M.G.S. UNIVERSITY,

BIKANER

Curriculum and Courses of Study For PG

M.A./M.Sc. (MATHEMATICS) 2024-2026

SEMESTER SCHEME

1. **M.A./M. Sc. Semester I**
2. **M.A./ M. Sc. Semester II**
3. **M.A./M. Sc. Semester III**
4. **M.A./ M. Sc. Semester IV**

M.G.S. UNIVERSITY,

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Curriculum and Courses of Study

M.A/M.Sc. (MATHEMATICS) 2024-2026

Program Outcomes (PO)

On completing Master in Faculty of Science, the students shall be able to realize the following outcomes:

PO	Description
PO1	Develop ethical, moral and social values to make good human being for society.
PO2	Understand scientific thought for all aspect in social life.
PO3	Develop the problem solving thinking with scientific knowledge.
PO4	Demonstrate highest standards of Actuarial ethical conduct and Professional Actuarial behavior, critical, interpersonal and communication skills as well as a commitment to life-long learning.
PO5	Developed various communication skills such as reading, listening, speaking, etc., which will help express ideas and views clearly and effectively.
PO6	Develop entrepreneurship skill.

Program Specific Outcomes (PSO)

On completing M.Sc. in Mathematics, the students shall be able to realize the following outcomes:

PSO	Description
PSO1	Be competent to success in various national exams as NET-JRF, GATE, NBHM etc. for higher education.
PSO2	Have a strong foundation in core areas of Mathematics, both pure and applied.
PSO3	Provide advanced knowledge on topics in pure mathematics, empowering the students to pursue higher degrees and apart from the research jobs, students can also work or get jobs in marketing, business & other technical fields.
PSO4	Use their knowledge to start new dimension in the interdisciplinary field of research or teaching.
PSO5	Communicate mathematical ideas with clarity and coherence, both written and verbally. Imbibe effective scientific and/or technical communication in both oral and writing.
PSO6	Continue to acquire relevant knowledge and skills appropriate to professional activities and demonstrate highest standards of ethical issues in mathematical sciences.

SEMESTER I

SEMESTER SCHEME

Course code	Course Title	Lectures per week	Credits	Max. Marks		Min. Pass Marks
				Internal	External	
I	Advanced Abstract Algebra	6	6	10	50	15(25%)
II	Advanced Complex Analysis	6	6	10	50	15(25%)
III	Tensor Analysis	6	6	10	50	15(25%)
IV	Calculus of Variation and Special Functions-I	6	6	10	50	15(25%)
V	Numerical Methods – I	6	6	10	50	15(25%)
	Total Credits for Semester I - 30					

Scheme of examination **:**

Five Theory Papers **Max. Marks 300**

Paper-I : **3 hrs. duration** **50+10(Int) marks**

Paper-II : **3 hrs. duration** **50+10(Int) marks**

Paper-III: **3 hrs. duration** **50+10(Int) marks**

paper-IV : **3 hrs. duration** **50+10(Int) marks**

paper-V : **3 hrs. duration** **50+10(Int) marks**

DETAILED SYLLABUS

PAPER I

ADVANCED ABSTRACT ALGEBRA

Unit I

Homomorphism theorems on groups, conjugate elements. Classes and class equation of a finite group, Sylow Theorem, p - Sylow subgroup, structure theorem for finite abelian groups. Normal and subnormal series, Composition series, Jordan-Holder Theorem, Solvable group, Nilpotent groups.

Unit II

Euclidean and polynomial rings, Polynomials over rational fields. The Eisenstein criterion, Polynomial rings over commutative ring, unique factorization domain, Chain condition and rings.

Unit III

Modules, generators and relations, structure theorem for modules of Euclidean domains/PIDs.

Books Recommended for Reference :

1. Maclane and Birkoff : Algebra, Macmillan & Co.
2. I.N. Herstein : Topics in Algebra, Wiley Eastern India Ltd.
3. I.S. Luthar and B.S. Passi, : Algebra Vol-I Groups, Vol-II Rings, Narosa Publishing House.
4. Gokhroo et.al. : Advanced Abstract Algebra, Navkar Prakashan, Ajmer
5. Bhattacharya, P.B. etc. : Basic Abstract Algebra (II ed.) Camb. Univ. Press India, 1997
6. P.M. Cohn : Algebra vol I,II & III, John Wiley & Sons, 1982-89, 91
7. Vivek Sahai & Vikas Bist : Algebra, Narosa Publishing, 1999
8. Gopal Krishanan, N.S.(II ed.) :University Algebra, New Age International Publication,
9. B.S. Vatssa : Modern Algebra, 1999 New Age International Publication.

PAPER II

ADVANCED COMPLEX ANALYSIS

Unit I

Analytic functions, Cauchy-Reimann equations and it's properties. Complex line and contour integrals , Cauchy Theorem for an analytic function, Cauchy's integral formula and it's properties, Morera's Theorem ,Taylor's and Laurent's series, Lioville's Theorem, Maximum modulus principle , Schwarz Lemma**.**

Unit II

Zeros and Singularities, Branch points, Reimann Theorem on removable Singularity, open mapping Theorem, Casoratti-Weirstrass Theorem, Residue at a pole, Residue at infinity, Cauchy‘s

Residues theorem, Evaluation of Integrals**.**

Unit III

Meromorphic functions, Argument principle, Rouche’s Theorem, Analytic continuation, Complete analytic function,

Uniqueness of analytic continuation,

Analytic continuation by means of power series, Singularities of a power series on its circle of convergence, Schwarz's reflection principle.

Books recommended for Reference:

1. S. Ponnusamy : Foundation of Complex Analysis, Narosa Publishing House, New Delhi
2. Shanti Narain : Complex Analysis, S.Chand & Co., New Delhi
3. R.V. Churchil & J.W. Brown : Complex Variables and Applications, McGraw-Hill.
4. L.V. Ahlfords : Complex Analysis, McGraw Hill Co., 1979
5. Gokhroo et.al : Complex Analysis, Navkar Prakashan, Ajmer
6. K.P. Gupta : Complex Analysis, Krishana Prakashan Mandir, Meerut.
7. B. Choudhary : Complex Analysis, Wiley Eastern Ltd. New Delhi.
8. Purohit and Goel : Complex Analysis, Jaipur Publishing House, Jaipur.
9. S.K. Sharma etc. : Complex Analytic Functions Theory and Applications, New Age International Publishers.

