।। सा विद्या या विमुक्तये ।।

स्वामी रामानंद तीर्थ मराठवाडा विद्यापीठ, नांदेड

"ज्ञानतीर्थ" परिसर, विष्णुपुरी, नांदेड - ४३१६०६ (महाराष्ट्र)

SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY NANDED

"Dnyanteerth", Vishnupuri, Nanded - 431606 Maharashtra State (INDIA)

Established on 17th September 1994 – Recognized by the UGC U/s 2(f) and 12(B), NAAC Re-accredited with 'A' Grade

ACADEMIC (1-BOARD OF STUDIES) SECTION

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संलग्नित महाविद्यालयांतील विज्ञान व तंत्रज्ञान विद्याशाखेतील पदव्युत्तर स्तरावरील द्वितीय वर्षाचे **CBCS Pattern** नुसारचे अभ्यासक्रम शैक्षणिक वर्ष २०२०—२१ पासून लागू करण्याबाबत.

प रि प त्र क

या परिपत्रकान्वये सर्व संबंधितांना कळविण्यात येते की, **दिनांक २० जून २०२० रोजी संपन्न झालेल्या ४७व्या मा. विद्या परिषद बैठकीतील विषय क्र.११/४७—२०२०**च्या ठरावानुसार प्रस्तुत विद्यापीठाच्या **संलग्नित महाविद्यालयांतील विज्ञान व तंत्रज्ञान विद्याशाखेतील पदव्युत्तर स्तरावरील द्वितीय वर्षाचे** खालील विषयांचे **C.B.C.S. (Choice Based Credit System) Pattern** नुसारचे अभ्यासक्रम शैक्षणिक वर्ष २०२०—२१ पासून लागू करण्यात येत आहेत.

1. M.Sc.-II Year-Botany	2. M.Sc.-II Year-Herbal Medicine
3. M.Sc.-II Year-Analytical Chemistry	4. M.Sc.-II Year-Biochemistry
5. M.Sc.-II Year-Organic Chemistry	6. M.Sc.-II Year-Physical Chemistry
7. M.Sc.-II Year-Computer Management	8. M.Sc.-II Year-Computer Science
9. M.Sc.-II Year-Information Technology	10. M.C.A. (Master of Computer Applications)-II Year
11. M.Sc.-II Year-Software Engineering	12. M.Sc.-II Year-System Administration & Networking
13. M.Sc.-II Year-Dairy Science	14. M.Sc.-II Year-Environmental Science
15. M.Sc.-II Year-Applied Mathematics	16. M.Sc.-II Year-Mathematics
17. M.Sc.-II Year-Microbiology	18. M.Sc.-II Year-Physics
19. M.Sc.-II Year-Zoology	20. M.Sc.-II Year-Biotechnology
21. M.Sc.-II Year-Bioinformatics	

सदरील परिपत्रक व अभ्यासक्रम प्रस्तुत विद्यापीठाच्या **www.srtmun.ac.in** या संकेतस्थळावर उपलब्ध आहेत. तरी सदरील बाब ही सर्व संबंधितांच्या निदर्शनास आणून द्यावी.

'ज्ञानतीर्थ' परिसर,
विष्णुपुरी, नांदेड — ४३१ ६०६.
जा.क्र.: शैक्षणिक—१/परिपत्रक/पदव्युत्तर—सीबीसीएस अभ्यासक्रम/ २०२०—२१/**३३५**
दिनांक : १६.०७.२०२०.

स्वाक्षरित/—
उपकुलसचिव
शैक्षणिक (१—अभ्यासमंडळ) विभाग

प्रत माहिती व पुढील कार्यवाहीस्तव :
१) मा. कुलसचिव यांचे कार्यालय, प्रस्तुत विद्यापीठ.
२) मा. संचालक, परीक्षा व मूल्यमापन मंडळ यांचे कार्यालय, प्रस्तुत विद्यापीठ.
३) प्राचार्य, सर्व संबंधित संलग्नित महाविद्यालये, प्रस्तुत विद्यापीठ.
४) साहाय्यक कुलसचिव, पदव्युत्तर विभाग, प्रस्तुत विद्यापीठ.
५) उपकुलसचिव, पात्रता विभाग, प्रस्तुत विद्यापीठ.
६) सिस्टम एक्सपर्ट, शैक्षणिक विभाग, प्रस्तुत विद्यापीठ.

SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED.

CHOICE BASED CREDIT SYSTEM (CBCS)

SEMESTER PATTERN

FACULTY OF ARTS / SCIENCE

M.A. /M. Sc. (Second Year)

(Mathematics) Revised Syllabus

Effective from June-2020 onwards

Swami Ramanand Teerth Marathwada University, Nanded.

M.A. /M. Sc. (Second Year) (Mathematics) (CBCS) Syllabus

Semester	Paper No.	Name of the paper	Hrs./Week	Credits	Max. Marks		
					IA	EA (ESE)	Total
III	XIII	Functional Analysis	4	4	25	75	100
	XIV	Topology	4	4	25	75	100
	Elective-III XV(A) XV(B) XV(C)	Choose any one Analytical Number Theory Theory of Linear operators-I Fuzzy Sets and their Applications-I	4	4	25	75	100
	Elective-IV XVI(A) XVI(B) XVI(C)	Choose any one Fluid Mechanics-I Difference Equations-I Mathematical Softwares-I (Theory and Practical)	4	4	25	75	100
	Elective-V XVII(A) XVII(B) XVII(C)	Choose any one Integral Transforms Financial Mathematics Fractional Calculus and its Applications-I	4	4	25	75	100
	XVIII	Tutorial-III (Compulsory)	2 Hrs./ Batch / Week. Max-25, Min-20	5		125	125
IV	XIX	Numerical Analysis	4	4	25	75	100
	XX	Abstract Algebra-II (Field Theory)	4	4	25	75	100
	Elective–VI XXI(A) XXI(B) XXI(C)	Choose any one Classical Mechanics Theory of Linear operators-II Fuzzy Sets and their Applications-II	4	4	25	75	100
	Elective-VII XXII(A) XXII(B) XXII(C)	Choose any one Fluid Mechanics-II Difference Equations-II Programming in C++ (Theory and Practical)	4	4	25	75	100
	Elective-VII XXIII(A) XXIII(B) XXIII(C)	Choose any one Integral Equations lattice Theory Fractional Calculus and its Applications-II	4	4	25	75	100
	XXIV	Project Work (Compulsory)		5		125	125
		Total		50			1250

Swami Ramanand Teerth Marathwada University, Nanded.

M.A./M. Sc. (Second Year) (Mathematics) (CBCS) Revised Syllabus
Effective from June-2020

Third Semester		Fourth Semester	
Paper No.	**Name of the paper**	**Paper No.**	**Name of the paper**
XIII	Functional Analysis	XIX	Numerical Analysis
XIV	Topology	XX	Abstract Algebra-II
One paper to be chosen from each of the following groups which are taught in the department.			
XV(A)	Analytical Number Theory	XXI(A)	Classical Mechanics
XV(B)	Theory of Linear operators-I	XXI(B)	Theory of Linear operators-II
XV(C)	Fuzzy Sets and their Applications-I	XXI(C)	Fuzzy Sets and their Applications-II
XVI(A)	Fluid Mechanics-I	XXII(A)	Fluid Mechanics-II
XVI(B)	Difference Equations-I	XXII(B)	Difference Equations-II
XVI(C)	Mathematical Softwares-I (Theory and Practical)	XXII(C)	Programming in C++
XVII(A)	Integral Transforms	XXIII(A)	Integral Equations
XVII(B)	Financial Mathematics	XXIII(B)	Lattice Theory
XVII(C)	Fractional Calculus and its Applications-I	XXIII(C)	Fractional Calculus and its Applications-II
XVIII	Tutorial-III (Compulsory)	XXIV	Project Work (Compulsory)

Swami Ramanand Teerth Marathwada University, Nanded.

M.A./M. Sc. (Second Year) (Mathematics) (CBCS pattern)

Program Educational Objectives (PEOs):

PEO1: To equip students with knowledge, abilities and insight in mathematics and related fields.

PEO2: Have the ability to pursue interdepartmental research in Universities in India and abroad.

PEO3: To develop the ability to utilize the mathematical problem solving methods such as analysis, modeling, programming and mathematical software applications in addressing the practical and heuristic issues.

PEO4: To enable them to work as a mathematical professional or qualify for training as scientific researcher.

PEO5: To enable students to recognize the need for society and the ability to engage in life-long learning.

PROGRAMME OUTCOMES (POs):

After the completion of the program, students will able to:

PO1: Identify, formulate, and analyze the complex problems using the principles of Mathematics.

PO2: Solve critical problems by applying the Mathematical tools.

PO3: Apply the Mathematical concepts, in all the fields of learning including higher research, and recognize the need and prepare for lifelong learning.

PO4: Able to crack competitive examinations, lectureship and fellowship exams approved by UGC like CSIR-NET and SET.

PO5: Apply ethical principles and commit to professional ethics, responsibilities and norms in the society.

PO6: Gain the knowledge of software which will be useful in Industry

PROGRAM SPECIFIC OUTCOMES (PSOs):

PSO1: To understand the basic concepts of advanced mathematics.

