
# MAHARAJA SURAJMAL BRIJ UNIVERSITY, BHARATPUR

## SYLLABUS

## M.A./M.Sc MATHEMATICS
## (SEMESTER SYSTEM)
### SEMESTER I, II, III & IV

अकादमिक प्रभारी
महाराजा सूरजमल बृज विश्वविद्यालय
भरतपुर (राज.)

# Maharaja Surajmal Brij University, Bharatpur (Raj)

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

### Syllabus

**Scheme of Examination:-** There shall be twenty papers in four semesters of two years duration and five papers in each semester. In first and second semesters all five papers are compulsory. In third and fourth semesters 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.

## FIRST SEMESTER (I)

Five Compulsory Papers

Total Max Marks 600 for regular students and 500 for non-collegiate. No internal assessment for non-colegiate students.

| Paper | Name of paper | Teaching hrs per weak | Exam Duration | Max. Marks | Internal assessment |
|---|---|---|---|---|---|
| MC101 | Advance Abstract Algebra | 6 | 3 | 100 | 20 |
| MC102 | Real Analysis | 6 | 3 | 100 | 20 |
| MC103 | Differential Equations | 6 | 3 | 100 | 20 |
| MC104 | Differential Geometry | 6 | 3 | 100 | 20 |
| MC105 | Dynamics of Rigid Bodies | 6 | 3 | 100 | 20 |

## SECOND SEMESTER

Five Compulsory Papers

Total Max Marks 600 for regular students and 500 for non-collegiate. No internal assessment for non-collegiate students.

| Paper | Name of paper | Teaching hrs per weak | Exam Duration | Max. Marks | Internal assessment |
|---|---|---|---|---|---|
| MC201 | Advance Linear Algebra | 6 | 3 | 100 | 20 |
| MC202 | Topology | 6 | 3 | 100 | 20 |
| MC203 | Calculus of Variations and Special Functions | 6 | 3 | 100 | 20 |
| MC204 | Reimannian Geometry and Tensor Analysis | 6 | 3 | 100 | 20 |
| MC205 | Operations Research | 6 | 3 | 100 | 20 |



Chairperson
BOS Maths

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## M. A./M. Sc. Semester-I Examination Dec-2018

**Note :** 1. All five papers in Semester - I are compulsory.

2. Continuous assessment (Internal) will be done by the teacher concerned on the basis of test papers, regularity in the class and performance of the candidate. Maximum marks in continuous assessment of each paper is 20.It will be for regular students only.

### Paper – I : MC 101

### Advanced Abstract Algebra

**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:** 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).

**Unit-II :** Normal Series, Solvable groups, Zassenhaus Lemma. Composition Series, Maximal Normal Subgroup, Refinement Theorem, Jordan-Holder theorem. p-groups, Class Equation, Cauchy's theorems, Sylow theorems.

**Unit- III :** 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.

**Unit- IV :** Galios Theory- The elements of Galios Theory, Automorphism of extensions, Fundamental theorem of Galios Theory, Solution of polynomial equations by radicals, Insolvability of general equation of degree five by radicals. Modules- Sub modules, quotient modules, cyclic modules, simple modules, semi simple modules, Schuler's lemma, free modules.

## Paper – II : MC 102

## Real Analysis

**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 :** 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.

**Unit-II :** 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, Convergence in measure, F Reisz theorem, Structure of measurable functions, Weierstrass's theorem on the approximation of continuous functions by polynomials.

**Unit-III :** 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.

**Unit-IV :** Summability of Lebesgue integral- Space of summable functions, Space of square summable functions, Orthonormal system, Fourier series, Reisz-Fischer theorem. $L^p$ Space- Space of p-summable functions, Reisz-Holder's inequality, Reisz-Minkowsky inequality, Convergence in norm in $L^p$ space, Summable series.

## Paper – III : MC 103

## Differential 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*

*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 :** 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 :** Series solution- ordinary and singular point, radius of convergence, series solution near a singular point, method of differentiation, Cauchy-Euler equation, solution near a regular singular point (method of Frobenius), solution of Gauss-Hypergeometric equation.

