reference Books:

1. H. A. Taha, Operations Research – An Introduction, Prentice-Hall, 1997.
2. J. K. Sharma, Operations Research: Theory and Applications, Macmillan, 1997
3. F. S. Hillier and G. J. Lieberman, Introduction to Operations Research, McGraw-Hill, 2001

MMT3E09: FIELD THEORY

Unit I: Algebraic Extension of fields

1.1 Irreducible polynomials and Eisenstein criterion, adjunction of roots
1.2 Algebraic extensions, algebraically closed fields

Unit II: Normal and Separable extensions

2.1 Splitting fields
2.2 Normal extensions, multiple roots, finite fields, separable extensions

Unit III: Galois Theory

3.1 Automorphism groups and fixed fields
3.2 Fundamental theorem of Galois theory
3.3 Fundamental theorem of algebra.

Unit IV: Applications of Galois Theory to classical problems

4.1 Roots of unity and cyclotomic polynomials, cyclic extensions
4.2 Polynomials solvable by radicals, symmetric functions
4.3 Ruler and compass constructions

Recommended Book:

1. P. B. Bhattacharyya, S. K. Jain and S. R. Nagpaul, Basic Abstract Algebra, Cambridge University Press, Second Edition.

Reference Books:

1. D. Dummit and R.M.Foote, Abstract Algebra, 2nd Edition, Wiley Eastern Ltd.
2. T. A. Hungerford, Algebra, Graduate Texts in Mathematics, Vol. 73, SpringerVerlag, 1980 (Indian Reprint 2004).
3. O. Zariski and P. Sammuel, Commutative Algebra, Vol. 1, Van Nostrand.
4. S. Luthar, I. B. S. Passi, Algebra, Vol. 4, Field Theory, Narosa Publishing House.
5. M. Artin, Algebra, Prentice Hall India, Second Edition.

MMT3E10: MEASURE AND INTEGRATION THEORY

Unit I:

1.1 Measure spaces
1.2 Measurable functions
1.3 Integration
1.4 General convergence theorems
1.5 Signed measures
1.6 The Radon-Nikodym theorem
1.7 The L^p spaces

Unit II:

2.1 Outer measure and measurability
2.2 The Extension theorem
2.3 The Lebesgue-Stieltjes integral
2.4 Product measures
2.5 Integral operators
2.6 Inner measure
2.7 Extension by sets of measure zero
2.8 Caratheodory outer measure
2.9 Hausdorff measure

Unit III:

3.1 Baire sets and Borel sets
3.2 The regularity of Baire and Borel measures
3.3 The construction of Borel measures
3.4 Positive linear functionals and Borel measures
3.5 Bounded linear functionals on $C(X)$

Unit IV:

4.1 Homogeneous spaces
4.2 Topological equicontinuity
4.3 The existence of invariant measures
4.4 Topological groups
4.5 Group actions and quotient spaces
4.6 Unicity of invariant measures
4.7 Group of diffeomorphisms

Recommended Book:

1. Royden H.L., Real Analysis, Macmillan Pub. Co. Inc., 4th Edition, New York, 1993

Reference Book:

1. Bartle R.G., The Elements of Integration, John Wiley & Sons, Inc. New York, 1966.

MMT3T12: MATLAB-PROGRAMMING

Unit I:

1.1 Introduction of MATLAB
1.2 Arithmetic Operation, Variables
1.3 Mathematical Functions, Array, Operators (Element by Element)
1.4 Generating Vectors from functions,
1.5 MATLAB Special Variables, M-File.

Unit II: Matrices:

2.1 Addition of Matrix, Multiplication of two matrix,
2.2 Finding of Determinant of matrix, Inverse of matrix, Eigen value, Eigen Vector and Rank of Matrix
2.3 Selection of particular elements from matrix,
2.4 Solution of simultaneous equations in MatLab,

Graphs:

2.5 Plot of graphs in 2D
2.6 Plot of graphs 3D,
2.7 Hold on, Pi diagram, Bar and histogram.

Unit III: Loops

3.1 For, While, Do…while, if, if … else.
3.2 Programming.

Unit IV:

4.1 Solution of System of Linear Algebraic equations
4.2 Curve fitting and Interpolation
4.3 Numerical differentiation

Reference Books:

