KUVEMPU UNIVERSITY

SYLLABUS

COURSE: M.Sc. MATHEMATICS

With Effective from A/Y: 2020-21

DEPARTMENT OF P.G. STUDIES AND RESEARCH IN MATHEMATICS

KUVEMPU UNIVERSITY

JNANA SAHYADRI

SHANKARAGHATTA- 577 451

SHIVAMOGGA, KARNATAKA, INDIA.

PHONE; 08282 257310

FAX: 08282 256221

WEB: www.kuvempu.ac.in

M.Sc., MATHEMATICS SYLLABUS (CBCS-Scheme)

1st Revised: 2010-11

2nd Revised: 2015-16

3rd Revised: 2020-21

With Effective from A/Y: 2020-21

COURSE STRUCTURE

SEMESTER – I:

	PAPER CODE	SUBJECT	MARKS ALLOTMENT			TOTAL	CREDIT
			EXAM	IA	LAB		
Hard Core	MSM 1.1	ALGEBRA	75	25	--	100	05
	MSM 1.2	ANALYSIS-I	75	25	--	100	05
	MSM 1.3	COMPLEX ANALYSIS-I	75	25	--	100	04
	MSM 1.4	ORDINARY DIFFERENTIAL EQUATION	75	25	--	100	04
Soft Core	MSM 1.5	DISCRETE MATHEMATICS AND C-PROGRAMMING	75	25	--	100	04
Practical	MSM 1.6	LAB: C-PROGRAMMING	--	--	50	50	02
TOTAL						**550**	**24**

SEMESTER – II:

	PAPER CODE	SUBJECT	MARKS ALLOTMENT			TOTAL	CREDIT
			EXAM	IA	LAB		
Hard Core	MSM 2.1	LINEAR ALGEBRA	75	25	--	100	05
	MSM 2.2	ANALYSIS – II	75	25	--	100	05
	MSM 2.3	COMPLEX ANALYSIS-II	75	25	--	100	04
Soft Core	MSM 2.4	PARTIAL DIFFERENTIAL EQUATION	75	25	--	100	04
	MSM 2.5	DIFFERENTIAL GEOMETRY	75	25	--	100	04
Practical	MSM 2.6	LAB: MAT LAB PROGRAMMING	--	--	50	50	02
Elective-I	MSM 2.7	BASIC MATHEMATICAL MODELLING	40	10	--	50	02
TOTAL						**600**	**26**

SEMESTER – III:

	PAPER CODE	SUBJECT	MARKS ALLOTMENT			TOTAL	CREDIT
			EXAM	IA	LAB		
Hard Core	MSM 3.1	MEASURE THEORY AND INTIGRATION	75	25	--	100	05
	MSM 3.2	TOPOLOGY-I	75	25	--	100	05
	MSM 3.3	NUMERICAL ANALYSIS-I	75	25	--	100	04
Soft core	MSM 3.4	RIEMANNIAN GEOMETRY	75	25	--	100	04
	MSM 3.5	FLUID MECHANICS	75	25	--	100	04
Practical	MSM 3.6	LAB-NUMERICAL METHODS	--	--	50	50	02
Elective-II	MSM 3.7	STATISTICAL TECHNIQUES	40	10	--	50	02
TOTAL						**600**	**26**

SEMESTER – IV:

	PAPER CODE	SUBJECT	MARKS ALLOTMENT			TOTAL	CREDIT
			EXAM	IA	LAB		
Hard Core	MSM 4.1	FUNCTIONAL ANALYSIS	75	25	--	100	04
	MSM 4.2	TOPOLOGY-II	75	25	--	100	04
Soft Core	MSM 4.3	NUMERICAL ANALYSIS-II	75	25	--	100	03
	MSM4.4	TENSOR ANALYSIS AND RELATIVITY THEORY	75	25	--	100	03
	MSM 4.5A MSM 4.5B MSM 4.5C MSM 4.5D (**Anyone**)	FINSLER GEOMETRY AND RELATIVITY CONTACT GEOMETRY MAGNETOHYDRODYNAMICS GRAPH THEORY	75	25	--	100	03
Practical	MSM 4.6	LAB-NUMERICAL METHODS			50	50	02
	MSM 4.7	PROJECT WORK	75	25 **(viva)**	--	100	04
TOTAL						**650**	**23**

Sl.No	Semester	Total Marks	Credits
1	1st Semester	550	24
2	2nd Semester	600	26
3	3rd Semester	600	26
4	4th Semester	650	23
GRAND TOTAL		**2400**	**99**

SYLLABUS (CBCS-Scheme)

(Revised on 2020-21)

M.Sc., MATHEMATICS

WITH EFFECT FROM A/Y: 2020-21

FIRST SEMESTER

Paper-MSM 1.1: ALGEBRA

(**Max marks: 100=75+25. Credits: 05)**

UNIT-1: Groups: Definition and examples of groups, Subgroups, abelian groups, cyclic groups, Lagrange's theorem, normal subgroups and quotient groups, homomorphism, isomorphism, Cauchy's theorem for abelian groups, application of Cauchy's theorem, automorphism, inner and outer automorphism.

UNIT-2: Permutation Groups: Examples, orbit, cycle, transposition, alternating groups, Cayley's Theorem, Conjugate class, class equation, Cauchy theorem for finite groups,

UNIT-3: Sylow's Theorem and Problems: solvable groups, direct products, Fundamental theorem on finite abelian groups.

UNIT-4: Rings: Definition and examples of Rings, Integral domain, Field, Characteristic of a Ring, Homomorphism, Kernel, isomorphism, ideals and quotient rings, maximal ideal, prime ideal, principal ideal ring.

UNIT-5: Euclidean Ring: Definition and examples, greatest common divisor, prime and irreducible elements, unique factorization domain, unique factorization theorem.

UNIT-6: Polynomial Rings: Division Algorithm, irreducible polynomial, primitive polynomial, Gauss Lemma, Eisenstein criterion, polynomial ring over commutative rings.

UNIT-7: Extension Fields: Definition and example, algebraic extension, transitivity of algebraic extension, roots of polynomial, Remainder Theorem, Factor theorem.

UNIT-8: Splitting Fields: Degree of Splitting fields, Normal extension, criterion for polynomial to have a multiple root in any extension field, characteristic of a ring, separable element, perfect fields.

References:

1. *Topics in Algebra*: ISBN-9971-512-53-X : I.N.Herstein
2. *A First course in Abstract Algebra* : J.B.Fraleigh
3. *Algebra* : Michael Artin

Paper-MSM 1.2: ANALYSIS-I

(Max marks: 100=75+25. Credits: 05)

UNIT-1: Real Number System: Ordered sets, Fields, Real field, Extended real number system, Euclidean spaces.

