RayatShikshanSanstha's
Sadguru Gadage Maharaj College, Karad
Department of Mathematics
Syllabus for Autonomy
Subject:- Mathematics
Structure of M.A./M.Sc. (Mathematics) Semester - I (25 credits)

Course Code	Title of course	Instruction hrs/week	Duration of Term end Exam in hrs.	Marks-Term end exam	Marks-(Internal) Continuous Assessment	Credits
MT-101	Algebra	5	3	90	30	5
MT-102	Advanced Calculus	5	3	90	30	5
MT-103	Real Analysis	5	3	90	30	5
MT-104	Differential Equations	5	3	90	30	5
MT-105	Classical Mechanics	5	3	90	30	5

Title of the Program: M.A./M. Sc. (Mathematics) (Part I)
M.Sc. program has semester pattern and Choice Based Credit System.
The following table gives the course Structure with details about instruction hrs per week, credits etc.:

Structure of M.A./M.Sc. (Mathematics) Semester -II (25 credits)

Course Code	Title of course	Instruction hrs/week	Duration of Term end Exam in hrs.	Marks-Term end exam	Marks-(Internal) Continuous Assessment	Credits
MT-201	Linear Algebra	5	3	90	30	5
MT-202	Topology	5	3	90	30	5
MT-203	Complex Analysis	5	3	90	30	5
MT-204	Numerical Analysis	5	3	90	30	5
MT-205	Differential Geometry	5	3	90	30	5

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Subject:- Mathematics
M.Sc-I Semester-I

Paper: MT 101

Title of paper: Algebra – I

Course Outcomes: Upon successful completion of this course, the student will be able to:
i) analyze Zassenhaus lemma, Schreier refinement theorem.
ii) apply Sylow's theorem.
iii) apply the division algorithm in polynomials over fields.
iv) apply Eisenstein criterion and Gauss lemma.
v) have a demonstrable knowledge of modules theory.

Unit I. : Simple groups, simplicity of A_n (n>5), commutator subgroups, normal subgroup and subnormal series, Jordan-Holder theorem, solvable groups, isomorphism theorems, Zassenhaus Lemma, Schreier refinement theorem.

(15 L)

Unit II. : Group action on a set, isometry subgroups, Burnside theorem, syllow's theorems, p-subgroups, class equation and applications**.**

(15 L)

Unit III. :Rings of polynomials, factorization of polynomials over fields, irreducible polynomials, Eisenstein criterion, ideals in F[x], unique factorization domain, principle ideal domain, Gauss lemma, Euclidean Domain**.**

(15 L)

Unit IV. Modules, sub-modules, quotient modules, homomorphism and isomorphism theorems, fundamental theorem for modules**.**

(15 L)

Recommended Books:

1.John B. Fraleigh , A first course in Abstract Algebra (Third Edition), Narosa publishing house, New Delhi.
2. C. Musili, Introduction to Rings and Modules (Second Revised Edition), Narosa Publishing house, New Delhi.

Reference Books:

1. Joseph A. Gallian, Contemporary Abstract Algebra (Fourth Edition), Narosa Publishing house, New Delhi.
2. Bhattacharya, Jain and Nagpal, Basic Abstract Algebra, 2nd edition, Narosa Publishing House, New Delhi.
3. I. N. Herstein, Topics in Algebra, Vikas Publishing House.
4. N. Jacobson, Basic Algebra, Hind Publishing Corporation, 1984.

Paper: MT 102

Title of paper: Advanced calculus

Course Outcomes : Upon successful completion of this course, the student will be able to:

i) analyze convergence of sequences of functions.
ii) analyze convergence of series of functions.
iii) check differentiability of functions of several variables.
iv) apply mean value theorem for differentiable function
v) apply Green's theorem, Stoke's theorem and Gauss divergence theorem.

Unit 1: Sequence of function: Pointwise convergence of sequence of function,Examples of sequence of real valued functions, Definition of uniform convergence, Uniform convergence and continuity,Cauchy condition for uniform convergence,Uniform convergence and Riemann Integration, Uniform convergence and Differentiation,double sequence, Uniform convergence and double sequence, Mean Convergence.