1. MATLAB for Beginners: A Gentle Approach, Peter Issa Kattan
2. Matlab: A Practical Introduction to Programming and Problem Solving, Stormy Attaway
3. Programming Mathematics Using MATLAB, Lisa A. Oberbroeckling
4. Applied Numerical Analysis by Gerald & Wheatley, Pearson- 7th Edition, 2003.
5. Elements of Numerical Analysis by R.S. Gupta, second edition, Cambridge university press
6. Numerical Methods Using MATLAB by Mathew & Fink, Pearson, 1998.
7. Getting started with Matlab: A quick introduction for scientist & engineers by Rudra Pratap, Oxford, 2010

Practical list:

1. Arithmetic Operation and Array
2. Basic Matrix operations and Element by Element matrix operation
3. Find determinant of matrix, Inverse of matrix, Find Eigen value, Eigen Vector, Rank of Matrix,
4. Solve simultaneous equation.
5. Plot 2D, 3D graphs
6. Pi diagram, Bar, histogram
7. For, if, if … else. Programming
8. While, Do…while Programming
9. Solving System of Linear Algebraic equations
10. Curve fitting and Interpolation, Numerical differentiation

MMT3O14: ELEMENTARY MATHEMATICS I
(For the student of other than the mathematics department)

Unit I: Differentiation

1.1 Derivative of a constant function
1.2 Derivative of trigonometric functions
1.3 Derivative of inverse trigonometric functions
1.4 Derivative of hyperbolic function
1.5 Derivation of parametrically defined functions, logarithmic differentiation.

Unit II: Integration

2.1 Methods of integration
2.2 Integration by substitution
2.3 Three important forms of integrals, six important integrals
2.4 Integration by parts, definite integrals, reduction formulae

Unit III: Matrices & Determinant

3.1 Transpose of matrix
3.2 Orthogonal matrices, unitary matrices, Hermitian and Skew-Hermitian matrices, idempotent matrix, Involutory matrix
3.3 Minors and factors
3.4 Properties of determinants, determinants-general treatment,
3.5 Symmetric & Skew-symmetric determinant.

Unit IV: Complex Number

4.1 Definition, conjugate, modulus and argument
4.2 Algebra of complex number (Addition, Subtraction, Multiplication and Division)
4.3 Power and square root of complex number
4.4 Properties of complex number, Argand diagram
4.5 Solution of quadratic equation in complex number system.

Reference Books:

1. Differential Calculus by Shanti Narayan (Unit 1 & Unit 2)
2. An Introduction to Matrices by S.C. Gupta (Unit 3 & Unit 4)

MMT4T01: ADVANCED DISCRETE MATHEMATICS

UNIT I:

1.1 Matrix representation of graphs- Incidence matrix, cut set matrix, Path Matrix, Circuit Matrix and Adjacency matrix.
1.2 Directed graphs, types of directed graphs, Binary search trees.

UNIT II:

2.1 Discrete Numeric functions, Asymptotic Behavior of Numeric functions, Generating functions.
2.2 Recurrence Relations- Linear Recurrence Relations with constant coefficients
2.3 Homogeneous solutions, particulars solutions, Total Solutions.

UNIT III:

3.1 Computability and Formal languages- Languages,
3.2 Phrase structure grammars, Derivation, Sentential forms, Language generated by grammar.
3.3 Regular, context-free and context sensitive grammar

UNIT IV:

4.1 Finite State Automata, Diagram & Language determined by an Automaton,
4.2 Finite State Acceptors,
4.3 Deterministic and Non-deterministic Finite Automata.
4.4 Finite State Machines, their transition tables & diagrams.
4.5 Equivalent machines.

Recommended Book:

1. J.P. Tremblay & R. Manohar, Discrete Mathematical Structures, McGraw Hill.
2. N. Deo, Graph theory with applications, Prentice Hall.

Reference Book:

1. C.L. Liu, Elements of Discrete Mathematics McGraw Hill.
2. Semyour Lipschutz and Marc Lipson, Discrete Mathematics, McGraw Hill.

