

M. A./M. Sc. (Previous/Final) Examination, 2022

MATHEMATICS

I/II/III/IV/V/ PAPER

( Title of paper )

Time allowed: 3.00 hours

Max. Marks- 100

NOTE : Attempt any FIVE questions in all out of nine questions without considering units.

All

questions carry equal marks..

Q. 1. Attempt all sub parts:

- (i)
- (ii)
- (iii)
- (iv)
- (v)
- (vi)
- (vii)
- (viii)
- (ix)
- (x)

(2 x 10 = 20)

UNIT - I

Q. 2 (a)

(b)

20 marks

Q. 3 (a)

(b)

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20 marks

UNIT - II

Q. 4(a)

(b)

20 marks

Q. 5(a)

(b)

20 marks

UNIT - III

Q. 6(a)

(b)

20 marks

Q. 7(a)

(b)

20 marks

UNIT - IV

Q. 8(a)

(b)

20 marks

Q. 9(a)

(b)

20 marks

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**Maharaja Surajmal Brij University  
Bharatpur (Raj)**

**SYLLABUS**

**M. A./M. Sc. ( Mathematics)**

*(Annual Scheme)*

**Session 2021-22**

**M. A. /M. Sc. (Previous) Examination 2022**

As per decision taken in the Examination Planning and Management Committee of the university the syllabus has been reduced by 30% only for the session 2021-22.

*Dr. K. C. Sharma*

(Dr. K. C. Sharma)

External Member

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**Session 2021-22**

*Dr.*  
**अकादमिक प्रभारी**  
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भरतपुर (राज.)

**Maharaja Surajmal Brij University, Bharatpur (Raj)****M. A./M.Sc. (Mathematics)****Syllabus**

**Scheme of Examination:-** There shall be ten papers in two years duration and five papers in each year. In first year all five papers are compulsory. In the final year two papers shall be compulsory and three papers shall be optional(elective).

The syllabus of each paper is divided into four units. There shall be two parts in the question paper. Part 'A' of the question paper shall contain FIRST question which is compulsory. The first question shall contain 10 subparts consisting of very short answer type questions based on the knowledge, understanding and applications of the topics covering the syllabus of all four units. Each question of subpart will carry 2 marks. Part 'B' of the question paper shall be divided into FOUR units. Each unit will contain TWO questions and each question will have two subparts. Student has to attempt one question from each unit. Each question is of 20 marks.

**M. A./M. Sc. ( Previous ) Examination 2022**

Five Compulsory Papers

Total Max Marks 500 for regular and non-collegiate students.

Paper	Name of paper	Teaching hrs per weak	Exam Duration	Max. Marks
I	Advanced Modern Algebra	6	3	100
II	Measure Theory and Topology	6	3	100
III	Differential Equations and Special Functions	6	3	100
IV	Differential Geometry and Tensor Analysis	6	3	100
V	Dynamics of Rigid Bodies and Operations Research	6	3	100

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## Advanced Modern Algebra

Teaching : 6 hours per week

Theory Paper

Exam Duration: 3 Hours

Maximum Marks 100

**Note :-** The syllabus of this paper is divided into four units. There shall be two parts in the question paper. Part 'A' of the question paper shall contain FIRST question which is compulsory. The first question shall contain 10 subparts consisting of very short answer type questions based on the knowledge, understanding and applications of the topics covering the syllabus of all four units. Each question of subpart will carry 2 marks. Part 'B' of the question paper shall be divided into FOUR units. Each unit will contain TWO questions and each question will have two subparts. Student has to attempt one question from each unit. Each question is of 20 marks.

**Unit-I: Normal Subgroups-** Normalizer, Commutators, Derived subgroups, Conjugate class, conjugate subgroup, Quotient Groups. **Homomorphism -** Homomorphism and Isomorphism Theorems, Diamond isomorphism theorem, Butterfly Lemma, Direct product of groups (external and internal). **Normal Series,** Solvable groups, Zassenhaus Lemma. Composition Series, Maximal Normal Subgroup.

**Unit- II : Factorization of Integral Domains-** Prime element, Composite element, Euclidean Algorithm for polynomials, Einstein's Theorem, Euclidean rings, Euclidean domains, Unique Factorisation Theorem. **Field Theory-** Extension fields, Algebraic and Transcendental Extensions, Separable and Inseparable Extensions, Normal Extensions, Splitting Fields. **Galois Theory-** The elements of Galois Theory, Automorphism of extensions, Fundamental theorem of Galois Theory, Solution of polynomial equations by radicals, Insolvability of general equation of degree five by radicals.

**Unit-III : Linear Transformations on Vector Spaces-** Rank and Nullity of linear transformation, Sylvester's theorem, algebra of linear transformations, Linear functionals, Dual Spaces, Dual basis and their properties, Dual maps, Annihilator. **Matrices-** Matrices of linear transformations, Matrices of composition maps, Matrices of Dual maps, change of basis, similarity of matrices, trace of matrix.

**Unit-IV : Determinants-** Determinants of matrices and its computations, existence and uniqueness of determinants, Cramer rule, cofactor expansion formula, characteristic polynomial, eigen values and eigen vectors, Cayley-Hamilton theorem, diagonalisable operator and matrices, minimal polynomial, minimal equation. **Inner product spaces-** Schwarz inequality, normed vector space, matrix of inner product, conjugate transpose of matrix, Hermitian matrix, orthogonality, Pythagoras theorem, complete orthonormal set, Gram-Schmidt orthogonalization theorem, Bessel's inequality, orthogonal complements, linear maps on inner product spaces, adjoint of a linear transformation, principal axis theorem.