(15 L)

Unit 2: Rearrangement of Series, subseries, double series, Rearrangement theorem for double series, Multification of series, Power series, Real Power series, The Taylors series generated by function, Bernstein's theorem, Binomia series, Abel's limit theorem, Taubers theorem.

(15 L)

Unit 3 : Multivariable differential Calculus: The Directional derivative, The directional derivative and continuity, Total derivative, Total derivative in terms of partial derivative ,The matrix of linear function , Jacobian matrix, Chain Rule, Mean value function for differentiable function, A sufficient condition for differentiability, Sufficient condition for equality of mixed partial derivatives, Taylors formula for functions R^n to R^1 , The Inverse function theorem (statement only), Implicit function theorem (statement only) and their applications, Extrema of real valued function of one variable, Extrema of real valued function of several variables. **(15 L)**.

Unit 4:- Path and line integral, Multiple integral double integral (Theorem without proof) application to area and volume (without proof), Greens theorem in the Plane, Applications of Green's theorem's, Change of variables special case for transformation formula, Surface integral, Change of parametric representation, Other notations for Surface Integral, Stokes theorem, Curl and divergence of the vector field, Gauss divergence theorem. **(15 L)**

Recommended Reading :

1. T.M.Apostol, Mathematical Analysis, second edition, Narosa publishing house
2. T.M.Apostol, Calculus Vol II, 2nd edition Willey India Pvt. Ltd.
3. Walter Rudin, Principles of Mathematical Analysis, third edition, McGraw Hill book company

References Books :

1. W.Fleming, Functions of several Variables,2nd Edition ,Springer Verlag, 1977.
2. J.R.Munkres, Analysis on Manifolds.CRC Press Taylor and Francis group 2018

Paper: MT 103

Title of the Paper: Real Analysis

Course Outcomes: Upon successful completion of this course, the student will be able to:
1. generalise the concept of length of interval.
2. analyse the properties of Lebesgue measurable sets.
3. demonstrate the measurable functions and their properties.
4. understand the concept of Lebesgue integration of measurable functions.
5. characterize Riemann and Lebesgue integrability.
6. prove completeness of L^P Spaces.

UNIT -1: Open Sets , Closed Sets and Borel sets, Lebesgue Outer measure, The sigma Algebra of Lebesgue Measurable Sets, Countable Additivity, Continuity and Borel-Cantelli Lemma, Non-measurable Sets. **(15L)**

UNIT – 2: Sums, Product and Composition of Measurable Functions , Sequential pointwise limits and simple approximation, Littlewood's Three Principles, Egoroff's theorem and Lusin's theorem, Lebesgue Integration of a Bounded Measurable Function, Lebesgue Integration of a non-negative Measurable function. **(15 L)**

UNIT-3 : The General Lebesgue Integral, Characterization of Riemann and Lebesgue Integrability, Differentiability of Monotone Functions, Lebesgue's Theorem, Functions of Bounded Variations : Jordan's theorem. **(15 L)**

UNIT-4: Absolutely Continious functions , Integrating derivatives: Differentiating indefinite integrals, Normed Linear Spaces, Inequalities of Young, Holder and Minkowski, The Riesz- Fischer theorem.

(15 L)

Recommended Books:

1. H. L. Royden, P.M. Fitzpatrick, Real Analysis, Fourth Edition,PHI Learning Pvt. Ltd.,New Delhi, 2010

Reference Books:

1. G. deBarra, Measure Theory and Integration, New Age International (P) Ltd., 1981.
2. I. K. Rana, An Introduction to Measure and Integration, Narosa Book Company, 1997.
3. S. K. Berberian, Measure and Integration, McMillan, New York, 1965.
4. P. K. Jain, V. P. Gupta, Lebesgue Measure and Integration, Wiley Easter Limited, 1986.
5. P. K. Halmos, Measure Theory, Van Nostrand, 1950.

