M.Sc.

Applied Mathematics Syllabus

(Two Years Programme)

School of Applied Sciences

Centurion University of Technology & Management

2025-26

DEPARTMENT OF MATHEMATICS

M.Sc. Mathematics

Two Year Programme

Course Structure 2025-26

Basket I - Core Courses					
Sl. No.	Code	Subject Name	T-P-P	Credits	Level
SEMESTER – I					
1.	CUTM1530	Advanced differential equations	**2-1-1**	**4**	**6**
2.	CUTM1532	Optimization techniques	**3-1-0**	**4**	**6**
3.	CUTM1536	Topology	**3-0-1**	**4**	**6**
4.	CUTM1537	Differential Geometry	**3-0-1**	**4**	**6**
5.	CUTM1538	Advanced Algebra	**3-0-1**	**4**	**6**
SEMESTER – II					
6.	CUTM1527	Fluid Dynamics	**3-0-1**	**4**	**6**
7.	CUTM1018	Data Analysis and Visualization using Python	**0-1-3**	**4**	**6**
8.	CUTM1535	Advanced complex analysis	**3-0-1**	**4**	**6**
9.	CUTM1531	Graph Theory	**3-1-0**	**4**	**6**
10.	CUTM1534	Applied Number Theory	**3-1-0**	**4**	**6**
SEMESTER – III					
11.	CUTM4527	Scientific computing using MATLAB	**2-1-1**	**4**	**6.5**
12.	CUTM1533	Advanced Statistical Methods	**2-1-1**	**4**	**6.5**
SEMESTER – IV					
13.	CUTM4525	Quantum Computing	**2-1-1**	**4**	**6.5**
14.	CUTM1526	Numerical Methods for CFD	**2-1-1**	**4**	**6.5**
		Total	**14*4=56**		
			Basket II (Specialization)	24	
			Basket III (Research Methodology and IPR)	04	
			Skill	04	
			Grand Total	**88**	

CUTM1526 NUMERICAL METHODS FOR CFD

Subject Name	Code	Type of course	T-P-Pj (Credit)	Prerequisite
NUMERICAL METHODS FOR CFD	CUTM1526	Theory, Practice & Project	2-1-1	Nil

Objective

- To introduce basic concepts of computational fluid dynamics (CFD).
- To familiarize different numerical methods to deal with the problems of CFD.
- To facilitate computational tools for solving linear and non-linear partial differential equations related to fluid dynamics and heat transfer.

Course outcome

After completion of the course, students will be able to

COs	Course outcomes
CO1	explain basic concepts of CFD
CO2	classify the equations governing the CFD problems
CO3	Demonstrate the principles of numerical analysis and concepts of consistency, stability, and convergence.
CO4	Examine finite difference/volume schemes on model problems of computational fluid dynamics.
CO5	Construct program-code using Python to obtain numerical solutions of partial differential equations, relevant to Computational Fluid Dynamics.

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2		1	3	1	2	2			1		3	3	2	3
CO2	3	2		2	1		1			2	1	1	2	1	3
CO3	3	2	1	1		2				1		2	1	2	2
CO4	3		2		2		1				2	3	2	2	3
CO5		1		1		1	1		1	2		1	2	3	1

***High-3, Medium-2, Low-1**

Course Outline

CUTM1526 Numerical Methods for CFD (2-1-1)

MODULE I

Introduction to CFD:
Basics of computational fluid dynamics, Definition and overview of CFD - need, advantages, problem areas, Governing equations of fluid dynamics – Continuity, Momentum and Energy equations, Non-Dimensional form of these governing equations, Classifications of PDE: Elliptic, Parabolic and Hyperbolic equations.

MODULE II

Finite Difference Method (FDM):
Derivation of Finite difference equations (FDE) of 1st and 2nd order derivatives using Taylor series expansion. Explicit method-FTCS Method, Implicit method-BTCS Method, Crank-Nicholson method, Error, Convergence and stability analysis of above numerical Scheme, Keller Box Method.

MODULE III

Solution of Simultaneous Equations:
Direct and Iterative methods; Gauss-elimination, Gauss-Jordan, Gauss-Jacobi and Gauss-Seidel methods, Tri Diagonal Matrix Algorithm (TDMA) (Thomas)

Practice 1: Gauss-elimination method using Python

Practice 2: Gauss-Seidel method using Python

Practice 3: Tri Diagonal Matrix Algorithm using Python

Practice 4: Gauss- Jordan elimination method using Python

Practice 5: Gauss- Jacobi elimination method using Python

Project 1: Solution of Simultaneous Equations using Gauss-Jordan method.
Project 2: Solution of Simultaneous Equations using Gauss-Jacobi method.

MODULE IV

Application of FDM:

Solutions of Elliptic PDE: One-and Two-dimensional steady heat conduction, Laplace's Equation, Poisson's equation, Parabolic PDE: Unsteady heat conduction, Stoke's 1st& 2nd Problems, Hyperbolic PDE: One-dimensional wave equation

Practice 4: Solution of One-dimensional steady heat conduction using Python.
Practice 6: Solution of One-dimensional steady heat conduction using Python.

Practice 7: Solution of Laplace's equation using Python.

Practice 8: Solution of Unsteady heat conduction using Python.

Practice 9: Solution of One-dimensional wave equation using Python.

Practice 10: Solution of Stoke's Problem.

Project 3: Solution of Poisson's equation.

Project 4: Solution of Burger's equation.

MODULE V

Finite Volume Method (FVM):

Fundamentals of FVM, Integral Form of 1-D Conservation equation, Finite Volume Method in 2-D

MODULE VI

Application of FVM:

Solutions of 1-D steady state Diffusion and Convection equations.

Project 5: Solutions of1-D steady state Diffusion equation.

MODULE VII

Application of FVM:

Solutions of 2-D steady state Diffusion and Convection equations.

Project 6: Solutions of2-D steady state Convection equation.

Text Books:

1. Computational Fluid dynamics by John D. Anderson, Jr
2. Computational Fluid dynamics and Heat Transfer, by John C. Tannehill , Dale A. Anderson , Richard H. Pletcher
3. Introduction to finite elements in engineering, by Tirupathi R. Chadraupala, Ashok D. Belegundu, Chapter 3.
4. An introduction to computational fluid dynamics, by H K Versteeg and W Malalasekera, Chapter 4,5

CUTM1527 FLUID DYNAMICS

Subject Name	Code	Type of course	T-P-Pj (Credit)	Prerequisite
FLUID DYNAMICS	**CUTM1527**	**Theory & Project**	**3-0-1**	**Nil**

Objective

- To introduce the foundations of fluid dynamics.
- To provide a clear view on governing equations of fluid dynamics.
- To work with different types of flows.

Course outcome

After completion of the course, students will be able to

COs	Course outcomes
CO1	recognize different types of flow
CO2	explain mass, momentum and energy conservation and their mathematical equations in different physical situations.
CO3	distinguish and analyze the governing equations of fluid dynamics in various formulations for compressible and incompressible, viscous and inviscid flows.
CO4	estimate the impact of different physical phenomena based on dimensional analysis
CO5	examine mathematical properties of governing equations and be able to critically evaluate correct boundary/initial value problems for various flows.

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1		1	1	3	1	2	2			1		3	3	3	2
CO2	1	2		2		1	1			2	1	1	2	1	3
CO3	3		2		1	2	2			1	1	2	1	1	3
CO4	2		2		2					2	2		2	3	2
CO5	2	1		1		1	1			2		1	2	1	1

***High-3, Medium-2, Low-1**

Course Outline

CUTM1527 Fluid Dynamics (3-0-1)

MODULE – I (4hr+0hr+2hr)

Kinematics of Fluids, Methods describing Fluid motion, Lagrangian and Eulerian Methods, Translation, Rotation and Rate of Deformation, Streamlines, Path lines and Streak lines.

PROJECT 1: A Report on Steady vs Unsteady Flow, Compressible vs incompressible Flow, Laminar vs Turbulent Flow, Newtonian vs Non-Newtonian Flow, Invisid vs Viscous Flow, Rotational vs Irrotational Flow. (Definition, Comparative Study & Examples)

MODULE – II (5hr+0hr+0hr)

Fundamental equations of the flow of viscous compressible fluids: Equations of continuity**,** motion and energy in Cartesian coordinate systems, The equation of state, Fundamental equations of continuity, motion and energy in Cylindrical & Spherical coordinate systems.

MODULE – III (4hr+0hr+2hr)

2-D and 3-D inviscid incompressible flow: Basic equations and concepts of flow, Circulation theorems, Velocity potential, Rotational and Irrotational flows, Bernoulli's Equation.

PROJECT 2: A study on Stokes Circulation Theorem

MODULE – IV (4hr+0hr+8hr)

Laminar Flow of Viscous Incompressible Fluids: Flow between parallel flat plates:Couette flow, Steady Flow in pipes: Hagen-Poiseuille flow, Unsteady motion of a flat Plate.

PROJECT 3: A study on plane Poiseuille flow.

PROJECT 4: A report on steady flow of viscous incompressible fluid between two porous parallel plates.

PROJECT 5: A study on laminar flow between two coaxial circular cylinders (i.e. an annulas).

PROJECT 6: A report on unsteady flow of a viscous incompressible fluid over an oscillating plate.