PSO2: To develop the problems solving skills and computational skills.

PSO3: To enhance self learning and improve own performance.

PSO4: To formulate mathematical models.

M.A. / M.Sc. (Second Year) Mathematics Programme: Course objectives and outcomes

Paper No.	Name of Paper	Course Objectives	Course Outcomes (CO) After the completion of the program, students will able to:
XIII	Functional Analysis	This course introduce the concepts and develop working knowledge on Banach Space, Norm of continuous Linear Transformations, continous Linear functional, Conjugate space, Banach Algebra, Inner Product Space, Hilbert Space, Orthogonal vectors, Orthonormal vectors and sets, conjugate space H*, self adjoint, normal and unitary operators, Projections, eigen value and eogen vectors, eigen space and Spectrum of T.	CO1: Identify Normed Linear Space, Banach Space, continous Linear transformations, Conjugate space, Banach Algebra, Graph of L.T.,Hahn-Banach Theorem and it's applications, Open Mapping and Closed Graph Theorems. CO2: Analyze Hilbert space, Orthogonal and Orthonormal vectors and sets, Orthogonal Compliments and conjugate space H*.,Schwart Lemma, Bessel's Inequality and Riesz representation theorem. CO3: To Identify, Self Adjoint, Normal, Unitary and Positive operators and to analyze the invariant subspace and reducible transformations. CO4: To Provide information on Eigen and Vectors, Eigen Spaces and Spectrum of T.
XIV	Topology	The goal of the course is to provide in depth knowledge of this fundamental core course in mathematics to show various techniques from analysis, set theory, logic that are used in topological spaces to obtain their properties, to demon-strate application in physics.	CO1: Understand basics of Topological Spaces and their properties. CO2: Study Continuous functions, Metric Topology Connected Spaces, Limit Point,Compactness, Local Compactness,Limit point compactness. CO3: Achieve the zenith in treating Countable Axioms, Separable, Regular and Normal spaces. CO4: Understand the Urysohn's Lemma, Urysohn's Metrization Theorem and their applications.
XV(A)	Analytical Number Theory	This course introduce the concepts of congruence's and their properties, Chinese Remainder theorem, Primitive roots & indices, Euler's criterion, Legendre symbol, Quadratic recipro-city, arithmetical functions and dirichlet multiplication.	CO1: Understand the concepts of congruence and their properties, solve systems of linear congruence's with different moduli using the Chinese Remainder Theorem. CO2: Analyze primitive roots and indices. CO3: Discuss Legendre symbol and its properties, Quadratic reciprocity law. CO4: Study arithmetical functions and Dirichlet multiplication.
XV(B)	Theory of Linear Operators-I	This course introduce the concepts of spectral theory of linear operators in normed, spaces, compact linear operators on normed spaces and their spectrum, spectral theory of bounded self-adjoint linear operators.	CO1: Understand the Spectral properties of bounded linear operators, Resolvent and Spectrum. CO2: Analyze the concept of Linear Operators on Normed Spaces. CO3: Discuss the Spectral Properties of Compact Linear Operators. CO4: Study Spectral Properties of Bounded Self-Adjoint Linear Operators, Projection operators

XV(C)	Fuzzy Sets and their Applications-I	This course introduces the concepts of Crisp sets and fuzzy sets, operations on fuzzy sets and fuzzy relations.	CO1: Understand the concepts of Crisp sets and fuzzy sets. CO2: Analyze the operations on fuzzy sets. CO3: Discuss Crisp and fuzzy relation. CO4: Study Fuzzy relation equation.
XVI(A)	Fluid Mechanics–I	The course introduces basic idea of various fluid flow, velocity and acceleration of fluid motion. The main objective of the course is to study Equation of continuity, Euler equation, Bernoulli equation, effect of pressure on fluid flow, stream function, some two dimensional flows and applications to real life.	CO1: Visualize the fluid flow pattern. CO2: Assimilate the meaning of continuity equation. CO3: Solve flow problems. CO4: Acquire command on stream function.
XVI(B)	Difference Equations - I	The course introduced the elementary analysis and linear algebra to investigate solution to difference equation. To study linear difference equations, stability theory and asymptotic methods.	CO1: Understand the role of differential operator in differential calculus. CO2: Analyze the linear and nonlinear difference equations. CO3: Study the stability of linear and nonlinear systems. CO4: Discuss asymptotic methods for solving of linear and nonlinear systems.
XVI(C)	Mathematical Softwares-I (Modeling and Simulation in Scilab/Scicos)	The course introduces the Scilab object, Scilab Programming, Scilab graphics, interfacing, Modeling and Simulation in Scilab, optimization and applications of Scilab.	CO1: Understanding the concepts of Scilab programming, input and output functions. CO2: Analyze the types of models and simulation tools. CO3: Solve Nonlinear Equations using Scilab. CO4: Create mathematical Modeling and Simulation in Scilab.
XVII(A)	Integral Transforms	The objective of this course is to introduce students the different types of integral transforms which are commonly used, their formulation concerned to real world problems, their evaluation and applications to solve ordinary and partial differential equations.	CO1: Classify the different types of integral transforms they come across. CO2: Formulate the physical problem under consideration in terms of different types of ordinary and partial differential equations with initial and boundary conditions. CO3: Solve the initial value problems and boundary value problems using the appropriate integral transform. CO34: Analyze the nature of the solution of the initial value problems and boundary value problems.
XVII(B)	Financial Mathematics	In this course the student will learn about Financial Markets and Derivatives, Binomial model, Finite Market model, Black-Scholes Model, Multi-dimensional Black- Scholes Model.	CO1: Understand the concept of Simple Discrete Financial market model. CO2: Analyze the first and second fundamental theorem of Asset model. CO3: Study Black-Scholes Model. CO4: Discuss the Multi-dimensional Black-Scholes Model.

XVII(C)	Fractional Calculus and its Applications-I	This course introduces the some special functions of the fractional calculus, Riemann-Liouville fractional derivative, Caputo's fractional derivative, Laplace, Fourier and Mellin transforms of fractional derivatives, Existence and uniqueness theorem as a method of solution.	CO1: Understand the Gamma, Mittag-Leffler, Wright functions of the fractional calculus. CO2: Study Riemann-Liouville and Caputo's fractional derivative. CO3: Analyze the integral transform methods of solution of fractions differential equations. CO4: Study existence and uniqueness theorem of \ fractions differential equations.
XVIII	Tutorial-II / Lab work (Compulsory)		
XIX	Numerical Analysis	To introduce the concepts and to develop working knowledge on Iteration Methods to Solve the Equations, Rate of Convergence of Iteration Methods, Solution of the System of Equations by using Different Direct and Iteration Methods, Eigen Value Problems, Bounds of Eigen Values, Interpolation, Lagrange, Iterated and Newton's Interpolations of Different Orders, Least Square Approximation.	CO1: Identify the roots of equations and to obtain them by using different iteration Methods. Also to obtain rate of convergence of Iteration Methods. CO2: Analyze the direct methods to solve the the system of n equations in n unknowns by using different direct methods CO3: Identify the Iteration Methods to Solve the System of n Equations in n Unknowns, Eigen Value problems and to obtain Bounds on Eigen Values. CO4: Provide information on Interpolations and Approximations for the given function.
XX	Abstract Algebra-II (Field Theory)	This course is aimed to provide an introduction to the theories, concepts and to develop working knowledge on field in order to develop a background for studying Commutative algebra and Representation Theory. To introduce the concepts and to develop working knowledge of field extensions, Galois groups and interrelation between group theory and field theory.	CO1: Understand the main algebraic properties of fields. CO2: Analyze properties of Finite, Algebraic, Normal, Simple, Cyclic & Separable extension and Splitting Fields. CO3: Compute Galois groups in simple cases and to apply the group-theoretic information to comprehend results about fields and field extensions. CO4: Develop knowledge of some classical Greek problems. CO5: Understand the concepts Cyclotomic polynomials, Polynomials solvable by radicals, symmetric functions, ruler and compass construction to Develop abstract Mathematical thinking about field.
XXI(A)	Classical Mechanics	To understand the concepts of Mechanics of system of particles, generalized co-ordinates, Degree of freedom. To Study mechanics developed by	CO1: Understand D' Alembert's Principle and applications of the Lagrangian Formulation. CO2: Distinguish the concept of the Hamilton Equations of Motion and the Principle of Least Action. CO3: Analyze the Fundamental lemma of calculus

		Newton, Lagrange and Hamilton and their applications. To solve motivating problems of calculus of variations.	of variations. CO4: Solve problems of calculus of variations using Euler's equation.
XXI(B)	Theory of Linear Operators -II	This course introduce the concepts of spectral theory of bounded self-adjoint linear operators, Unbounded Linear Operators in Hilbert Space, Unbounded Linear Operators in Quantum Mechanics.	CO1: Understand the Spectral properties of bounded self-adjoint linear operators. CO2: Analyze the concept of Unbounded Linear Operators and their Hilbert-Adjoint Operators. CO3: Discuss the Spectral Representation of Self-Adjoint Linear Operators. CO4: Study Unbounded Linear Operators in Quantum Mechanics.
XXI(C)	Fuzzy Sets and their applications-II	This course introduces the concepts of Fuzzy measures, Uncertainty & Information and applications of fuzzy sets.	CO1: Understand the concepts of fuzzy measures. CO2: Study types of uncertainty. CO3: Discuss Uncertainty & information and complexity. CO4: Study the application of Fuzzy in different fields.
XXII(A)	Fluid Mechanics – II	The aim of this course is tostudy two dimensional image system, Milne-Thomson circle theorem, theorem of Blasius, concepts of gas dynamics, stress strain relations, uniqueness theorem, important relations related to Navier-Stokes equations and various applications in all fields.	CO1: Apply Milne-Thomson circle theorem CO2: Identify appropriate governing equation for particular flow. CO3: Explain stress strain relations. CO4: Evaluate the velocity of fluid flow.
XXII(B)	Difference Equations-II	The course introduced the elementary analysis and linear algebra to investigate solution to difference equation. To study self adjoint second order linear equation, the sturm-liouville problem, discrete calculus of variations, Boundary value problem for nonlinear equations.	CO1: Study self adjoint equation.. CO2: Analyze sturm-liouville problem for difference equations. CO3: Understand the Lipschitz case and existence of solutions. CO4: Discuss the boundary value problem for nonlinear equations.
XXII(C)	Programming in C++	In this course we will study the basics of the programming language C++ such as tokens, expressions, Classes and Objects, Constructors and Destructors, Inheritance, Polymorphism and Files.	CO1: Identify the basic concept of Tokens, Expressions and Control structures-Functions in C++ CO2: Analyze Classes and Objects.. CO3: Understand Constructors and Destructors CO4: Apply the concept of Extending classes-Pointers, Virtual Functions & Polymorphism. CO5: Study practical course.

XXIII(A)	Integral Equations	Many physical problems that are usually solved by differential equation methods can be solved more effectively by integral equation methods. Such problems abound in applied mathematics, theoretical mechanics, and mathematical physics. This course enables the students to get the detailed idea about the integral equation, its classification, different types of kernals, the relationship between the integral equations and ordinary differential equations and how to solve the linear integral equations by different methods with some problems which give rise to integral equations.	CO1: Acquire sound knowledge of different types of Integral equations. CO2: Obtain integral equations from ODEs and PDEs arising in applied mathematics and different engineering branches and solve accordingly using various method of solving integral equation. CO3: Demonstrate a depth of understanding in advanced mathematical topics in relation to geometry of curves and surfaces. CO4: Apply the knowledge of integral transformation like Laplace transformation, Fourier transformation to solve different types of integral equation.
XXIII(B)	Lattice Theory	This course introduces the concept of two definitions of Lattices, distributive lattices, congruence's and ideals, modular and semi-modular lattices.	CO1: Describe the Lattices and some concepts of Lattices. CO2: Understand the concepts of distributive Lattices. CO3: Analyze the Weak Projectivity and Congruence's, Standard, and Neutral ideals. CO4: Study the modular and semi-modular lattices.
XXIII(C)	Fractional Calculus and its Applications-II	This course introduces the concept of fractional green's functions, other methods for the solution of fractional order equations, numerical evaluation of fractional derivatives, numerical solution of fractional differential equations.	CO1: Study the solution of the initial value problem for the Ordinary fractional linear differential equation with constant coefficients using only its Green's function. CO2: Understand the different methods for the solution of fractional order equations. CO3: Analyze the numerical evaluation of fractional derivatives. CO4: Study the numerical solution of fractional differential equations.
XXIV	Project Work (Compulsory)		

Semester-III

Paper-XIII
Functional Analysis

Max. Periods: 60(04 Credits)

Course Objective(s):

This course introduce the concepts and develop working knowledge on Banach Space, Norm of continuous Linear Transformations, continous Linear functional, Conjugate space, Banach Algebra, Inner Product Space, Hilbert Space, Orthogonal vectors, Orthonormal vectors and sets, conjugate space H*, self adjoint, normal and unitary operators, Projections, eigen value and eogen vectors, eigen space and Spectrum of T.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Identify Normed Linear Space, Banach Space, continous Linear transformations, Conjugate space, Banach Algebra, Graph of L.T.,Hahn-Banach Theorem and it's applications, Open Mapping and Closed Graph Theorems.
CO2: Analyze Hilbert space, Orthogonal and Orthonormal vectors and sets, Orthogonal Compliments and conjugate space H*.,Schwart Lemma, Bessel's Inequality and Riesz representation theorem.
CO3: To Identify, Self Adjoint, Normal, Unitary and Positive operators and to analyze the invariant subspace and reducible transformations.
CO4: To Provide information on Eigen Value, Eigen Vectors, Eigen Spaces and Spectrum of T.

Unit-I: Banach Spaces

Normed linear Space, Banach Space, Some examples, Subspace and Quotient Space Holder's Inequality, Continuous linear transformations, The Hahn-Banach theorem, Applications of Hahn Banach Theorem, The natural embedding of N in N**, The Open Mapping Theorem, Closed Graph Theorem, The conjugate of an operator, Uniform Boundedness Principle Theorem.

Unit-II: Hilbert Spaces

Inner product. Inner product space, Hilbert space, The definition and some properties, Parallelogram law, Polarization identity, Schwarz Inequality, Orthogonal vectors, Orthogonal set, Vector orthogonal to a set, Pythagoras theorem and applications,Orthogonal complements, Pythagoras theorem and applications, Orthonormal vectors, Orthonormal set, Complete orthonormal set, Bessel's Inequality, The conjugate space H*, Riesz Representation Theorem.

Unit-III: Operator and Adjoint of an Operator

Operator, The adjoint of on operator, definition and examples. Properties of adjoint of operator of T, The Self adjoint operators, Positive operators, Normal operators, Real and Imaginary part of an operator. Normal Operator, Unitary operator, Projections on Hilbert space, Orthogonal Projection. Invariant subspace, Reducibility.

Unit-IV: Finite dimensional Spectral Theory

Introduction, Finite dimensional Hilbert space, eigen value, eigen vector, eigen space, spectrum of an operator, The spectral theorem.

Text Book:

1. **S.H. Friedberg, A.J. Insel, L.E. Spence**, Introduction to "Topology and Modern Analysis" McGraw-Hill Book Company, International student Edition, New York.

Scope: Unit I - Chapter 9.
Unit II - Chapter 10 - Art 52 to 55.
Unit III - Chapter 10 - Art 56 to 59.
Unit IV - Chapter 11 - Art 62.

Reference Books:

1. **B.V. Limaye,** "Functional Analysis", Wiley Eastern Ltd.
2. **G. Bachman and L. Narici** "Functional Analysis" Academic Press 1966.
3. **D. Somasundaram ,** "A First Course in Functional Analysis" Narosa Publication.

Paper-XIV
Topology

Max. Periods: 60(04 Credits)

Course Objective(s):

The goal of the course is to provide in depth knowledge of this fundamental core course in mathematics to show various techniques from analysis, set theory, logic that are used in topological spaces to obtain their properties, to demonstrate application in physics.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Understand basics of Topological Spaces and their properties.
CO2: Study Continuous functions, Metric Topology, Connected Spaces, Limit Point, Compactness, Local Compactness, Limit point Compactness.
CO3: Achieve the zenith in treating Countable Axioms, Separable, Regular and Normal spaces.
CO4: Understand the Urysohn's Lemma, Urysohn's Metrization Theorem and their applications.

Prerequisites: Cartesian Products, Finite Sets, Countable and Uncountable Sets, Infinite Sets and Axiom of Choice, Well Ordered Sets.

Unit-I:

Topological Spaces: Basis for a topology, Order topology, Subspace Topology, Product topology, closed sets and limit points.

Unit-II:

Continuous functions, Metric Topology, Connected spaces, Connected Subspaces of Real Line, Components and Local Connectedness.

Unit-III:

Compact spaces, Compact Subspaces of the Real Line, Limit point compactness, Local Compactness.

Unit-IV:

Countability Axioms, Separation axioms, Normal Spaces, Urysohn's Lemma (without proof), The Urysohn's Metrization Theorem (without proof), Tietze Extension Theorem (Without Proof), Tychonoff's Theorem.

Text Book:

1. **J.R. Munkres, "Topology"** Prentice Hall of India, Second Edition.

Scope: Unit I - Chapter 2 Art 12 to 17.
Unit II - Chapter 2 - Art 18 to 20. Chapter 3- Art 23 to 25.
Unit III - Chapter 3- Art 26 to 29.
Unit IV - Chapter 4 - Art 30 to 35. Chapter 5- Art 37.

Reference Books:

1. **Stephen Willard,** "General Topology", Addison-Wesley Publishing Company, 1970.
2. **J. Dugundji,** "Topology", Allya and Bacon. (1966) reprinted: Printice Hall of India.
3. **W. J. Pervin,** "Foundations of general topology", academic press Inc. N.Y. H
4. **S. T.Hu**, "Elements of general topology". Holden day Inc. 1965.

Paper-XV (A)
Analytical Number Theory
Max. Periods: 60(04 Credits)

Course Objective(s):

This course introduce the concepts of congruence's and their properties, Chinese Remainder theorem, Fermat's and Wilson's theorem, Primitive roots and indices, Euler's criterion, The Legendre symbol and its properties, Gauss Lemma, Quadratic reciprocity law, Pythagorean triple, arithmetical functions and dirichlet multiplication.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Understand the concepts of congruence and their properties, solve systems of linear congruence's with different moduli using the Chinese Remainder Theorem.
CO2: Analyze primitive roots and indices.
CO3: Discuss Legendre symbol and its properties, Quadratic reciprocity law.
CO4: Study arithmetical functions and Dirichlet multiplication.

Unit-I:

Congruence's, Basic properties of congruence's, Binary and decimal representation of integers, Linear congruence's and Chinese Remainder theorem, Pierre de Fermat theorem, Fermat's little theorem and pseudo-primes, Wilson's theorem.

Unit-II:

The order of an integer modulo n, primitive roots for primes, Lagrange's theorem, Composite numbers having primitive roots, the theory of indices.

Unit-III:

Euler's criterion, The Legendre symbol and its properties, Gauss Lemma, Quadratic reciprocity, Quadratic reciprocity law, Quadratic congruence's with composite moduli, The equation $x^2+y^2=z^2$, Pythagorean triple.

Unit-IV:

The Mobius function $\mu(n)$, The Eular Totient function $\varphi(n)$, A relation connecting μ and φ, The product formula for $\varphi(n)$, Dirichlet product of arithmetic function, Dirichlet inverses and Mobius inversion formula, The Managoldt function $\Lambda(n)$, Multipicative function, Multipicative function and Dirichlet Multiplication, Inverse of Completely multiplicative function, Liouville's function, The divisor function, Generalized convolution, Formal power series, The Bell series of an arithmetic function, bell series and Dirichlet multiplication, derivatives of arithmetic function, The Selberg identity.

Text Book:

1. **David M. Burton,** "Elementary Number Theory" Tata McGraw-Hill Pub. VI Edition.
2. **Tom M. Apostol**, "Introduction to Analytic Number Theory" Springer International Student Edition, Narosa, Publishing house 1989.

Scope: Unit I - Chapter 4, Chapter 5- Art 5.1 to 5.3.

Unit II - Chapter 8.

Unit III - Chapter 9, Chapter12 - Art 12.1.

Unit IV - Chapter 2.

Reference Books:

1. **J.P. Serre, "**A course in arithmetic", GTM Vol.7, Springer Verlage 1973.
2. **Niven and H.S. Zuckerman**, "An Introduction to the Theory of Numbers", Wiley Eastern Limited, New Delhi, 1976.

Paper-XV (B)
Theory of Linear Operators-I

Max. Periods: 60(04 Credits)

Course Objective(s):

This course introduce the concepts of spectral theory of linear operators in normed, spaces, compact linear operators on normed spaces and their spectrum, spectral theory of bounded self-adjoint linear operators.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Understand the Spectral properties of bounded linear operators, Resolvent and Spectrum.
CO2: Analyze the concept of Linear Operators on Normed Spaces.
CO3: Discuss the Spectral Properties of Compact Linear Operators.
CO4: Study Spectral Properties of Bounded Self-Adjoint Linear Operators, Projection Operators.

Unit-I:

Spectral theory in finite dimensional normed spaces, Basic concepts, Spectral properties of bounded linear operators, Further Properties of Resolvent and Spectrum, Use of Complex Analysis in Spectral Theory, Banach Algebras, Further Properties of Banach Algebras.

Unit-II:

Compact Linear Operators on Normed Spaces, Further Properties of Compact Linear Operators, Spectral Properties of Compact Linear Operators on Normed Spaces.

Unit-III:

Further Spectral Properties of Compact Linear Operators, Operator Equations Involving Compact Linear Operators, Further Theorems of Fredholm Type, Fredholm Alternative.

Unit-IV:

Spectral Properties of Bounded Self-Adjoint Linear Operators, Further Spectral Properties of Bounded Self-Adjoint Linear Operators, Positive Operators, Square Roots of a Positive Operator, Projection Operators.

Text Book:

1. **E. Kreyszig**, Introductory functional analysis with applications, Johan-Wiley& Sons, New York, 1978.
   Scope: Unit I - Chapter 7.
   Unit II - Chapter 8 Art 8.1 to 8.3.
   Unit III - Chapter 8 Art 8.4 to 8.7.
   Unit IV - Chapter 9 Art 9.1 to 9.5.

Reference Books:

1. **P.R. Halmos**, Introduction to Hilbert space and the theory of spectral multiplicity, 2nd Edn. Chelsea Pub., Co., N.Y. 1957.
2. **G. Bachman & Narici**, Functional analysis, Aca-demic Press, New York, 1966.
3. **Akniezer, N.I. and I.M. Glazman**, Theory of linear operators in Hilbert space, Frederick Ungar Pub. Co. NY, Vol. 1 (1961), Vol. 2(1963).
4. **P.R. Halmos**, A Hilbert space problem book, D.Van Nostrand Co. Inc, 1967.

Paper-XV(C)
Fuzzy Sets and their Applications-I

Max. Periods: 60(04 Credits)

Course Objective(s):

This course introduces the concepts of Crisp sets and fuzzy sets, operations on fuzzy sets and fuzzy relations.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Understand the concepts of Crisp sets and fuzzy sets.
CO2: Analyze the operations on fuzzy sets.
CO3: Discuss Crisp and fuzzy relation.
CO4: Study Fuzzy relation equation.

Unit-I:

Introduction, Crisps Set: An Overview, The notation of fuzzy sets, Basic concepts of fuzzy sets, Classic Logic: An overview, Fuzzy logic.

Unit-II:

General discussion, Fuzzy complement, Fuzzy union, Fuzzy intersection, combinations of operations, general aggregation operations.

Unit-III:

Fuzzy Relations: Crisp and fuzzy relation, Binary relations, Binary relation on a single set.

Unit-IV:

Equivalence & similarity relations, Compatibility or Tolerance relations, Ordering, morphisms, Fuzzy relation equation.

Text Book:

1. **George J. Klir & Tina A. Folger**, Fuzzy sets, uncertainty & information (Prentice Hall of India Pvt. Ltd.) Sixth Printing 2001.

   Scope : Unit-I Chapter 1.
   Unit-II Chapter 2.
   Unit-III Chapter 3 Art 3.1 to 3.3.
   Unit-IV Chapter 3 Art 3.4 to 3.8.

Reference Books:

1. **D. Drinkov, H. Hellendora & M. Reinfrank**, Introduction to Fuzzy control, Narosa Publishing House.
1. **H.J. Zimmermann**, Fuzzy Set Theory & Its Applications, Allied Publishers Ltd. New Delhi-1991.
2. **G.J. Klir & B.Yuan,** Fuzzy Sets & Fuzzy Logic.Prentice Hall of India New Delhi-1995.

Paper – XVI(A)
Fluid Mechanics – I

Max.Periods: 60(04 Credits)

Course Objectives:

The course introduces basic idea of various fluid flow, velocity and acceleration of fluid motion. The main objective of the course is tostudy Equation of continuity, Euler equation, Bernoulli equation, effect of pressure on fluid flow, stream function, some two dimensional flows and applications to real life.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Visualize the fluid flow pattern.
CO2: Assimilate the meaning of continuity equation.
CO3: Solve flow problems.
CO4: Acquire command on stream function.

Unit-I:

Real fluids and Ideal fluids, Velocity of fluid at a point, Streamlines and Pathlines, steady and unsteady flows, the velocity potential, the vorticity vector, Local and particle rates of change, the equation of continuity, worked examples, acceleration of fluid, Conditions at a rigid boundary, general analysis of fluid motion.

Unit – II:

Pressure at a point in a fluid at rest, Pressure at a point in a moving fluid, Conditions at a boundary of two inviscid immiscible fluids, Eulers equation of motion, Bernoullis equation, Mechanism of Pitot Tube and Venturi meter, worked examples.

Unit – III:

Discussion of the case of steady motion under conservative body forces, some potential theorems (statement only), Some flows involving axial symmetry, some special two dimensional flows, Impulsive motion, some further aspects of vortex motion.

Unit – IV:

Meaning of two dimensional flow, use of cylindrical polar coordinates, The Stream function, The complex velocity potentials for standard two-dimensional flows, Uniform stream, line sources and line sinks, line doublets, line vortices, some worked examples.

Text Book:

1. **F Charlton, "**Text book of Fluid Dynamics" , Reprint 1998, C B S Publishers and distributors, Delhi –110 002.

Scope : Unit-I Chapter 2, 2.1-2.11.
Unit-II Chapter 3, 3.1-3.6.
Unit-III Chapter 3, 3.7-3.12.
Unit-IV Chapter 5, 5.1-5.6.

Reference Books:

1. **G.K. Batchelor**, An Introduction to Fluid Mechanics(Foundation Book-New Delhi 1994)
2. **W.H. Besaint and A.S. Ramsey**, A Treatise on Hydro Mechanics Part II, CBS Publisher- 1998.
3. **S.W.Yuan** , Foundations of Fluid Mechanics, Prentice Hall of India Pvt. Ltd- New Delhi 1976.