PAPER III

TENSOR ANALYSIS

Unit I

Transformation of Coordinates, Covarient, Contravarient and mixed tensor, Invariants, Addition, subtraction and multiplication of tensors. Contractions of tensors, Quotient Law of tensors. Fundamental Tensors, Length of Curve, Associated tensors.

Unit II

Christoffel symbols, Covariant Differentiation of tensors, Laws of covariant differentiation, Geodesics, Null Geodesics, Geodesics Co-ordinates Parallelism, Covarient derivatives.

Unit III

Reimann-christroffel tensor, curvature tensor, Ricci tensor, Bianchi Reimann curvature, Flat space, space of constant curvature.

Commented [RM1]:

Covariant and intrinsic derivatives, Curvature tensor and its properties, Curl, Divergence and Laplacian operators in tensor form, Physical components.

Books Recommended for Reference :

1.Berry Spain : Tensor Calculus

2.Bansal J.L. : Tensor Calculus, Jaipur Publishing House, Jaipur.

3.Raj Bali : Tensor Calculus, Navkar Prakashan, Ajmer

4.Goodbody, A M : Cartesian Tensor

PAPER IV

CALCULUS OF VARIATION AND SPECIAL FUNCTIONS-I

Unit I

Functionals, Variation of a functional and its properties, Variational problems with fixed boundaries, Euler's equation, Extremals, Functional dependent on several unknown functions and their first order derivatives.Functionals dependent on higher order derivatives,

Unit II

Functionals dependent on the fuction of more than one independent variable. Variatonal problems in parametric form. Applications of Calculus of variations

Unit III

Series solution of Gauss hypergeometric equation, Gauss hypergeometric function and its properties, integral representation, contiguous function relations, Kummer's Confluent Hypergeometric Functions.

Legendre's polynomial, generating function, recurrence relations, orthogonal properties, Beltrami's result, Legendre function of first and second kind, Associated Legendre's functions.

Books Recommended for Reference :

1. Rainville E.D. : Special Functions chapter : 1, 6, 8, 11 & 12

2. Slater L.J. : Confluent Hypergeometric Functions, Cambridge University Press. 1966

3. L.J. Slater : Generalized Hypergeometric Functions, Cambridge University Press, 1966

4. Gokhroo et.al : Special Functions, Navkar Prakashan, Ajmer

5. Saran et al; : Speical Functions, Pragati Prakashan, Meerut

6. Gokhroo et.al : Calculus of Variations, Navkar Prakashan, Ajmer

PAPER V

NUMERICAL METHODS – I

Unit I

Iterative methods : Simple iteration, theory of iteration, acceleration of convergence, methods for multiple and complex roots, Newton Raphson method, convergence of iteration process in the case of several unknowns.

Unit II

Solution of polynomial equations, polynomial evaluation, real and complex roots, synthetic division, the Birge-Vieta, Baristow and Graffe's root squaring methods, system of simultaneous equation (Linear) –direct methods –Methods of determination

Unit III

Solution of simultaneous equations : Gauss elimination, Gauss Jordan, Cholesky, Partition methods of successive, approximate –conjugate Gracient, Gauss and Jacobi iteration, Gauss Seidal iteration & Relaxation methods. Eigen value problem, basic properties of eigen values and eigen vectors, power methods for finding all eigen pairs of a matrix, complex eigen values.

Books Recommended for Reference :

1. Jain, Iyengar & Jain : Numerical Analysis
2. Jain M.K. : Numerical Solution of differential equations
3. Gokhroo et. al. : Advanced Numerical Methods, Navkar Prakashan, AJMER

SEMESTER II

SEMESTER SCHEME

Course code	**Course Title**	**Lectures per week**	**Credits**	**Max. Marks**		**Min. Pass Marks**
				Internal	**External**	
I	Advanced Linear Algebra	6	6	10	50	15(25%)
II	Measure Theory and Integration	6	6	10	50	15(25%)
III	Integral Transforms	6	6	10	50	15(25%)
IV	Special Functions-II	6	6	10	50	15(25%)
V	Numerical Methods -II	6	6	10	50	15(25%)
	Total Credits for Semester II - 30					

***Scheme of examination* :**

Five Theory Papers		**Max. Marks 300**
Paper-I :	**3 hrs. duration**	**50+10(Int) Marks**
Paper-II :	**3 hrs. duration**	**50+10(Int) Marks**
Paper-III:	**3 hrs. duration**	**50+10(Int) Marks**
paper-IV :	**3 hrs. duration**	**50+10(Int) Marks**
paper-V :	**3 hrs. duration**	**50+10(Int) Marks**

PAPER I

ADVANCED LINEAR ALGEBRA

Unit I

Vector space of a linear transformation, Matrix representation of a linear transformation, Change of Basis, Similarity, Eigen value and eigenvectors for a linear operator, Cayley-Hamilton theorem,

Unit II

Diagonalization, Minimal Polynomial and equation. Linear functionals, Dual and bidual of a vector space and their properties, Annhilators, Invariance, projections and its properties, Adjoints of a linear transformation and its properties, Bilinear quadratic and hermitian forms, Inner product spaces, Cauchy- Schwarz inequality.

Unit III

Orthogonal vectors, orthogonal complements, ortho-normal sets and bases, Bessel's inequality for finite dimensional spaces, Gram-Schmidt orthogonalization process.

