

M.Sc. MATHEMATICS

LOCF SYLLABUS 2026



Department of Mathematics

School of Computing Sciences

St. Xavier's College (Autonomous) Palayamkottai

Tirunelveli – 627 002, Tamil Nadu, India

Vision

To mould young men and women as leaders in all walks of life so that they may serve the people especially the poor and the oppressed of our nation in truth, justice and love.

Mission

To achieve a synthesis of academic excellence and the formation of character.

To ensure social justice through equity and access

To include the excluded for empowerment

To equip students with global competencies

To engage in relevant research activities.

To promote Lab to Land through the Outreach Programme – Student Training and Action for Neighbourhood Development (STAND)

SCHOOLS OF EXCELLENCE WITH CHOICE-BASED CREDIT SYSTEM (CBCS)**Essential Features of CBCS**

Standardisation of degree courses to internationally accepted levels

Focus on skill-based curriculum

Emphasis on value education

Institution - Industry collaboration

Provision for earning more credits

Development of communication skills

Post Graduate Courses

The existing PG curriculum was thoroughly upgraded based on the expectations of the academicians and the aspirations of the student community. The PG syllabus has two parts : Core and Elective. The minimum number of credits to be earned by a student is 100. The aim of the project work at the PG level is to develop the skill of solving problems and to promote research motivation. All the I-year PG students are offered one Value - Added Course and during their II year they are supposed to do one Extra Credit course outside their class hours to enhance their employability skills. However, during every semester, they are free to learn one ECC paper, offered by the respective departments.

Credit system

The credit system at St. Xavier's College (Autonomous) assigns weightage to courses based on the hours allocated to each course. Typically, one credit is equivalent to one hour of instruction per week. However, credits are awarded regardless of actual teaching hours to ensure consistency and adherence to guidelines. The credits and hours allotted to each course within a programme are detailed in the Programme Pattern table. While the table provides a framework, there may be some flexibility due to practical sessions, field visits, tutorials, and the nature of project work. For postgraduate (PG) courses, students are required to accumulate a minimum of 100 credits, as stipulated in the programme pattern table. The total number of courses offered by the department is outlined in the Programme Structure.

OUTCOME-BASED EDUCATION (OBE)

Outcome-Based Education (OBE) is a student-centric teaching and learning methodology that focuses on measuring student performance through clearly defined outcomes. For St. Xavier's College, with its commitment to excellence and NAAC/NBA accreditation requirements, OBE is not just a regulatory expectation but a pathway to academic quality, global competitiveness, and improved employability of graduates.

We prepare students to meet future industry requirements and reinforce St. Xavier's College, Palayamkottai, as a leader in quality higher education. St. Xavier's College introduced OBE in 2018, and for the Attainment Calculation, we developed our own method in 2018. From the academic year 2025-26 onwards, in examinations, for each question we mark Course Outcome (CO), Competency and Performance Indicator, Programme Outcome / Programme Specific Outcome, Bloom's Revised Cognitive Level and we follow the OBE procedure for the calculation of the Attainment of Outcome for each student, course, semester, programme.

EVALUATION PATTERN (PG)

Continuous Internal Assessment

There is no internal minimum for any paper. However, Continuous Internal Assessment (CIA) is a mandatory requirement for all students. A student must take at least one CIA test out of two tests and must fulfil at least one mode of assessment among assignments, quiz, seminars, etc., otherwise he/she will not be permitted to write the semester examination.

S.No	Component	Marks Allotted
1	I CIA Test	70
2	II CIA Test	70
	Total	140

The total CIA marks of 140 will be converted to 70 marks. An additional 30 marks will be awarded through other internal assessment components.

The Continuous Internal Assessment (CIA) consists of two component tests, each carrying 15 marks (15 + 15).

The final internal assessment marks will be calculated out of 100 (70 + 30). The obtained marks will be **converted to 50 marks**.

Semester (External) Examination

- The External Semester Examination will be conducted for **100 marks**.
- The obtained marks will be **converted to 50 marks**.

Question Pattern

PG Semester Examinations (3 Hours)

PART	TYPE	Mark Distribution	Total Marks
A	MCQ	10X1	10
B	ALL	5X3	15
C	Either/or	5X6	30
D	3 out of 5	3X15	45
		Total	100

PG Internal Examinations (2 Hours)

PART	TYPE	Mark Distribution	Total Marks
A	MCQ	10X1	10
B	ALL	3X3	09
C	Either/or	3x7	21
D	2 out of 3	2X15	30
		Total	70

Grading System

Range of Marks	Letter Grade	Grade Point	Description
90-100	A+	9.0-10.0	Outstanding
80-89	A	8.0-8.9	Excellent
70-79	B+	7.0-7.9	Very Good
60-69	B	6.0-6.9	Good
50-59	U	5.0-5.9	Average
00-49	U	0	Reappear

PROGRAMME : M.Sc. MATHEMATICS

PROGRAMME CODE : PMT

Programme Outcomes (POs)

Students of all Postgraduate Degree Programmes at the time of graduation will be able to attain the following at the institution level:

PO1. Critical Thinking: Acquire the knowledge in the respective field and take informed actions.

PO2. Communication: Speak, read, write and listen clearly in person and through electronic media in English and in one Indian language, and make meaning of the world by connecting people, ideas, books, media and technology.

PO3: Individual and teamwork: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO4: Problem analysis: Identify, formulate, review research literature, and analyze complex problems reaching substantiated conclusions using the principles of all branches of Sciences, commerce, economics, management studies, language and literature.

PO5: Design/development of solutions: Design solutions for problems and design system components or processes that meet the specified needs with appropriate consideration for the public, health and safety, and the cultural, societal, and environmental considerations.

PO6: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO7. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern IT tools including prediction and modeling to complex activities with an understanding of the limitations.

PO8. Self-directed and Life-long Learning: Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of socio-technological changes.

Program Specific Outcomes (PSOs):

Students of all Postgraduate Degree Programmes at the time of graduation will be able to attain the following at the department level:

PSO1: Mathematical Mastery: Apply deep knowledge of algebra, analysis, topology, and differential equations to model, solve, and interpret advanced mathematical problems.

PSO2: Logical Reasoning and Proof Techniques: Develop and validate mathematical proofs using axiomatic, deductive, and constructive reasoning in abstract and applied contexts.

PSO3: Computational and Programming Skills: Use mathematical software tools such as Sage Math, Python and programming languages (e.g., Java) to simulate and solve mathematical models.

PSO4: Research Orientation: Formulate and investigate conjectures, apply mathematical research methodologies, and prepare for scholarly inquiry or doctoral-level study.

PSO5: Interdisciplinary Connections: Integrate mathematical knowledge with fields such as physics, cryptography, computer science, and operations research for real-world applications.

PSO6: Data and Algorithmic Thinking: Analyze data-driven problems and design algorithms through the lens of number theory, graph theory, and optimization methods.

PSO7: Problem Solving in Theoretical and Applied Settings: Choose appropriate mathematical tools and techniques to analyze and solve complex problems in pure and applied mathematics.

PSO8: Ethical and Professional Mathematical Communication: Communicate mathematical ideas clearly and ethically through written, verbal, and symbolic language, adhering to academic integrity.

M.Sc. MATHEMATICS PROGRAMME PATTERN

Sem	Part	Status	Sub. Code	Title of the Paper	Hours	Credit
I	A	Core -1	26PMTC11	Algebraic Structures	6	5
		Core -2	26PMTC12	Real Analysis - I	6	5
		Core -3	26PMTC13	Ordinary Differential Equations	6	4
	B	EC -1	26PMTE11	Python and Data Science / Modelling and Simulation with Excel	4	2
		EC-2	26PMTE12	Python and Data Science Practical/ Modelling and Simulation with Excel Practical	2	1
		EC -3	26PMTE13	Mathematical Programming/ Formal Languages and Automata/ Introduction of Fuzzy Sets and Their Applications	6	3
Sub Total					30	20
Sem	Part	Status	Sub. Code	Title of the Paper	Hours	Credit
II	A	Core -4	26PMTC21	Linear Algebra	6	5
		Core -5	26PMTC22	Real Analysis – II	6	5
		Core -6	26PMTC23	Partial Differential Equations	6	4
	B	EC -4	26PMTE21	Calculus of Variations and Integral Equations / Combinatorics	5	3
		EC -5	26PMTE22	Numerical Analysis / Number Theory and Cryptography	5	3
		SEC1	26PMTS21	Training for Mathematical Competitive Examinations - I	2	2
	C	Extension Activities		STAND	-	1
Sub Total					30	23
Sem	Part	Status	Sub. Code	Title of the Paper	Hours	Credit
	A	Core – 7	26PMTC31	Topology	6	5
		Core – 8	26PMTC32	Complex Analysis	6	5
		Core – 9	26PMTC33	Mechanics	5	4
		Core -10	26PMTC34	Graph Theory and Applications	5	4

III	B	EC – 6	26PMTE31	Object Oriented Programming with Java/ Advanced PHP Architecture and Backend Design / Mathematical Computing and Visualization using Sagemath	4	2
		EC – 7	26PMTE32	Object Oriented Programming with Java Practical/ Advanced PHP Architecture and Backend Design Practical/ Mathematical Computing and Visualization using Sagemath Practical	2	2
		SEC2	26PMTS31	Training for Mathematical Competitive Examinations -II	2	2
		Internship	26PMTI35	Internship		2
Sub Total					30	26
Sem	Part	Status	Sub. Code	Title of the Paper	Hours	Credit
IV	A	Core – 11	26PMTC41	Functional Analysis	5	4
		Core – 12	26PMTC42	Differential Geometry	5	4
		Core - 13	26PMTE43	Project with viva voce	8	6
	B	EC – 8	26PMTE41	Advanced Operations Research/ Algorithms and Complexity	5	3
		EC – 9	26PMTE42	Advanced Statistics/ Stochastic Processes	5	3
		SEC 3	26PMTS41	Database Management Systems Practical	2	2
Sub Total					30	22
					120	91
Additional Compulsory Courses						
I Year (Value–Added Course)						3
II Year (Extra-Credit Course)						3
MOOC						2
Field Visit						1
					120	100

Value Added Courses:

	Part	Course Code	Title of the Paper	Credits
Any one	V	26PMTVA1	Problem Solving in Algebra and Linear Algebra	3
	V	26PMTVA2	Integral Transforms	3
	V	26PMTVA3	Problem solving in advanced algebra and analysis	3
	V	26PMTVA4	Mathematical Documentation Using LaTeX	3

Extra Credit Courses:

	Part	Course Code	Title of the Paper	Credits
Any one	V	26PMTEC1	Placement and Competitive Readiness skills	3
	V	26PMTEC2	Analysis I for Competitive Examinations	3
	V	26PMTEC3	Analysis II for Competitive Examinations	3
	V	26PMTEC4	Algebraic Graph Theory	3
	V	26PMTEC5	History of Mathematics	3
	V	26PMTEC6	Problem Solving in Differential Equations	3
	V	26PMTEC7	Queuing and Inventory Models	3
	V	26PMTEC8	Neural Networks	3
	V	26PMTEC9	Tensor Analysis and Relativity	3

ALGEBRAIC STRUCTURES

(Course Code: 26PMTTC11)

Semester - I **Core -1** **Hours - 6** **Credits - 5**

Course Outcomes: By the end of the course the students will be able to

- | | | |
|------------|---|------|
| CO1 | Demonstrate basic counting principle, class equations, Sylow's theorem and its applications | (K3) |
| CO2 | Discuss direct products and the properties of finite abelian groups | (K2) |
| CO3 | Investigate the concepts in Extension fields | (K4) |
| CO4 | Illustrate the properties of normal extension and Galois Theory | (K3) |
| CO5 | Determine the roots of a polynomial by radicals and splitting fields | (K3) |
| CO6 | Summarize the properties of Finite fields | (K5) |

UNIT- I: (18 hours)

Another Counting Principle - Class equation for finite groups and its applications
- Sylow's theorems (For theorem 2.12.1, any one of the Proof).

Chapter 2: 2.11 - 2.12 (Omit Lemma 2.12.5)

UNIT- II: (18 hours)

Direct products – Finite abelian groups

Chapter 2: 2.13, 2.14 (Omit Lemma 2.14.2)

UNIT- III: (18 hours)

Extension Fields - Roots of Polynomials (Proofs are excluded) - More about Roots -

Chapter 5: 5.1, 5.3, 5.5

UNIT- IV: (18 hours)

The Elements of Galois Theory

Chapter5: 5.6

UNIT- V: (18 hours)

Solvability by Radicals - Finite fields

Chapter 5: 5.7,7:7.1, 7.2

Activity:

Problem solving skills: Solve problems related to Group Theory and Galois Theory

Text book:

I.N. Herstein. Topics in Algebra (II Edition) Wiley Eastern Limited, New Delhi, 1975.

Reference books:

1. M.Artin, Algebra, Prentice Hall of India, 1991.
2. P.B.Bhattacharya, S.K.Jain, and S.R.Nagpaul, Basic Abstract Algebra (II Edition) Cambridge University Press, 1997. (Indian Edition)
3. D.S.Malik, J.N. Mordeson and M.K.Sen, Fundamental of Abstract Algebra, McGraw Hill (International Edition), New York. 1997.
4. David S. Dummit and Richard M. Foote, Abstract Algebra, Third Edition, Wiley India Pvt. Ltd., 2014

E-Learning Sources:

- 1) www.algebra.com
- 2) https://onlinecourses.nptel.ac.in/noc26_ma47/preview
- 3) <https://youtu.be/Ct2fyigNgPY>

REAL ANALYSIS - I

(Course Code: 26PMTTC12)

Semester – I

Core – 2

Hours – 6

Credits – 5

Course Outcomes: By the end of the course the student will be able to

- | | | |
|------------|--|------|
| CO1 | Recall the concepts of Limits, sequence and series | (K1) |
| CO2 | Analyze functions of bounded variation and Rectifiable Curves | (K4) |
| CO3 | Determine the limits of sequence and series of functions | (K3) |
| CO4 | Analyze the concepts of Riemann-Stieltjes integrals and its properties | (K4) |
| CO5 | Evaluate the sequence of continuous, differentiable, integrable functions and their limits | (K5) |
| CO6 | Develop the various properties of double sequence and series | (K6) |

UNIT - I:

(18 hours)

Introduction - Properties of monotonic functions - Functions of bounded variation - Total variation - Additive property of total variation - Total variation on $[a, x]$ as a function of x - Functions of bounded variation expressed as the difference of two increasing functions - Continuous functions of bounded variation - Absolute and conditional convergence - Dirichlet's test and Abel's test - Rearrangement of series - Riemann's theorem on conditionally convergent series. **(Chapter – 6 : 6.1 to 6.8 and Chapter 8 : 8.8, 8.15, 8.17, 8.18)**

UNIT - II:

(18 hours)

Introduction - Notation - The definition of the Riemann - Stieltjes integral - Linear Properties - Integration by parts - Change of variable in a Riemann - Stieltjes integral - Reduction to a Riemann Integral – Euler's summation formula - Monotonically increasing integrators, Upper and lower integrals - Additive and linearity properties of upper, lower integrals - Riemann's condition - Comparison theorems. **(Chapter - 7 : 7.1 to 7.14)**

UNIT - III:

(18 hours)

The Riemann - Stieltjes Integral - Integrators of bounded variation - Sufficient conditions for the existence of Riemann - Stieltjes integrals - Necessary conditions for the existence of Riemann - Stieltjes integrals - Mean value theorems - integrals as a function of the interval – Second fundamental theorem of integral calculus - Change of variable - Second Mean Value Theorem for Riemann integral - Riemann - Stieltjes integrals depending on a parameter-

Differentiation under integral sign - Lebesgue criteriaon for existence of Riemann integrals.
(Chapter - 7 : 7.15 - 7.26)

UNIT- IV:

(18 hours)

Double sequences - Double series - Rearrangement theorem for double series - A sufficient condition for equality of iterated series - Multiplication of series – Cesarosummability - Infinite products - Power series - Multiplication of power series - The Taylor's series generated by a function - Bernstein's theorem - Abel's limit theorem - Tauber's theorem.

(Chapter – 8: 8.20, 8.21 to 8.26 and Chapter 9 :9.14 9.15, 9.19, 9.20, 9.22, 9.23)

UNIT - V:

(18 hours)

Point wise convergence of sequences of functions - Examples of sequences of real - valued functions - Uniform convergence and continuity - Cauchy condition for uniform convergence - Uniform convergence of infinite series of functions - Riemann - Stieltjes integration – Non-uniform Convergence and Term-by-term Integration - Uniform convergence and differentiation - Sufficient condition for uniform convergence of a series - Mean convergence. (Chapter - 9:9.1 to 9.6,9.8,9.9,9.10,9.11, 9.13)

Text Book:

Tom M. Apostol, Mathematical Analysis, 2nd Edition, Addison-Wesley Publishing Company Inc. New York, 1974.

