UNIVERSITY OF PUNE, PUNE.

Syllabus for M.Sc/M. A.

Subject: MATHEMATICS

(With effect from June 2013)

Introduction:

University of Pune has decided to change the syllabi of various faculties from June,2013. Taking into consideration the rapid changes in science and technology and new approaches in different areas of mathematics and related subjects, Board of studies in Mathematics after a thorough discussion with the teachers of Mathematics from different colleges affiliated to University of Pune has prepared the syllabus of M.Sc./M. A. Mathematics course. The model curriculum as developed by U. G. C. served as a guideline for the present syllabus.

Aims:

i) Strengthening the understanding of the students and substantiating the conceptual framework of the Graduates in Mathematics for furthering their potential and capabilities in the subject.

ii) Introducing advanced theories in the subject in an orderly manner with a clearly defined path of interdependence.

iii) Introducing the specializations in different areas of Mathematics and at the same time emphasizing the underlying interconnections in different branches of Mathematics.

iv) Generating more interest in the subject and motivating students for self learning beyond the realm of syllabi and examinations.

v) Inculcating the spirit of inquiry among the students and preparing them to take up the research in Mathematics.

vi) Exhibiting the wide range of applications of Mathematics and preparing students to apply their knowledge in diverse areas such as Physics, Astronomy, Biology, Social Sciences, etc.

Objectives:

(i) A student should be able to understand the proof techniques in Mathematics and importance of theorems for sorting out typical examples.

(ii) A student should acquire sufficient technical competence to solve the problems of varying difficulty levels and high notational complexity.

(iii) A student should be able to make observations, experimentation and pattern recognition which would stimulate the research potential

(iv) A student should acquire the communication skill to present technical Mathematics so as to take up a career in Teaching Mathematics at various levels including schools, colleges, universities, etc.

Eligibility: 1. Bachelor of Science with Mathematics or/Mathematics
atleast upto second year B.E./B.Tech.
2. B.A. or B.Sc. with mathematics (special or subsidiary).
3. Other rules and regulations of the University of Pune.

Structure of the course:

1. There are five compulsory courses in semester I and five compulsory courses in semester II.
2. There are three compulsory courses and two departmental courses in semester III and three compulsory courses and two departmental courses in semester IV.
3. The list of compulsory as well as departmental courses is given below.
4. The evaluation pattern will be according to the credit system to be introduced at post-graduate centres in the affiliated colleges.

Medium of Instruction: English

Examination:

A) Pattern of examination: Semester
B) Standard of passing : As per credit system.
C) Pattern of question papers: As per credit system
D) External Students: Allowed.
E) Verification/Revaluation: Allowed for all courses

Equivalence of Previous syllabus along with new syllabus:

Sr.No	Old Course	New (Equivalent) Course
1	MT 501 (Real Analysis)	MT 501 (Real Analysis)
2	MT 502 (Advanced Calculus)	MT 502 (Advanced Calculus)
3	MT 503 (Linear Algebra)	MT 604 (Linear Algebra)
4	MT 504 (Number Theory)	MT 801 (Number Theory)
5	MT 505 (Ordinary Differential Equations)	MT 505 (Ordinary Differential Equations)
6	MT 601 (General Topology)	MT 602 (General Topology)
7	MT 602 (Differential Geometry)	MT 802 (Differential Geometry)
8	MT 603 (Groups and Rings)	MT 503 (Group Theory)
9	MT 604 (Complex Analysis)	MT 601 (Complex Analysis)
10	MT 605	MT 605

	(Partial Differential Equations)	(Partial Differential Equations)
11	MT 606 Object Oriented Programming Using C++	
12	MT 701 (Functional Analysis)	MT 703 (Functional Analysis)
13	MT 702 (Rings and Modules)	MT 603 (Rings and Modules)
14	MT 703 (Mechanics)	MT 705(Departmental) (Classical Mechanics)
15	MT 704 (Measure and Integration)	
16	MT 705 (Graph Theory)	MT 704(Departmental) (Graph Theory)
17	MT 801 (Field Theory)	MT 702 (Field Theory)
18	MT 802 (Combinatorics)	MT 701 (Combinatorics)
19	MT 803 (Differential Manifolds)	
20	MT 804 (Algebraic Topology)	
21	MT 805 (Lattice Theory)	MT 804 (Lattice Theory)

Qualifications of Teacher: M.Sc. Mathematics (with NET /SET as per existing rules)

M. Sc. (Mathematics) Syllabus

M.Sc. I All courses are compulsory.