Paper – XVI(B)

Difference Equations - I

Max.Periods: 60(04 Credits)

Course Objectives:

The course introduced the elementary analysis and linear algebra to investigate solution to difference equation. To study linear difference equations, stability theory and asymptotic methods.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Understand the role of differential operator in differential calculus.
CO2: Analyze the linear and nonlinear difference equations.
CO3: Study the stability of linear and nonlinear systems.
CO4: Discuss asymptotic methods for solving of linear and nonlinear systems.

Unit-I:

The Difference operator, Summation, Generating functions and approximate summation.

Unit – II:

First order equations, General results for linear equations, Solving linear equations, Applications, Equations with variable coefficients, Nonlinear equations that can be linearized, The Z-Transform.

Unit – III:

Initial value problems for linear systems, Stability of linear systems, Stability of nonlinear systems.

Unit – IV:

Introduction, Asymptotic analysis of sums, linear equations, non-linear equations.

Text Book:

1. **Walter G. Kelley and Allan C. Peterson**, "Difference Equations", Academic Press, Second Edition.

Scope : Unit-I Chapter 2.
Unit-II Chapter 3.
Unit-III Chapter 4 Art 4.1, 4.2, 4.5.
Unit-IV Chapter 5.

Reference Books:

1. **Calvin Ahlbrandt and Allan C. Peterson**, "Discrete Hamiltonian Systems: Difference Equations, Continued Fractions and Riccati Equations, "Kluwer, Boston, 1996.
2. **Saber N. Elaydi** "An Introduction to Difference Equations" Springer, Second Edition.

Paper – XVI(C)

Mathematical Softwares-I

(Modeling and Simulation in Scilab/Scicos)

Max.Periods: 60(04 Credits)

Course Objectives:

The course introduces the Scilab object, Scilab Programming, Scilab graphics, interfacing, Modeling and Simulation in Scilab, optimization and applications of Scilab.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Understanding the concepts of Scilab programming, input and output functions.
CO2: Analyze the types of models and simulation tools.
CO3: Solve Nonlinear Equations using Scilab.
CO4: Create mathematical Modeling and Simulation in Scilab.

Unit-I:

General information, Introduction to Scilab, Scilab objects, Scilab programming, input and output functions, Scilab Graphics, Interfacing.

Unit – II:

Modeling and Simulation in Scilab: Types of models and Simulation tools -ordinary differential equation, boundary value problem, difference equation, differential algebraic equation, hybrid systems, .

Unit – III:

Optimization: Comments on Optimization and Solving Nonlinear Equations, General Optimization, Solving Nonlinear Equations, Nonlinear Least Squares, Parameter Fitting, Linear and Quadratic Programming, Differentiation Utilities.

Unit – IV:

Modeling and Simulation of an N-Link Pendulum, Modeling and Simulation of a Car, Open-Loop Control to Swing Up a Pendulum, Parameter Fitting and Implicit Models.

Text Book:

1. **Stephen L. Campbell, Jean-Philippe Chancelier and Ramine Nikoukhah,** "Modeling and Simulation in Scilab/Scicos", Springer, 2006.

Scope : Unit-I Chapter 1 and 2.
Unit-II Chapter 3.
Unit-III Chapter 4.
Unit-IV Chapter 5.

Reference Books:

1. Programming in Scilab by Vinu V Das, New Age International Publisher.

Paper – XVII (A)

Integral Transforms

Max. Periods: 60(04 Credits)

Course Objectives:

The objective of this course is to introduce students the different types of integral transforms which are commonly used, their formulation concerned to real world problems, their evaluation and applications to solve ordinary and partial differential equations.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Classify the different types of integral transforms they come across.
CO2: Formulate the physical problem under consideration in terms of different types of ordinary and partial differential equations with initial and boundary conditions.
CO3: Solve the initial value problems and boundary value problems using the appropriate integral transform.
CO34: Analyze the nature of the solution of the initial value problems and boundary value problems.

Unit-I:

The Laplace Transform: Introduction, The Laplace Transform of some typical functions, Basic operational properties, Transforms of more complicated functions, The inverse Laplace Transform, Complex Inversion Formula, Additional Topics.

Unit-II:

Applications involving Laplace Transform: Introduction, Evaluating integrals, Solutions of ODEs, Solutions of PDEs. The Mellin transform, Evaluation of Mellin transform, Complex variable methods, Applications.

Unit-III:

Fourier integrals and Fourier Transforms: Introduction, Fourier integral representations, Proof of the Fourier integral theorem, Fourier transform pairs, Properties of the Fourier Transform, The convolution integrals of Fourier, Transforms involving generalized functions.

Unit-IV:

Applications involving Fourier transforms: Introduction, Boundary value problems, Heat conduction in solids, The Hankel Transform, Introduction, Evaluation of Hankel Transform, Applications.

Text Books:

1. **Larry C. Andrews, Bhimsen K. Shivamoggi**, Integral Transforms for Engineers, Prentice Hall of India, New Delhi.

Scope: **Unit-I:** Chapter 4 complete.

Unit-II: Chapter 5, Sections 5.1 to 5.4, Chapter 6, Sections 6.1 to 6.4

Unit-III: Chapter2, Sections 2.1 to 2.5, 2.7, 2.8

Unit-IV: Chapter 3, Sections 3.1 to 3.3, Chapter 7, Sections 7.1 to 7.3.

Reference Books:

1. **J. K. Goyal, K. P. Gupta**, Integral Transforms, Pragati Prakashan, Meerut.
2. **R. Vasishtha, Dr. K. L. Gupta**, Integral Transforms, Krishna Prakashan Mandir, Meerut.

Paper-XVII (B)
Financial Mathematics

Max. Periods: 60(04 Credits)

Course Objectives:

In this course the student will learn about Financial Markets and Derivatives, Binomial model, Finite Market model, Black-Scholes Model, Multi-dimensional Black-Scholes Model.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Understand the concept of Simple Discrete Financial market model.
CO2: Analyze the first and second fundamental theorem of Asset model.
CO3: Study Black-Scholes Model.
CO4: Discuss the Multi-dimensional Black-Scholes Model.

Unit-I:

Financial Markets, derivatives, Binomial or CRR Model, Pricing a European Contingent Claim, Pricing an American Contingent Claim.

Unit – II:

Definition of the finite market model, First fundamental theorem of Asset model, Second fundamental theorem of Asset model, Pricing European Contingent Claims, Incomplete markets, separating hyperplane theorem.

Unit – III:

Black-Scholes Model, Equivalent Martingale Measure, European Contingent Claims, Pricing European Contingent Claims, European Call option-Black-Scholes Formula, American Contingent Claim, American Call option, American put option.

Unit – IV:

Multi-dimensional Black-Scholes Model, First fundamental theorem of Asset Pricing, Form of Equivalent local Martingale Measure, Second fundamental theorem of Asset Pricing, Pricing European Contingent Claims, Incomplete Markets.

Text Book:

1. **R. J. Williams**, Introduction to the Mathematics of Finance, American Mathematical Society, 2011.

Scope : Unit-I Chapter 1, 2.
Unit-II Chapter 3.
Unit-III Chapter 4.
Unit-IV Chapter 5.

Reference Books:

1. **S. Roman**, Introduction to the Mathematics of Finance, Springer, 2004.

Paper-XVII (C)
Fractional Calculus and its Applications-I

Max. Periods: 60(04 Credits)

Course Objective(s):

This course introduces the some special functions of the fractional calculus, Riemann-Liouville fractional derivative, Caputo's fractional derivative, Laplace, Fourier and Mellin transforms of fractional derivatives, Existence and uniqueness theorem as a method of solution.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Understand the Gamma, Mittag-Leffler, Wright functions of the fractional calculus.
CO2: Study Riemann-Liouville and Caputo's fractional derivative.
CO3: Analyze the integral transform methods of solution of fractions differential equations.
CO4: Study existence and uniqueness theorem of fractions differential equations.

Unit-I:

Definition of Gamma function and Beta function, Some properties of Gamma and Beta functions, Relation between Gamma and Beta functions, Definition of Mittag-Leffler functions of one and two parameters, Relations of Mittag-Leffler function in two parameters, Wright function, Definition of Wright function, Integral relation and relation to other functions.

Unit-II:

Grunwald-Letnikov fractional derivatives, Riemann-Liouville fractional derivative, Some other approaches-Caputo's fractional derivative, Generalized functions approach, Sequential fractional derivatives, Left and right fractional derivatives.

Unit-III:

Laplace transform of fractional derivatives, Fourier transform of fractional derivative and Mellin transform of fractional derivative.

Unit-IV:

Linear Fractional differential equations, fractional differential equations of a general form, Existence and uniqueness theorem as a method of solution, dependence of a solution on initial conditions.

Text Book:

1. **Igor Podlubny**, "Fractional Differential Equations", Academic Press, San Diego, California, 92101-4495, USA

Scope: **Unit I** - Chapter 1.
Unit II - Chapter 2- Art 2.1 to 2.6.
Unit III - Chapter 2- Art 2.7 to 2.10.

Unit IV - Chapter 3.