UNIT-2: Basics of Set theory: Ordered pairs, Relation and functions, one-to-one correspondence, equivalent sets, cardinal number, finite and infinite sets, Countable and uncountable sets with examples.

UNIT-3: Basic Topology: Metric spaces, Open sets, Closed sets, Compact sets, Perfect sets, Connected sets.

UNIT-4: Numerical Sequence and Series: Convergent sequences, subsequences, Cauchy sequences, some special sequences, Series, Series of non-negative series, summation by parts, absolute convergence, addition and multiplication of series, Rearrangement.

UNIT-5: Continuity: Limits of function, Continuous function, Continuity and Compactness, Continuity and Connectedness, Discontinuity, Monotonic functions, Infinite limits and limits at infinity.

UNIT-6: Differentiation: The derivative of a real function, Mean value theorems, The continuity of derivatives, Derivatives of higher order, Taylor's theorem, differentiation of vector valued functions.

References:

1. *Principles of Mathematics Analysis*: ISBN-0-07-085613-3 : Walter Rudin
2. *Methods of Real Analysis* : R.R. Goldberg
3. *Mathematical Analysis* : T.M. Apostal

Paper-MSM 1.3: COMPLEX ANALYSIS-I (Max marks: 100=75+25. Credits: 04)

UNIT-1: Introduction to Complex Numbers: Definition of complex numbers, arithmetic operations, square roots, conjugation, absolute value, Cauchy' inequality, geometry of complex numbers, stereographic projection.

UNIT-2: Analytic Functions: Limits, continuity and differentiability of complex valued functions, Cauchy-Riemann equations, Laplace equation, harmonic functions, polynomials, Lucas's theorem.

UNIT-3: Power Series: Sequence and series-review, uniform convergence, radius of convergence, power series as an analytic function, Abel's limit theorem.

UNIT-4: Conformal Mappings: Arcs and closed curves, analytic functions in regions, principle of conformal mapping, length and area.

UNIT-5: Mobius Transformation: Matrix interpretation and group structure, fixed points, cross ratio and its invariance property, principle of symmetry.

UNIT-6: Complex Integration: Line integral, rectifiable arcs, line integrals as functions of arcs, Cauchy's theorem of rectangle, Cauchy-Goursat theorem, Cauchy's theorem in a disk.

UNIT-7: Cauchy's Integral Formula: Index of a point with respect to a closed curve, the integral formula, representation formula.

UNIT-8: Higher Derivatives: Morera's theorem, Liouville's theorem, fundamental theorem of algebra, Cauchy's estimate.

References:

1. *Complex Analysis*: ISBN-0-07-000657-1 : L.V. Ahlfors
2. *Functions of One Complex Variable* : John B.Conway
3. *Complex Analysis* : T.O.Moore &E.H.Hadlock
4. *Complex Analysis* : Serge Lang
5. *Foundation of Complex Variables Analysis* : Ponnuswamy 6. *Complex* : I. Steward & D. Tall.

Paper-MSM 1.4: ORDINARY DIFFERENTIAL EQUATIONS

(Max marks: 100=75+25. Credits: 04)

UNIT-1: First Order Linear Differential Equations: Introduction, first order linear differential equations, separable equations, exact equations, Bernoulli's equation and method of substitutions.

UNIT-2: Higher Order Linear Differential Equations: Homogeneous equations and general solutions; Initial value problems; existence and uniqueness of solutions, linear dependence and independence of solutions, Solutions of nonhomogeneous equations by Method of Variation of parameters, Method of Undetermined Coefficients. Homogeneous equation of order n, initial value problems, non-homogeneous equations. Linear equations with variable coefficients, reduction of order of the equation.

UNIT-3: Oscillations of Second Order Equations: Introduction, Oscillatory and non-Oscillatory differential equations and some theorems on it. Boundary value problems; Sturm Liouville theory; Green's function.

UNIT-4: Solution in Terms of Power Series: -Solution near an ordinary point and a regular singular point–Frobenius method–Legendre, Bessel's and Hypergeometric equations and their polynomial solutions, Rodregue's relation, generating functions, orthogonal properties, and recurrence relations.

UNIT-5: Successive Approximations Theory: Introduction, solution by successive approximations, Lipschitz condition, Convergence of successive approximations, Existence and Uniqueness theorem (Picard's theorem),

UNIT-6: System of First Order Equations: First order systems, Linear system of homogeneous and non-homogeneous equations (matrix method) Non-linear equations-Autonomous systems-Phase plane-Critical points–stability-Liapunov direct method-Bifurcation of plane autonomous systems.

References:

1. *An Introduction to Ordinary Differential Equations* : Eurl A. Coddington
2. *Differential Equations with Applications and Historical Notes* : Simmons, G.F.
3. *Theory of ordinary differential equations* : M.S.P.Eastham
4. *Differential equations* (3rd edition) : S.L.Ross
5. *Ordinary Differential Equations and Stability Theory* : Deo SG and Raghavendra V

6.*Theory of ordinary differential equations* : A.Coddington and N.Levinson
7. *Differential equations* : A.C.King, J.Billingham and S.R.Otto

Paper-MSM 1.5: DISCRETE MATHEMATICS AND C-PROGRAMMING

(Max marks: 100=75+25. Credits: 04)

UNIT-1: Lattice Theory: Partially ordered sets, Lattice, Distributive Lattice, Complements, Demorgan's Laws.

UNIT-2: Boolean Algebra: Boolean Lattice, Finite Boolean lattice, Boolean Expression and function, Conjunctive and disjunctive normal forms.

UNIT-3: Number theory: Introduction, Divisibility, Greatest common, prime numbers, The fundamental theorem of Arithmetic, The series of reciprocals of the primes, The Euclidean algorithm, The greatest common divisor of more than two numbers.

UNIT-4: Congruence: Definition and basic properties of congruences, Residue classes and complete residue systems, Linear congruences, Reduced residue systems and the Euler-Fermat theorem.

UNIT-5: Introduction to 'C': Development of C, Features, Constants and Variables, Data types, Operators and Expressions, Library functions.

UNIT-6: I/O Statements: Formatted and Unformatted I/O, scanf(), printf(), getchar() and putchar() functions.

UNIT-7: Control Structures: Conditional and Unconditional, If, For, While and do-while, Switch, Break and Continue, Goto statement.

UNIT-8: Arrays and functions: One and Multi-dimensional arrays, Strings and String functions, Definition and declaration of a function, Different types, Calling a function, Passing parameters, Local and Global variables, Recursive functions.

Reference:

1. *C Programming* :Schaum Series
2. *Spirit of C* :Mullish& Cooper
3. *Let us C* *:YeswantKanetkar*
4. *Introduction to computers and C-programming-* :P.B.Kottor:
5. *General Lattice theory* :Birkhauser.
6. *Discrete Mathematics* :Purna Chandra Biswal.