Semester I
i) Real Analysis
ii) Advanced Calculus
iii) Group theory
iv) Numerical Analysis
v) Ordinary Differential Equations

Semester II
i) Complex Analysis
ii) Topology
iii) Rings and Modules
iv) Linear Algebra
v) Partial Differential Equations

M.Sc. II

There will be three compulsory courses and two departmental courses in both the semesters.

Compulsory courses:

Semester III		**Semester IV**
i)	Combinatorics	i) Number theory
ii)	Field Theory	ii) Differential Geometry
iii)	Functional Analysis	iii) Fourier Analysis

Departmental courses: (Any Two)

i)	Graph Theory	i) Lattice Theory
ii)	Classical Mechanics	ii) Operations Research
iii)	Topics in Algebra	iii) Topics in Algebra
iv)	Topics in Analysis	iv) Topics in Analysis
v)	Topics in Geometry	v) Topics in Geometry
vi)	Discrete Mathematics	vi) Discrete Mathematics
vii)	Applied Mathematics	vii) Applied Mathematics
viii)	C language	viii) C++ language

The syllabi of first two departmental courses will be provided by the University.

. Semester I

MT - 501: Real Analysis

1. Measure Theory: Preliminaries, Exterior Measure, Measurable Sets and Lebesgue Measure, Measurable Functions.
2. Integration Theory: The Lebesgue Integral, basic properties and convergence theorems. The space L^1 of integrable functions, Fubini's theorem.
3. Differentiation and Integration: Differentiation of the integral, Good kernels and approximation to the identity, differentiation of functions.

Text Book: Real Analysis, E. Stein and R. Shakharchi, New Age International Publishers, Princeton Lecture Notes III. Chapter 1 - Sections 1 to 4, Chapter 2 - Sections 1 to 3, Chapter 3 - Sections 1 to 3.

Reference Books:

1. Karen Saxe : Beginning Functional Analysis (Springer International Edition)
2. N. L. Carothers: Real Analysis (Cambridge University Press)
3. W. Rudin : Principles of Mathematical Analysis (Mc-Graw Hill)
4. H. Royden, Real Analysis, McMillan Publishing Company

MT - 502: Advanced Calculus

1. Derivative of a scalar field with respect to a vector, Directional derivative, Gradient of a scalar field, Derivative of a vector field, Matrix form of the chain rule, Inverse function theorem and Implicit function theorem.
2. Path and line integrals, The concept of work as a line integral, Independence of path, The first and the second fundamental theorems of calculus for line integral, Necessary condition for a vector field to be a gradient.
3. Double integrals, Applications to area and volume, Green's Theorem in the plane, Change of variables in a double integral, Transformation formula, Change of variables in an n-fold integral.
4. The fundamental vector product, Area of a parametric surface, Surface integrals, The

theorem of Stokes, The curl and divergence of a vector field, Gauss divergence theorem, Applications of the divergence theorem.

Text Book:

T. M. Apostol: Calculus, Vol. II (2nd edition) (John Wiley and Sons, Inc.)
Chapter 1: Sections 81 to 8.22
Chapter 2: Sections 10.1 to 10.11 and 10.14 to 10.16
Chapter 3: Sections 11.1 to 11.5 and 11.19 to 11.22 and 11.26 to 11.34
Chapter 4: Sections 12.1 to 12.15, 12.18 to 12.21
(For Inverse function theorem and Implicit function theorem refer the book "Mathematical Analysis" by T. M. Apostol.)

