PONDICHERRY UNIVERSITY

RAMANUJAN SCHOOL OF MATHEMATICAL SCIENCES

DEPARTMENT OF MATHEMATICS

CHOICE BASED CREDIT SYSTEM

FOR M.Sc MATHEMATICS PROGRAMME

Offered in Affiliated Colleges of Pondicherry University

SYLLABI

WITH EFFECT FROM THE ACADEMIC YEAR

2021-2022 onwards

Eligibility Criteria for admission to M.Sc Mathematics:

A pass in B.Sc Mathematics or B.Sc Applied Mathematics

Duration of the programme:

- M.Sc Mathematics program should have a duration of Two years/four semesters.
- Maximum time to pass the program by a student is four years.

Medium of instruction :
English is the medium of instruction for all subjects.

Preamble and Objectives:
The Choice Based Credit System (CBCS) is being introduced in affiliated colleges of Pondicherry University for M>Sc Mathematics from the academic year 2020-2021 in accordance with the directives of University Grant Commision(UGC) . The system provides an opportunity to students to design curriculum to self individual needs.
CBCS in M.Sc Mathematics is aimed at

- Offering courses on credit mode and enrich the quality of teaching – learning at higher education level.
- Encouraging faculty to design and develop newer soft core courses.
- Enabling students to make a choice between different streams of Soft core courses.

Hard core and Soft core:

- Subjects which are basic and essential to a program are called Hard core (compulsory) courses.
- Courses which can be selected from the list of courses are known as soft core (elective) courses.

Course Design:
All hard core courses are compulsory courses. Soft core courses are elective streams. Soft core courses are designed based on skill requirements of employers /career objectives of students and market trends.

Semester wise Course Design

Sl. No.	Hard/soft core	SUBJECT CODE	SUBJECT TITLE	Credits	Contact hours (per/week)
SEMESTER I					
1	Hard core	MATH-411	Advanced Algebra	4	6
2	Hard core	MATH-412	Real Analysis – I	4	6
3	Hard core	MATH-413	Ordinary Differential Equations	4	6
4	Hardcore	MATH-414	Topology	4	6
5	Soft core	MATH-415	Scilab Practical	2	4
			Total	18	28
SEMESTER II					
1	Hard core	MATH-421	Galois Theory	4	6
2	Hard core	MATH-422	Real Analysis – II	4	6
3	Hard core	MATH-423	Complex Analysis	4	6
4	Hard core	MATH-424	Lebesgue Measure Theory	4	6
5	Soft core	MATH- 425	Mathematical SoftwarePractical	2	4
			Total	18	28
SEMESTER III					
1	Hard core	MATH-511	Linear Algebra	4	6
2	Hard core	MATH-512	Partial Differential Equations	4	6
3	Hard core	MATH-513	Functional Analysis	4	6
4	Hard core	MATH-514	Number Theory	4	6
5	Soft core	MATH-515	Project -1	2	4
				18	28
SEMESTER IV					
1	Soft core		Soft core course -1	4	6
2	Soft core		Soft core course - 2	4	6
3	Soft core		Soft core course -3	4	6
4	Soft core		Soft core course - 4	4	6
5	Soft core	MATH-525	Project-2	2	4
				18	28

The four soft core courses are to be taken from the list of the soft core courses given below.

SYLLABI

List of Hard Core Courses offered from the Academic Year 2021-2022

Sl. No.	SUBJECT CODE	SUBJECT TITLE
1	MATH-411	Advanced Algebra
2	MATH-412	Real Analysis – I
3	MATH-413	Ordinary Differential Equations
4	MATH-414	Topology
5	MATH-421	Galois Theory
6	MATH-422	Real Analysis – II
7	MATH-423	Complex Analysis
8	MATH-424	Lebesgue Measure Theory
9	MATH-511	Linear Algebra
10	MATH-512	Partial Differential Equations
11	MATH-513	Functional Analysis
12	MATH- 514	Number Theory

M.Sc. Mathematics - List of Soft Core Courses to be offered from the Academic Year 2021- 2022

Sl. No.	SUBJECT CODE	SUBJECT TITLE
1.	MATH-415	Scilab Practical
2.	MATH- 425	Mathematical Software
3.	MATH-435	Project
4	MATH-445	Project
5.	MATH -530	Discrete Mathematics
6.	MATH -531	Difference Equations
7.	MATH-532	Graph Theory
8.	MATH-533	Algorithmic Graph Theory
9.	MATH-534	Fluid Mechanics
10.	MATH-535	Advanced Fluid Mechanics
11.	MATH-536	Numerical Analysis for Ordinary Differential Equations
12.	MATH-537	Operations Research
13.	MATH-538	Differential Geometry
14.	MATH-539	Integral Equations
15.	MATH-540	Optimization Techniques
16.	MATH -541	Mathematical Programming

HARD CORE
MATH 411- ADVANCED ALGEBRA (4 Credits)

Objectives:
To study Dihedral groups, Group Actions, The Sylow theorems, Direct and semi-direct products, Ring Homomorphism

Course Outcomes: At the end of the course the students will able to

- Understand basic definitions of Groups axioms, Subgroup generated by subsets of a group
- Understand basic definitions of Quotient groups and Group Actions
- Understand Compact space and its characteristics.
- Characterize direct, semi-direct products and abelian groups.
- Define Euclidean domains and prove related theorems.

Unit I: Introduction to groups- Dihedral groups- Homomorphism and Isomorphisms- Groups axioms- Subgroups: Definition and Examples - Centralizer and normalizer , Stabilizer and Kernels -Cyclic groups of a subgroup-Subgroup generated by subsets of a group.

Unit II: Quotient groups and Homomorphisms: Definitions and Examples- more on cosets and Lagrange's Theorem- The isomorphism theorems -Transpositions and Alternating groups- Group Actions: Group Actions and Permutation representations-Group acting on themselves by left multiplication-Cayley's theorem.

Unit III: Group acting on themselves by conjugation -The class equation- Automorphisms- The Sylow theorems- The simplicity of A_n.

Unit IV: Direct and semi-direct products and abelian groups: Direct products- The fundamental theorem of finitely generated abelian groups.

Unit V: Ring Homomorphism and quotient rings- properties of ideals-Rings of fractions- The Chinese Remainder theorem- Euclidean domains, Principal ideal domains and Unique factorization domains.

Text Book:
Abstract Algebra (Third Edition) by David S. Dummit and Richard M. Foote,
Chapter 1 (Sections 1.2,1.6 and 1.7 only), Chapter 2 (Sections 2.1 to 2.4), Chapter 3 (except 3.4), Chapter 4, Chapter 5 (Sections 5.1 and 5.2 only), Chapter 7 (Section 7.3 to 7.6), chapter 8 and Chapter 10 (Section 10.1 to 10.3).

Reference books

1 M. Artin: Algebra, Prentice-Hall of India, 1991.
2. I.N.Herstein: Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.
3. N.Jacobson: Basic Algebra, Volumes I & II, W.H.Freeman, 1980.
4. S.Lang: Algebra, 3rd edition, Addison-Wesley, 1993.

HARD CORE

MATH-412: REAL ANALYSIS – I (4 Credits)

Objectives:
To study basic definitions on countability, compactness and connectedness, Convergence of sequence and series, limits, continuous functions, derivatives, Riemann- Stieltjes integral.
Course outcomes: At the end of the course, the students will be able to

- Understand the basic definition of compact sets, connected sets, sequences.
- Solve problems on root and ratio tests and define addition and multiplication of series.
- Understand limits of function, continuous function, Monotonic function.
- Find derivatives of higher order and vector-valued function.
- Understand the definition and existence of integral, properties and related theorems.

Unit-I

Finite, countable and uncountable sets - Metric spaces - Compact sets - Perfect sets - Connected sets - Convergent sequence - Subsequences - Cauchy sequences - Upper and lower limits – Some special sequences.