Paper-MSM 1.6: LAB: C-PROGRAMMING

(Max marks: 50. Credits :02)

List of programs:

1. Program to accept three integers and print the largest among them.
2. Program to check whether the integer is even or odd and also positive or negative.
3. Program to find roots of quadratic equation.
4. Program to perform arithmetic operations using switch case.
5. Program to convert binary number to decimal number and decimal number to binary number.
6. Program to calculate factorial of a number.
7. Program to print Fibonacci numbers.
8. Program to search an element in the array.
9. Program to arrange a set of given integers in an ascending order and print them.
10. Program to find sum and differences of two matrices.
11. Program to find the Transpose, Trace and Norm of a matrix.
12. Program to find the product of two matrices.
13. Program to find row sum and column sum of a matrix.
14. Program to generate prime number between two give number.
15. Program to find the Armstrong Number between two given number.
16. Program to test whether the number is Palindrome or not.

SECOND SEMESTER

Paper-MSM 2.1: LINEAR ALGEBRA

(Max marks: 100=75+25. Credits: 05)

UNIT-1: Vector spaces: Definition and example, linear dependence and independence, Basis, dimension, subspaces, homomorphism, isomorphism, Hom(V, W) as a vector space, dual spaces.

UNIT-2: Inner Product Spaces: Annihilator, Schwarz inequality, orthonormal basis, GramSchmidt orthogonalization process, orthogonal complement.

UNIT-3: Linear Transformations: The algebra of Linear Transformation, singular and non-singular transformations, characteristic polynomials, minimal polynomials, Rank and Nullity, Eigen values and eigen vectors.

UNIT-4: Matrix of Linear Transformation: Examples, matrix of change of basis, similar matrices.

UNIT-5: Canonical Forms: Similar transformations, Invariant subspaces, Triangular forms, Nilpotent Transformations, Jordan form, Trace and Transpose, Determinants.

UNIT-6: Hermitian adjoint: Hermitian transformations, Unitary and Normal Transformations, Real quadratic forms**:** Sylvester's law of Inertia, rank and signature.

References:

1. *Topics in Algebra*: ISBN-9971-512-53-X : I.N. Herstein
2. *Linear Algebra with Applications* : Otto Bretscher.
3. *Linear Algebra* : Surjeet Sing
4. *Finite Dimensional Vector Space* : P.R. Halmos.
5. *Linear Algebra* : Hoffman and Kunze

Paper-MSM 2.2: ANALYSIS-II

(Max marks: 100=75+25. Credits: 05)

UNIT-1: The Riemann–Steiltje's Integral: Definition and existence of the integral, Properties of the integral, Integration and Differentiation.

UNIT-2: Sequences and Series of Functions: Pointwise and uniform convergence, Uniform convergence& continuity, Uniform convergence & integration, Uniform convergence & differentiation,

UNIT-3: Equicontinuous Families of Functions: Pointwise and uniformly bounded, equicontinuous family of functions, The Stone-Weierstrass theorem.

UNIT-4: Special Functions: Power series, the exponential and Logarithmic functions, the trigonometric functions.

UNIT-5: Functions of Several Variables: Linear transformations, invertible linear operators, matrix representation, Differentiation, partial derivatives, gradients, directional derivative, continuously differentiable functions, The contraction principle.

UNIT-6: The Inverse and Implicit Function Theorem: The Inverse function theorem, Implicit function theorem with examples, Jacobians, Derivatives of Higher order and differentiation of integrals.

References:

1. *Principles of Mathematical Analysis* : W. Rudin
2. *Real Analysis* : ISBN-978-81-203-4280-4 : H.L. Royden
3. *Mathematical Analysis* : T.M. Apostal
4. *Real Functions* : C. Goffman
5. *Measure and Integration* : G. De barra
6. *Calculus of variations* : I.M. Geifand & S.V. Famin.

Paper-MSM 2.3: COMPLEX ANALYSIS-II

(Max marks: 100=75+25. Credits: 04)

UNIT-1: Local Properties of Analytic Functions: Isolated and non-isolated singularities, removable singularities, Taylors's theorem, zeros and poles, meromorphic functions, zeros and poles of order 'h', essential singularity, Weierstrass theorem.

UNIT-2: Maximum Modules Principle: The maximum principle, Schwarz lemma, Some applications of Schwarz's lemma, Hadamard's three circles theorem.

UNIT-3: The General Form of Cauchy's Theorem: Chains and cycles, general statement of Cauchy's theorem, locally exact differentials, multiply connected regions.

UNIT-4: Calculus of Residues: Residue at a finite point, residue at the point at infinity, The Residue theorem, The argument principle, Rouche's theorem. Evaluation of the integrals of the type, $\int_{\alpha}^{2\pi+\alpha} R(\cos\theta, \sin\theta)\, d\theta$, $\int_{-\infty}^{\infty} g(x)\cos mx\, dx$, Cauchy principal value.

UNIT-5: Harmonic Functions: Laplace's equation, The Mean value property, maximum principle for Harmonic functions, Poisson's formula, Schwarz's formula, Schwarz's theorem, The reflection principle.

UNIT-6: Power Series Expansion: Weierstrass's theorem, Hurwitz theorem, the Taylor series, the Laurent series.

UNIT-7: Partial Fractions and Factorization: Partial fractions, infinite products, the gamma function, Stirling's formula.

UNIT-8: Entire Functions: Jensen's formula, Poisson-Jensen formula, Hadamard's theorem.

References:

1. *Complex Analysis*: ISBN-0-07-000657-1 : L.V. Ahlfors
2. *Functions of One Complex Variable* : John B.Conway
3. *Complex Analysis* : T.O. Moore & E.H. Hadlock
4. *Complex Analysis* : Serge Lang
5. *Foundation of Complex Variables* : S Ponnuswamy
6. *Complex Analysis* : I. Steward & D. Tall

Paper-MSM 2.4: PARTIAL DIFFERENTIAL EQUATIONS

(Max marks: 100=75+25. Credits: 04)

UNIT-1: First Order Partial Differential Equations: Introduction, Construction of Firstorder Partial Differential Equations, Solutions of First Order Partial Differential Equations, Solutions Using Charpit's Method, Method of Cauchy Characteristics, Method of Separation of Variables

UNIT-2: Second Order Partial Differential Equations: Introduction, Origin of Second Order Equations, Equations with Variable Coefficients, Canonical Forms.

UNIT-3: Parabolic Equations: Introduction, Solutions by Separation of Variables, Solutions by Eigenfunction Expansion Method, Solutions by Laplace Transform Method, Solutions by Fourier Transforms Method, Duhamel's Principle, Higher Dimensional Equations, Solutions to parabolic equations in cylindrical and spherical coordinate systems.