Books Recommended for Reference :

1. Hofman and Kunz. : Linear Algebra, Prentice Hall of India.
2. K.B. Datta : Matrix and Linear Algebra, Prentice Hall of India Pvt. Ltd., New Delhi.
3. Gokhroo et.al : Advanced Linear Algebra, Navkar Prakashan, Ajmer
4. Purohit, Pareek, Sharma, : Linear Algebra, Jaipur Publishing House
5. P.M. Cohn : Algebra vol I,II & III, John Wiley & Sons, 1982-89, 91
6. Gopal Krishanan, N.S. (II ed.): University Algebra New Age International Publication
7. Gopal Krishanan,N.S:University Algebra through 600 problems New Age International Publicaton
8. B.S. Vatssa : Modern Algebra, 1999 New Age International Publication, (1999)

PAPER II

MEASURE THEORY AND INTEGRATION

Unit I

Countable sets. Outer measure of a set and its properties. Measurable sets. Lebesgue measure, a non-measurable set. Measurable functions and their properties.

Unit II

Convergence of sequence of measurable functions. Concept of almost everywhere. Littlewood's three principles. Lebesgue integral of measurable functions, Lebesgue theorem on the passage to the limit under the integral sign.

Unit III

Summable functions, the space of square summable functions, function of finite variation, stieltjes integral, the indefinite lebesgue integral.

Books Recommended for Reference :

1. T.M. Apostal : Mathematical Analysis, Narosa Publishing House, New Delhi (1985)

2. P.K. Jain and V.P. Gupta: Lebesgue Measure and Integration, New Age International Pub. Ltd., New Delhi (Reprint 2000)

3. G.N. Purohit : Lebesgue Measure and Integration, Jaipur Publishing House, Jaipur

4. T.S. Nahar : Measure Theory, Navkar Publications, Ajmer.

5. Indra Kumar Rana : An Introduction to Measure and Integration,
Narosa Publishing House, New Delhi (1997)
6.G-de Barra, Gupta : Measure Theory and Integration, Wiley Eastern Ltd. 1981

PAPER III

INTEGRAL TRANSFORMS

Unit I

Laplace Transforms : Definition and properties, Rules of manipulation: Laplace Transform of derivatives. Inverse Laplace Transform, Convolution theorem , Complex inversion formula. Application of Laplace Transform for the solution of ordinary differential equations with constant coefficients and with variable coefficient, Simultaneous ordinary differential equations. Partial differential equations, Integral and difference equations,

Unit II

Fourier Transform : Fourier Sine and Cosine transform, Inverse Fourier Transform convolution Theorem. Fourier transform of derivatives. Application of Fourier Transform in the solution of boundary value problems. Application to the solution of partial differential equations,

Unit III

Hankel Transform : Definition and Elementary properties: Inverse theorem Hankel Transform of derivatives. Parsesals Theorem. Mellin Transform :Properties and integrals. Application of Hankel Transform in the solution of boundary value problems.

Books Recommended for Reference :

1. Sneddon.I.N : The use of integral Transforms, Mcgraw Hill Co., 1966
2. Spegal M.R : Theory and problems of Laplace transform, Schaum Series,TMH
3. Gokhroo et. al. : Integral Transform, Navkar Prakashan, Ajmer.
4. Vasishtha et. al. : Integral Transforms, Krishna Prakashan Mandir, Meerut
5. M.D. Raisingania : Integral Transforms, Kedar Nath Ram Nath, Meerut.

Paper IV

SPECIAL FUNCTIONS-II

Unit I

Bessel's differential equation and its solution, Bessel's functions. Recurrence relations. Orthogonal properties. Rodrigue's formula, modified Bessel function. Integral representation of Bessel's function.

Unit II

Hermite Polynomial, their generating function and general integral properties, recurrence formulae, Rodrigue's formula, orthogonality. Lagurre polynomials and functions, their generating function and general integral properties. Rodrigue's formula, orthogonal expansion of polynomials.

Unit III

Jacobi Polynomial, Generating Function, Rodrigues formula, orthogonality of Jacobi Polynomial, Chebyshev Polynomial, Generating Function of Chebysheve Polynomial, Orthogonal Properties of Chebyshev Polynomial.

Books Recommended for Reference :

1. Rainville E.D. : Special Functions chapter : 1, 6, 8, 11 & 12
2. Gokhroo et.al : Special Functions, Navkar Prakashan, Ajmer
3. Saran et al; : Speical Functions, Pragati Prakashan, Meerut

Paper V

Numerical Methods II

Unit I

Curve fitting and function approximation, least square error criterion, linear regression, polynomial fitting and other curve fitting, approximation of functions by Taylor series and Chebyshev polynomials.

Unit II

Numerical solution of ordinary differential equations, Taylor series methods, Euler's and modified Euler's method, Runge-Kutta method upto fourth order, multi step method (Predictor -Corrector Strategies).

Unit III

Stability analysis -single and multi step methods, Difference methods for Boundary value problems, ordinary differential equations, boundary value problems, shooting methods. Finite difference methods, difference scheme for non linear boundary value problems of the certain type with the given initial conditions..

Books Recommended for Reference :

1. Jain, Iyengar & Jain : Numerical Analysis
2. Jain M.K. : Numerical Solution of differential equations
3. Gokhroo et. al.: Advanced Numerical Methods, Navkar Prakashan, AJMER

SEMESTER III

SEMESTER SCHEME

Course code	Course Title	Lectures per week	Credits	Max. Marks		Min.Pass Marks
				Internal	External	
CORE COMPULSORY						
I	Differential Equations	6	6	10	50	15(25%)
II	General Topology	6	6	10	50	15(25%)
CORE ELECTIVE (Any2)						
I	Relativistic mechanics	6	6	10	50	15(25%)
II	Dynamics of Rigid Bodies – I	6	6	10	50	15(25%)
III Anyone of (a) and (b)	a)Hydro Dynamics	6	6	10	50	15(25%)
	b)Continuum Mechanics– I	6	6	10	50	15(25%)
IV	Operations Research	6	6	10	50	15(25%)
V	Programming in C++	6	6 (4Th+ 2Pra)	10	50 (35Th+ 15Pra)	11(25%)Th 4 (25%)Pra
VI	Generalized Hypergeometric Function	6	6	10	50	15(25%)
VII	Discrete Mathematics	6	6	10	50	15(25%)
OPEN ELECTIVE (Any1)						
I	Mathematical modelling– I	6/5	6(5 for students of other subjects)	10	50 (40 for students of other subjects)	13(25%)
II	Mathematical Statistics – I	6/5	6(5 for students of other subjects)	10	50 (40 for students of other subjects)	13(25%)
	Total Credits for Semester III		**30**			