Reference Books :

1. T. M. Apostol: Mathematical Analysis (Narosa publishing house)
2. W. Rudin: Principles of Mathematical Analysis (Mc-Graw Hill)
3. A. Devinatz: Advanced Calculus, (Holt, Rinehart and Winston), 1968

MT-503 : Group Theory

1. Revision of definition and examples of groups, subgroups.
2. Cyclic Groups, Classification of subgroups of cyclic groups.
3. Permutation Groups - Revision
4. Isomorphism, Cayley's theorem, properties of isomorphisms, automorphism,
5. Revision of Cosets and Lagrange's theorem. Orbit-stabilizer theorem, the rotation group of a cube and a soccer ball
6. External Direct Products
7. Normal subgroups and factor groups, Internal direct products
8. Group Homomorphism
9. Fundamental theorem of finite abelian groups
10. Sylow theorems
11. Finite simple groups

Text Books:

Joseph Gallian – Contemporary Abstract Algebra (Narosa Publishing House).
Chapter 2 to 11, 24, 25.

Reference Books:

1. I.S. Luthar and I.B.S. Passi : Algebra (Volume 1) Groups (Narosa Publishing House)
2. I.N. Herstein : Topics in Algebra (Wiley -Eastern Ltd)
3. M. Artin : Algebra (Prentice Hall)
4. N.S. Gopala Krishnan : University Algebra (Wiley-Eastern Ltd)
5. Fraleigh : A First Course in Abstract Algebra
6. Dummit and Foote : Abstract Algebra (Wiley-Eastern Ltd)

MT-504: Numerical Analysis

0. Preliminaries :

Convergence, Floating Point Number Systems, Floating Point Arithmetic.

1. Root finding methods :

Fixed Point Interaction Schemes, Newton's Method, Secant Method, Accelerating

Convergence.

2. System of Equations :

Formation of Systems of Equations, Gaussian Elimination, Pivoting Strategies, Errors Estimates and Condition Number, LU decomposition, Direct Factorization, Iterative Techniques for Linear Systems, Nonlinear Systems of Equations.

3. Eigenvalues and Eigenvectors :

The Power Method, The Inverse Power Method, Reduction to Symmetric Tridiagonal form, Eigenvalues of Symmetric Tridiagonal Matrices.

4. Differentiation and Integration:

Numerical differentiation, using Lagrange's Interpolating polynomial, Numerical Integration, Newton-Cotes Quadrature, Composite Newton-Cotes Quadrature.

5. Initial Value Problems of Ordinary Differential Equations :

Euler's Method, Runge-Kutta Methods, Multistep Methods, Convergence and Stability Analysis.

Text Book :

1. Brian Bradie, A Friendly Introduction to Numerical Analysis, Pearson Prentice Hall 2007.

Articles from the Text Book : 1.2 – 1.4, 2.3 – 2.6, 3.1, 3.2, 3.4 -3.6, 3.8, 3.10, 4.1, 4.2, 4.4, 4.5, 6.1, 6.2, 6.4-6.6, 7.2-7.6.

2. John H. Mathews; Kurtis D. Fink, NUMERICAL METHODS Using Matlab, 4th Ed., Pearson Education (Singapore) Pte. Ltd., Indian Branch, Delhi 2005

(SciLab commands similar to MatLab commands can be used for problems)

Reference Books:

1. K .E. Atkinson: An Introduction to Numerical Analysis.
2. J. I. Buchaman and P. R. Turner, Numerical Methods and Analysis.
3. M.K. Jain, S.R.K. Iyengar, R.K. Jain, Numerical Methods for scientific & Engineering Computation, 5th Edition New Age International Publication.

MT-505 : Ordinary Differential Equations

Review : General remarks on solutions of differential equations, Families of curves, Orthogonal trajectories.