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**Reference Books:**

1. In. Herstein : *Topics in Algebra (2<sup>nd</sup> Edition)* ; John Wiley and Sons 2006.
2. Qazi Zameeruddin and Surjeet Singh : *Modern Algebra*; Vikas Publishing, 2006.
3. Joseph A. Gallian : *Contemporary Abstract Algebra*; Narosa Publishing House, 1999.
4. S. MacLane and G. Birkhoff : *Algebra*; Macmillan Publishing Co. , Newyork.
5. G. C. Sharma: *Modern Algebra*; Shivalal Agrawal & Co. , Agra ,1998
6. Adv Course in Modern Algebra: *J.K. Goyal & K.P. Gupta*, Pragati Prakashan, Meerut

**Paper – II****Measure Theory and Topology****Teaching : 6 hours per week****Theory.Paper****Exam Duration: 3 Hours****Maximum Marks 100**

**Note :-** The syllabus of this paper is divided into four units. There shall be two parts in the question paper. Part 'A' of the question paper shall contain FIRST question which is compulsory. The first question shall contain 10 subparts consisting of very short answer type questions based on the knowledge, understanding and applications of the topics covering the syllabus of all four units. Each question of subpart will carry 2 marks. Part 'B' of the question paper shall be divided into FOUR units. Each unit will contain TWO questions and each question will have two subparts. Student has to attempt one question from each unit. Each question is of 20 marks.

**Unit-I :** Algebra and algebras of sets- algebras generated by a class of sub sets, Borel sets, Cantor set, Lebesgue- Concept of Lebesgue outer measure, inner measure, Countable sub additivity of outer measure, Measurable sets, properties of measurable sets, Non measurable sets. Measurable functions- Definition, properties of measurable functions, operations of measurable functions, pointwise and uniform convergence of the sequence of measurable functions, Egorov's theorem, Lebesgue theorem.

**Unit-II :** Lebesgue Integration- Lebesgue integral and its comparison with Reimann integral, properties of Lebesgue integral of bounded measurable functions, Lebesgue theorem on the passage to the limit under the sign of integral for bounded measurable functions. Lebesgue integral of non negative measurable functions, Fatou's lemma, Lebesgue monotone convergence theorem, Countable additivity of Lebesgue integral, Lebesgue integral of an arbitrary function and summability of Lebesgue integral, Lebesgue dominated convergence theorem. Summability of Lebesgue integral- Space of summable functions, Space of square summable functions, Orthonormal system, Fourier series, Reisz-Fischer theorem.

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**Unit-III :** Topological spaces : Topology, T-open sets, sub spaces, open sets and closed sets, neighbourhood system, closure, interior, limit point, relative topology, co-finite topology, upper limit topology, intersection of topological spaces, Kuratowsky theorem, metric spaces, Bases , sub-bases and countability. Continuous mappings: Continuity, Sequentially continuous functions, Homeomorphism, Topological properties, Open and Closed maps, Uniform continuity, product invariant, restriction maps, isometry, Nets and Convergence: directed sets, Residual subsets, Co-final subsets.

**Unit-IV :** Separation axioms(  $T_0, T_1, T_2, T_3, T_4$  ), normal spaces, regular spaces, Tychonoff space, Completely normal, Hausdorff space, Problems related to hereditary property, Problems related to topological property, Urysohn's lemma, Tietze extension theorem. Compact and locally compact spaces, continuity and compactness. Product and Quotient spaces: Product topology, Projection maps, Tychonoff topology, Embedding, Tychonoff cube, Hausdorff maximal principle, Alexander sub base lemma.

#### Reference Books:

1. G. De Barra: *Measure theory and Integration*; New Age International (P) Ltd, New Delhi
2. H. L. Royden: *Real Analysis*; Prentice Hall of India, New Delhi.
3. K. C. Sharma: *Measure theory and Integration*; Ramesh Book Depot, Jaipur.
4. T. M. Apostol: *Mathematical Analysis*; Narosa Publishing House , New Delhi.
5. G. F. Simmons: *Introduction to Topology and Modern Analysis*; McGraw-Hill, Newyork.
6. K. P. Gupta: *Topology*; Pragati Prakashan , Meerut.
7. S. C. Malik and Savita Arora: *Mathematical Analysis*; New Age International (P) Ltd, New Delhi

#### Paper – III

#### Differential Equations and Special Functions

Teaching : 6 hours per week

Theory Paper

Exam Duration: 3 Hours

Maximum Marks 100

**Note :-** The syllabus of this paper is divided into four units. There shall be two parts in the question paper. Part 'A' of the question paper shall contain FIRST question which is compulsory The first question shall contain 10 subparts consisting of very short answer type questions based on the knowledge, understanding and applications of the topics covering the syllabus of all four units. Each question of subpart will carry 2 marks. Part 'B' of the question paper shall be divided into FOUR units . Each unit will contain TWO questions and each question will have two subparts. Student has to attempt one question from each unit . Each question is of 20 marks.

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**Unit-I :** Non-linear differential equations of particular forms, Riccati's equation- general solution and the solution when one, two or three particular solutions are known, equations not containing  $y$  directly, equations not containing  $x$  directly. Total differential equations- necessary and sufficient conditions, methods of solution, geometric meaning of total differential equation.

**Unit-II :** Partial differential equations of second order with variable coefficient - Monge's method, Canonical forms. Classification of second order linear partial differential equations, Cauchy's problem. Boundary value problem- eigen values and eigen functions, Sturm-Liouville boundary value problems, orthogonality of eigen functions, normalised eigen functions, Non-homogeneous boundary value problems.

**Unit-III :** Calculus of Variation- Functionals, Euler-Lagrange differential equation for an extremal, variational problems with several dependent variables, variational problems involving several independent variables, isoperimetric problems and isoperimetric conditions; geodesic problems, variational problems involving constraints, Variational problems with moving boundaries, applications of calculus of variation to the problems of mechanics. Legendre's Function of first and second kind- Legendre equation and its solution, Legendre functions  $P_n(x)$  and  $Q_n(x)$ , generating function, Laplace's integrals for  $P_n(x)$ , Rodrigue's formula, orthogonal properties of Legendre's polynomial, recurrence relations, Christoffel's expansion, Christoffel's summation formula, Beltrami's result.

**Unit-IV :** Bessel's Function- Bessel's equation and its solution, Bessel's function  $J_n(x)$ , recurrence formulae, generating function, integral expression for Bessel's function, addition formula for Bessel's function, orthogonal property, Fourier-Bessel expansion. Gauss-Hypergeometric equation and its solution- hypergeometric function, integral representation, Gauss's theorem, Vandermonde's theorem, Kumar's theorem, confluent hypergeometric equation and its solution, confluent hypergeometric function. Hermite differential equation and its solution, Hermite polynomials, generating function, orthogonal property, recurrence relations.