Scheme of examination :

Five Theory Papers		**Max. Marks 300**
Paper-I : Core Compulsory	**3 hrs. duration**	**50+10(Int) Marks**
Paper-II : Core Compulsory	**3 hrs. duration**	**50+10(Int) Marks**
Paper-III: Core Elective	**3 hrs. duration**	**50+10(Int)Marks**
paper-IV : Core Elective	**3 hrs. duration**	**50+10(Int) Marks**
paper-V : Open Elective	**3 hrs. duration**	**50+10 (Int) Marks [40+10(Int) Marks for other subjects]**

CORE COMPULSORY

PAPER I

DIFFERENTIAL EQUATIONS

Unit I

Numerical Solutions of ordinary differential Equations, Euler's method, Picard's Method of Successive approximation, Picard's method for simultaneous equation, Taylor's series method, Runge Kutta Method, Two point Boundary value Problems, Pertubations Method.

Unit II

Existence and uniqueness of solution of dy/dx = f (x,y), Classification of second order PDE, Canonical forms, Separation of variable for heat Equation, Wave equations and Laplace Equation, Linear homogeneous BVP, Eigen values and eigen functions, Sturm-Liouville BVP.

Unit III

Orthogonality of eigen functions, Lagrange's identity, properties of Eigen functions, important theorems of sturm Liouville system, Periodic functions. Green's functions : Non-homegeneous

Sturm-Liouville BVP (method of Green's function), Procedure of contructing the Green's function and solution of BVP, properties of Green's function, Inhomogeneous boundary conditions, Dirac delta function, Bilinear formula for Green's function, Modified Green's function.

Book s Recommended for Reference :

1. Fred A Hinchey : Introduction to Applicable Mathematics Part- II, Wiley Eastern Ltd.
2. A.N. Sneddon : Mixed Boundary Value Problem in Potential theory
3. Gokhroo et.al : Advanced Differential Equations, Navkar Prakashan, Ajmer.
4. Bansal at al; : Differential Equation Volume II , Jaipur Publishing House, Jaipur.

PAPER II

GENERAL TOPOLOGY

Unit I

Metric spaces and their examples, Diameter of a set and bounded set, open sphere, interior point of a set, limit point of a set, closed set, closed ball, convergent and Cauchy sequence, complete metric space, Cantor's intersection theorem, Baire's category theorem, Continuity in metric spaces.Contracting mapping, Fixed point theorem.

Unit II

Neighbourhood and neighbourhood system, coarser and finer topologies, relative topologies, equivalent definitions of topologies. Open and closed functions. Homeomorphic spaces, topological properties, topologies induced by functions.

Unit III

T1 space, Hausdorff spaces, regular spaces, Functions that separate points. Completely regular spaces sequentially compact sets, Countably compact sets. Locally compact spaces, compactness in metric spaces.

Books Recommended for Reference :

1. Nahar, T.S : Metric Spaces, Navkar Prakashan, AJMER
2. S.Lipsechutz : General topology. The any problem, MCgraw Hill Co. (ch.V,VI,X,Xi)
3. Gokhroo et. al. : Topology, Navkar Prakashan, AJMER

4. G.F.Summous : Introduction of Topology and Modern Analysis, MCgraw Hill Co.

CORE ELECTIVE (ANY TWO)

PAPER -I

RELATIVISTIC MECHANICS

Unit I

Inertial frame, Galilean Transformations, Michelson and Morely Experiment, Relative character of space and time, Principle of relativity and its postulates, Derivation of special Lorentz's transformation equations. Lorentz Fitzgerald Contraction formula, Simultaneity, time dilation, Proper time.

Unit II

Composition of parallel velocities, Relativistic formulae for composition of Accelerations, Relativistic Aberration. Variation of mass with velocity, Equivalence of mass and energy, Transformation formulas for mass, momentum, Energy, Force and density.

Unit III

Minkowski space, Space & time like intervals, Null Cone, World point & World line, Proper time. Relativistic Lagrangian & Hamiltonian, Minkowski's equation of Motion. Energy momentium four vector, Relativity and causality, Clock Paradox, General Lorantz transformation, Principal of Covariance and Principal of equivalence.

Books Recommended for Reference :

1. Parkash : Relativistic Mechanics
2. Goyal et al; : Theory of Relativity, Pragati Parkashan Merrut.
3. Rajbali : Theory of Relativity, Jaipur Publishing House, Jaipur

PAPER II

DYNAMICS OF RIGID BODIES - I

Unit I

Moment of inertia of a body with respect to a given line, product of inertia in simple cases, theorem of parallel axes, theorem of six constants of a body, momental ellipsoid, momental ellipse, principal axes.

Unit II

The general equations of motion of a rigid body. Motion of centre of inertia and motion relative to centre of inertia. Moment of momentum of a body about the fixed axis, kinetic energy, motion of the effective forces about the axis, Equation of motion, motion under torque, the compound pendulum, Centre of suspension, centre of oscillation, centre of percussion.

Unit III

Dynamical equation of motions, moment of momentum or angular momentum, Dynamical equation, conservation of momentum (linear and angular), kinetic energy, equation of Vis Viva.

Books Recommended for Reference:

1. M.Ray : Dynamics of a Rigid Body, Students Friends & Co.
2. S.L.Loney : Dynamics of a Particle & of Rigid Body, The Macmillan & Co.
3. Anil Rao : Dynamics of a Particle & of Rigid Body, Cambridge
4. William Duncan : Dynamics of Rigid Bodies , Mac Millan
5. Jorge V. Jose : Classical Dynamics, Cambridge

PAPER III (a)

HYDRO DYNAMICS

Unit I

Kinematic of ideal fluid, Lagrange's and Euler's method, Equation of continuity in cartesian, Polar and cylinderical co-ordinals, Boundary surfaces, stream lines, Path lines.