Reference Books:

1. Robert G. Bartle and Donald R. Sherbert, Introduction to Real Analysis, Fourth edition, John Wiley and Sons, 2011.
2. S. K. Mappa, Introduction to Real Analysis, 7 thedtion, Sarat Book House, 2013.
3. Kenneth A. Ross, Elementary Analysis: The theory of Calculus, Springer, New York, 2004.
4. Richard R. Goldberg, Methods of Real Analysis, Oxford & IBH Publishing co. Pvt. Ltd., New Delhi 1970.
5. Walter Rudin, Principles of Mathematical Analysis, Third edition, McGraw Hill Book company, New York, 1976.
6. S. Kumaresan, Topology of Metric Spaces, 2 nd Edition, Narosa Publishing House, 2011.
7. S. Ponnusamy, Foundations of Mathematical Analysis, Springer Birkhauser, 2012.

8. S. C. Malik and Savita Arora, Mathematical Analysis, Wiley Eastern Ltd., New Delhi, 1991.

E-Learning Sources:

1. <http://mathforum.org>
2. <https://epgp.inflibnet.ac.in/Home/ViewSubject?atid=ZLCHeZEhCZ8yCri36nSF3A>
3. https://youtube.com/playlist?list=PLbJCOW-02l3--KOg_ZaCn6UwzB8RSPgc&si=QtkY4AFYOe0fEjE7

ORDINARY DIFFERENTIAL EQUATIONS

(Course Code: 26PMTTC13)

Semester – I

Core - 3

Hours - 6

Credits – 4

Course Outcomes: By the end of the course the students will be able to

- CO1** Solve second and higher order linear homogeneous differential equations with constant coefficients and formulate solutions to associated initial value problems (K3)
- CO2** Analyze linear dependence and independence of solutions using the Wronskian and construct fundamental sets of linearly independent solutions (K4)
- CO3** Apply appropriate techniques to obtain solutions of non-homogeneous linear differential equations of order two and higher (K3)
- CO4** Analyze and solve linear differential equations with variable coefficients using reduction of order, analytic coefficient methods, and power series techniques (K4)
- CO5** Classify differential equations with regular singular points and analyze the solutions of special equations such as Euler, Legendre, and Bessel equations (K4)
- CO6** Evaluate existence, uniqueness, and convergence of solutions to first-order differential equations using successive approximations and Lipschitz conditions (K5)

UNIT - I: Linear Equations With Constant Coefficients (18 hours)

Introduction – The Second order homogeneous equations - Initial value problems for second order equations - Linear dependence and independence - A formula for the Wronskian.
(Chapter 2: Sections 1 to 5)

UNIT-II: Linear Equations With Constant Coefficients(Cont'd.) (18 hours)

The Non- homogenous equations of order two - The Homogeneous equations of order n –Initial value problems for n -th order equations - Equations with real constants – The non-homogeneous equations of order n – A special method for solving the non-homogeneous equation.

(Chapter 2 : Sections 6 to 11)

UNIT - III: Linear Equations With Variable Coefficients (18 hours)

Introduction – Initial value problem for the homogenous equation - solutions of the homogeneous equation - The Wronskian and linear independence - Reduction of the order of a homogenous equation - The non-homogenous equation - Homogenous equations with analytic coefficients - The Legendre equation.

(Chapter 3: Sections 1 - 8)

UNIT–IV: Linear Equations With Regular Singular Points

(18 hours)

Introduction - The Euler equation - Second order equations with regular singular points – an example - Second order equations with regular singular points – the general case- The Bessel equation – The Bessel equation (continued).

(Chapter 4: Sections 1 – 4,7 and 8)

UNIT –V: Existence and Uniqueness Of Solutions To First Order Equations(18 hours)

Introduction - The method of successive approximations - The Lipschitz Condition - Convergence of the successive approximations - Approximations to, and uniqueness of, solutions.

(Chapter 5: Sections 1, 4 to 6 and 8)

Activity:

Project on the recent developments and applications of differential equations.

Text book:

E.A.Coddington, A introduction to ordinary differential equations (3rd Printing), Prentice-Hall of India Ltd.,New Delhi, 1987.

Reference Books:

1. Williams E. Boyce and Richard C. DiPrima Elementary Differential Equations and Boundary Value Problems, 10th edition John Wiley and Sons, New York 2012.
2. M.D. Raisinghania, Advanced Differential Equations, S. Chand & Company Ltd., New Delhi 2012.
3. George F. Simmons, Differential Equations with Application And Historical Notes, Tata McGraw Hill, New Delhi 1974.
4. B. Rai, D.P. Choudhury and H.I. Freedman, A Course in Ordinary Differential Equations, Narosa Publishing House Pvt. Ltd, New Delhi 2012.
5. Ravi P. Agarwal and Ramesh C. Gupta, Essentials of Ordinary Differential Equations, McGraw Hill, New York, 1991.

E-learning Sources: 1. <https://nptel.ac.in/courses/111104031>

2. <https://nptel.ac.in/courses/111104521>

PYTHON AND DATA SCIENCE

(Course Code: 26PMTE11)

Semester - I

EC -1

Hours: 4

Credit: 2

Course Outcomes: By the end of the course the students will be able to

- | | | |
|------------|---|------|
| CO1 | Understand basic Python programming concepts | (K2) |
| CO2 | Apply mathematical functions, string operations, formatting techniques, and basic object methods to develop graphical outputs | (K3) |
| CO3 | Use decision making, loops, and functions in programs | (K3) |
| CO4 | Develop programs using classes and objects | (K4) |
| CO5 | Analyze data using lists and NumPy arrays | (K4) |
| CO6 | Use Pandas and Matplotlib for data analysis and visualization | (K5) |

UNIT-I: (12 hours)

Elementary Programming: Introduction – Writing a Simple Program- Reading Input from the console – Identifiers – Variables, Assignment Statements, and Expressions – simultaneous Assignments – Named Constants – Numeric Data Types and Operators - Evaluating Expressions and Operator Precedence – Augmented Assignment Operators – Type Conversion and Rounding. **Mathematical Functions, Strings and Objects:** Common Python Functions – Strings and Characters – Introduction to Objects and Methods – Formatting Numbers and Strings – Drawing shapes.

(Text Book 1: Chapter 2: Sections: 2.1-2.11,
Chapter 3: Sections : 3.1-3.7)

UNIT-II: (12 hours)

Selections: Introduction – Boolean Types, Values and Expressions – Generating Random Numbers if Statement – Two-Ways if-else Statements – Nested if and Multi-Way if-elif-else Statements – Conditional Expressions - **Loops** : Introduction – The While Loop – The for Loop – Nested Loops – Keywords break and continue - **Functions:** Introduction – Defining a Function – Calling a Function – Functions with/without Return Values - **Objects and Classes** : Introduction – Defining Classes for Objects

(Text Book 1: Chapter 4: Sections: 4.1-4.4, 4.6, 4.7, 4.14,
Chapter 5: Sections : 5.1-5.4, 5.7,
Chapter 6: Sections : 6.1-6.4, Chapter 7: Sections: 7.1-7.2)

UNIT-III: (12 hours)

Lists – Introduction – Lists Basics - **Introduction to NumPy:** Basics of NumPy Array – Computation on NumPy Arrays – Aggregations: Min, Max, and Everything in Between - Sorting Arrays.

(Text Book 1: Chapter 10: Sections : 10.1-10.2,
Text Book 2: Chapter 2)

UNIT-IV: (12 hours)

Data Manipulation with Pandas: Installing Using Panda Objects – Introducing Pandas Objects – Data Indexing and Selection - Operating Data on Pandas–Working with Time Series

(Text Book 2: Chapter 3)
(12 hours)

UNIT-V:

Visualization with Matplotlib: General Matplotlib Tips- Simple Line Plots – Simple Scatter plot –Three – Dimensional Plotting in Matplotlib.

(Text Book 2:Chapter4)

Text Books:

1. Y. Daniel Lang, “*Introduction to Programming using Python, 2nd Edition*”, Pearson Education Inc., 2013.
2. Jake Vander Plas, “*Python Data Science Handbook: Essential Tools for Working with Data*”, 1st Edition, O'Reilly Media, 2016.

References Books:

1. Eric Matthes, “*Python Crash Course- A Hands – on, Project –Based Introduction to Programming*”, no starch press, San Francisco, 2016.
2. Allen B. Downey, “*Think Python. How to Think Like a Computer Scientist*”, 2nd edition, O'Reilly Publishers, 2016.
3. Amit Saha, “*Doing Math With Python, Use programming to explore Algebra, Statistics, Calculus, and More*”, no starch press, San Francisco, 2015.
4. David Beazley, Brian K. Jones, “*Python Cookbook: Recipes for Mastering Python 3*”, 3rd Edition, 2013.
5. Harsh Bhasin, “*Python for Beginners*”, New Age International Publishers, 2018.
6. Jeeva Jose and P. Sojan Lal, “*Introduction to Computing and Problem Solving with PYTHON*”, Khanna Book Publishing Co. (P) Ltd., 2016.

E-Learning References:

<https://www.geeksforgeeks.org/web-technology>
<https://aclm.in/advanced-web-technology-training.html>
<https://www.bcit.ca/programs/advanced-web-technologies>
<https://docs.python.org/3/tutorial/index.html>
https://www.python-course.eu/advanced_topics.php

PYTHON AND DATA SCIENCE PRACTICAL

(Course Code: 26PMTE12)

Semester - I

EC -2

Hours: 2

Credit: 1

1. Program to perform basic input, processing and output operations.
2. Program to illustrate functions, string handling and basic graphical output.
3. Program to demonstrate conditional statements.
4. Program to demonstrate loops and user- defined functions.
5. Program to demonstrate list operations.
6. program to demonstrate NumPy array operations.
7. Program to perform Data Indexing and Selection using Pandas
8. Program to perform time-series operations using Pandas such as date indexing.
9. Program to visualize data using Matplotlib by plotting Simple line graphs, scatter plots.
10. Program to visualize data using Matplotlib by plotting a three - dimensional plot.

MODELLING AND SIMULATION WITH EXCEL

(Course Code: 26PMTE11)

Semester - I **EC -1** **Hours: 4** **Credit: 3**

Course Outcomes: By the end of the course the student will be able to

CO1	Recall the basics of Excel functions	(K1)
CO2	Explain the different type of functions in diagrams	(K2)
CO3	Apply functions to solve simple problems	(K3)
CO4	Analyze lists and databases using database functions	(K4)
CO5	Evaluate the data analysis skill in Excel	(K5)
CO6	Create model using Excel	(K6)

UNIT - I: (15 hours)

Mathematical Functions: SUM, SUMIF, COUNT, COUNTIF, ROUND, PRODUCT, LCM, GCD; **Basic Statistical Functions:** MAX, MIN, AVERAGE, COUNT, MEDIAN, QUARTILE, STDEV, CORREL; **Logical Functions:** AND, OR, XOR, IF.
(Text Book 1)

UNIT - II: (15 hours)

Presentation of Quantitative Data: Data Visualization: Introduction - Data Classification -Data Context and Data Orientation - Types of Charts and Graphs - An Example of Graphical Data Analysis and Presentation.

Analysis of Quantitative Data: Introduction - What Is Data Analysis? - Data Analysis Tools - Data Analysis for Two Data Sets - Analysis of Time Series Data: Forecasting/Data Relationship Tools.
(Text Book 2: Ch: 2.1 to 2.5, Ch: 3.1 to 3.5)

UNIT - III: (15 hours)

Presentation of Qualitative Data - Data Visualization: Introduction-What Is Qualitative Data? - Essentials of Effective Qualitative Data Presentation - Data Entry and Manipulation - Data Queries with Sort, Filter, and Advanced Filter.

Analysis of Qualitative Data: Introduction - Essentials of Qualitative Data Analysis - Dealing with Data Errors - PivotChart or PivotTable Reports.

(Text Book 2: Ch 4.1 to 4.4 Ch 5.1 to 5.3)

UNIT - IV:**(15 hours)**

Modeling and Simulation- Part 1: Introduction - What Is a Model? - How Do We Classify Models? - An Example of Deterministic Modeling - Understanding the Important Elements of a Model - Model Building with Excel

(Text Book 2: Ch 7.1 to 7.5)**UNIT - V:****(15 hours)**

Modeling and Simulation- Part 2: Introduction - Types of Simulation and Uncertainty - The Monte Carlo Sampling Methodology - A Financial Example–Income Statement

(Text Book 2: Ch 8.1 to 8.4)**Text books:**

1. B. Held, B. Moriarty and T. Richardson, Microsoft Excel Functions and Formulas, Fifth Edition, Mercury Learning and Information, 2019.
2. Hector Guerrero, Excel Data Analysis Modeling and Simulation, Second Edition, Springer, 2019.

Reference book:

1. Wayne Winston, MS Excel 2013: Data Analysis & Business Modelling, PHI, 2014.

MODELLING AND SIMULATION WITH EXCEL PRACTICAL

(Course Code: 26PMTE12)

Semester - I

EC -2

Hours: 2

Credit: 1

Course Outcomes: By the end of the course, the student will be able to

- CO1** Apply Excel mathematical and logical functions for data processing (K3)
- CO2** Analyse quantitative data using statistical tools and charts (K4)
- CO3** Organise and summarise qualitative data using sort, filter and Pivot Tables (K3)
- CO4** Construct deterministic spreadsheet models and perform What-if analysis (K6)
- CO5** Perform simulation using random number generation and interpret the results (K5)
- CO6** Present and interpret data analysis results in a clear and meaningful manner using appropriate Excel tools (K4)

List of Practicals

1. Perform calculations using mathematical functions – SUM, PRODUCT, ROUND, GCD, LCM.
2. Apply conditional and counting functions – COUNT, COUNTIF, SUMIF for a given data set.
3. Compute statistical measures – MAX, MIN, AVERAGE, MEDIAN, QUARTILE, STDEV.
4. Prepare a mark sheet and assign result and grade using logical functions – IF, AND, OR, XOR.
5. Construct charts (Bar, Line, Pie) for quantitative data with proper formatting.
6. Plot time series data, add trendline and perform forecasting.
7. Perform data sorting and filtering (single level, multi-level and advanced filter) for qualitative data.
8. Create Pivot Table and Pivot Chart for summarising and analysing data.
9. Develop a spreadsheet model for Cost–Revenue–Profit and perform What-if analysis using Goal Seek.
10. Generate random numbers and carry out a simple Monte Carlo simulation for a financial / business model.

MATHEMATICAL PROGRAMMING

(Course Code: 26PMTE13)

Semester - I

EC -3

Hours: 6

Credit: 3

Course Outcomes: By the end of the course the students will be able to

- CO1** Understand the fundamental concepts, assumptions, and scope of mathematical programming and optimization techniques (K2)
- CO2** Formulate real-world decision making problems as appropriate mathematical programming models (K4)
- CO3** Analyze and solve Goal Programming models using graphical and modified simplex methods to handle multiple and conflicting objectives (K4)
- CO4** Apply classical optimization techniques to solve unconstrained and constrained multivariable optimization problems with equality and inequality constraints (K3)
- CO5** Compare non-linear programming and linear programming problems (K5)
- CO6** Evaluate optimal solution of an optimization problem using simplex method (K5)

UNIT - I:

(18 hours)

Integer Linear Programming: Introduction - Types of Integer Linear Programming Problems – Enumeration and Cutting Plane concept - Gomory's All Integer Cutting Plane Method - Gomory's mixed Integer Cutting Plane method - Branch and Bound Method. – Application of Zero-One Integer Programming.

(Chapter 7: 7.1 - 7.7)

UNIT - II: Goal Programming

(18 hours)

Introduction - Difference between LP and GP approach - Concept of Goal Programming - Goal Programming Model formulation - Graphical Solution Method for Goal Programming - Modified Simplex method of Goal Programming.

(Chapter 8: 8.1 - 8.4, 8.6(Except Alternative Simplex Method for Goal Programming problem))

UNIT - III: Classical Optimization Methods

(18 hours)

Introduction - Unconstrained Optimization - Constrained Multi-variable Optimization with Equality Constraints - Constrained Multi-variable Optimization with inequality Constraints.