#### Reference Books:

1. A. R. Forsyth: *A Treatise of Differential Equations*; Macmillan & Co Ltd., London
2. I. N. Sneddon: *Elements of Partial Differential Equations*; McGraw-Hill & Co., Newyork
3. M.D.Raisinghania: *Ordinary and Partial Differential Equations*; S.Chand & Co., New Delhi
4. J. L. Bansal and H. S. Dharmi: *Differential Equations*; J. P. H. , Jaipur
5. M. Ray, J. C. Chaturvedi, H. S. Sharma and K. C. Sharma: *A Text Book of Differential Equations*; Students' Friends & Co. Raja Mandi, Agra-282002.
6. N. Saran and S. D. Sharma: *Special Functions*; Pragati Prakashan Meerut.

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**Differential Geometry and Tensor Analysis**

Teaching : 6 hours per week

Theory Paper

Exam Duration: 3 Hours

Maximum Marks 100

**Note :-** The syllabus of this paper is divided into four units. There shall be two parts in the question paper. Part 'A' of the question paper shall contain FIRST question which is compulsory. The first question shall contain 10 subparts consisting of very short answer type questions based on the knowledge, understanding and applications of the topics covering the syllabus of all four units. Each question of subpart will carry 2 marks. Part 'B' of the question paper shall be divided into FOUR units. Each unit will contain TWO question and each question will have two subparts. Student has to attempt one question from each unit. Each question is of 20 marks.

**Unit-I :** Curves in Space- class of a curve, tangent line, length of space curve, order of contact of a curve and surface, inflexional tangent, osculating plane, principal normal and binormal, Curvature and torsion, Frenet-Serret's formulae, osculating circle and sphere. Envelops and Developable Surfaces- Envelope of one and two parameter family of surfaces, edge of regression, ruled surfaces. Metric of a surface- first, second and third fundamental forms, Fundamental magnitudes of some important surfaces.

**Unit-II :** Curves on surfaces- parametric curves on surfaces, direction coefficient, angle between two tangential directions, orthogonal trajectory, condition that  $Pdu^2 + 2Qdudv + Rdv^2 = 0$  may represent orthogonal family of curves. Normal curvature and curvature of normal section, Meunier's theorem, principal directions and principal curvatures, mean curvature, Gaussian curvature, minimal surface, Lines of curvatures, Euler's theorem, Dapin's theorem, Rodrigues formula, Joachimsthal's theorem, Relation between fundamental forms. Conjugate directions, Asymptotic lines, differential equation and theorems of asymptotic lines, curvature and torsion of asymptotic lines, Beltrami-Enneper's theorem.

**Unit-III :** Geodesics- Introduction, differential equation of geodesic, canonical equation, Geodesic on a surface of revolution, Geodesic on conoidal surface, geodesic on a developable surface, geodesic on conicoids, Geodesic curvature, Liouville's formula for geodesic curvature, Bonnet's formula for geodesic, Torsion of a geodesic, Bonnet's formula for torsion, Gauss-Bonnet's theorem, Joachimsthal Theorem. Tensors-Introduction, Kronecker delta, Contravariant and Covariant tensors, symmetric tensors, algebraic operations with tensors, contraction of tensors, quotient law of tensors, relative tensor, Riemannian space, Metric tensor, indicator.

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**Unit-IV : Christoffel's Symbols and Covariant Differentiation-** Christoffel' symbols and their properties, Covariant differentiation of tensors, intrinsic derivative, Ricci's theorem, divergence of a vector. Curvature of a curve, Geodesic, Euler's condition, differential equation of geodesic, geodesic coordinates. Parallelism of vectors- parallelism in subspace, Fundamental theorem of local Riemannian Geometry, Riemann-Christoffel tensor and its properties, Ricci's Tensor.

**Reference Books:**

1. R. J. T. Bell : *Elementary Treatise on Coordinate Geometry of Three Dimensions*; Macmillan India Ltd, New Delhi.
2. T. J. Willmore: *An Introduction to Differential Geometry*; Oxford University Press.
3. Weatherbum: *Reimannian Geometry and Tensor Calculus*; Cambridge University Press.
4. J. L. Bansal : *Tensor Analysis*, Jaipur Publishing House, Jaipur
5. Mittal And Agrawal : *Differential Geometry*; Krishna Prakashan , Meerut.
6. Barry Spain: *Tensor Calculus*; Radh Publishing House Calcutta.

**Paper – V**

**Dynamics of Rigid Bodies and Operations Research**

Teaching : 6 hours per week

Theory Paper

Exam Duration: 3 Hours

Maximum Marks 100

**Note :-** The syllabus of this paper is divided into four units. There shall be two parts in the question paper. Part 'A' of the question paper shall contain FIRST question which is compulsory The first question shall contain 10 subparts consisting of very short answer type questions based on the knowledge, understanding and applications of the topics covering the syllabus of all four units. Each question of subpart will carry 2 marks. Part 'B' of the question paper shall be divided into FOUR units. Each unit will contain TWO questions. and each question will have two subparts. Student has to attempt one question from each unit. Each question is of 20 marks.

**Unit-I : D'Alembert's Principle-** General equations of motion of a rigid body, motion of centre of inertia, motion relative to centre of inertia. Motion about a fixed axis- Moment of momentum of a body about the fixed axis, moment of effective force about the axis, equation of motion, Compound Pendulum, Centre of Percussion.

**Unit-II : Lagrange's Equations of Motion-** generalised coordinates, degree of freedom, holonomic system, Lagrange's equations of motion for finite forces, Lagrange's function, small oscillations, normal coordinates, Lagrange's equations of motion for impulsive forces. Hamilton's equations of motion, Hamilton's Principle and Principle of Least action. Motion in three dimensions- Rigid body moving with one fixed point, moving

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axes and fixed axes, Euler's dynamical equations of motion, instantaneous axis, motion under no forces.