1. Second order linear equations : The general solution of the homogeneous equations, Use of a known solution to find another solution, Homogeneous equations with constant coefficients.The method of undetermined coefficients.The method of variation of parameters.

2. Qualitative Properties of solutions of ordinary differential equations of order two : Sturm separation theorem. Normal form, Standard form, Sturm's comparison theorem.

3. Power Series solutions : Review of power series, Series solutions of first order equations, Second order linear equations, Ordinary points, Regular singular points, Indicial equations, Gauss's Hypergeometric equation, The point at infinity.

4. Systems of first order equations : General remarks on systems, Linear systems, Homogenous linear systems with constant coefficient. Non-linear systems, Volterra's Prey-Predator equations.

5. Non-linear equations : Autonomous systems, Critical points, Stability, Liapunov's direct method, Nonlinear mechanics, Conservative systems.
6. The existence and uniqueness of solutions. The method of successive approximations, Picard's theorem, Systems, The second order linear equations.

Text Book :
G.F. Simmons : Differential equations with applications and Historical Notes, Second Edition (Mc-Graw Hill). Sections : 15 to 19, 24 to 31, 54 to 63, 68 to 70.

Reference Books :
1. G. Birkhoff and G.C. Rota : Ordinary differential equations. (John Wiley and Sons)
2. E. A. Coddington : Ordinary differential equations. Prentice Hall of India.
3. S. G. Deo, V. Lakshmikantham, V. Raghvendra. Text book of Ordinary Differential Equations. Second edition.Tata Mc-Graw Hill.

Semester II

MT- 601: Complex Analysis

1. Preliminaries : Functions on Complex Plane, Integration along curves
2. Cauchy's theorem and its applications: Goursat's theorem, Local existence of primitives and Cauchy's theorem in a disc, Evaluation of some integrals, Cauchy integral formulas, Further applications - Morera's theorem, sequences of holomorphic functions, holomorphic functions defined in terms of integrals, Schwarz reflection principle, Runge's approximation theorem.
3. Meromorphic functions and the Logarithm, Zeros and poles, the residue formulae, singularities and meromorphic functions, the argument principle and applications, homotopies and simply connected domains, the complex logarithm, Fourier series and harmonic functions.

Text Book: Complex Analysis, E. Stein and Shakarchi, Overseas Press (India) Ltd., Princeton Lectures in Analysis. Chapters 1, 2 and 3.

Reference Books:
1.John B. Conway : Functions of one complex variable (Narosa Publishing house)
2. Lars V. Ahlfors : Complex Analysis (McGraw Hill)
3. Ruel V. Churchill / James Ward Brown : Complex Variables and Applications (McGraw Hill)

MT-602 : General Topology

1. Countable and uncountable sets : Infinite sets, the Axiom of Choice, Continuum Hypothesis, Well-ordered sets, The maximum principle.
2. Topological spaces and continuous functions : Basis for topology, Order topology, Continuous functions, Product topology, Metric topology, Quotient topology.
3. Connectedness and compactness : Connected spaces, Components and local

connectedness, Compact spaces, Limit point compactness, Local compactness. One point compactification.
4. Countability and Separation Axioms : The Countability Axioms, Separation Axioms, Normal spaces, The Urysohn Lemma, The Urysohn Metrization Theorem (statement only), The Tietze extension theorem (statement only).
5. Tychonoff theorem, Completely regular spaces.

Text Book : J.R. Munkres : Topology, a first course (Prentice Hall of India).
Sections : 1.7, 1.9, 1.10, 1.11, 2.1 to 2.11, 3.1 to 3.8, 4.1 to 4.4, 5.1 and 5.2.