(Chapter 23: 23.1 – 23.4)

UNIT - IV: Non-linear Programming Methods

(18 hours)

Introduction – General NLPP – Graphical solution method – Quadratic Programming – application of Quadratic Programming.

(Chapter 24: 24.1 – 24.5)

UNIT - V: Theory of Simplex Method**(18 hours)**

Introduction - Canonical and Standard form of LPP - Slack and Surplus Variables -

Reduction of Feasible solution to a Basic Feasible solution - Alternative Optimal solution -

Unbounded solution - Optimality conditions - Some complications and their resolutions.

(Chapter 25: 25.1 - 25.4, 25.6-25.9)**Activity:**

Using digital tools plot a simple Goal Programming problem with two goals on a graph.

Text Book:

J.K.Sharma, Operations Research, Theory and Applications, Third Edition (2007) Macmillan India Ltd.

Reference Books:

1. Hamdy A. Taha, Operations Research, (seventh edition) Prentice - Hall of India Private Limited, New Delhi, 1997.
2. F.S. Hillier & J.Lieberman Introduction to Operation Research (7th Edition) Tata- McGraw Hill company, New Delhi, 2001.
3. Beightler. C, D.Phillips, B. Wilde, Foundations of Optimization (2nd Edition) Prentice Hall Pvt Ltd., New York, 1979
4. S.S. Rao - Optimization Theory and Applications, Wiley Eastern Ltd. New Delhi. 1990

E-Learning Resources:

1. <https://cbom.atozmath.com/CBOM/Simplex.aspx?q=01>
2. <https://archive.nptel.ac.in/content/storage2/courses/112102107/mod6/mod63/p1.htm>
3. <https://www.youtube.com/watch?v=2e1dZpOk3Zc>

FORMAL LANGUAGES AND AUTOMATA THEORY

(Course Code: 26PMTE13)

Semester - I

EC - 3

Hours - 6

Credit - 3

Course outcomes: By the end of the course the students will be able to

- CO1** Recall the fundamental concepts and terminology of formal languages, automata, (K1) and mathematical models of computation
- CO2** Explain deterministic, nondeterministic, and ϵ -finite automata and interpret their (K2) equivalence with regular expressions
- CO3** Apply the pumping lemma, NFA–DFA conversion, and DFA minimization (K3) techniques to solve problems related to regular languages
- CO4** Analyze context-free grammars using derivation trees and convert grammars into (K4) Chomsky Normal Form and Greibach Normal Form
- CO5** Evaluate the equivalence between pushdown automata and context-free (K5) grammars and distinguish deterministic and nondeterministic PDAs
- CO6** Design automata, grammars, or formal language models to solve real-life and (K4) theoretical problems involving regular and context-free languages

UNIT - I: (18 hours)

Finite Automata and Regular Expressions: Finite state systems - Deterministic Finite state Automata - Non deterministic Finite Automata - Finite Automata with Epsilon - Transitions – Regular Expressions - Finite Automata and Regular Expressions.

(Chapter 2: Sec 2.1- 2.5)

UNIT - II: (18 hours)

Properties of Regular Sets: The Pumping Lemma for Regular Sets – Application of the Pumping Lemma – Converting NFA's to DFA'S – Minimization of DFA's.

(Chapter 3: Sec 3.1,3.4.)

UNIT - III: (18 hours)

Context Free Grammars and Languages: Context Free Grammars – Derivation Trees – Normal forms for Context Free Grammars – Chomsky Normal Form – Greibach Normal Form.

(Chapter 4: Sec 4.2- 4.6.)

UNIT - IV: (18 hours)

Pushdown Automata: Definition – The languages of a PDA – Equivalence of PDA's and CFG's – Deterministic Pushdown Automata.

(Chapter 5: Sec 5.2- 5.3.)

UNIT - V: (18 hours)

Properties of Context - Free Languages : The Pumping Lemma for Context - free Languages – Closure Properties of Context - Free Languages – Decision properties of CFL's.

(Chapter 6: Sec 6.1- 6.3.)

Activity:

Find real life problems and converting NFA's to DFA's.

Text Book:

John E. Hopcroft and Jeffery D. Ullman, Introduction to Automata theory, Languages and Computations, Narosa Publishing House, Chennai, 2002.

Reference Books:

1. Harry R. Lewis and Christos H. Papadimitriou, Elements of the Theory of Computation, Second Edition, Prentice Hall, 1997.
2. A.V. Aho, Monica S. Lam, R. Sethi, J.D. Ullman, Compilers: Principles, Techniques, and Tools, Second Edition, Addison-Wesley, 2007.
3. John C. Martin, Introduction to Languages and theory of Computations (2nd Edn), Tata – McGraw Hill company Ltd., New Delhi, 1997.
4. Dr. Rani Siromoney, Formal Languages and Automata, The Christian Literature Society, 1979.

E-Learning Sources:

1. NPTEL – Formal Languages and Automata Theory
<https://nptel.ac.in/courses/106/106/106106049/>
2. MIT Open Course Ware – Automata, Computability, and Complexity
<https://ocw.mit.edu/courses/18-404j-theory-of-computation-fall-2020/>
3. Stanford Online – Automata Theory (Lecture Videos)
<https://theory.stanford.edu/~aiken/automata.html/>

INTRODUCTION OF FUZZY SETS AND THEIR APPLICATIONS

(Course Code: 26PMTE13)

Semester - I **EC - 3** **Hours - 6** **Credit - 3**

Course outcomes: By the end of the course the students will be able to

CO1	Recall basic concepts of fuzzy theory and develop intuitive understanding	(K1)
CO2	Understand the concept of uncertainty and fuzziness in logic	(K2)
CO3	Evaluate fuzzy operations, fuzzy relations like projections, composition, etc	(K3)
CO4	Analyze fuzzy arithmetic	(K4)
CO5	Make decisions on real life problems through Individual and Multi Person Decision Making	(K5)
CO6	Develop fuzzy relations	(K6)

UNIT - I: (18 hours)

Crisp sets and Fuzzy sets: Overview of Classical Sets, Membership Function, Height of a fuzzy set – Normal and sub normal a fuzzy set – Support – Level sets, fuzzy points, α -cuts – Decomposition Theorems - Extension Principle.

(Chapter1: 1.2 -1.4 &Chapter2: 2.1-2.3.)

UNIT - II: (18 hours)

Operation on fuzzy sets: Standard fuzzy operations – Union, intersection and complement – properties

(Chapter 3: 3.1& 3.2.)

UNIT - III: (18 hours)

Fuzzy Arithmetic: Fuzzy numbers - Linguistic variables - Arithmetic operations on intervals - Arithmetic operations on fuzzy numbers - Fuzzy equations.

(Chapter 4: Sec 4.1 - 4.4, 4.6.)

UNIT - IV: (18 hours)

Fuzzy relations: Crisp and fuzzy relations – Projections and Cylindrical Extensions – Binary Fuzzy relations – Binary Relations on a Single Sets– Fuzzy Equivalence Relations.

(Chapter 5: 5.1 - 5.5.)

UNIT - V: (18 hours)

Decision Making in Fuzzy environments: General discussion – Individual Decision making – multi person decision making – multi criteria decision making – multi stage decision making.

(Chapter 15: Sec 15.1-15.5.)

Activity:

- Differentiate between classical and fuzzy sets, exploring their respective applications.
- Perform operations such as union, intersection, and complement on fuzzy sets.
- Perform arithmetic operations on fuzzy intervals and fuzzy numbers.
- Develop and interpret fuzzy relations, projections, and cylindrical extensions.
- Apply fuzzy decision-making techniques for individual and group scenarios.

Text Book:

George J. Klir and Bo Yuan, Fuzzy sets and Fuzzy Logic Theory and Applications, Prentice Hall of India Private Limited, New Delhi (2007).

Reference Books:

1. K.Pundir and R.Pundir, Fuzzy sets and their application, Published by APragati edition(2012).
2. H.J.Zimmermann, Fuzzy set theory and its applications, Second Edition, Springer New Delhi, 2012.
3. Timothy J. Ross, Fuzzy logic with Engineering Applications, McGraw-Hill, Inc. New Delhi, 2000.
4. George J. Klir, Tina A. Folger, Fuzzy sets, uncertainty and information, Prentice Hall of India Pvt Ltd, New Delhi, 2008.

E-Learning Sources:

1. <http://www.pzs.dstu.dp.ua/logic/bibl/yuan.pdf>
2. <https://nptel.ac.in/courses/108104157>
3. <https://nptel.ac.in/courses/111102130>

LINEAR ALGEBRA
(Course Code : 26PMTTC21)

Semester - II

Core -4

Hours - 6

Credits – 5

Course Outcomes: By the end of the course the student will be able to

- CO1** Explain linear transformations, null spaces, ranges, and change of coordinates (K2)
- CO2** Apply matrix representations and compositions to study invertibility and isomorphisms (K3)
- CO3** Solve systems of linear equations using elementary operations, rank, and matrix inverses (K3)
- CO4** Analyze eigenvalues, eigenvectors, diagonalizability, and invariant subspaces (K4)
- CO5** Evaluate matrices using the Cayley–Hamilton theorem for theoretical and computational purposes (K4)
- CO6** Construct Jordan, minimal polynomial, and rational canonical forms to classify linear operators

Unit- I: (18 hours)

Linear transformations, null spaces, and ranges - the matrix representation of a linear transformation - combination of linear transformations and matrix multiplication - invertibility and isomorphism - the change of coordinate matrix.

(Chapter 2: Sections 2.1 - 2.5)

Unit- II: (18 hours)

Elementary matrix operations and elementary matrices - the rank of a matrix and matrix inverses - system of linear equations - theoretical aspects and computational aspects

(Chapter 3)

Unit- III: (18 hours)

Eigen values and eigenvectors - diagonalizability – invariant subspaces and Cayley Hamilton theorem.

(Chapter 5: Sections 5.1-5.2 and 5.4)

Unit- IV: (18 hours)

The Jordan canonical form 1 - the Jordan canonical form 2

(Chapter 7: Sections 7.1 to 7.2)

Unit- V: (18 hours)

The minimal polynomial- Rational Canonical Form

(Chapter 7: Sections 7.3 to 7.4)

Activity:

1. Write the matrix in the standard basis, then pick a random new basis and use the "Change of Coordinate" matrix to see how the numbers shift but the transformation stays the same

2. Solve systems of linear equations using elementary row operations and discuss solution strategies.
3. Interpret Jordan canonical form, minimal polynomial, and rational canonical form for given any one linear operators and classify them accordingly.
4. Use of MATLAB / Python / GeoGebra / online tools to compute matrix properties, eigenvalues, and canonical forms for enhanced conceptual understanding.

Text book:

Stephen H. Friedberg, Arnold J. Insel and Lawrence E. Spence, Linear Algebra, Fourth Edition, PHI Learning Private Limited, New Delhi, 2014.

Reference books:

1. Kenneth Hoffman and Ray Kunze, Linear Algebra, Second Edition, Pearson India Pvt. Ltd., 2017
2. S. Kumaresan, Linear Algebra, First edition, PHI learning, 2004.

E-Learning Sources:

1. https://onlinecourses.nptel.ac.in/noc24_ma04/preview
2. <https://nptel.ac.in/courses/111106135>
3. <https://www.coursera.org/specializations/linear-algebra-elementary-to-advanced>
4. <https://ocw.mit.edu/courses/18-06-linear-algebra-spring-2010/>

REAL ANALYSIS II

(Course Code : 26PMTTC22)

Semester - II Core - 5 Hours - 6 Credits – 5

Course Outcomes: By the end of the course the student will be able to

- CO1** Compute Lebesgue outer measure for intervals and simple sets on the real line (K3)
- CO2** Investigate the relationship between Riemann integrability and Lebesgue measurability (K4)
- CO3** Describe properties of Fourier coefficients and orthogonal systems (K2)
- CO4** Interpret the matrix form of the total derivative and mean value theorem (K2)
- CO5** Solve for implicit functions given a system with invertible Jacobian (K3)
- CO6** Evaluate extrema for real-valued functions of several variables with/without constraints (K5)

UNIT - I: (18 hours)

Measure on the Real line: Lebesgue Outer Measure - Measurable sets - Regularity - Measurable Functions - Borel and Lebesgue Measurability.

(Text book 1: Chapter – 2: 2.1 to 2.5)

UNIT - II: (18 hours)

Integration of Functions of a Real variable: Integration of Non- negative functions - The General Integral - Riemann and Lebesgue Integrals.

(Text book 1: Chapter – 3: 3.1, 3.2 and 3.4)

UNIT - III: (18 hours)

Fourier Series and Fourier Integrals: Introduction - Orthogonal system of functions - The theorem on best approximation - The Fourier series of a function relative to an orthonormal system - Properties of Fourier Coefficients - The Riesz-Fischer Theorem - The convergence and representation problems in for trigonometric series - The Riemann - Lebesgue Lemma - The Dirichlet Integrals - An integral representation for the partial sums of Fourier series - Riemann's localization theorem - Sufficient conditions for convergence of a Fourier series at a particular point – Cesaro summability of Fourier series- Consequences of Fejer's theorem - The Weierstrass approximation theorem

(Text book 2: Chapter 11 : 11.1 to

UNIT - IV: (18 hours)

Multivariable Differential Calculus: Introduction - The Directional derivative - Directional derivative and continuity - The total derivative - The total derivative expressed in terms of partial derivatives - The matrix of linear function - The Jacobian matrix - The

chain rule - Matrix form of chain rule - The mean - value theorem for differentiable functions - A sufficient condition for differentiability - A sufficient condition for equality of mixed partial derivatives - Taylor's theorem for functions of R^n to R^1 .

(Text book 2: Chapter 12 : 12.1 to 12.14)

UNIT - V:

(18 hours)

Implicit Functions and Extremum Problems: Functions with non-zero Jacobian determinants – The inverse function theorem-The Implicit function theorem-Extrema of real valued functions of severable variables-Extremum problems with side conditions.

(Text book 2: Chapter 13 : 13.1 to 13.7)

Text books:

1. G. de Barra, Measure Theory and Integration, Wiley Eastern Ltd., New Delhi, 1981.
2. Tom M.Apostol: Mathematical Analysis, 2nd Edition, Addison-Wesley Publishing Company Inc. New York, 1974.

Reference books:

1. Burkill, J.C. The Lebesgue Integral, Cambridge University Press, 1951.
2. Munroe, M.E. Measure and Integration. Addison-Wesley, Mass.1971.
3. Roydon, H.L. Real Analysis, Macmillan Pub. Company, New York, 1988.
4. Rudin, W. Principles of Mathematical Analysis, McGraw Hill Company, New York,1979.
5. Malik, S.C. and Savita Arora. Mathematical Analysis, Wiley Eastern Limited. New Delhi, 1991.
6. Sanjay Arora and Bansilal, Introduction to Real Analysis, Satya Prakashan, New Delhi, 1991.

E-Learning Sources:

- 1.<http://mathforum.org>,
- 2.<https://epgp.inflibnet.ac.in/Home/ViewSubject?atid=ZLCHeZEhCZ8yCri36nSF3A==>

PARTIAL DIFFERENTIAL EQUATIONS

(Course Code: 26PMTTC23)

Semester - II

Core - 6

Hours - 6

Credits - 4

Course Outcomes: By the end of the course the student will be able to:

- | | | |
|------------|---|------|
| CO1 | Recall definitions, classifications and basic concepts of first and second order partial differential equations | (K1) |
| CO2 | Explain the genesis, classification and physical significance of first and second order partial differential equations | (K2) |
| CO3 | Apply Charpit's method, Jacobi's method and separation of variables to solve standard partial differential equations problems | (K3) |
| CO4 | Analyze wave and heat conduction equations under different initial and boundary conditions | (K4) |
| CO5 | Evaluate boundary value problems using Dirichlet and Neumann conditions and maximum–minimum principles | (K5) |
| CO6 | Formulate and solve mathematical models for wave propagation and heat conduction in one-dimensional domains | (K6) |

UNIT - I:

(18 hours)

First order P.D.E – curves and surfaces – genesis of first order P.D.E – classification of integrals – linear equations of the first order – partial differential equations – compatible systems – Charpit's Method.