UNIT-4: Hyperbolic Equations: Introduction, Method of Characteristics (D'Alembert Solution), Solutions by Separation of Variables, Solutions by Eigenfunctions Expansion Method, Solutions by Laplace Transform Method, Solutions by Fourier Transform Method, Duhamel's Principle, Solutions to Higher Dimensional Equations, Solutions to hyperbolic equations in cylindrical and spherical coordinate systems.

UNIT-5: Elliptic Equations: Introduction, Solutions by Separation of Variables, Solutions by Eigen functions Expansion Method, Solutions by Fourier Transform Method, Similarity Transformation Method, Solutions to Higher Dimensional Equations, Solutions to ellipticequations in cylindrical and spherical coordinate systems.

References:

1. *Nonlinear Partial Differential Equations in Engineering* : Ames, W.F.
2. *Integral Transforms and Their Applications* : Debnath, L
3. *Partial Differential Equations for Scientists and Engineers* : Stanley J. Farlow
4. *Partial Differential Equations of Mathematical Physics* : Tyn Myint-U
5. *Elements of Partial Differential Equations* : I.N. Sneddon
6. *Linear Partial Differential Equations for Scientists and Engineers* : Tyn Myint-U and Lokenath Debnath

Paper-MSM 2.5: DIFFERENTIAL GEOMETRY

(Max marks: 100=75+25. Credits: 04)

UNIT-1: Curves and Surfaces-An Introduction: What is Curve? Parametrized curve, Level curves, Curvature, Plane curves, Space curves. What is Surface? Smooth surfaces, Examples of Surface.

UNIT-2: Calculus on Euclidean Space: Euclidean space, Tangent Vectors, Vector field, Directional derivatives, Curves in R^3.

UNIT-3: Differential Forms: 1-Forms, Differential forms, Mappings on Euclidean spaces, Derivative map, Dot product on R^3, Dot product of tangent vectors, Frame at a point.

UNIT-4: Surfaces in R^3: Calculus on a Surface, Cross product of tangent vectors, Curves in R^3, Arc length, Reparametrization, The Frenet formulas, Frenet frame field, Curvature and Torsion of a unit speed curve.

UNIT-5: Frame Fields: Arbitrary speed curves, Frenet formulas for arbitrary speed curve, Covariant derivatives, Frame field on R^3, Connection forms of a frame field, Cartan's structural equations.

UNIT-6: Calculus on a Surface: Calculus on a Surface, Co-ordinate patch, Proper patch, Surface in R^3, Monge Patch, Patch computations, Parameterization of a cylinder, Differentiable functions and tangent vectors, Tangent of a Surface, Tangent plane, Vector field, Tangent and Normal Vector field on a Surface.

UNIT-7: The First and Second Fundamental Form: First fundamental form, Length of curves on Surfaces, Isometries of Surfaces, Conformal mappings of surfaces. Second fundamental form, The Curvature of curves on a surfaces with examples.

UNIT-8: Shape operators: Definition of Shape Operator, Normal curvature, Gaussian curvature, Computational techniques, Special curves in Surfaces.

References:

1. *Elementary Differential Geometry* : Andrew Pressly
2. *Elementary Differential Geometry* : Barret O'Neil.
3. *An introduction to Differential Geometry* : T.J. Willmore
4. *Differential Geometry – An Integrated approach* : Nirmala Prakash
5. *An Introduction to Differential Manifolds* : Y. Matsushima.

Paper-MSM 2.6: LAB: MATLAB PROGRAMMING

(Max marks: 50. Credits: 02)

List of programs:

1. Program to find solution to system of linear equations by matrix inversion method (check for all conditions on input matrix).
2. Program to find solution to system of linear equations by Cramer's rule (check for all conditions on input matrix).
3. Program to find area of one of the geometric figures (circle, triangle, rectangle and square) using switch statements.
4. Program to find the approximate solution of a differential equation with initial condition by Picard's method of successive approximation (for e.g., , $\frac{dy}{dx} = x^2 + 2y$ with $y(0) = 1$).
5. Program to find the numerical solution of differential equation with initial condition by Euler's method (for e.g., $\frac{dy}{dx} = \frac{x-y}{x+y}$ with $y(0) = 1$.)
6. Program to find the numerical solution of differential equation with initial condition by
   Runge-Kutta II order method (for e.g., $\frac{dy}{dx} = 1 + \frac{2xy}{1+x^2}, y(0) = 0$ with $h = 0.2$).
7. Program to find the numerical solution of differential equation with initial condition by Runge-Kutta IV order method (for e.g., $\frac{dy}{dx} = \frac{3x+y}{x+2y}, y(1) = 1$ with $h = 0.2$).
8. Program to implement Newton Gregory Forward Difference method.
9. Program to implement Lagrange interpolation polynomial.
10. Program to plot a neat labelled graph of sine and cosine function on the same graph.
11. Program to plot a neat labelled graph of functions f(x)=x^2, g(x)=$x^3 - 1$, and h(x)=e^x on the same graph.
12. Program to obtain the graph of plane curves cycloid and asteroid in separate figure on a single run.
13. Program to obtain a neat labelled graph of space curves elliptical helix and circular helix in separate figure on a single run.
14. Program to obtain a neat labelled graph of surfaces elliptic paraboloid and hyperbolic paraboloid in separate figure on a single run.
15. The following table is a list of countries by gold production

Gold Production (in metric tons)	280	495	190	150	270	125	750
Country	Australia	China	Canada	Peru	Russia	Mexico	Others

Draw the Bar graph and Pie chart for it.

16. Program to animate the Sine curve.

Paper-MSM 2.7: Elective: BASIC MATHEMATICAL MODELLING

(Max marks: 50=40+10. Credits: 02)

Unit-1: Concept of Mathematical Modelling: Definition, Classification, Characteristics and Limitations.

Unit-2: Basic Modelling: Modelling through geometry, Modelling through algebra, Modelling through trigonometry.

Unit-3: Development of Model Equations: Origin of ODE and PDEs. Special types of differential equations.

Unit-4: Modelling Through Graphs: Koningsberg bridge problem, Models in terms of directed graphs, models in terms of signed graphs, models in terms of weighted digraphs.

Unit-5: Linear Programming: Introduction, linear inequalities and their graphs, statement of the linear programming problem (LPP), classification of solutions, solution by graphical method.

References:

1. *Mathematical Modelling* : J.N. Kapur

2. *Modelling with Differential Equations* **:** D.N. Burghes

3. *Operations Research* : S.D. Sharma

4.Graphs and Digraphs *:* M. Bejzad,G. Charatrand and L. Leniak-foster.

THIRD SEMESTER

Paper-MSM 3.1: Measure Theory and Integration

(Max marks:100=75+25. Credits :05)

UNIT-1: Lebesgue Measure: Introduction, Outer measure, measurable sets and Lebesgue measure, translation invariant, algebra of measurable sets, countable subadditivity, countable additively and continuity of measure, Borel sets, a non- measurable set.