Reference Books :
1. J. Dugundji : Topology (Allyn and Bacon, Boston, 1966.)
2. K. D. Joshi : Introduction to General Topology (Wiley Eastern Limited).
3. J. L. Kelley : General Topology (Springer Verlag, New York 1991.)
4. L. A. Steen and J. A. Seebach Jr. : Counterexamples in Topology (Holt Rinehart and Winston, Inc. New York 1970.)
5. S. Willard : General Topology (Addison-Wesley Publishing company, Inc., Reading, Mass., 1970)

MT 603: RING THEORY

1. Preliminaries: Rings- Definition, Examples, types of the rings: matrix, polynomial, power series, Laurent series, Boolean rings, opposite rings
2. Ideals, maximal ideal, quotient rings, local rings
3. Homomorphism of rings, fundamental theorems, endomorphism rings, field of fractions, prime fields
4. Fractions in domain: Euclidean Domains, P.I.D.'s, U.F.D.'s.
3. Polynomial Rings: Definition, properties, Polynomial Rings over Fields, Polynomial Rings that are U.F.D.'s, Irreducibility Criteria.
4. Basic Definitions and Examples of Modules, Quotient Modules and Module Homomorphisms

Text Book: C. Musili, Rings and Modules, 2nd Revised Edition, Narosa Publishing House, [Chapters 1, 2, 3, 4, 5].

Reference Books:
1. Dummit and Foote, Abstract Algebra, second edition (Wiley India).
2. Luther and Passi, Algebra II, Narosa Publishing House.
3. Jain and Bhattacharya, Basic Abstract Algebra, Second Edition, Cambridge University Press.

MT-604: Linear Algebra

1. **Vector spaces:** Definition and Example, Subspace, Basis and Dimension (revision)

2. **Linear mapping and matrices:** Linear Mappings, Quotient Spaces, Vector Space of Linear Mapping, Linear Mapping and Matrices, Change of Basis, Rank of a Linear Mapping, Decomposition of a Vector Space
3. **Reduction of matrices to canonical forms:** eigenvalues and eigenvectors, triangularization of a matrix, jordan canonical form
4. **Metric vector space:** Bilinear form, Symmetric Bilinear Forms, Quadratic Forms, Hermitian Forms, Euclidean Vector Space, Canonical Representation of Unitary Operator, Euclidean Space, Classification of Quadrics in Three- Dimensional Euclidean Space

Text Book: First Course in Linear Algebra - P.B. Bhattacharya, S.R. Nagpaul, S.K. Jain [Chap 4: Revision, Chapters 5, 6, 7].

Reference Books:
i) K. Hoffman and Ray Kunje : Linear Algebra (Prentice -Hall of India private Ltd.)
ii) M. Artin : Algebra (Prentice -Hall of India private Ltd.)
iii) A.G. Hamilton : Linear Algebra (Cambridge University Press),1989.
iv) N.S. Gopala Krishnan : University algebra (Wiley Eastern Ltd.).
v) J.S. Golan : Foundations of linear algebra (Kluwer Academic publisher),1995.
vi) Henry Helson : Linear Algebra, (Hindustan Book Agency), 1994.
vii) I.N. Herstein : Topics in Algebra, Second edition, (Wiley Eastern Ltd.)

MT- 605 : Partial Differential Equations

1. First Order P.D.E. : Introduction, Charpit's Method, Jacobi's Method, Quasi-Linear Equations, Non-Linear First Order P.D.E.
2. Second Order P.D.E.: Introduction, One Dimensional Wave Equation, Laplace Equation, Boundary Value Problems, the Cauchy Problem, Dirichlet and Neumann Problem for different regions, Harnack's Theorem, Heat Conduction Problem, Duhamel's Principle, Classification of P.D.E. in the case of n-variables, Families of Equipotential Surfaces, Kelvin's Inversion Theorem.

Text Book
T. Amarnath : An Elementary Course in Partial Differential Equations (2nd edition) (Narosa Publishing House) [Chapters 1 and 2].

Reference Books :
1. K. Sankara Rao: Introduction to partial differential equation, third edition.
2. W. E. Williams: Partial Differential equations (Clarendon press-oxford)
3. E. T. Copson : Partial differential equations (Cambridge university press)
4. I.N. Sneddon: Elements of partial differential equations (Mc-Graw Hill book company).