(Chapter 1: Sections 1.1 - 1.7)

UNIT - II:

(18 hours)

Jacobi's Method - Integral Surfaces through a given curve – quasi linear equations – non-linear first order P.D.E

(Chapter 1: Sections 1.8 - 1.11)

UNIT - III:

(18 hours)

Genesis of second order P.D.E – classification of second order P.D.E – one dimensional Wave Equation- vibration of an infinite string- vibration of semi- infinite string- vibration of a string of finite length (method of separation of variables)

(Chapter 2: Sections 2.1 - 2.3 (2.3.1, 2.3.2, 2.3.5 only))

UNIT - IV:

(18 hours)

Boundary value problem - maximum and minimum principles – the Cauchy problem – the dirichlet problem for the upper half plane – The Neumann problem for the upper half plane – The Dirichlet interior problem for a circle – The Dirichlet exterior problem for a circle- The Neumann problem for a circle – The Dirichlet problem for a rectangle – Harnack's Theorem.

(Chapter 2: Sections 2.4.1 – 2.4.10)

UNIT - V:

(18 hours)

Heat conduction problem – heat conduction – infinite rod case – heat conduction finite rod case – Duhamel's Principle – Wave Equation – Heat Conduction Equation

(Chapter 2: Sections 2.5.1 – 2.5.2 and 2.6.1-2.6.2)

Text book:

T. Amaranath, An Elementary Course in Partial Differential Equations, Second Edition, Narosa Publishing House, New Delhi, 2010.

Reference books:

1. Clive R. Chester, Techniques in Partial Differential Equations, McGraw-Hill, 1970.
2. I.N. Sneddon, Elements of Partial Differential Equations, Dover Publications Inc. 2006

E-Learning Sources:

1. <https://youtu.be/vZxgPhtLkPk?si=Q40SMiIGAUXoqHtt>
2. <https://youtu.be/nlYomL-A1RE?si=f8AytRRkhaP0sv9S>
3. <https://youtu.be/4O0r8CYY6Ac?si=oXfuUIIoFAvBl8g7>
4. <https://youtu.be/NChTSbYbeC8?si=bRWnRkzyRWI222cw>
5. <https://youtu.be/a7zqNXa8gUY?si=nCL1e7m0iHgJR-cS>

CALCULUS OF VARIATIONS AND INTEGRAL EQUATIONS

(Course Code: 26PMTE21)

Semester - II

EC -4

Hours - 5

Credits - 3

Course Outcomes: By the end of the course the students will be able to

- | | | |
|------------|--|------|
| CO1 | Describe variational problems involving one or more unknown functions | (K2) |
| CO2 | Solve geodesics and isoperimetric problems of standard types | (K3) |
| CO3 | Illustrate general variation of a functional | (K3) |
| CO4 | Discuss methods such as Hamilton's principle and Lagrange's equations | (K2) |
| CO5 | Classify Fredholm equations and Volterra integral equations with separable kernels and symmetric kernels | (K4) |
| CO6 | Summarize the relations between Linear differential equations and Volterra integral equations | (K5) |

UNIT - I:

(15 hours)

The calculus of variations - functionals – Euler's equations – geodesics – variational problems involving several unknown functions.
(Chapter 9: Sections 1 – 11)

UNIT - II:

(15 hours)

Functionals dependent on higher order derivatives – variational problems involving several independent variables – constraints and Lagrange multipliers - isoperimetric problems

(Chapter 9: Sections 12 - 15)

UNIT - III:

(15 hours)

The general variation of a functional – variational problems with moving boundaries – Hamilton's principle and Lagrange's equations - Sturm – Liouville's problems and variational methods – Rayleigh's principle – Ritz method.

(Chapter 9: Sections 16 – 21)

UNIT - IV:

(15 hours)

Integral equations – introduction – relation between differential and integral equations – relationship between linear differential equations and Volterra integral equations - The Green's function and its use in reducing boundary value problems to integral equations.

(Chapter 10: Sections 1 - 5)

UNIT - V:**(15 hours)**

Fredholm equations with separable kernels – Fredholm equations with symmetric kernels - Hilbert Schmidt theory – iterative methods for the solution of integral equations of the second kind – The Neumann series – orthogonal kernels.

(Chapter 9: Sections 6 - 11)**Activity:**

- Solve basic Euler's equation problems with worked examples.
- Solve constrained optimization problems using Euler-Lagrange equations.
- Identify different types of integral equations from given problems.

Textbook:

Dr. M.K. Venkataraman, Higher Mathematics for Engineering and sciences, The National Publishing Company, 2001.

Reference books:

1. M. D. Raisingania, Advanced Differential Equations, Seventeenth Revised Edition, S. Chand and Company Ltd, New Delhi, 1995.
2. M. D. Raisingania, Integral Equations and Boundary Value Problems, S. Chand and Company Ltd, New Delhi, 2016.

E-Learning Sources:

1. [https://phys.libretexts.org/Bookshelves/Classical_Mechanics/Variational_Principles_in_Classical_Mechanics_\(Cline\)/05%3A_Calculus_of_Variations](https://phys.libretexts.org/Bookshelves/Classical_Mechanics/Variational_Principles_in_Classical_Mechanics_(Cline)/05%3A_Calculus_of_Variations)
2. <https://youtu.be/VCHFCXgYdvY>
3. <https://youtu.be/GiPOQC5nYMs>

COMBINATORICS

(Course Code: 26PMTE21)

Semester - II

EC - 4

Hours - 5

Credits - 3

Course Outcomes: By the end of the course the student will be able to

CO1	Recall the concepts of permutation, combination and partition of integers	(K1)
CO2	Describe the concept of inclusion and exclusion principle	(K2)
CO3	Use the generating function as a tool to solve recurrence relations	(K3)
CO4	Analyze the linear homogeneous and non-linear recurrence relations	(K4)
CO5	Compare permutation and combination	(K5)
CO6	Assess Polya's counting formula	(K5)

Unit I:

(15 Hours)

The pigeon hole principle: Simple form, Strong form- Theorem of Ramsey -Four basic counting principles- Permutations of sets -Combinations of sets.

(Chapter 2 : Sections 2.1- 2.3 and Chapter 3 : Sections 3.1-3.3)

Unit II:

(15 Hours)

Permutations of multisets- Combinations of multisets-Generating permutations- Inversion in permutations- Generating combinations -Generating r-combinations

(Chapter 3: Sections 3.4- 3.5 and Chapter 4 : Sections 4.1-4.4)

Unit III:

(15 Hours)

Pascal's formula- The binomial theorem- Identities-Unimodality of binomial coefficients-The multinomial theorem- Newton's binomial theorem- The inclusion exclusion principle - Combinations with repetition- Derangements.

(Chapter 5: Sections 5.1-5.6 and Chapter 6 : Sections 6.1-6.3)

Unit IV:

(15 Hours)

Some number sequences- Linear homogeneous recurrence relations- Non-homogeneous recurrence relations -Generating functions - Recurrences and generating functions - Exponential generating function.

(Chapter 7: Sections 7.1-7.7)

Unit V:**(15 Hours)**

Permutation and symmetry groups - Burnside theorem - Polya's counting formula.

(Chapter 14: Sections 14.1- 14.3)

Text Book:

Richard A. Brualdi, Introductory Combinatorics, Fifth edition, Pearson Education, Inc., 2010.

Reference books:

1. C.L. Liu, Introduction to Combinatorial Mathematics, McGraw Hill, 1968. Chapters 1 to 5.
2. V. K. Balakrishnan, Combinatorics, schaum's outlines, First edition, TataMcGraw-Hill Publishing Company Limited, New Delhi, 1994.
3. Martin Aigner, A Course in Enumeration (Graduate text in Mathematics), Springer, 2007.

E -Learning Source:

<https://itk.ilstu.edu/faculty/chungli/DIS300/dis300chapter8.pdf>

NUMERICAL ANALYSIS

(Course Code: 26PMTE22)

Semester - II

EC-5

Hours - 5

Credits - 3

Course outcomes: By the end of the course the students will be able to

- CO1** Recall fundamental concepts of numerical errors, their sources, and basic error computation techniques (K1)
- CO2** Explain and compare numerical methods for solving algebraic and transcendental equations (K2)
- CO3** Apply interpolation techniques and finite difference methods to estimate function values and detect data errors (K3)
- CO4** Analyze numerical differentiation and integration methods, including Gaussian quadrature and Fourier integrals, for accuracy and efficiency (K4)
- CO5** Evaluate direct and iterative methods for solving linear systems and eigenvalue problems with respect to convergence and stability (K5)
- CO6** Develop and implement appropriate numerical algorithms to solve real-world mathematical problems (K6)

UNIT - I: Errors in Numerical Calculations (15 hours)

Mathematical preliminaries- Errors and their computations- A general error formula- Error in a series approximations.

(Chapter 1: 1.2-1.5)

UNIT - II: Solutions of algebraic and transcendental equations (15 hours)

The Bisection method- the method of False position-the iteration methods-Newton-Raphson method-The secant method-Muller's method.

(Chapter 2: 2.2-2.5,2.7,2.8)

UNIT - III: Interpolation (15 hours)

Errors in polynomial interpolation- finite differences-detection of errors by use of difference table-differences of a polynomial-Newton's formulae for interpolation-central difference interpolation formulae.

(Chapter 3: 3.2-3.7)

UNIT - IV: Numerical differentiation and integration (15 hours)

Numerical differentiation-numerical integration-Gaussian integration-numerical calculation of Fourier integrals.

(Chapter 5: 5.2-5.9)

UNIT - V: Matrices and linear systems of equations (15 hours)

Basic definitions-solution of linear systems -Direct methods-solution of linear systems-iterative methods-the Eigen value problem.

(Chapter 6: 6.2-6.5)

Text Book:

S.S. Sastry, Introductory Methods of Numerical Analysis, 4th Edition, Prentice-Hall of India private limited, 2006.

Reference Books:

1. Richard L. Burden and J. Douglas .Faires, Numerical Analysis, 9th Edition. Brooks/cole, Cengage Learning.
2. K.E. Atkinson, An introduction to Numerical Analysis, 2nd Edition, John Wiley, 2008.
3. Kindall Atkinson, Weiman Han, Elementary Numerical Analysis, 3rd Edition John Wiley & Sons, Inc.
4. M.T.Heath, Scientific Computing: An Introductory Survey, McGraw Hill, 2002.

E-Learning Sources:

1. <https://www.scribd.com/document/206674612/An-introduction-to-Numerical-Analysis>
2. <https://www.scribd.com/document/395892018/Numerical-Analysis-Book49>
3. <https://www.aerostudents.com/courses/applied-numerical-analysis/IntroductoryMethodsOfNumericalAnalysis.pdf>

NUMBER THEORY AND CRYPTOGRAPHY

(Course Code: 26PMTE22)

Semester - II

EC-5

Hours - 5

Credits – 3

Course Outcomes: By the end of the course the students will be able to

- | | | |
|------------|--|------|
| CO1 | Recall fundamental definitions and concepts in number theory | (K1) |
| CO2 | Discuss the concept of congruence, Euler's theorem, Wilson's theorem and Euclidean Algorithm | (K2) |
| CO3 | Apply quadratic residues, reciprocity laws and Chinese remainder theorem in problem solving | (K3) |
| CO4 | Solve problems involving arithmetic functions, Möbius inversion and Diophantine equations | (K3) |
| CO5 | Evaluate number theoretic sums and representations as sum of powers and sum of squares | (K5) |
| CO6 | Apply number theory concepts in cryptography | (K6) |

UNIT - I:

(15 hours)

Ramanujam's contribution to number theory - Divisibility and Euclidean algorithm - Congruence's - Euler's theorem - Wilson's Theorem

(Text Book 3 – Chapter P: Sections: P4, P5, P6 Text Book 1-Sections: 1.2, 2.1)

UNIT - II:

(15 hours)

Chinese Remainder Theorem- Quadratic residues - Quadratic reciprocity – The Jacobi symbol.

(Text Book 1-Sections: 2.3, 3.1-3.3)

UNIT - III:

(15 hours)

Arithmetic functions – The Mobius Inversion formula - Multiplication of arithmetic functions.

(Text Book 1-Sections: 4.2-4.3)

UNIT - IV:

(15 hours)

Linear Diophantine equations – Sum of Four and Five Squares – Sum of Fourth Powers - Sum of Two Squares.

(Text Book 2- Sections: 2.4. 12.2-12.3-5.4)

UNIT - V:

(15 hours)

Public key Cryptography – Concepts of public key Cryptography – RSA – Discrete logarithm – Elliptic curve Cryptography.

(Text Book 2- Sections: 7.5)

Activity:

- Solve problems involving congruences and apply modular arithmetic to real-life situations like clock arithmetic and calendar problems.

- Implement basic public key cryptographic techniques such as RSA using small prime numbers and explain the role of number theory in secure communication

Text Books:

1. An Introduction to Theory of Numbers by Ivan Niven and Herbert Zuckerman, Third Edition, 1972, Wiley Eastern Limited, New Delhi.
2. David M. Burton, Elementary Number Theory, Wm. C. Brown Publishers, Dubuque, Iowa, 1989.
3. Ramanujan, The Man and The Mathematician by S. R. Ranganathan, Asia Pub. House (Great thinkers of India series), 1967

Reference Books:

1. Tom Apostol, Introduction to Analytic Number theory, Narosa Publications, New Delhi
2. Neal Koblitz, A Course in Number Theory and Cryptography, Springer-Verlag, New York, 1987.
3. Cryptography and Network Security Principles and Practice by William Stallings, Prentice Hall, Fifth Edition, New Delhi, 2011.

E-Learning Sources:

1. [https://uou.ac.in/sites/default/files/slm/MIT\(CS\)-204.pdf](https://uou.ac.in/sites/default/files/slm/MIT(CS)-204.pdf)

TRAINING FOR MATHEMATICAL COMPETITIVE EXAMINATIONS – I

(Course Code: 26PMTS21)

Semester - II **SEC- 1** **Hours - 2** **Credits - 2**

Course Outcomes: By the end of the course the student will be able to

- | | | |
|------------|--|------|
| CO1 | Recall Archimedean property, supremum and infimum | (K1) |
| CO2 | Discuss the convergence of sequences and Bolzano–Weierstrass theorem | (K2) |
| CO3 | Apply infimum and supremum in various problems related to them | (K4) |
| CO4 | Test the uniform convergence of sequence and series of functions | (K5) |
| CO5 | Compare continuous, uniform continuous and differentiable functions | (K5) |
| CO6 | Build the mental ability to face GATE, CSIR and SET examinations | (K6) |

Unit - I: (6 Hours)

Problems in elementary set theory, finite -countable and uncountable sets - Real number system as a complete ordered field - Archimedean property – Supremum and Infimum.

Unit - II: (6 Hours)

Problems in real sequences and Series – Convergence – limsup and liminf - Bolzano Weierstrass theorem.

Unit - III: (6 Hours)

Problems in continuity - Uniform Continuity – Differentiability - Mean Value Theorem in Real Number System.

Unit - IV: (6 Hours)

Problems in contour integral, Cauchy's theorem - Cauchy's integral formula - Liouville's theorem, Maximum modulus principle - Schwarz lemma - Open mapping theorem.

Unit - V: (6 Hours)

Problems in Taylor series, Laurent series, calculus of residues, Conformal mappings, Mobius transformations.

Reference:

Previous year CSIR – NET Mathematical Sciences Question papers.

E-Learning Sources: <https://csirhrdg.res.in/Home/Index/1/Default/2769/81>

QUESTION PATTERN

Internal Assessment (CIA)

Part A	$10 \text{ MCQ} \times 2 \text{ marks} = 20$
Part B	$10 \text{ MSQ (Descriptive)} \times 5 \text{ marks} = 50$
Total Marks	70

Semester Examination

Part A	$20 \text{ MCQ} \times 2 \text{ marks} = 40$
Part B	Answer 15 MSQ Questions (out of 20) $\times 4 \text{ marks} = 60 \text{ marks}$
Total Marks	100

TOPOLOGY

(Course Code : 26 PMTC31)

Semester - III **Core - 7** **Hours - 6** **Credits - 5**

Course Outcomes: By the end of the course the student will be able to

- | | | |
|------------|--|------|
| CO1 | Define and illustrate the concept of topological spaces and the basic definitions of open sets, neighbourhood, interior, exterior, closure and their axioms for defining topological space | (K1) |
| CO2 | Understand continuity, compactness, connectedness, homeomorphism and topological properties | (K2) |
| CO3 | Analyze and apply the topological concepts in Functional Analysis | (K4) |
| CO4 | Determine whether a given point in a topological space is a limit point of a given subset | (K3) |
| CO5 | Develop qualitative tools to characterize connectedness, compactness, second countable and Hausdorff spaces | (K6) |
| CO6 | Develop tools to identify when two spaces are equivalent (homeomorphic) | (K6) |

UNIT-I : (18 hours)

Topological spaces : Topological spaces – Basis for a topology – The order topology – The product topology on $X \times Y$ – The subspace topology – Closed sets and limit points.