MODULE – V (5hr+0hr+0hr)

The Laminar boundary layer Flow: Properties of Navier-Stokes equations, Boundary layer equations in 2-D flow, Similarity of Flows, Reynold's Number, The boundary layer along a flat plate, Boundary layer on a surface with pressure gradient.

MODULE – VI (4hr+0hr+0hr)

Momentum Integral theorems for the boundary layer, Von karman-Pohlhausen method, Separation of boundary layer flow, Boundary layer control

MODULE – VII (4hr+0hr+0hr)

The origin of Turbulence, Reynold's modification of the Navier-Stokes equations for Turbulent flow, Reynold's stresses, Prandtl's mixing length theory.

BOOK PRESCRIBED

1. S. W. Yuan, "Foundations of Fluid Mechanics", Prentice – Hall of India Chapters: 3 (3.1 to 3.4), 5 (5.1 to 5.6), 7 (7.1 to 7.5), 8(8.1, 8.3, 8.4, 8.8),9 (9.1 to 9.6, 9.8, 9.9), 10(10.1 to 10.3(a))

BOOK REFERENCE

1. J. L. Bansal , "Viscus Fluid Dynamics", IBH Publication, Joypur.
2. M. D. Raisinghania, "Fluid Dynamics with Complete Hydrodynamics", S. Chand & Company Ltd, New Delhi.

Link: https://nptel.ac.in/courses/112/105/112105171/

QUANTUM COMPUTING

Subject Name	Code	Type of course	T-P-Pj (Credit)	Prerequisite
QUANTUM COMPUTING	**CUTM4525**	**Theorv +Practice+ Project**	**1-2-1**	Linear Algebra, Basic Quantum Mechanics, Classical Computing Concepts

Objective

- Build conceptual understanding of quantum mechanics as it applies to computation, including superposition, entanglement, and quantum gates.
- Familiarize students with quantum algorithms such as Deutsch-Jozsa, Grover's Search, and Shor's algorithm.
- Introduce quantum programming using tools like Qiskit, enabling students to simulate and implement quantum circuits on classical and quantum simulators.

Course outcome

After completion of the course, students will be able to

Course Outcome to Program Outcome Mapping:

Cos	Course outcomes
CO1	Understand the fundamental concepts of quantum mechanics that form the basis of quantum computation, including qubits, superposition, entanglement, and quantum measurement.
CO2	Analyze and design quantum circuits using quantum logic gates and evaluate the behavior of basic quantum algorithms such as Deutsch-Jozsa, Grover's, and Shor's algorithms.

CO3	Apply quantum programming frameworks (e.g., Qiskit) to simulate quantum circuits and perform quantum computations on real or simulated quantum processors.
CO4	Solve scientific and computational problems using quantum approaches in domains such as optimization, cryptography, and quantum chemistry.
CO5	Demonstrate critical thinking, teamwork, and communication skills through mini-projects or case studies involving interdisciplinary applications of quantum computing.

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1		1	1	3	1	2	2			1		3	3	3	2
CO2	1	2		2		1	1			2	1	1	2	1	3
CO3	3		2		1	2	2			1	1	2	1	1	3
CO4	2		2		2					2	2		2	3	2
CO5	2	1		1		1	1			2		1	2	1	1

***High-3, Medium-2, Low-1**

Course outline

Course Outline

Module 1: Foundations of Quantum Computing (T-2Hrs | P-4Hrs | Pj-1Hr)

Theory (2 Hrs.)

- **Motivation & Overview**
  - Why Quantum Computing? Moore's Law & Classical Limits.
  - Classical vs Quantum Computation: Bits vs Qubits.
  - Applications Landscape (Medicine, AI, Cryptography).
- **Essential Linear Algebra & Complex Numbers**
  - Complex number and its Polar Representation
  - Vectors, Linear Independence, Vector Space, Oorthonormal Basis. Unitary Matrix.
- **Qubits, Quantum States & Dirac Notation**
  - Quantum State, Wave function, State vectors in Hilbert space
  - Bra-Ket Notation: Inner, Outer, Tensor Products, Nnormalization
  - Phase and Pprobability Aamplitudes, Superposition & Entanglement
  - Measurement: Projective measurement, Born rule, Quantum state collapse
  - Bloch Sphere representation of Qubits

Practice (4 Hrs.)

- Single Qubit state visualization using Bloch Sphere
- Hands-on with simple state preparations using Qiskit

Project 1 (1Hrs.)

- Simulation and visualization of basic quantum states

Module 2: Quantum Gates & Circuits (T-2Hrs | P-6Hrs | Pj-1Hrs)

Theory (3 Hrs.)

- Single Qubit Gates: Identity (I), Pauli Gates (X, Y, Z), Hadamard Gate (H), General Phase Gate R(ϕ), Phase (S) & $S^{\dagger}$, T & $T^{\dagger}$, Rotation Gates (R_x, R_y, R_z)
- Matrix representations, Circuit symbols, Bloch sphere Action
- Multi-Qubit Systems: Tensor Product, Basis States, State Space Growth
- **Multi-Qubit Gates:** CNOT, CZ, SWAP, iSWAP, Toffoli (CCNOT), Fredkin (CSWAP) Gates.
- Quantum Entanglement: Bell states, GHZ states, Non-locality (EPR paradox, Bell inequalities)
- Arbitrary n-Qubit Unitaries (U_2^n): Representation and Decomposition
- Universality of Quantum Gates
- Introduction to Quantum Circuit Design and Simulation (Basics of Quantum Circuits, Circuit Elements, Circuit Design Principles, Quantum Measurements and Simulation Concepts)

Practice (6 Hrs.)

- Visualize multi-qubit state vectors through Q-Sphere.
- Implement single qubit gates: X, Y, Z, H, R(ϕ), S, $S^{\dagger}$, T, $T^{\dagger}$, R_x, R_y, R_z.
- Implement single qubit gates: CNOT, CZ, SWAP, iSWAP, Toffoli (CCNOT), Fredkin (CSWAP) Gates
- Create quantum circuits producing Bell states and GHZ States
- Decompose arbitrary unitary gates (1-2 Qubits)

Project 2 (1 Hrs.)

- Design and implement custom gate sequences and analyze output states

Module 3: Quantum Communication Protocols (T-2Hrs | P-4Hrs | Pj-1Hr)

Theory (2 Hrs.)

- No-Cloning Theorem, Quantum Teleportation Protocol
- Superdense Coding
- Quantum Cryptography: BB84, Quantum Key Distribution (QKD), Post-quantum cryptography overview

Practice (4 Hrs.)

- Simulate Quantum Teleportation and Superdense Coding.
- QKD Simulation using BB84 Protocol

Project 3 (1 Hrs.)

- Simulate Teleportation on State Vector Simulator and Real Quantum Computer.

Module 4: Quantum Algorithms-I (T-2Hrs | P-4Hrs | Pj-1Hrs)

Theory (1 Hr.)

- Quantum Parallelism, Quantum Interference.
- Deutsch-Jozsa Algorithm, Oracle Concept, Grover's Algorithm and Amplitude Amplification

Practice (4 Hrs.)

- Simulate Deutsch-Jozsa algorithm.
- Simulate Grover's algorithm for a small database.

Project 4 (2 Hrs.)

- Developing Quantum Oracles for Specific Search Problems: Design, Testing, and Evaluation.

Module 5: Quantum Algorithms-II (T-2Hrs | P-4Hrs | Pj-1Hrs)

Theory (2 Hrs.)

- Quantum Fourier Transform (QFT)
- Period Finding and Integer Factorization
- Shor's Algorithm

Practice (4 Hrs.)

- Implement and simulate QFT
- Implement and simulate Shor's algorithm

Project 5 (1 Hr.)

- Quantum Fourier Transform and Its Applications in Period Finding and Integer Factorization

Module 6: Quantum Error Correction & Noise (T-2Hrs | P-4Hrs | Pj-1Hr)

Theory (2 Hrs)

- Quantum Decoherence and Errors
- Types of Noise Affecting Qubits
- Classical Error Correction Analogies
- Quantum Error Correcting Codes: Bit-flip, Phase-flip, Shor's 9-qubit, Surface Code

Practice (4 Hrs)

- Error simulation using Qiskit Aer
- Demonstration of 3-qubit repetition code

Project 6(1 Hr)

- Simulation of Quantum Error Correction Codes on Noisy Quantum Devices Using Qiskit

Module 7: Quantum Programming & Applications (T-2Hrs | P-4Hrs | Pj-1Hr)

Theory:

- Quantum Programming Languages (Qiskit (IBM), Cirq (Google), Braket (AWS), PennyLane, Q#)
- Applications of Quantum Computing
- Quantum Machine Learning (Variational Circuits, QNNs)
- Quantum Chemistry (Hamiltonian simulation, Variational Quantum Eigen solver)
- Optimization (QAOA, MaxCut)

- Current **Quantum Hardware and Roadmaps (**NISQ devices vs. Fault-tolerant devices)

Practice:

- Advanced circuit building
- Simulate H_2 molecule energy using VQE
- Hybrid quantum-classical workflows (e.g., VQE, QAOA)

Project 6 (1 Hr.)