MMT4T02: ADVANCE NUMERICAL METHODS

Unit I: **Interpolation**

1.1 Polynomial interpolation
1.2 Trigonometric interpolation
1.3 Spline interpolation
1.4 Bezier polynomials

Unit II: Numerical Integration

2.1 Interpolatory quadrature
2.2 Convergence of quadrature formulae
2.3 Gaussian quadrature formulae
2.4 Quadrature of periodic functions
2.5 Romberg integration
2.6 Improper integrals

Unit III: **Initial Value Problem**

3.1 The Picard-Lindelof theorem
3.2 Euler's method
3.3 Single-step methods
3.4 Multistep methods

Unit IV: **Boundary Value Problems**

4.1 Shooting method
4.2 Finite difference methods
4.3 The Riesz and Lax-Milgram theorem
4.4 Weak solutions
4.5 The finite element method

Recommended Book:

1. Rainer Kress, Numerical Analysis Springer (India) Pvt. Ltd. (2014).

Reference Books:

1. S.S. Sastry, Introductory Methods of Numerical Analysis, 5th Ed., PHI Learning Pvt. Ltd. (2015)
2. K.E. Atkinson, An introduction to Numerical Analysis, 2nd Ed., Wiley India (P) Ltd. (2008)
3. J.W. Thomas, Numerical Partial Differential Equations Finite Difference Methods, Springer-Verlag New York, Inc. (1995).

MMT4T03: USE OF INTEGRAL TRANSFORMS

Unit I: Fourier Transform

1.1 Fourier integral theorem
1.2 Fourier transforms
1.3 Fourier cosine and sine transform
1.4 Fourier transforms of derivatives
1.5 Fourier transforms of some simple functions
1.6 The Fourier transforms of rational functions
1.7 The convolution integral
1.8 Parseval's theorem for Cosine and Sine transforms
1.9 Multiple Fourier transform
1.10 Finite Fourier transform

Unit II: Applications of Fourier Transform

2.1 The solution of integral equations of convolution type
2.2 Solution of partial differential equation by means of Fourier transform (Laplace's Equation, Diffusion Equation, Vibration Problems)
2.3 Fourier transform in Statistics
2.4 Fourier transforms in Quantum Mechanics.

Unit III: The Mellin Transform

3.1 Elementary properties of the Mellin transform
3.2 Mellin transforms of derivatives and integrals
3.3 The mellin inversion theorem
3.4 Convolution theorems for the Mellin transform
3.5 The solution of some integral equations
3.6 The distribution of the potential in a wedge
3.7 An application to the summation series
3.8 Finite Mellin transform

Unit IV: Hankel Transform

4.1 Elementary properties of the Hankel transforms
4.2 The Hankel inversion theorem
4.3 Hankel transforms of derivatives of functions
4.4 Hankel trnsforms of some elementary functions
4.5 The Parseval relation for Hankel transforms
4.6 Relations between Fourier and Hankel transforms
4.7 The modified operator of Hankel transforms
4.8 The use of Hankel transforms in the solution of partial differential equations
4.9 Finite Hankel transforms

Recommended Book:

1. I N. Sneddon, The use of integral transforms, Tata Mc Graw Hill Publishing Company Ltd.

Reference Book:

1. Edwin F Beckenbach, Modern Mathematics for Engineers, Second series, Mc Graw Hill Book Company.
2. L. Andrews and B. Shivanmogg, Integral Transforms for Engineers, Prentice Hall of India, 1999.

MMT4E04: OPERATOR THEORY

Unit I:

1.1 Basic concepts about spectrum
1.2 Spactral properties of bounded linear operators
1.3 Further properties of resolvent and spectrum
1.4 Use of complex analysis in spectral theory

Unit II:

2.1 Banach Algebras
2.2 Further properties of Banach Algebras
2.3 Compact linear operators on normed spaces
2.4 Further properties of Compact linear operators
2.5 Spectral properties of compact linear operators

Unit III:

3.1 Further spectral properties of Compact linear operators
3.2 Operator equations involving compact linear operators
3.3 Further theorems of Fredholm types
3.4 Fredholm alternative

Unit IV:

4.1 Spectral properties of bounded self-adjoint linear operators
4.2 Further Spectral properties of bounded self-adjoint linear operators
4.3 Positive operators, Square roots of a positive operator.
4.4 Projection operator
4.5 Further properties of projections. Spectral family
4.6 Statement of spectral representation theorem.

Recommended Book:

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

Reference Books:

1. A.E. Taylor and D.C. Lay, Introduction to Functional Analysis, John Wiley and Sons

MMT4E05: FLUID DYNAMICS-II

Unit I:

1.1 Stress components in a real fluid
1.2 Relation between Cartesian components of stress translation motion of fluid element
1.3 The rate of strain quadric and principal stresses
1.4 Some further properties of the rate of the strain quadric
1.5 Stress analysis in fluid motion, the relation between stress and rate of strain
1.6 The coefficient of viscosity and laminar flow
1.7 The Navier-Stokes equations of motion of a viscous fluid
1.8 Some solvable problems in viscous flow
1.9 Diffusion of vorticity, energy dissipation due to viscosity, steady flow past a fixed sphere.

Unit II:

2.1 Nature of magneto-hydrodynamics
2.2 Maxwell electromagnetic field equations
2.3 Motion at rest, Motion in medium
2.4 Equation of motion of conducting fluid
2.5 Rate of flow of charge
2.6 Simplification of electromagnetic field equation
2.7 Magnetic Reynold number
2.8 Alfven's theorem
2.9 The magnetic body force. Ferraro's Law of Isorotation.

Unit III:

3.1 Dynamical similarity, Buckingham Theorem.
3.2 Renold number. Prandtl's boundary layer, Boundary layer equation in two dimensions
3.3 Blasius solutions, Boundary layer thickness, Displacement thickness
3.4 Karman integral conditions, Separation of boundary layer flow.

Unit IV:

4.1 Equations of motion for turbulent flow
4.2 Reynolds Stresses Cylindrical coordinates
4.3 Equation for the conservation of a transferable scalar quantity in a turbulent flow
4.4 Double correlations between turbulence-velocity components
4.5 Change in double velocity correlation with time
4.6 Introduction to triple velocity correlations
4.7 Features of the double longitudinal and lateral correlations in a homogeneous turbulence. Integral scale of turbulence.

Recommended Book:

1. F. Chorlton, Text book of Fluid Dynamics, CBS Publishers, Delhi 1985.
2. Joseph Spurk, Fluid Mechanics, Springer.
3. J.O. Hinze, Turbulence, 2nd edition, Mc Graw-Hill, chapter 1 sections 1.1 to 1.7
4. M.D. Raisinghania, Fluid Mechanics, S. Chand and Company, Delhi.

Reference books:

1. G.K. Batchelor, An Introduction to fluid Mechanics, Foundation Books, New Delhi 1994.
2. H. Schichting, Boundary Layer Theory, Mc Graw Hill Book Company, New York 1971.

MMT4E06: COSMOLOGY

Unit I:

1.1 Static cosmological models of Einstein and de Sitter and their derivation
1.2 Properties: (i) The geometry of the Universe (ii) Density and pressure (iii) Motion of test particle (iv) Doppler shift (v) comparison with actual universe
1.3 Comparison between Einstein and de-Sitter models.

Unit II:

2.1 Cosmological principle,
2.2 Hubble law
2.3 Weyl's postulate
2.4 Derivation of Robertson Walker Metric and its properties
2.5 Motion of a particle and light rays in FRW model
2.6 Red shift, Deceleration parameter and Hubble's constant
2.7 Matter Dominated era.

Unit III:

3.1 Friedman Model
3.2 Fundamental equation of dynamical cosmology
3.3 Density and pressure of the present universe
3.4 Matter dominated era of the universe, critical density, flat, closed and open universe
3.5 Age of the universe.

Unit IV:

4.1 Steady state cosmology
4.2 Distance measure in cosmology
4.3 Comoving distance
4.4 Apparent luminosity and luminosity distance
4.5 Angular diameter and Lookback time, Horizons and the Hubble radius
4.6 Galaxy count, the Particle horizons, the Event Horizon.

Recommended book:

1. Richard C. Tolman, Relativity, Thermodynamics and Cosmology, Oxford Press
2. Steven Weinberg, Gravitation and Cosmology: Principles and Applications of the General Theory of Relativity.