Chapter 2 : Sections 12 to 17.

UNIT-II (18 hours)

Continuous functions: Continuous functions – the product topology – The metric topology.

Chapter 2 : Sections 18 to 21 (Omit Section 22).

UNIT-III : (18 hours)

Connectedness: Connected spaces- connected subspaces of the Real line – Components and local connectedness.

Chapter 3 : Sections 23 to 25.

UNIT-IV : (18 hours)

Compactness : Compact spaces – compact subspaces of the Real line – Limit Point Compactness – Local Compactness.

Chapter 3 : Sections 26 to 29.

UNIT-V: (18 hours)

Countability and Separation Axiom: The Countability Axioms – The separation Axioms – Normal spaces – The Urysohn Lemma – The Urysohn metrization Theorem – The Tietz extension theorem - Narasiman - Seshadri theorem (Statement only)

Chapter 4 : Sections 30 to 35 and E-Learning Sources 3.

Activity:

- Identifying compact sets on the Real line (using Heine-Borel theorem) and other spaces. Exploring limit point compactness and local compactness. Solving questions related to these concepts in NET and other examinations.
- Problems on exploring Normed spaces, verifying completeness in Banach spaces, Analyzing Linear operators (checking linearity and boundedness conditions)

Text book:

James R. Munkres, *Topology* (2nd Edition) Pearson Education Pvt. Ltd., Delhi-2002 (Third Indian Reprint)

Reference books:

1. J. Dugundji, *Topology*, Prentice Hall of India, New Delhi, 1975.
2. George F. Simmons, *Introduction to Topology and Modern Analysis*, McGraw Hill Book Co., 1963.
3. J.L. Kelly, *General Topology*, Van Nostrand, Reinhold Co., New York.
4. L. Steen and J. Subhash, *Counter Examples in Topology*, Holt, Rinehart and Winston, New York, 1970.
5. S. Willard, *General Topology*, Addison - Wesley, Mass., 1970.

E-Learning Sources:

1. <http://mathforum.org>
2. <http://ocw.mit.edu/ocwweb/Mathematics>
3. <http://www.opensource.org>
4. <http://en.wikipedia.org>
5. <https://projecteuclid.org/journals/journal-of-differential-geometry/volume-18/issue-2/A-new-proof-of-a-theorem-of-Narasimhan-and-Seshadri/10.4310/jdg/1214437664.full>

COMPLEX ANALYSIS

(Course Code : 26PMT32)

Semester - III

Core - 8

Hours - 6

Credits - 5

Course Outcomes: By the end of the course the student will be able to

- CO1** Explain fundamental concepts of analytic functions and complex integration (K2)
- CO2** Apply Cauchy's theorems and integral formulas to solve problems (K3)
- CO3** Analyze singularities, zeros, poles, and mapping properties of analytic functions (K4)
- CO4** Evaluate complex and real integrals using residue theory and argument principle (K5)
- CO5** Represent analytic functions using Taylor, Laurent series and infinite products (K5)
- CO6** Interpret harmonic and elliptic functions, including Weierstrass functions and periodicity (K2)

UNIT-I :

Line integrals - Cauchy's theorem for a rectangle - Cauchy's theorem in a disk - Index of a point with respect to a closed curve - Cauchy's integral formula - Higher derivatives. (18 hours)

Chapter 4 : Section 1.1-1.4, 1.5, 2.1-2.3

UNIT-II :

Removable singularities - Taylor's theorem - Zeros and poles - The local mapping theorem - The maximum principle - Definition of Chains and Cycles - Simple connectivity - Homology - The general statement of Cauchy's theorem - Multiply connected regions. (18 hours)

Chapter 4: Sections 3.1-3.4, 4.1-4.5, 4.7

UNIT-III :

The Residue theorem - The argument principle - Evaluation of Definite integrals including Exercise problems)- Definition and basic properties of Harmonic functions - The mean value properties - Poisson's formula. (18 hours)

Chapter 4: Sections 5.1-5.3, 6.1-6.3

UNIT-IV :

Weierstrass's theorem - The Taylor's series - The Laurent series - partial fractions - Infinite product - Canonical products - The Gamma function - Jensen's formula. (18 hours)

Chapter 5: Sections 1.1-1.3, 2.1-2.4, 3.1

UNIT-V:

Representation by exponentials - The period module - Unimodular transformation - General properties of elliptic functions - The Weierstrass p - function - The functions $\zeta(z)$ and $\sigma(z)$ - The Differential equation. (18 hours)

Chapter 7: Sections 1.1, 2.1, 2.2, 2.4, 3.1-3.3

Activity:

1. Pick a polynomial, using the Argument Principle, determine how many roots lie within the unit disk $|z| < 1$ by analyzing the change in argument along the boundary.
2. Demonstrate how a change of basis (unimodular transformation) affects the period module, and why the lattice itself remains unchanged.
3. Choose a closed curve that loops multiple times around several points. Calculate the winding number for points in different regions.
4. Solve a real integral that is impossible in standard calculus such as $\int_0^{\infty} \frac{\sin x}{x} dx$ by constructing a semicircular contour in the complex plane and applying the Residue Theorem.

Text book:

Lars V. Ahlfors, Complex Analysis, (3rd Edition) McGraw Hill Book Company, New York, 1979.

Reference books:

1. H.A. Presfly, Introduction to complex Analysis, Clarendon Press, oxford, 1990.
2. J.B. Corway, Functions of one complex variables, Springer - Verlag, International student Edition, Narosa Publishing Co.1973.
3. E. Hille, Analytic function Thorey (2 vols.), Gonm& Co, 1959.
4. M.Heins, Complex function Theory, Academic Press, New York,1968.

E-learning Resources:

1. <https://nptel.ac.in/courses/111106141>
2. <https://nptel.ac.in/courses/111103070>
3. <https://www.coursera.org/learn/complex-analysis>
4. https://onlinecourses.nptel.ac.in/noc25_ma66/preview?utm_source=chatgpt.com
5. https://www.coursera.org/learn/complex-analysis?utm_source=chatgpt.com
6. <https://www.edx.org/>

MECHANICS

(Course Code: 26PMT C33)

Semester - III

Core – 9

Hours - 5

Credits - 4

Course outcomes: By the end of the course the students will be able to

- CO1** Explain the fundamental concepts of mechanics of particles and systems of particles, constraints, D'Alembert's principle, and Lagrange's equations (K2)
- CO2** Apply Lagrangian formulation and Hamilton's principle to derive equations of motion for simple mechanical systems including non-holonomic systems (K3)
- CO3** Analyze central force motion, reduction to one-body problem, classification of orbits, Kepler's problem, and motion under inverse square law forces (K4)
- CO4** Analyze rigid body dynamics using inertia tensor, principal axes transformation, Euler's equations, torque-free motion, and motion of a heavy symmetric top (K4)
- CO5** Evaluate mechanical systems using Hamiltonian formulation, cyclic coordinates, Routh's procedure, conservation theorems, and principle of least action (K5)
- CO6** Develop and formulate advanced solutions to classical mechanics problems using variational principles and generalized coordinate methods (K6)

UNIT - I:

(15 hours)

Mechanics of a particle - Mechanics of a system of particles – Constraints - D'Alembert's principle and Lagrange's equations - Simple applications of the Lagrangian formulation.

(Chapter 1: Sections 1.1 - 1.4 and 1.6)

UNIT- II:

(15 hours)

Hamilton's principle - Some techniques of the calculus of variations - Derivation of Lagrange's equations from Hamilton's principle - Extension of Hamilton's principle to non holonomic systems - Simple applications.

(Chapter 2: Sections 2.1 - 2.4)

UNIT- III:

(15 hours)

Reduction to the equivalent one body problem - The equation of motion and first integrals - The equivalent one dimensional problem and classification of orbits - The Virial theorem - The differential equation for the orbit and integrable power law potentials - The Kepler's problem : Inverse square law of force - The motion in time in the Kepler problem.

(Chapter 3: Sections 3.1 - 3.5, 3.7 and 3.8)

UNIT- IV:**(15 hours)**

Angular momentum and Kinetic Energy of motion about a point - Tensors and dyadics - The inertia tensor and the moment of inertia - The eigen values of the inertia tensor and the principal axis transformation - Methods of solving rigid body problems and the Euler's equations of motion - Torque free motion of a rigid body - The heavy symmetrical top with one point fixed.

(Chapter 5: Sections 5.1 - 5.7)**UNIT- V:****(15 hours)**

The Hamilton equations of motion - Cyclic co-ordinates and conservation theorems - Routh's procedure - Derivation of Hamilton's equations from a variational principle - The principle of least action.

(Chapter 8: Sections 8.1 - 8.3, 8.5 and 8.6)**Text book:**

Herbert Goldstein, Classical Mechanics, Second edition, Narosa Publishing House, 2018

Reference books:

1. Donald T. Greenwood, Principles of Dynamics, Second edition, Pearson College Division, 1988.
2. N. C. Rana P. S. Joag, Classical Mechanics, Tata McGraw-Hill Education Pvt. Ltd., 2015.

E-Learning Source:

<https://www.physics.rutgers.edu/~shapiro/507/book.pdf>

GRAPH THEORY AND APPLICATIONS

(Course Code: 26PMTTC34)

Semester - III

Core -10

Hours - 5

Credits - 4

Course Outcomes: By the end of the course the student will be able to:

CO1	Identify the types of graphs	(K1)
CO2	Determine the chromatic number and domination number	(K3)
CO3	Generate graph models for real time problems	(K6)
CO4	Solve real time problems using various methods in graph theory	(K3)
CO5	Illustrate various characteristics of graphs	(K4)
CO6	Categorize the graphs using isomorphism	(K4)

UNIT- I: (12 hours)

Graphs and graph models- connected graphs – common classes of graphs – the degree of a vertex – regular graphs – degree sequence.

(Chapter 1: Sections 1.1-1.3; Chapter 2: Sections 2.1-2.3)

UNIT - II: (12 hours)

The definition of isomorphism – isomorphism as a relation - bridges – trees - Cut vertices – Blocks.

(Chapter 3: Sections 3.1-3.2; Chapter 4: Sections 4.1-4.2; Chapter 5: Sections 5.1-5.2)

UNIT - III: (12 hours)

Connectivity-Eulerian graphs - Hamiltonian graphs – Strong digraphs – Tournaments

(Chapter 5: Section 5.3; Chapter 6: Sections 6.1-6.2;

Chapter 7: Sections 7.1-7.2)

UNIT - IV: (12 hours)

Matchings – factorization - planar graphs

(Chapter 8: Sections 8.1-8.2; Chapter 9: Sections 9.1)

UNIT - V: (12 hours)

The four color problem - vertex coloring - edge coloring -The center of a graph-Distant vertices-The domination number of a graph

(Chapter 10: Sections 10.1 - 10.3; Chapter 12: Section 12.1-12.2;

Chapter 13: Section 13.1)

Activity :

- Graph Exploration Activity: Students categorize different types of graphs using diagrams.
- Degree Calculation Exercise: Compute vertex degrees and identify regular graphs.
- Isomorphism Identification Task: Given pairs of graphs, determine if they are isomorphic.
- Tree Construction Activity: Create spanning trees from a given graph
- Hands-on Problem Solving: Analyze bridge removal effects on connectivity.

Text book:

Gary Chartrand and Ping Zhang, Introduction to Graph Theory, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2006.

Reference books:

1. J. A. Bondy and U. S. R. Murty, Graph theory with applications, The MacMillan Press Ltd., 1976.
2. Choudum, A First Course in Graph Theory, Laxmi Publications, 2000.

OBJECT ORIENTED PROGRAMMING WITH JAVA

(Course Code: 26PMTE31)

Semester - III

EC-6

Hours - 4

Credits - 2

Course outcomes: By the end of the course the students will be able to

CO1	Recall OOPS, data types and operators in Java	(K1)
CO2	Discuss control statements, loops, classes, objects, methods and constructors	(K2)
CO3	Explain inheritance, packages and interfaces	(K2)
CO4	Use exception handling in program execution	(K3)
CO5	Analyze mathematical problems using the above concepts	(K4)
CO6	Create own threads in Java	(K6)

UNIT - I: (12 hours)

Overview of Java language - data types - variables - arrays.

(Chapters 2 and 3)

UNIT - II: (12 hours)

Operators - control statements.

(Chapters 4 and 5)

UNIT - III: (12 hours)

Introducing classes – A closer look at methods and classes.

(Chapters 6 and 7)

UNIT - IV: (12 hours)

Inheritance - packages and interfaces.

(Chapters 8 and 9)

UNIT - V: (12 hours)

Exception handling - multi threaded programming.

(Chapters 10 and 11)

Text book:

Java 2, The Complete Reference, Herbert Schildt, 5th Edition, Tata McGraw Hill, 1999.

Reference books:

1. E. Balagurusamy, Programming with Java : A Primer Second edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2000.
2. Herbert Schildt, Java 2, The Complete Reference, Fourth edition, Tata McGraw Hill, 2001.

E-Learning Sources:

https://www.google.com/url?sa=t&source=web&rct=j&opi=89978449&url=https://www.youtube.com/playlist%3Flist%3DPLfn3cNtmZdPOe3R_wO_h540QNfMkCQ0ho&ved=2ahUKEwjhi6jo5rySAxU3SGcHHU69I0sQFnoECEEQAQ&usg=AOvVaw1UxERKwTN2LwDd6Pp4hqoR

OBJECT ORIENTED PROGRAMMING WITH JAVA PRACTICAL

(Course Code:26PMTE32)

Semester - III

EC-7

Hours - 2

Credit – 2

Course outcomes: By the end of the course the student will be able to

CO1	Recall control statements, loops, classes, objects, methods and constructors	(K1)
CO2	Discuss exception handling in program execution	(K2)
CO3	Illustrate inheritance, packages and interfaces using different programs	(K3)
CO4	Analyze mathematical problems using the above concepts	(K4)
CO5	Compare overloading and overriding methods	(K5)
CO6	Create multi-threads in JAVA programs	(K6)

1. Simple Java Programs
2. Programs using 1-D, 2-D arrays
3. Programs using control statements
4. Programs using classes and objects
5. Programs using overloading
6. Programs using overriding and inheritance
7. Programs using interface
8. Programs using package
9. Programs using threading concept
10. Programs using exception handling

Note: To input values, use assignment statement method or use command - line arguments.

ADVANCED PHP ARCHITECTURE AND BACKEND DESIGN

(Course Code: 26PMTE31)

Semester - III

EC-6

Hours - 4

Credits - 2

Course Outcomes: By the end of the course the student will be able to

- | | | |
|------------|---|------|
| CO1 | Understand PHP fundamentals and backend logic | (K2) |
| CO2 | Apply PHP and OOP concepts to backend development | (K3) |
| CO3 | Analyze and design database-driven architectures | (K4) |
| CO4 | Design secure and scalable backend components | (K5) |
| CO5 | Create optimized and deployable backend applications | (K6) |
| CO6 | Implement version control using Git and deploy a complete PHP backend project in a production environment | (K3) |

Unit- I: (12 hours)

PHP Fundamentals & Mathematical Logic

PHP syntax, variables, data types- Control structures and recursion- Arrays and mathematical computations - Precision and number handling

Unit- II: (12 hours)

Object-Oriented PHP & Design Principles

OOP concepts and SOLID principles- MVC architecture - Code modularity and reusability

Unit- III: (12 hours)

Database Design & Backend Data Modeling

Relational databases and normalization - MySQL with PHP (PDO) - CRUD operations and query Optimization

Unit- IV: (12 hours)

Backend Architecture & APIs

RESTful API design - Authentication and authorization - Session handling and error logging

Unit- V: (12 hours)

Security, Optimization & Deployment

Backend security threats and prevention - Performance optimization - Version control using Git - Deploy a PHP backend project using Git

Text book:

1. “PHP & MySQL: Novice to Ninja”by *Kevin Yank*
2. “Modern PHP: New Features and Good Practices”by *Josh Lockhart*
3. “Learning PHP, MySQL & JavaScript”by *Robin Nixon*

E-Learning Sources:

1. <https://www.php.net/docs.php>
2. <https://dev.mysql.com/doc/>

Reference book:

1. “Design Patterns: Elements of Reusable Object-Oriented Software”
by *Erich Gamma, et al.*
– Classic text on software design patterns relevant to backend architecture.
2. “Web Application Architecture: Principles, Protocols and Practices”
by *Leon Shklar & Richard Rosen*
– Broad view of web backend architecture, best practices and security.
3. “Database System Concepts”
by *Abraham Silberschatz, Henry F. Korth, & S. Sudarshan*
– Comprehensive book on database design and optimization (useful for Unit III).
4. “REST API Design Rulebook”
by *Mark Masse*
– Practical guide to designing scalable backend services.
5. “The Pragmatic Programmer”
by *Andrew Hunt & David Thomas*
– Useful for coding best practices, project structuring, and professional habits.