Unit- II

Series- Series of non- negative terms - The number e – The root and ratio tests - Power series - Summation by parts - Absolute convergence – Addition and multiplication of series - Rearrangements of series.

Unit- III

Limits of functions - Continuous functions - Continuity and compactness - Continuity and connectedness - Discontinuities - Monotonic functions - Infinite limits and limits at infinity.

Unit- IV

The derivative of a real function - Mean value theorems – The continuity of derivatives - L'Hospital's rule - Derivatives of higher order - Taylor's theorem - Derivatives of vector – valued functions.

Unit- V

The Riemann- Stieltjes integral- Definition and existence of the integral - Properties of the integral - Integration and differentiation - Integration of vector- Valued functions - Rectifiable curves.

Text Book
Walter Rudin, Principles of Mathematical Analysis- McGraw Hill International Editions, Mathematics series, 1976 (Chapters 2-6)

Reference Books

1. Patrick M. Fitzpatrick, Advanced Calculus, AMS, Pure and Applied Undergraduate Texts, Indian Edition, 2nd edition, 2009.
2. Tom Apostol, Mathematical Analysis, Narosa Publishing House, Indian edition, 1985.
3. N.L.Carothers, Real Analysis, Cambridge University Press, 2000.
4. Karl.R.Stormberg, An Introduction to Classical Real Analysis, AMS Chelsea Publishing, 2015.

HARD CORE: MATH-413

ORDINARY DIFFERENTIAL EQUATIONS (4 Credits)

Objectives:

This course introduces theQualitative properties of solutions, Series solutions of first and second order equations, Legendre polynomials, Linear systems, The method of successive approximations.

Course Outcomes: At the end of the course the students will able to

- Understand Qualitative properties of solutions, Eigen values and Eigen functions and vibrating string.
- Solve Series solutions of first and second order equations.
- Construct Legendre polynomials, Bessel functions and their properties.
- Solve Homogeneous linear system with constant coefficients.
- Find the method of successive approximations and prove Picards's theorem.

Unit-I

Qualitative properties of solutions – The Sturm comparison theorem – Eigen values and Eigen functions and vibrating string.

Unit-II

Series solutions of first order equations – Second order linear equations – Ordinary points - Regular singular points – Gauss Hyper Geometric equations.

Unit-III

Legendre polynomials – Properties of Legendre polynomials – Bessel functions- The Gamma function - Properties of Bessel Function.

Unit-IV

Linear systems – Homogeneous linear system with constant coefficients.

Unit-V

The existence and uniqueness of solutions – The method of successive approximations – Picards's theorem.

Text Book

G. F. Simmons, Differential Equations with Applications and Historical Notes, McGraw Hill Book Company, 1972.

Sections: 22-30, 32-35, 37-38 and 55-56.

Reference

1. Earl Coddington and Norman Levinson, Theory of ordinary Differential equations, TATA McGraw Hill, 2017.

HARDCORE
MATH-414: TOPOLOGY (4 Credits)

Objectives:
To study topological spaces, Bases, Compactness, Regular space, Normal Space and Connected space.
Course Outcomes: At the end of the course the students will able to

- Understand definitions of sets, Lattices, Metric Spaces.
- Understand basic definitions of Topology, Separability, Countability.
- Can elaborate Compact space and its characteristics.
- Define Sequential compactness, Hausdroff space.
- Understand connected space and prove related theorems.

Unit-I
Revision of sets - Functions - Product of sets – Relations – Countable sets – Uncountable sets – Partially ordered sets and lattices – Metric spaces – Definition and examples – Open sets and closed sets in metric spaces – Open subsets of real line.
Unit -II
Topological spaces -- Definitions and examples - Closure and related concepts – Open bases and open sub bases – Separability and second countability - Lindloff's Theorem
Unit-III
Compactness – Basic results -- Continuous maps on compact sets - Characterization of compactness by basic and sub basic open covers – Tychonoff's theorem - Generalized heine – Borel theorem.
Unit – IV
Compactness for metric spaces – Sequential compactness - Lebesgue covering lemma - Sequential compactness and compactness coincide on metric spaces - T_1 spaces - Hausdorff spaces.
Unit -V
Completely regular spaces and normal spaces – Urysohn's lemma and Tietze extension theorem-–Connected spaces – Components of a space.

Text Book
G. F. Simmons, an Introduction to Topology and Modern Analysis, McGraw-Hill Kogakusha, Tokyo, 1963
Chapter 1 – Revision of Sections 1—3, Section 4—8.
Chapter 2 – Sections 9 - 12
Chapter 3 – Sections 16, 17 and 18
Chapter 4 – Sections 21 - 24
Chapter 5 – Sections 26 - 28
Chapter 6 – Sections 31 and 32

Reference Books

1. J. R. Munkres, Toplogy, Pearson Education Inc., Second Edition, 2000.
2. Stephen Willard, General Topology, Dover Publication 2004.
3. J. Dugundgi, Toplogy, Allyn and Bacon, Boston, 1966.
4. Fred.H.Croom, Principles of Topology, Dover publications, 2016.

HARD CORE
MATH- 421- GALOIS THEORY (4 Credits)

Objectives:
To study Polynomial rings, Field theory, Splitting fields and Algebraic closures, Galois Theory and Composite extension and simple extensions.

Course Outcomes: At the end of the course the students will able to

- Understand basic definitions of Polynomial rings, Irreducible criteria
- Study basic definitions of Algebraic Extensions
- Analyze Separable and inseparable extensions.
- Prove The fundamental theorem of Galois Theory .
- Formulate Cyclotomic extensions and abelian extensions over Q.

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Unit I: Polynomial rings: Definitions and basic properties- Polynomial rings over fields- Polynomial rings that are unique factorization domains -Irreducible criteria- Polynomial rings over fields.

Unit II: Field theory: Basic theory of field extensions-Algebraic Extensions.

Unit III: Splitting fields and Algebraic closures - Separable and inseparable extensions- Cyclotomic polynomials and extensions.

Unit IV: Galois Theory: Basic definitions- The fundamental theorem of Galois Theory - Finite Fields.

Unit V: Composite extension and simple extensions- Cyclotomic extensions and abelian extensions over Q.

Text Book:

Abstract Algebra (Second Edition) by David S. Dummit and Richard M. Foote, Chapter 9 (Sections 9.1 to 9.6), Chapter 13 (Section 13.1,13.2 and 13.4 to 13.6), Chapter 14 (Sections 14.1 to 14.4 and 14.6).

Reference books

1 M. Artin: Algebra, Prentice-Hall of India, 1991.
2. I.N.Herstein: Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.
3. N.Jacobson: Basic Algebra, Volumes I & II, W.H.Freeman, 1980.
4. S.Lang: Algebra, 3rd edition, Addison-Wesley, 1993.

HARD CORE
MATH-422: REAL ANALYSIS – II (4 Credits)

Objectives:
To study Improper Riemann integrals, Sequence and Series of functions, Power Series, Functions of Several Variables.
Course Outcome: At the end of the course the students will able to

- Understand the basics of Bounded variation, Metric Spaces, Nowhere dense sets.
- Find uniform convergence Iterated limits, Equi-continuous Families of Functions
- Solve Exponential, Trigonometric and Logarithmic Functions
- Define Linear Transformation, the Contraction Principle and prove related theorems.
- Analyze implicit Function, and theorems on Rank and Determinants.