Reference Books:

1. Landau I.D. and Lifshitz E.M., The Classical Theory of Fields, By Pub. Pergamon Press (1978).
2. T M Karade, G S Khadekar and Maya S Bendre, Lecture on General Relativity, Sonu Nilu Publication (2004) by
3. Moller C, The Theory of Relativity Pub. Oxford University Press (1982).

MMT4E07: MULTIVARIATE ANALYSIS

Unit I: Correlation and Regression

1.1 Multiple and partial correlation
1.2 Linear and multiple regression coefficient of determination and its uses.
1.3 Tests of significance of multiple and partial correlation coefficient
1.4 Multivariate normal distribution
1.5 Singular and non-singular multivariate distributions
1.6 Characteristic functions, moments, marginal and conditional distributions
1.7 Inference of parameters of multivariate normal distributions
1.8 One population and two population cases

Unit II:

2.1 Wishart distribution and its properties
2.2 Distribution of Maximum Likelihood Estimators of parameters of Multivariate Normal Distribution
2.3 Distribution of Sample
2.4 Generalized variance.
2.5 Wilks λ (Introduction, definition, and distribution)

Unit III:

3.1 Hotelling's T square statistic and its null distribution
3.2 Mahalanobis D square
3.3 Application in tests on mean vector for one and more multivariate normal populations and also on the equality of the components of a mean vector in a multivariate normal population
3.4 Application of T square statistic and its relationship with Mahalanobis' D square statistic
3.5 Confidence region for the mean vector
3.6 Applications of D^2 statistics

Unit IV:

4.1 Discriminant Analysis
4.2 Classification and discrimination
4.3 Procedures for discrimination between two multivariate normal populations
4.4 Fisher's discriminant function
4.5 Tests associated with discriminant function
4.6 Sample discriminant function
4.7 Probabilities of misclassification and their estimation
4.8 Classification in to more than two multivariate populations
4.9 Principal components. Dimension reduction. Canonical variables and canonical correlation definition uses estimation and computation

Recommended Books:

2. Anderson T.W., An introduction to multivariate statistical analysis.
3. Kshirsagar A.M., Multivariate Analysis

MMT4E08: OPERATIONS RESEARCH-IV

UNIT I: Game Theory

1.1 Two-person zero-sum games
1.2 The maximin-minimax principle
1.3 Games without saddle points
1.4 Graphic solutions
1.5 Dominance property
1.6 Arithmetic method
1.7 General solution of $m \times n$ rectangular games
1.8 Game against passivity

UNIT II: Inventory Control-I

2.1 The concept of EOQ
2.2 Deterministic inventory problems without shortages
2.3 Deterministic inventory problems with shortages
2.4 Problems of EOQ with price breaks
2.5 Multi-item deterministic problems
2.6 Dynamic order quantity
2.7 Selective inventory control techniques

UNIT III: Inventory Control-II

3.1 Inventory problems with uncertain demand
3.2 Systems of inventory control
3.3 One period problem
3.4 One period problem without set-up cost
3.5 One period problem with set-up cost

UNIT IV: Queueing Theory

4.1 Probability
4.2 Conditional probability
4.3 Random variables
4.4 Expectation of a random variable
4.5 Central tendency and dispersion
4.6 Elements of queueing system
4.7 Operating characteristics of queueing system
4.8 Probability distributions in queueing system
4.9 Classifications of queueing models
4.10 Definition of transient and steady states
4.11 Poisson queueing systems

Recommended Book:

1. Kanti Swarup, P.K. Gupta and Man Mohan, Operations Research, Sultan Chand and Sons New Delhi.

Reference Books:

1. H. A. Taha, Operations Research – An Introduction, Prentice-Hall, 1997.
2. J. K. Sharma, Operations Research: Theory and Applications, Macmillan, 1997
1. F. S. Hillier and G. J. Lieberman, Introduction to Operations Research, McGraw-Hill, 2001

MMT4E09: DYNAMICAL SYSTEMS

Unit I: Fundamental Theory

1.1 Dynamical systems and vector fields
1.2 The fundamental theorem
1.3 Existence and uniqueness
1.4 Continuity of solutions in initial conditions
1.5 On extending solutions
1.6 Global solutions
1.7 The flow of a differential equation.