Skill-Oriented Content

- Translating mathematical algorithms into PHP functions
- Backend problem decomposition using OOP
- Data modeling using set theory and relations
- API design using logical flow
- Security validation using mathematical constraints
- Performance analysis using complexity estimation

Learning Activities

- Implement mathematical series and recursive functions in PHP
- Convert mathematical formulas into backend logic
- Design PHP classes for mathematical entities (Matrix, Graph, Set)
- Apply MVC pattern to a mini backend project
- Design normalized databases for mathematical datasets
- Implement CRUD operations with optimized queries

- Build a REST API for mathematical computation services
- Implement authentication for backend access
- Secure backend application against common attacks
- Deploy a PHP backend project using Git

E-Learning Sources:

- PHP Official Documentation – php.net
- W3Schools PHP Tutorials
- Laravel Documentation (for architecture concepts)
- FreeCodeCamp – Backend Development
- MySQL Official Documentation
- SQLZoo (interactive SQL)
- Martin Fowler – Software Architecture articles
- Clean Code concepts (Robert C. Martin – videos/articles)

ADVANCED PHP ARCHITECTURE AND BACKEND DESIGN PRACTICAL
(Course Code: 26PMTE32)

Semester - III

EC-7

Hours - 2

Credit – 2

Course Outcomes: By the end of the course the student will be able to

- | | | |
|-----|--|------|
| CO1 | Explain PHP fundamentals, control structures, recursion, arrays and mathematical computations for backend logic | (K2) |
| CO2 | Apply object-oriented PHP concepts and SOLID principles to develop modular and reusable components | (K3) |
| CO3 | Analyse relational database schemas and perform optimized CRUD operations using MySQL with PHP (PDO) | (K4) |
| CO4 | Design RESTful APIs with authentication, authorization, session handling and structured error management | (K5) |
| CO5 | Develop secure and scalable backend applications by addressing common security threats and performance optimization techniques | (K6) |
| CO6 | Implement version control using Git and deploy a complete PHP backend project in a production environment | (K3) |

List of Practicals

1. Write PHP programs to demonstrate variables, data types, operators and simple mathematical computations.
2. Develop PHP programs using control structures and recursion (factorial / Fibonacci).
3. Implement PHP programs for array manipulation and precision-based number handling.
4. Create a PHP class with properties and methods and demonstrate object creation and method invocation.
5. Develop a PHP application to illustrate inheritance, polymorphism and encapsulation.
6. Connect PHP with MySQL using PDO and perform database and table creation.
7. Implement CRUD operations for a database-driven application with query optimization.
8. Design and test a simple RESTful API using PHP.
9. Develop a login and logout module with authentication, session handling and error logging.
10. Implement input validation, password hashing, manage the project using Git and deploy the PHP backend application.

MATHEMATICAL COMPUTING AND VISUALIZATION USING SAGEMATH

(Course Code: 26PMTE31)

Semester - III

EC - 6

Hours: 4

Credit: 2

Course Outcomes: By the end of the course the students will be able to

- CO1** Illustrate mathematical concepts using SageMath through 2D and 3D graphics including curves, vector fields, and contour plots (K3)
- CO2** Explain and apply computational domains, object-oriented structures, and symbolic computation in SageMath (K2)
- CO3** Perform computations in polynomial rings including factorization, roots, rational functions, and power series (K3)
- CO4** Construct and analyze matrices using computational methods including normal forms, eigenvalues, and spectral decomposition (K4)
- CO5** Solve ordinary and partial differential equations analytically and numerically using SageMath (K4)
- CO6** Apply computational thinking and SageMath tools to model, experiment, and solve advanced mathematical problems (K5)

UNIT-I: (18 hours)

2D Graphics – Drawing Curves – Graphical Representation of a Function – Parametric Plot – Curves in Polar Coordinates – Curve defined by an Implicit Equation – Vector Fields – Complex Functions – Density and Contour Plots – Data Plot – More Graphic Primitives – 3D Graphics – Plotting Functions – Drawing the Graph of a Function – Parametric Plots – Implicit Plot – Vector Fields – More Graphic Primitives

(Chapter 6: 6.1–6.6 & Chapter 7: 7.1–7.3)

UNIT-II: (18 hours)

Sage is Object-Oriented – Elements and Parents – Domains with a Normal Form – Elementary Domains – Compound Domains – Expressions vs Computational Domains – Symbolic Polynomials vs Polynomial Rings – Applications – Example: The Aliquot Sequence – Primality Test

(Chapter 8: 8.1–8.5)

UNIT-III: (18 hours)

Polynomial Rings – Euclidean Arithmetic – Divisibility – Ideals and Quotients – Factorization and Roots – Rational Functions – Formal Power Series – Operations on Truncated Power Series – Applications – Lazy Power Series

(Chapter 9: 9.1–9.4)

UNIT-IV:**(18 hours)**

Matrices – Constructions and Elementary Manipulations – Matrix Spaces and Groups – Matrix and Vector Constructions – Basic Manipulations – Matrix Computations – Gaussian Elimination – Linear System Solving – Spectral Decomposition – Eigenvalues – Eigenvectors – Jacobi Normal Form

(Chapter 10: 10.1–10.3)**UNIT-V:****(18 hours)**

First Order ODEs – Types of First Order ODEs – Parametric Equations – Numerical Solving – Second Order Equations – Heat Equation – Laplace Transform – Systems of Differential Equations – Numerical Methods

(Chapter 12: 12.1–12.4)**Text Books:**

Dr. Saskia Roos and Michael Jung, An Introductory Course on Sage.

References:

1. Paul Zimmermann, Mathematical Computation with Sage, available from sagemath.org.
2. Robert Beezer, A First Course in Linear Algebra, available online at linear.ups.edu.
3. Tom Judson and Robert Beezer, Abstract Algebra: Theory and Applications, abstract.ups.edu.
4. Razvan A. Mezei, An Introduction to SAGE Programming: With Applications to SAGE Interacts for Numerical Methods, Springer.
5. Ajit Kumar and Vikash Bist, Group Theory: An Expedition with SageMath, Narosa, 2021.

E-Learning Sources:

1. www.sagemath.org
2. <http://linear.ups.edu/>
3. <http://abstract.ups.edu/>

MATHEMATICAL COMPUTING AND VISUALIZATION USING SAGEMATH

PRACTICAL

(Course Code: 26PMTE22)

Semester - III

EC - 7

Hours: 2

Credit: 2

Course Outcomes: By the end of the course the students will be able to

- | | | |
|------------|---|------|
| CO1 | Understand SageMath syntax, computational domains, parents, polynomial rings, and matrix construction concepts for performing mathematical computations | (K2) |
| CO2 | Apply SageMath to perform polynomial arithmetic operations, factorization, root finding, power series expansion, matrix operations, and solving linear systems | (K3) |
| CO3 | Apply 2D plotting techniques in SageMath to generate and interpret basic function plots, parametric and polar plots, implicit curves, vector fields, stream plots, density plots, and contour plots | (K3) |
| CO4 | Analyze multivariable functions and geometric structures using 3D surface plots, parametric and implicit 3D plots, and visualization of computational domains | (K4) |
| CO5 | Analyze and solve eigenvalue problems and systems of differential equations using SageMath and interpret the obtained results | (K4) |
| CO6 | Evaluate numerical solutions of first-order differential equations and systems of differential equations for mathematical modeling and computational problem solving using SageMath | (K5) |

Program List

1. Plotting basic functions using 2D graphics in SageMath.
2. Parametric and polar plots of curves.
3. Visualization of vector fields and stream plots.
4. 3D surface plotting of functions.
5. Parametric and implicit 3D plots.
6. Working with computational domains and parents.
7. Factorization and root finding of polynomials.
8. Matrix construction and elementary operations.
9. Solving linear systems and eigenvalue problems.
10. Solving first order differential equations numerically.

TRAINING FOR MATHEMATICAL COMPETITIVE EXAMINATIONS - II

(Course Code: 26PMTS31)

Semester - III

SEC- 2

Hours - 2

Credits - 2

Course Outcomes: By the end of the course the student will be able to

- CO1** Apply basic probability concepts including Bayes' theorem and independence (K3)
- CO2** Analyze random variables, distribution functions, expectation, and moments (K4)
- CO3** Evaluate joint, marginal, conditional distributions and MGFs (K4)
- CO4** Explain probability inequalities, convergence concepts, LLN and CLT (K2)
- CO5** Apply standard probability distributions to solve problems (K3)
- CO6** Use sampling distributions and perform hypothesis testing and ANOVA (K3)

Unit - I: (6 Hours)

Problems in Sample space – Discrete Probability – Independent events – Baye's theorem – Random variables and Distribution functions (Univariate and Multivariate) – Expectation and Moments.

Unit - II: (6 Hours)

Problems in Moment Generating function – Characteristic functions and Cumulants – Independent Random variables – Marginal and conditional distributions.

Unit - III: (6 Hours)

Problems in Probability inequalities (Tchebyshev, Markov, Jensen) – Modes of convergence, Weak and Strong laws of large numbers – Central limit theorem

Unit - IV: (6 Hours)

Problems in Probability distributions – Binomial, Poisson, Uniform, Normal, Exponential, Gamma, Beta, Cauchy distributions.

Unit - V: (6 Hours)

Problems in Standard Errors – Sampling distributions of t, F and Chi square and their uses in tests of significance – ANOVA – Large sample tests for mean and proportions.

E-Learning Sources:

Previous year PG TRB Mathematics Question papers.

Ref: https://www.tamilaruvi.in/2021/09/pg-trb-maths-previous-year-all-original-question-paper-collections-download-pdf.html?utm_source=chatgpt.com

QUESTION PATTERN

Internal Assessment (CIA)

Part A	10 MCQ $\times$ 2 marks = 20
Part B	10 MSQ (Descriptive) $\times$ 5 marks = 50
Total Marks	70

Semester Examination

Part A	20 MCQ $\times$ 2 marks = 40
Part B	Answer 15 MSQ Questions (out of 20) $\times$ 4 marks = 60 marks
Total Marks	100

FUNCTIONAL ANALYSIS

(Course Code: 26PMTC41)

Semester - IV

Core - 11

Hours - 5

Credits - 4

Course Outcomes: By the end of the course the student will be able to

- | | | |
|------------|---|------|
| CO1 | Explain the structure and properties of normed spaces, Banach spaces, finite dimensional spaces, and compactness | (K2) |
| CO2 | Apply bounded and continuous linear operators, operator norms, and linear functionals in solving problems | (K3) |
| CO3 | Use dual spaces and spaces of operators to analyze linear mappings on finite and infinite dimensional spaces | (K3) |
| CO4 | Analyze inner product and Hilbert spaces using orthogonality, orthonormal sets, complements, and direct sums | (K4) |
| CO5 | Analyze adjoint, self-adjoint, unitary, and normal operators and represent functionals on Hilbert spaces | (K4) |
| CO6 | Evaluate and apply major theorems such as Hahn–Banach, Uniform Boundedness, Open Mapping, Closed Graph, and reflexivity results | (K5) |

Unit - I: (15 hours)

Normed space. Banach space - Further properties of normed spaces - Finite dimensional normed spaces and subspaces - Compactness and finite dimension -Linear operators.

(Chapter 2 - Sections 2.2 – 2.6)

Unit - II: (15 hours)

Bounded and Continuous Linear Operators - Linear Functionals - Linear Operators and Functionals on Finite Dimensional Spaces - Normed Spaces of Operators. Dual Space.

(Chapter 2 - Section 2.7 to 2.10)

Unit - III: (15 hours)

Inner Product Space. Hilbert Space - Further Properties of Inner Product Space - Orthogonal Complements and Direct Sums - Orthonormal Sets and Sequences - Total Orthonormal Sets and Sequences.

(Chapter 3 - Sections 3.1 to 3.4 and 3.6)

Unit-IV: (15 hours)

Representation of Functionals on Hilbert spaces - Hilbert Adjoint Operators- Self Adjoint, Unitary and Normal Operators - Zorn's lemma - Hahn- Banach theorem.

(Chapter 3 - Sections 3.8 to 3.10, Chapter 4 – Sections 4.1 to 4.2)

Unit-V:**(15 hours)**

Hahn - Banach Theorem for Complex Vector Spaces and Normed Spaces - Adjoint Operators - Reflexive Spaces - Category Theorem (Statement Only). Uniform Boundedness Theorem - Open Mapping Theorem - Closed Linear Operators. Closed Graph Theorem.

(Chapter 4 – Sections 4.3, 4.5 to 4.7, 4.12 to 4.13)

Activity:

Problems on exploring Normed spaces, verifying completeness in Banach spaces, Analyzing Linear operators (checking linearity and boundedness conditions)

Text Book:

Erwin Kreyszig, Introductory Functional Analysis with Applications, John Wiley and sons(Asia). Pvt. Ltd., Singapore, 2006

Reference books:

1. M. Thamban Nair, Functional Analysis - A First Course, Prentice Hall of India Pvt. Ltd., New Delhi, 2002.
2. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill International Editions, 2004.
3. Balmohan.V. Limaye, Functional analysis, Revised 3rd edition, New Age International Pvt. Ltd., 2014.

E-learning Sources:

1. <https://nptel.ac.in/courses/111106147>
2. https://onlinecourses.nptel.ac.in/noc25_ma25/preview

DIFFERENTIAL GEOMETRY

(Course Code: 26PMT42)

Semester - IV

Core - 12

Hours - 5

Credits - 4

Course Outcomes: By the end of the course the students will be able to

CO1	Calculate curvature and torsion of space curves	(K3)
CO2	Describe the fundamental theorems for space curves	(K2)
CO3	Demonstrate the Serret–Frenet formula and its applications	(K3)
CO4	Analyse the intrinsic properties and properties of geodesics	(K4)
CO5	Analyse the curvatures and the developable surfaces	(K4)
CO6	Compare the minimal and the ruled surfaces	(K5)

UNIT- I: **(15 hours)**

Definitions - arc length - tangents - principal normal – binormal– curvature – torsion – contact between curves and surfaces- tangent surfaces – involutes - evolutes.

(Chapter I: Sections 1 - 7)

UNIT - II: **(15 hours)**

Intrinsic equations - fundamental theorem – helices – curves on a surface - surface of revolution – helicoids – metric - direction coefficients.

(Chapter I: Sections 8 and 9, Chapter II: Sections 1 - 6)

UNIT - III: **(15 hours)**

Families of curves - isometric correspondence - intrinsic properties – geodesics - canonical geodesic equation - normal property of geodesics.

(Chapter II: Sections 7 - 12)

UNIT - IV: **(15 hours)**

Second fundamental form - principal curvatures - lines of curvatures- developable.

(Chapter III: Sections 1 - 4)

UNIT - V: **(15 hours)**

Developables associated with space curves - developable associated with curves on surfaces - minimal surface - ruled surfaces.

(Chapter III: Sections 5 - 8)

Activity:

Create an animation pictures using AI tools that showing tangent, principal normal binormal concepts.

Text book:

T.J. Wilmore, An Introduction to Differential Geometry, Oxford University Press, 2007.

Reference books:

1. D. Somasundaram, Differential Geometry: A first course, Narosa Publishing House, New Delhi, India, 2005.
2. J. N. Sharma and A. R. Vasistha, Differential Geormetry, KedarNath Ram Nath, Meerut, 1998.
3. D.T. Struik, “Lectures on Classical Differential Geometry”, Addition –Wesley, Mass, 1950.
4. S. Kobayashi and K. Nomizu, “Foundations of Differential Geometry”, Interscience Publishers, 1963.
5. W. Klingenberg, “A Course in Differential Geometry”, Graduate Texts in Mathematics, Springer – Verlag 1979.
6. C.E.Weatherburn, “Differential Geometry of Three Dimensions”, University Press, Cambridge, 1930

ADVANCED OPERATIONS RESEARCH

(Course Code: 26PMTE41)

Semester - IV

EC - 8

Hours - 5

Credits - 3

Course Outcomes: By the end of the course the student will be able to

- | | | |
|------------|--|------|
| CO1 | Recall the fundamental concepts and principles of Dynamic Programming | (K1) |
| CO2 | Explain the various types of deterministic inventory models and their characteristics | (K2) |
| CO3 | Apply graphical methods and Linear Programming techniques to solve two-person zero-sum games | (K3) |
| CO4 | Analyze resource leveling, probability, and cost considerations in project scheduling techniques | (K4) |
| CO5 | Evaluate and select appropriate queuing models for different real-life situations | (K5) |
| CO6 | Design and construct project networks using suitable scheduling techniques | (K6) |

UNIT – I:

(15 hours)

Network models - Scope and definition of network models – Minimal spanning tree algorithm – Shortes-Route algorithms - CPM and PERT - Network Representation – Critical Path Method (CPM) Computations - Construction of the Time Schedule – Linear Programming Formulation of CPM – PERT networks.