UNIT-2: Measurable Function: Examples: Characteristic function, constant function and continuous function, Sums, products and compositions, Sequential point wise limits, Simple functions, Littlewood's three principles,

UNIT-3: Lebesgue Integral of Bounded Functions: The Riemann integral, integral of simple functions, integral of bounded functions over a set of finite measure, bounded convergence theorem.

UNIT-4: The General Lebesgue Integral: Lebesgue integral of measurable nonnegative functions, Fatou's lemma, Monotone convergence theorem, the general Lebesgue integral, integrable functions, linearity and monotonicity of integration, additivity over the domains of integration. Lebesgue dominated convergence theorem.

UNIT-5: Differentiation and Integration: Differentiation of monotone functions, Vitali covering lemma, Dini derivatives, Lebesgue differentiation theorem, functions of bounded variation, Jordan's theorem, differentiation of an integral, indefinite integral, absolute continuity.

UNIT-6: The L^p Spaces: L^p spaces, the Holder and Minkowski inequalities, convergence and completeness, bounded linear functions on the L^p spaces.

References:

1. *Real Analysis:* ISBN-978-81-203-4280-4 : H.L. Royden
2. *Measure Theory & Integration* : DeBarra
3. *Measure Theory* : P.R. Halmos

Paper-MSM 3.2: TOPOLOGY-I

(Max marks: 100=75+25. Credits: 05)

UNIT-1: Set Theory and Logic: Revive of Basic concept, Cartesian product, principles of recurrence relations, well order set, maximum principles.

UNIT-2: Topological Spaces: Basic topological spaces, Topological spaces: The definition and examples, Bases for a topology, Open sets and closed sets; Interior closure of a set, Exterior and boundary, Relative or subspace topology; sub bases.

UNIT-3: Continuity and convergence: Hausdorff spaces, continuous function, open and closed maps, Pasting Lemma, convergence, uniform convergence theorem, Homeomorphism, maps into products.

UNIT-4: Product topology: Order topology, product topology, The weak topology and the product topology, The uniform Metric, Quotient space, metric topology, examples for nonmetrizable spaces.

UNIT-5: Connectedness: Connected spaces, path connected spaces; various counter examples, Connected subspaces of Real line, Components and path components; locally connected and locally path connected spaces, totally disconnected spaces.

UNIT-6: Compactness: Converging properties, Lindelof spaces, Basic properties of Lindeloff compact spaces, Compact subspaces of the real line, Extreme value theorem, Uniform continuity theorem, Countable compactness; Sequential compactness, limit point compactness; Bolzano-Weierstrass property, Compactness in metric spaces; Tychnoffs theorem.

References:

1. *A First Course in Topology*: ISBN-81-203-2046-8 : J.R. Munkres
2. *Topology* : J. Dugundji
3. *General Topology* : S. Willard
3. *Algebraic Topology, A First Course* : M.J. Greenberg.

Paper-MSM 3.3: NUMERICAL ANALYSIS-I (Max marks: 100=75+25. Credits: 04)

UNIT-1: Solutions of Linear System of Equations: Introduction to Direct Methods via., Gauss Elimination method, Gauss-Jordan method, LU factorization, Triangularisation method, Iteration Methods: Gauss Jordan methods, Gauss-Seidel method, Successive Over relaxation method, Convergence Criteria, and problems on each methods.

UNIT-2: Solutions of Nonlinear/Transcendental Equations: Fixed point iteration, Method of Falsi position, Newton Raphson Method, Secant method, Regula-Falsi Method, Muller's Method, Aitken's Δ^2 method, Orders of convergence of each methods. Problems on each methods. Origin of roots by Sturm Sequences. Extraction of quadratic polynomial by Bairstow's method.

UNIT-3: Eigenvalues and Eigenvectors of a Matrix: The characteristics of a polynomial, The eigenvalues and eigenvectors of matrix by Jocobi's method, Given's method, House holders method, power method, Inverse Power method, QR Algorithm.

UNIT-4: Interpolation Theory: Polynomial interpolation theory, Gregory Newtons forward, back ward and Central difference interpolation polynomial. Lagranges interpolation polynomial, truncation error. Hermite interpolation polynomial, Inverse interpolation, Piece wise polynomial interpolation, Trigonometric interpolation, Convergence Analysis,

UNIT-5: Approximation Theory: Introduction, Spline approximation, Cubic splines, Best approximation property, Least square approximation for both discrete data and for continuous functions, Reme's single and multiple exchange algorithm. Problems on each.

References:

1. *A First Course in Numerical Analysis* : A. Ralston
2. *Numerical Analysis & Computation* : E.K. Blum
3. *Elements of Numerical Analysis* : P. Henrici
4. *Introduction to Numerical Analysis* : F.R. Hindebrand
5. *Principles & Procedures of Numerical Analysis* : F. Szidarovszky& S. Yakowitz.

Paper-MSM-3.4: RIEMANNIAN GEOMETRY

(Max marks: 100=75+25. Credits: 04)

UNIT-1: Introduction to Manifolds: Preliminary comments on R^n, R^n and Euclidean space, Toplogical Manifolds with examples. Further examples of Manifolds: Cutting and pasting. Abstrac Manifold some examples.

UNIT-2: Differentiable Manifolds: Definition of Differentiable Manifolds, Examples of Differentiable Manifolds, Differentiable (smooth) functions, Local coordinate system, Differentiable Mappings, Tangent vectors and Tangent spaces, vector fields, Jacobian of derivative map. Lie bracket. Immersion and Imbedding of Manifolds, submanifolds.

UNIT-3: Riemannian Manifolds: Riemannian metric, Riemannian manifold and maps, Riemannian manifold as metric space, Groups and Riemannian manifolds, Local representation of metrics. Connections, the connections in local coordinates, Riemannian connections.

UNIT-4: Curvature: Curvature, fundamental curvature equations: Gauss and CodazziMainardi Equations; Tangential curvature equation, Normal or Mixed curvature equations, some Tensor concepts, Riemannian curvature, Riemannian Christoffel curvature tensors and sectional curvature. Fundamental theorem of Riemannian Geometry.

UNIT-5: Hypersurface: Gauss Map, Weingarten map, Existence of Hypersurface, Fundamental theorem of Hypersurface theory and Gauss Bonnet Theorem.

UNIT-6: Geodesics: Geodesics, Metric structure of Riemannian Manifold, Gauss Lemma. Why short Geodesics are segments?

References:

1. *An introduction to Differential Geometry* : Barret O'Neil.
2. *An Introduction to Differential Manifolds* : N.J. Hicks
3. *An Introduction to Differential Manifolds* : Y. Matsushima
4. *An Introduction to Differential Manifolds* : Nirmala Prakash
5. *Differential Manifolds and Reimannian Geometry* :W.M.Boothby.
6. Riemannian Geometry : Peter Petersen.