Unit - II: Stability of Equilibria

2.1 Nonlinear sinks
2.2 Stability
2.3 Liapunov functions
2.4 Gradient systems
2.5 Gradients and Inner products

Unit III: The Poincare-Bendixson Theorem

3.1 Limit sets
3.2 Local sections and flow boxes
3.3 Monotone sequences in planar dynamical systems
3.4 The Poincare Bendixson theorem
3.5 Applications of Poincare-Bendixson theorem
3.6 Ecology

Unit IV: Periodic Attractors

4.1 Asymptotic stability of the closed orbit
4.2 Discrete dynamical systems
4.3 Stability and closed orbits
4.4 Non-autonomous equations and differentiability of flows
4.5 Persistence of equilibria, the persistence of closed orbits. Structural stability

Recommended Book:

1. M.W. Hirsch and S. Smale, Differential Equations, Dynamical Systems and Linear Algebra, Academic Press, 1975.

Reference Book:

1. V.I. Arnold, Dynamical systems, Springer Verlag, 1992.

MMT4E10: CRYPTOGRAPHY

Unit I:

1.1 Time estimates for doing arithmetic
1.2 Divisibility and Euclidean algorithm
1.3 Congruence's, quadratic residues and reciprocity
1.4 Fermat's little theorem, applications to factoring, finite fields

Unit II:

2.4 Classical cryptosystems
2.5 Public key cryptography
2.6 Hash function
2.7 Probabilistic encryption
2.8 RSA cryptosystem
2.9 Pseudo primes
2.10 Pollard's P-1 method
2.11 The Rho method.

Unit III:

3.4 The El Gamal cryptosystem
3.5 Discrete logarithm
3.6 Diffee-Hellman key exchange system
3.7 Algorithms for discrete logarithm problem- Shank's algorithm, the Pollard Rhoalgorithm, the Pohlig-Hellman Algorithm
3.8 Security of ElGamal systems, the ElGamal signature scheme.

Unit IV:

4.6 Elliptic curves
4.7 Elliptic curve cryptosystems
4.8 Elliptic curve primality test
4.9 Elliptic curve factorization.

Recommended Books:

1. Neal Koblitz, A Course in Number Theory and Cryptography (second edition), SpringerVerleg.
2. Douglas R. Stinson, Cryptography: Theory and practice (Third Edition), CRC Press.

Reference Book:

1. William Stallings, Cryptography and Network Security, Prentice Hall.

MMT4T12: PROGRAMMING WITH PYTHON

Unit I:

1.1 **Introduction:** Features of Python: Easy; Type and Run ; Syntax; Mixing; Dynamic Typing; Built in Object Types; Numerous Libraries and Tools. Chronology and Uses: Chronology; Uses. Installation of Anaconda. Basic Data Types Revisited: Fractions. Strings. Lists and Tuples: List; Tuples; Features of Tuples.

1.2 **Conditional Statements:** if, if-else, and if-el if-else constructs. The if-el if-else Ladder. Logical Operators. The Ternary OperatorThe get Construct and Examples

1.3 **Looping:** While, Patterns, Nesting and Applications of Loops in Lists.

Unit II:

2.1 **Functions**: Features of a functions: Modular Programming; Reusability of Code; Manageability. Basic Terminology: Name of Functions; Arguments; Return Value. Definition and Invocation: Working. Type of Functions: Advantage of Arguments. Implementing Search. Scope. Recursion: Rabbit Problem; Disadvantages of Using Recursion.

2.2 **Iterations, Generators, and Comprehensions:** The Power of "For". Iterators. Defining an Iterable Object. Generators. Comprehensions.

2.3 **File Handling:** The File Handling Mechanism. The Open Function and File Access Modes. Python Functions for File Handling: The Essential Ones; The OS Methods. Miscellaneous Functions and File Attributes. Command Line Arguments. Implementation and Illustrations.

Unit III:

3.1 **Strings:** The Use of "For" and "While". String Operators: The Concatenation Operator (+); The Replication Operator; The Membership Operator. Functions for String Handling: len(); Capitalize(); find(); count; Endswith(); Encode; Decode;Miscellaneous Functions.