Unit II

Velocity potential, Rotational and Irrotational motion, Equation of motion, Bernoulli's theorem, D'Alembert's paradox, Euler's momentum theorem, D'Alember's paradox, Euler's momentum theorem, Helmholtz, Cauchy's integrals.

Unit III

Motion due to impulsive forces, Motion in two dimensions, Stream function, Irrotational motion, Complex potential, Sources, Sinks, Doublets and images.

Books Recommended for Reference :

1. M.Ray : A Text book on Hydrodynamics
2. Ram Say and Besant : A Treatise on Hydrodynamics
3. Shanti Swaroop : Fluid Dynamics, Krishana Prakashan, Meerut.
4. J.L.Bansal : Hydronynamics ,Jaipur Publishing House ,Jaipur

PAPER III (b)

Commented [RM2]:

CONTINUUM MECHANICS-I

Unit I

Cartesian Tensors, Index notations and transformation, Laws of Cartesian tensors, Addition, Subtraction and multiplication of Cartesian tensor, Gradient of a scalar function, Divergence of a vector function and curl of a vector function using the Index notation, The identity stokes, Gauss and Green's theorems.

Unit II

The continuum approach classification of continuous media, Body forces and surface forces, Components of stress tensor, Force and moment equation of equilibrium.

Unit III

The stress quardric, Principle stresses and Principle axes, Stress invariants and the stress deviator tensor, Maximum shearing stress, Lagrangian and Eulerian description of deformation of flow, the comoving derivative, Velocity and acceleration, The continuity equation. Strain tensors, The linear rotation tensor and rotation vector, Analysis of rotation displacement.

Books Recommended for Reference :

1. D. Frederic and T.S. Chang : Continuum Mechanics, Ally and Bacon. Inc. Boston
2. Mase. G.E. : Continuum Mechanics (Schaum series)
3. Sommefield A. : Mechanics Deformable bodies.
4. Mortone E. gurtin : An Introduction to Continuum Mechanics, (Academic Press)
5. Sharma, K.D. :Continuum Mechanics, Navkar Prakashan, AJMER

PAPER IV

OPERATIONS RESEARCH

Unit I

The theory of simplex method, Simplex algorithm, Duality, Degeneracy, Variation of the simplex method

Unit II

Dual Simplex method, Revised simplex method, Sensitivity analysis (Post optimal solution)

Unit III

Integer programming, Bounded variable problem, Convex function, Saddle point.

Books Recommended for Reference :

1.Hadle:Linear Programming

2.Gokharoo et al: Operations Research ,Navkar Publishers

3. Satty :Mathematical Methods of Operational Research

4.Sadieni, Friendmand and Yaspann:Operations Research

5. Vajda : Mathematical Programming

6. P.K. Gupta & Man Mohan :Operations Research, Sultan Chand & Sons, New Delhi.

7. Kanti Swarup, P.K. Gupta & D. S. Hira :Operations Research-An Introduction,S. Chand & Company Ltd., New Delhi.

PAPER V

PROGRAMMING IN C++

THEORY:

Unit I

Introduction to C++, Character set, Constant, Variables and Data Types, Operator, precedence associativity and priority of operations.

Unit II

Arithmetic Expression, Operator Precedence and Associatively, Input, conditional Statements, Conditional Operator, Scope of Variables, Type Conversion. Decision making statement, Looping and branching, while statement, do statement , for statement, go to statement.

Unit III

Standard and User-Defined Function, Recursive function, Passing By Value And Reference, Pointers and Functions, Reference and Functions. Array: One Two And Multidimensional, Passing Array to a Function.

PRACTICAL

Simple C++ Programming of problems of numerical analysis, solution of quadratic equations, mean and standard deviation, fitting of curves, correlation coefficient, applications into matrices, sorting of numerical character string data etc.

Distribution of Marks:

Two Practicals - 5 Marks each	=	10 Marks
Practical Record	=	2 Marks
Viva - Voce	=	3 Marks
Total Marks	=	15 Marks

Note: 1. Each candidate is required to appear in the Practical examination to be conducted by internal and external examiner. External examiner will be appointed by the University through BOS and internal examiner will be appointed by the Head of the Department / Principal of the College.

2. Each candidate has to prepare his / her practical record.

3. Each candidate has to pass in Theory and Practical examinations separately

Book Recommended for Reference :

Object-Oriented Programming with C++ : E Balaguruswamy ,McGraw Hill

PAPER VI

GENERALIZED HYPERGEOMETRIC FUNCTION

Unit I

Generalized Hypergeometric Functions: Definition, Convergence conditions for pFq

differential equation and its solution, Watson's, Dixon's, Whipple's and Saalschutz theorems for the series 3F2 with unit argument, Thomae's thorem.

Unit II

Euler's type integrals involving pFq. Product formulas due to Ramanujan, Preece and Bailey Theorems. Contour integral representation for pFq.

H-Function: Definition, Convergence conditions, Series representations, Special cases,Transformation formulas, Identities.

Unit III

H-Function: Differentiation formulas, Multiplication formulas, Recurrence relations, Contiguous function relations.

Books Recommended for Reference :

1. Raninville, E.D. : Special functions, The MacMaillan Co., (1960)

2. Saran, N.,Sharma, S.D. et.al. : Special functions, Pragati Prakashan, Meerut.

3. Mathai, A.M., Saxena, R. K and Hans J. Haubold, H. J.: The H-Function Theory and Applications, Springer New York.

PAPER VII

DISCRETE MATHEMATICS

Unit I

Lattices: Lattices as partially ordered sets, their properties, duality, Lattices as algebraic systems, Sub lattices, Direct products, Bounded Lattices, Complete Lattices, Complemented Lattices and Distributive lattices.

Unit II

Boolean Algebras: Boolean Algebras as lattices, Various Boolean Identities, The Switching Algebra examples. Sub algebras, Direct products and Homeomorphisms,

Boolean forms and their Equivalence, Min-term Boolean forms, Sum of product Canonical forms, Minimization of Boolean functions.

Unit III

Formal Logic: Statements, Symbolic Representation of statements, Truth tables, Logical equivalence, Algebra of propositions, Conditional proposition, Converse, Contrapositive and Inverse, Bi-conditional Proposition, Negation of compound statement, Tautologies and contradictions, Normal forms , Predicates and Validity of arguments, Quantifiers.

Languages, Automata, Grammars:

Alphabet, Words, Free Semigroup, Languages, Regular Expressions, Regular Languages, Finite State Automata, Grammars.

Books Recommended for Reference :

1. Seymour Lipschutz and Marc Lars Lipson , The Theory and Problems of Discrete Mathematics, Third Edition, McGraw-Hill Book Co. New –York.

2. J. E. Hopcroft and J.D. Ullman, Introduction to Automata Theory Languages & Computation, Narosa Publishing House, Delhi,2007.

3. S.K.Sarkar, A Text book of Discrete Mathematics, S Chand and Company Ltd., 2006.

4. C. L. Liu, elements of Discrete Mathematics, McGraw-Hill Book Co,2010.

5. N. Deo, Graph Theory with Applications to Engineering and Computer Sciences, PHI, New Delhi.

OPEN ELECTIVE (ANY ONE)

PAPER I

MATHEMATICAL MODELLING - I

Unit I

The process of Applied mathematics, Setting up first order differential equations,

Unit II

Qualitative solution sketching. Difference and differential equation growth models. Single-species population models, Population growth- An age structure model.

Unit III

The spread of Technological innovation. Higher order linear models - A model for the detection of Diabetes, Combat models Traffic models - Car-following models.

Books Recommended for Reference :

1. Kapur J.N. : Mathematical Modelling, New Age Publishers, New Delhi.

2. Saxena V.P. : Mathematical Models in Biology

3. Mauriya R.P. : Mathematical Modelling, Navkar Prakashan, AJMER

PAPER II

MATHEMATICAL STATISTICS - I

Unit I

Sample spaces, Combination of events, Statistical independence, Conditional probability-Bays theorem Repeated trials, Random Variable, Distribution function, Probability function, Density function.

Unit II

Mathematical expectation, Generating function (mfg and pgf) continuous probability distribution characteristic function, Fourier's Inversion, Chebyshev and Kolmogorov inequality. Weak and Strong laws of large numbers, Normal, Hyper-geometric, Rectangular, Negative Binominal, Beta, Gamma and Cauchy's distribution.

Unit III

Methods of least square and curve fitting, correlation and regression coefficient. Index numbers, Introduction, Price-relatives, Quantity relatives, Value relatives. Link and Chain relatives, Aggregate methods, Fisher's Ideal Index, Change of the base period of the index numbers.

Books Recommended for Reference :

1. Kapur and Saxena : Mathematical Theory of Statistics.

2. Weatherburn : A First Course in Mathematical Statistics.

3. M.G. Kendall : The Advanced Theory of Statistics.

4. Uspensky : Introduction of Mathematical Probability.

5. Gokhroo et. al. : Advanced Mathematical Statistics, Navkar Prakashan, AJMER

SEMESTER IV

SEMESTER SCHEME

Course code	Course Title	Lectures per week	Credits	Max.Marks		Min.Pass Marks
				Internal	External	
CORE COMPULSORY						
I	Integral Equations	6	6	10	50	15(25%)
II	Functional Analysis	6	6	10	50	15(25%)
CORE ELECTIVE (Any 2)						
I	Graph Theory	6	6	10	50	15(25%)
II	Dynamics of Rigid BODIES – II	6	6	10	50	15(25%)
III Anyone of (a) and (b)	a) Viscous Fluid Dynamics	6	6	10	50	15(25%)
	b) CONTINUUM Mechanics– II	6	6	10	50	15(25%)
IV	Non Linear programming and dynamic Programming	6	6	10	50	15(25%)
V	General Relativity and Cosmology	6	6	10	50	15(25%)
VI	Dissertation	6	6	10	50	15(25%)
OPEN ELECTIVE (Any 1)						
I	Mathematical modelling– II	6/5	6(5 for students of other subjects)	10	50 (40 for students of other subjects)	13(25%)
II	Mathematical Statistics - II	6/5	6(5 for students of other subjects)	10	50 (40 for students of other subjects)	13(25%)
	Total Credits for Semester - 30					

Scheme of examination :

Five Theory Papers		**Max. Marks 300**
Paper-I : Core Compulsory	**3 hrs. duration**	**50+10 (Int) Marks**
Paper-II : Core Compulsor	**3 hrs. duration**	**50+10 (Int) Marks**
Paper-III: Core Elective	**3 hrs. duration**	**50+10 (Int) Marks**
paper-IV : Core Elective	**3 hrs. duration**	**50+10 (Int) Marks**
paper-V : Open Elective	**3 hrs. duration**	**50+10(Int) Marks**
		[40+10(Int) Marks for other subjects]

CORE COMPULSORY

PAPER I

INTEGRAL EQUATION

Unit I

Linear integral equations : Definition and classification. Conversion of initial and boundary value problems to an integral equation. Eigen values and Eigen functions. Solution of homogeneous and general fredholm integral equations of second kind with separable kernels.

Unit II

Solution of Fredholm and Volterra integral equations of second kind by methods of successive substitutions and successive approximations. Resolvent kernel and its results . Integral equations with symmetric kernels : Orthogonal system of functions. Fundamental properties of eigen values and eigen functions for symmetric kernels.

Unit III

Hilbert-Schmidt theorem. Solution of Fredholm integral equations of second kind by using Hilbert-Schemidt theorem. Solution of Volterra integral equations of second kind with convolution type kernels by Laplace transform . Classical Fredholm theory : Fredholm theorems. Solution of Fredholm integral equation of second kind by using Fredholm first therorem.

Books Recommended for References :

1. Lovittee W.V : Integral Equations, Dover Publications.
2. Kanwal R.P : Linear Integral Equations, Academic Press, New York.
3.
4. Shanti Swaroop: Linear Integral Equations, Krishna Prakashan Mandir, Merrut.
5. Gokhroo et.al., : Linear Integral Equations, Navkar Prakashan, Ajmer

PAPER II

FUNCTIONAL ANALYSIS

Unit I

Normed Vector spaces, Banach Spaces and their examples, Continuous linear transformations, The Hahn-Banach theorem and its application.

Unit II

The open mapping theorem , the closed graph theorem ,the uniform boundedness theorem, Inner product spaces. Hilbert space and their examples, Cauchy Schwarz's inequality, Parallelogram Law, Orthogonal complements, Orthonormal sets.

Unit III

Bessel's inequality, Gram Schmidt orthogonlization process. Riesz representation theorem. The adjoint of an operator, self adjoint and normal operators projections, process.

Books Recommended for Reference :

1. L.A. Luesternik and L.J. Soboler :Elements of Functional Analysis,Hindustan Publishing Company (1974).
2. A.E. Taylor : Introduction to Functional Analysis (1958), John Wiley and Sons.
3. J.Dieudonne : Foundations of Modern Analysis (1969), Academic Press.
4. Kosaku Yosida : Functional Analysis (1974), Narosa Publishing House, New Delhi.
5. B. Choudhary and Sudarshan Nanda : Functional Analysis with Application (1989), Wiley Eastern Limited
6. Nahar, T.S. : Functional Analysis, Navkar Prakashan.
8. Sharma, J.N.. : Functional Analysis, Krishana PrakashanMandir, Meerut.

CORE ELECTIVE (ANY TWO)

PAPER I

GRAPH THEORY

Unit I

Graph and related terminology.

Complete graph, Weighted graph, Planar and non-planar graph, Regular graph, Graph isomorphism and homeomorphism, Euler's formula, Statement and applications of Kuratowski's theorem

Unit II

Representing graphs in computer system, Coloring of graph. Graph connectivity, Konigsberg bridge problem, Euleria path and Elerian circuit, Hamiltonian path and Hamiltonian circuit. Study of Shortest path and shortest distance, Dijkstra's algorithm.

Unit III

Paths between the vertices, Path matrix, Warshall's algorithm, cut point, bridge, cut sets and connectivity, Menger's theorem.

Tree and related terminology, spanning tree, Finding minimum spanning tree by Kruskal's algorithm and Prim's algorithm, inorder, preorder, and postorder tree traversals, Binary tree, Expression trees and reverse polish notation (RPN).

Books Recommended for Reference :

1. Harary, Addison: Graph Theory ,Wesley 1969

2. D. B. West: Introduction to Graph Theory, Prentice Hall 1996.

3. Jonathan Gross and Jay Yellan: Graph Theory and its Applications, CRC 1998.

4. Gokhroo et. al.: Advanced Discrete Mathematics, Navkar Prakashan, AJMER

5. N.Deo : Graph Theory with Application to Engineering Computer Science.Prentice hall of India.

PAPER II

DYNAMICS OF RIGID BODIES – II

Unit I

Principle of conservation of linear momentum, Principle of conservation of angular momentum, when impulsive forces act, sudden fixtures, principle of conservation of energy, conservative forces. Lagrange's equation of first kind, Lagrange's equations of second kind, Generalized co-ordinates, degree of freedom, Lagrange's function, principle of energy, small oscillation.

Unit II

Moving axes and the fixed axes, Eiler dynamical equations, Kinetic energy of a rigid body with a fixed point, Euler's equation (impulsive forces), Eulerian angles and geometrical relations, Instantaneous axis of rotation, Invariables line, Locus of invariable line, Deduction of Euler's equations from Lagrange's equations

Unit III

Hamilton's equations of motion, Hamilton's variables. Hamilton cononical equations cyclic coordinates, Poisson's Bracket. Poisson's identity. Jacobi-Poisson Theorem. Hamilton Jacobi Equations.Hamilton's principle and principle of least action. Equation of motion of a top (Derived from Euler's equations, Principle of energy and momentum, Deduced from Lagrange's equations), Steady motion, Stable motion (axis vertical, axis is not vertical), Limit of q

Books Recommended for Reference :

1. M.Ray : Dynamics of a Rigid Body, Students Friends & Co.
2. S.L.Loney : Dynamics of a Particle & of Rigid Body, The Macmillan & Co.
3. Anil Rao : Dynamics of a Particle & of Rigid Body, Cambridge
4. William Duncan : Dynamics of Rigid Bodies , Mac Millan
5. Jorge V. Jose : Classical Dynamics, Cambridge.
6. Gokhroo et.al. : Rigid Body Dynamics, Navkar Prakashan, Ajmer.

PAPER III (a)

VISCOUS FLUID DYNAMICS

Unit I

Viscosity, Analysis of stress, Relation between stress and rate of strain, Dynamical similarity and inspection and dimensional analysis, Buckingham theorem. Physical importance of non-dimensional parameters, Reynolds number, Fruoude number, Mach number, Prandtl number and Grashoff number.

Unit II

Navier- Stoke's equations, some exact solutions of Navier-stoke's equations, Plane couete flow, Plane posiseulle flow, Generalised plane couetel flow, Hagan-Poiseuille flow.

Flow in tubes in uniform cross-section, Flow in convergent and divergent channels, Stagnation point flows, Flow due to a rotating disc.

Unit III

Flow due to a plane wall suddenly set in motion (stokes first problem), Flow due to an oscillating plane wall (Stoke's second problem), Starting flow in a pipe. Theory of very slow motion, Stoke's flow pas a sphere, Oseen's flow past a sphere, Lubricandtion theory.

Books Recommended for Reference :

1. M.Ray : A Text book on Hydrodynamics
2. Ram Say and Besant : A Treatise on Hydrodynamics
3. Shanti Swaroop : Fluid Dynamics, Krishana Prakashan, Meerut.
4. J.L.Bansal : Viscous Fluid Dynamics, ,Jaipur Publishing House,Jaipur

PAPER –III(b)

CONTINUUM MECHANICS-II

Unit I

Geometrical meaning of the components of the linear strain tensor, Principle axis theory for the linear strain tensor, properties of Linear strain tensors, The linear cubical dilatation, Compatibility equations for the linear strain components.