Paper-MSM 3.5: FLUID MECHANICS

(Max marks: 100=75+25. Credits: 04)

UNIT-1: Motion of Inviscid Fluids: Pressure at a point in a fluid at rest and that in motion, Euler's equation on motion, Barotropic flows, Bernoullis equations in standard forms, Illustrative examples thereon, Vortex motion, Circulation, Kelvin's circulation theorem, Helmhotz Vorticity equation, Performance in Vorticity and Circulation, Kelvin's Minimum Energy Theorem, Illustrative examples.

UNIT-2: Two Dimensional Flows of Inviscid Fluids: Meaning of two dimensional flows and Examples, Stream function, Complex potential, Line Sources and Line Sinks, Line Doublets and Line Vortices, Milne Thomson circle theorem and Applications, Blasius theorem and Applications.

UNIT-3: Motion of Viscous Fluids: Stress tensor of viscous fluid flow, Stoke's law, Navierstoke's equation, Simple exact solutions of the Navier-Stoke's equation, Standard applications, **i)** Plane Poiseuille and Hagen Poiscuileflows **ii)**Couette flow **iii)** Steady flow between concentric cylinders **iv)** Beltrami flows **v)** Unsteady flow near an oscillating plate **vi)** Slow and steady flow past a rigid sphere and cylinder. Diffusion of Vorticity, Energy dissipation due to Viscosity, Dimensional analysis (Brief discussion), Reynolds number, Laminar and Turbulent flows, Examples of flow at low and high Reynolds number, Brief discussion of boundary layer theory with illustrative examples.

UNIT-4: Gas Dynamics: Compressible fluid flows, Standard forms of equations of State,Speed of sound in a gas, Equations of motion of Non-Viscous and Viscous Compressible flows, Subsonic, Sonic and supersonic flows, Isentropic flows, Gas Dynamical Equations, Illustrative examples.

References:

1. *Fluid Dynamics* : F. Chorlton
2. *Theoretical Hydrodynamics* : L.M. Milne-Thomson
3. *Foundations of Fluid Mechanics* : S.W. Yuan
4. *Continuum Mechanics* : D.S. Chandrashekharaiah&L.Debnath.

Paper-MSM 3.6: LAB: NUMERICAL METHODS (Max marks: 50. Credits: 02)

List of programs:

1. Program to solve system of equations using Gauss Elimination Method.
2. Program to find inverse of the matrix using Gauss Jordan Method.
3. Program to find solution of system of equations using Jacobi Iterative Method.
4. Program to find solution of system of equations using Gauss Seidal Method.
5. Program to find real root of a polynomial using fixed point iterative method.
6. Program to find real root of a polynomial using Newton Raphson Method.
7. Program to find real root of a polynomial using Secant Method.
8. Program to find the value of function using Newton Forward Difference Method and Newton Backward Difference Method.
9. Program to find the value of the function using Lagrange interpolation method.
10. Program to find the largest eigenvalue and eigenvector of the matrix by using Power Method.
11. Program to find the smallest eigenvalue and eigenvector of the matrix using inverse power method.
12. Program to find the value of a function by using Hermite interpolation method.
13. Program to find the polynomial by using Least square approximation Method.
14. Program to find the tri-diagonal matrix using House holder's method.

Paper-MSM 3.7: Elective: STATISTICAL TECHNIQUES

(Max marks: 50=40+10. Credits: 02)

UNIT-1: Collection and Presentation of Data: Primary and Secondary data, Primary methods of data collection, Drafting Questions and Questionnaires, Source of Secondary Data. General rules for constructing diagrams, one dimensional diagram, two dimensional diagrams, Pictograms and Cartograms.

UNIT-2: Measure of Central Tendency: Arithmetic mean, Median, Mode, Geometric mean and Harmonic mean, Merits and demerits.

UNIT-3: Measure of Variation: Introduction, mean deviation, Standard deviation, merits and limitations.

UNIT-4: Correlation Analysis: Types of Correlation, methods of studying correlation, Karl Person's co-efficient of correlation, Rank correlation co-efficient, methods of least squares.

UNIT-5: Regression Analysis: Introduction, Regression lines, Regression equations of Y on X, Regression Co-efficient.

UNIT-6: Probability: Random experiment, Sample space and events, Axioms of probability, Conditional probability and independence, Addition, Multiplication and Baye's theorem.

References:

1.Business Statistics : S.P. Gupta and M.P. Gupta

2. An Introduction to Statistical methods : C.B. Gupta

FOURTH SEMESTER

Paper-MSM 4.1: FUNCTIONAL ANALYSIS

(Max marks: 100=75+25. Credits: 04)

UNIT-1: Normed linear spaces and Banach Spaces: Normed linear spaces, Banach spaces, definition with examples, quotient spaces, Bounded linear transformation. equivalent form of continuity and boundedness.

UNIT-2: Isometric isomorphism: Topological isomorphism, operators, equivalent norms, Reisz lemma.

UNIT-3: Functional conjugate spaces: Functional, conjugate space, extension of functional, Hahn-Banach theorem and its consequences, natural imbedding, induced functional, open mapping theorem, closed graph theorem, Uniform boundedness principle.

UNIT-4: Hilbert spaces: Definition and examples, Inner product, Schwarz inequality, parallelogram law and polarization identity, orthogonal complements, Pythagorean theorem, Orthonormal sets, Bessel's inequality.

UNIT-5: Conjugate Space H^*: Reisz representation theorem. The adjoint of an operator, self-adjoint operators, normal and unitary operators,

UNIT-6: Projections: Range space and null space, perpendicular projections, finite dimensional spectral theory.

References:

1. *Introduction to Topology & Modern Analysis* : G.F. Simmons
2. *First Course in Functional Analysis* : Goffman & Pedrick 3.
   Introduction to Functional Analysis : A.E. Taylor & D.C. Lay
4. *Functional Analysis* : Walter Rudin.

Paper-MSM 4.2: TOPOLOGY-II

(Max marks: 100=75+25. Credits: 04)

UNIT-1: Countablity and Separation axioms: First and second countable spaces, sperable and Lindeloff spaces and examples. T_0, $T_1$and T_2 spaces, Hausdorff, Regular and completely regular spaces, normal and completely normal spaces; Complete and collection wise normal spaces; The countability axioms, Local compactness.

UNIT-2: Uryshon's Theorem: Uryshon's lemma, Tietze's extension theorem, Uryshon's metrization theorem.

UNIT-3: Tychonoff Theorem: Tychonoff theorem, the Stone- Cech compactification: compactification, equivalence.

UNIT-4: Paracompactness: Local finiteness, refinement, Nagata-Smirnov metrization theorem, paracampactness and paracompact spaces.

UNIT-5: Homotopy: Homotopy, product of path homotopy, the fundamental Group, simply connected spaces.