**Unit-III :** 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.

**Unit-IV :** 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. Method of separation of variables-Laplace, Wave, and diffusion equations, Green's function, Eigen value formula for Green's function.

## Paper – IV : MC 104

## Differential Geometry

**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 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, Involutes and Evolutes, Bertrand curves, Spherical indicatrix, Fundamental theorem of space curve .

**Unit-II :** Envelops and Developable Surfaces- Envelope of one and two parameter family of surfaces, edge of regression, ruled surfaces, necessary and sufficient condition that a surface $z = f(x, y)$ should represent a developable surface; tangent, principal normal and binormal surfaces, Central point and line of Striction. Metric of a surface- first, second and third fundamental forms , Fundamental magnitudes of some important surfaces.

**Unit-III :** 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.

**Unit-IV :** Conjugate directions, Asymptotic lines, differential equation and theorems of asymptotic lines, curvature and torsion of asymptotic lines, Beltrami-Enneper's theorem,. Gauss's formulae, Gauss characteristic equation, Wiengarten formulae, Mainardi-Codazzi equations, Fundamental existence theorem for surfaces, Parallel surfaces and Bonnet's theorem, Gaussian curvature and mean curvature for a parallel surface.

## Paper – V : MC 105

## Dynamics of Rigid Bodies

**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 :** 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 :** Motion of a rigid body in two dimensions under finite forces- equation of motion, friction, pure rolling, slipping of rods, motion when one of the body is fixed, motion on a horizontal plane, motion when both the bodies are movable . Conservation of momentum- principle of conservation of linear momentum, principle of conservation of angular momentum, Sudden fixtures, principal of conservation of energy.

**Unit-III :** 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.

**Unit- IV :** Motion in three dimensions- Rigid body moving with one fixed point, moving axes and fixed axes, Euler's dynamical equations of motion, instantaneous axis, Eulerian angles, Euler's geometrical equations of motion, motion under no forces, motion under impulsive forces. Motion of top.

## M. A./M. Sc. Semester-II Examination May-2019 (II)

**Note :**1. All five papers in Semester - II are compulsory.

2. Continuous assessment (Internal) will be done by the teacher concerned on the basis of test papers, regularity in the class and performance of the candidate. Maximum marks in continuous assessment of each paper is 20. It will be for regular students only.

### Paper – I : MC 201

### Advanced Linear Algebra

**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 :** 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.

**Unit-II :** Matrices- Matrices of linear transformations, Matrices of composition maps, Matrices of Dual maps, change of basis, similarity of matrices, trace of matrix, invertible matrices, invariance, reducibility, projections, adjoint or transpose of linear transformations, adjoint of projections.

**Unit-III :** 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.

**Unit-IV :** 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-Schmdt orthogonalization theorem , Bessel's inequality, orthogonal complements, linear maps on inner product spaces, adjoint of a linear transformation, principal axis theorem, normal operators, Spectral theorem. Quadratic forms, reduction and classification of quadratic forms.

## Paper – II : MC 202

## Topology

**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 :** 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.

**Unit-II :** 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, Sequence convergence of a set, Cluster point, subnet, Isotone mapping. Filters and Ultra filters: Co-finite filters, Convergent filters, Zorn's lemma .

**Unit-III :** Separation axioms( $T_0, T_1, T_2, T_3, T_4$ ), normal spaces, regular spaces, Tychonoff space, Completely normal, Huasdorff 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.

**Unit IV :** Product and Quotient spaces: Product topology, Projection maps, Tychonoff topology, Embedding, Tychonoff cube, Hausdorff maximal principle, Alexander sub base lemma, Tychonoff's one point Compactification, Stone-Cesh Compactificatiopn theorem Connected and Locally connected spaces, Continuity and Connectedness.



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**Paper – III : MC 203**

## Calculus of Variations and Special Functions

**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 :** 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.

**Unit-II :** 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, Zeros of $P_n(x)$, Legendre polynomial $Q_n(x)$, recurrence relations , relation between $P_n(x)$ and $Q_n(x)$, properties of $Q_n(x)$, Christoffel's second summation formula, Newman's Integral.

**Unit-III :** 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, Leguerre's Function- Leguerre's differential equation and its solution, Leguerre's polynomials, generating function, orthogonal property, recurrence relations.

**Unit-IV :** Gauss-Hypergeometric equation and its solution- hypergeometric function, integral representation, Guass'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.

**Paper – IV : MC 204**

## Reimannian Geometry and Tensor Analysis

**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 :** 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, Lioville'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, Geodesic coordinates and geodesic parallels, Existence theorem, isometric lines.

**Unit-II :** 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, angle between two vectors, Permutation symbols and Permutation tensors.

**Unit-III :** Christoffel's Symbols and Covariant Differetiation- 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.

**Unit-IV :** Parallelism of vectors- parallelism in subspace, Fundamental theorem of local Riemannian Geometry, Riemann-Christoffel tensor and its properties, Ricci's Tensor, Covariant curvature tensor, Bianchi Identity, Flat space, Einstein Space, Schur's theorem.

**Paper – V : MC 205**

## Operations Research

**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 :** Introduction to O. R., Modelling and applications. Problems of Replacement- Introduction, concept of present value, replacement models and their solutions, mortality tables, group replacement method, staffing problems.

**Unit-II :** Inventory Control- Introduction, Classification of inventory models, Deterministic models, Economic lot-size models, production lot-size models, quantity discount, deterministic models with shortages, fixed time model, lost sales shortages, Multi-item deterministic models.

**Unit-III :** 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), M/M/c :(N/FIFO), $M/E_k/1$ :(infinity/FIFO).

**Unit-IV :** 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, algebraic method, Solution of two person zero-sum game by transforming into l. p. p. using Simplex method. Iterative method for approximate solution of game, Fundamental theorem of game theory. Method of oddments to solve game.

# Maharaja Surajmal Brij University, Bharatpur (Raj)

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

## Syllabus

**Scheme of Examination:-** There shall be twenty papers in four semesters of two years duration and five papers in each semester. In first and second semesters all five papers are compulsory. In third and fourth semesters 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.

## THIRD SEMESTER (III)

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

Total Max Marks 600 for regular students and 500 for non collegiate students.

| Paper | Name of paper | Teaching hrs per weak | Exam Duration | Max Marks | Int. assessment |
|---|---|---|---|---|---|
| Compulsory Papers | | | | | |
| MC301 | Functional Analysis | 6 | 3 | 100 | 20 |
| MC302 | Hydrodynamics | 6 | 3 | 100 | 20 |
| Optional Papers | | | | | |
| MO303 | Mathematical Programming I | 6 | 3 | 100 | 20 |
| MO304 | Mathematical Theory of Statistics I | 6 | 3 | 100 | 20 |
| MO305 | Combinatorics and Graph Theory I | 6 | 3 | 100 | 20 |
| MO306 | Integral Transforms | 6 | 3 | 100 | 20 |
| MO307 | Relativistic Mechanics | 6 | 3 | 100 | 20 |
| MO308 | Computational Techniques | 6 | 3 | 100 | 20 |



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## FOURTH SEMESTER

Five Papers (Two compulsory and three optional papers)

Total Max Marks 600 for regular students and 500 for non collegiate students.

| Paper | Name of paper | Teaching hrs per weak | Exam Duration | Max Marks | Int. assessment |
|---|---|---|---|---|---|
| Compulsory Papers | | | | | |
| MC401 | Operator Theory and Calculus in Banach Spaces | 6 | 3 | 100 | 20 |
| MC402 | Viscous Fluid Dynamics | 6 | 3 | 100 | 20 |
| Optional Papers | | | | | |
| MO403 | Mathematical Programming II | 6 | 3 | 100 | 20 |
| MO404 | Mathematical Theory of Statistics II | 6 | 3 | 100 | 20 |
| MO405 | Graph Theory II | 6 | 3 | 100 | 20 |
| MO406 | Integral Equation | 6 | 3 | 100 | 20 |
| MO407 | General Relativity and Cosmology | 6 | 3 | 100 | 20 |
| MO408 | Dissertation and Viva-voce | 6 | 3 | 100 | 20 |

**Note :-** Students offering optional papers MO303, MO304, MO305, MO306, MO307, MO308 in **third semester** will offer optional papers MO403, MO404, MO405, MO406, MO407, MO408 respectively in **fourth semester**. Thus prerequisite of the paper MO403 is MO303, for MO404 is MO304, for MO405 is MO305, for MO406 is MO306 for MO407 is MO307 and for MO408 is MO308.

## M. A./M. Sc. Semester-III Examination Dec-2018

**Note :** 1. The first two papers ( MO301 & MO302 ) in Semester-III are compulsory. The remaining three papers can be chosen from optional papers MO303, MO304, MO305, MO306, MO307, MO308.

2. Continuous assessment (Internal) will be done by the teacher concerned on the basis of test papers, regularity in the class and performance of the candidate. Maximum marks in continuous assessment of each paper is 20. It will be for regular students only.

## Paper – I : MC 301

## Functional Analysis

**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 :** Normed Linear Space- Topological properties of normed linear spaces, Equivalent norms, Quotient normed linear spaces, Reisz Theorem.

**Unit-II :** Banach Spaces – Banach spaces and examples. Bounded linear transformations, Normed linear space of bounded linear transformations, Haun-Banach Theorem and its consequences.

**Unit- III :** Open mapping theorem, Closed graph theorem, Uniform boundedness principle, Conjugate of an operator, Uniform boundedness theorem, Embedding and reflexivity of normed spaces, Dual spaces with examples.

**Unit-IV :** 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, Parseval's identity, Structure of a Hilbert space, Reisz representation theorem, Reflexivity of Hilbert space.

## Paper – II : MC 302

## Hydrodynamics

**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), Equation continuity by Lagrangian method,

Boundary surface, Stream lines, path lines and streak lines, Velocity potential, Rotational and irrotational motion,

**Unit-II** : Equations of Motion- Euler's dynamical equation of motion, Equation of motion under impulsive forces, Lagrange' equations, Cauchy's integral, Hemholtz equations, Bernoulli's equations and its application.

**Unit-III** : Motion in two dimensions- Stream function, Complex potential, Stagnation points, sources, sinks, doublets, Images in two dimensions, Milne-Thomson circle theorem, Theorem of Blasius.

**Unit-IV** : 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, rectilinear vortices, two vortex filament, image of a vortex filament in a plane, vortex doublet, Karman's vortex street.

## Paper – III : MO 303

## Mathematical Programming-I

**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** : Separating and supporting hyperplane theorems, Revised simplex method to solve linear programming problems, Bounded variable problems.

**Unit-II** : Integer programming: Gomory's algorithm for all and mixed integer programming problems, Branch and bound algorithm; Goal programming: Graphical goal attainment method, simplex method to solve goal programming problems.

**Unit- III**: Separable programming: Piecewise linear approximations to non linear functions, Reduction of separable programming problem to l p p, Separable programming algorithm; Fractional programming, computational procedure.

**Unit-IV** : Dynamic Programming: Introduction, Bellman Principle of optimality, solution of problems with finite number of stages, Solution of l p p by dynamic programming.

## Paper – IV : MO 304

### Mathematical Theory of Statistics-I

**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** : Sample space, combination of events, Statistical independence, Conditional probability, Bay's repeated trials, Random variable, Distribution function, Probability function, Density function.

**Unit-II** : Mathematical expectation, Generating function, Continuous probability distribution, Characteristic function, Fourier's inversion, Chebyshev and Kolmogorovea,s inequality, Weak and strong laws of large numbers. Normal distribution, Hypergeometric distribution.

**Unit- III**: Rectangular, Negative, Binomial, Beta, Gamma and Chauchy's distributions. Method of least squares and curve fitting.

**Unit-IV :** Correlation and regression coefficients, Association of attributes. Interpolation : Introduction, Newton-Gregory theorem , Newton, Lagrange, Gauss and Stirling formulae.

## Paper – V : MO 305

### Combinatorics and Graph Theory-I

**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 :** 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, inclusion and exclusion principle.

**Unit-II :** Discrete numeric functions and combinatorial problems. Generating function and recursions. Power series and their algebraic properties. Homogeneous and non-homogeneous recursions.

**Unit- III:** Graphs- Basic terminology, simple graphs, multi graphs, weighted graphs. Walk and connectedness, Paths and circuits, Shortest paths in weighted graphs, Eulerian paths and circuits, Hamiltonian paths and circuits.

**Unit-IV** : Travelling salesman problem, operations on graphs. Trees- Trees, rooted trees, path-lengths in rooted trees, spanning trees, minimum spanning trees.

**Paper – VI : MO 306**

**Integral Transforms**

**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 :** Laplace Transform- Definition and its properties, Rules of manipulation, Laplace transform of derivatives and integrals, Properties of inverse Laplace transform, Convolution theorem. Complex inversion formula.

**Unit-II :** Fourier transform- Definition and properties of Fourier sine, cosine and complex transforms. Convolution theorem, Inversion theorems, Fourier transform of derivatives.

**Unit- III:** Mellin Transform- definition and properties of Mellin transform, Mellin transform of derivatives and integrals, Inversion theorem, Convolution theorem.

**Unit-IV** : Hankel transform- Definition and properties of Hankel transform, Hankel transform of derivatives, Inversion theorem, Parseval Theorem.

## Paper – VII : MO 307

## Relativistic Mechanics

**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 :** Relative Character of space and time, Principle of relativity and its postulates, derivation of special Lorentz transformation equations, Composition of parallel velocities, Lorentz-Fitzgerald contraction formula, Time dilation.

**Unit-II :** 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- III:** 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, Relativistic Lagrangian and Hamiltonian .

**Unit-IV :** Minkowski's space, space-like, time-like and light-like intervals, Null cone, Relativity and Causality, Proper time, World line of a particle, Principle of equivalence and general covariance.

## Paper – VIII : MO 308

## Computational Techniques

**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, Acceleration of convergence, Chebyshev method, Muller's method, methods for multiple and complex roots, Newton-Raphson method for simultaneous equations, Convergence of iteration process in the case of several unknowns. Polynomial equations: Real and complex roots, synthetic division, Birge-Vieta method, Bairstow method, Graeffe's root squaring method.

**Unit-II :** Solution of system of simultaneous linear equations: LU factorization method, Doolitle'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 and Rutishauser method, Complex Eigen values.

**Unit- III:** Numerical Solution of Ordinary Differential Equations: Taylor's series method, Picard method, Runge-Kutta methods upto fourth order, Multi-step method, Predictor and Corrector method. Stability analysis- single and multi-step methods.

**Unit-IV :** Boundary Value Problems of Ordinary differential equations: Boundary value problems (BVP's), Shooting methods, Finite difference methods, Difference schemes for linear boundary value problems of the type- $y'' = f(x,y)$, $y'' = f(x,y,y')$, $y^{iv} = f(x,y)$.

## M. A./M. Sc. Semester-IV Examination May-2019 (IV)

**Note :** 1. The first two papers ( MO401 & MO402 ) in semester IV are compulsory. The remaining three papers can be chosen from optional papers MO403, MO404, MO405, MO406, MO407, MO408. The prerequisite of the paper MO403 is MO303, for MO404 is MO304, for MO405 is MO305, for MO406 is MO306 for MO407 is MO307 and for MO408 is MO308.

2. Continuous assessment (Internal) will be done by the teacher concerned on the basis of test papers, regularity in the class and performance of the candidate. Maximum marks in continuous assessment of each paper is 20. It will be for regular students only.

**Paper – I : MC 401**

## Operator Theory and Calculus in Banach Spaces

**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** : 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, Spectral analysis of self adjoint operators, Spectral theorem.

**Unit- II** : 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, Directional derivative, mean value theorems and its applications.

**Unit-III** : Partial derivatives and Jacobian matrix, Continuously differentiable maps, Higher derivatives, Taylor's theorem, Taylor's formula, Existence theorem on differentiable maps.

**Unit-IV** : 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, Lipschitz's property, Existence theorem, uniqueness theorem.

**Paper – II: MC 402**

## Viscous 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.*



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**Unit-I** : 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, Vorticity and Circulation.

**Unit-II** : Dynamical similarity, Inspectional and dimensional analysis , Bukingham 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, velocity and temperature distribution for plane couette flow, plane Poiseuille flow, generalised plane couette flow.

**Unit-III** : Flow in a circular pipe (Hagen Poisueille 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, Variable viscosity plane Poisueille flow.

**Unit IV** : 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, Stoke and ocean's flow past a cylinder, lubrication theory.

## Paper – III : MO 403

## Mathematical Programming-II

**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** : Convex functions, Quadratic forms, Constrained problems of maxima minima, Lagrange's method , Non linear programming: Formulation and graphical method .

**Unit-II** : Non linear programming and its fundamental ingredients, Kuhn Tucker necessary and sufficient conditions, Saddle point and saddle point theorems.

**Unit- III:** Quadratic Programming: Kuhn-Tucker conditions, Wolfe's method, Duality in quadratic programming.

**Unit-IV :** Beale's method to solve QPP, Geometric Programming: Formulation, geometric arithmetic inequality, necessary conditions of optimality.

## Paper – IV : MO 404

## Mathematical Theory of Statistics-II

**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** : 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. Elementary sampling theory, Distribution of means of samples for binomial, Chauchy, rectangular, and normal population.

**Unit-II :** Exact distributions of $\chi^2$, t, z and F. Statistics in samples from a normal population, their simple properties and applications. Elementary statistical theory of estimation, Fisher' criterion for the estimator

**Unit- III:** Consistent, Efficient and Sufficient estimators, method of maximum likelihood, maximum likelihood estimator, Other methods of estimation. Methods of moments, minimum variance, Minimum Chi-square and least squares.

**Unit-IV :** Test of significance and difference between two means and two standard deviations for the large samples with modification of small samples and taken from normal population. Analysis of variance, simple cases (one criteria and two criteria of classification).

## Paper – V : MO 405

## Graph Theory -II

**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.*



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**Unit – I :** Cut sets- Cut sets, cut vertices, fundamental cut sets, connectivity and separativity, network flows, Max-flow min-cut theorem.

**Unit-II :** Planner graphs- Combinatorial and Geometric graphs, Kuratowski's graphs, Euler's formula, Detection of planarity, Geometric dual, Thickness and crossing number.

**Unit- III:** Graph colouring, vertex colouring, Edge colouring and Map colouring, Chromatic number, Chromatic polynomials, The four and five colour theorems.

**Unit-IV :** Digraphs- Binary relations, Directed graphs and directed trees, Arborescence, Polish notation method, Tournaments. Counting of labelled trees- caley's theorem, Counting methods, Polya's theory .

## Paper – VI : MO 406

## 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 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 :** 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 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. Conditions of uniform convergence and uniqueness of series solutions.

**Unit- III:** 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 Fredholm integral equations of second kind by using Hillbert-Schmidt theorem.

**Unit-IV :** 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, solution of Fredholm integral equation of second kind by using Fredholm first theorem.

## Paper – VII : MO 407

## Relativity and Cosmology

**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 :** 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 .

**Unit-II :** 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, Relativistic differential equation for the orbit of the planet.

**Unit- III:** 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-IV :** 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, Einstein space, Hubble's law, Weyl's postulate.

## Paper – VIII : MO 408

## Dissertation and Viva-voce

( For regular students only )

**Maximum Marks 100 ( Dissertation – 50 marks, Viva-voce – 50 marks )**

**Internal Assessment – 20 marks**

**Dissertation :** A dissertation is to be written by each regular student on the topic of his interest under the supervision of an Assistant Professor/Associate Professor/Professor. It should depict the current development of the subject chosen. The dissertation is to be sent for evaluation to an external examiner. Maximum marks for the evaluation of the thesis are 50.

**Viva-voce :-** The viva-voce is to be conducted by inviting the external examiner. The maximum marks of the viva-voce are 50.

**Internal Assessment :-** The internal assessment is to be done by concern teacher.



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