3.2 **Introduction to Object-Oriented Paradigm:** Creating New Types: Attributes and Functions: Attributes; Functions. Elements of Object-Oriented Programming: Class; Object; Encapsulation; Data Hiding; Inheritance; Polymorphism; Reusability.

3.3 **Classes and Objects:** Defining a Class. Creating an Object. Scope of Data Members. Nesting. Constructor. Constructor Overloading. Destructors.

Unit IV:

4.1 **Inheritance:** Introduction to Inheritance and Composition: Inheritance and Methods, Composition. Inheritance: Importance and Types: Need of Inheritance; Types of Inheritance. Methods: Bound Methods; Unbound Method; Methods are Callable Objects; The Importance and Usage of Super; Calling the Base Class Function Using Super. Search in Inheritance Tree. Class Interface and Abstract Classes.

4.2 **Operator Overloading:** _init_Revisited: Overloading _init_(Sort of). Methods for Overloading Binary Operators. Overloading the += Operator. Overloading the > and < Operators. Overloading the _boolEan_ Operators: Precedence of _bool_over _len_. Destructors

4.3 **Exception Handling:** Importance and Mechanism: An exaple of Try/Catch; Manually Raising Exception. Built-In Exceptions in Python: The Process: Exception

Handling: Try/Except; Raising Exceptions. Crafting User-Defined Exceptions. An Example of Exception Handling.

Text Book:

1. H. Bhasin: Python Basics, MERCURY LEARNING AND INFORMATION Dulles, Virginia Boston, Massachusetts New Delhi

Chapter 1: 1.2, 1.4, 1.5. Chapter 2: 2.2 to 2.4. Chapter 3: 3.2 to 3.7;Chapter 4: 4.2 to 4.4. Chapter 5: 5.2, to 5.8. Chapter 6: 6.2 to 6.6. Chapter 7: 7.1, to 7.6; Chapter 8: 8.1, to 8.4. Chapter 9: 9.1, 9.2, 9.3, 9.4. Chapter 10: 10.1, to 10.8.; Chapter 11: 11.1to 11.5. Chapter 12: 12.2, to 12.8.; Chapter 13: 13.2, to 13.6.

Reference Books:

1. Beginning-Python, Second Edition by Magnus Lie Hetland
2. The Complete Reference Python by Martin C. Brown
3. Head First Python by Patrick Barry
4. Learning Python, O‟Reilly by Mark Lutz
5. Python in a Nutshell, O‟Reilly by Alex Martelli

Practical list:

1. Program to find roots of quadratic equation.
2. Program to add digits of a number.
3. Program to print given number in reverse order.
4. WAP to print the Fibonacci sequence
5. WAP to Find the Factorial of a Number
6. Make a Simple Calculator
7. WAP Add Two Matrices

MMT4O14: ELEMENTARY MATHEMATICS-II
(For the students other than M.Sc. Mathematics)

Unit I: Mathematical Logic

1.1 Proposition, compound Proposition, Proposition and truth tables
1.2 logical equivalence, algebra of Proposition, conditional Proposition, converse, contra positive & inverse, bi conditional statement, negation of compound statements,
1.3 Tautologies & contradictions, normal forms, logic in proof

Unit II: Lattice

2.1 Lattice as partially ordered sets, their properties
2.2 Lattices as algebraic system, sub lattices
2.3 Some special lattices (Complete, complemented and distributive lattices)

Unit III: Boolean algebra and Logic Circuits

3.1 Boolean algebra, basic operations, Boolean functions
3.2 De-Morgan's theorem, logic gate, sum of products and product of sum forms, normal form, expression of Boolean function as a canonical form
3.3 simplification of Boolean expression by algebraic method
3.4 Boolean expression form logic & switching network.

Unit IV: Graph Theory

4.1 Basic terminology, simple graph, multigraph, degree of a vertex
4.2 Types of a graph, sub graphs of isomorphic graphs
4.3 Matrix representation of graphs
4.4 Euler's theorem on the existence of Eulerian path & circuits
4.5 Directed graph, weighted graphs, strong connectivity, chromatic number.

Reference Book:

1. Tremblay and R. Manohar J.P., Discrete Mathematical structures with applications to computer science, McGraw-Hill book company, 1997.