(Chapter 6: Sections 6.1, 6.2, 6.3.2, 6.5)

UNIT - II:

(15 hours)

Deterministic Dynamic Programming – Recursive nature of Dynamic programming (D.P.) computations – Forward and Backward recursion – Selected DP applications – Knapsack/Fly-Away Kit/ Cargo – Loading model – work force size model – Equipment Replacement Model – Investment model – Problem of Dimensionality -

(Chapter 12 (Exclude 12.3.5))

UNIT - III:

(15 hours)

Deterministic Inventory Models – Role of demand in the development of inventory models - Static Economic-Order-Quantity (EOQ) models – Dynamic EOQ models.

(Chapter 13)

UNIT - IV:

(15 hours)

Decision under uncertainty – Game theory

(Chapter 15: Sections 15.3 and 15.4.)

UNIT - V:

(15 hours)

General Poisson queuing model – Specialized poisson queues – $(M/G/1):(GD/\infty/\infty)$ - Pollaczek-Khintchine (P-K) formula.

(Chapter 18: Sections 18.5, 18.6 and 18.7)

Activity:

1. Write a case study on Mahalanobis's flood control modeling

Assignment on decision making for choosing optimum strategy to get high marks under certain situations using Laplace, Minimax (or Maximin), Salvage and Hurwicz criteria.

Text book:

Hamdy A.Taha., Operations Research - An Introduction, Ninth Edition, Pearson Publication, 2012.

Reference books:

1. KantiSwarup, P.K. Gupta and Man Mohan, Operations Research, Eighth edition, Sulltan Chand and Sons, New Delhi, 1997.
2. Prem Kumar Gupta and D.S. Hira, Problems in Operations Research, S. Chand and Company Ltd., New Delhi, 2010

E-Learning resources:

1. Operations research tool kit - <http://s2.smu.edu/~barr/ortoolkit/>

ALGORITHMS AND COMPLEXITY

(Course Code: 26 PMTE 41)

Semester - IV **EC- 8** **Hours - 5** **Credits - 3**

Course Outcomes: By the end of the course the student will be able to

CO1	Describe various counting methods	(K1)
CO2	Use various algorithms for the given model	(K3)
CO3	Apply the network flow method	(K3)
CO4	Apply primality, factorization and pseudoprimality tests	(K3)
CO5	Solve some contextualized problems	(K3)
CO6	Outline an algorithm for the given real time problem	(K4)

UNIT- I: (15 hours)

Orders of magnitude - Positional number systems - Manipulation with series-
Recurrence relations – Counting - Graphs

(Chapter 1: Sections 1.1 - 1.6)

UNIT - II: (15 hours)

Introduction - Quick sort - Recursive graph algorithms - Fast matrix multiplication

(Chapter 2: Sections 2.1 - 2.4)

UNIT - III: (15 hours)

The discrete fourier transform - Applications of the FFT - Algorithms for the network
flow problem - Algorithm of ford and fulkerson - The max-flow min-cut theorem - The
complexity of the Ford - Fulkerson algorithm.

(Chapter 2: Sections 2.5 - 2.7; Chapter 3: Sections 3.1 - 3.5)

UNIT - IV: (15 hours)

Layered networks - The MPM algorithm - Applications of network flow - The
greatest common divisor – The extended euclidean algorithm - Primality testing - The ring of
integers modulo n.

(Chapter 3: Sections 3.6 - 3.8; Chapter 4: Sections 4.1 - 4.5)

UNIT - V:

(15 hours)

Pseudoprimality tests - Proof of goodness of the strong pseudoprimality test - Factoring and cryptography - Factoring large integers- Proving primality.

(Chapter 4: Sections 4.6 - 4.10)

Text book:

Herbert S. Wilf, Algorithms and Complexity, Prentice Hall International, 1986.

Reference books:

1. Alfred V. Aho, John E. Hopcroft and Jeffrey D. Ullman, The Design and Analysis of Computer Algorithms, Pearson Education Pte. Ltd, Delhi, 2004.
2. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein, Introduction to Algorithms, 3rd edition, MIT Press, Cambridge, 2009.

ADVANCED STATISTICS

(Course Code: 26PMTE42)

Semester - IV

EC - 9

Hours - 5

Credits - 3

Course Outcomes: By the end of the course the student will be able to

- CO1** Recall definitions and basic properties of bivariate random variables, probability distributions, expectations, and standard probability distributions (K1)
- CO2** Explain conditional distributions, conditional expectations, correlation coefficient, and independence of random variables (K2)
- CO3** Apply discrete and continuous probability distributions such as Binomial, Poisson, Normal, Gamma, Chi-square, Beta, t and F distributions to solve problems (K3)
- CO4** Analyze convergence concepts, moment generating functions, and limit theorems including the Central Limit Theorem (K4)
- CO5** Analyze convergence in probability and convergence in distribution (K4)
- CO6** Evaluate statistical hypotheses using tests on proportions, means, variances, and chi-square goodness of fit tests inference (K5)

UNIT -I: (15 hours)

Distributions of two random variables - expectation - transformations: bivariate random variables - conditional distributions and expectations.

(Text book 1: Chapter 2: Sections 2.1, 2.1.1, 2.2 and 2.3)

UNIT - II: (15 hours)

The correlation co-efficient - independent random variables - the binomial and related distributions - the poisson distribution.

(Text book 1: Chapter 2: Sections 2.4 and 2.5; Chapter 3: Sections 3.1 and 3.2)

UNIT - III: (15 hours)

The gamma, chi-square and beta distributions - the normal distributions - the t-distribution - the F-distribution - Student's Theorem.

(Text book 1: Chapter 3: Sections 3.3, 3.4 and 3.6 (Except 3.4.1))

UNIT - IV: (15 hours)

Expectations of functions - convergence in probability- convergence in distributions - moment generating function technique- Central Limit Theorem.

(Text book 1: Chapter 4: Sections 4.1- 4.4 (Except 4.3.1. and 4.3.2)

UNIT - V:**(15 hours)**

Tests about proportions - Tests about one mean and one variance (Except problems 7.2.1, 7.2.4, 7.2.5) - Tests of equality of two normal distributions (Except problems 7.3.3, 7.3.4) - Chi- square goodness of fit tests.

(Text book 2: Chapter 7: Sections 7.1 -7.3 and 7.5)

Text book:

1. Robert V. Hogg, Joseph W. McKean and Allen T. Craig, Introduction to Mathematical statistics, Sixth Edition, Pearson Education, Inc 2006.
2. Hogg, Tanis, Rao, Probability and Statistical Inference, Seventh Edition, Pearson Edition.

Reference books:

1. Goon A.M., Gupta M.K., Das Gupta.B. (1999): Fundamentals of Statistics, Vol.II, World Press, Calcutta.
2. S.M. Ross, Introduction to Probability Models, Academic Press, India, 2000
3. Understanding Statistics, Graham Upton and Ian Cook, Oxford University Press.

Websites and e-learning sources:

1. <https://www.khanacademy.org/math/statistics-probability>
2. https://youtu.be/X_Agh1X1INI?si=Egf0U9-w2Ph_7mt6
3. <https://youtu.be/sVBOSwT5K8I?si=0cxsbuRTngsdV-K>
4. <https://youtu.be/XWJKxotGfbc?si=zUk9P0lcftuoBJyc>
5. https://youtu.be/sfc8RcTlg8s?si=5FmQbDaaek_jeu4X

STOCHASTIC PROCESSES
(Course Code: 26PMTE42)

Semester - IV

EC - 9

Hours - 5

Credits - 3

Course Outcomes: By the end of the course the student will be able to

- | | | |
|------------|--|------|
| CO1 | Recall the concepts of probability distributions and their generating function | (K1) |
| CO2 | Discuss the structure of Markov chain and Markov process | (K2) |
| CO3 | Examine the stability of Markov chain | (K3) |
| CO4 | Outline the simulation of stochastic models | (K4) |
| CO5 | Summarize the Poisson process and its related distributions | (K5) |
| CO6 | Compose random walk and renewal equation for the real-life problem | (K6) |

Unit- I: (15 hours)

Generating Functions - Laplace transforms - Laplace (Stieltjes) Transform of Probability Distribution of a Random variable - Classification of Distributions.

(Chapter 1: Sections 1.1 - 1.4)

Unit – II: (15 hours)

Markov Chains Definitions and Examples - Higher Transition Probabilities - Generalization of Independent Bernoulli Trials - Classification of States and Chains – Determination of Higher Transition Probabilities - Stability of a Markov System - Graph Theoretic Approach.

(Chapter 2: Sections 2.1 – 2.7)

Unit - III: (15 hours)

Poisson Process - Poisson Process and Related Distributions - Generalizations of Poisson Process - Birth and Death Process - Markov Processes with Discrete State Space (Continuous Time Markov Chains).

(Chapter 3: sections 3.1 - 3.5)

Unit - IV: (15 hours)

Renewal Process - Renewal Processes in Continuous Time - Renewal Equation - Stopping Time - Renewal Theorems.

(Chapter 6: Sections 6.1 - 6.5)

Unit - V: (15 hours)

Simulation (Introduction) – Evaluation of Integrals using Random Numbers – Generation Of Continuous Random Variables – Simulation of Discrete Random Variates- Simulation of Stochastic Process.

(Chapter 11: Sections 11.1 - 11.5)

Text book:

J. Medhi, Stochastic Processes, 4th edition, New Age International (P) Ltd, 2017.

Reference books:

1. U. Narayan Bhat, Elements of Applied Stochastic Processes, second edition, John Wiley and Sons, New York, 1972.
2. N.V. Prabhu, Stochastic Processes, Macmillan, New York, 1970.

DATABASE MANAGEMENT SYSTEMS PRACTICAL

(Course Code: 26PMTS41)

Semester - IV

SEC - 3

Hours - 2

Credits – 2

Course Outcomes: By the end of the course, the student will be able to:

- | | | |
|------------|---|------|
| CO1 | Construct database tables using appropriate data types, constraints and alter table operations | (K3) |
| CO2 | Demonstrate data manipulation operations such as inserting, updating and deleting records in a database | (K3) |
| CO3 | Retrieve data using conditional queries, arithmetic expressions and built-in SQL functions | (K4) |
| CO4 | Perform grouping, aggregation and join operations to integrate and summarise data from multiple tables | (K4) |
| CO5 | Develop SQL queries using subqueries and set operators for solving complex database problems | (K5) |
| CO6 | Implement privilege management and design structured SQL solutions for real-time database applications | (K6) |

1. Create a table using appropriate data types and constraints.
2. Display the structure of an existing table.
3. Add, modify, and drop a column in an existing table.
4. Insert records into a table.
5. Update existing records and delete specific rows.
6. Retrieve data using conditions and arithmetic operators.
7. Perform group operations and apply conditions.
8. Perform different types of joins between two tables.
9. Use subqueries and retrieve top-performing students.
10. Demonstrate set operators and grant privileges.

VALUE ADDED COURSES

PROBLEM SOLVING IN ALGEBRA AND LINEAR ALGEBRA

(Course Code: 26PMTVA1)

Hours-2

Credits – 3

Course Outcomes: By the end of the course the student will be able to:

CO1	Identify the problems in algebra and linear algebra	(K1)
CO2	Discuss the concepts in algebra and linear algebra	(K2)
CO3	Determine the techniques for solving problems	(K3)
CO4	Classify methods for solving problems	(K4)
CO5	Compare UFD, PID and ED	(K5)
CO6	Build the mental ability to face the competitive examination	(K6)

UNIT I:

(6 hours)

Problems in Groups – Subgroups – Homomorphism - Cyclic Groups - Permutation Groups - Cayley's Theorem.

UNIT II:

(6 hours)

Problems in Rings – Ideals - Prime and Maximal Ideals - Polynomial Rings and Irreducibility Criteria.

UNIT III:

(6 hours)

Problems in Unique Factorization Domain (UFD) - Principal Ideal Domain (PID) - Euclidean Domain (ED) - Fields.

UNIT IV:

(6 hours)

Problems in Vector Spaces – Subspaces - Linear Dependence – Basis – Dimension - Algebra of Linear Transformations - Eigenvalues and Eigenvectors - Cayley-Hamilton Theorem.

UNIT V:

(6 hours)

Problems in Matrix Representation of Linear Transformation - Change of Basis - Canonical Forms - Diagonal Forms - Triangular Forms and Jordan Forms.

Reference: Previous year CSIR – NET Mathematical Sciences Question papers.

Ref: <https://csirhrdg.res.in/Home/Index/1/Default/2769/81>

INTEGRAL TRANSFORMS

(Course Code: 26PMTVA2)

Hours-2

Credits – 3

Course Outcomes: By the end of the course the student will be able to:

CO1	Identify the types of transforms	(K1)
CO2	Determine the solution of integral equations using Fourier Transform	(K3)
CO3	Solve the BVP using Mellin transform	(K3)
CO4	Solve boundary value problems using Laplace transform	(K3)
CO5	Analyze Hilbert transform	(K4)
CO6	Compare all transforms	(K5)

Unit I: Fourier Transform

(6 hours)

The Fourier Integral Formulas- Definition of the Fourier Transform and Examples- Applications of Fourier Transforms to Ordinary Differential Equations - Solutions of Integral Equations.
(Chapter 2: 2.2-2.3, 2.10-2.12)

Unit II: Laplace Transform

(6 hours)

Definition of the Laplace Transform and Examples-Solutions of Integral Equations - Solutions of Boundary Value Problems.
(Chapter 3: 3.2, Chapter 4:4.4-4.5)

Unit III: Mellin Transform

(6 hours)

Definition of the Mellin Transform and Examples-Applications of Mellin Transforms.
(Chapter 8: 8.2, 8.4)

Unit IV: Hilbert Transform

(6 hours)

Definition of the Hilbert Transform and Examples-Applications of Hilbert Transforms.

(Chapter 9: 9.2, 9.5)

Unit V: Z Transform

(6 hours)

Definition of the Z Transform and Examples- Basic Operational Properties of Z Transforms -The Inverse Z Transform and Examples - Applications of Z Transforms to Finite Difference Equations.
(Chapter 12: 12.3-12.6)

Text Book:

LokenathDebnath, DambaruBhatta, Integral Transforms and their Applications, 3rd Edition, CRC Press.

E-Learning Sources: <https://nptel.ac.in/courses/111102129>

PROBLEM SOLVING IN ADVANCED ALGEBRA AND ANALYSIS

(Course Code:26PMTVA3)

Hours-2

Credits-3

Course Outcomes: By the end of the course the student will be able to:

CO1	Identify the problems in algebra and analysis	(K1)
CO2	Discuss the concepts in algebra and linear algebra	(K2)
CO3	Determine the techniques for solving problems	(K3)
CO4	Classify methods for solving problems	(K4)
CO5	Evaluate the integral equations	(K5)
CO6	Build the mental ability to face the competitive examination	(K6)

UNIT I: (6 hours)

Problems in algebra.

UNIT II: (6 hours)

Problems in linear algebra.

UNIT III: (6 hours)

Problems in real analysis and complex analysis.

UNIT IV: (6 hours)

Problems in Calculus of variations and integral equations.

UNIT V: (6 hours)

Problems in quantitative aptitude and reasoning.

Text Books:

1. Previous year CSIR – NET Mathematical Analysis Question papers.
Ref: <https://csirhrdg.res.in/Home/Index/1/Default/2769/81>
2. Dr. R. S. Aggarwal, Quantitative Aptitude, Revised Edition 2022.

E-Learning Sources:

<https://annamalaimaths.wordpress.com/downloads-2/>

MATHEMATICAL DOCUMENTATION USING LATEX

Course Code:26PMTVA4)

Hours-2

Credits-3

Course Outcomes: By the end of the course the student will be able to:

- | | | |
|------------|---|------|
| CO1 | Quote different commands for typing math equations | (K1) |
| CO2 | Illustrate multiline equations, footnotes and combine different LaTeX files | (K3) |
| CO3 | Analyse errors in LaTeX files | (K4) |
| CO4 | Build BibTeX file | (K6) |
| CO5 | Design LaTeX documents | (K6) |
| CO6 | Create new articles, book and thesis using LaTeX | (K6) |

UNIT-I:

Typing Short Article -Typing Math - Typing equations and aligned formula – article templates.