- Capstone project: Implementation of a Real-world application-based project

Assessment Scheme:

Component	Weightage
Theory Exams	30%
Lab Assignments	20%
Module Projects	20%
Final Capstone Project	30%

Textbooks and References

Textbooks:

1. Michael A. Nielsen and Isaac L. Chuang, Quantum Computation and Quantum Information, 10th Anniversary Edition, Cambridge University Press, 2010. ISBN: 978-1107002173

Chapters:1 (Art. 1.1, 1.2, 1.3, 1.4, 1.5),2 (Art. 2.1–2.9),4 (Art. 4.1–4.10),5 (Art. 5.1–5.3),6 (Art. 6.1–6.8),7 (Art. 7.1–7.3),8 (Art. 8.1),10 (Art. 10.1–10.9),12 (Art. 12.1–12.3)

2 **Jack D. Hidary**, *Quantum Computing: An Applied Approach*, 2nd Edition, Springer, 2021. ISBN: 978-3030239213

Chapters:1 (Art. 1.1, 1.2),2 (Art. 2.1–2.4),3 (Art. 3.1–3.3),4 (Art. 4.1–4.3),5 (Art. 5.1–5.2),6 (Art. 6.1–6.6),7 (Art. 7.1–7.3),8 (Art. 8.1, 8.3),11 (Art. 11.1–11.2),
12 (Art. 12.1–12.2)

References:

1. **Eric R. Johnston, Nic Harrigan, Mercedes Gimeno-Segovia**, *Programming Quantum Computers: Essential Algorithms and Code Samples*, O'Reilly Media, 2019.
    - ISBN: 978-1492039686

   Chapters: 1 (Art. 1.1–1.3), 2 (Art. 2.1–2.2), 3 (Art. 3.1–3.4), 4 (Art. 4.1–4.3), 5 (Art. 5.1–5.4), 6 (Art. 6.1–6.3), 7 (Art. 7.1–7.2)

2. **Sarah Kaiser & Christopher Granade**, *Learn Quantum Computing with Python and Q#*, Manning Publications, 2021.
3. **Thomas G. Wong**, *Introduction to Classical and Quantum Computing*, Springer, 2022.

4. **Qiskit Textbook** (Open Source): *"Learn Quantum Computing using Qiskit"*, IBM Quantum(https://qiskit.org/learn/)

IBM Quantum Lab: https://quantum-computing.ibm.com

CUTM1530 ADVANCED DIFFERENTIAL EQUATIONS

Subject Name	Code	Type of course	T-P-Pj	Prerequisite
ADVANCED DIFFERENTIAL EQUATIONS	**CUTM1530**	**Theory, Practice & Project**	**2-1-1**	Nil

Objective

- To work with nonlinear ordinary differential equations.
- To develop and understand the qualitative behavior of the solution.
- To introduce wave equations, Laplace equations, Heat equations, Diffusion equations.

Course outcome:

After completion of the course, students will be able to

COs	Course outcomes
CO1	identify classes of non-linear ordinary differential equations.
CO2	select an appropriate method for the solution of non-linear ordinary differential equations.
CO3	classify non-linear partial differential equations of 2^{nd} order.
CO4	solve partial differential equations using method of separation of variables.
CO5	execute Python programming for solving ordinary and partial differential equations.

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2		2			2				3			3	2	3
CO2	2	1		2	1	1				2	1	1	3	1	1
CO3	3	1	2	1		1	1			3		3	3	3	3
CO4	1	1	3		1					2		1	2	3	2
CO5	2	1		1						2		3	1	1	2

***High-3, Medium-2, Low-1**

Course outline

Module I:

Introduction to Ordinary Differential Equations and Partial Differential Equations, First Order Non- linear Ordinary differential equations such as Equations solvable for x, Equations solvable for y, Equations solvable for p.

Practice- 1: Solve Ordinary Differential Equations in Python

Practice-2: Solve Partial differential Equations by python

Module II

Partial differential equation of second order with variable coefficients- Monge's method and its properties.

Project 1: Monge’s Method of Solution of Non-linear Partial Differential Equations of Order Two

Module III

Classification of linear partial differential equation of second order, Cauchy's problem, Method of separation of variables.

Module IV

Solution of one- dimensional Laplace equation by method of separation of variables and Fourier series

Project 2 : Solution of Laplace’s Equation for a Disk

Module V

Solution of one- dimensional Wave equation by method of separation of variables and Fourier series

Project 3: D’ Alembert’s solution of the wave equation

Practice 3: Solution of wave equation associated condition $u(x,0)=\varphi(x),u_t(x,0)=\psi(x),u(0,t)=0,x\epsilon(0,\infty),t>0$

Practice 4: Solution of wave equation associated condition $u(x,0)=\varphi(x),u(0,t)=a,x\epsilon(0,\infty),t\geq 0$

Module VI

Solution of one- dimensional Diffusion equation by method of separation of variables and Fourier series

Project 4: Solution of Diffusion equation in n-dimensional

Practice 5: Solution of one-dimensional diffusion equation by using boundary conditions $u(x,0)=\varphi(x),u(0,t)=a,x\epsilon(0,\infty),t\geq 0$

Practice 6: Solution of one-dimensional diffusion equation $u(x,0)=\varphi(x),u(0,t)=a,u(1,t)=b,0<x0$

Module VII

Solution of one- dimensional Heat equation by method of separation of variables and Fourier series

Project 5: Two dimensional Heat equations- Polar form

Project 6: Temperature distribution in Rectangular plate

Text Books

1. Differential Equations and Their Applications, by Martin Braun, Springer, 4e, ISBN 9781111827052 (1993).

S. L. Ross: Differential Equations, Blaisdell Publishing Company, Londan, 1964

Reference books:

1. S.J. Farlow: An Introduction to Ordinary Differential Equations, PHI
2. M.D. Raisinghania: Ordinary and Partial Differential Equations, S. Chand & Co.
3. V. Sundarapandian: Ordinary and Partial Differential Equations, McGraw-Hill

CUTM1531 GRAPH THEORY

Subject Name	Code	Type of course	T-P-Pj (Credit)	Prerequisite
GRAPH THEORY	**CUTM1531**	**Theory & Practice**	**3-1-0**	**Nil**

Objective:

- To understand the concept of graphs, their properties and their applications as models of networks.
- To define the basic concepts of graphs, directed graphs, and weighted graphs, the properties of bipartite graphs, particularly in trees.
- To apply the technique of generating functions and graph theory-based tools in solving practical problems.

Course outcome:

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

COs	Course outcomes
CO1	explain basic definitions and concepts of graph theory and Write in a coherent and technically accurate manner.
CO2	describe how to develop graph theoretical algorithm and discuss about many different coloring problems for graphs.
CO3	demonstrate that many problems-theoretical or real-life, can be analyzed and solved by using graphs.
CO4	develop the skill of translating problems to graph-theoretic problems and translating the solutions to the real-life problems.
CO5	use abstract concepts of graph theory in modeling and solving non-trivial problems in different field of study

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3		1			2				1		2	2	2	3
CO2	3		3	1	1	1	3			2	1	1	3	1	1
CO3	2	1		1			1			1		3	2	2	3
CO4	2		1			2					1	2	1	3	2
CO5	3				1		1			2		1	3	2	3

***High-3, Medium-2, Low-1**

Course Outline

Module-I

Introduction to Graphs and Definition of graphs; Basic terminologies and types of graphs; Degree of a vertex, Isolated and Pendant Vertices; Subgraphs and graph Isomorphism.

Practice 1: Determine if two graphs are isomorphic and identify the isomorphism

Module-II

Directed Graphs and Types of Digraphs; Out-degree, In-degree, Connectivity and Orientation; Digraphs and Binary relations, Directed paths and contentedness; Euler Digraphs, De-Brujin sequences; Tournaments.

Practice 2: Ways to Represent Graphs using Python

Module-III

Basic concepts of Planar Graphs; Kuratowski’s Two graphs ; Representation of Planar Graphs; Detection of planarity ; Euler’s formula for planar graphs;

Practice 3: A look in to Planar Graphs and Euler's Relationship

Module-IV

Distance, cut-vertices, cut-edges, blocks; weighted graphs, connectivity; Dijkstra’s shortest path algorithm; Floyd-War shall Shortest path algorithm;

Module-V

Proper Coloring of graphs; Chromatic numbers of a graph; Chromatic polynomial; Chromatic Partitioning; Four Colour theorem.

Practice 4: Finding **C**hromatic number using python-networks.

