S.S. JAIN SUBODH P.G. COLLEGE

RAM BAGH CIRCLE, JAIPUR-302004

DETAILED COURSE STRUCTURE & SCHEME OF EXAMINATION

AS PER

UGC CURRICULUM AND CREDIT FRAMEWORK FOR POST UNDERGRADUATE

PROGRAMMES UNDER NEP 2020

FOR

MASTER OF SCIENCE/ARTS (M.SC. / M.A.)

SUBJECT–MATHEMATICS

(2023-2024 & ONWARDS)

MEDIUM OF INSTRUCTION: ENGLISH

M.Sc. / M.A. Mathematics Programme Details

Programme Objectives (POs):

The M.Sc. Mathematics programme's main objectives are-

- To inculcate and develop mathematical aptitude and the ability to think abstractly in the student.
- To develop computational abilities and programming skills.
- To develop in the student the ability to read, follow and appreciate mathematical text.
- Train students to communicate mathematical ideas in a lucid and effective manner.
- To train students to apply their theoretical knowledge to solve problems.
- To encourage the use of relevant software such as MATLAB and MATHEMATICA.

Programme Specific Outcomes (PSOs):

On successful completion of the M.Sc. Mathematics programme a student will

- Have a strong foundation in core areas of Mathematics, both pure and applied.
- Be able to apply mathematical skills and logical reasoning for problem solving.
- Communicate mathematical ideas effectively, in writing as well as orally.
- Have sound knowledge of mathematical modeling, programming and computational techniques as required for employment in industry.

The Credit Courses have been classified as:

a) Discipline Specific Core (DSC)

b) Discipline Specific Elective (DSE)

Scheme for Choice Based Credit System of M.Sc. Mathematics

Semester - I						
S. No.	**Paper Code**	**Nomenclature of paper**	**Course Category**	**Credit**	**Contact hour per week**	**EoSE Duration (Hrs.)**
1.	MSMA101	Algebra -I	DSC	4	4	3
2.	MSMA102	Real Analysis	DSC	4	4	3
3.	MSMA103	Differential Equations-I	DSC	4	4	3
4.	MSMA104	Differential Geometry	DSC	4	4	3
5.	MSMA105	Dynamics of Rigid Bodies	DSC	4	4	3
6.	MSMA106	Calculus of Variation and Special Function-I	DSC	4	4	3
		Total Credit in the Semester		**24**		

Semester - II						
S. No.	**Paper Code**	**Nomenclature of paper**	**Course Category**	**Credit**	**Contact hour per week**	**EoSE Duration (Hrs.)**
1.	MSMA201	Algebra -II	DSC	4	4	3
2.	MSMA202	Topology	DSC	4	4	3
3.	MSMA203	Differential Equations-II	DSC	4	4	3
4.	MSMA204	Riemannian Geometry and Tensor Analysis	DSC	4	4	3

5.	MSMA205	Hydrodynamics	DSC	4	4	3
6.	MSMA206	Special Function-II	DSC	4	4	3
		Total Credit in the Semester		**24**		

EoSE: End of Semester Examination

Discipline Specific Elective

Elective Course	Specialization	Paper	Prerequisite	Credit
MSMA304A	MP	Mathematical Programming-I	-	4
MSMA304B	CM	Continuum Mechanics-I	-	4
MSMA305A	RC	Relativistic Mechanics	-	4
MSMA305B	CA	Computer Applications-Theory	-	4
MSMA306A	NA	Numerical Analysis -I	-	4
MSMA306B	CC	Certificate Course on Swayam/ MOOCs/ Coursera portal.	-	4
MSMA404A	MP	Mathematical Programming-II	MSMA304A	4
MSMA404B	CM	Continuum Mechanics-II	MSMA304B	4
MSMA405A	RC	General Relativity and Cosmology	MSMA305A	4
MSMA405B	CA	Computer Applications-Practical	MSMA305B	4
MSMA406A	NA	Numerical Analysis -II	MSMA306A	4
MSMA306B	CC	Certificate Course on Swayam/ MOOCs/ Coursera portal.	-	4

Semester – III						
S. No.	**Paper Code**	**Nomenclature of paper**	**Course Category**	**Credit**	**Contact hour per week**	**EoSE Duration (Hrs.)**
1.	MSMA301	Functional Analysis-I	DSC	4	4	3
2.	MSMA302	Viscous Fluid Dynamics-I	DSC	4	4	3
3.	MSMA303	Integral Transforms	DSC	4	4	3

Candidates are required to opt any three elective core courses (4 credits each) from MSMA304A/MSMA304B, MSMA305A/MSMA305B and MSMA306A/MSMA306B. Student has to take Prior permission by the Head of the Department for the online Certificate Course on Swayam/ MOOCs/ Coursera portal.

Total Credit in the Semester 24

Semester – IV						
S. No.	**Paper Code**	**Nomenclature of paper**	**Course Category**	**Credit**	**Contact hour per week**	**EoSE Duration (Hrs.)**
1.	MSMA401	Functional Analysis-II	DSC	4	4	3
2.	MSMA402	Viscous Fluid Dynamics-II	DSC	4	4	3
3.	MSMA403	Integral Equations	DSC	4	4	3
4.	MSMA451	Project/ Dissertation	DSC	4	-	-

Candidates are required to opt the corresponding three elective core courses of same specialization cluster obtained in Semester Third (4 credits each) from MAMA404A/MAMA404B, MAMA405A/MAMA405B and MAMA406A/ MAMA406B. Student has to take Prior permission by the Head of the Department for the online Certificate Course on Swayam/ MOOCs/ Coursera portal. A Project/ Dissertation work is a compulsory course to be taken up in the Fourth Semester. This work will be of 4 Credits. The Project work will be of 100 Marks.

Total Credit in the Semester 28

Scheme for Choice Based Credit System of M.A. Mathematics

Semester - I						
S. No.	**Paper Code**	**Nomenclature of paper**	**Course Category**	**Credit**	**Contact hour per week**	**EoSE Duration (Hrs.)**
7.	MAMA101	Algebra -I	DSC	4	4	3
8.	MAMA102	Real Analysis	DSC	4	4	3
9.	MAMA103	Differential Equations-I	DSC	4	4	3
10.	MAMA104	Differential Geometry	DSC	4	4	3
11.	MAMA105	Dynamics of Rigid Bodies	DSC	4	4	3
12.	MAMA106	Calculus of Variation and Special Function-I	DSC	4	4	3
		Total Credit in the Semester		**24**		
Semester - II						
S. No.	**Paper Code**	**Nomenclature of paper**	**Course Category**	**Credit**	**Contact hour per week**	**EoSE Duration (Hrs.)**
7.	MAMA201	Algebra -II	DSC	4	4	3
8.	MAMA202	Topology	DSC	4	4	3
9.	MAMA203	Differential Equations-II	DSC	4	4	3
10.	MAMA204	Riemannian Geometry and Tensor Analysis	DSC	4	4	3

11.	MAMA205	Hydrodynamics	DSC	4	4	3
12.	MAMA206	Special Function-II	DSC	4	4	3
		Total Credit in the Semester		**24**		

EoSE: End of Semester Examination

Discipline Specific Elective

Elective Course	Specialization	Paper	Prerequisite	Credit
MAMA304A	MP	Mathematical Programming-I	-	4
MAMA304B	CM	Continuum Mechanics-I	-	4
MAMA305A	RC	Relativistic Mechanics	-	4
MAMA305B	CA	Computer Applications-Theory	-	4
MAMA306A	NA	Numerical Analysis -I	-	4
MAMA306B	CC	Certificate Course on Swayam/ MOOCs/ Coursera portal.	-	4
MAMA404A	MP	Mathematical Programming-II	MAMA304A	4
MAMA404B	CM	Continuum Mechanics-II	MAMA304B	4
MAMA405A	RC	General Relativity and Cosmology	MAMA305A	4
MAMA405B	CA	Computer Applications-Practical	MAMA305B	4
MAMA406A	NA	Numerical Analysis -II	MAMA306A	4
MAMA306B	CC	Certificate Course on Swayam/ MOOCs/ Coursera portal.	-	4

Semester - III						
S. No.	**Paper Code**	**Nomenclature of paper**	**Course Category**	**Credit**	**Contact hour per week**	**EoSE Duration (Hrs.)**
4.	MAMA301	Functional Analysis-I	DSC	4	4	3
5.	MAMA302	Viscous Fluid Dynamics-I	DSC	4	4	3
6.	MAMA303	Integral Transforms	DSC	4	4	3

Candidates are required to opt any three elective core courses (4 credits each) from MAMA304A/MAMA304B, MAMA305A/MAMA305B and MAMA306A/MAMA306B. Student has to take Prior permission by the Head of the Department for the online Certificate Course on Swayam/ MOOCs/ Coursera portal.

Total Credit in the Semester 24

Semester – IV						
S. No.	**Paper Code**	**Nomenclature of paper**	**Course Category**	**Credit**	**Contact hour per week**	**EoSE Duration (Hrs.)**
5.	MAMA401	Functional Analysis-II	DSC	4	4	3
6.	MAMA402	Viscous Fluid Dynamics-II	DSC	4	4	3
7.	MAMA403	Integral Equations	DSC	4	4	3
8.	MAMA451	Project/ Dissertation	DSC	4	-	-

Candidates are required to opt the corresponding three elective core courses of same specialization cluster obtained in Semester Third (4 credits each) from MAMA404A/MAMA404B, MAMA405A/MAMA405B and MAMA406A/ MAMA406B. Student has to take Prior permission by the Head of the Department for the online Certificate Course on Swayam/ MOOCs/ Coursera portal. A Project/ Dissertation work is a compulsory course to be taken up in the Fourth Semester. This work will be of 4 Credits. The Project work will be of 100 Marks.

Total Credit in the Semester 28

Examination Scheme for Each Paper

Duration: 3 hrs. Max. Marks: 70

Note: There will be two parts in end semester theory paper.

Part A- comprises of eight very short answer questions from all units. It's a compulsory question and attempt any seven (Science/Arts) 7 × 2 mark each =14 Marks

Part B- 4 questions (one question from each unit with internal choice) and all questions are compulsory. Each Question Carries 14 Marks. (Science/Arts)

4 × 14 mark each = 56 Marks

Total of End semester exam (duration of exam 3 hours) =70

Marks Internal assessment = 30Marks

Evaluation Scheme of Project/ Dissertation

Total Marks 100

Internal Marks: 30

Viva-Voice: 20 Marks

Presentation: 20 Marks

Dissertation/ Project: 30 Marks

SEMESTER – I

Algebra-I

Course Objectives:

Students will have the knowledge and skills to apply the concepts of the course in pattern recognition in the field of computer science and also for diverse situations in physics, chemistry and other streams. This course is a foundation for next course in Algebra. Fields form one of the important and fundamental algebraic structures and has an extensive theory dealing mainly with field extensions which arise in the study of roots of polynomials. In this course we study fields in detail with a focus on Galois theory which provides a link between group theory and roots of polynomials.

Course Learning Outcomes:

After studying this course, the student will be able to

CO1. understand, explain in depth, and apply the fundamental concepts of Groups, Structure of Groups, isometries, Rings and integral domains.

CO2. To introduce the concepts and to develop working knowledge on fundamentals of algebra. identify and construct examples of fields, distinguish between algebraic and transcendental extensions, characterize normal extensions in terms of splitting fields and prove the existence of algebraic closure of a field.

CO3. characterize perfect fields using separable extensions, construct examples of automorphism group of a field and Galois extensions as well as prove the fundamental theorem of Galois theory.

CO4. classify finite fields using roots of unity and Galois theory and prove that every finite separable extension is simple.

CO5. Use Galois Theory of equations to prove that a polynomial equation over a field of characteristic is solvable by radicals iff its group (Galois) is a solvable group and hence deduce that a general quintic equation is not solvable by radicals.

Contents:

Unit-1

Direct product of groups (External and Internal). Isomorphism theorems – Diamond isomorphism Theorem, Butterfly Lemma, Conjugate classes (Excluding p-groups). Sylow’s

Theorem (Without Proof). Cauchy's theorem for finite abelian groups.

Unit - 2

Commutators, Derived subgroups, Normal series and Solvable groups, Composition series, Refinement theorem and Jordan-Holder theorem for infinite groups.

Unit - 3

Polynomial Ring and irreducibility Criteria, Field theory – Extension fields, Algebraic and Transcendental extensions, Separable and inseparable extensions, Normal extensions. Splitting fields.

Unit -4

Galois theory – the elements of Galois theory, Automorphism of extensions, Fundamental theorem of Galois theory, Solutions of polynomial equations by radicals and Insolvability of general equation of degree five by radicals.

Reference Books:

1. Deepak Chatterjee, Abstract Algebra, Prentice Hall of India (PHI), New Delhi, 2004
2. N. S. Gopalkrishnan, University Algebra, New Age International, 1986.
3. Qazi Zameeruddin and Surjeet Singh, Modern Algebra, Vikas Publishing, 2006
4. G. C. Sharma, Modern Algebra, Shivlal Agrawal & Co., Agra, 1998.
5. Joseph A. Gallian, Contemporary Abstract Algebra (4th Ed.), Narosa Publishing House, 1999.
6. David S. Dummit and Richard M. Foote, Abstract Algebra (3rd Edition), John Wiley and Sons (Asia) Pvt. Ltd, Singapore, 2004.
7. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra (4th Edition), Prentice-Hall of India Pvt. Ltd., New Delhi, 2004.
8. I.N. Herstein, Topics in Algebra (2nd edition), John Wiley & Sons, 2006
9. Michael Artin, Algebra (2nd edition), Pearson Prentice Hall, 2011.

Real Analysis

Course Objectives:

The main objective is to familiarize yourself with the Measurable sets, Measurable functions, Integration, Convergence of sequences of functions and their integrals, Functions of bounded variation, L_p -spaces.

Course Learning Outcomes: After studying this course the student will be able to

CO1. verify whether a given subset of a real valued function is measurable.

CO2. understand the requirement and the concept of the Lebesgue integral (a generalization of the Reimann integration) along its properties.

CO3. demonstrate understanding of the statement and proofs of the fundamental integral convergence theorems and their applications.

CO4. know about the concepts of functions of bounded variations and the absolute continuity of functions with their relations.

CO5. extend the concept of outer measure in an abstract space and integration with respect to a measure.

CO6. learn and apply Fourier series and coefficients, Parseval's identity, Riesz-Fisher Theorem.

in Lp -spaces and understand completeness of Lp -spaces and convergence in measures.

Contents:

Unit – 1

Algebra and algebras of sets, Algebras generated by a class of subsets, Borel sets, Lebesgue measure of sets of real numbers, Measurability and Measure of a set, Existence of Non-measurable sets.

Unit – 2

Measurable functions, Realization of non-negative measurable function as limit of an increasing sequence of simple functions, Structure of measurable functions, Convergence in measure, Egoroff's theorem.

Unit - 3

Weierstrass's theorem on the approximation of continuous function by polynomials, Lebesgue integral of bounded measurable functions, Lebesgue theorem on the passage to the limit under the integral sign for bounded measurable functions.

Unit - 4

Summable functions, Space of square Summable functions. Fourier series and coefficients, Parseval's identity, Riesz-Fisher Theorem.

Reference Books:

1. Shanti Narayan, A Course of Mathematical Analysis, S. Chand & Co., N.D., 1995.
2. S. C. Malik and Savita Arora, Mathematical Analysis, New Age International, 1992.
3. T. M. Apostol, Mathematical Anslysis, Narosa Publishing House, New Delhi, 1985.
4. R.R. Goldberg, Real Analysis, Oxford & IBH Publishing Co., New Delhi, 1970.
5. S. Lang, Undergraduate Analysis, Springer-Verlag, New York, 1983.
6. Walter Rudin, Real and Complex Analysis, Tata McGraw-Hill Pub. Co. Ltd., 1986.
7. I.N. Natansen, Theory of Functions of a Real Variable, Fredrik Pub. Co., 1964.

Differential Equations- I

Course Objectives:

The objective of this course is to study the solutions of various types of nonlinear differential equations, total differential equations of the three and four variables and total differential equations of second degree. Also using series solution method solutions of differential equations will be obtained. By applying Monge's method partial differential equations will be solved.

Course Learning Outcomes:

After studying this course the student will be able to

CO1. Students will have the knowledge and skills to solve various types of non-linear differential equations.

CO2.Can solve total differential equation of the three and four variables and total differential equations of second degree.

CO3. Describe solutions of differential equations using series solution method.

CO4. Have skills to solve partial differential equations using Monge's method.

Contents:

Unit - 1

Non-linear ordinary differential equations of particular forms. Riccati's equation – General solution and the solution when one, two or three particular solutions are known.

Unit - 2

Total Differential equations. Forms and solutions, necessary and sufficient condition, Geometrical Meaning Equation containing three and four variables, total differential equations of second degree.

Unit - 3

Series Solution: Radius of convergence, method of differentiation, Cauchy-Euler equation, Solution near a regular singular point (Method of Forbenius) for different cases, Particular integral and the point at infinity.

Unit - 4

Partial differential equations of second order with variable coefficients- Monge's method.

Reference Books:

1. J. L. Bansal and H. S. Dhami, Differential Equations Vol-II, JPH, 2004.
2. M.D. Raisinghania, Ordinary and Partial Differential Equations, S. Chand & Co., 2003.

3. L. C. Evans, Partial Differential Equations, Graduate Studies in Mathematics, Vol. 19, AMS, 1999.
4. IN. Sneddon, Elements of Partial Differential Equations, McGraw-Hill, 1988.
5. E.A. Codington, An Introduction to Ordinary Differential Equations, Prentice Hall of India, 1961.
6. Frank Ayres, Theory and Problems of Differential equations, TMH, 1990.
7. D.A. Murray, Introductory Course on Differential Equations, Orient Longman, 1902.
8. A. R. Forsyth, A Treatise on Differential Equations, Macmillan & Co. Ltd, London, 1956.

Differential Geometry

Course Objectives:

The primary objective of this course is to understand the notion of space curves, Tangent, Osculating plane, Serret-Frenet's formulae, Osculating circle and Osculating sphere, Metric of a surface, First, Second and Third fundamental forms, Orthogonal trajectories, Gauss's characteristic equation, Fundamental existence theorem for surfaces, Gaussian and mean curvature for a parallel surface.

Course Learning Outcomes:

After studying this course the student will be able to

CO1. understand the space curves, their curvature and torsion, Serret-Frenet's formulae and its applications

CO2. learn about envelops and ruled surfaces with emphasis on the properties of developable and skew surfaces.

CO3. know about Asymptotic lines, Differential equation of an asymptotic line, Curvature and Torsion of an asymptotic line.

CO4. deal with Gauss's formulae, Gauss's characteristic equation, Weingarten equations, Mainardi-Codazzi equations.

Contents:

Unit - 1

Space curves, Tangent, Contact of curve and surface, Osculating plane, Principal normal and Binormal, Curvature, Torsion, Serret-Frenet's formulae, Osculating circle and Osculating sphere, Existence and Uniqueness theorems, Bertrand curves, Involute and Evolutes.

Unit - 2

Conoids, Inflexional tangents, Singular points, Indicatrix. Ruled surface, Developable surface, Tangent plane to a ruled surface. Necessary and sufficient condition that a surface $\zeta = f(\xi, \eta)$ should represent a developable surface. Metric of a surface, First, Second and Third fundamental forms. Fundamental magnitudes of some important surfaces, Orthogonal trajectories.

Unit - 3

Normal curvature, Principal directions and Principal curvatures, First curvature, Mean curvature, Gaussian curvature, Radius of curvature of a given section through any point on $z = f(x, y)$. Lines of curvature, Principal radii, Relation between fundamental forms.

Unit - 4

Asymptotic lines, Differential equation of an asymptotic line, Curvature and Torsion of an asymptotic line. Gauss's formulae, Gauss's characteristic equation, Weingarten equations, Mainardi-Codazzi equations. Fundamental existence theorem for surfaces, Parallel surfaces, Gaussian and mean curvature for a parallel surface.

Reference Books:

1. R.J.T. Bell, Elementary Treatise on Co-ordinate geometry of three dimensions, Macmillan India Ltd., 1994.
2. Mittal and Agarwal, Differential Geometry, Krishna publication, 2014.
3. Barry Spain, Tensor Calculus, Radha Publ. House Calcutta, 1988.
4. J.A. Thorpe, Introduction to Differential Geometry, Springer-Verlog, 2013.
5. T.J. Willmore - An Introduction to Differential Geometry. Oxford University Press. 1972.
6. Weatherbum, Reimanian Geometry and Tensor Clculus, Cambridge Univ. Press, 2008.
7. Thorpe, Elementary Topics in Differential Geometry, Springer Verlag, N.Y. (1985).
8. R.S. Millman and G.D. Parker, Elements of Differential Geometry, Prentice Hall, 1977.

Dynamics of Rigid Bodies

Course Objectives:

This course will enable the students to -

1. Acquaint the students with mechanical systems under generalized coordinate systems, virtual work, energy and momentum.
2. Aware about the mechanics developed by Lagrange's, Hamilton.

Course Learning Outcomes:

After studying this course the student will be able to

CO1. Understand D'Alembert's Principle and its simple applications. Able to construct General equation of motion of a rigid body under fixed force, no force and impulsive force.

CO2. Describe the concept of Motion of a rigid body in two dimensions, Rolling and sliding friction, rolling and sliding of uniform rod and uniform sphere.

CO3. Able to Describe Motion in three dimensions with reference to Euler's dynamical and geometrical equations, Motion under no forces, Motion under impulsive forces.

CO4. Analyse the Derivation of Lagrange's Equations to holonomic Systems. Understand the motion of top.

CO5. Distinguish the concept of the Hamilton Equations of Motion and the Principle of Least Action.

Contents:

Unit - 1

D'Alembert's principle, The general equations of motion of a rigid body, Motion of centre of inertia and motion relative to centre of inertia, Motion about a fixed axis.

Unit - 2

The compound pendulum, Centre of percussion, Conservation of momentum (linear and angular) and energy for finite as well as impulsive forces.

Unit - 3

Motion in three dimensions with reference to Euler's dynamical and geometrical equations. Motion under no forces, Motion under impulsive forces. Motion of Top.

Unit - 4

Lagrange's equations for holonomous dynamical system, Energy equation for conservative field, Small oscillations, Hamilton's equations of motion, Hamilton's principle and principle of least action.

Reference Books:

1. N. C. Rana and P.S. Joag, Classical Mechanics, Tata McGraw-Hill, 1991.
2. M. Ray and H.S. Sharma, A Text Book of Dynamics of a Rigid Body,
Students' Friends & Co., Agra, 1984.
3. H. Goldstein, Classical Mechanics, Narosa, 1990.
4. J. L. Synge and B. A. Griffith, Principles of Mechanics, McGraw-Hill, 1991.
5. L. N. Hand and J. D. Finch, Analytical Mechanics, Cambridge University Press, 1998

Calculus of Variation and Special Function-I

Course Objectives:

This course will enable the students to

1. Learn about functional, variational problems.
2. Solve brachistochrone, problem of geodesics, isoperimetric problem.
3. Understand the properties of special functions like Gauss hypergeometric, Legendre functions with their integral representations.
4. Understand how special function is useful in differential equations.

Course Learning Outcomes:

At the end of the course Students will have the knowledge and skills to understand, explain in depth and apply in various situations the techniques to-

CO1. Solving the problem of brachistochrone, problem of geodesics, isoperimetric problem, Variation and its properties, functions and functionals,

CO2. Solving Variational problems with the fixed boundaries.

CO3. Variational problems involving higher order derivatives, constraints involving several variables and their derivatives.

CO4. Explain the applications and the usefulness of these special functions.

CO5. To analyse properties of special functions by their integral representations and symmetries.

CO6. Identified the application of some basic mathematical methods via all these special functions.

Contents:

Unit - 1

Calculus of variation – Functional, Variation of a functional and its properties, Variational problems with fixed boundaries, Euler's equation, Extremals, Functional dependent on several unknown functions and their first order derivatives. (Variational Problems with fixed boundaries)

Unit - 2

Functionals dependent on higher order derivatives, Functionals dependent on the function of more than one independent variable. Variational problems in parametric form. (Variational Problems with fixed boundaries)

Unit - 3

Gauss hypergeometric function and its properties, Series solution of Gauss hypergeometric equation. Integral representation, Linear and quadratic transformation formulas, Contiguous function relations, Differentiation formulae, Linear relation between the solutions of Gauss hypergeometric equation, Kummer's confluent hypergeometric function and its properties, Integral representation, Kummer's first transformation.

Unit - 4

Legendre polynomials and Series Solution of Legendre's equation and functions $P_n(x)$ and $Q_n(x)$.

Reference Books:

1. J. L. Bansal and H. S. Dhami, Differential Equations Vol-II, JPH, 2004.
2. M.D. Raisinghania, Ordinary and Partial Differential Equations, S. Chand & Co., 2003.
3. J. N. Sharma and R. K. Gupta, Differential Equations with Special Functions, Krishna Prakashan, 1991.
4. Earl D. Rainville, Special Functions, Macmillan Company, New York, 1960.
5. L. C. Evans, Partial Differential Equations, Graduate Studies in Mathematics, Vol. 19, AMS, 1999.
6. I.N. Sneddon, Elements of Partial Differential Equations, McGraw-Hill, 1988

SEMESTER - II

Algebra II

Course Objectives:

The primary objective of this course is to provide knowledge and skills to demonstrate a competence in formulating, analysing and solving problems in several core areas of higher level of Linear Algebra concepts- linear form, dual spaces, orthogonal basis.

Course Learning Outcomes:

After studying this course, the student will be able to

CO1. To explain demonstrate accurate and efficient use of Eigen values and eigen vectors.

CO2. To understand application of Orthogonal Projection.

CO3. To learn the concept of dual spaces and dual basis, maps and annhilator.

CO4. To understand the Real inner product space and Schwartzs inequality.

CO5. To explain invertible matrices and similar matrices.

Contents:

Unit - 1

Linear transformation of vector spaces, Dual spaces, Dual basis and their properties, Dual maps, Annihilator.

Unit - 2

Matrices of linear maps, Matrices of composition maps, Matrices of dual map, Eigen values, Eigen vectors, Rank and Nullity of linear maps and matrices, Invertible matrices, Similar matrices.

Unit - 3

Determinants of matrices and its computations, Characteristic polynomial, minimal polynomial and Eigen values. Real inner product space, Schwartzs inequality.

Unit - 4

Orthogonality, Bessel's inequality, Adjoint, Self-adjoint linear transformations and matrices, orthogonal linear transformation and matrices, Principal Axis Theorem

Reference Books:

1. Deepak Chatterjee, Abstract Algebra, Prentice Hall of India (PHI), New Delhi, 2004
2. N. S. Gopalkrishnan, University Algebra, New Age International, 1986.
3. Qazi Zameeruddin and Surjeet Singh, Modern Algebra, Vikas Publishing, 2006

4. G. C. Sharma, Modern Algebra, Shivlal Agrawal & Co., Agra, 1998.
5. Joseph A. Gallian, Contemporary Abstract Algebra (4th Ed.), Narosa Publishing House, 1999.
6. David S. Dummit and Richard M. Foote, Abstract Algebra (3rd Edition), John Wiley and Sons (Asia) Pvt. Ltd, Singapore, 2004.
7. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra (4th Edition), Prentice-Hall of India Pvt. Ltd., New Delhi, 2004.
8. I.N. Herstein, Topics in Algebra (2nd edition), John Wiley & Sons, 2006.
9. Michael Artin, Algebra (2nd edition), Pearson Prentice Hall, 2011.

Topology

Course Objectives: To introduce basic concepts of point set topology, basis and sub-basis for a topology and order topology. Further, to study continuity, homeomorphisms, open and closed maps, product and introduce notions of connectedness, path connectedness, local connectedness, local path connectedness, convergence, nets, Filters, and compactness of spaces.

Course Learning Outcomes:

After studying this course the student will be able to

CO1. Determine interior, closure, boundary, limit points of subsets and basis and sub-basis of topological spaces.

CO2. check whether a collection of subsets is a basis for a given topological spaces or not, and determine the topology generated by a given basis.

CO3. Identify the continuous maps between two spaces and maps from a space into product space and determine common topological property of given two spaces.

CO4. Determine the connectedness and path connectedness of the product of an arbitrary family of spaces.

CO5. find Hausdorff spaces using the concept of Net and Filter in topological spaces and learn about 1st and 2nd countable spaces, separable, Lindelöf spaces and Tychonoff's theorem.

Contents:

Unit - 1

Topological spaces, Subspaces, Open sets, closed sets, Neighbourhood system, Bases and sub-bases.

Unit – 2

Continuous mapping and Homeomorphism, Nets, Filters.

Unit – 3

Separation axioms (To, T1, T2, T3, T4). Compact and locally compact spaces. Continuity and Compactness.

Unit - 4

Product and Quotient spaces. Tychonoff's one point compactification. Connected and locally connected spaces, Continuity and Connectedness.

Reference Books:

1. Shanti Narayan, A Course of Mathematical Analysis, S. Chand & Co., N.D., 1995.
2. S. C. Malik and Savita Arora, Mathematical Analysis, New Age International, 1992.
3. James R. Munkres, Topology, 2nd Edition, Pearson International, 2000.
4. J. Dugundji, Topology, Prentice-Hall of India, 1975.
5. George F. Simmons, Introduction to Topology and Modern Analysis, McGraw- Hill, 1963.

Differential Equation-II

Course Objectives:

The objective of this course is to study the Classification of linear partial differential equation of second order, Canonical forms, Cauchy's problem, boundary value problems, eigen values and eigen functions of Sturm Liouville systems, Green's function.

Course Learning Outcomes:

After studying this course, the student will be able to

CO1. Students will have the knowledge and skills to classify and reduce various types of linear partial differential equation of second order into Canonical forms.

CO2. understand with eigen values and eigen functions of Sturm□Liouville systems and the solutions of initial and boundary value problems.

Contents:

Unit - 1

Classification of linear partial differential equation of second order, Canonical forms, Cauchy's problem of first order partial differential equation.

Unit - 2

Linear homogeneous boundary value problem, Eigen values and Eigen functions, Sturm-Liouville boundary value problems, orthogonality of Eigen functions, Lagrange's identity, properties of Eigen functions, important theorems of Sturm Liouville system, Periodic functions.

Unit - 3

Non-homogeneous boundary value problems, Non-homogeneous Sturm-Liouville boundary value problems (method of Eigen function expansion). Method of separation of variables, Laplace, wave and diffusion equations.

Unit - 4

Green's Functions: Non-homogeneous Sturm-Liouville boundary value problem (method of Green's function), Procedure of constructing the Green's function and solution of boundary value problem, properties of Green's function, Inhomogeneous boundary conditions, Dirac delta function, Bilinear formula for Green's function, Modified Green's function.

Reference Books:

1. J. L. Bansal and H. S. Dhami, Differential Equations Vol-II, JPH, 2004.
2. M.D. Raisinghania, Ordinary and Partial Differential Equations, S. Chand & Co., 2003.
3. L. C. Evans, Partial Differential Equations, Graduate Studies in Mathematics, Vol. 19, AMS, 1999.
4. I.N. Sneddon, Elements of Partial Differential Equations, McGraw-Hill, 1988.
5. E.A. Codington, An Introduction to Ordinary Differential Equations, Prentice Hall of India, 1961.
6. Frank Ayres, Theory and Problems of Differential equations, TMH, 1990.
7. D.A. Murray, Introductory Course on Differential Equations, Orient Longman, 1902.
8. A.R. Forsyth, A Treatise on Differential Equations, Macmillan & Co. Ltd., London,1956.

Riemannian geometry and Tensor Analysis

Course Objectives:

The objective of this course is to study the geodesic, differential equation of geodesic and various types of tensors.

CO1: Study the most fundamental knowledge for understanding tensors were taught in the traditional way.

CO2: Prior to our applying tensor analysis to our research area of modern continuum mechanics.

CO3: Tensor analysis provides a kind of bridge between elementary aspects of linear algebra, geometry and analysis.

Contents:

Unit - 1

Geodesics, Differential equation of a geodesic, Single differential equation of a geodesic, Geodesic on a surface of revolution, Geodesic curvature and torsion, Gauss-Bonnet Theorem.

Unit - 2

Tensor Analysis– Kronecker delta. Contravariant and Covariant tensors, Symmetric tensors, Quotient law of tensors, Relative tensor. Riemannian space. Metric tensor, Indicator, Permutation symbols and Permutation tensors.

Unit - 3

Christoffel symbols and their properties, Covariant differentiation of tensors. Ricci's theorem, intrinsic derivative, Geodesics, Differential equation of geodesic, Geodesic coordinates, Field of parallel vectors.

Unit - 4

Reimann-Christoffel tensor and its properties. Covariant curvature tensor, Einstein space, Bianchi's identity, Einstein tensor, Flat space, Isotropic point, Schur's theorem.

Reference Books:

1. R.J.T. Bell, Elementary Treatise on Co-ordinate geometry of three dimensions, Macmillan India Ltd., 1994.
2. Mittal and Agarwal, Differential Geometry, Krishna publication, 2014.
3. Barry Spain, Tensor Calculus, Radha Publ. House Calcutta, 1988.
4. J.A. Thorpe, Introduction to Differential Geometry, Springer-Verlog, 2013.
5. T.J. Willmore - An Introduction to Differential Geometry. Oxford University Press. 1972.
6. Weatherbum, Reimanian Geometry and Tensor Clculus, Cambridge Univ. Press, 2008.
7. Thorpe, Elementary Topics in Differential Geometry, Springer Verlag, N.Y. 1985.
8. R.S. Millman and G.D. Parker, Elements of Differential Geometry, Prentice Hall, 1977.

Hydrodynamics

Course objective:

This course will enable the students to -

Understand the motion of fluid and develop the concept of models and give the techniques which enable us to solve the problems of fluid flow.

Course Learning Outcomes:

After the completion of the course the students will be able to:

CO1- Understand the basic principles of ideal fluid, such as Lagrangian and Eulerian approach, conservation of mass etc.

CO2- Use Euler and Bernoulli's equations and the conservation of mass to determine velocity and acceleration for incompressible and non-viscous fluid.

CO3-Understand the concept of rotational and irrotational flow, stream functions, velocity potential, complex potential due to sink, source and doublets.

CO4-Understand the motion of a fluid element, Vorticity, Body forces, Surface forces, Stress & Strain analysis, Flow and circulation, Connectivity, Irrotational motion in multiple connected space,

CO5-Distinguish the concept of Irrotational motion of a cylinder in two dimensions, Motion of a circular cylinder in a uniform stream and two co-axial cylinders, Streaming and circulation for a fixed circular cylinder.

Contents:

Unit - 1

Kinematics of ideal fluid. Lagrange's and Euler's methods. Equation of continuity in Cartesian, cylindrical and spherical polar coordinates. Boundary surface. Stream-lines, path-lines and streak lines, velocity potential, irrotational motion.

Unit - 2

Euler's hydrodynamic equations. Bernoulli's theorem. Helmholtz equations. Cauchy's integral.

Unit - 3

Motion due to impulsive forces. Motion in two-dimensions, Stream function, Complex potential. Sources, Sinks, Doublets, Images in two-dimensions.

Unit - 4

Vortex Motion Definition, rectilinear vortices, centre of vortices, properties of vortex tube, two vortex filaments, vortex pair, vortex doublet, vortex inside and outside circular cylinder, four vertices, motion of vortex situated at the origin and stream lines.

Reference Books:

1. M.D. Raisinghania, Hydrodynamics, S. Chand & Co. Ltd., N.D. 1995.
2. M. Ray and G.C. Chadda, A Text Book on Hydrodynamics, Students' Friends & Co., Agra, 1985.
3. N. C. Rana and P.S. Joag, Classical Mechanics, Tata McGraw-Hill, 1991.
4. H. Goldstein, Classical Mechanics, Narosa, 1990.
5. J. L. Synge and B. A. Griffith, Principles of Mechanics, McGraw-Hill, 1991.
6. L. N. Hand and J. D. Finch, Analytical Mechanics, Cambridge University Press, 1998.

Special Functions- II

Course Objectives: This course will enable the students to

1. Understand the concept of Bessel's function, Hermite function, Laguerre and Associated Laguerre polynomials. Jacobi Polynomial, Chebyshev polynomials with its properties like recurrence relations, orthogonal properties, generating functions etc.

2. Understand how special function is useful in differential equations.

Course Learning Outcomes:

After the completion of the course the students will be able to:

CO1: Explain the applications and the usefulness of these special functions.

CO2: Classify and explain the functions of different types of differential equations.

CO3: To analyse properties of special functions by their integral representations and symmetries.

CO5: Identified the application of some basic mathematical methods via all these special functions.

CO6: Apply these techniques to solve and analyse various mathematical problems.

Contents:

Unit - 1

Bessel functions Jn(x).

Unit - 2

Hermite polynomials Hn(x), Laguerre and Associated Laguerre polynomials.

Unit - 3

Jacobi Polynomial: Definition and its special cases, Bateman's generating function, Rodrigue's formula, orthogonality, recurrence relations, expansion in series of polynomials.

Unit - 4

Chebyshev polynomials Tn(x) and Un(x): Definition, Solutions of Chebyshev's equation, expansions, Generating functions, Recurrence relations, Orthogonality.

Reference Books:

1. J. L. Bansal and H. S. Dhami, Differential Equations Vol-II, JPH, 2004.
2. M. D. Raisinghania, Ordinary and Partial Differential Equations, S. Chand & Co., 2003.
3. J. N. Sharma and R. K. Gupta, Differential Equations with Special Functions, Krishna Prakashan, 1991.
4. Earl D. Rainville, Special Functions, Macmillan Company, New York, 1960.
5. L. C. Evans, Partial Differential Equations, Graduate Studies in Mathematics, Vol. 19, AMS, 1999.
6. I. N. Sneddon, Elements of Partial Differential Equations, McGraw-Hill, 1988.

SEMESTER - III

Functional Analysis- I

Course Objectives:

To familiarize with the basic tools of Functional Analysis involving normed spaces and Banach spaces their properties dependent on the dimension and the bounded linear operators from one space to another.

Course Learning Outcomes:

After studying this course, the student will be able to

CO1. verify the requirements of a norm, completeness with respect to a norm, relation between compactness and dimension of a space, check boundedness of a linear operator and relate to continuity, convergence of operators by using a suitable norm, compute the dual spaces.

CO2. Understand the concepts of metric spaces and continuous mapping.

CO3. To be able to solve problems based on Banach contraction theorem, Baire's category theorem and compact sets.

CO4. Understand the concepts of Normed linear space of bounded linear transformations and boundness theorem.

Contents:

Unit 1:

Subspace of Metric space, product space, Continuous mapping, Sequence in a metric space, convergent, Cauchy sequence, Complete metric space.

Unit – 2

Banach contraction theorem, Baire's category theorem, compact sets, compact spaces, separable metric space, and connected metric spaces.

Unit - 3

Normed linear spaces. Quotient space of normed linear spaces and its completeness. Banach spaces and examples. Bounded linear transformations. Normed linear space of bounded linear transformations.

Unit – 4

Equivalent norms. Basic properties of finite dimensional normed linear spaces and compactness. Reisz Lemma. Multilinear mapping. Open mapping theorem. Closed graph theorem. Uniform boundness theorem.

Reference Books:

1. E. Kreyszig, Introductory Functional Analysis with Applications, John Wiley and Sons., 1978.

2. A. E. Taylor, Introduction to Functional Analysis, John Wiley, 1958.
3. Bowers and N. Kalton, An Introductory Course in Functional Analysis, Springer Verlog, 2014.
4. W. Rudin, Functional Analysis, McGraw-Hill, 1973.

Viscous Fluid Dynamics-I

Course Objectives:

Prepare a foundation to understand the motion of fluid and develop concept of models and techniques which enables to solve the problems of fluid flow and help in advanced studies and research in the broad area of fluid motion.

Course Learning Outcomes:

After studying this course, the student will be able to

CO1. understand the concept of fluid and their classification, models and approaches to study the fluid flow.

CO2. understand the concept of stress and strain in viscous flow

CO3. formulate the Governing Equations for fluid motion.

CO4. know Buckingham theorem and its application, Non-dimensional parameters and their relationships..

CO5. understand the different types of flows related to viscosity.

CO6. know flow near Stagnation point.

Contents:

Unit – 1

Viscosity, Analysis of stress and rate of strain, Stoke's law of friction, Thermal conductivity and generalized law of heat conduction, Equations of state and continuity, Navier- Stokes equations of motion.

Unit – 2

Vorticity and circulation, Dynamical similarity, Inspection and dimensional analysis, Buckingham theorem and its application, Non-dimensional parameters and their physical importance : Reynolds number, Froude number, Mach number, Prandtl number, Eckart number, Grashoff number, Brinkmann number, Non – dimensional coefficients: Lift and drag coefficients, Skin friction, Nusselt number, Recovery factor.

Unit – 3

Exact solutions of Navier – Stokes equations, Velocity distribution for plane couette flow, Plane

Poiseuille flow, Generalized plane Couette flow, Hagen-Poiseuille flow, Flow in tubes of uniform cross-sections.

Unit – 4

Flow between two concentric rotating cylinders. Stagnation point flows: Hiemenz flow, Homann flow. Flow due to a rotating disc.

Reference Books:

1. J. L. Bansal, Viscous Fluid dynamics, JPH, Jaipur, 2008.
2. M. D. Raisinghania, Fluid Dynamics, S. Chand, 2003.
3. F. Chorlton, A Text Book of Fluid Dynamics, CBC, 1985.
4. S. W. Yuan, Foundations of Fluid Mechanics, Prentice-Hall, 1976.
5. S. I. Pai, Viscous Flow Theory I- Laminar Flow, D. Van Nostrand Co., Ing., Princeton, New Jersey, N.Y., Landon, Toronto, 1956.
6. F. M. White, Viscous Fluid Flow, McGraw-Hill, N.Y., 1974.

Integral Transforms

Course Objectives:

This course will enable the students to -

1. To expose the students with the concept of popular and useful transformations techniques like: Laplace and inverse Laplace transform, Fourier transform, Mellin transform and Hankel transform, with its properties and applications.
2. To solve ordinary and partial differential equations with different forms of initial and boundary conditions.

Course Learning Outcomes:

The students will be able to –

CO1. Gain the idea that by applying the theory of Integral transform the problem from its original domain can be mapped into a new domain where solving problems becomes easier.

CO2. Apply these techniques to solve research problems of signal processing, data analysis and processing, image processing, in scientific simulation algorithms etc.

CO3. Develop the ability of using the language of mathematics in analysing the real-world problems of sciences and engineering.

CO4. Think logically and mathematically and apply the knowledge of integral transform to solve complex problems.

Contents:

Unit - 1

Laplace transform– Definition and its properties. Rules of manipulation. Laplace transform of derivatives and integrals. Properties of inverse Laplace transform. Convolution theorem.

Unit – 2

Fourier transform – Definition and properties of Fourier sine, cosine and complex transforms. Convolution theorem. Inversion theorems. Fourier transform of derivatives.

Unit – 3

Mellin transform– Definition and elementary properties. Mellin transforms of derivatives and integrals. Inversion theorem. Convolution theorem.

Unit – 4

Complex inversion formula. Infinite Hankel transform– Definition and elementary properties. Hankel transform of derivatives. Inversion theorem. Parseval Theorem.

Reference Books:

1. Lokenath Debnath and Dambaru Bhatta, Integral Transforms and their Applications, Taylor and Francis Group, 2014.
2. Abdul J. Jerry, Introduction to Integral Equations with applications, Marcel Dekkar Inc. NY, 1999.
3. L. G. Chambers, Integral Equations: A short Course, Int. Text Book Company Ltd. 1976.
4. Murry R. Spiegal, Laplace Transform (SCHAUM Outline Series), McGraw- Hill, 1965.

Discipline Specific Elective (DSE)

Mathematical Programming –I

Course Objectives:

Students will have the knowledge and skills to apply the concepts of the course in Advanced level of Mathematics related to Mathematical Programming including Integer programming, Dynamic programming and Separable programming.

Course Learning Outcomes:

After the completion of the course the students will be able to:

CO1: Understand the core principles of mathematical modelling. Apply precise and logical reasoning to problem solving.

CO2: Frame quantitative problems and model them mathematically analyse the importance of differential equations in mathematical modelling.

CO3: Formulate the observable real problem mathematically.

CO4: Apply methods to solve Integer programming problems and examine the solutions

Contents:

Unit – 1

Separating and supporting hyper plane theorems. Revised simplex method to solve Linear Programming problems, Bounded variable problems.

Unit – 2

Integer programming: Gomory's algorithm for all and mixed integer programming problems Branch and Bound algorithm; Goal programming: Graphical goal attainment method, Simplex method for GPP.

Unit – 3

Separable programming: Piece-wise Linear approximations to non-linear functions, Reduction to separable programming problem to L.P.P., separable programming algorithm, fractional programming: computational procedure.

Unit - 4

Dynamic programming: Introduction, Bellman principle of optimality, solution of problems with finite number stages, solution of L.P.P. by dynamic programming.

Reference Books:

1. Kanti Swaroop, P.K.Gupta and Manmohan, Operation Research, Sultan Chand & Sons., N.Delhi, 2007.

2. S.D.Sharma, Operations Research, Kedar Nath Ram Nath and co. Meerut, 2005.

3. F. S. Hillier and G. J. Lieberman, Introduction to Operations Research Concepts and Cases (9th Edition), Tata McGraw Hill, 2010.

4. Hamdy A. Taha, Operations Research, An Introduction (9th edition), Prentice- Hall, 2010.

5. G. Hadley, Linear Programming, Narosa Publishing House, New Delhi, 2002.

Continuum Mechanics -I

Course objective:

1. Demonstrate knowledge of the physical meanings, principles, and mathematics of continuous media represented as solids, liquids, and gases.

2. Formulate and solve simplified problems using the language and methods of continuum mechanics.
3. Be able to combine distinct concepts and to introduce reasonable assumptions when faced with ambiguity in data or instructions.
4. Set up and discuss solvability of complicated continuum boundary value problems. mechanics manuscripts in the open literature.

Course Learning Outcomes:

After the completion of the course the students will be able to:

CO1- Get familiar with Cartesian tensors, as generalization of vectors, and their properties which are used in the analysis of stress and strain to describe the phenomenon of solid mechanics.

CO2 -Analyse the basic properties of stress and strain components, and their transformations.

CO4 -Use different types of elastic symmetries to derive the stress-strain relationship for isotropic elastic materials for applications to architecture and engineering.

Contents:

Unit 1:

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 the index notation. ε -δ identity. Conservative vector field and concept of a scalar potential function. Stokes, Gauss and Green's theorems.

Unit 2:

Continuum approach, Classification of continuous media, Body forces and surface forces. Components of stress tensor, Force and Moment equations of equilibrium. Transformation law of stress tensor. Stress quadric. Principal stress and principal axes. Stress invariants and stress deviator. Maximum shearing stress.

Unit 3:

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.

Unit - 4

Geometrical meaning of the components of the linear strain tensor, Properties of linear strain tensors. Principal axes, Theory of linear strain. Linear strain components. Rate of strain tensors. The vorticity tensor. Rate of rotation vector and vorticity, Properties of the rate of strain tensor, Rate of cubical dilation.

Reference Books:

1. W. Prager, Introduction to Mechanics of Continua, Lexinton Mass, Ginn, 1961.
2. A.C. Eringen, Mechanics of Continua, Wiley, 1967.
3. T.J. Chung, Continuum Mechanics, Prentice-Hall, 1988.

Relativistic Mechanics

Course objective:

This course will enable the students to -

1. Acquaint them with the basics of principles of relativity and its applications.
2. Understand Virtual work, energy, and momentum.
3. Make them aware about the mechanics developed by Newton, Lagrange's, Hamilton.

Course Learning Outcomes:

After the completion of the course the students will be able to:

CO1- Understand the basics of principles of relativity and its postulates and their simple applications. Able to apply the concepts of composition of parallel velocities and time dilation.

CO2- Describe the concepts of Simultaneity, Velocity of light as fundamental velocity, Relativistic aberration and its deduction to Newtonian theory clearly and solve basic problems based on these concepts.

CO3- Analyse the concepts of Relativistic Lagrangian and Hamiltonian and Minkowski space.And describe the relation of time and space using the theorems of relativity.

Contents:

Unit – 1

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 – 2

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 - 3

Variation of mass with velocity, Equivalence of mass and energy, Transformation formulae for mass, Momentum and energy, Problems on conservation of mass, Momentum and energy, Relativistic Lagrangian and Hamiltonian.

Unit - 4

Minkowski space, Space-like, Time-like and Light-like intervals, Null cone, Relativity and Causality, Proper time, World line of a particle. Principles of Equivalence and General Covariance.

Reference Books:

1. J.V. Narlikar, Lectures on General Relativity and Cosmology, Macmillan Co. Ltd. India, N.Delhi, 1978.
2. C. Moller, The Theory of Relativity, Oxford Clarendon Press, 1952.
3. P.G. Bergmann, Introduction to the Theory of Relativity, Prentice Hall of India, 1969.
4. J.L. Anderson, Principles of Relativity Physics, Academic Press, 1967.
5. W. Rindler, Essential Relativity, Van Nostrand Reinhold Company, 1969.
6. V. A. Ugarov, Special Theory of Relativity, Mir Publishers, 1979.

Computer Applications-Theory

Course objective:

The objectives of this course is to introduce coding on MATLAB/Mathematica/Maple software to students who have chosen Mathematics as their Stream Core and enable them to consider these software not just as a computing software bust also as a programming and visualizing platform.

Course Learning Outcomes:

After going through this software lab, a student will be able to:

CO1-Understand computer arithmetic and computer data representation formats.

CO2-Understand arithmetic and logical unit design and implementation.

CO3-Use MATLAB/Mathematica/Maple as a basic arithmetic, computing and plotting platform.

Contents:

Unit - 1

Introduction to computers, Computer organization, Input-output devices, Memory system. Hardware and software. Operating system.

Unit-2

Computer languages, System software and application software. Windows: Graphical user interface, control panel and all features there in files and folders management. Using Accessories, getting help, copying, moving and sharing information between programs. Setting up printer and fonts. Configuring modem. Introduction to MS Word and Ms-Excel. Algorithms and flow charts. Programming languages and problem solving on computers.

Unit 3:

Programming using Matlab/Mathematica/Maple - Variables, Vector and Matrix Computation, Built-in-functions, Plotting, output, M-files.

Unit 4:

Programming using Matlab/Mathematica/Maple - Functions, Loops, Conditional Execution, Matrix Multiplication.

Reference Books:

1. Y. Kanetkar, Let Us C, BPB Publications, 2008.
2. C. Ghezzi and M. Jazayeri, Programming Languages Concepts, John Wiley,1977.
3. M. Marcotty & H.F. Ledgard, Programming Language Landscape, Galgotia Publication, 1981.
4. B.S. Gottfried, Schaum's Outline of Theory and Problems of Programmingwith C, McGraw-Hill, 1996.
5. Brian R. Hunt, Ronald L. Lipsman, Jonathan M. Rosenberg, A Guide to MATLAB, Cambidge Univ. Press, 2001.
6. Duane hanselman and Bruce Littlefield, Mastering Matlab-7, Pearson Education 2005.
7. William J. Palm III, Introduction to Matlab-7 for Engineers, McGraw Hill, 2005.
8. Mureşan, Marian, Introduction to Mathematica® with Applications, Springer,2017.
9. José Guillermo Sánchez León, Mathematica Beyond Mathematics: The Wolfram Language in the Real World, Chapman and Hall/CRC, 2017.

Numerical Analysis – I

Course objective:

Students will have the knowledge and skills various methods to find the root of the equation and System of simultaneous Equations.

Course Learning Outcomes:

At the end of the course Students will have the knowledge and skills to use different iterative methods and utilise them to solve equation and simultaneous and polynomial equations.

Contents:

Unit – 1

Iterative methods – Theory of iteration method, Acceleration of the convergence, Chebyshev method, Muler's method, Methods for multiple and complex roots.

Unit - 2

Newton-Raphson method for simultaneous equations, Convergence of iteration process in the case of several unknowns. Solution of polynomial equations – Polynomial equation, Real and complex roots, Synthetic division, the Birge-Vieta, Bairstow and Graeffe's root squaring method.

Unit - 3

System of simultaneous Equations (Linear)- Direct method, Method of determinant, Gauss-Jordan, LU-Factorizations-Doolitte's, Crout's and Cholesky's. Partition method. Relaxation methods.

Unit - 4

Eigen value problems– Basic properties of Eigen values and Eigen vector, Power methods, Method for finding all Eigen values of a matrix. Jacobi, Givens' and Rutishauser method. Complex Eigen values

Reference Books:

1. S. S. Sastry, Introductory Methods of Numerical Analysis, PHI, 1979.
2. V. Rajaraman, Computer Oriented Numerical Methods, PHI, 1993.
3. M. K. Jain, S.R.K. Eyenger and R.K. Jain, Numerical Methods for Mathematics and Applied Physicists, Wiley-Eastern Pub., N.Delhi, 2005.
4. B. Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, India, 2007.
5. C. F. Gerald and P. O. Wheatley, Applied Numerical Analysis, Pearson Education, India, 7th edition, 2008.
6. C.F. Gerald, P.O. Wheatley, Applied Numerical Analysis, Addison-Wesley, 1998.
7. S. D. Conte, C de Boor, Elementary Numerical Analysis, McGraw-Hill, 1980.
8. C.E. Froberg, Introduction to Numerical Analysis, (Second Edition), Addition- Wesley, 1979.

SEMESTER – IV

Functional Analysis II

Course Objective:

This course will enable the students to -

1. Cover theoretical needs of Partial Differential Equations and Mathematical Analysis.
2. Inter-relate the problems arising in Partial Differential Equations, Measure Theory and other branches of Mathematics.
3. Know about various spaces such as Banach spaces, Hilbert Spaces.
4. Use the operators on these spaces.

Course Learning Outcomes:

After the completion of the course the students will be able to:

CO1- Explain the fundamental concepts of functional analysis in applied contexts.

CO2- Use elementary properties of Banach space and Hilbert space.

CO3- Identify normal, self-adjoint or unitary operators.

CO4- Communicate the spectrum of bounded linear operator.

CO5- Construct orthonormal sets.

Contents:

Unit – 1

Continuous linear functionals, Hahn-Banach theorem and its consequences. Embedding and Reflexivity of normed spaces. Dual spaces with examples. Inner product spaces.

Unit – 2

Hilbert space and its properties. Cauchy Schwartz inequality, Orthogonality and Functionals in Hilbert Spaces. Pythagorean theorem, Projection theorem, Separable Hilbert space and Examples

Unit - 3

Orthonormal sets, Bessel's inequality, Existence of Orthonormal bases by Gramschimidt orthogonalization process, Complete orthonormal sets, Parseval's identity, Structure of a Hilbert space, Riesz representation theorem, Reflexivity of Hilbert spaces.

Unit – 4

Adjoint of an operator on a Hilbert space. Self-adjoint, Positive, Normal and Unitary operators and their properties. Projection on a Hilbert space. Invariance. Reducibility. Orthogonal projections. Eigen values and Eigen vectors of an operator, Spectrum of an operator spectral theorem.

Reference Books:

1. E. Kreyszig, Introductory Functional Analysis with Applications, John Wiley and Sons., 1978.
2. A. E. Taylor, Introduction to Functional Analysis, John Wiley, 1958.
3. A. Bowers and N. Kalton, An Introductory Course in Functional Analysis, Springer Verlog, 2014.
4. W. Rudin, Functional Analysis, McGraw-Hill, 1973.

Viscous Fluid Dynamics – II

Course objective:

This course will enable the students to -

1. Understand the fundamentals of Fluid Dynamics and an appreciation of their application to real world problems.
2. Provide a treatment of topics in fluid mechanics to a standard where the student will be able to apply the techniques used in deriving a range of important results and in research problems.

Course Learning Outcomes:

After the completion of the course the students will be able to:

CO1- To understand the properties of unsteady flow by using stokes' problems.

CO2- To understand the equation of energy and different types of temperature distribution.

CO3. To analyse suction and injection device in transpiration cooling

CO4. To illustrate the very slow motion by stokes' and Oseen's flow

CO5. To know the concept of Boundary layer.

Contents:

Unit – 1

Concept of unsteady flow, Flow due to plane wall suddenly set in the motion (Stokes' first problem), Flow due to an oscillating plane wall (Stokes' second problem), Starting flow in plane Couette motion, Suction/injection through porous wall.

Unit - 2

Equation of energy, Temperature distribution: Between parallel plates, in a pipe, between two concentric rotating cylinders.

Unit - 3

Variable viscosity plane Couette flow, temperature distribution of plane Couette flow with transpiration cooling. Theory of very slow motion: Stokes' and Oseen's flows past a sphere.

Unit – 4

Concept of boundary layer, Derivation of velocity and thermal boundary equations in two dimensional flow. Boundary layer on flat plate (Balsius-Topfer solution), Simple solution of thermal boundary layer equation for Pr = 1.

Reference Books:

1. J. L. Bansal, Viscous Fluid dynamics, JPH, Jaipur, 2008.
2. M. D. Raisinghania, Fluid Dynamics, S.Chand, 2003.
3. F. Chorlton, A Text Book of Fluid Dynamics, CBC, 1985.
4. S. W. Yuan, Foundations of Fluid Mechanics, Prentice-Hall, 1976.
5. S. I. Pai, Viscous Flow Theory I- Laminar Flow, D. Van Nostrand Co., Ing.. Princeton, New Jersey, N.Y., Landon, Toronto, 1956.
6. F. M. White, Viscous Fluid Flow, McGraw-Hill, N.Y., 1974.

Integral Equations

Course objective:

This course will enable the students to -

1. Understand the concept of the relationship between the integral equations and ordinary differential equations.
2. Understand the linear and nonlinear integral equations by different methods with some problems which give rise to integral equations.
3. Learn different types of solution methods like successive approximation, resolvent kernel and iteration method, integral transform method and which method is applicable for which type of integral equation

Course Learning Outcomes:

After the completion of the course the students will be able to:

CO1. Acquire knowledge of different types of Integral equations: Fredholm and Volterra integral equations.

CO2. Obtain integral equation from ODE arising in applied mathematics and different engineering branches and solve accordingly using various method of solving integral equation.

CO3. Think logically and mathematically and apply the knowledge of transforms to solve complex problems.

CO4. The Conversion of Volterra Equation to ODE, IVP and BVP to Integral Equation.

CO5. The Fredholm's first, second and third theorem, Integral Equations with symmetric kernel, Eigen function expansion, Hilbert-Schmidt theorem

Contents:

Unit – 1

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

Unit - 2

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 solution.

Unit – 3

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 form. Hilbert-Schmidt theorem. Solution of Fredholm integral equations of second kind by using Hilbert-Schmidt theorem.

Unit - 4

Solution of Volterra integral equations of second kind with convolution type kernels by Laplace transform. 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.

Reference Books:

1. Shanti Swarup, Integral Equations, Krishna Publications, Meerut.

2. M. D. Raisinghania, Integral Equations and Boundary Value Problems, S.Chand, 2010.

3. Abdul J. Jerry, Introduction to Integral Equations with applications, Marcel Dekkar Inc. NY, 1999.

4. L .G. Chambers, Integral Equations: A short Course, Int. Text Book Company Ltd. 1976.

Discipline Specific Elective (DSE)

Mathematical Programming – II

Course Objectives:

Students will have the knowledge about Non-linear programming, Formulation and their solution by different methods.

Course Learning Outcomes:

After the completion of the course the students will be able to understand the core principles of mathematical modelling. They can frame quantitative problems and model them mathematically and solve them by different methods.

Contents:

Unit – 1

Convex function, Quadratic forms, constrained problem of maxima and minima, Lagrangian method, Non-linear programming: Formulation and Graphical method.

Unit – 2

Non-linear programming and its fundamental ingradients, Kuhn-Tucker necessary and sufficient conditions; Saddle point, Saddle-point theorems.

Unit – 3

Quadratic Programming: Kuhn-Tucker conditions, Wolfe method, Duality in Quadratic Programming.

Unit - 4

Beals method to solve QPP, Geometric Programming: Formulation, geometric arithmetic inequality, necessary conditions of optimality.

Reference Books:

1. Kanti Swaroop, P.K.Gupta and Manmohan, Operation Research, Sultan Chand & Sons., N.Delhi, 2007.
2. S.D.Sharma, Operations Research, Kedar Nath Ram Nath and co. Meerut, 2005.
3. F. S. Hillier and G. J. Lieberman, Introduction to Operations Research Concepts and Cases (9th Edition), Tata McGraw Hill, 2010.
4. Hamdy A. Taha, Operations Research, An Introduction (9th edition), Prentice- Hall, 2010.
5. G. Hadley, Linear Programming, Narosa Publishing House, New Delhi, 2002.

Continuum Mechanics – II

Course objective: Student will learn about the basic principles and equations applicable to all constitutive models. State capabilities and limitations of the specific constitutive models covered in this course

Course Learning Outcomes:

After the completion of the course the students would gain knowledge about spatial, material coordinates, general stresses and strain in continuous materials. The students also gain knowledge about tensor calculus and the ideas about to apply mathematical concepts in real world problem related to continuum mechanics.

Contents:

Unit - 1

Law of conservation of mass and Eulerian continuity equation. Reynolds transport theorem. Momentum integral theorem and equation of motion.

Unit-2

Kinetic equation of state. First and the second law of thermodynamics and dissipation function. Applications (Linear elasticity and Fluids) - Assumptions and basic equations. Generalized Hook's law for an isotropic homogeneous solid.

Unit-3

Compatibility equations (Beltrami-Michell equations). Classification of types of problems in linear elasticity. Principle of superposition, Strain energy function, Uniqueness theorem, p- ρ relationship and work kinetic energy equation, Irrotational flow and Velocity potential.

Unit-4

Kinetic equation of state and first law of Thermodynamics. Equation of continuity. Equations of motion. Vorticity-stream surfaces for inviscid flow, Bernoulli’s equations. Irrotational flow and velocity potential. Similarity parameters of fluid flow.

Reference Books:

1. W. Prager, Introduction to Mechanics of Continua, Lexinton Mass, Ginn, 1961.
2. A. C. Eringen, Mechanics of Continua, Wiley, 1967.
3. T. J. Chung, Continuum Mechanics, Prentice-Hall, 1988.

General Relativity & Cosmology

Course objective:

This course will enable the students to provide a detailed knowledge of the general relativity and its applications in Cosmology. Solve the problems and help in research in these broad areas.

Course Learning Outcomes:

After the completion of the course the students will be able to:

CO1- Formulate Einstein field equation for matter and empty space.

CO2- Understand the concept of clock paradox in general relativity.

CO3- Derive the differential equation for planetary orbit, analogues of Kepler's law.

CO4- Understand the properties of Einstein & de-Sitter cosmological models .

Contents:

Unit - 1

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 - 2

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 – 3

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 – 4

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.

Reference Books:

1. J.V. Narlikar, Lectures on General Relativity and Cosmology, Macmillan Co. Ltd. India, N. Delhi, 1978.

2. C. Moller, The Theory of Relativity, Oxford Clarendon Press, 1952.
3. P.G. Bergmann, Introduction to the Theory of Relativity, Prentice Hall of India, 1969.
4. J.L. Anderson, Principles of Relativity Physics, Academic Press, 1967.
5. W. Rindler, Essential Relativity, Van Nostrand Reinhold Company, 1969.
6. V. A. Ugarov, Special Theory of Relativity, Mir Publishers, 1979.

Computer Applications- Practical Teaching (Practical Paper)

Duration: **3 hrs. Max. Marks: 70**

Note: There shall be five practical with internal choice and candidates are required to attempt all given practical.

Course objective:

The objectives of this software lab course are to introduce coding on MATLAB/Mathematica/Maple software to solve system of linear equations, Integrations and differentiation and differential equations.

Course Learning Outcomes:

CO1-Use MATLAB/Mathematica/Maple as a basic arithmetic, computing and plotting platform.

CO2-Write functions on MATLAB/Mathematica/Maple and run them

CO3-Use Symbolic methods to perform calculus and solve differential equations.

CO4-To develop problem-solving skills and apply them independently to problems in pure and applied mathematics.

Contents:

Solution of system of linear equations - Gauss elimination, Gauss-Seidel, Eigenvalues and Eigenvectors - Power method and inverse power method. Least Squares Approximation - Fitting of straight line, parabola and cubic equation. Numerical integration - Trapezoidal and Simpson's methods, Differential equations and graphics: Double integration, Roots of polynomial, two- and three-dimensional plots, Numerical solution of Initial value problems - Euler's method, Fourth order Runge-Kutta method, solution of Boundary value problems by using inbuilt functions of MATLAB/Mathematica/Maple.

Distribution of Marks:

Five Practical - 10 Marks each= 50 Marks

Practical Record= 10 Marks

Viva-Voice= 10 Marks

Total Marks (ESPE) = 70 Marks

Internal Marks: 30

Numerical Analysis – II

Course objective:

The objective of the course to enrich the Students with the technique to solve numerically Ordinary Differential Equations and boundary value problem.

Course learning objective:

On the completion of the course, student can utilize the Numerical Methods to convert the scatter data into the equation and solutions of the ODE and BVP.

Contents:

Unit – 1

Curve Fitting and Function Approximations – Least square error criterion. Linear regression. Polynomial fitting and other curve fittings, Approximation of functions by Taylor series and Chebyshev polynomials.

Unit – 2

Numerical solution of Ordinary differential Equations – Taylor series Method, Picard method, Runge-Kutta methods up to fourth order, Multistep method (Predictor-corrector strategies).

Unit - 3

Stability analysis – Single and Multistep methods. BVP's of ordinary differential Equations – Boundary value problems (BVP's), Shooting methods.

Unit - 4

Finite difference methods. Difference schemes for linear boundary value problems of the type $y'' = f(x, y)$, $y'' = f(x, y, y')$ and $y^{iv} = f(x, y)$.

Reference Books:

1. S. S. Sastry, Introductory Methods of Numerical Analysis, PHI, 1979.
2. V. Rajaraman, Computer Oriented Numerical Methods, PHI, 1993.
3. M. K. Jain, S.R.K. Eyenger and R.K. Jain, Numerical Methods for Mathematics and Applied Physicists, Wiley-Eastern Pub., N. Delhi, 2005.
4. B. Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, India, 2007.
5. C. F. Gerald and P. O. Wheatley, Applied Numerical Analysis, Pearson Education, India, 7th edition, 2008.
6. C.F. Gerald, P.O. Wheatley, Applied Numerical Analysis, Addison-Wesley, 1998.
7. S. D. Conte, C de Boor, Elementary Numerical Analysis, McGraw-Hill, 1980.
8. C.E. Froberg, Introduction to Numerical Analysis, (Second Edition), Addition- Wesley, 1979.