**Unit-III :** Replacement Theory- Introduction, concept of present value, replacement models and their solutions. Inventory Control- Introduction, Classification of inventory models, Deterministic models, Economic lot-size models, production lot-size models, quantity discount.

**Unit-IV :** Queueing Theory- Introduction, Components of queueing system, Classification of queues and their problems, Steady, transient and explosive states, distribution of arrivals and service times, queue models, M/M/1 :(infinite/ FIFO), M/M/1(N/FIFO), M/M/c :(infinity/FIFO), Game Theory- Introduction, Description of games, Maximin and minimax principles, Saddle point, Dominance in games, Solution of rectangular games, Solution of 2x2 game without saddle point, Solution of two person zero sum 2xn game, graphical method.

**Reference Books:**

1. S. L. Loney: *An Elementary Treatise on the Dynamics of particle and of Rigid Bodies*; Macmillan India Ltd, new Delhi
2. H. Goldstein: *Classical Mechanics*; Narosa Publishing Co., New Delhi
3. M. Ray and H. S. Shrama: *Dynamics of Rigid Bodies*; Students' Friends & Co. Raja Mandi, Agra-282002.
4. Kanti Swaroop: *Operations Research*; S. Chand & Co. , New Delhi.
5. H. M. Wagner: *Principles of Operations Research*; Prentice Hall of India , New Delhi.
6. Hillier and Lieberman: *Introduction to Operations Research*; McGraw-Hill, New Delhi
7. S. D. Sharma: *Operations Research*; Kedarnath Ramnath & Co. , Meerut
8. R. K. Gupta: *Operations Research*; Krishna Prakashan, Meerut.

(Dr. K. C. Sharma)

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**Maharaja Surajmal Brij University**  
**Bharatpur (Raj)**

**SYLLEBUS**

**M. A./M. Sc. ( Mathematics)**

*(Annual Scheme)*

**Session 2021-22**

**M. A. / M. Sc. ( Final ) Examination 2022**

As per decision taken in the Examination Planning and Management Committee of the university the syllabus has been reduced by 30% only for the session 2021-22.

(Dr. K. C. Sharma)

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**Maharaja Surajmal Brij University, Bharatpur (Raj)****M. A./M.Sc. (Mathematics)****Syllabus**

**Scheme of Examination:-** There shall be ten papers in two years duration and five papers in each year. In first year all five papers are compulsory. In the final year two papers shall be compulsory and three papers shall be optional(elective).

The syllabus of each paper is divided into four units. There shall be two parts in the question paper. Part 'A' of the question paper shall contain FIRST question which is compulsory. The first question shall contain 10 subparts consisting of very short answer type questions based on the knowledge, understanding and applications of the topics covering the syllabus of all four units. Each question of subpart will carry 2 marks. Part 'B' of the question paper shall be divided into FOUR units. Each unit will contain TWO questions and each question will have two subparts. Student has to attempt one question from each unit. Each question is of 20 marks.

**M. A. / M. Sc. ( Final ) Examination 2022**

Five Papers (Two compulsory and three optional(elective) papers)

Total Max Marks 500 for regular and non collegiate students.

Paper	Name of paper	Teaching hrs per weak	Exam Duration	Max Marks
Compulsory Papers				
I	Functional Analysis	6	3	100
II	Fluid Dynamics	6	3	100
Optional Papers (Any three of the following)				
III	Mathematical Programming	6	3	100
IV	Mathematical Theory of Statistics	6	3	100
V	Combinatorics and Graph Theory	6	3	100
VI	Integral Transforms and Integral Equations	6	3	100
VII	Relativistic Mechanics and Cosmology	6	3	100
VIII	Advanced Numerical Analysis	6	3	100
IX	Continuum Mechanics	6	3	100
X	Boundary Layer Theory	6	3	100

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## Functional Analysis

Teaching : 6 hours per week

Theory Paper

Exam Duration: 3 Hours

Maximum Marks 100

**Note :-** The syllabus of this paper is divided into four units. There shall be two parts in the question paper. Part 'A' of the question paper shall contain FIRST question which is compulsory. The first question shall contain 10 subparts consisting of very short answer type questions based on the knowledge, understanding and applications of the topics covering the syllabus of all four units. Each question of subpart will carry 2 marks. Part 'B' of the question paper shall be divided into FOUR units. Each unit will contain TWO questions and each question will have two subparts. Student has to attempt one question from each unit. Each question is of 20 marks.

**Unit-I :** Normed Linear Space- Topological properties of normed linear spaces, Equivalent norms, Quotient normed linear spaces, Banach Spaces - Banach spaces and examples. Bounded linear transformations, Normed linear space of bounded linear transformations.


**Unit-II :** Open mapping theorem, Closed graph theorem, Uniform boundedness principle, Conjugate of an operator, Uniform boundedness theorem, Inner product space, Hilbert space and its properties, Orthogonality and functionals in Hilbert space, Pythagorean theorem, Projection theorem, Orthonormal sets, Bessel's inequality, Complete orthonormal sets.

**Unit-III :** Adjoint of an operator on a Hilbert space, Self adjoint, normal and unitary operators and their properties, Projection on a Hilbert space, Invariance, Reducibility, Orthogonal projections. The space of Continuous functions, Stone-Weierstrass Approximation theorem, Equicontinuous sets, Derivative of a continuous map from an open subset of Banach space to a Banach space, Rules of differentiation, Derivative of a composite function, mean value theorems and its applications.

**Unit-IV :** Partial derivatives and Jacobian matrix, Continuously differentiable maps, Higher derivatives, Taylor's theorem, Taylor's formula. Fixed point theorems, inverse function theorem, implicit function theorem, step function, regulated function, primitive and integrals, differentiation under the integral sign, Riemann integral of function of real variable with values in normed linear space, solution of differential equation in normed linear space.

**Reference Books:**

1. J. Deudonne: *Foundations of Modern Analysis*; Academic Press, Newyork.
2. E. Kreyszig : *Introductory Functional Analysis with Applications*; John Wiley , Newyork.

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- 3. A. E. Taylor : *Introductory Functional Analysis*; John Wiley ; Newyork
- 4. B. D. Gupta : *Functional Analysis*; Students' Friends & Co. Raja Mandi, Agra.
- 5. G. N. Purohit : *Advanced Analysis*; Jaipur Publishing House, Jaipur.