Module-VI

Definition and properties of trees; Rooted and Binary trees; Counting trees, Spanning trees;

Practice 5: Applications of graphs with Euler and Hamiltonian path and circuits (Chinese postman Problem)

Module-VII

Minimum spanning trees; Fundamental Circuit;Cut set and Separability;

Practice 6: Application of Minimum spanning tree in a Net work model

Text Book:

1. Deo, N., "Graph Theory with Applications to Engineering and Computer Science", Prentice Hall India 2004 **Chapters:** 1(1.1,1.2,1.3,1.4,1.5) ,2 (2.1,2.2,2.4,2.4,2.6,2.9), 3 (3.1,3.2,3.5,3.7,3.8,3.9,3.10), 4 (4.1,4.4,4.5), 5(5.2,5.3,5.4,5.5), 7(7.1,7.2), 8 (8.1,8.2,8.3,8.6), 9 (9.1,9.2,9.3,9.4, 9.5)

Reference Books:

1. West, D. B., "Introduction to Graph Theory ", Prentice Hall India (2nd Edition 2009)
2. Aldous, J. M., Wilson, R. J. and Best S., "Graphs and Applications: An Introductory Approach", Springer2003.
3. Deistel, R., "Graph Theory", Springer (4th Edition) 2010.
4. Chartrand, G. and Zhang, P., "Introduction to Graph Theory", Tata McGraw Hill2007.
5. Bondy, J. A. and Murty, U. S. R., "Graph Theory", Springer 2011

CUTM1532 OPTIMIZATION TECHNIQUES

Subject Name	Code	Type of Course	T-P-Pj (Credit)	Prerequisite
OPTIMIZATION TECHNIQUES	**CUTM1532**	**Theory & Practice**	**3-1-0**	**Nil**

Course Objective

- To introduce a brief understanding about Non Linear Programming Problems.
- To cater the characteristics of Non Linear Programming Problems and its Applications.
- To apply the evolutionary optimization techniques in machine learning prediction model

Course outcome:

After completion of the course, students will be able to

Cos	Course outcomes
CO1	explain the necessary and sufficient optimality conditions for Nonlinear programming.
CO2	use gradient method in solving applied engineering and fluid dynamic problems.
CO3	apply the optimization techniques learnt in this course to formulate new applications as optimal decision problems and seek appropriate solution algorithms.
CO4	examine evolutionary optimization techniques to optimize the forecasting models in machine learning.
CO5	develop game theory model to make decision in critical business problems

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1			2				2		3	3	3	3
CO2	2			2	1						1	1	2	1	3
CO3	1	1		1		2	1			1			2	3	2
CO4			1									2	1	3	3
CO5		1			1							1	3	2	3

***High-3, Medium-2, Low-1**

Course Outline

CUTM1532 Optimization Techniques (3-1-0)

Module-I (5 Hours)

Non Linear Constrained Optimization Problem: Constrained optimization using Lagrange Method, Lagrange Multiplier Equality Constraints, Constrained optimization using Kuhn Tucker Method, Kuhn Tucker inequality Constraints.

Practice-1: **(2 Hours)**

Solving minimization constrained optimization problem using python

Practice-2: **(2 Hours)**

Solving maximization constrained optimization problem using python

Module-II (5 Hours)

Direct Search Method for Unconstrained Optimization Problem: Univariate Search Method, Golden Section Search Method and Application of Golden Section Search Method.

Practice-3: **(2 Hours)**

Solving nonlinear system of equations using Python

Module-III (4 Hours)

Gradient Method for Unconstrained Optimization Problem: Gradient Descent Method, Algorithm for Gradient Descent Method, Steepest Descent Gradient Method.

Practice-4: **(2 Hours)**

Implementing Gradient Descent algorithm in Python

Practice-5: **(2 Hours)**

Linear Regression using Gradient Descent in Python

Module-IV (4 Hours)

Sequencing Models: Problems with n' Jobs through Two Machines, Problems with 'n' Jobs through Three Machines, Problems with Two Jobs through 'm' Machines.

Module-V (4 Hours)

Particle Swarm Optimization: Particle Swarm Optimization Theory, Particle Swarm Optimization Algorithm, Application of Particle Swarm Optimization,

Practice-6 & 7: **(2+2 Hours)**

Implementing the Particle Swarm Optimization (PSO) Algorithm in Python

Module-VI (4 Hours)

Game with Pure Strategy: Game and Strategy, Maximin-Minimax principle, Two person zero-sum game with Saddle Point, Solving matching coin problem using game theory.

Module-VII (4 Hours)

Game with Mixed Strategy: Mixed Strategy Game, Game without Saddle Point, Graphical Method to Solve Mixed Strategy Game, Dominance Principle to Solve Mixed Strategy Game.

Text Books:

1. Kanti Swarup, P.K. Gupta and Man Mohan-Operations Research, S. Chand and Co. Pvt.Ltd.

2. Engineering Optimization Theory and Practice by Singiresu S. Rao, JOHN WILEY & SONS, INC., Fourth Edition

Reference Book:

Mathematical Programming by N. S. Kambo, East West Press.

CUTM1533 ADVANCED STATISTICAL METHODS

Course Title	Code	Type of course	T-P-Pj (Credit)	Prerequisite
ADVANCED STATISTICAL METHODS	**CUTM1533**	**Theory, Practice & Project**	**2-1-1**	**NIL**

Objective

- To develop the ability for numerical and visual data presentation.
- To determine the situations in which the various statistical techniques will be applied.
- To enhance the ability critically about data-based claims and quantitative arguments.

Course outcome

After completion of the course, students will be able to

COs	Course outcomes
CO1	describe the statistical methods and hypothesis testing to business problems
	use Chi Squared Tests and to understand different type of data.
CO2	interpret the complexities of Analysis of Variance (ANOVA)
CO3	compare different types of regression analysis
CO4	
	extract the complexities of multiple regression (MR).

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1			2		3				3	2	1	1
CO2	2	1		2	1	2		2			1	1	2	1	3
CO3	2	1	2	1		1	1	2					1	2	3
CO4	3	1	2		2			3				3	2	2	1
CO5		1		1			2	2				2	3	1	1

***High-3, Medium-2, Low-1**

Course Content

Module I: (2 hrs+0 hrs+2hr)

Statistics: Population, Sample, Sampling, Estimators and Estimates, Maximum Likelihood , Confidence Intervals

Project-1

Application of Confidence intervals as a tool in decision making

Module II: (3 hrs+0hr+2hr)

Hypothesis Testing: Null and the alternative hypothesis, Rejection region and significance level, Chi-Square Test

Project-2

Hypothesis Testing in Quality Management

Module III: (4 hrs+4 hrs+0hr)

Regression: Multiple Regression and Logistic Regression

Practice-1

Multiple Regression Analysis in Python

Practice-2

Logistic Regression using Python

Module IV: (3 hrs+4 hrs+2hr)

Analysis of Variance (ANOVA): F- Distribution, One way ANOVA, Two Way ANOVA

Practice-3

One way ANOVA using Python

Practice-4

Two way ANOVA using Python

Project-3

The utility of multivariate statistical techniques in hydro geochemical studies

Module V: (3 hrs+2 hrs+2hr)

Covariance: (ANCOVA): Analysis of Covariance (ANCOVA), Bivariate Pearson Correlation, Alternative Correlation Coefficients

Practice-5

Python Analysis of covariance (ANCOVA)

Project-4

Application of Analysis of covariance (ANCOVA) in psychological research

Module VI: (3 hrs+0hr+2hr)

Multivariate analysis of variance (MANOVA): One-way MANOVA, Two-way MANOVA

Project-5

Comparison of MANOVA to ANOVA Using an Example

Module VII: (3 hrs+2 hrs+2hr)

Time Series Analysis: Introducing Time Series Analysis, Components of Time Series Analysis,

Multivariate Time Series Analysis

Practice-6

Time Series Analysis using Python

Project-6

A Report on Applications of Time Series Analysis in Census Analysis

Text Books:

1. Statistical Methods By S.P. Gupta (31st Edition) ; Publisher: Sultan Chand & Sons
2. Mathematical Statistics by S.C. Gupta & V.K. Kapur (10th Edition); Publisher: Sultan Chand & Sons.

Reference Books:

Understanding And Using Advanced Statistics by Jeremy Foster Emma Barkus Christian Yavorsky, SAGE Publications

CUTM1534 APPLIED NUMBER THEORY

Subject Name	Code	Type of course	T-P-Pj (Credit)	Prerequisite
APPLIED NUMBER THEORY	**CUTM1534**	**Theory & Practice**	**3-1-0**	**Nil**

Objective

- To analyze, evaluate, or solve problems with in given a set of circumstances or data.
- To understand and utilize mathematical functions and empirical principles and processes.
- To Enhance and reinforce the student's understanding of concepts through the use of technology when appropriate

Course outcome:

After completion of the course, students will be able to

COs	Course outcomes
CO1	describe the properties of prime number
CO2	implement Euclidian algorithm
CO3	solve Systems of linear Congruence's
CO4	distinguish Pseudo prime from prime numbers
CO5	appraise different types of cipherings.

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1			2				1		2	2	3	2
CO2	2	2		2	1	2					1	3	2	1	1
CO3	2	1	2	1		1	1			1			2	3	3
CO4		2			3						1	1	3	1	2
CO5	2		2		1		3				2	3	1	2	3

***High-3, Medium-2, Low-1**

Course Outline

CUTM 1534 APPLIED NUMBER THEORY (3-1-0)

Course Outline

CUTM 1534 APPLIED NUMBER THEORY (3-1-0)

MODULE – I (4hr+2hr+0hr)

Divisibility, Representations of Integers, Computer Operations with Integers, Prime Numbers

Practice-1: Write a program to decide whether an integer is prime using trial division of the integer by all primes not exceeding its square root.

MODULE – II (6hr+4hr+0hr)

Greatest common divisor, Euclidean Algorithm, Prime factorization, Factorization of Integers

Practice-2: Write a program to find the greatest common divisor of two integers using the Euclidean algorithm.

Practice-3:Find the prime factorization of a positive integer.

MODULE – III (5hr+2hr+0hr)

Congruence’s, Properties of Congruence’s, System linear Congruence’s

Chinese Remainder Theorem.

Practice -4: Write a program to solves systems of linear congruence.

MODULE – IV (5hr+4hr+0hr)

Wilson's Theorem, Fermat's Little Theorem, Pseudo prime, Carmichael number

Practice -5: Write a program to decide whether an integer is Pseudo prime or not.