The rate of strain tensors and the vorticity tensor, The rate of rotation vector and the vorticity, Properties of the rate of strain tensor, Rate of cubical dilatation.

Unit II

Law of conservation of mass and Eulerain Continuity equation, The momentum integral theorem and the equation of motion, Kinetic equation of state, The first and the second law of thermodynamics and the dissipation function.

Application: (Linear elasticity): Assumption and basic equations, Generalized Hooke's Law for an isotropic Homogeneous solid, Compatibility equations, Classification of types of problems in linear elasticity, The Principle of superposition.

Unit III

The strain energy function, The uniqueness theorem P.I. Relationship and the work kinetic energy equation, Irrotational flow and the velocity potential, Kinetic equation of state and the First Law of Thermodynamics. The equation of continuity, the equations of motion, Vorticity-Strema Surface for inviscid flow, Bernoulli's equations, Irrotational flow and the velocity potential, Similarity parameters and fluid flow.

Books Recommended for Reference :

1. D. Frederic and T.S. Chang : Continuum Mechanics, Ally and Bacon. Inc. Boston
2. Mase. G.E. : Continuum Mechanics (Schaum series)
3. Sommefield A. : Mechanics Deformable bodies.
4. Mortone E. gurtin : An Introduction to Continuum Mechanics, (Academic Press)
5. Sharma, K.D. : Continuum Mechanics, Navkar Prakashan, AJMER

PAPER IV

NON LINEAR PROGRAMMING AND DYNAMIC PROGRAMMING

Unit I

Conditions for non-linear programming problem, Kuhn Tucker conditions for optimization for non-linear programming problem.

Convex programming with separable convex objectives.

Unit II

Quadratic programming method for quadratic programmes due to Wolfe and Frank, Duality theorem for quadratic programming,

Unit III

Dynamic programming its notion and formulation.

Books Recommended for Reference :

1. . Hadley : Non-linear Programming
2. Satty : Mathematical Methods of Operational Research
3. Sadieni, Friendmand and Yaspann : Operations Research
4. Bellmen R. : Dynamic Programming
5. Vajda : Mathematical Programming
6. G Hadley : Nonlinear and Dynamic Programming :, Addison-Wesley
7. O.L.Mangasrian : Non Linear Programming : McGraw Hill
8. Gokhroo et. al. : Advanced Operations Research, Navkar Prakashan, AJMER
9. Sharma S.D. : Operations Research.

PAPER V

GENERAL RELATIVITY AND COSMOLOGY

Unit I

Mach's principle, Newtonian approximation of equation of motion, Einstein's field equation for matter and empty space, Reduction of Einstein's field equation to Poisson's equation, Removal of clock paradox in General Relativity.Schwarzschild exterior metric, its isotropic form, Singularity and singularities in Schwarzschild exterior metric, Derivation of the formula $GM=c^2 m$, Mass of sun in gravitational unit.

Unit II

Relativistic differential equation for the orbit of the planet. Birkhoff's theorem.Three crucial tests in General Relativity and their detailed descriptions, Analogues of Kepler's laws in General Relativity, Trace of Einstein tensor, Energy-momentum tensor and its expression for perfect fluid, Schwarzschild interior metric and boundary condition.

Unit III

Lorentz invariance of Maxwell's equations in emptry space, Lorentz force on charged particle, Energy-momentum tensor for electro-magnetic field. Electromagnetism in General Relativity, Derivation of Einstein's Maxwell's equations from Action Principal. Einstein's field equation with cosmological term, static cosmological models (Einstein & de-Sitter models) with physical and geometrical properties,difference between Einstein and de-sitter universe.

1. **Books Recommended for Reference**
2. Parkash : Relativistic Mechanics
3. Goyal et al; : Theory of Relativity, Pragati Parkashan Merrut.
4. Rajbali : Theory of Relativity, Jaipur Publishing House, Jaipur

PAPER VI

DISSERTATION

OPEN ELECTIVE (ANY ONE)

PAPER I

MATHEMATICAL MODELLING – II

Unit I

Equilibrium speed distributions.Non linear population growth models. Prey-Predator models, Epidemic growth models.

Unit II

Models from Political Science - Proportional representation cumulating voting, comparison voting. Applications in Ecological and Environmental subject areas- Urban waste water Management planning.

Unit III

Mathematical Modelling through calculus of variations, dynamic programming , mathematical programming, maximum principle and maximum entropy principle.

Books Recommended for Reference :

1. Kapur J.N. : Mathematical Modelling, New Age Publishers, New Delhi.

2. Saxena V.P. : Mathematical Models in Biology

3. Mauriya R.P. : Mathematical Modelling, Navkar Prakashan.

PAPER II

MATHEMATICAL STATISTICS – II

Unit I

Elementary sampling theory, Distribution of means of samples from Binomial, Cauchy, Rectangular and normal distributions. Distribution of second order moments in samples from normal population, Exact distributions of χ^2, t, z and F.

Unit II

Statistics in samples from a normal population, Their simple properties and applications. Test of significance of difference between two means and two standard deviations for large samples with modification for small samples and taken from normal population.

Unit III

Association of attributes, Analysis of variance, simple cases (one criteria and two criteria of classification), Elementary statistical Theory of Estimation. Fisher's criteria for the best estimator, Consistent, Efficient and sufficient estimator, Method of Maximum Likelihood estimators and other methods of estimation, Method of least squares.

Books Recommended for Reference :

1. Kapur and Saxena : Mathematical Theory of Statistics.
2. Weatherburn : A First Course in Mathematical Statistics.
3. M.G. Kendall : The Advanced Theory of Statistics.
4. Uspensky : Introduction of Mathematical Probability.
5. Gokhroo et. al. :Advanced Mathematical Statistics, Navkar Prakashan, AJMER