Paper : MT-104

Title of the paper: Differential Equations

Course Outcomes: Upon successful completion of this course, the student will be able to:
i) application problems modeled by linear differential equations.
ii) use power series methods to solve differential equations about ordinary points and regular singular points.
iii) use Wronskian to verify linearly dependence or independence.
iv) analyze Bessel's equations and its properties.
v) to find Green's function.

A brief note: Theorems and proofs are expected to be prepared from an introduction into ordinaryDifferential equations by E. A. Coddington.

Unit- 1: Linear Equations with constant coefficients:The second order homogeneous equations, Initial value problems for second order equations, Linear dependance and independence, A formula for the Wronskian, The non- homogeneous equations of order two, The homogeneous equations of order n**.** **(15 L)**

Unit -2:Initial value problems for the n^{th} order equations, The non-homogeneous equations of n^{th} order. Linear Equations with variable coefficients : Initial value problems for the homogeneous equations, Solutions of the homogeneous equations, The Wronskian and linear independence , Reduction of the of a homogeneous equation , The non-homogeneous equations. **(15 L)**

Unit-3: Green's function, Sturm Liouville's theory, Homogeneous equations with analytic coefficients, The Legendre equations, Linear equations with regular singular points: The Euler equations, Second order equations with regular singular points. **(15 L)**

Unit -4 : The Bessel equation, Regular singular points at infinity , Existance and uniqueness of solutions: The method of successive approximations, The Lipschitz condition of the successive approximation, Convergence of the successive approximation. **(15 L)**

Recommended books:

1.E.A.Coddington: An introduction to ordinary differential equations. (2012) Prentice Hall of India Pvt.Ltd. New Delhi.
2. G. Birkoff and G.G.Rota: Ordinary Differential equations, John Willey and Sons
3. Mark Pinsky: Partial differential equations and boundary-value problems with applications, AMS,3rd edition(2011).

Reference books:

1.G.F. Simmons Differential Equations with Applications and Historical note, MeGraw Hill, Inc. New York. (1972)
2. E.A. Coddington and Levinson: Theory of ordinary differential equations McGraw Hill, New York(1955).
3. E.D. Rainvills :Elementary differential equations, The Macmillan company, New York. (1964).

Paper- MT105

Title of Paper: Classical mechanics

Course Outcomes: Upon successful completion of this course, the student will be able to:
i) discuss the motion of system of particles using Lagrangian and Hamiltonian approach.
ii) apply D'Alembert's Principle on Lagrange's equation.
iii) solve extremization problems using variational calculus.
iv) analyze Routh's procedure.
v) discuss the motion of rigid body.

UNIT	No. of Lectures
UNIT-I: Mechanics of a particle, Mechanics of a system of particles, Conservation theorems, Conservative force with examples, Constraints, Generalised co-ordinates, D'Alembert's Principle, Lagrange's equations of motion , The forms of Lagrange's equation for non-conservative system and partially conservative and partially non-conservative system, Lagrangian for charged particle in electromagnetic field, Kinetic energy as a homogeneous function of generalised velocities, Non-conservation of total energy due to the existence of non-conservative forces, Cyclic co-ordinates and generalised momentum, conservation theorems, motion of a particle under central force and first integral.	**(15 L)**
UNIT-II: Functionals , Basic lemma in calculus of variations, Euler-Lagrange's equations, First integrals of Euler-Lagrange's equations, the case of several dependent variables Undetrmined end conditions, Geodesics in a plane and space, the minimum surface of revolution, The problem of Brachistochrone, Isoperimetric problems, Problem of maximum enclosed area, Shape of a hanging rope. Hamilton's principle for conservative and non-conservative systems, Derivation of Hamilton's principle from D'Alembert's principle, Lagrange's equations of motion for conservative and non-conservative systems from Hamilton's principle, Lagrange's equations of motion for non-conservative systems (method of Lagrange's undtermined multipliers).	(**15 L)**
UNIT –III : Hamiltonian function, Hamiltonian Canonical equations of motion, Derivation of Hamilton's equations from variational principle, Physical significance of Hamiltonian, The principle of least action, Jacobi's form of the least action principle, Cyclic co-ordinates and Routh's procedure, Orthogonal transformations, Properties of transformation matrix, Infinitesimal rotations.	**(15 L)**
UNIT –IV: The Kinematics of rigid body motion: The independent co-ordinates of rigid body, The Eulerian angles, Euler's theorem on motion of rigid body, Angular momentum and kinetic energy of a rigid body with one point fixed, The inertia tensor and moment of inertia, Euler's equations of motion, Caley- Klein parameters, Matrix of transformation in Caley Klein parameters, Relations between Eulerian angles and Caley-Klein parameters**.**	**(15 L)**