Practice -6: Write a program to decide whether an integer is Carmichael number or not

MODULE – V (4hr+6hr+0hr)

Euler's Theorem, Euler Phi-function, Perfect Numbers, Mersenne Primes

Practice -7: Write programs to find values of the Euler phi-function

Practice -8: Write a program to decide whether an integer is Perfect Numbers or not.

Practice -9: Write a program to decide whether an integer is Mersenne prime or not.

MODULE – VI (3hr+2hr+0hr)

Character Ciphers, Block Ciphers, Exponentiation ciphers, Public-Key Cryptography (RSA Cryptosystem).

Practice-10: Write a program for RSA crypto system/Algorithm

MODULE – VII (3hr+0hr+0hr)

Knapsack ciphers, Some applications to computer science.

BOOK PRESCRIBED

1. Elementary Number Theory and lts Applications by Kenneth H. Rosen, ADDISON-WESLEY PUBLISHING COMPANY ISBN 0-201-06561c chapter- 1(1.2-1.5), 2(2.1-2.4), 3,5,6(6.1-6.3),7

BOOKS FOR REFERENCE

1. Elementary Number Theory by David M. Burton, fifth edition, McGraw-Hill Publication, ISBN- 0-07-232569-0
2. A Course in Number Theoretic Cryptography by Neal Koblitz, Springer Verlag, GTM

CUTM1535 ADVANCED COMPLEX ANALYSIS

Subject Name	Code	Type of course	T-P-Pj (Credit)	Prerequisite
ADVANCED COMPLEX ANALYSIS	CUTM1535	Theory & Project	3-0-1	Nil

Objective

- To introduce the concept of residue.
- To know about special functions like Riemann zeta function
- To provide brief idea about Laurent series

Course outcome

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

COs	Course outcomes
CO1	explain basic concept of residue.
CO2	classify different types of real integrals.
CO3	demonstrate Mean-Value Property and Poisson's formula
CO4	use Taylor and Laurent series for expressing analytic functions
CO5	examine the convergence of Riemann Zeta function.

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1			3			2	1			1		2	3	2	3
CO2		2		2	1					2	1	1	3	1	1
CO3	2	2	1	1	1	1	2			1			2	3	2
CO4	2		1								1	3	2	2	2
CO5	2	1		1	2	1	1			1		2	2	3	3

***High-3, Medium-2, Low-1**

CUTM1535 Advanced Complex Analysis (3-0-1)

MODULE – I (3hr+0hr+0hr)

Index of a point with respect to a closed curve, Simply connected region, General statement of Cauchy's theorem.

MODULE – II (4hr+0hr+2hr)

Residue, process for finding out the residues, Residue theorem,the Argument Principle.
PROJECT 1: Study on Residues and their applications.

MODULE – III (5hr+0hr+2hr)

Definite Integrals: Evaluation of definite integrals (Types -1, 2, 3, 4, 5).
PROJECT 2: Evaluation of different types of real definite integrals using Residue theorem.

MODULE – IV (4hr+0hr+2hr)

Harmonic functions, conjugate differential, The Mean-Value Property, Poisson's formula.
PROJECT 3: A study on Harmonic functions.

MODULE – V (6hr+0hr+2hr)

Taylor Series, Taylor's theorem, Laurent series, Laurent's theorem, infinite products, theorems on infinite products.

PROJECT 4: A study on Laurent series expansion of different types of meromerphic functions.

MODULE – VI (3hr+0hr+2hr)

Entire functions: Jensen's formula, Riemann Zeta function, theorem on Riemann Zeta function.

PROJECT 5: A study on Riemann Zeta function and it's properties.

MODULE – VII (6hr+0hr+2hr)

Simply periodic function, Module, Discrete module, Unimodular transformation, Canonical basis, theorem on Canonical basis.

PROJECT 6: A study on discrete modules.

BOOK PRESCRIBED

1. 1 L. V. Ahlfors, "Complex Analysis", McGraw-Hill, Inc.

Chapters: 4 (2.1, 4.2 to 4.5, 5.1 to 5.3, 6.1 to 6.3), 5 (1.2, 1.3, 2.2, 3.1, 4.1), 7 (1.1, 2.1, 2.2,2.3)

CUTM1536 TOPOLOGY

Subject Name	Code	Type of course	T-P-P	Prerequisite
TOPOLOGY	**CUTM1536**	**Theory & Project**	**3-0-1**	**NIL**

Objective

- To introduce elementary properties of topological spaces and structures
- To introduce the student to maps between topological spaces
- To develop the student's ability to handle abstract ideas of Mathematics and Mathematical proofs

Course outcome:

After completion of the course, students will be able to

Cos	Course outcomes
CO1	describe elementary properties of topological spaces and structures
CO2	solve the problems on Countable compact spaces , continuous functions and Homeomorphisoms
CO3	compare To and T1 - spaces and sequence
CO4	implement Urysohn's metrization theorem , Urysohn's Lemma, Metrization, Tietze extension theorem
CO5	execute proves on Metric topology, Metric products, Dense set

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3		3		1	1	1	1				3	3	3	2
CO2	2	2		2			2				1	1	3	1	1
CO3	2		1		3	1	2						2	2	3
CO4		3	1								1	2	2	2	3
CO5	2	1		1	2		1					3	2	3	2

***High-3, Medium-2, Low-1**

Course outline

Module I

Introduction of topological space, Open sets and limit points,Closed sets and closure, Bases and relative topologies

Project 1: Applications of Topology to the Analysis of 1-Dimensional Objects

Project 2: Topologies sequentially equivalent to Kuratowski Painlev´e convergence

Module II

Connected sets and components, compact and Countable compact spaces, continuous functions, Homeomorphisoms

Project 3: Sober topological space

Module III

To-and T1-spaces and sequence, Separation axioms

Module IV

Axioms of count ability, Regular and normal spaces, Completely regular spaces

Project 4: Upper Topology

Module V

Urysohn's metrization theorem , Urysohn's Lemma, Metrization, Tietze extension theorem

Project 5: Scott topology

Project 6: Scott continuity

Module VI

Finite products, product invariant properties, product topology

Module VII

Metric topology, Metric products, Dense set

Text Books

1. W.J. Pervin, Foundations of General Topology, Academic Press. Chapters: 3 (3.1, 3.2 and 3.4), 4(4.1 to 4.4), 5 (5.1 to 5.3, 5.5 and 5.6), 8 (8.1 to 8.4), 10 (10.1only).
2. J. R. Munkres; Topology – A First Course, Prentice Hall of India, 1996.

Reference Book

1. K. D. Joshi, Introduction to General Topology, Wiley Eastern Ltd., 1983.
2. http://mat.uab.cat/ret/sites/default/files/material/otras_contribuciones/Proceedings WI AT10.pdf

CUTM1537 DIFFERENTIAL GEOMETRY

Subject Name	Code	Type of course	T-P-Pj	Prerequisite
DIFFERENTIAL GEOMETRY	**CUTM 1537**	**Theory & Project**	**3-0-1**	**NIL**

Objective

- To introduce the basic ideas and techniques of Differential Geometry for use in many other courses.
- To study about different geometrical skills for figure and their representation in mathematical equations
- To study about notations and operations of Tensor.

Course outcome:

After completion of the course, students will be able to

COs	Course outcomes
CO1	describe equation of normal, binormal and tangent to a curve.
CO2	explain Curvatures and Torsion of curves.
CO3	sketch the shape of geometrical figure from equation.
CO4	differentiate curves of different in nature.
CO5	to distinguish different type of tensor.

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1			3		1	1	1			3		3	3	3	2
CO2		2		2			2			3	1	1	3	1	1
CO3	2		2		1	1	1			3	2	2	2	3	3
CO4	2	3	1			2				3	1	2	2	1	3
CO5	3	2	2	3		2				3	3	2	3	3	3

***High-3, Medium-2, Low-1**

Course outline

Module-I

Introduction to Differential Geometry,Osculating plane and Rectifying Plane

Project 1:.finding the direction of tangent , normal and binormal at any point of curve

Module-II

Curvatures of a curve at a point,Torsion of a curve at a point, Expression of Curvature and Torsion in terms of arc length parameter, Expression of Curvature and Torsion in terms of arbitrary parameter

Project 2: Compute the Curvature of an ellipse.

Module-III

Spherical Indicatrix, Evolutes , Involutes

Project 3: Determine the evolutes of the given curve.

Module-IV

Betrand Curve, Osculating Spheres , Osculating circles.

Project-4 : Show that the tangent to the locus of osculating sphere passes through the centre of the Oscilating Circle.

Module-V

Surface: Tangent planes and Normals, The two fundamental forms

Project 5: Find the normal to a given surface

Module-VI

Tensor : Definitions and explanations,Vector Space,Free systems, Basis and Dimension, Suffix Conventions,Transformation law for change of Basis Vectors and Components ,Dual Spaces

Module-VII

Transformation law for change of Basis in dual Space, Isomorphism, Tensor Product of Vector Spaces, Real Valued Bilinear Functions, Special Tensors

Project-6: Show that the velocity of a fluid at any point is component of a contravariant vector

BOOK PRESCRIBED

1. A text book of vector calculus-Shanti Narayana and J.N.Kapoor Chapters: II and III
2. An Introduction to Differential Geometry by T.G. Willmore-Oxford University Press (1983) Chapters: V

BOOK FOR REFERENCE

1. Differential Geometry-P.P.Gupta,G.S.Malik, S.K.Pundir
2. Tensor Analysis- Edward Nelson(Princeton University Press & University of Tokyo Press),1967
3. Introduction to Tensor Analysis and the Calculus of Moving Surfaces-Pavel Grinfeld, Springer

CUTM1538 ADVANCED ALGEBRA

Subject Name	Code	Type of course	T-P-P(Credit)	Prerequisite
ADVANCED ALGEBRA	**CUTM1538**	**Theory & Project**	**3-0-1**	**Nil**

Objective

- To introduce students to the language and precision of modern algebra. This means that the course will be proof-based, in the sense that students will be expected to understand, construct, and write proofs.
- To balance the understanding with the communication of mathematical statement is true or false.
- To know how to construct a legitimate proof involves different skills and expertise than the discovery part of the process.

Course outcome:

After completion of the course, students will be able to

COs	Course outcomes
CO1	explain about Ring and some special classes of Ring.
CO2	locate and use theorems to solve problems in number theory and theory of polynomials over a field.
CO3	implement Sylow's Theorems
CO4	use field of Quotients and Integral Domain in Ring
CO5	compare linear dependent and independent vectors

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1			2		1		1		1	3	3	2
CO2	2			2	1	2	2				1	1	2	1	3
CO3	3	3	2		2			2				2	2	3	2
CO4	2		2			1					2	2	2	3	3
CO5	1	1		2	2	1	1			1		3	1	2	3

***High-3, Medium-2, Low-1**

Course Outline

CUTM1538 Advanced Algebra (3-0-1)

MODULE – I (6hr+0hr+2hr)

Group Theory: Another Counting Principle, Sylow's Theorems.

Project 1 : A Notes on the Proof of the Sylow Theorem

MODULE – II (6hr+0hr+2hr)

Ring Theory: Introduction to Ring, Some special classes of ring, Ring homomorphisms.

Project 2: A study on ring theory and it's property

MODULE – III (3hr+0hr+2hr)

More Ideals and Quotient Rings, The Field of Quotients of an Integral Domain.

Project 3: The Quotient Field of an Intersection of Integral Domains

MODULE – IV (4hr+0hr+2hr)

Euclidean Rings, A Particular Euclidean Ring, Polynomial Rings.

Project 4: On the Existence of a Euclidean Algorithm in Number Rings with Infinitely Many Units

MODULE – V (4hr+0hr+0hr)

Polynomial Rings over the Rational Field, Polynomial Rings over Commutative Rings.

MODULE – VI (3hr+0hr+2hr)

Fields: Extension Fields, Roots of polynomials

Project 5: A study on Structure of a Finite Field

MODULE – VII (4hr+0hr+2hr)

Vector Spaces: Elementary Basic Concepts of Vector Space, Linear Independence and Basis, Dual Spaces, Inner Product Spaces

Project 6: Notes on dual spaces

BOOK PRESCRIBED

1. Topics in Algebra – I. N. Herstein (John Wiley and Sons or Vikas Publication), 2nd Edition Chapters: 2 (2.11 to 2.12), 3 (3.1 to 3.11), 4 (4.1 to 4.4), 5(5.1 and 5.3)

BOOKS FOR REFERENCE

1. S.Singh and Q. Zameeruddin, Modern Algebra, Vikas Publishing House, 1990
2. P.B. Bhattacharya, S. K. Jain and S. R. Nagpal, Basic Abstract Algebra, Cambridge University Press, 1995.

Data Analysis and Visualization Using Python (70 Hours)

Course Title	Code	Type of course	Credit	T-P-PJ
Data Analysis and Visualization Using Python	**CUTM1018**	**Practice & Project**	**4**	**0-1-3**

Course Description: This course emphasizes the use of tools and techniques to collect, analyze, and interpret data.

Course Objectives:

- Understand how to read, store and display each data type.
- Get skill to quickly and easily draw plot or visualize the information through visualization technique.
- The ability to develop visualization to tell the story.

Course Outcomes (COs):

- **CO1**: Able to gain knowledge on visualization with good story line and perform job of a data analyst. (Understand)
- **CO2**: Able to analyse and visualize the dataset. (Analyze)
- **CO3**: Ability to design dashboard. (Create)
- **CO4**: Analyze Text data and gain insights. (Analyze)
- **CO5**: Select appropriate data visualization technique for given data. (Understand)

CO-PO-PSO Mapping:

CO/PO/PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	-	-	2	2	2	3	3	3
CO2	3	3	3	3	3	-	-	2	2	2	3	3	3
CO3	3	3	3	3	3	-	-	2	2	2	3	3	3
CO4	3	3	3	3	3	-	-	3	2	3	3	3	3
CO5	3	3	3	3	3	-	-	3	2	3	3	3	3

Course Syllabus:

Module 1: STORY BOARD DEVELOPMENT (20 hours)

- The objective and flow of the story to be understood through cases

Module 2: DATA READING USING PYTHON FUNCTIONS (23 hours)

- Python libraries: Pandas, NumPy, Plotly, Matplotlib, Seaborn, Dash
- Data collection from online data sources, Web scrap, and data formats such as HTML, CSV, MS Excel, data compilation, arranging and reading data, data munging

Module 3: DATA VISUALSATION USING PYTHON LIBRARIES (27 hours)

- Different graphs such as Scatterplot, Line chart, Histogram, Bar chart, Bubble chart, Heatmaps etc.
- Dashboard Basics – Layout, Reporting, Infographics, Interactive components, live updating

Projects List:

1. COVID 19
2. World Development Indicators
3. ERP dashboarding
4. Details of Social/ Empowerment schemes of Govt. etc.

References:

- https://www.programmer-books.com/wp-content/uploads/2019/04/Python-for-Data-Analysis-2nd-Edition.pdf
- https://towardsdatascience.com/data-visualization/home

(Domain Courses)
NET Domain

Sl.No	Code	Subject Name	Cerdit	Course Type (Th+Pr+Pj)
1	CUNT2480	Functional Analysis	4	3-0-1
2	CUNT2481	Integral Equation	4	3-0-1
3	CUNT2482	Advanced Calculus	4	3-0-1
4	CUNT2483	Operation Research	4	3-0-1
5	CUNT2484	Descriptive statistics & Data analysis	4	3-0-1
		Total	20	

CUNT2480 Functional Analysis

Subject Name	Code	Type of course	T-P-Pj (Credit)	Prerequisite
FUNCTIONAL ANALYSIS	**CUNT2480**	**Theory & Project**	**3-0-1**	**Nil**

Objective

- To introduce different analytical structures, concepts and Theorems.
- To enable students to solve problems involving linearly independent and dependent sets and basis.
- To emphasis not only on finding explicit solutions to specific problems, but also on determining which problems can be solved and what general properties solutions may share.

Course Outcome

After completion of the course, students will be able to

COs	Course outcomes
CO1	Describe fundamental concepts like linear space, linear map, and Continuous map.
CO2	Explain the terms like dimension, basis, compactness, normed space.
CO3	Solve problems involving linearly independent and dependent sets, basis.
CO4	Examine bounded linear maps, Lp spaces.
CO5	Compare Sequence spaces, Lp space, Function spaces and Inner product spaces.

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	3		2			2	3	2	3	2	3	2
CO2	3	2	1	3		2			2	3	2	2	2	3	2
CO3	3	3	2	2	2	1			2	2	3	2	3	2	1
CO4	3	3	2	2	2	1			2	3	2	3	2	3	2
CO5	3	2	1	3		2			2	3	2	2	2	2	2

***High-3, Medium-2, Low-1**

Course outline

CUNT2480 Functional Analysis

MODULE-I

Linear space, Hamel basis, Span of a linear space, Quotient space, Product space.

Project-1: A study on Linear spaces.

MODULE -II

Linear map, Range space, Zero space, Hyperspace, Linear maps on finite dimensional linear spaces.

Project-2: A study on Linear maps.

MODULE – III

Compactness, Some fundamental theorems regarding compactness.

Project-3: A study on Compactness.

MODULE – IV

Normed space, Euclidian norm, Sequence spaces, Lp space, Function spaces, Inner product spaces.

Project-4: A study on Normed spaces.

MODULE – V

Quotient norm, Riesz Lemma, Some theorems regarding normed spaces.

MODULE – VI

Continuity of linear maps, Complete space, Some fundamental theorems.

Project-5: A study on Continuous linear maps.

MODULE – VII

Bounded Linear maps, Some fundamental theorems,

Project-6: A study on Bounded Linear maps.

BOOK PRESCRIBED

1. Functional Analysis—B. V. Limayee (New Age— International Limited, Publishers, Second Edition)
2. Chapters: 2, 2.1, 2.2, 2.3, 2.4, 2.5, 3.5, 3.6, 3.7, 5, 5.1, 5.2, 5.3, 5.4, 6, 6.1, 6.2, 6.3, 6.6, 6.7, 6.8.

CUNT2481 INTEGRAL EQUATION

Subject Name	Code	Type of course	T-P-Pj (Credit)	Prerequisite
INTEGRAL EQUATION	**CUNT2481**	**Theory & Project**	**3-0-1**	**Nil**

- To identify different type of Integral equations.
- To solve different type of Boundary value problems of Integral Equations in nature.
- To convert differential equations into Integral equations.

Objective

Course Outcome

After completion of the course, students will be able to

COs	Course outcomes
CO1	Classify the integral equations.
CO2	Explain conversion of multiple integrals into single ordinary integral
CO3	Solve Integral equations of different types
CO4	Differentiate the solution of homogeneous and non-homogeneous Integral Equations
CO5	Evaluate Volterra Integral Equation of the Second Kind

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1	3	3	1					2	3	1	1
CO2	2	2	1	2	3						1	1	2	1	2

CO3	**3**	**2**	**1**	**2**	**1**	**1**	**2**					**3**	**2**	**1**	**2**
CO4	**2**	**1**	**1**	**1**	**1**	**1**						**2**	**3**	**1**	**2**
CO5	**2**	**1**		**1**	**2**	**1**	**1**					**1**	**3**	**1**	**2**

***High-3, Medium-2, Low-1**

<u>Course outline</u>

INTEGRAL EQUATION

MODULE– I

Introduction, Definitions of Integral Equation, Linear, Non Linear Equations ,Fredholm Integral Equation, Volterra Integral Equation, Singular Integral Equation, Special Kinds of Kernels, Integral equations of Convolution type, Iterated Kernel sand Resolvent Kernel.

Project 1: Prepare a detail report of different kind of Integral Equations.

MODULE-II

Eigen values, Leibnitz's rule of differentiation under integral sign, Formula for converting multiple integrals into single ordinary integral, Regularity conditions, Inner product of two functions, Definition and some simple examples of Solution of Integral Equations.

Project 2: Prepare a report on Leibnitz's rule of differentiation under integral sign and Formula for converting multiple integral into single ordinary integral.

MODULE-III

Conversion of Ordinary differential equations into integral equations.

Project 3: Prepare a report on advantages of Conversion of Ordinary differential equations into integral equations

MODULE-IV

Homogeneous Fredholm Integral Equations of the Second kind with Separable Kernels.

Project-4: Prepare a report on advantages of Fredholm Integral Equations of the Second kind.

MODULE-V

Fredholm Integral Equations of the Second kind with Separable Kernels.

MODULE-VI

Method of Successive approximations: Concepts, Solution of Fredholm Integral Equation of the Second Kind by Successive Substitutions.

Project 5: Prepare a report on Solution of Fredholm Integral Equation of the Second Kind by Successive Substitutions.

MODULE-VII

Solution of Volterra Integral Equation of the Second Kind by Successive Substitutions.

Project-6: Prepare a report on Solution of Volterra Integral Equation of the Second Kind by Successive Substitutions

BOOK PRESCRIBED

1. Integral Equations and Boundary Value Problems by M.D. Raisinghania, S.Chand & Company pvt Ltd. Ch-1, Ch-2, Ch-3, Ch-4 Ch-5 (5.1-5.7)

BOOK FOR REFERENCE

1. Introduction to Integral Equations with Applications , A.J. Jerri, Wiley-Interscience Publication,1999
2. Linear Integral Equations, W.V Lovitt, McGraw Hill, New York

CUNT2482 ADVANCED CALCULUS

Subject Name	Code	Type of course	T-P-Pj (Credit)	Prerequisite
ADVANCED CALCULUS	**CUNT2482**	**Theory+ Project**	**3-0-1**	**Nil**

Objective

- To study about Taylor'stheorem. It provides a framework for application of Taylor's theorem in problems
- To construct an over view on Green, Gauss & Stokes Theorem
- To familiarize on Differentiation of Transformations

Course Outcome

After completion of the course, students will be able to

COs	Course outcomes
CO1	describe derivatives of functions on R^n, Differentiation of composite functions, Taylor'stheorem.
CO2	solve problems related to theorems on Green, Gauss & Stokes.
CO3	*discuss problems on differentiation of transformations, Linear functions and transformations.*
CO4	implement the major problems on Power Series, Improper integrals with parameters.
CO5	experiment other important classes of functions such as Gamma Function. Beta Function

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3		3	3	1					2	2	3	1
CO2	2	2		2	3						1	1	1	1	2

CO3	**2**	**2**	**1**		**1**	**1**	**2**					**3**	**2**	**3**	**2**
CO4	**2**		**1**	**1**		**3**						**2**	**3**	**1**	**2**
CO5	**2**	**1**		**1**	**2**	**1**	**1**					**1**	**3**	**3**	**2**

***High-3, Medium-2, Low-1**

Course outline

ADVANCED CALCULUS

MODULE– I

Derivatives of functions on R^n, Differentiation of composite functions, Taylor's theorem, Differential forms.

Project 1: A brief report on Taylor's Theorem.

MODULE– II

Theorems of Green, Gauss & Stokes,

Project 2: An over view on Green, Gauss & Stokes Theorem.

MODULE– III

Differentiation of Transformations, Linear functions and Transformations, Differential and Transformations.

MODULE– IV

Inverse of Transformations, Implicit function Theorems, Functional Dependence.

Project 3: A project report on Implicit function Theorem.

MODULE– V

Set functions, Transformations and Multiple integrals, curves and Arc Length.

Project 4: A discussion on curves and Arc length

MODULE– VI

Surfaces and surface area, integrals over curves and surfaces.

Project 5:A note on integrals over curves.

MODULE– VII

Power Series, Improper integrals with parameters, The Gamma Function.

Project 6:A brief report on Gamma function.

BOOK PRESCRIBED

1. Advanced calculus – R. C. Buck (Mc. Graw hill– Kogakusha Ltd.)Chapters:3 (3.3, 3.4, 3.5), 6 (6.3,6.4),7,8, 9 (9.2, 9.4, 9.5)

CUNT2483 OPERATION RESEARCH

Subject Name	Code	Type of course	T-P-P (Credit)	Prerequisite
OPERATION RESEARCH	**CUNT2483**	**Theory & Project**	**3-0-1**	**Nil**

Objective:

- To demonstrate the utilization of Linear Programming Problems in industry and business.
- To apply the inventory control techniques in real-life application problems.
- To apply queuing model to find the optimum service rate and to minimize the number of servers.

Course outcome

After completion of the course, students will be able to

Cos	Course outcomes
CO1	Explain the concept of extreme values of some real-world objective: the maximum (of profit, performance, or yield) or minimum (of loss, risk, or cost).
CO2	Solve the necessary and sufficient optimality conditions for linear programming and demonstrate the geometrical interpretation of these conditions.
CO3	Use of duality theory to solve the real-life application problems by reducing the large number of constraints.
CO4	Justify various techniques to solve basic inventory problems.
CO5	Validate various techniques to solve basic queuing theory problems.

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	3		3	3	1					2	2	3	1
CO2	2	2		2	3						1	1	1	1	2
CO3	2	2	1		1	1	2					3	2	3	2
CO4	2		1	1		3						2	3	1	2
CO5	2	1		1	2	1	1					1	3	3	2

***High-3, Medium-2, Low-1**

Course Outline

Module-I:

Linear programming problem & Simplex method: Introduction to linear programming problem, Formulation of linear programming problem, Graphical solution of linear programming problem, Solution of linear programming problem using simplex method, Artificial variables, Solution of linear programming problem using Big-M and two-phase method

Module -II:

Duality in Linear Programming: Introduction, General primal-dual pair, formulating primal-dual problem, Duality in simplex method, Dual simplex method.

Module – III:

Inventory Controls: Introduction, Inventory decision, Cost associate with inventories, Factor affecting inventory control, Economic order quantity (EOQ).

Module - IV:

Deterministic inventory problem with no shortages, Deterministic inventory problem with shortages, Economic order quantity (EOQ) problem with price breaks.

Module – V:

Elementary queuing theory: Introduction, Queuing system, Elements of queuing system, Operating characteristics of queuing system.

Module – VI:

Probability distribution in queuing systems, Classification of queuing models, Definition of transient and steady state.

Module – VII:

Steady-state solutions of Markovian queuing models: M/M/1, M/M/1 with limited waiting space, M/M/C, M/M/C with limited waiting space, M/G/1.

Projects:

1. Project on Inventory management system
2. Project on queuing theory

Text Books:

1. Kanti Swarup, P.K. Gupta and Man Mohan-Operations Research, S. Chand and Co. Pvt. Ltd.
2. Engineering Optimization Theory and Practice by Singiresu S. Rao, JOHN WILEY & SONS, INC., Fourth Edition

Reference Book:

1. Mathematical Programming by N. S. Kambo, East West Press.

CUNT2484 DESCRIPTIVE STATISTICS & DATA ANALYSIS

Subject Name	Code	Type of course	T-P-P (Credit)	Prerequisite
DESCRIPTIVE STATISTICS & DATA ANALYSIS	**CUNT2484**	**Theory & Project**	**3-0-1**	**Nil**

Objective:

- To familiarize students with the fundamental concepts and techniques of probability theory and statistical analysis.
- To provide mathematical concepts and build strong mathematical foundations to support data science algorithms.
- To build-up a hypothetical model and validate through different techniques.

Learning Outcome:

After completion of the course, students will be able to

Cos	Course outcomes
CO1	explain the concepts of sampling which can apply to business decision
CO2	apply the concepts of discrete and continuous probability distributions to make the prediction to the real-life application
CO3	solve the problems based on practical situations using the Binomial, Poisson and Normal distributions.
CO4	analyze the multivariate data through ANOVA and Co-ANOVA
CO5	develop the feature reduction techniques principle component analysis, discriminant analysis, cluster analysis for prediction analysis for data science algorithm

Course Outcome to Program Outcome Mapping:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	3		3	3	1					2	2	3	1
CO2	2	2		2	3						1	1	1	1	2
CO3	2	2	1		1	1	2					3	2	3	2
CO4	2		1	1		3						2	3	1	2
CO5	2	1		1	2	1	1					1	3	3	2

***High-3, Medium-2, Low-1**

Course Outline

Module:1

Random variables and distributions functions (univariate and multivariate); Expectations and moments. Marginal and conditional distributions. Characteristic functions.

Module:2:
Standard discrete and continuous univariate distributions.Sampling distributions, Standard errors and asymptotic distributions, Distributions of order statistics and range.

Module:3
Simple non-parametric tests for one and two sample problems, Rank correlation and test for independence.

Module:4
Analysis of variance and covariance. Fixed, random and mixed effects models. Simple and multiple linear regression, Logistic regression.

Module:5
Multivariate normal distribution, Wishart distribution and their properties. Distributions of quadratic forms. Inference for parameters.

Module:6

Data reduction techniques: Principle component analysis, Discriminant analysis, Cluster analysis.

Module:7

Simple random sampling, stratified sampling and systematic sampling. Probability proportional to size sampling.

Projects:

1. Prepare a report on Gauss Markov models.
2. Prepare a report on correlation and regression analysis.

Text Book:

1. Irwin Miller and Marylees Miller, John E. Freund, Mathematical Statistics with Applications, 7th Ed., Pearson Education, Asia, 2006.
2. Sheldon Ross, Introduction to Probability Models, 9th Ed., Academic Press, Indian Reprint, 2007.
3. Devore, J. L.: Probability & Statistics for Engineering and the Sciences, 8th edition, Cengage Learning, 2012.

Reference Book:

1. Milton, J. S. and Arnold J. C.: Introduction to Probability and Statistics: Principles and Applications for Engineering and the Computing Sciences, 4th edition, Tata McGraw-Hill, 2007.
2. Johnson, R. A., Miller: Freund's Probability and Statistics for Engineers, 8th edition, PHI, 2010.

3. Meyer, P.L.: Introductory Probability and Statistical Applications, 2nd edition, Addison Wesley, 1970.
Ross, S. M.: Introduction to Probability Models, 11th edition, Academic Press, 2014.

Syllabus: Scientific Computing using MATLAB

Course Code:

CUTM4527

Semester:

Target Audience: M.Sc. (Physics, Chemistry, Mathematics)

Credits: 1-2-1 (T-P-P: 1 Theory, 2 Practice, 1 Project)

Contact Hours: 12 Theory, 22 Practice, 11 Project Sessions

- Course Objectives

This course aims to equip postgraduate students in the physical and mathematical sciences with essential computational skills using the MATLAB environment. The primary objective is to empower students to apply numerical methods and data analysis techniques to solve complex scientific problems, visualize results effectively, and automate research tasks. By the end of the course, students will be proficient in using MATLAB as a powerful tool for computation, modeling, and analysis, including an introduction to its machine learning capabilities.

- 2. Learning Outcomes

Upon successful completion of this course, students will be able to:

  - Navigate and utilize the MATLAB Integrated Development Environment (IDE) with confidence.
  - Develop and debug structured programs using MATLAB scripts and functions.
  - Implement fundamental numerical algorithms to solve scientific problems (e.g., solving systems of equations, ODEs, and data interpolation).
  - Process, analyze, and visualize scientific data to extract meaningful insights and create publication-quality graphics.
  - Apply basic signal, image, and machine learning techniques to relevant datasets using MATLAB toolboxes.
  - Independently design and execute a computational project from problem formulation to final presentation.

- Prerequisites
- Undergraduate-level knowledge of mathematics, particularly linear algebra and calculus.

4. Course Structure and Session Distribution

Module	Module Title	Theory Sessions	Practice Sessions	Project Sessions
1	Introduction to the MATLAB Environment	2	4	0
2	Programming Fundamentals in MATLAB	2	4	0
3	Data Handling, Analysis, and Visualization	1	4	0
4	Numerical Methods for Scientists	3	4	0
5	Introduction to Signal and Image Processing	1	3	0
6	Machine Learning using MATLAB	3	3	1
7	Project Work and Advanced Topics	0	0	10
	Total	12	22	11

Module 1: Introduction to the MATLAB Environment

- Theory: MATLAB IDE (Command Window, Workspace, Editor, Help Browser), basic syntax, defining variables. [2 Hours]
- Practice Sessions (1-4):
    1. Aim: To familiarize with the MATLAB IDE by calculating the energy of a photon using Planck's equation (E=hν). [1 Hour]
    2. Aim: To create and manipulate vectors representing position in 3D space (Physics) and matrices for linear transformations. [1 Hour]
    3. Aim: To understand element-wise operations for stoichiometric calculations in a chemical reaction. [1 Hour]
    4. Aim: To generate and customize a 2D plot of a projectile's trajectory. [1

Hour] Module 2: Programming Fundamentals in MATLAB

- Theory: Script files vs. functions, function definition and calling, control flow (if-elseif- else, switch), loops (for, while), logical operators. [2 Hours]
- Practice Sessions (5-8):
- 5. Aim: To write a user-defined function to calculate the pH from a given hydrogen ion concentration. [1 Hour]
- 6. Aim: To implement control flow to determine the phase of water (solid, liquid, gas) based on temperature and pressure inputs. [1 Hour]

- 7. Aim: To use a for loop to calculate the terms of a Taylor series expansion for a function like sin(x) [1 Hour]
- 8. Aim: To use a struct to store properties of chemical elements (e.g., name, symbol, atomic number, mass) [1 Hour].

Module 3: Data Handling, Analysis, and Visualization

- Theory: Importing and exporting data (CSV, TXT, Excel), data types, descriptive statistics. [1 Hour]
- Practice Sessions (9-12):
- 9. Aim: To import experimental data from a spectrometer (.csv file) into the MATLAB workspace. [1 Hour]
- 10. Aim: To perform descriptive statistical analysis (mean, median, standard deviation) on a set of experimental measurements. [1 Hour]
- 11. Aim: To create a semi-log plot to analyze first-order reaction kinetics (Chemistry). [1 Hour]
- 12. Aim: To generate a 3D surface plot to visualize an electric potential field or a mathematical function $z = f(x,y)$ [1 Hour].

Module 4: Numerical Methods for Scientists

- Theory: Solving systems of linear equations, polynomial interpolation and curve fitting, concepts of numerical integration and differentiation, introduction to Ordinary Differential Equations (ODEs). [3 Hours]
- Practice Sessions (13-16):
- 13. Aim: To solve a system of linear equations representing Kirchhoff's laws for an electrical circuit. [1 Hour]
- 14. Aim: To perform a polynomial curve fit for a Beer-Lambert law calibration curve. [1 Hour]
- 15. Aim: To compute the numerical integral of a Gaussian function to find the area under the curve. [1 Hour]
- 16. Aim: To solve the ODE for radioactive decay of an isotope using ode45 [1 Hour].

Module 5: Introduction to Signal and Image Processing

- Theory: Concepts of frequency domain, Fast Fourier Transform (FFT), basic digital filtering. Fundamentals of digital images. [2 Hours]
- Practice Sessions (17-19):
- 17. Aim: To analyze a noisy signal from an instrument by computing its Fast Fourier Transform (FFT) to identify primary frequencies [1 Hour].
- 18. Aim: To read, display, and crop a micrograph image (e.g., from SEM or AFM) of a nanostructured surface. [1 Hour]
- 19. Aim: To enhance a micrograph image by applying spatial filters for noise

reduction and edge detection to better visualize surface features. [1 Hour]

Module 6: Machine Learning using MATLAB

- Theory: Overview of Machine Learning (ML), supervised vs. unsupervised learning, concepts of classification, regression, and clustering. [3 Hours]
- Practice Sessions (20-22):
- 20. Aim: To use the Classification Learner App to classify chemical compounds based on their spectroscopic data. [1 Hour]
- 21. Aim: To use k-means clustering to group particles based on size and shape from image analysis data. [1 Hour]
- 22. Aim: To build a regression model to predict a material's property (e.g., band gap) based on experimental parameters. [1 Hour]

Module 7: Project Work and Advanced Topics

- Theory: Introduction to Symbolic Math Toolbox, principles of parallel computing in MATLAB (parfor). [1 Hour]
- Practice & Project: Students will work on a semester-long project relevant to their domain. Sessions will be dedicated to project brainstorming, development, debugging, and final presentations. [10 Hour Sessions]

7. Recommended Books and Resources

1. Textbooks:
    - *Turk, Irfan. Practical MATLAB. Berkeley, CA, USA: Apress, 2019.*
    - *Xue, D. and Chen, Y., 2018. Scientific computing with MATLAB. Chapman and Hall/CRC.*
    - *Paluszek, M. and Thomas, S., 2016. MATLAB machine learning. Apress.*
2. Online Resources:
    - MathWorks Official Documentation: https://www.mathworks.com/help/matlab/
    - MathWorks Onramp (Free interactive tutorial).
    - Coursera / edX courses on MATLAB.