Unit-I
(**Sections**: 7.9 and 7.10 of [3] ; Chapter:6 of [2]; Chapter:4 of [4]-Subsections: 4.7-1 & 4.7-2)
Improper Riemann integrals - Functions of Bounded variation – Completeness of Metric Spaces - Nowhere dense sets - Baire's Category Theorem.
Unit-II (Chapter: 7 of [1], Subsections 7.1 to 7.25)
Sequence and Series of functions - Examples - Uniform convergence and Continuity - Uniform convergence and Integration - Uniform convergence and Differentiation - Double sequences and series - Iterated limits- Equi-continuous Families of Functions - Arzela – Ascoli Theorem
Unit- III (Chapter: 7 of [1] subsections: 7.26 to7.33 and chapter 8 of [1])
The Weierstrass theorem for algebraic polynomials- The Stone - Weierstrass Theorem - Power Series - The Exponential and Logarithmic Functions - The Trigonometric Functions - Fourier Series - The Weierstrass theorem for the Trigonometric polynomials.
Unit- IV (Chapter:9 of [1], Subsections: 9.6 to 9.23)
Functions of Several Variables - Linear Transformation - Differentiation - The Contraction Principle.
Unit- V (Chapter: 9 of [1], Subsections:9.24 to 9.38)
The inverse function Theorem - The implicit Function Theorem - The Rank Theorem – Determinants.

Text Books

1. Walter Rudin, Principles of Mathematical Analysis- McGraw Hill International Editions, Mathematics series, 1976.
2. Apostol, Mathematical Analysis, Narosa Publishing House, Indian edition,2002.
3. Richard R. Goldberg, Methods of Real Analysis, Oxford &IBH Publishing Co.1970.
4. Erwin Kreyszig, Introductory Functional analysis with Applications, John –Wiley, 1989.

Reference Books

1. Patrick M. Fitzpatrick Advanced Calculus, Amer. Math. Soc. Pine and Applied Undergraduate Texts, Indian Edition, 2009.
2. Kenneth A. Ross, Elementary Analysis, The Theory of Calculus, Springer-Verlag,1980.
3. G.F.Simmons, Introduction to Topology and Modern Analysis, McGraw Hill, 2017.
4. Ervin Kreyszig, Introductory Functional Analysis with Applications,Wiley, 2007.

HARD CORE
MATH 423 COMPLEX ANALYSIS (4 Credits)

Objectives:
To study Abel's Limit theorem, Elementary conformal mappings, Line integrals, The general form of Cauchy's theorem and Harmonic functions

Course Outcomes: At the end of the course the students will able to

- Understand basic definitions of Analytic functions and Luca's Theorem.
- Define Linear transformations, Cross ratio and construct elementary conformal mappings.
- Perceive Cauchy's theorem for rectangle and disc.
- Understand basic definitions of Zeros and poles.
- Understand Definite integrals, Taylor's and Laurent's series.

Unit I: Analytic functions- Cauchy Riemann equations-Luca's Theorem-Rational functions-Elementary theory of power series- Abel's Limit theorem-Exponential and trigonometric functions-The Logarithm. *[Chapter-2, Sections 1,2 and 3]*

Unit II: Conformality-Linear transformations-Cross ratio- Elementary conformal mappings. *[Chapter-3, Sections:2,3 and 4]*

Unit III: Line integrals-Cauchy's theorem for a rectangle- Cauchy's theorem in a disc-Cauchy's integral formula. *[Chapter:4, Sections: 1 and 2]*

Unit IV: Local properties of analytic functions-Zeros and poles- the Maximum principle- The general form of Cauchy's theorem. *[Chapter: 4, Sections:3and 4.]*

Unit V: The Residue Theorem- Argument principle-Evaluation of Definite integrals- Harmonic functions- Poisson's formula- Schwarz's theorem- Taylor series expansion-Laurent's series.
[Chapter: 4, Sections:5,6, Chapter:5, Sections: 1]

Text Book:

L.V.Ahlfors, Complex analysis, Third Edition, McGraw Hill Book Company,1979.

References:

1. John. B. Conway, Functions of one Complex Variable, Second Edition, Narosa Publishing House, 2002.
2. B.C.Palka, An Inroduction to the Complex function Theory, Springer, 1991.
3. H.A. Priestley, Introduction to Complex Analysis, Second Edition, Oxford University Press, 2003.
4. Donald Sarason, Notes on Complex Function Theory, Hindustan Book agency ,1994.

HARD CORE
MATH-424 LEBESGUE MEASURE THEORY (4 Credits)

Objectives:
To introduce Algebras and σ – algebras, Measurable sets, Measurable functions, Integrable functions, Functions of bounded variation, Lebesgue integrability and Characterization of absolutely continuous functions as indefinite integrals.

Course Outcome: At the end of the course the students will able to

- Understand the basic definition of σ - algebras and examples.
- Interpret Measurable functions with examples and related theorems.
- Understand Lebesgue integral of non- negative measurable functions, Lebesgue integral of integrable functions and related theorems.
- Compare Riemann and Lebesgue integration and can prove theorem on almost everywhere differentiable monotonically increasing functions.
- Understand Absolutely continuous functions, their examples and properties and can Characterize absolutely continuous functions as indefinite integrals.

Unit-I
Ring and algebra of sets-σ - algebras- Examples- Algebras and σ - algebras generated by a class of sets - Borel algebra and Borel sets. Lebesgue outer measure on R - Countable sub-additivity - Measurable sets - Examples - σ - algebra structure of measurable sets - Countable additivity of Lebesgue measure on R - Cantor set.

Unit-II
Construction of a non- measurable subset of [0, 1] - Measurable functions- Examples and basic properties - Approximation of measurable and bounded measurable functions by simple measurable functions - Approximation by step functions and continuous functions - Egorov's theorem.

Unit-III
Lusin's theorem - Lebesgue integral of non- negative measurable functions- Integrable functions and Lebesgue integral of integrable functions - Linearity- Monotone Convergence theorem - Fatou's lemma - Dominated convergence theorem - Applications of convergence theorems.

Unit-IV
Comparison of Riemann and Lebesgue integration - Lebesgue integrability of Riemann integrable functions - Characterization of Riemann integrable functions – Improper Riemann integrals and their Lebesgue integrals - Riemann- Lebesgue lemma - Functions of bounded variation - Statement of Vitali's lemma and theorem on almost everywhere differentiability of monotone increasing functions.

Unit-V
Absolutely continuous functions - Examples and properties - Absolute continuity of indefinite integral of Lebesgue integrable functions - Differentiation of indefinite integrals - Characterization of absolutely continuous functions as indefinite integrals.

Text Book

1. H.L.Royden, and P.M.Fitzpatrick, Real Analysis, (Fourth Edition) PHI Learning Private Limited, 2011.

Reference Books

1. P.R. Halmos, Measure Theory, Springer, 2nd edition, 1976.
2. Walter Rudin, Real and Complex Analysis (Unit 3), Mc Graw-Hill, 1989.
3. Inder K. Rana, An Introduction to Measure and Integration(Second Edition), Narosa Publishing House, 2007.
4. G de Barra, Measure Theory and Integration(Second Edition), New Age Publishers, 2013.
5. N.L.Carothers, Real Analysis, Cambridge University Press, 2000

HARD CORE
MATH-511 LINEAR ALGEBRA (4 Credits)

Objectives:
To study Linear Transformation, Nilpotent Transformation, Cannonical forms, Trace, Transpose, Determinants, Quadratic forms.
Course Outcome: At the end of the course the students will able to

- Understand the basic of Linear Transformation, Invariant subspace and matrices.
- Able to find the Nilpotent transformation, index and invariance.
- Formulate Jordan forms, Modules and related theorems
- Understand rational canonical form, trace, transpose and determinants.
- Analyze Normal transformations and Real Quadratic forms.

Unit-I
The Algebra of linear transformations- Characteristic roots- Similarity of linear transformations, Invariant subspaces and matrices.

Unit-II
Reduction to triangular forms- Nilpotent transformations - Index of nil potency and invariant of nilpotent transformation.

Unit-III
Jordan blocks and Jordan forms- Modules - Cyclic modules - Fundamental theorem on modules over PID.

Unit-IV
Rational canonical form- Trace- Transpose and Determinants.

Unit-V
Hermitian - Unitary and Normal transformations - Real quadratic forms.

Text Book
I.N.Herstein,Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.
Sections – 6.1, 6.2 and 6.3
Sections – 6.4 and 6.5
Sections – 6.6 and 4.5
Sections - 6.7, 6.8 and 6.9
Sections – 6.10 and 6.11

Reference Books

1. M.Artin, Algebra, Prentice-Hall of India, 1991
2. N.Jacobson, Basic Algebra, Volumes I & II, W.H.Freeman, 1980.
3. S.Lang, Algebra, 3rd edition, Addison-Wesley, 1993
4. P. B. Bhattacharya, S. K. Jain and S.R. Nagpaul, Basic Abstract Algebra (2nd Edition) Cambridge University Press, Indian edition, 1997
5. Kenneth Hoffmann and Ray Kunze, Linear Algebra, (Second edition), Pearson, 2015

HARD CORE

MATH-512: PARTIAL DIFFERENTIAL EQUATIONS (4 Credits)

Objectives:

To study first order PDEs, Non-linear first order PDEs, Classification of second order PDEs, Wave Equations, Laplace equations, Heat Equations.

Course Outcome: At the end of the course the students will able to

- Understand the basic of first order PDE, Non-linear first order PDEs.
- Classify Second order PDE, and can solve Linear PDE with constant solutions.
- Prove one dimensional wave equation, find adjoint operators.
- Derive Laplace equation, Poisson equation, Neumann problems for a rectangle and circle.
- Define Heat Conduction Problem and classify n-variables.

Unit – I: First Order PDEs

Curves and surfaces- Genesis of first order PDE- Classification of Integrals- Linear equations of first Order- Pfaffian Differential equations- Compatible systems- Solutions of Quasi linear equations

Non-linear first order PDEs : Charpit's method- Special Types of Charpit's- Jacobi's method,-Integral surfaces through a given curve-The Cauchy problem for Quasi Linear case and nonlinear first order PDEs

Unit – II: Second Order PDEs

Genesis of Second order PDEs- Classification of second order PDEs- Canonical forms of Hyperbolic- Elliptic and parabolic type PDEs - Linear PDE with constant coefficients – Method of finding CF and particular integral- Homogeneous linear PDE

Unit – III: Wave Equations

One –dimensional wave equations- Vibrations of a string of Infinite length- Semi-infinite length and finite length- Adjoint Operators, Riemann's Method- Method of separation of variables

Unit – IV: Laplace equations

Derivation of Laplace equations & poisson equation- Boundary value problems- Properties of Harmonic functions- Mean value theorem- Maximum and minimum principles- Separation of variables- Dirichlet problem and Neumann problems for a rectangle and circle

Unit – V: Heat Equations

Heat Conduction Problem in infinite rod case and finite rod case- Duhamel's Principle- Heat conduction equation - Elementary solution- Solution by separation of variables- Classification in n-variables- Families of equi potential surfaces

Text Books

1. T. Amarnath, An Elementary Course in Partial Differential Equations, Narosa Publishing House, 2010.
2. K. Shankara Rao, Introduction to Partial Differential Equations, PHI Publications, 3rd Edition. 2011.

Reference Books

1. I. N. Sneddon, Elements of Partial DifferentiaI Equations, McGraw Hill, International Edition, 1986.
2. F. John, Partial Differential Equations, Springer Verlag, 1975.
3. Lawrence C. Evans, Partial Differential Equations, Graduate Studies in Mathematics, 1998.
4. Clive Chester, Techniques in Partial Differential equations, McGraw-Hill Inc.,US , 1971.
5. Richard Courant and David Hilbert, Methods of Mathematical Physics, Vol-II, Wiley VCH, 1989.

HARD CORE

MATH- 513: FUNCTIONAL ANALYSIS (4 Credits)

Objectives:
To study Normed Linear Spaces, Continuity, Equivalent norms, Hahn-Banach theorem for real vector spaces, Closed and open maps, Separable Hilbert spaces, Orthogonal projections.
Course Outcome: At the end of the course the students will able to

- Understand the basics of Normed Linear Spaces, Dual Spaces.
- Characterize finite dimensional normed linear spaces and prove related theorems..
- Prove Hahn-Banach theorem and related theorems
- Understand Orthonormal sets, Orthonormal basis and prove related theorems.
- Prove theorems on Separable Hilbert spaces, Orthogonal projections.

Unit-I
Normed Linear Spaces – Examples of sequence and function spaces and Linear transformations –Continuity – Dual Spaces – Product and quotient of normed linear spaces – Completeness of product and quotient of normed linear Spaces – Completeness of the space of all bounded, linear transformations.
Unit- II
Equivalent norms - Completeness of finite dimensional normed linear spaces – Riesz's lemma - Characterization of finite dimensional normed linear spaces as those with compact unit sphere - Continuity of linear maps defined on finite dimensional normed linear spaces.
Unit-III
Hahn-Banach theorem for real vector spaces – Hahn-Banach theorem for real and complex normed linear spaces –Corollaries to Hahn-Banach theorem – The Principle of uniform boundedness – Banach – Steinhauss theorem – Weakly Bounded sets are bounded.
Unit-IV
Closed and open maps – Maps with closed graph – Example of discontinuous, linear map with closed graph – Open mapping theorem and the closed graph theorem – Applications – Inner product spaces – Examples – Inner product spaces and parallelogram law for norm – Orthonormal sets – Bessel's inequality – Gram-Schmidt orthonormalization – Orthonormal basis-Examples.

Unit- V Separable Hilbert spaces and countable orthonormal basis – Linear isometry onto - Example of a non-separable Hilbert space – Uncountable orthonormal basis and definition of convergence of Fourier series – Riesz-Fisher's theorem-Orthogonal projections – Closed subspaces are Chebychev - Riesz's representation theorem.
Text Book
M. Thamban Nair, Functional Analysis, Eastern Economy Edition , Prentice~ Hall of India Private Limited, New Delhi (2002).

Reference Books
1. M. Fabian, P. Habala, P. Hakek, V. M Santalucia, J. Pelant and V. Zizler, Functional Analysis and Infinite Dimensional Geometry, CMS Books in Mathematics, Springer- 2001
2. B.V.Limaye, Functional Analysis, Wiley Eastern, New Delhi, 1981.

HARD CORE

MATH-514 NUMBER THEORY (4 Credits)

Objectives:

This course aims to explore primes, Power residues, Quadratic reciprocity, functions of number theory, Diophantine equations.

Course Outcome: At the end of the course the students will able to

- Understand the basic Divisibility.
- Define Congruences, Number theory from an algebraic view point.
- Understand the Concepts of Quadratic residues and reciprocity.
- Interpret Arithmetic, Recurrence functions and Mobius Inversion Formula.
- Solve Diophantine equations.

Unit-I

Divisibility: Introduction - Divisibility - Primes.

Unit-II

Congruences - Solution of congruences - Congruences of higher degree - Prime power moduli - Prime modulus - Congruences of degree two, prime modulus - Power residues - Number theory from an algebraic view point

Multiplicative groups, rings and fields.

Unit-III

Quadratic reciprocity: Quadratic residues - Quadratic reciprocity - The Jacobi symbol.

Unit-IV

Some functions of number theory: Greatest integer function - Arithmetic functions - The Mobius Inversion Formula - Multiplication of arithmetic functions – Recurrence functions.

Unit-V

Some Diophantine equations: The equation $ax+by = c$ - Positive solutions - Other linear equations - The equation $x^2 + y^2 = z^2$ - The Equation $x^4 + y^4 = z^2$ - Sum of fourth powers - Sum of two squares - The equation $4x^2 + y^2 = n$.

Text Book

Treatment as in Ivan Niven and S. Zuckerman, An Introduction to the Theory of Numbers, John Wiley, New York, 2000.

UnitI: Sections 1.1 – 1.3

UnitII: Sections 2.1 - 2.11

UnitIII: Sections 3.1 – 3.3

UnitIV: Sections 4.1 – 4.5

UnitV: Sections 5.1 - 5.6, 5.10 and 5.11

M.Sc. Mathematics
SOFTCORE: MATH 415: SCILAB PRACTICAL

Unit-I: SCILAB Basics
Overview of SCILAB – Get started – Basic elements of the language – Matrices

Unit-II: SCILAB Programming
Looping and Branching – Functions – Plotting

Unit-III: Application into Basic Statistics
Measures of Central Tendency – Descriptive Statistics – Measures of Dispersion

Unit-IV: Application into Advanced Statistics
Cumulated distribution function – Data with missing values – Hypothesis Testing

Unit-V: Optimization Toolbox
FOSSEE SCILAB Optimization Toolbox – fminsearch – fsolve – fminbnd – fmincon – linprog – intlinprog – intfmincon – quadprog – intquadprog, Genetic Algorithm (optim_ga)

Text Books:
1. Introduction to SCILAB – Michael Baudin From SCILAB Consortium, 2010
2. SCILAB Online Help – https://help.scilab.org/docs/5.5.2/en_US/section_33491857221a48388b878311e9f4b67e.html
3. FOSSEE SCILAB Toolbox – Optimization Toolbox https://scilab.in/fossee-scilab-toolbox/optimization-toolbox/functions
4. SCILAB Online Help – optim_ga – https://help.scilab.org/docs/5.5.2/en_US/optim_ga.html.

Reference Books:
1. https://www.scilab.org/tutorials
2. SCILAB help documentation – Statistics
3. Basic Statistics and Probability with SCILAB – Gilberto E. Urroz infoclearinghouse.com https://www.scilab.org/sites/default/files/Basic%20Statistics%20and%20Probability%20with%20SCILAB%20-%20Gilberto%20E.%20Urroz%20-%202001.pdf

Unit-I: Chapter 1, 2, 3, 4 of Text Book 1
Unit-II: Chapter 5, 6, 7 of Text Book 1
Unit-III: Text Book 2
Unit-IV: Text Book 2
Unit-V: Text Book 3 and 4

SOFTCORE:
MATH 425: MATHEMATICAL SOFTWARE PRACTICAL

Unit-I: LaTeX Basics
LaTeX introduction- Installation – Math symbols and tables – TeX symbol and tables, Matrix and lists – Typing Math and text – Text environments.

Unit-II: Document Preparation using LaTeX
Document structure – Latex Documents – The AMS articles document class, Bemer Presentation and PDF documents, Long Documents – BibTeX – Make index – Books in LaTeX, Colours and Graphics – TeXCAD – LaTeX CAD.

Unit-III: Python Basics
Getting started with Python – Intrinsic operations and Input/ Output – Programming Basics – Functions – Modules – Files

Unit-IV: SciPy in Python
SciPy – Introduction – Basic functions – Special functions – Integration – Optimization – Linear Algebra

Unit-V: R Software
A few concepts before starting – Data with R – Graphics with R – Statistical analysis with R – Programming with R in practice

Text Books:
1. G. Gratzer, More Math Into LATEX, 4th edition, Springer, (2007).
2. https://texcad.sourceforge.io/
3. Rashi Gupta, Making use of Python, Wiley Publishing, Inc, (2002).
4. SciPy v1.4.1 Reference Guide by SciPy.org – https://docs.scipy.org/doc/scipy/reference/index.html.
5. Emmanuel Paradis, R for Beginners – https://cran.r-project.org/doc/contrib/Paradis-rdebuts_en.pdf.

Unit-I: Appendix A, B, C; Chapter 2, 3, 5, 6 of Text Book 1
Unit-II: Chapter 10, 11, 13, 14, 16, 17, 18, of Text Book 1
Unit-III: Chapter 2 to 7 of Text Book 2
Unit-IV: Specified submodules of the Text Book 3
Unit-V: Chapter 2 to 6 of Text Book 4.

Reference Books:
1. https://rstudio.com/resources/books/
2. https://tex.loria.fr/graph-pack/grf/grf.pdf
3. Jaan Kiusalaas, Numerical Methods in Engineering with Python, Cambridge University Press, (2010).
4. http://drdg.tripod.com/sitebuildercontent/sitebuilderfiles/PythonDocStart16dec2010.pdf
5. Sandip Rakshit, R programming for beginners, Mc Graw Hill, (2017).

SOFT CORE

MATH- 530 DISCRETE MATHEMATICS (4 Credits)

Objectives:

This course aims to explore Posets, Lattices, Boolean Lattices, Boolean Algebra, Boolean expressions, Logic gates, Karnaugh maps, Directed Graphs.

Course Outcome: At the end of the course the students will able to

- Understand the basic definition of Posets and lattices with examples .
- Study special lattices and their properties.
- Understand Atoms, Boolean functions, canonical forms of Boolean expressions.
- Form Logic gates and solve K-Maps.
- Understand Directed graphs and related theorems.

Unit- I:

Posets and lattices - Lattices as partially ordered sets – Properties of lattices - Lattices as algebraic systems – Sub lattices – Direct product – Homomorphism.

Unit – II:

Special lattices (Complete lattices, Bounded lattices, Complemented lattices, Distributive lattices, Modular lattices) and their properties – Boolean algebra – Switching algebra – Sub algebra – Direct product of Boolean algebra – Boolean homomorphism.

Unit - III:

Join irreducible elements – Atoms – Stone theorem – Boolean forms and their equivalence – Min terms – Sum of products canonical form – Free Boolean algebra – Max terms and product of sums canonical form – Values of Boolean expressions – Boolean functions – Symmetric Boolean expressions.

Unit – IV:

Logic gates – Combination of gates – Adders – Karnaugh maps – Representation and Minimization of Boolean functions.

Unit –V:

Directed graphs – In and out degrees – Connectedness - – Directed paths and cycles – Moon theorem.

Text Books

1. J.P Trembly and R. Manohar: Discrete Mathematical Structures with Applications to Computer Science, Tata McGraw – Hill Publishing Company Ltd, New Delhi 1997.
   For Units– I, II, III, IV: Relevant portions of Chapter - 4.
2. J.A. Bondy and U.S.R. Murthy: Graph Theory with Applications, Macmillan Press Ltd, New Delhi- 1976.
   For Unit –V: Relevant portions of Chapter 10.

Reference Books

1. J. Johnsonbaugh, Discrete Mathematics, MacMillan Publishing company, New York 1989.
2. R.P. Grimaldi, Discrete and Combinatorial Mathematics (An Applied Introduction), Pearson Edition Asia, New Delhi – 2002.
3. B. Kolman, R.C. Busby and S.C Ross, Discrete Mathematical Structures, Pearson Editionn Pvt Ltd, New Delhi –2003.

SOFT CORE
MATH-531 DIFFERENCE EQUATIONS (4 Credits)

Objectives:
To study the basics of Difference Calculus, First order difference equation, General Linear equation, Linear Difference equations, Inhomogeneous equations, Linear Difference equation with constant coefficients.

Course Outcome: At the end of the course the students will able to

- Understand the Derivation, Operators and Factorial polynomials.
- Understand general first-order equation.
- Understand Fundamental theorem for homogeneous equations.
- Understand Sturm Liouville Difference equation.
- Construct a difference equation.

Unit-I
The Difference Calculus Definition, Derivation of difference equation- Existence and uniqueness theorem- Operators and E- Elementary difference operators. Factorial polynomials - Operators and the sum calculus - Examples.

Unit-II
First order difference equation General Linear equation- Continued fraction.
A general first-order equation – Expansion Techniques.

Unit-III
Linear Difference equations -Introduction- Linearly dependent functions-Fundamental theorem for homogeneous equations.

Unit-IV
Inhomogeneous equations In homogeneous equations- Second order equations. Sturn Liouville Difference equations.

Unit-V
Linear Difference equation with constant coefficients introduction- Homogeneous equation- Construction of a difference equation having specified solution- Relationship between Linear difference and differential equation.

Text Book
Ronald E. Mickens, Difference equation - Theory and Application, Chapman &
Hall, Second Edition, New York – London, 1990.

Unit 1: Chapter 1: (Sections 1.2-1.8)
Unit 2: Chapter 2: (Sections 2.1-2.8)
Unit 3: Chapter 3: (Sections 3.1-3.3)
Unit 4: Chapter 3: (Sections 3.5-3.6)
Unit 5: Chapter 4: (Sections 4.1-4.4)

HARD CORE

MATH- 532 GRAPH THEORY (4 Credits)

Objectives:

To study basic of Graphs and Trees, Counting the Number of Spanning Trees, Matchings, Chromatic Number and Planarity of Graphs.

Course Outcome: At the end of the course the students will able to

- Understand the operations on Graphs.
- Get an idea of Cut sets and Connectivity.
- Understand Coverings, Matchings in Bipartite Graphs and prove related theorems.
- Define Coloring, Girth and prove related theorems.
- Understand Planarity and prove related theorems.

Unit -I

Graphs – Subgraphs – Isomorphism of graphs – Degrees of Vertices – Paths and Connectedness – Autumorphism of a Simple Graph – Operations on Graphs – Trees – Centers and Centroid.

Unit -II

Counting the Number of Spanning Trees – Cayley's Formula – Vertex Cuts and Edge Cuts – Connectivity and Edge-connectivity – Blocks – Cyclical Edge-connectivity of a Graph.

Unit -III

Vertex Independent sets and Vertex Coverings – Edge-Independent Sets – Matchings and Factors –M-Augmenting Paths – Matchings in Bipartite Graphs – Halls Theorem on Bipartite graphs – Tutte's 1-Factor Theorem.

Unit –IV

Vertex Coloring – Chromatic Number – Critical Graphs – Brooks' Theorem – Girth – Triangle-Free Graphs – Mycielski's Construction – Edge Colorings of Graphs – Vizing's Theorem – Chromatic Polynomials.

Unit –V

Planar and Nonplanar Graphs – Euler's Formula and its Consequences – K_5 and $K_{3,3}$ are Nonplanar graphs – Dual of a Plane Graph – The Four Color Theorem and the Heawood Five-Color Theorem – Kuratowski's Theorem (without proof).

Text Books:-

1. R. Balakrishnan and K. Ranganathan, A Textbook of Graph Theory (Universitext), Second Edition, Springer New York 2012.

Chapter 1: 1.1-1.6, 1.8
Chapter 3: 3.1-3.5
Chapter 4: 4.1-4.5
Chapter 5: 5.1-5.5
Chapter 7: 7.1,7.2,7.3.1, 7.5,7.6.2,7.9
Chapter 8: 8.1-8.7

Reference Books:-

1. J.A. Bondy and U.S.R. Murty, Graph Theory, Springer 2008.
2. Douglas B. West, Introduction to Graph Theory, Second Edition, PHI Learning Private Ltd, New Delhi-2011.
3. G. Chartrand, Linda Lesniak and Ping Zhang, Graphs and Digraphs, Fifth Edition, CRC press 2011.

SOFT CORE

MATH – 533 ALGORITHMIC GRAPH THEORY (4 Credits)

Objectives:

To study Graphs and notations, Spanning trees and Search methods, Finding all spanning trees of a graph, matrix in graphs and algorithm for finding spanning tree.

Course Outcome: At the end of the course the students will able to

- Understand the basics of Graphs and notations, Operations on graphs.
- Define Search methods ,groups, fields and vector spaces
- Understand Fundamental cut sets ,Connectivity and separability.
- Define Incidence matrix, Cycle matrix, cut set matrices and Path matrix
- Analyze The shortest path problem using algorithm

Unit- I

Graphs and notations – Null, complement and complete graphs – Degrees – Isomorphism – Sub graphs – Paths and cycles – Connectedness - Components – Operations on graphs - Distance, Radius, Diameter, Centers and medians in graphs - Rooted and m ary trees.

Unit – II

Binary trees – and their search – Spanning trees - Search methods: Breadth first search and depth first search algorithms – Introduction to groups, fields and vector spaces – Vector spaces of graphs – Dimensions, Relationships, orthogonality of cycle and cut set subspaces.

Unit – III

Fundamental cycles – Finding all spanning trees of a graph – Cut sets and their properties – Fundamental cut sets – Relation in fundamental cycles and cut sets – On Connectivity and separability – Network flows - (1) isomorphism.

Unit – IV

Incidence matrix and its sub matrices – Cycle matrix – Fundamental cycle matrix and its rank and nullity – Cut set and fundamental cut set matrices – Relationship theorem – Path matrix – Adjacency matrix.

Unit –V

The connector problem – Kruskal algorithm – Prim algorithm – The shortest path problem – Dijkstra's algorithm – Network models – Flows – cuts – Maximum flow algorithm – The max. flow, min. cut theorem.

Text Books

1. K. Thulasiraman and M.N.S. Swamy, Graphs : Theory and Algorithms – John Wiley and Sons, Inc., New York (1992).
2. Narsingh Deo, Graph Theory with Applications to Engineering and Computer Science, Prentice Hall of India Ltd (1974).
3. J. A. Bondy and U.S.R. Murthy: Graph Theory with Applications, Elsevier Science North Holland (1982).

Reference Books

1. G. Chartrand and O. R. Oellermann, Applied and Algorithmic Graph Theory, McGraw Hill New York (1993).
2. W. Kocay and D. L. Kreher, Graphs, Algorithms and Optimization, Chapman and Hall – CRC Press, London (2005).
3. J. Johnsonbaugh, Discrete Mathematics, Macmillan Publishing Company, New York (1989).

SOFT CORE

MATH- 534 FLUID MECHANICS (4 Credits)

Objectives:

This course aims to explore Conservation of mass and energy, Rotations and vorticity, Stokes equations, Potential flow, Boundary layers

Course Outcome: At the end of the course the students will able to

- Understand the basic laws of mass and energy.
- Define the Concepts of circulation of fluid in incompressible flows.
- Interpret Navier- Stokes equations and Decomposition concepts.
- Understand the flows in Potential and its paradox.
- View on Boundary layers and prove related theorems.

Unit-I

Equations of motion - Euler's Equation – Conservation of mass – Balance of momentum – Transport theorem - Conservation of energy – Incompressible Flows – Isentropic Fluids – Bernoulli's theorem.

Unit-II

Rotations and vorticity – Kelvin's circulation theorem – Helmholtz's theorem.

Unit-III

Navier- Stokes equations – Scaling properties – Decomposition theorem - Stokes equations – Poiseuille flow .

Unit-IV

Potential flow – Complex potential – Blasius theorem - Kutta-Joukowski theorem – D'Alembert's paradox – Stokes paradox.

Unit-V

Boundary layers – Prandt boundary layer equations –Steady boundary layer flow on a flat plate of infinite width.

Text Book

A. J. Chorin and J. E Marsden, A Mathematical Introduction to Fluid Mechanics, Texts in Applied Mathematics 4, Springer Verlag, 1990.

References:

1. D.J.Acheson, Elementary Fluid Dynamics, Oxford University Press, 1990.

SOFT CORE
MATH- 535 ADVANCED FLUID MECHANICS (4 Credits)

Objectives:

This course aims to explore Wave equation, Prandtl's relation and Compressive shocks, Riemann problem, conservation laws and Non convex systems of conservation laws, Numerical methods.

Course Outcome: At the end of the course the students will able to

- Understand the Riemann invariants.
- Define the Concepts of Systems of conservation laws.
- Get an idea of Riemann problem and Solution of the Riemann problems.
- View on the basic conservation laws and Non convex systems of conservation laws.
- Solve Numerical problems in different methods.

Unit-I
Characteristics - Wave equation - Examples - Riemann invariants - Hodograph transformation - Piston problem.

Unit-II
Shocks - Systems of conservation laws - Weak solution - Rankine - Hugoniot relations - Hugoniot relation - Prandtl's relation - Compressive shocks - Entropy condition.

Unit-III
Riemann problem - Centered waves - Solution of the Riemann problem - Courant – Fricdricts - Lewy condition.

Unit-IV
Combustion waves - Single conservation law - Convex conservation laws - Oleinik's condition – Non convex systems of conservation laws - Solution.

Unit-V
Numerical methods - Finite difference Methods- Forward Difference - Backward Difference - Central difference - Consistency - Order - Stability - Lax's Theorem – Von Neumann Analysis - Godunov scheme - l8 stability - l_2 stability - Lax – Fricdricks scheme - Lax Wendroff scheme - Crank - Nicolson scheme.

Text Books

1. Chorin and Marsden, A Mathematical Introduction to Fluid Mechanics, Texts in Applied Mathematics, Springer, Third Edition, 2009.
2. A Iserles , A First course in the Numerical Analysis of Differential Equations, Cambridge University Press, 2009.

Reference Books:

1. D.J.Acheson, Elementary Fluid Dynamics, Oxford University Press, 1990.

SOFT CORE

MATH- 536 NUMERICAL ANALYSIS FOR ORDINARY DIFFERENTIAL EQUATIONS

(4 Credits)

Objectives:
To study the order and convergence of differential equations, Gaussian quadrature, Stiff equations, Error Control.

Course Outcome: At the end of the course the students will able to

- Interpret the concepts of Euler,Trapezoidal and Theta method.
- Understand order and convergence of Adams - Bashforth method
- View on Explicit and Implicit Runge Kutta scheme.
- Understand A-stability of RK and multistep methods.
- Solve the errors in Runge Kutta method.

Unit-I
Euler's method - Trapezoidal rule - Theta method.

Unit-II
Adams - Bashforth method - Order and convergence - Backward differentiation formula.

Unit-III
Gaussion quadrature - Explicit Runge - Kutta scheme - Implicit Runge Kutta scheme - Collocation.

Unit-IV
Stiff equations - Linear stability domain and A- Stability -- A-stability of RK and multistep methods.

Unit-V
Error Control - Milne Device - Embedded Runge Kutta method.

Text Book

1. Arieh Iserles, A First Course in the Numerical Analysis of Differential Equations, Cambridge University press, 2^{nd} edition, 2008.

Reference Book:

1. Richard L. Burden and J.Douglas faires,Numerical Analysis(9^{th} Edition), Cengage Learning India, 2012.

SOFT CORE

MATH-537 OPERATIONS RESEARCH (4 Credits)

Objectives:

To study the Linear programming problems, Linear programming problems in Graphical Method and Simplex Method, Network models, Integer Programming, Decision Theory, Game Theory.

Course Outcome: At the end of the course the students will able to

- Formulate Linear programming problems.
- Solve Linear programming problems using Graphical Method and Simplex Method.
- Find Shortest route problem .
- Solve Integer Programming using Branch and Bound Technique.
- Analyze Decision under risk and uncertainty, and solving Linear programming problems in Game Theory.

Unit-I: Hyperplanes and half-spaces – Supporting and separating hyper planes – Convex functions – Linear programming basic concepts – Convex sets – Linear programming problems – Examples of LPP – Feasible, basic feasible and optimal solutions – Extreme points.

Unit-II: Linear Programming – Graphical Method - Simplex Method.

Unit-III: Network models – Network definitions – Minimal spanning tree algorithm – Shortest route problem.

Unit-IV: Integer Programming – Cutting plane algorithm - Branch and Bound Technique.

Unit-V: Decisions under risk – Decision trees – Decision under uncertainty. Game Theory - Two - Person, Zero - Sum Games - Games with Mixed Strategies - Graphical Solution - Solution by Linear Programming.

Text books 1. Hamdy A. Taha: Operations Research, Fourth Edition, 1971 Chapter 8 – Sections 8.3, 8.4 and Chapter 11– Sections 11.1 to 11.4. 2. J.K.Sharma: Mathematical Models in Operations research, Tata McGraw Hill, 1990 Chapter 2 – Sections 2.12 to 2.14 and Chapter 4 – Sections 4.3 to 4.4.

SOFT CORE

MATH – 538 DIFFERENTIAL GEOMETRY (4 Credits)

Objectives:

This course aims to explore Curves, Torsion, surface, Isometrics of surfaces, Curvature of curves on a surface.

Course Outcome: At the end of the course the students will able to

- Understand the Concepts of Curvature - Plane curves.
- Interpret the Isoperimetric Inequality- The Four vertex Theorem.
- Define Tangents, normal and orientability.
- Perceive the Concepts of Conformal mapping of surfaces.
- Understand the geometric interpretation of principal curvatures and prove related theorems.

Unit-I

Curves- arc length- Re-parametrization-Level curves - Curvature - Plane curves.
[Sections: 1.1 to 1.4 and Sections 2.1,2.2.]

Unit-II

Space curves-Torsion- Serret Frenet equations- Simple closed curves- The Isoperimetric Inequality- The Four vertex Theorem.
[Sections 2.3 and Sections 3.1 to 3.3.]

Unit-III

Smooth surface- Tangents, normal and orientability- Examples of surfaces- Quadratic surfaces- Triple orthogonal systems- Applications of Inverse function theorem.[Sections 4.1 to 4.7]

Unit-IV

Lengths of curves on surfaces- First fundamental form- Isometrics of surfaces- Conformal mapping of surfaces-Surface area- Equi-areal maps and a theorem of Archimedes.
[Sections: 5.1 to 5.5]

Unit-V

The Second Fundamental form- The Curvature of curves on a surface- The normal and principal curvature- Euler's theorem- The geometric interpretation of principal curvatures.
[Sections: 6.1 to 6.4]

Text Book:

1. Andrew Pressley, *Elementary Differential Geometry*, Springer, 2004.

Reference Books:

1. Christian Bar, *Elementary Differential Geometry*, Cambridge University Press, 2011.
2. Thomas F. Banchoff and Stephen T. Lovett, *Differential Geometry of Curves and Surfaces*, A.K Peters/CRC press, 2010.
3. W. Klingenberg, *A course in Differential Geometry*, Springer-Verlag, New York, 1978.

SOFT CORE
MATH- 539 INTEGRAL EQUATIONS (4 Credits)

Objectives:
This course aims to explore basic of Integral equations, BVP for ODE, Second order ODE, Integral equations of the second kind, Operators.
.
Course Outcome: At the end of the course the students will able to

- Classify integral equation, IVP for ODE
- Define the Concepts of BVP for elliptic PDE and Abel's problem.
- Solve Singular boundary value problems.
- Understand Degenerate kernels and a different approach .
- Prove theorems on Newmann series.

Unit-I
Introduction - Classification of integral equation - examples - IVP for ODE.

Unit-II
BVP for ODE - BVP for elliptic PDE - Abel's problem.

Unit-III
Second order ODE and integral equations -Differential equation theory - initial value problems - Boundary value problems - Singular boundary value problems.

Unit-IV
Integral equations of the second kind - Introduction - Degenerate kernels - a different approach.

Unit-V
Operators - Newmann series.

Text Book
Porter and Stirling, Integral equations, pp 1-94. A practical treatment from spectral theory to applications. - Cambridge: Cambridge University Press, 1996.

Reference Books

NB. L. Moiseiwitsch, Integral Equations, Dover Books on Mathematics, 2011

A M Wazwaz , A First Course in Integral Equations, https://doi.org/10.1142/3444, December1997.