Paper – II

Fluid Dynamics

Teaching : 6 hours per weak

Theory Paper

Exam Duration: 3 Hours

Maximum Marks 100

**Note :-** The syllabus of this paper is divided into four units. There shall be two parts in the question paper. Part 'A' of the question paper shall contain FIRST question which is compulsory The first question shall contain 10 subparts consisting of very short answer type questions based on the knowledge, understanding and applications of the topics covering the syllabus of all four units. Each question of subpart will carry 2 marks. Part 'B' of the question paper shall be divided into FOUR units . Each unit will contain TWO questions and each question will have two subparts. Student has to attempt one question from each unit . Each question is of 20 marks.

**Unit-I :** Kinematics- Approaches of study, Lagrangian and Eulerian methods, Equation of continuity by Eulerian method ( in vector form, Cartesian coordinates, Spherical polar coordinates, Cylindrical coordinates). Boundary surface, Stream lines, path lines and streak lines, Velocity potential, Rotational and irrotational motion, Equations of Motion- Euler's dynamical equation of motion, Bernoulli's equation and its applications.

**Unit-II :** Motion in two dimensions- Stream function, Complex potential, Stagnation points, sources, sinks, doublets, Images in two dimensions. Motion of a sphere – Motion of a sphere through an infinite mass of a liquid at rest, Liquid streaming past a fixed sphere, Equation of motion of a sphere, Pressure distribution on a sphere, Concentric spheres(initial motion). Rectilinear Vortices(vortex motion)- vorticity, vortex line, vortex tube, Helmholtz's vorticity theorem.

**Unit-III :** Theory of stress and strain- Viscosity, stress, stress vector and stress tensor, principal stresses, principal directions stress tensor, strain, normal and shearing strain, Stoke's law of friction, Thermal conductivity and generalised law of heat conduction, Equation of state and continuity, Naveir-Stoke's equation of motion. Dynamical similarity, Inspectional and dimensional analysis , Bukiingham theorem and its applications, non-dimensional parameters and their physical significance, Reynolds number, Froude number, Mach number, Prandtl number, Eckart number, Grashoff, number, Brickmann number, non-dimensional coefficient, Exact solution of Naveir-Stoke's equations, steady incompressible flowwith constant fluid properties, Flow between parallel plates.

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**Unit-IV :** Flow in a circular pipe (Hagen Poiseuille flow), Flow in a tube of uniform cross section, Flow between two concentric rotating cylinders, flow in convergent and divergent channels, Stagnation point flows, Homann flow, flow due to rotating disc, variable viscosity plane Couette flow, Unsteady incompressible flow with constant fluid properties, flow due to an accelerated plane wall, Flow due to plane wall suddenly set in motion, Flow due to an oscillating plane wall, starting flow in a plane Couette motion, starting flow in a pipe, Steady compressible flow, plane Couette flow with transpiration cooling. Theory of very slow motion, Stoke and ocean's flow past a sphere.

**Reference Books:**

1. F. Chorlton : *A Text Book of Fluid Dynamics*; CBC, 1985
2. S. W. Yuan : *Foundations of Fluid Mechanics*; Prentice-hall, New Delhi.
3. S. I. Pai : *Viscous Flow Theory I – Laminar Flow*; D. Van Nostrand Co. , Ing., N. Y.
4. M. D. Raisinghania : *Hydrodynamics*; S.Chand & Co. New Delhi.
5. H.S. Sharma, G.C. Sharma, R.G. Sharma: *Hydrodynamics*; Shival Agrawal & Co. Agra
6. M. Ray and G.C. Chadda: *A Text Book of Hydrodynamics*; Students' Friends & Co. Agra
7. J. L. Bansal : *Viscous Fluid Dynamics*; J P H, Jaipur

**Paper – III**

**Mathematical Programming**

**Teaching : 6 hours per week**

**Theory Paper**

**Exam Duration: 3 Hours**

**Maximum Marks 100**

Note :- The syllabus of this paper is divided into four units. There shall be two parts in the question paper. Part 'A' of the question paper shall contain FIRST question which is compulsory The first question shall contain 10 subparts consisting of very short answer type questions based on the knowledge, understanding and applications of the topics covering the syllabus of all four units. Each question of subpart will carry 2 marks. Part 'B' of the question paper shall be divided into FOUR units . Each unit will contain TWO questions and each question will have two subparts. Student has to attempt one question from each unit . Each question is of 20 marks.

**Unit – I :** Separating and supporting hyperplane theorems, Revised simplex method to solve linear programming problems, Integer programming; Gomory's algorithm for all and mixed integer programming problems, Branch and bound algorithm.

**Unit-II :** Separable Programming: Piecewise linear approximations to non linear functions, Reduction of separable programming problem to l p p, Separable programming algorithm; Dynamic Programming: Introduction, Bellman Principle of optimality, solution of problems with finite number of stages, Solution of l p p by dynamic programming.

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**Unit-III :** Convex functions, Quadratic forms, Constrained problems of maxima minima, Lagrange's method, Non linear programming: Formulation and graphical method, Non linear programming and its fundamental ingredients, Kuhn Tucker necessary and sufficient conditions, Saddle point and saddle point theorems.

**Unit- IV :** Quadratic Programming: Kuhn-Tucker conditions, Wolfe's method, Duality in quadratic programming, Beale's method to solve QPP, Geometric Programming: Formulation, geometric arithmetic inequality, necessary conditions of optimality.

**Reference Books:**

1. F. S. Hillier and G. J. Lieberman: *Mathematical Programming*; Tata McGraw Hill
2. G. Hadley: *Non Linear and Dynamic Programming*; Addison Wesley Pub Co Massachusetts, London.
3. N. S. Kambo : *Mathematical programming*; Wiley Eastern Pvt Ltd, New Delhi
4. Kanti Swaroop : *Operations Research*; Sultan Chand & Sons, New Delhi.
5. S.D. Sharma: *Non Linear and Dynamic Programming*; Kedarnath Ramnath & Co., Meerut
6. S. K. Mittal and C. P. Sethi : *Linear Programming* ; Pragati Prakashan, Meerut.

**Paper – IV**

**Mathematical Theory of Statistics**

**Teaching : 6 hours per week**

**Theory Paper**

**Exam Duration: 3 Hours**

**Maximum Marks 100**

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**Unit –I : Probability :** Classical and Empirical definition, Axiomatic approach, Sample space, Mutually exclusive and compound events, Addition theorem, Conditional probability, Mathematical Expectation, Baye's theorem. Continuous Frequency Distributions : Chi-square distribution, sum of random variables, Convolution, Marginal and Conditional Probabilities,

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Chebyshev's and Markov inequalities, Bivariate distributions, Marginal distribution, Binomial distribution.

**Unit- II** : Poisson distribution, Normal distribution, Fitting of Normal distribution, Central limit theorem, Laws of large numbers, Weak law of large number numbers, Method of Least Squares and Curve Fitting. Bivariate Distributions : Correlation and Regression coefficients, Rank correlation, Cauchy and Schwarz's Inequalities, Multiple and Partial Correlation, Association of attributes.

**Unit-III** : Index number: Introduction, Price relatives, Quantity relatives, Value relatives, Link and Chain relatives. Aggregate methods, Fisher's ideal index, Change of the base of the index numbers. Moment Generating Function and Cumulants, Characteristic Function. Sampling: Simple Sampling of Attributes, Test of Significance, Comparison of Large Samples, Testing of Hypothesis, Null Hypothesis, Levels of Significance, Fiducial and Confidence Limit, Test of Significance of the means of two large samples.

**Unit-IV** :  $\chi^2$ - distribution, Test of goodness of fit, Test for Independence, Yate's Correction for Continuity, t- distribution, z- test, F- distribution, Test of Significance of correlation coefficient (Small Samples). Analysis of Variance, Two Criterion of Classification, Design of Experiments, Randomization and Latin Squares, Estimation, Method of Maximum of Likelihood, Maximum Likelihood Estimation, Consistent Estimator. Efficiency Estimator, Sufficient Estimator, Simple and Composite Hypothesis, Neymen-Pearson Lemma

#### Reference Books:

1. S. M. Ross : *Introduction to Probability Models*; Academic Press, N. Y.
2. S. C. Gupta and V. K. Kapoor : *Fundamentals Mathematical Statistics*; Sultan Chand & Sons, New Delhi.
3. J. K. Goyal and J. N. Sharma : *Mathematical Statistics*; Krishna Prakashan, Meerut.
4. Ray, Sharma and Chaudhary : *Mathematical Statistics*; Ram Prasad & Sons, Agra
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#### Paper - V

##### Combinatorics and Graph Theory

Teaching : 6 hours per week

Theory Paper

Exam Duration: 3 Hours

Maximum Marks 100

**Note :-** The syllabus of this paper is divided into four units. There shall be two parts in the question paper. Part 'A' of the question paper shall contain FIRST question which is compulsory The first question shall contain 10 subparts consisting of very short answer type questions based on the knowledge, understanding and applications of the topics covering the syllabus of all four units. Each

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question of subpart will carry 2 marks. Part 'B' of the question paper shall be divided into FOUR units. Each unit will contain TWO questions and each question will have two subparts. Student has to attempt one question from each unit. Each question is of 20 marks.

**Unit-I : Combinatorics-** Counting of sets and multi-sets, binomial and multinomial numbers, unordered section with repetitions, selection without repetition. Counting objects and functions. Functions and the Pigeonhole principle. Discrete numeric functions and combinatorial problems. Generating function and recursions. Power series and their algebraic properties. Homogeneous recursions.

**Unit- II : Graphs-** Basic terminology, simple graphs, multi graphs, weighted graphs. Walk and connectedness, Paths and circuits, Shortest paths in weighted graphs, Eulerian paths and circuits. Travelling salesman problem, operations on graphs. Trees- Trees, rooted trees, path-lengths in rooted trees, spanning trees.

**Unit-III : Cut sets-** Cut sets, cut vertices, fundamental cut sets, connectivity and separativity, network flows. **Planner graphs-** Combinatorial and Geometric graphs, Kuratowski's graphs, Euler's formula, Detection of planarity, Geometric dual.

**Unit-IV :** Graph colouring, vertex colouring, Edge colouring and Map colouring, Chromatic number, Chromatic polynomials, The four colour theorems. **Digraphs-** Binary relations, Directed graphs and directed trees, Arborescence, Polish notation method, Tournaments. Counting of labelled trees- caley's theorem, Counting methods .

**Reference Books:**

1. C. L. Liu : *Elements of Discrete Mathematics*; McGraw-Hill , Newyork
2. N. Deo: *Graph Theory with Applications to Computer Science*; PHI
3. Ian Anderson: *A First Course Combinatorial Mathematics*; Springer
4. J. P. Tremblay and R. Manohar: *Discrete Mathematical Structures with Applications to Computer Science*; McGraw Hill Book Co., N. Y.

**Paper – VI**

**Integral Transforms and Integral Equations**

Teaching : 6 hours per weak

Theory Paper

Exam Duration: 3 Hours

Maximum Marks 100

**Note :-** The syllabus of this paper is divided into four units. There shall be two parts in the question paper. Part 'A' of the question paper shall contain FIRST question which is compulsory The first question shall contain 10 subparts consisting of very short answer type questions based on the knowledge, understanding and applications of the topics covering the syllabus of all four units. Each

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question of subpart will carry 2 marks. Part 'B' of the question paper shall be divided into FOUR units. Each unit will contain TWO questions and each question will have two subparts. Student has to attempt one question from each unit. Each question is of 20 marks.

**Unit -I :** Laplace Transform- Definition and its properties, Rules of manipulation, Laplace transform of derivatives and integrals, Properties of inverse Laplace transform, Convolution theorem. Fourier transform- Definition and properties of Fourier sine, cosine and complex transforms. Convolution theorem, Inversion theorems.

**Unit- II :** Mellin Transform- definition and properties of Mellin transform, Mellin transform of derivatives and integrals, Inversion theorem, Convolution theorem. Hankel transform- Definition and properties of Hankel transform, Hankel transform of derivatives, Inversion theorem. Solution of Ordinary differential equations with constant and variable coefficients by Laplace Transforms.

**Unit -III :** Solution of boundary value problems by Laplace, Fourier and infinite Hankel transforms. Linear Integral Equations- Definition and classification, conversion of initial and boundary value problems to the integral equations, Eigen values and Eigen functions, Solution of homogeneous integral equations of second kind with separable kernels. Solution of Fredholm and Volterra integral equations of second kind by methods of successive substitutions and successive approximations. Resolvent kernel and its results.

**Unit- IV :** Conditions of uniform convergence and uniqueness of series solutions. Integral Equations with symmetric kernels- Orthogonal system of functions, Fundamental properties of eigen values and eigen functions for symmetric kernels. Expansion in eigen functions and bilinear forms, Hillbert-Schmidt theorem. Solution of Volterra integral equations of second kind with convolution type kernels by Laplace transforms, Solution of singular integral equations by Fourier transform. Classical Fredholm theory- Fredholm theorems.

#### Reference Books:

1. M. R. Spiegel : *Laplace Transforms (SCHAUM Outline Series)*, McGraw Hill
2. Shanti Swaroop: *Integral Equations*; Krishna Publication, Meerut.
3. D. C. Gokhroo and J.P.N. Ojha: *Integral Transforms*; JPH, Jaipur.
4. L. G. Chambers: *Integral Equations: A short Course*; Text Book Co. Ltd.
5. S. S. Seth: *Integral Transforms*; Students' Friends & Co. Raja Mandi, Agra-282002
6. J. K. Goyal and K. P. Gupta: *Integral Transforms*; Pragati Prakashan, Meerut
7. S. P. Goyal and A. K. Goyal *Integral Transform* JPH,
8. S. P. Goyal and A. K. Goyal *Integral Equations* JPH

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Paper – VII

Relativistic Mechanics and Cosmology

Teaching : 6 hours per week

Theory Paper

Exam Duration: 3 Hours

Maximum Marks 100

Note :- The syllabus of this paper is divided into four units. There shall be two parts in the question paper. Part 'A' of the question paper shall contain FIRST question which is compulsory The first question shall contain 10 subparts consisting of very short answer type questions based on the knowledge, understanding and applications of the topics covering the syllabus of all four units. Each question of subpart will carry 2 marks. Part 'B' of the question paper shall be divided into FOUR units. Each unit will contain TWO questions and each question will have two subparts. Student has to attempt one question from each unit. Each question is of 20 marks.

Unit – I : Relative Character of space and time, Principle of relativity and its postulates, derivation of special Lorentz transformation equations, Composition of parallel velocities, Time dilation. Simultaneity, Relativistic transformation formulae for velocity, Lorentz contraction factor, Particle acceleration, velocity of light as fundamental velocity, relativistic aberration and its deduction to Newtonian theory.

Unit -II : Variation of mass with velocity, equivalence of mass and energy, transformation formula for mass, momentum and energy, problems on conservation of mass, Momentum and energy. Minkowski's space, space-like, time-like and light-like intervals, Null cone, Relativity and Causality, Proper time, World line of a particle.

Unit-III : 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, Schwarzschild exterior metric, its isotropic form, Singularity and singularities in Schwarzschild exterior metric, derivation of the formula  $GM = c^2m$ , mass of sun in gravitational unit.

Unit- IV: 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. Lorentz invariance of Maxwell's equations in empty space, Lorentz force on charged particle, Energy-momentum tensor for electro-magnetic field, Einstein's field equation with cosmological term, static cosmological models ( Einstein & de-Sitter models ) with physical and geometrical properties, Non-static form of de-Sitter line-element and Red shift in this metric.

Reference Books:

1. Satya Prakash: *Relativistic Mechanics* ; Pragati Prakashan, Meerut.

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2. J. V. Narlikar: *Lectures on General Relativity and Cosmology*; Macmillan Co. Ltd, India
3. J. L. Anderson: *Principles of Relativity Physics*; Academic Press, London
4. Rajbali : *Relativity and Cosmology*; JPH., Jaipur

**Paper – VIII**

**Advanced Numerical Analysis**

**Teaching : 6 hours per weak**

**Theory Paper**

**Exam Duration: 3 Hours**

**Maximum Marks 100**

**Note :-** 1. The syllabus of this paper is divided into four units. There shall be two parts in the question paper. Part 'A' of the question paper shall contain FIRST question which is compulsory The first question shall contain 10 subparts consisting of very short answer type questions based on the knowledge, understanding and applications of the topics covering the syllabus of all four units. Each question of subpart will carry 2 marks. Part 'B' of the question paper shall be divided into FOUR units Each unit will contain TWO questions and each question will have two subparts. Student has to attempt one question from each unit . Each question is of 20 marks.

2. Scientific calculator is to be permitted for numerical calculation.

**Unit – I :** Numerical solution of Algebraic and transcendental equations: Iteration methods based on first degree equation – Secant and Regula-Falsi methods, Newton-Raphson method; Iterative methods based on second degree equation - Chebyshev method, Muller's method, methods for multiple and complex roots, Rate of Convergence, General iteration methods Acceleration of convergence, Newton-Raphson method for simultaneous equations, Convergence of iteration process in the case of several unknowns. Polynomial equations: Descartes' rule of signs, Sturm functions and Sturm sequences, Real and complex roots, synthetic division, Graeffe's root squaring method.

**Unit-II :** Solution of system of simultaneous linear equations: LU factorization method, Doolittle's, Crout's and Cholesky's partition methods, method of successive approximation, relaxation methods. Eigen value problems: Basic properties of Eigen values and Eigen vectors, Power method, Method for finding all eigen values of a matrix, Jacobi's, Given's method, Householder's method.

**Unit- III:** Numerical Solution of Ordinary Differential Equations Initial Value problems: local truncation error, Convergence Stability, Euler's method- backward and mid point Euler's methods, Singlestep methods, Taylor's series method, Picard method, Runge-Kutta methods upto fourth order, Multi-step method- Explicite multi-step method, Adoms Basforth method, Nystrom method, Predictor and Corrector method.

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**Unit-IV : Boundary Value Problems of Ordinary differential equations:** Boundary value problems (BVP's), Boundary conditions of first kind, second kind and third kind, Shooting method (Initial value problem method), Linear and nonlinear second order differential equations. Finite difference methods, Difference schemes for linear boundary value problems of the type-  $y'' = f(x,y)$ ,  $y'' = f(x,y,y')$ . Convergence and Stability of finite difference schemes. Finite Element methods: Solution of variation problem, Ritz method, Finite elements solution of linear boundary value problems, Assembly of element equations, Mixed boundary conditions..

**Reference Books:**

1. M. K. Jain, S.R.K. Eyenger and R.K. Jain: *Numerical Methods for Mathematics and Physicists*; Wiley Eastern, New Delhi
2. C.E. Froberg: *Introduction to Numerical Analysis*; Addison Wesley, N. Y.
3. S. S. Satry: *Introduction to Numerical Analysis*; PHI, New Delhi
4. S. D. Conte and C. De Boor: *Elementary Numerical Analysis*; McGraw-Hill, N.Y.

**Paper – IX**

**Continuum Mechanics**

**Teaching : 6 hours per week**

**Theory Paper**

**Exam Duration: 3 Hours**

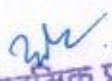
**Maximum Marks 100**

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**Unit – I :** Cartesian Tensors, Index notation and transformation laws of Cartesian tensors, Addition, Subtraction and Multiplication of Cartesian tensors, Gradient of a scalar function, Divergence of a vector function and Curl of a vector function using index notation,  $\epsilon$ - $\delta$  identity, Conservative vector field and concept of a scalar potential function, Stocke's, Gauss's and Green's theorems. Continuum approach, Classification of continuous media, Body forces and surface forces, Components of stress tensor

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**Unit-II :** Force and Moment equations of equilibrium, transformation of laws of stress tensor ; Stress quadric, Principal stress and principal axes , Stress invariants and stress deviator, maximum shearing stress. Lagrangian and Eulerian description of deformation of flow, Comoving derivative , Velocity and Acceleration, Continuity equation, Strain tensors, Linear rotation tensor and rotation vector, Analysis of relative displacements. Geometric meaning of the components of the linear stress tensor, properties of linear strain tensors, Principal axes, Theory of linear strain. Linear strain components.

**Unit- III:** Rate of strain tensors. The vorticity tensor, rate of rotation vector and vorticity, properties of rate strain tensor, rate of cubical dilation. Law of conservation of mass and Eulerian continuity equation, Reynold's transport theorem, Momentum integral equation and equation of motion, Kinetic equation of state. First and second law of thermodynamics and dissipation function, Applications ( Linear elasticity and Fluids ) – Assumptions and basic equations. Generalised Hooks' law for an isotropic homogeneous solid.

**Unit-IV :** Compatibility equations ( Beltrami – Michell equation ), Classification of types of problems in linear elasticity. Principle of superposition, Strain energy function, Uniqueness theorem, p-p relationship and work kinetic energy equation, irrotational flow and velocity potential, Kinetic equation of state and first law of thermodynamics, Equation of continuity. Equation of motion, Vorticity - stream surfaces for inviscid flow, Bernaulli's equations, Irrotation flow and velocity potential, Similarity parameters of fluid flows.

**Reference Books:**

1. T. J. Chung: *Continuim Mechanics*; Prenice- Hall, India
2. A. C. Eringen: *Mechnics of Continua*; John Wiley, N. Y.

**Paper – X**

**Boundary Layer Theory**

**Teaching : 6 hours per weak**

**Theory Paper**

**Exam Duration: 3 Hours**

**Maximum Marks 100**

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 भरतपुर (राज.)



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units. Each unit will contain TWO questions and each question will have two subparts. Student has to attempt one question from each unit. Each question is of 20 marks.

**Unit - I :** Derivation of boundary layer equations for two dimensional flow, boundary layer along a flat plate ( Blasius Topfer solution ), Characteristic boundary layer parameters, similar solutions, Exact solution of the steady state boundary layer equations in two dimensional flow, Flow past a wedge, Flow along the wall of a convergent channel, Boundary layer separation. Flow past a symmetrically placed cylinder ( Blasius series solution), Gortler new series method.. Plan free jet, Circular jet, Plane wall jet.

**Unit-II :** Prandtl-Mises transformation and its application of plane free jet, Axially symmetrical boundary layers on bodies at rest, Boundary layers on a body of revolution, Mangler's transformation. Three dimensional boundary layers – Boundary layer flow on yawed cylinder, Growth three dimensional boundary layer on a rotating disc impulsively set in motion. Unsteady boundary layers – method successive approximation, Boundary layer growth after impulsive start of motion.

**Unit- III:** Boundary layer for periodic flow (Pulsatile pressure gradient). Approximate methods for the solution of the boundary layer equations, Karman momentum integral equation, Karman- Pohlhausen method and its application, Waltz – Thwaites method. Energy integral equation, Derivation of two dimensional thermal boundary layer equation for flow over a plane wall.

**Unit-IV :** Forced convection in a laminar boundary layer on a flat plate, Crocco's first and second integral s, Reynold's analogy. Temperature distribution in the spread of a jet – (i) Plane free jet, (ii) Circular jet (iii) Plane wall jet. Free Convection from a heated vertical plate, Thermal energy integral equation. Approximate solution of the Pohlhausen's problem of free convection from a heated vertical plate.

**Reference Books:**

1. S. I. Pai: *Viscous Flow Theory I: Leminar Flow*; D. Van Nostrand Co. Ing.
2. S. W. Yuan: *Foundations of Fluid Mechanics*; Prentice Hall
3. H. Schlichting: *Boundary Layer Theory*; McGraw-Hill
4. K. Stewartson: *The theory of Leminar Boundary layersin Compressible Fluids*; Clarendon Press, Oxford.

(Dr. K. C. Sharma)

External Member .

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(Dr. Ashok Kumar Roy) Convener

(Dr. K. C. Sharma) Ext. Member

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