Recommended Books :

1. Goldstein, H. Classical Mechanics. (1980), Narosa Publishing House, New Delhi.
2. Weinstock: Calculus of Variations with Applications to Physics and Engineering (International Series in Pure and Applied Mathematics). (1952), Mc Graw Hill Book Company, New York.

Reference Books :

1. Whittaker, E. T. A treatise on the Analytical Dynamics of particles and rigid bodies. (1965), Cambridge University Press.
2. Gupta, A. S. Calculus of Variations with Applications (1997), Prentice Hall of India.

3.Gelfand, I. M. and Fomin, S. V. Calculus of Variations (1963), Prentice Hall of India.
4. Rana, N.C. and Joag, P. S. Classical Mechanics. (1991) Tata McGraw Hill, New Delhi.

M.Sc-I Semester-II

Paper :-MT-201

Title of Paper :- Linear Algebra

Course Outcomes: Upon successful completion of this course, the student will be able to:
i) know basic notions in Linear Algebra
ii) use the results in developing advanced mathematics.
iii) analyze the relation between linear transformation and its matrix equivalent.
iv) represent Canonical forms and Bilinear forms.
v) use relation between eigen values and trace, determinant

(i) A brief note :- Theorems and proofs are expected to be prepared from Topics in Algebra by Herstein I .N and Linear Algebra by Hoffiman , Kenneth and Kunze R.

UNITS		No. of Lectures
UNIT-I :	Direct sum of a vector space, Dual Spaces, Annihilator of a subspace, Quotient Spaces,Algebra of Linear trasformation.	**(15 L)**
UNIT-II :	Adjoint of a Linear Transformation, Inner product spaces, eigen values and eigen vectors of a linear transformation, Diagonalization, Invariant subspaces.	**(15 L)**
UNIT-III :	Canonical forms, Similarity of Linear transformations, Reduction to Triangular forms , Nilpotent transformation, Primary decomposition theorem, Jordan blocks and Jordan forms , Invariants of Linear transformations.	**(15 L)**
UNIT-IV :	Hermitian, Self adjoint, Unitary and normal Linear trasformation, symmetric bilinear forms, skew symmetric bilinear forms , group preserving bilinear forms.	**(15 L)**

Recommended reading:

1. Hoffman Kenneth and Kunze R : Linear Algebra, Prentice hall of India, Pvt. Ltd.,1984
2. Sahi and Bist, Linear algebra, Narosa Publishing House.
3. Herstein I.N. : Topics in Algebra , Second Edition, Willey eastern Ltd.

Reference Books :

1. A.R. Rao and P. Bhimashankaran, Linear Algebra, Hindustan Book Agency(2000)
2.Surjit Sing, Linear Algebra, Vikas Publishing House(1997)

Paper : MT 202

Title of Paper :- Topology

Course Outcomes: Upon successful completion of this course, the student will be able to:

i) have a demonstrable knowledge of topological spaces.

ii) obtained the bases and subbases of topological subbases.

iii) find a relation between T_{0}, T_1 , T_2 spaces.

iv) construct examples on T_0, spaces.

v) Urysohn lemma and Urysohn metrization theorem.

(i) **A brief note :-** Theorems and proofs are expected to be prepared from Foundation of General Topology by W.J.Pervin.