(Chapter I)

UNIT-II:

Instructing LaTeX – Commands - Special Characters - Lines Paragraph and pages – Text Spaces – Boxes – Footnotes - combining files - Multiline math displays.

(Chapter II)

UNIT III:

LaTeX documents - preamble - document classes - AMS - LaTeX documents sequences.

(Chapter III)

UNIT-IV:

Customizing LaTeX - user defined commands - user defined environments- Numbering.

(Chapter IV)

UNIT-V:

BibTeX - The database – Articles - Books – Theses - Sample files – The four steps of Bibtensing - BibTeX rules and messages.

(Chapter V)

Text Book:

George Gratzner, Math into LATEX: an introduction to LaTeX and AMS-LaTeX, Birkhauser, Berlin

E-Learning Sources:

https://www.msuniv.ac.in/images/distance%20education/learning%20materials/ug%20pg%202023/pg%202021/Msc%20mathematics%202023/SMAS21_IISem_MathematicalDocumentationusingLaTeX.pdf.

EXTRA CREDIT COURSES
PLACEMENT AND COMPETITIVE READINESS SKILLS
(Course Code: 26PMTEC1)

ECC (Self Study)

Credits - 3

Course Outcomes: By the end of the course the student will be able to

CO1	Recall basic quantitative concepts and formulas	(K1)
CO2	Understand methods for solving profit, loss, time, and distance problems	(K2)
CO3	Apply interest, alligation, permutation, and probability techniques	(K3)
CO4	Analyze data interpretation and logical reasoning problems	(K4)
CO5	Evaluate solution strategies for mensuration, equations, and inequalities	(K5)
CO6	Design efficient approaches for complex aptitude problems	(K6)

Unit I:

Simplification-average-problems on ages -percentage- ratio and proportion.

(Text Book 1-Chapters:4,6,8,11,13)

Unit II:

Profit and loss- partnership- time and work- time and distance-boats and stream

(Text Book 1-Chapters:12,14,17,18,19)

Unit III:

Alligation of mixture-Simple interest- compound interest-permutations and combinations- probability.

(Text Book 1-Chapters:21,22,23,30,31)

Unit IV:

Data interpretation-Coding and decoding- blood relation -puzzle test- alpha numeric sequence-cubes and dice.

(Text Book 1-Chapters: 36-39)

Text Book 2-Part I Chapters:4,5,6,11, Part II-14)

Unit V:

Missing numbers- mensuration-quadratic equation-inequalities-syllogism- seating arrangement.

(E-Learning sources)

Text Book:

1. Dr. R. S. Aggarwal, Quantitative Aptitude, S Chand and Company Limited, 2022.
2. Dr. R. S. Aggarwal, A modern approach to verbal and Non-verbal reasoning, S Chand and Company Pvt.Ltd.

E-Learning sources:

1. <https://www.indiabix.com/aptitude/odd-man-out-and-series/072003>
2. <https://testbook.com/objective-questions/mcq-on-mensuration--5eea6a1039140f30f369e829>
3. <https://www.examadda.in/aptitude/quadratic-equations/1001>
4. <https://www.indiabix.com/verbal-reasoning/syllogism/>
5. <https://www.geeksforgeeks.org/ssc-banking/inequality-reasoning-concept-questions-answers/>
6. <https://www.indiabix.com/verbal-reasoning/seating-arrangement/>

QUESTION PATTERN

Part A	35 objective type Questions (for each unit, 7 Questions) 35×2 marks = 70 marks
Part B	15 Short Questions (for each unit, 3 Questions): 15×2 marks = 30 marks
Total Marks	100

ANALYSIS I FOR COMPETITIVE EXAMINATIONS

(Course Code: 26PMTEC2)

ECC (Self Study)

Credits - 3

Course Outcomes: By the end of the course the student will be able to

- | | | |
|------------|--|------|
| CO1 | Recall Archimedean property, supremum and infimum | (K1) |
| CO2 | Discuss the convergence of sequences and Bolzano–Weierstrass theorem | (K2) |
| CO3 | Apply infimum and supremum in various problems related to them | (K4) |
| CO4 | Test the uniform convergence of sequence and series of functions | (K5) |
| CO5 | Compare continuous, uniform continuous and differentiable functions | (K5) |
| CO6 | Build the mental ability to face GATE, CSIR and SET examinations | (K6) |

UNIT - I:

Elementary set theory, finite -countable and uncountable sets - Real number system as a complete ordered field - Archimedean property – supremum and infimum.

UNIT - II:

Real sequences and series – convergence – limsup and liminf - Bolzano Weierstrass theorem.

UNIT - III:

Continuity, uniform continuity, differentiability, mean value theorem in Real number system.

UNIT - IV:

Sequence and series of real functions, uniform convergence.

UNIT - V:

Riemann sums and Riemann integral, Improper Integrals, Monotonic functions, types of discontinuity.

Text Books:

1. Narayan Shanti and Mittal P.K., A Course of Mathematical Analysis, S. Chand Publishers, 2005
2. Robert G. Bartle and Donald R. Sherbert, Introduction to Real Analysis, Fourth edition, John Wiley and Sons, 2011.
3. S C Maik and Savita Arora, Mathematical Analysis, second edition, New Age International(P) Limited Publishers, 2005

E-Learning sources:

1. <https://nptel.ac.in/courses/111106053>

ANALYSIS II FOR COMPETITIVE EXAMINATIONS

(Course Code: 26PMTEC3)

ECC (Self Study)

Credits - 3

Course Outcomes: By the end of the course the student will be able to

- | | | |
|------------|--|------|
| CO1 | Describe the concepts of topological properties of metric spaces | (K1) |
| CO2 | Associate the concept of continuity and connectedness | (K2) |
| CO3 | Apply Cauchy's integral formula and Maximum modulus principle to evaluate integral | (K3) |
| CO4 | Outline Liouville's theorem and open mapping theorem | (K4) |
| CO5 | Generate Taylor's series for analytic functions | (K6) |
| CO6 | Build the mental ability to face GATE, CSIR and SET examinations | (K6) |

UNIT - I:

Metric spaces – Convergence – Complete.

UNIT - II:

Metric space – Connected – Continuity- totally bounded.

UNIT - III:

Algebra of complex numbers- the complex plane - polynomials - Power series - transcendental functions such as exponential - trigonometric and hyperbolic functions - Analytic functions - Cauchy-Riemann equations.

UNIT - IV:

Contour integral -Cauchy's theorem - Cauchy's integral formula - Liouville's theorem - Maximum modulus principle - Schwarz lemma- Open mapping theorem.

UNIT - V:

Taylor series - Laurent series - calculus of residues - Conformal mappings - Mobius transformations.

Text Books:

1. Arumugam. S, Thangapandi Issac. A and Somasundaram. A, Modern Analysis, Scitech Publications (I) Pvt. Ltd., 2010.
2. Robert G. Bartle and Donald R. Sherbert, Introduction to Real Analysis, Fourth edition, John Wiley and Sons, 2011.
3. S C Maik and Savita Arora, Mathematical Analysis, second edition, New Age International(P) Limited Publishers, 2005
4. John B. Conway, Functions of one complex variable I, second edition, Springer, 1995.

E-Learning sources:

1. <https://nptel.ac.in/courses/111106053>

ALGEBRAIC GRAPH THEORY

(Course Code: 26PMTEC4)

ECC (Self Study)

Credits - 3

Course Outcomes: By the end of the course the student will be able to

CO1	Describe graphs from finite groups	(K2)
CO2	Determine the zero-divisor graph of commutative rings	(K3)
CO3	Analyze zero-divisor graph of commutative rings	(K4)
CO4	Analyze zero-divisor graph of semigroup	(K4)
CO5	Design total graph of a ring	(K6)
CO6	Formulate the domination in graphs from commutative ring	(K6)

UNIT- I:

Graphs from Finite Groups: An Overview

UNIT- II:

The zero-divisor graph of commutative rings: A survey

UNIT- III:

The Zero-divisor graph of semigroup: A survey

UNIT- IV:

On the total graph of a ring and its related graphs: A survey

UNIT- V:

On the domination in graphs from commutative ring: A survey

Text Books:

Unit I: Yusuf F. Zakariya: Graphs from Finite Groups: An Overview, Proceedings of Annual National Conference-2016, Nigeria, 2017.

Unit II: Marco Fontana, Salah-Eddine Kabbaj, Bruce Olberding, Irena Swanson:
Commutative Algebra: Noetherian and Non-Noetherian Perspectives,
Springer London, (2010). (Chapter 2)

Unit III: M. Droste, L. Fuchs, B. Goldsmith, L. Strüngmann: Groups, Modules, and
Model Theory-Surveys and Recent Developments, Springer, London,
(2014). (Chapter 2)

Unit IV: Marco Fontana, Sophie Frisch and Sarah Glaz: Commutative Algebra:
Recent Advances in Commutative Rings, Integer-Valued Polynomials and
Polynomial functions, Springer, London, (2014). (Chapter 3)

Unit V: Syed Tariq Rizvi, Asma Ali, Vincenzo De Filippis, Algebra and its
Applications, Springer, (2014). (Chapter 23)

E-Learning Sources:

https://www.youtube.com/watch?v=NFjiBr1EeO4&list=PLyqSpQzTE6M_ciAYiv53KZyKncwXZw8TU

HISTORY OF MATHEMATICS

(Course Code: 26PMTEC5)

ECC (Self Study)

Credits - 3

Course Outcomes: By the end of the course the student will be able to

CO1	Describe graphs from finite groups	(K2)
CO2	Determine the zero-divisor graph of commutative rings	(K3)
CO3	Analyze zero-divisor graph of commutative rings	(K4)
CO4	Analyze zero-divisor graph of semigroup	(K4)
CO5	Design total graph of a ring	(K6)
CO6	Formulate the domination in graphs from commutative ring	(K6)

UNIT- I:

Indian mathematics during the classical age - Aryabhata- Brahmagupta- Bhaskaracarya II- Rules of computation - Algorithms in Indian Mathematics- Algorithms for square and the cube root
(Text Book II :Pages 12 - 21; 122-130; 159-161)

UNIT- II:

Al-Khwarizmi and the Basics of Algebra – The Life of Al-Khwarizmi - Omar Khayyam and the Resolution of the Cubic - The solution of a Quadratic Equation – A Particular Equation – The General Case – The Brief and Tragic Lives of Abel and Galois - The Work of Abel and Galois in Context – Introductory Remarks – The Life of Rene Descartes – The Real Number Line -The Cartesian Plane - Coordinates in Three-Dimensional Space.

(Text Book I-Sections: 4.2.1, 4.2.2, 4.2.4, 5.6, 5.7.1, 5.7.2, 5.8.1, 5.9, 6.0-6.3, 6.5)

UNIT- III:

The Life of Fermat - Fermat's Method -Fermat's Lemma and Maximum/Minimum Problems Progenitors of the Complex Number System – Cardano – Euler – Argand – Cauchy-Riemann – Complex Number Basics – The Fundamental Theorem of Algebra - Finding the Roots of a Polynomial - Why Do We Need the Real Numbers?

(Text Book I-Sections: 7.1 - 7.2, 7.4,8.2 - 8.5, 10.2)

UNIT- IV:

The Sieve of Eratosthenes - The Infinitude of the Primes - The Life of Dirichlet -The Pigeonhole Principle - Riemann and the Geometry of Surfaces - Introduction –George Cantor and the Orders of Infinity – Introductory Remarks – What is a Number - An Uncountable Set– Countable and Uncountable– The Existence of Transcendental Numbers.

(Text Book I-Sections:11.1 - 11.2,12.1 - 12.2,13.0,14.1 - 14.3)

UNIT- V:

Henri Poincare, Child Prodigy – Introductory Remarks – Emmy Noether and Algebra– TheLife of Emmy Noether– Emmy Noether and Abstract Algebra: Groups – Emmy Noether and Abstract Algebra: Rings-The Idea of an Ideal - Cryptography - What is Cryptography?

(Text Book I-Sections:16.1,18.1 - 18.3.1,20.3)

Textbooks:

1. Steven G. Krantz, An Episodic History of Mathematics, Mathematical Association of America, 2010.

2. Contributions to the History of Indian Mathematics, Gurgaon : Hindustan Book Agency : Imprint: Hindustan Book Agency, Emch, Gerard G. editor.; Sridharan, R. editor.; Srinivas, M. D. editor.2005

References:

1. C.B. Boyer and U. Merzbach, History of Mathematics, John Wiley & Sons, New York, 1988.
2. E.T.Bell, Men of Mathematics, Penguin Books Ltd., Harmondsworth, Middlesex, UK, 1953.

E-Learning Sources:

<https://jontalle.web.engr.illinois.edu/uploads/298/HistoryMath-Burton.85.pdf>

DIFFERENTIAL EQUATIONS FOR COMPETITIVE EXAMINATIONS

(Course Code: 26PMEC6)

ECC (Self Study)

Credits - 3

Course Outcomes: By the end of the course, the student will be able to

- | | | |
|------------|--|------|
| CO1 | Describe the basic concepts in solutions for differential equations | (K2) |
| CO2 | Describe various properties of homogeneous and non-homogeneous linear ODEs | (K2) |
| CO3 | Describe Sturm–Liouville boundary value problem | (K2) |
| CO4 | Determine solution for PDEs by various methods | (K3) |
| CO5 | Analyze the properties of PDEs | (K4) |
| CO6 | Evaluate the solution for Laplace, Heat and Wave equations | (K5) |

Unit - I:

Existence and Uniqueness of solutions of initial value problems for first order ordinary differential equations, singular solutions of first order ODEs, system of first order ODEs.

Unit - II:

General theory of homogenous and non-homogeneous linear ODEs, variation of parameters, Sturm-Liouville boundary value problem, Green's function.

Unit - III:

Lagrange and Charpit's methods for solving first order PDEs, Cauchy problem for first order PDEs.

Unit - IV:

Classification of second order PDEs, General solution of higher order PDEs with constant coefficients.

Unit – V:

Method of separation of variables for Laplace, Heat and Wave equations.

Text Books:

1. E. A.Coddington, An Introduction to Ordinary Differential Equations, First edition, Prentice Hall of India Pvt Ltd, New Delhi, 1989.

2. George F. Simmons, Differential Equations, Second edition, Tata McGraw Hill Publishing Company Ltd, New Delhi, 1991.

3. S.G. Deo, V. Lakshmikantham, V. Raghavendera, Text book of Ordinary Differential equations, second edition, Tata McGraw - Hill Educational Private Limited, New Delhi, 1997.

E-Learning sources:

1. <https://www.youtube.com/watch?v=ES741wg3APA&list=PLo2fuKadGpUTmZX6ubb3dIB7zrhs8Eyj8>

QUEUEING AND INVENTORY MODELS

(Course Code: 26PMTEC7)

ECC (Self Study)

Credits - 3

Course Outcomes: By the end of the course, the student will be able to

CO1	Describe the concepts of Probabilistic Queueing Processes	(K1)
CO2	Explain the behaviour of Inventory Models	(K2)
CO3	Examine the various Exponential Models	(K3)
CO4	Outline the components of Inventory Models	(K4)
CO5	Compare a Stochastic Continuous Review Model and Stochastic Periodic Review Model	(K5)
CO6	Design Stochastic Single Period Model for Perishable Products	(K6)

Unit I

Queueing Systems: General Concepts: Introduction - Queueing Processes – Notation – Transient and Steady State Behavior – Limitations of the Steady State Distribution - Some General Relationships in Queueing Theory – Poisson Arrival Process and Its Characteristics.

(Textbook 1-Chapter: 2)

Unit II

Birth and Death Queueing Systems: Exponential Models: Introduction – The Simple M/M/1 Queue – System with Limited Waiting Space: The M/M/1/K Model – Birth and Death Processes: Exponential Models – The M/M/∞ Model: Exponential Model with an Infinite Number of Servers – The Model M/M/c – The M/M/c System: Erlang Loss Model.

(Textbook 1 - Chapter: 3 (3.1-3.7))

Unit III

Non-Birth and Death Queueing Systems: Markovian Models: Introduction – Bulk Queues – Queueing Models with Bulk (Batch) Service – M/M(a,b)/1: Transient State Distribution – