



**Centurion**  
**UNIVERSITY**  
*Shaping Lives...  
Empowering Communities...*

**M.Sc.**

# **Applied Mathematics Syllabus**

**(Two Years Programme)**

## **School of Applied Sciences**

### **Centurion University of Technology & Management**

# **2022**

## DEPARTMENT OF MATHEMATICS

### Course Structure (Core Courses)

Sl.No	Code	Subject Name	Cerdit	Course Type (Th+Pr+Pj)
1	CUTM1525	Heat and Mass Transfer	4	2+1+1
2	CUTM1526	Numerical Methods for CFD	4	2+1+1
3	CUTM1527	Fluid Dynamics	4	3+1+0
4	CUTM2380	Grid Generation and CFD Simulation using Simulia	4	0+2+2
5	CUTM1530	Advanced Differential Equations	4	2+1+1
6	CUTM1531	Graph Theory	4	3+1+0
7	CUTM1532	Optimization Techniques	4	3+1+0
8	CUTM1533	Advanced Statistical Methods	4	2+1+1
9	CUTM1534	Applied Number Theory	4	3+1+0
10	CUTM1535	Advanced complex analysis	4	3+0+1
11	CUTM1536	Topology	4	3+0+1
12	CUTM1537	Differential Geometry and Tensor Calculus	4	3+0+1
13	CUTM1538	Advanced Algebra	4	3+0+1
14	CUTM1018	Data Analysis and Visualisation using Python	4	0+1+3
15	CUTM1019	Machine Learning using Python	4	1+2+1
16	CUTM2378	Research Methodology IPR	4	2+0+2
<b>Total</b>			<b>64</b>	



## HEAT AND MASS TRANSFER

Subject Name	Code	Type of course	T-P-Pj (Credit)	Prerequisite
HEAT AND MASS TRANSFER	CUTM1525	Theory + Practice + Project	2-1-1	Nil

### Objective

- To understand the basic concepts and mechanisms of heat and mass transfer under steady state and transient conditions.

### Course Outcome

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

- Apply heat conduction equations to different surface configurations under steady state and transient conditions and solve problems.
- Apply free and forced convective heat transfer correlations to internal and external flows through/over various surface configurations and solve problems.
- Explain basic laws for radiation and apply these principles to radiative heat transfer between different types of surfaces to solve problems.
- Apply diffusive and convective mass transfer equations and correlations to solve problems for different applications.

### Module I

(T-3 Hrs.+P-2Hrs.)

Conduction:

Fourier's Law of Conduction, General Heat Conduction Equation in Different Coordinate Systems (No Derivation), One Dimensional Steady State Conduction in Plane Wall, Composite Wall, One Dimensional Steady State Conduction in Composite Cylinders and Composite Spheres with Convective Atmosphere. Electrical Analogy, Conduction with Internal Heat Generation.

**Practice 1:** To find the thermal conductivity of a material by the two slabs guarded hot plate method.

**Project 1:** Assignment on Conduction.

## **Module II**

**(T-2 Hrs.+P-2Hrs.)**

Fins and Transient Conduction:

Overall Heat Transfer Coefficients, Critical Thickness of Insulation, Heat Transfer from Extended Surfaces, Effectiveness and Efficiency, Unsteady State Heat Conduction, Lumped Heat Capacity System and Lumped Capacitance Method.

**Practice 2:** To find the thermal resistance of the sample.

**Project 2:** Assignment on Fins and Transient Conduction.

## **Module III**

**(T-4 Hrs.+P-4Hrs.)**

Convection:

Hydrodynamic and Thermal Boundary Layer, Principles and Governing Equations, Forced Convection: External Flow over a Flat Plate, Cylinder, Sphere and Non-Circular Ducts, Use of Empirical Relations, Internal Flow Through Pipe, Annular Spaces and Non-Circular Conduits, Natural Convection: Vertical, Horizontal, Inclined Surfaces.

**Practice 3:** To determine the overall heat transfer coefficient at the surface of a given vertical metal cylinder by the natural convection method.

**Practice 4:** To verify Newton's Law of Cooling of different materials and different liquids.

**Project 3:** Assignment on Convection.

## **Module IV**

**(T-2 Hrs.+P-2Hrs.)**

Heat Transfer with Phase Change:

Film Wise and Drop Wise Condensation, Boiling Heat Transfer, Regimes of Boiling.

## **Module V**

**(T-2 Hrs.+P-2Hrs.)**

Heat Exchangers:

Types of Heat Exchangers, Heat Exchanger Analysis, LMTD, Overall Heat Transfer Coefficient, Heat Exchanger Effectiveness, NTU.

**Practice 5:** Determination of Effectiveness and Efficiency of Parallel Flow and Counter Flow Heat Exchanger.

**Project 4:** Assignment on Heat Exchangers.

## **Module VI**

**(T-4 Hrs.+P-2Hrs.)**

Radiation:

Electromagnetic Spectrum, Black Body Emission, Emissive Power, Laws of Radiation, Nature of Black and Grey Bodies, Concepts, Radiation Shape Factor, Thermal Resistance and Electrical Analogy, Radiation Heat Transfer Between Two Surfaces, Reradiating Surface, Radiation Shield.

**Practice 6:** To find the emissivity of different material surface.

**Project 5:** Assignment on Radiation.

## **Module VII (T-3 Hrs.+P-2Hrs.)**

Mass Transfer:

Introduction, Analogy between heat and mass transfer, Mass diffusion, Fick's law of diffusion, boundary conditions, Steady mass diffusion through a wall, Mass convection.

**Project 6:** Assignment on Mass Transfer.

### **Text Books:**

1. Mahesh M. Rathore, Engineering Heat Transfer , Jones & Bartlett Learning, 2011
2. Yunus A. Cengel&Afshin J. Ghajar, "Heat and Mass Transfer-Fundamentals and Applications", McGraw Hill, 5th Edition 2015
3. YunusCengel, Heat And Mass Transfer: Fundamentals And Applications, McGraw-Hill Higher Education, 2014

### **Reference Books:**

1. R.C Sachdeva, Fundamentals of Heat and Mass Transfer
2. R.K. Rajput, Heat Transfer, Laxmi Publication

## 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 learn fundamentals of computational methods like FDM and FVM for solving linear and non-linear partial differential equations related to fluid dynamics and heat transfer.

### Course Outcome

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

- Assess the principles of numerical analysis and concepts of consistency, stability, and convergence.
- Evaluate finite difference/volume schemes on model problems of computational fluid dynamics.
- Construct program-code using Python to obtain numerical solutions of partial differential equations, relevant to Computational Fluid Dynamics.

### 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 1<sup>st</sup> and 2<sup>nd</sup> 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

**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 1<sup>st</sup> & 2<sup>nd</sup> Problems.

Hyperbolic PDE: One-dimensional wave equation

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

**Practice 5:** Solution of Laplace's equation using Python.

**Practice 6:** Solution of Unsteady heat conduction using Python.

**Practice 7:** Solution of One-dimensional wave equation using Python.

**Practice 8:** 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 of 1-D steady state Diffusion equation.

## MODULE VII

**Application of FVM:** Solutions of 2-D steady state Diffusion and Convection equations.

**Project 6:** Solutions of 2-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 HK Versteeg and W Malalasekera, Chapter 4,5

## FLUID DYNAMICS

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

### Objective

- To introduce the foundations of fluid dynamics, various formulations of governing equations and their mathematical properties in order to establish a firm basis for other modules.

### Course Outcome

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

- Distinguish and analyse the governing equations of fluid dynamics in various formulations for compressible and incompressible viscous and inviscid flows.
- Estimate the impact of different physical phenomena based on dimensional analysis.
- Examine mathematical properties of governing equations and be able to critically evaluate correct boundary/initial value problems for various flows.

### 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, Inviscid 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 annulus).

**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, "Viscous 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/>

**GRID GENERATION AND CFD SIMULATION USING SIMULIA**

<b>Subject Name</b>	<b>Code</b>	<b>Type of course</b>	<b>T-P-P(Credit)</b>	<b>Prerequisite</b>
<b>GRID GENERATION AND CFD SIMULATION USING SIMULIA</b>	<b>CUTM2380</b>	<b>Practice + Project</b>	<b>0-2-2</b>	<b>Nil</b>

### **Objective**

- To introduce the concepts of grid generation required for Computational Fluid Dynamics applications providing hands-on experience using Simulia.
- To produce a CFD simulation in order to generate an exact picture of a particular flow problem in various engineering fields.
- To apply for resolving different fluid flow related problems like flow velocity, density, temperature, and chemical concentrations for any area where flow is present.

### **Course Outcome**

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

- Evaluate the requirements of grid generation for Computational Fluid Dynamics applications.
- Understand the construction techniques of grids using Simulia.
- To apply CFD simulation in various industries in order to achieve flawless product designs using computational tools.

## **Course Outline**

### **Grid Generation & CFD Simulation using Simulia(0-2-2)**

**Practice: 2Hrs.**

**Project: 4Hrs.**

**Practice 1.**Getting Started with the 3D Experience Platform.

**Practice 2.**CFD analysis of steady-state internal Laminar Pipe flow.

**Practice 3.**Grid generation for pipe at  $Re=500$ .

**Project 1.**Analysis of pipe flow at  $Re= 500$ .

**Practice 4.**3D Coarse/ Medium/ Fine unstructured mesh for Aerofoil.

**Practice 5.**CFD analysis Steady-state external flow over an Airfoil.

**Project 2.**Estimation of Drag and lift coefficients in the flat plate at  $Re=10,000$ .

**Practice 6.** Grid Independence study for the above cases (pipe/airfoil) using different solver schemes.

**Practice 7.**Generation of 3D mapped meshing for Cylinder.

**Project 3.**Flow analysis over a circular cylinder at  $Re=10^7$ .

**Practice 8.**Grid generation for cross flow heat exchanger.

**Project 4.** Temperature analysis through cross-flow heat exchanger.

**Practice 9.** Generation of 3D Mesh for Ahmed Body.

**Project 5.** Turbulent analysis of Ahmed body.

**Practice10.** Grid generation for turbulent flow turbine blade

**Project 6.** Flow Analysis in the Turbine Blade.

**Practice 11.**Generation of 3D Sweep mesh for U-Bend Pipe.

**Practice12.** Post processing results for above studies.

## ADVANCED DIFFERENTIAL EQUATIONS

Subject Name	Code	Type of course	T-P-Pj	Prerequisite
<b>ADVANCED DIFFERENTIAL EQUATIONS</b>	<b>CUTM1530</b>	<b>Theory+Practice+ Project</b>	<b>2-1-1</b>	

### Objective

- Working with systems of ordinary differential equations and non-linear ordinary differential equations is also stressed.
- Developing and understanding and appreciation of the qualitative behaviour of the solution
- To introduce wave equations, Laplace equations, Heat equations, Diffusion equations.

### Course Outcome

- After successfully completing this course the expectation is that students will be able to:
1. Solve wave equation and understand significance of transverse waves.
  2. Identify classes of non-linear ordinary differential equations.
  3. Apply an appropriate method for the solution of non-linear ordinary differential equations.
  4. Solve the problems choosing the most suitable method.
  5. Solve Laplace equation, Diffusion equation, heat equation
  5. Competence in solving applied problems which are linear and nonlinear form.

### 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

$$u(x,0)=\varphi(x),u_t(x,0)=\psi(x),u(0,t)=0,x\in(0,\infty),t>0$$

Practice 4: Solution of wave equation associated condition

$$u(x,0)=\varphi(x),u(0,t)=a,x\in(0,\infty),t\geq 0$$

#### **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

$$u(x,0)=\varphi(x),u(0,t)=a,x\in(0,\infty),t\geq 0$$

**Practice 6:** Solution of one-dimensional diffusion equation

$$u(x,0)=\varphi(x),u(0,t)=a,u(1,t)=b,0<x<1$$

#### **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).

2. S. L. Ross: *Differential Equations*, Blaisdell Publishing Company, London, 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. Sundarandian: *Ordinary and Partial Differential Equations*, McGraw-Hill

## GRAPH THEORY

Subject Name	Code	Type of course	T-P-Pj (Credit)	Prerequisite
GRAPH THEORY	CUTM-1531	Theory	3-1-0	Nil

### Objective:

- To introduce the students to graphs, their properties and their applications as models of networks.
- To represent almost any physical situation involving discrete objects and a relationship among them.
- To introduce the students to generating functions and their applications.

### Course Outcome:

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

- Know the basic definitions and concepts of graph theory and Write in a coherent and technically accurate manner.
- Learn about how to develop graph theoretical algorithm and Know about many different coloring problems for graphs.

## Course Outline

### Module-I

Introduction to Graphs and Definition of graphs;Basic terminologies and types of graphs;Degree of a vertex,Isolated and Pendent vertices;Sub graphs 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-Bruijn 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 Chromatic 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

## OPTIMIZATION TECHNIQUES

Subject Name	Code	Type of Course	T-P-Pj (Credit)	Prerequisite
<b>OPTIMIZATION TECHNIQUES</b>	<b>CUTM1532</b>	<b>T + P</b>	<b>3-1-0</b>	<b>Nil</b>

### 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 demonstration of the utilization of Non Linear Programming Problems in industry and business.
- To apply the evolutionary optimization techniques in machine learning prediction model
- To solve the case study related to strategic management

### Course Outcome

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

- Formulate the necessary and sufficient optimality conditions for Non linear programming and demonstrate the geometrical interpretation of these conditions.
- Use Evolutionary optimization techniques to optimize the forecasting models in machine learning.
- Use the optimization techniques learned in this course to formulate new applications as optimal decision problems and seek appropriate solutions algorithms.

### Course Outline

#### 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:**

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

## ADVANCED STATISTICAL METHODS

Code	Course Title	T-P-Pj (Credit)	Prerequisite
CUTM1533	ADVANCED STATISTICAL METHODS	2-1-1	NIL

### Objective

- Ability to summarize and present data numerically and visually.
- Knowledge of which statistical methods to use in which situations
- Ability to think critically about data-based claims and quantitative arguments.
- Ability to learn new statistical analysis techniques on your own.

### Course Outcome

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

- Apply statistical methods and hypothesis testing to business problems
- Learn the details and complexities of Analysis of Variance (ANOVA)
- Understand Chi Squared Tests
- Learn some of the details and complexities of Multiple Regression (MR)
- Understand different types of data

### 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

## APPLIED NUMBER THEORY

Subject Name	Code	Type of course	T-P-Pj (Credit)	Prerequisite
APPLIED NUMBER THEORY	CUTM1534	Theory	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.
- Enhance and reinforce the student's understanding of concepts through the use of technology when appropriate

### Course Outcome

Upon successful completion of this course a students will:

- Demonstrate knowledge and understanding of topics including applications.
- Learn methods and techniques used in number theory.
- Use mathematical induction and other types of proof writing techniques and programming to compute number theoretic problems.

## Course Outline

### CUTMAPPLIED 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, Modified 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+0hr+0hr)

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

**MODULE – V** (4hr+2hr+0hr)

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

Practice -5: Write programs to find values of the Euler phi-function

**MODULE – VI** (3hr+2hr+0hr)

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

Practice-6: 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 Its 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

## ADVANCED COMPLEX ANALYSIS

Subject Name	Code	Type of course	T-P-Pj (Credit)	Prerequisite
<b>ADVANCED COMPLEX ANALYSIS</b>	<b>CUTM1535</b>	<b>Theory</b>	<b>3-0-1</b>	<b>Nil</b>

### Objective

- To understand the applications of Residue for evaluation of definite and improper integrals occurring in Real analysis and Applied mathematics.
- To know about special functions like Riemann zeta function which plays a pivotal role in analytic number theory and has applications in physics, probability theory, and applied statistics.

### Course Outcome

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

- Get a deep understanding of the fundamental concepts of Residues, Laurent series, Harmonic and Periodic functions.
- Evaluate definite and improper real integrals applying the Cauchy's Residue Theorem.

### 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 meromorphic 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 its 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 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)

## TOPOLOGY

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

### Objective

- To introduce the student to elementary properties of topological spaces and structures defined on them
- 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

- Understanding elementary properties of topological spaces and structures defined on them
- Construct maps between topological spaces
- ability to handle abstract ideas of Mathematics and Mathematical proofs
- Demonstrate an understanding of the concepts of metric spaces and topological spaces, and their role in mathematics.
- Demonstrate familiarity with a range of examples of these structures.
- Prove basic results about completeness, compactness, connectedness and convergence within these structures.

### 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 Painlevé convergence**

#### Module II

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

**Project 3: Sober topological space**

#### Module III

To- and  $T_1$ -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/ProceedingsWIAT10.pdf](http://mat.uab.cat/ret/sites/default/files/material/otras_contribuciones/ProceedingsWIAT10.pdf)

## DIFFERENTIAL GEOMETRY

Subject Name	Code	Type of course	T-P-Pj	Prerequisite
<b>DIFFERENTIAL GEOMETRY</b>	<b>CUTM 1537</b>	<b>Theory &amp; Project</b>	<b>3-0-1</b>	<b>NIL</b>

### Objective

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

### Course Outcome

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

- write equation of normal , binormal and tangent to a curve.
- able to understand tensorial expressions.

### Course outline

#### Module-I

Introduction to Differential Geometry, 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 , Involutives

**Project 3:** Determine the evolutes of the given curve.

## **Module-IV**

Bertrand Curve, Osculating Spheres, Osculating circles.

**Project-4** : Show that the tangent to the locus of osculating sphere passes through the centre of the Osculating 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

## ADVANCED ALGEBRA

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

### Objective

- A major objective is 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.
- A challenge for all students of mathematics is to balance the understanding with the communication. There is a tendency to think you are finished once you see why a mathematical statement is true or false.
- In fact you are just half-way there because constructing a legitimate proof involves different skills and expertise than the discovery part of the process. In this course both angles of problem-solving will be stressed.

### Course Outcome

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

- Effectively write abstract mathematical proofs in a clear and logical manner.
- Locate and use theorems to solve problems in number theory and theory of polynomials over a field.
- Demonstrate ability to think critically by interpreting theorems and relating results to problems in other mathematical disciplines.
- Demonstrate ability to think critically by recognizing patterns and principles of algebra and relating them to the number system.
- Work effectively with others to discuss homework problems put on the board.

### 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**

Topics in Algebra – I. N. Herstein (John Wiley and Sons or Vikas Publication), 2<sup>nd</sup> 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. Singh and Q. Zameeruddin, Modern Algebra, Vikas Publishing House, 1990
2. B. Bhattacharya, S. K. Jain and S. R. Nagpal, Basic Abstract Algebra, Cambridge University Press, 1995.

## RESEARCH METHODOLOGY AND IPR

Code	Subject Name	Type of course	T-P-Pr (Credit)
CUTM 2378	Research Methodology and IPR	Theory + Project	(2-0-2)

### Objective

- To develop an appropriate framework for research studies
- To develop an understanding of various research designs and techniques.
- To identify various sources of information for literature review and data collection.
- To develop an understanding of the ethical dimensions of conducting applied research.
- To Demonstrate enhanced Scientific writing skills
- warn the common mistakes in the field of research methodology.
- To make expertise in academic writing, patenting

### Course Outcome

- Search, select and critically analyse research articles and papers
- Formulate and evaluate research questions
- Develop the ability to apply the methods while working on a research project work
- Describe the appropriate statistical methods required for a particular research design
- Choose the appropriate research design and develop appropriate research hypothesis for a research project

### Module 1: Elementary Research Methodology

Research Concept, Objective, characteristics, Steps and Significance of Research, Arbitrary and Scientific Research, Research approaches. Types of research: Historical, Descriptive, Analytical, Case Study, Quantitative vs. qualitative, Conceptual, Empirical Action Research, Research Methods vs Methodology. Research Problems: Selection and definition of the research problems, formulating a research problem, identifying variables and Constructing hypothesis; Choosing a mentor, lab and research question; maintaining a lab notebook; Selection of problems - stages in the execution of research

### Module II: Academic Writing and Presentation

Technical writing skills - types of reports; layout of a formal report; standard of Journal (Impact Factor, Citation Index), Scientific writing skills - importance of communicating science; problems while writing a scientific document; plagiarism, software for plagiarism; scientific publication writing: elements of a scientific paper including abstract, introduction, materials & methods, results, discussion, references; drafting titles and framing abstracts; publishing scientific papers - peer review process and problems, recent developments such as open access and non-blind review; characteristics of effective technical communication; scientific presentations; ethical issues; scientific misconduct.

### **Module III: Scientific communication skills**

Concept of effective communication- setting clear goals for communication; determining outcomes and results; barriers to effective communication; non-verbal communication- importance of body language, power of effective listening; Presentation skills - formal presentation skills; preparing and presenting using over-head projector, PowerPoint; defending interrogation; scientific poster preparation & presentation; participating in group discussions; Computing skills for scientific research - web browsing for information search.

### **Module IV: Introduction to IPR**

Introduction to intellectual property; types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, protection of new GMOs; IP as a factor in R&D; IPs of relevance to biotechnology and few case studies; plant variety protection and farmers rights.

### **Module V: Types of Patents**

Basics of patents: types of patents; Indian Patent Act 1970; recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications; filing of a patent application; role of a Country Patent Office; precautions before patenting- disclosure/non-disclosure - patent application- forms and guidelines including those of National Bio-diversity Authority (NBA) and other regulatory bodies, fee structure, time frames; types of patent applications: provisional and complete specifications.

### **PROJECTS**

1. Write a review article and submit to a journal
2. Write a book chapter/ book for publishing
3. Write an original article for a journal

### **Books:**

1. Geoffrey Marczyk, David DeMatteo, David Festinger (2005) *Essentials of Research Design and Methodology*, John Wiley & Sons, Inc.
2. Carol Ellison (2010) *McGraw-Hill's Concise Guide to Writing Research Papers*, McGraw-Hill
3. Kothari CR (2016) *Research Methodology: Methods and Techniques*, New Age Pvt Ltd
4. Ganbawale RM, (2017) *Biostatistics and Research Methodology*, New Central Book Agency
5. Sinha, S.C. and Dhiman, A.K., (2002). *Research Methodology*, Ess Ess Publications. 2 volumes.
6. Trochim, W.M.K., (2005). *Research Methods: the concise knowledge base*, Atomic Dog Publishing. 270p.
7. Wadehra, B.L. (2000). *Law relating to patents, trademarks, copyright designs and geographical indications*. Universal Law Publishing.

Neuman, W.L. (2008). *Social research methods: Qualitative and quantitative approaches*, Pearson Education