Unit –I : Topological Spaces, Examples, Open Sets, Closed sets, Neighborhoods, Bases, Subbases, Limit Points, Closer Interior, Various ways of defining topologies, Hereditary properties. (**15L)**

Unit –II: Continuous functions,Homeomorphisms,Topologicalproperties,Compact Spaces, connected spaces ,Connectedsubspsces of real lines, Components, Separation axioms T_0 , T_1 , T_2 axioms. (**15L)**

Unit –III: First and second axioms spaces, Separable Spaces, Lindelofspaces,Regular and normal Spaces, Product Spaces (For T_0,T_1,T_2 Compact and Connected) **(15L)**

Unit- IV: Completely regular and completely normal Spaces,Urysohn Lemma and Urysohn Metrization theorem (**15L)**

Recommended Books:

1. W. J. Pervin, Foundations of General Topology, Academic Press, New York, 1964.

2. J. R. Munkers, Topology, Second Edition, Pearson Education (Singapore), 2000.

Reference Books:

1. J. L. Kelley, General Topology, Springer-Verlag, New York, 1955.

2. S. Willard, General Topology, Addison-Wesley Publishing Company, 1970.

3. K. D. Joshi, Introduction to General Topology, New Age International, 1983.

4. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill Book Company, New Delhi, 1963.

Paper: MT 203

Title of the Paper: Complex Analysis

Course Outcomes: Upon successful completion of this course, the student will be able to:
i) enjoy the beauty of analytic functions and related concepts.
ii) analyze the mobius transformation.
ii) apply Cauchy's theorem and integral formula to evaluate complex variable integral.
iv) use residue theorems to evaluate real integrals.
v) use Rouche's theorem to locate roots of polynomial.

A brief note: Theorems and proofs are expected to be prepared from Functions of one Variable by J.B.Conway ; this should be taken in to account for examination point of view.

Unit 1: Power series , Radius of convergence, Bilinear Transformation, Analytic functions , Cauchy's-Riemann equations, Harmonic functions, Power series representation of analytic functions.

(15 L)

Unit 2: Zeros of Analytic functions, Cauchy's theorem, Moreras theorem, Cauchy's Integral formula, Cauchy's inequality' Liouville's Theorem, Fundamental theorem of algebra, Maximum modulus theorem, Open mapping theorem.

(**15 L)**

Unit 3: Laurent series expansion theorem, Cauchy residue theorem, classification of singularities, Evaluation of integral, The argument principle, Rouche's theorem.

(15 L)

Unit 4: Conformal maps, Normal families, Hurwitz theorem, Riemann mapping theorem.

(15 L)

Recommended Reading :

1. J. B. Conway: Functions of One Complex Variable (3rd Edition) Narosa Publishing House.

Reference Books :

1.S.Ponnusamy, Foundations of Complex Analysis, Narosa Publishing House.

2. Alfors L. V.: Complex Analysis, McGraw 1979.

3. Churchill and Brown, Complex Variables and applications, MacGraw Hill(India). (8^{th} Edition, 2014)

4. Serge Lang, Complex Analysis, Springer.

5. Steven G. Krantz, Complex Analysis, A Geometric view Point, The Carus Mathematical Monographs.

6. T. W. Gamelin, Complex Analysis, Springer.

Paper : MT 204

Title of the Paper: Numerical Analysis

Course Outcomes: Upon successful completion of this course, the student will be able to:

i) discuss the methods to solve linear and nonlinear equations.
ii) find numerical integration and analyze error in computation.
iii) solve differential equations using various numerical methods.
iv) apply Runge – Kutta method.
v) analyze sufficient condition for convergence.

Units and No. Of Lectures

Unit 1

Algebraic and transcendental equations:

Rate of convergence of Secant Method, Regula _Falsi Method and Newton-Raphson Method. Bairstow method.

System of linear equations: Matrix factorization methods (Doo little reduction, Crout reduction) Eigen Values and eigenvectors ,Gerschgorin theorem, Brauer theorem, jacobi Method for symmetric matrices.

(15L)

Unit 2

Numerical Integration: Error estimates of trapezoidal and Simpson's Numerical Integration rule.

Gauss- Legendre integration Methods (n= 1,2) , Lobatto Integration Method (n=2) , Radau Integration method (n=2) and their error estimates. **(15 L)**

Unit 3

Runge – KuttaMethod : second order methods , The coefficient tableau, Third order methods (without proof) , order conditions, Fourth order methods (without proof) , Implicit Runge- kutta methods, Stability characteristics.

Taylor Series Methods: Introduction to Taylor series methods, Manipulation of Power Series, an example of a Taylor series solution. **(15 L)**

Unit 4

Linear multistep methods : Adams Methods, General form of linear multistep methods, Predictor- corrector Adams methods, Starting Methods.

Analysis of linear multistep methods: Convergence, consistancy, Sufficient condition for convergence, Stability characteristics**.** **(15 L)**

Recommended Books:

1. M.K. Jain, S. R. K. Iyengar, R. K. Jain, Numerical methods for scientific and Engineering Computation, New Age International Limited, 6th edition.(For Units 1 and 2)
2. J.C. Butcher ,Numerical methods for ordinary differential equations, , John Wiley & Sons Ltd, 2nd edition. (For Units 3 and 4)

Reference Books :

1. , P. Henrici, Discrete variable methods in ordinary differential equations, John Wiley &Sons Ltd.
2. S. S. Sastry, Introductory methods of Numerical Analysis', Prentice Hall of India New Delhi,5th edition2012
3. M. K. Jain, Numerical solutions of Differential Equations John Wiley &Sons Ltd 1984.

Paper: MT-205

Title of the Paper :-Differntial Geometry

Course Outcomes : Upon successful completion of this course, the student will be able to:
1. find the directional derivatives of the functions.
2. compare the unit-speed and arbitrary-speed curves.
3. apply the Frenet formulas to analyze the curves.
4. examine whether the given set in R^3 is a surface.
5. construct the parametrizations of different surfaces.
6. formulate different types of curvatures of given surface.

A brief note:-Theorems and proofs are expected to be prepared from books given in basic readings.

Unit – I

Vector Space, Euclidean Space in R^3, Tangent Vectors and vector fields, Frame fields, Natural Frame Fields, Directional Derivatives, Curve in R^3 and reparametrization of curves, Standard curves, Speed of curve,length of curve, 1-forms, differential forms. **(15 L)**

Unit –II

The Frenet Formulae for unit speed curve, Frenet approximation of curves, Arbitrary Speed Curves, Frenet formula's for arbitrary speed curves, Co-variant Derivative, Isometries in R^3 ,Orthogonal Transformations. **(15 L)**

Unit-III

Co-ordinate Patches, Surface in R^3 , Simple Surface, Cylinder Surface, Surface of Revolution, parametrization of a region, parametrization of a cylinder and surface of revolution, Smooth overlaping patches, Tangent and normal vector fields on a surface. **(15 L)**

Unit-IV

The Shape operator of surface M in R^3, Normal curvature, Principal curvature, Gaussian and mean curvatures, Umbilic Points, Fundamental forms of a surface, Computational Techniques, Special curves on surface, Asymptotic and Geodesic Curves. **(15 L)**

Recommended Books:

1. O'Neill, B., Elementary Differential geometry, Academic Press, Revised Edition 2006.

Reference Books:

1. D. Somasundaram, Differential Geometry- First Course, Narosa Publishing House, New Dehli, 2010.
2. Nirmala Prakash, Differential Geometry, Tata Mcgraw Hill, 1981.
3. K. S. Amur and et al., Differential Geometry, Narosa Publishing House, 2010.
4. Millman, R. and Parker, G. D. Elements of Differential Geometry, Prentice-Hall of India Pvt. Ltd. 1977.
5. Hicks, N. , Notes on Differential Geometry, Princeton University Press (1968)