Reference Books:

1. **Miller K.S. and Ross B**., “An Introduction to Fractional Calculus and Fractional Differential Equations”, New York, John Wiley, 1993.
2. **Oldham K.B. and Spanier J.**, “The Fractional Calculus”, New York, Academic Press, 1974.

Paper-XVIII

Tutorial –III **05 Credits**

Papers	Marks	Credits
Tutorial on theory paper -XIII	25	1
Tutorial on theory paper-XIV	25	1
Tutorial on theory paper- XV(A/B/C)	25	1
Tutorial on theory paper-XVI(A/B/C)	25	1
Tutorial on theory paper –XVII(A/B/C)	25	1
Total	**125**	**5**

The format for scheme of marking for tutorial of 25 marks in each paper is as follows:

Tutorial: ----- Paper No. and name: -----

Name of the teacher: -----

Sr.No.	Name of the student	Seat No.	Seminar	Attendance	Viva	Total
			10 Marks	5 Marks	10 Marks	25Marks

Signature of Teacher

The format, in which, the marks obtained by students in tutorial of 125 marks, to be submitted by HOD through the Principal, to the department of examination S.R.T.M.U. Nanded is as follows:

Sr. No.	Name of the student	Seat No.	Tutorial					Total
			Paper No.----	Paper No.----	Paper No.----	Paper No.----	Paper No.----	
			Marks out of 25	Marks out of 25	Marks out of 25	Marks out of 25	Marks out of 25	Marks out of 125

Head of the Department

Semester-IV

Paper-XIX
Numerical Analysis

Max. Periods: 60(04 Credits)

Course Objective(s):

To introduce the concepts and to develop working knowledge on Iteration Methods to Solve the Equations, Rate of Convergence of Iteration Methods, Solution of the System of Equations by using Different Direct and Iteration Methods, Eigen Value Problems, Bounds of Eigen Values, Interpolation, Lagrange, Iterated and Newton's Interpolations of Different Orders, Least Square Approximation.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Identify the roots of equations and to obtain them by using different iteration Methods. Also to obtain rate of convergence of Iteration Methods.
CO2: Analyze the direct methods to solve the the system of n equations in n unknowns by using different direct methods
CO3: Identify the Iteration Methods to Solve the System of n Equations in n Unknowns, Eigen Value problems and to obtain Bounds on Eigen Values.
CO4: Provide information on Interpolations and Approximations for the given function.

Unit-I: Transcendental and Polynomial equations

Introduction, Bisection method, Iteration Methods based on first degree equation: Secant and Regula Falsi Method, Newton - Raphson Method, Iteration Methods based on second degree equation: Muller Method, Chebyshev Method, Rate of Convergence.

Unit-II: Direct Methods to Solve the System of *n* Equations in *n* Unknowns

Some basic definitions: Square, Diagonal, Lower Triangular, Upper Triangular, Identity and Null Matrix. Symmetric and Skew-Symmetric Matrix, Hermitian and Skew-Hermitian Matrix, Orthogonal Matrix, Permutation Matrix, Property 'A', tri-diagonal and band Matrix, Positive definite Matrix, System of n equations in n unknowns. Direct methods to solve the system of n equations in n unknowns: Cramer's Rule, Gauss elimination method, Jordan elimination Method, Triangularization Method, Cholesky Method, Partition Method, Model Problems.

Unit-III: Iteration methods to solve the system of *n* equations in *n* unknowns

Introduction, Iteration methods to solve the system of n equations in n unknowns: Gauss-Seidel Method, Jacobi Iteration Method, Successive Over Relaxation Method, Model Problems, Iteration Method to Obtain Inverse of a Square Matrix. Convergence of Iteration methods, Norms of Matrix: Absolute Row sum and Absolujte Coloum sum Norm, Euclidean Norm, Hilbert Norm, Eigen Value and Eigen Vectors, Eigen Value Problem, Bounds on Eigen Values Gresgorin and Braur's Theorems, Model problems.

Unit-IV: Interpolations and Approximations

Introduction, Vandermonde's Determinant, Interpolating Polynomial, Langrange Interpolating Polynomial, Newton's Divided Difference Interpolating Polynomial, Aitken's Interpolating Polynomial, Quadratic Interpolation, Higher Order Interpolating Polynomials, Finite Difference Operators, Relation between the Finite Difference Operations and Derivatives, Interpolating polynomials using finite difference operators, Model Problems. Best Approximation, Least Square Approximation.

Text Book:

1. **M. K. Jain, S. R. K. Iyengar, R. K. Jain**, "Numerical methods for Scientific and Engineering computations." New Age International Limited Pub.

Scope: Unit I - Chapter 2 Art 2.1 to 2.5.
Unit II - Chapter 3 Art 3.1 to 3.3.
Unit III - Chapter 3 Art 3.4 to 3.6.
Unit IV - Chapter 4 Art 4.1 to 4.4, 4.8, 4.9.

Reference Books:

1. **S.S. Sastry**, "Introductory methods of Numerical Analysis" Prentice- Hall of India Private Ltd. (Second Edition) 1997.
2. **E.V. Krishnamurthi & Sen**. "Numerical Algorithm," Affiliate East. West press. Private Limited 1986.

Paper-XX

Abstract Algebra- II (Field Theory)

Maximum Periods: 60 (04 Credits)

Course Objective(s):

This course is aimed to provide an introduction to the theories, concepts and to develop working knowledge on field in order to develop a background for studying Commutative algebra and Representation Theory. To introduce the concepts and to develop working knowledge of field extensions, Galois groups and interrelation between group theory and field theory.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Understand the main algebraic properties of fields.
CO2: Analyze properties of Finite, Algebraic, Normal, Simple, Cyclic & Separable extension and Splitting Fields.
CO3: Compute Galois groups in simple cases and to apply the group-theoretic information to comprehend results about fields and field extensions.
CO4: Develop knowledge of some classical Greek problems.
CO5: Understand the concepts Cyclotomic polynomials, Polynomials solvable by radicals, symmetric functions, ruler and compass construction to Develop abstract mathematical thinking about field.

Prerequisites: Ring, Types of ring, Integral Domain, Characteristics of ring, Unit, PID, UFD, Polynomial ring, etc.

Unit-I:

Irreducible polynomial and Eisenstein criterion, Adjunction of roots, Algebraic extensions, Algebraically closed field.

Unit-II:

Splitting field, Normal extension, Multiple Roots, Finite Field, Separable Extensions.

Unit-III:

Automorphism groups and fixed fields, fundamental theorem of Galois theory, fundamental theorem of algebra.

Unit-IV:

Roots of unity and cyclotomic polynomials, Cyclic extension, polynomials solvable by radicals, symmetric functions, Ruler and Compass construction.

Text Book:

1. **P. B. Bhattacharya, S. K. Jain and S. R. Nagpaul**, “Basic Abstract Algebra (Second Ed.), Cambridge Univ. Press (Indian Ed.1995).

Scope: Unit I - Chapter 15, Art 1 to 4.
Unit II - Chapter 16 Art 1 to 5.
Unit III - Chapter 17 Art 1 to 3.
Unit IV - Chapter 18 Art 1 to 5.

Reference Books:

1. **Joseph A. Gallian**, Contemporary Abstract Algebra (Fourth Ed.), Narosa, 1999.
2. **I. S. Luthar and I. B. S. Passi**, “Algebra-Vol. II: Groups”, Narosa, New Delhi, 1996.
3. **V.K. Khanna, S.K. Bhambri**, “A Course in Abstract Algebra”, Vikas Publicing House. (Second Edition).

Paper-XXI (A)
Classical Mechanics

Max. Periods: 60(04 Credits)

Course Objective(s):

To understand the concepts of Mechanics of system of particles, generalized co-ordinates, Degree of freedom. To Study mechanics developed by Newton, Lagrange and Hamilton and their applications. To solve motivating problems of calculus of variations.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Understand D' Alembert's Principle and applications of the Lagrangian Formulation.
CO2: Distinguish the concept of the Hamilton Equations of Motion and the Principle of Least Action.
CO3: Analyze the Fundamental lemma of calculus of variations.
CO4: Solve problems of calculus of variations using Euler's equation.

Unit-I:

Mechanics of System of particles, generalized co-ordinates, Degree of freedom, Holonomic and Noholonomic system, Scleronomic and Rheonomic system, D'Alembert's principles and Lagrange's Equation of Motion, Different forms of Lagrange's Equation, Generalized Potential, Conservative fields and its Energy Equation, Application of Lagrange's formulation.

Unit-II:

Hamilton's Principle, Hamitton's canonical Equations, Lagrange's Equation from Hamilton's Principle, Extension of Hamilton's Principle to Non-holonomic systems, Application of Hamilton's formulation, cyclic co-ordinates and conservation theorems, Routn's Procedure, Hamilton's Equations from variational principle, principle of least Action.

Unit-III:

Functional, Linear Functional, Fundamental lemma of calculus of variations, Simple variational problems, The variation of functional, The extremum of functional, Necessary condition for Extreme, Euler Equation,

Unit-VI:

Eulers Equation of several variables, Invariance of Euler Equation, Motivating Problems of calculus of variation, Shortest Distance, Minimum surface of Revolution, Brachistochrone Problem, Isoperimetric Problem, Geodesic, Variational problems in Parametric form, Generalization of Euler Equation, Variational Problems with subsidiary conditions.

Text Book :

1. **H. Goldstein, Charles Poole, John Sabko**, "Classical Mechanics", Pearson 3rd Edition 2002.
   Scope: Unit-I Chapter 1.
   Unit-II Chapter 8.

2. **I.M. Gelfand and S.V. Fomin** "Calculus of Variations" Prentice Hall.

Scope: Unit-III Chapter 1.
Unit IV Chapter 2.

Reference Books:

1. **N. Rana and B. Joag**, “Classical Mechanics”, Tata McGraw Hill 1991.
2. **A.S. Ramsey**, “Dynamics Part II” The English Language Book Society and Cambridge University press, 1972.

Paper –XXI(B)
Theory of Linear Operators -II
Max. Periods-60(04 Credits)

Course Objective(s):

This course introduce the concepts of spectral theory of bounded self-adjoint linear operators, Unbounded Linear Operators in Hilbert Space, Unbounded Linear Operators in Quantum Mechanics.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Understand the Spectral properties of bounded self-adjoint linear operators.
CO2: Analyze the concept of Unbounded Linear Operators and their Hilbert-Adjoint Operators.
CO3: Discuss the Spectral Representation of Self-Adjoint Linear Operators.
CO4: Study Unbounded Linear Operators in Quantum Mechanics.

Unit-I:

Spectral family, Spectral family of a bounded self-adjoint linear operator and its properties, Spectral representation of bounded self-adjoint linear operators, Extension of the Spectral Theorem to Continuous Functions, Properties of the Spectral Family of a Bounded SelfAd,ioint Linear Operator.

Unit-II:

Unbounded Linear Operators and their Hilbert-Adjoint Operators, Hilbert-Adjoint Operators, Symmetric and Self-Adjoint Linear Operators, Closed Linear Operators and Closures.

Unit-III:

Spectral Properties of Self-Adjoint Linear Operators, Spectral Representation of Unitary Operators, Spectral Representation of Self-Adjoint Linear Operators, Multiplication Operator and Differentiation Operator

Unit-IV:

Basic Ideas. States, Observables, Position Operator, Momentum Operator. Heisenberg Uncertainty Principle, Time-Independent Schrodinger Equation, Hamilton Operator, Time-Dependent Schrodinger Equation

Text Book:

1. **E. Kreyszig**, Introductory functional analysis with applications, Johan-Wiley& Sons, New York, 1978.
   Scope: Unit I - Chapter 9 Art 9.7 to 9.11.
   Unit II - Chapter 10 Art 10.1 to 10.3.
   Unit III - Chapter 10 Art 10.4 to 10.7.
   Unit IV - Chapter 11.

Reference Books:

1. **P.R. Halmos**, Introduction to Hilbert space and the theory of spectral multiplicity, 2nd Edn. Chelsea Pub., Co., N.Y. 1957.
2. **G. Bachman & Narici**, Functional analysis, Aca-demic Press, New York, 1966.
3. **Akniezer, N.I. and I.M. Glazman**, Theory of linear operators in Hilbert space, Frederick Ungar Pub. Co. NY, Vol. 1 (1961), Vol. 2(1963).
4. **P.R. Halmos**, A Hilbert space problem book, D.Van Nostrand Co. Inc, 1967.

Paper XXI(C)

Fuzzy Sets and their applications-II

Max. Periods: 60(04 Credits)

Course Objective(s):

This course introduces the concepts of Fuzzy measures, Uncertainty & Information and applications of fuzzy sets.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Understand the concepts of fuzzy measures.
CO2: Study types of uncertainty.
CO3: Discuss Uncertainty & information and complexity.
CO4: Study the application of Fuzzy in different fields.

Unit-I:

General discussion, Belief & plausibility measures, Probability measures, Possibility & necessity measures, Relationship among classes of fuzzy measures.

Unit-II:

Uncertainty & Information, Types of uncertainty, Measures of fuzziness, Classical measure of uncertainty, Measures of dissonance.

Unit-III:

Measure of non specificity, Uncertainty & information and complexity. Principles of uncertainty and information.

Unit-IV:

Applications: General discussion, Natural, life & Social, Sciences, Engineering, Medicine, Management & decision making, Computer Science, Systems sciences, other applications.

Text Book:

1. **George J. Klir & Tina A. Folger**, Fuzzy sets, uncertainty & information (Prentice Hall of India Pvt. Ltd.) Sixth Printing 2001.

   Scope : Unit-I Chapter 4.
   Unit-II Chapter 5 Art 5.1 to 5.4.
   Unit-III Chapter 5 Art 5.5 to 5.9.
   Unit-IV Chapter 6.

Reference Books:

1. **D. Drinkov, H. Hellendora & M. Reinfrank**, Introduction to Fuzzy control, Narosa Publishing House.
2. **H.J. Zimmermann**, Fuzzy Set Theory & Its Applications, Allied Publishers Ltd. New Delhi-1991.
3. **G.J. Klir & B.Yuan,** Fuzzy Sets & Fuzzy Logic.Prentice Hall of India New Delhi-1995.

Paper – XXII(A)

Fluid Mechanics –II

Max. Periods: 60 (04 Credits)

Course Objective(s):

The aim of this course is tostudy two dimensional image system, Milne-Thomson circle theorem, theorem of Blasius, concepts of gas dynamics, stress strain relations, uniqueness theorem, important relations related to Navier-Stokes equations and various applications in all fields.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Apply Milne-Thomson circle theorem
CO2: Identify appropriate governing equation for particular flow.
CO3: Explain stress strain relations.
CO4: Evaluate the velocity of fluid flow.

Unit-I:

Two dimensional image system, The Milne- Thomson circle theorem, Applications of the circle theorem, the theorem of Blasius, some worked examples.

Unit-II:

Compressibility effects in real fluids, The elements of wave motion, The speed of sound in a gas, Equation of motion of a gas, Subsonic, sonic and Supersonic flows, Isentropic gas flow, Reservoir discharge through a channel of varying section, Shock waves.

Unit-III:

Stress components in a real fluid, Relations between Cartesian components of stress, Translational motion of fluid element, The rate of strain quadratic and principle stresses, Some further properties of the rate of strain quadratic, Stress analysis in fluid motion, Relation between stress and rate of strain, The coefficient of viscosity and laminar flow. The Naiver Stokes equations of motion of a viscous fluid.

Unit-IV:

Flow between two parallel planes, Steady flow through tube of uniform circular cross section, some solvable problems in viscous flow, Steady viscous flow between concentric rotating cylinders. Uniqueness theorem, Diffusion of vorticity, Energy dissipation due to viscosity, Steady flow past a fixed sphere, Prandtl's Boundary Layer.

Text Book:

1. **Text book of Fluid Dynamics, by F Charlton**, Reprint 1998, C B S Publishers and distributors, Delhi – 110 002

Scope: Unit-I Chapter 5, 5.7 to 5.9
Unit-II Chapter 7, 7.1-7.7
Unit-III Chapter 8, 8.1-8.9
Unit-IV Chapter 8, 8.10-8.13

Reference Books:

1. **G.K. Batchelor-** An Introduction to Fluid Mechanics (Foundation Book-New Delhi 1994)
2. **W.H. Besaint and A.S. Ramsey** – A Treatise on Hydro Mechanics Part II, CBS Publisher-1998.
3. **S.W. Yuan** – Foundations of Fluid Mechanics, Prentice Hall of India Pvt. Ltd- New Delhi 1976

Paper-XXII(B)
Difference Equations-II

Max. Periods: 60(04 Credits)

Course Objectives:

The course introduced the elementary analysis and linear algebra to investigate solution to difference equation. To study self adjoint second order linear equation, the sturm-liouville problem, discrete calculus of variations, Boundary value problem for nonlinear equations.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Study self adjoint equation..
CO2: Analyze sturm-liouville problem for difference equations.
CO3: Understand the Lipschitz case and existence of solutions.
CO4: Discuss the boundary value problem for nonlinear equations.

Unit-I:

Introduction, Sturmian theory, Green's functions, Disconjugacy, The Riccati equations, Oscillation.

Unit – II:

Introduction, Finite Fourier analysis, Non-homogeneous problem.

Unit – III:

Introduction, The Lipschitz case, Existence of solutions, Boundary value Problems for differential Equations.

Unit – IV:

Introduction, The Lipschitz case, Existance of solutions, Boundary value problem for differential equations.

Text Book:

1. **Walter G. Kelley and Allan C. Peterson**, "Difference Equations", Academic Press, Second Edition.

Scope : Unit-I Chapter 6.
Unit-II Chapter 7.
Unit-III Chapter 8.
Unit-IV Chapter 9.

Reference Books:

1. **Calvin Ahlbrandt and Allan C. Peterson**, "Discrete Hamiltonian Systems: Difference Equations, Continued Fractions and Riccati Equations, "Kluwer, Boston, 1996.
2. **Saber N. Elaydi** "An Introduction to Difference Equations" Springer, Second Edition.

Paper-XXII(C)
Programming in C++

Max. Periods: 60(04 Credits)

Course Objectives:

In this course we will study the basics of the programming language C++ such as tokens, expressions, Classes and Objects, Constructors and Destructors, Inheritance, Polymorphism and Files.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Identify the basic concept of Tokens, Expressions and Control structures-Functions in C++
CO2: Analyze Classes and Objects..
CO3: Understand Constructors and Destructors
CO4: Apply the concept of Extending classes-Pointers, Virtual Functions and Polymorphism.
CO5: Study practical course.

Unit-I:

Tokens, Expressions and Control structures-Functions in C++.

Unit – II:

Classes and Objects.

Unit – III:

Constructors and Destructors-Operator overloading and type conversions.

Unit – IV:

Inheritance: Extending classes-Pointers, Virtual Functions and Polymorphism.

Unit – V:

Working with Files.

Text Book:

1. **E. Balagurusamy**, Objected Oriented Programming with C++, Third Edition, Tata McGraw-Hill Education, 2008.

Reference Books:

1. **Steve Oualline**, Practical C++ Programming, O’Reilly Media, 2003.
2. **Chuck Easttom**, C++ Programming Fundamentals, Charles River Media, 2003.

Paper-XXIII (A)
Integral Equations

Max. Periods: 60(04 Credits)

Course Objectives:

Many physical problems that are usually solved by differential equation methods can be solved more effectively by integral equation methods. Such problems abound in applied mathematics, theoretical mechanics, and mathematical physics. This course enables the students to get the detailed idea about the integral equation, its classification, different types of kernals, the relationship between the integral equations and ordinary differential equations and how to solve the linear integral equations by different methods with some problems which give rise to integral equations.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Acquire sound knowledge of different types of Integral equations**.**
CO2: Obtain integral equations from ODEs and PDEs arising in applied mathematics and different engineering branches and solve accordingly using various method of solving integral equation.
CO3: Demonstrate a depth of understanding in advanced mathematical topics in relation to geometry of curves and surfaces.
CO4: Apply the knowledge of integral transformation like Laplace transformation, Fourier transformation to solve different types of integral equation.

Unit-I:

Preliminary Concepts, Integral Equation: Definition, Linear and nonlinear Integral Equations, Fredholm Integral Equations, Volterra Integral Equations, Singular Integral Equations, Special Kinds of Kernels, and classification of integral equations, Special kinds of kernels, Convolution integrals, Conversion of an initial value problem into a Volterra integral equation, Conversion of a boundary value problem into a Fredholm integral equation, Homogeneous integral equations of the second kind with separable kernel.

Unit-II:

Solution of Fredholm integral equations of the second kind with separable kernel, Fredholm alternative, an approximate method Method of successive approximation: Iterated kernel, Resolvent kernel, Solution of Fredholm and Volterra integral equations of the second kind by the method of successive substitutions, Solution of Fredholm and Volterra integral equations of the second kind by the method of successive approximations: Neumann series.

Unit-III:

Integral equations with symmetric kernels: Regularity conditions, Complex Hilbert space, An orthonormal system of functions, Fundamental properties of eigen values and eigen functions for symmetric kernels. Expansion in eigen functions and bilinear form, Hilbert-Schmidt theorem and some immediate consequences, Definite Kernels and Mercer's theorem

Unit-IV:

Singular integral equations, The solution of Abel integral equation, general form of Abel integral equation, Another general form of Abel integral equation, Integral transform method, Application of Laplace transform to solve Volterra integral equations with convolution type kernels, Examples.

Text Book:

1. Dr. M. D. Raisinghania, *Integral Equations and Boundary Value Problems*, S. Chand and Company Pvt. Ltd., New Delhi.

   Scope:
   Unit-I: Chapter 1 complete, Chapter 2 complete, Chapter 3 complete,
   Unit-II Chapter 4 complete, Chapter 5 sections 5.1 to 5.15
   Unit-III Chapter 7 sections 7.1 to 7.5
   Unit-IV Chapter 8 sections 8.1 to 8.4, Chapter 9 section 9.1 to 9.5

Reference Books:

1. **R.P. Kanwal**, Linear Integral Equantions Theory and Technique, Academic Press, Inc., New York.
2. **S.G. Mikhlin**, Linear integral equations (Translated from Russian) “Hindustan Book Agency 1960.
3. **B.L. Moiseiwitsch**, Integral Equations, Longman, London & New York.
4. **M. Krasnov, A Kiselev, G.Makaregko**, Problems and Exercises in integral equations (Translated from Russian) by George Yankovsky) MIR Publishers Moscow, 1971.

Paper XXIII (B)
Lattice Theory

Max. Periods: 60(04 Credits)

Course Objective(s):

This course introduces the concept of two definitions of Lattices, distributive lattices, congruence's and ideals, modular and semi-modular lattices.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Describe the Lattices and some concepts of lattices.
CO2: Understand the concepts of distributive Lattices.
CO3: Analyze the Weak Projectivity and Congruence's, Standard, and Neutral ideals.
CO4: Study the modular and semi-modular lattices.

Unit-I:

Two Definitions of Lattices, How to Describe Lattices, Some Algebraic Concepts, Polynomials, Identities, and Inequalities, Free Lattices, Special Elements.

Unit-II:

Characterization and Representation Theorems, Polynomials and Freeness, Congruence Relations, Boolean Algebras Topological Representation, Pseudo-complementation.

Unit-III:

Weak Projectivity and Congruence's, Distributive, Standard, and Neutral Elements, Distributive, Standard, and Neutral Ideals, Structure Theorems.

Unit-IV:

Modular Lattices, Semimodular Lattices, Geometrie Lattices, Partition Lattices, Complemented Modular Lattices

Text Book:

1. **G. Gratzer- Birkhauser,** General Lattice Theory, IInd Edition.

Scope: Unit I - Chapter 1.
Unit II - Chapter 2.
Unit III - Chapter 3.
Unit IV - Chapter 4.

Reference Books:

1. **Vijay K. Garg,** Introduction to lattice theory with computer science applications, John Wiley and Sons.

Paper XXIII(C)
Fractional Calculus and its Applications-II
Max. Periods: 60(04 Credits)

Course Objective(s):

This course introduces the concept of fractional green's functions, other methods for the solution of fractional order equations, numerical evaluation of fractional derivatives, numerical solution of fractional differential equations.

Course Outcome(s):

After completing this course, the student will be able to:

CO1: Study the solution of the initial value problem for the Ordinary fractional linear differential equation with constant coefficients using only its Green's function.
CO2: Understand the different methods for the solution of fractional order equations.
CO3: Analyze the numerical evaluation of fractional derivatives.
CO4: Study the numerical solution of fractional differential equations.

Unit-I:

Definition and some properties, one term equation, Two term equation, Three term equation, Four term equation, general Case:n-term equation.

Unit-II:

The Mellin transform method, Power series method, Babenko's symbolic calculus method, Method of orthogonal polynomials.

Unit-III:

Riemann-Liouville and Grunwald-Letnikov definitions of the fractional order derivatives, approximation of fractional derivatives, the short memory principle, order of approximation, computation of coefficients, higher order approximations calculations of heat load intensity, finite part integrals and fractional derivatives.

Unit-IV:

Initial conditions: Which problem to solve?, Numerical solution, examples of numerical solutions, the short memory principle in initial value problems for fractional differential equations.

Text Book:

1. **Igor Podlubny**, "Fractional Differential Equations", Academic Press, San Diego, California, 92101-4495, USA

Scope: Unit I - Chapter 5.
Unit II - Chapter 6.
Unit III - Chapter 7.
Unit IV - Chapter 8.

Reference Books:

1. **Miller K.S. and Ross B**., “An Introduction to Fractional Calculus and Fractional Differential Equations”, New York, John Wiley, 1993.
2. **Oldham K.B. and Spanier J.**, “The Fractional Calculus”, New York, Academic Press, 1974.

Paper-XXIV

Project Work

Marks: 125, **Credits-5**

Distribution of Marks:

Project Submission: 100 Marks **Viva-Voce: 25 Marks**

Project work as per S.R.T.M. University, Nanded Rules:

Swami Ramanand Teerth Marathwada University, Nanded.

Question Paper pattern

FACULTY OF ARTS / SCIENCE

M.A. /M. Sc. (Second Year) (Mathematics) (CBCS Pattern)

w. e. f. June-2020 onwards

Time: 03.00 Hrs. **Max.Marks:75**

Q. No. 1: **Attempt the following.** **Unit No. I**

a) Theory — 15 marks

or

b) Theory/problem — 15 Marks

Q. No. 2: **Attempt the following.** **Unit No. II**

a) Theory — 15 marks

or

b) Theory/problem — 15 Marks

Q. No. 3: **Attempt the following.** **Unit No. III**

a) Theory — 15 marks

or

b) Theory/problem — 15 Marks

Q. No. 4: **Attempt the following.** **Unit No. IV**

a) Theory — 15 marks

or

b) Theory/problem — 15 Marks

Q. No. 5: **Attempt any three of the following.** **Unit No. I, II, III, IV**

a) Theory / Problem

b) Theory / Problem — 5 Marks Each

c) Theory / Problem

d) Theory / Problem

Total **75**