UNIT-6: Covering Space: Slices, covering map, local homeomorphism, the fundamental group of circles, lifting.

References:

1. *Topology* (2nd Edition) : J.R. Munkres
2. *Algebraic Topology* : M.J. Greenberg and J. Harper 3.
   Algebraic Topology: An Introduction : W.S. Massey.

Paper-MSM 4.3: NUMERICAL ANALYSIS-II

(Max marks: 100=75+25. Credits: 03)

UNIT-I: Numerical Differentiation and Integration: Introduction, errors in numerical differentiation, Extrapolation methods, cubic spline method, differentiation formulae with function values, maximum and minimum values of a tabulated function, partial differentiation. Numerical Integration, Newton-Cotes integration methods;

Trapezoidal rule, Simpson's 1/3rd rule, Simpson's 3/8th rule and Weddle's rule. Gaussian integration methods and their error analysis. Gauss-Legendre,

GaussHermite, Gauss-Legurre and Gauss-Chebyshev integration methods and their error analysis. Romberg integration, Double integration.

UNIT-2: Numerical Solutions of Initial Value Problems (Ordinary Differential Equations): Introduction**,** Derivation of Taylor's series method**,** Euler's method, Modified Euler Method, Runge-Kutta Second, Third and Forth order methods, Runge-Kutta-Gill method, Predictor-Corrector methods; Milne's method, Adam's Bashforth Moulton method.

UNIT-3: Solutions of Boundary Value Problems (Ordinary Differential Equations): Introduction, Solution of boundary value problems method of undetermined coefficients, Finite difference methods, Shooting Method, and Midpoint method.

UNIT-4: Numerical Solutions of Partial Differential Equations: Introduction, Derivation of finite difference approximations to the derivatives, Solution of Laplace equation by Jacobi, Gauss Seidel and SOR Methods, ADI Method, Parabolic, Solution of heat equation by Schmidt and Crank-Nicolson Methods, Solution of wave equation using Finite difference method.

UNIT-5: Numerical Solutions of Integral Equations: Introduction, Numerical methods for Fredholm equations; method of degenerate kernel's, method of successive approximations, quadrature methods, Cubic spline method.

References:

1. *A First Course in Numerical Analysis* : A. Ralston
2. *Numerical Analysis & Computation* : E.K. Blum
3. *Elements of Numerical Analysis* : P. Henrici
4. *Introduction to Numerical Analysis* : F.R. Hindebrand
5. *Principles & Procedures of Numerical Analysis* : F. Szidarovszky & S. Yakowitz.

Paper- MSM 4.4: TENSOR ANALYSIS AND RELATIVITY THEORY

(Max marks: 100=75+25. Credits: 03)

UNIT – 1: Vectors and Tensors

Einstein summation convention, Transformations of co-ordinates, Dummy indices, Free indices, Contravariant vectors, Scalar invariants, Covariant vectors, Tensors of the second order, Tensors of any order, Symmetric and skew symmetric tensors, Addition and multiplication of tensors, Contraction.

UNIT – 2: Connection and Curvature

Riemannian metric, Parallel transport and Geodesic, Christoffel symbols, Covariant differentiation of contravariant and covariant vectors, Covariant differentiation of tensors, Gradient of a scalar, Divergence of a vector, Curl of a vector.

UNIT – 3: Riemann curvature

Riemann curvature tensor, Properties of curvature tensor, Bianchi identities, Ricci tensor, Scalar curvature, Einstein tensor, Conformal curvature tensor, Conformal invariance, Exterior derivatives, Lie derivatives, Isometries and killing vector fields.

UNIT – 4: Space-time

Inertial and non-inertial frames, Inertial and gravitational mass, Special theory of relativity, Minkowski space, The interval between events, Lorentz geometry, General theory of relativity, Principle of equivalence, Principle of general covariance, Need for the Riemannian geometry, Weak field and Newtonian limit, Flat and curved space-time, Static and Stationary space-times, Energy-Momentum tensor.

UNIT – 5: Einstein's Field Equations

Gravity as space-time curvature, Geodesics, Einstein's field equations, Vacuum field equation, Heuristic approach to derive field equations, Solutions of Einstein equations, The Schwarzschild solution, Birkhoff's theorem, Interior Schwarzschild solution, Singularities in Schwarzschild line element, Einstein's field equations with a cosmological constant, Schwarzschild-de Sitter solution, Reissner-Nordstrom solution, Vaidya metric, The Kerr solution.

UNIT – 6: Symmetric Spaces

Homogeneous and isotropic spaces, Maximally symmetric spaces, Tensors in a maximally symmetric space, Spherically symmetric space, Spherically symmetric space-time, Spherically symmetric homogeneous space-time.

References:

1. *Differential Geometry and Relativity Theory, An Introduction* : Richard L. Faber
2. *Gravitation and Cosmology: Principles and Applications of the General Theory of Relativity Operations Research* : Steven Weinberg

3. *The Classical Theory of Fields* : L. D. Landau and E. M. Lifshitz
4. *Space-time, Geometry and Gravitation* : Pankaj Sharan
5. *General Relativity and Cosmology* : S. K. Srivastava
6. *Differential Geometry and Tensors* : K. K. Dube
7. *Tensor Calculus (2nd Edition)* : U. C. De, A. A. Shaikh and Joydeep Sengupta
8. *Fundamentals of Special and General Relativity* : K. D. Krori

Paper-MSM 4.5A: FINSLER GEOMETRY AND RELATIVITY

(Max marks: 100=75+25. Credits: 03)

Unit 1: Tensor analysis: Introduction, definitions, dummy index and free index, contravariant and covariant tensors, mixed tensors, symmetric and skew-symmetric tensors.

Unit 2: Riemannian space fundamental tensor, Christoffel symbols, covariant derivative, Riemannian-Chrisoffel tensor, Ricci tensor and scalar curvature, Einstein space and Einstein tensor.

Unit 3:Finsler metric function: Its properties, tangent space, Indicatrix, metric tensor and C – tensor, Homogeneity properties of g_{ij} and c_{ijk}, dual tangent space, geodesics, δ – differentiation, partial δ – differentiation, properties of partial δ – differentiation.

Unit 4: Finsler space: Finsler metrics, Geometric objects of Finsler space, Geodesics of the Finsler space, Geodesics spray and symmetric Finsler connections, (α, β) – metrics, special Finsler spaces.

Unit 5: **Introduction to general relativity:** principle of equivalence and principle of general covariance, difference between Newtonian and Einsteinian gravity, flat and curved space-time, Einstein's Field equations.

Unit 6: **Classical tests of general relativity:** Gravitational red shift, advance of perihelion during planetary motion, deflection of light rays near sun.