SOFT CORE
MATH-540 MATHEMATICAL SOFTWARE (4 Credits)

Objectives:

This course aims to explore LATeX, Document structure, MATLAB, Programming in Maple, Abstract algebra in Maple.

Course Outcome: At the end of the course the students will able to

- Install LATeX , Typing Math and text.
- Interpret the Concepts of Beamer and BibteX.
- Understand MATLAB, Built in function, Two and three dimensional Plots.
- Understand the Concepts of Maple
- Understand Maple in Abstract algebra and Complex Arithmetic.

Unit-I
LATeX introduction- Installation – Math symbols and tables – TeX symbol and tables – Matrix and lists – Typing Math and text – Text environments.

Unit-II
Document structure – Latex Documents – The AMS articles document class – Bemer Presentation and PDF documents – Long Documents – BibteX – Make index – Books in LateX- Colours and Graphics – TeXCAD – LATeX CAD.

Unit-III
Starting with MATLAB- Variables Vectors, Matrices – Creating Array in MATLAB –Menu, Workspace, working Directory, Command window, Diary, Printing- Built_in function, User defined functions, Script M-files- Complex Arithmatic, Eigen values and Eigen vectors – Two and three dimensional Plots.

Unit-IV
Getting around with maple – Maple input and output - Programming in Maple.

Unit-V
Maple: Abstract algebra – Linear algebra – Calculus on numbers – Variables- Complex Arithmatic, Eigen values and Eigen vectors – Two and three dimensional plots.

Text Books

1. G. Gratzer, More Math Into LATEX, 4th edition, Springer, (2007).
2. AMOS Gilat, MATLAB an introduction with application, WILEY India Edition, (2009).
3. Brain R Hunt, Ronald L Lipsman,A Guide to MATLAB for beginners and Experienced users, Cambridge University Press. (2003)
4. Ander Heck, Introduction in Maple, Springer, (2007)

M.Sc. Mathematics
SOFTCORE: MATH 541: OPTIMIZATION TECHNIQUES

Unit-I: Linear Programming: Problem formulation of Linear Programming, Graphical solution to LPP, Canonical and standard forms, Simplex Method to solve LPP, Big-M Method for use of artificial variables, Alternate optima.

Unit-II: Mathematics of the Simplex Method and Duality in Linear Programming: Convex sets and other basic definitions, Elementary results for LPP, the Simplex algorithm: Main theorem, Dual of LPP, Duality theorems (without proof), Complementary Slackness theorem, Reading the solution of the Dual.

Unit-III: Transportation Problem & Assignment Problems: Mathematical modeling of transportation problem, Balanced transportation problem, Consequence of unimodularity, Optimality Conditions/ Stopping Criterion, Methods for finding starting solution, MODI method, Mathematical modeling for Assignment Problem, a transportation equivalent of the Assignment Problem, Hungarian method.

Unit-IV: Convex Optimization: Convex and Concave functions and their properties, Maxima and minima of convex functions, Convex optimization problems, Convex programming problems, Optimality Conditions.

Unit-V: Optimality Conditions for Nonlinear Programming: Feasible directions and Linearizing cone, Basic constraint qualification, Lagrangian and Lagrange multipliers: Optimization problems with equality constraints, Karush-Kuhn-Tucker necessary/sufficient optimality conditions.

Text Books:
1. Kanti Swarup , P.K. Gupta and Man Mohan, Operations Research – Introduction to Management Science, Sultan Chand & Sons, 19th Edition, 2018.
2. Suresh Chandra, Jayadeva, Aparna Mehra, Numerical Optimization with Applications, Narosa Publications, 2009.

Reference Books:
1. Hamdy A.Taha, Operations Research: An Introduction, 9th edition, Pearson, 2010
2. M.S. Bazaraa, H.D.Sherali, & C.M. Shetty, Nonlinear Programming Theory & Algorithms, John Willey & Sons, 2006, 3rd Edition.
3. O. Güler, Foundations of Optimization, Springer, 2010.
4. R.K. Sundaram, A First Course in Otimization Theory, Cambridge University Press, 2009.
5. Singiresu S. Rao, Engineering Optimization: Theory and Practice, John Wiley &Sons, 2009.

Unit-I: Chapter 2, 3, 4 of Text Book 1, Chapter 2: Section 2.7 of Text Book 2
Unit-II: Chapter 3: Section 3.2 – 3.5, Chapter 4: Sections 4.2 – 4.5 of Text Book 2
Unit-III: Chapter 5: Section 5.2 – 5.7, 5.10, 5.11, 5.13 of Text Book 2
Unit-IV: Chapter 7: Section 7.2 – 7.5 of Text Book 2
Unit-V: Chapter 8: Sections 8.1 – 8.5 of Text Book 2

SOFT CORE:

MATH 541: MATHEMATICAL PROGRAMMING

(Pre-requisite for this paper is Operations Research – Linear Programming)

Unit-I: Convex Analysis: Convex sets, Convex and Concave functions and their properties, Maxima and minima of convex functions, Convex optimization problems, Convex programming problems, Optimality Conditions.

Unit-II: Quadratic Programming: Quadratic programming problems, Wolfe's method for quadratic programming (Method and problems only).

Unit-III: Optimality Conditions for Nonlinear Programming: Unconstrained Optimization: Global and local minimum, strict local minimum, Necessary conditions for optimality, sufficient conditions for optimality, Feasible directions and Linearizing cone, Basic constraint qualification, Lagrangian and Lagrange multipliers: Optimization problems with equality constraints, Karush-Kuhn-Tucker necessary/sufficient optimality conditions.

Unit-IV: Duality in Nonlinear Programming: Duality in Nonlinear Programming, Lagrangian Dual, Wolfe's Dual, Weak Duality theorem, Certain Special Cases of Wolfe Dual.

Unit-V: Algorithms in Nonlinear Programming: Frank and Wolfe's method, Rosen's gradient projection method, Penalty function method.

Text Books:

1. Suresh Chandra, Jayadeva, Aparna Mehra, Numerical Optimization with Applications, Narosa Publications, 2009.
2. M.S. Bazaraa, H.D.Sherali, & C.M. Shetty, Nonlinear Programming Theory & Algorithms, John Willey & Sons, 2006, 3rd Edition.

Reference Books:

1. O. Güler, Foundations of Optimization, Springer, 2010.
2. R.K. Sundaram, A First Course in Otimization Theory, Cambridge University Press, 2009.
3. Singiresu S. Rao, Engineering Optimization: Theory and Practice, John Wiley &Sons, 2009.

Unit-I: Chapter 3: Section 3.2, Chapter 7: Sections: 7.2 – 7.5 of Text Book 1
Unit-II: Chapter 7: Sections 7.6 – 7.7 of Text Book 1
Unit-III: Chapter 4: Sections 4.1.1 – 4.1.5 of Text Book 2, Chapter 8: Sections 8.1 – 8.5 of Text Book 1
Unit-IV: Chapter 8: Sections 8.6 – 8.7 of Text Book 1
Unit-V: Chapter 10: Sections 10.2, 10.4, 10.5 – 10.7 of Text Book 1

QUESTION PAPER PATTERN FOR 60 MARKS

SECTION-A

Answer all the Questions (5 x 2 = 10 Marks)

SECTION-B

Answer any Five Questions (5 x 4 = 20 Marks)
(Either or type with one question from each Unit)

SECTION-C

Answer any Three Questions (3 x 10= 30 Marks)
(Three out of Five - Each questions should have two sub-divisions (a) & (b) for 5 Marks each.)

IMPORTANT INSTRUCTIONS

1. The colleges should have a good library stocking recent books related to Mathematics subjects updating regularly.

2. The college is required to procure at least 8 copies of the prescribed text book and keep it available in their libraries for each courses.

3. The number of Faculties in the Mathematics department should be as specified by the UGC norms of students teachers ratio.