References:

1. Differential Geometry and Tensors : K. K. Dube
2. Tensor Calculus (2nd Edition) : U.C. De, A. A.Shaikh and Joydeep Sengupta

3. Differential geometry of Finsler spaces : H. Rund
4. The Theory of sprays and Finsler spaces with Applications in Physics and Biology : P.L Antonelli, Ingarden R.S & M. Matsumoto
5. General Relativity and Cosmology : S. K. Srivastava

Paper-MSM 4.5 B: CONTACT GEOMETRY

(Max marks: 100=75+25. Credits: 03)

Unit-1: Riemannian Manifolds: Review of basic concepts: Riemannian metric, Levi-civita connection, Koszul's formula, sectional, Ricci and scalar curvatures, space of constant curvature, Lie derivative and Killing vector fields, Weyl conformal curvature tensor.

Unit-2: Almost Contact Manifolds: Contact manifold, almost contact structure, almost contact metric structure, contact metric structure, φ-basis, covariant derivative of φ.

Unit-3: Normal almost contact structure: Nijenhuis torsion tensor, four tensors $N^{(1)}$, $N^{(2)}$, $N^{(3)}$, $N^{(4)}$; 3-dimensional Normal almost contact manifold, necessary and sufficient conditions for 3-dimensional almost contact metric manifold to be normal.

Unit-4: K-contact manifolds: Killing vector field, K-contact structure in terms of $\nabla_X\xi$, sectional curvature of plane section containing ξ, Ricci curvature in the direction of ξ, the tensor field h, curvature of contact manifolds.

Unit-5: Sasakian manifolds: Characterization of Sasakian manifold in terms of $\nabla_X\varphi$ and $R(X, Y)\xi$, Sasakian manifolds are K-contact, curvature of Sasakian manifolds, locally symmetric and η-parallel conditions on Sasakian 3-manifolds.

Unit-6: Kenmotsu manifolds: Lie derivative of g, φ and η along ξ, locally symmetric and Nomizu's condition, the study of η-Einstein manifold, curvature tensor, conformally flat Kenmusu manifold of dimension greater than 3.

References:

1. *Contact manifolds in Riemannian Geometry* : David E. Blair
2. *Riemannian Geometry of Contact and Symplectic Manifolds* : David E. Blair
3. *Structures on manifolds* : K. Yano, M. Kon
4. *Almost contact metric manifolds* : R. S. Mishra
5. *Complex manifolds and contact manifolds* : U. C. De, A. A. Shaikh

Paper-MSM 4.5 C: MAGNETOHYDRODYNAMICS

(Max marks: 100=75+25. Credits: 03)

UNIT-1: Electrodynamics: Outline of electromagnetic units and Electrostatics, Derivations of Gauss Law, Faraday's Law, Ampere's Law and Solenoidal property, Dielectric material, Conservation of charges, Electromagnetic boundary conditions.

UNIT-2: Basic Equations: Outline of Basic equations of MHD, Magnetic Induction equation, Lorentz force, MHD approximations, Non-dimensional numbers, Velocity, Temperature and Magnetic field boundary conditions.

UNIT-3: Exact Solutions: Hartmann flow, isothermal boundary conditions, Temperature distribution in Hartmann flow, Hartmann-Couette flow.

UNIT-4: Applications: Concepts in Magnetostatics, Classical MHD and Alfven waves, Alfven theorem, Frozen-n-phenomena and equipartition of energy by Alfven waves.

References:

1. *An Introduction to Magnetofluid Mechanics* : V.C.A. Ferraro and Plumpton.
2. *An Introduction to Magnetohydrodynamics* : P.H. Roberts
3. *Magnetohydrodynamics* : Allen Jeffrey.

Paper-MSM 4.5 D: GRAPH THEORY

(Max marks: 100=75+25. Credits: 03)

UNIT-1: Introduction to Graph: Basic concept, Different types of graphs, walks and connectedness. Degree sequences, directed graphs, distances and self-complementary graphs.

UNIT-2: Factorization: 1-factorization, 2-factorization, decomposition and labelling of graphs,

UNIT-3: Coverings: Vertex covering, edge covering, independence number and matchings and matching polynomials.

UNIT-4: Planarity: Planar graphs, outer planar graphs, Kuratowaski criterion for planarity and Eulers polyhedron formula.

UNIT-5: Graph valued functions: Line graphs, subdivision graph and total graphs.

UNIT-6: Colourings: Chromatic numbers and chromatic polynomials.

UNIT-7: Spectra of Graphs: Adjacency matrix, incidence matrix, characteristic polynomials, Eigen values, graph parameters, strongly regular graphs and Friendship Theorem.

UNIT-8: Groups and Graphs: Automorphism group of a graph, operations on permutation graphs, the group of a composite graph.

References:

1. *Graphs and Digraphs* : M. Bejzad, G. Charatrand and L. Leniak-foster.
2. *Graph Theory* : F. Harary.
3. *Graph Theory and Applications*: J. A. Bonday and V. S.R. Murthy.
4. *Graph Theory* : Diestel.
5. *Graph Theory* : R Gould.
6. *Graph Theory with Applications to Engineering and Computer Science* : NaraisingDeo.
7. *Distance in Graphs* : F. Buckley and F. Harary.
8. *Theory of Graphs* : O.Ore 9. *Spectra in Graphs* :D. Cvetkovic.

Paper-MSM 4.6: LAB: NUMERICAL METHODS

(Max marks: 50. Credits: 02)

List of programs:

1. Program to evaluate the given integral using Trapezoidal rule/ Simpson's 1/3 rule/Simpson's 3/8 rule.
2. Program to solve initial value problem using Euler Method/ Euler Modified Method.
3. Program to evaluate double integration.
4. Program to find integral of a function by using Gauss-Legendre/Gauss-Chebyshev/Gauss-Hermite integration method.
5. Program to solve Boundary value problem using Shooting method.
6. Program to solve differential equation by Finite difference method.
7. Program to find solution of initial value problem using Runge Kutta IV order Method.
8. Program to find solution of initial value problem using Predictor-Corrector method (Milne's/Adam's method).

9. Program to find the numerical solution of Laplace equation by Gauss-Seidel method.
10. Program to find the numerical solution of Heat equation by Schmidt method.
11. Program to find the numerical solution of Heat equation by Crank-Nicolson method.
12. Program to find the numerical solution of wave equation using Finite difference method.

PROJECT

Paper-MSM 4.5: PROJECT WORK

(Max marks: 100=75+25. Credits: 04)

Dissertation-75 + Viva-Voce-25.

Question paper pattern

1. Set any 8 questions (each question may contain sub questions) on the respective paper according to unit order.
2. Each question carries 15 marks.
3. Answer any 5 full questions.

Question pattern of elective paper

1. Set any 8 questions (each question may contain sub questions) on the respective paper according to unit order.
2. Each question carries 8 marks.
3. Answer any 5 full questions.

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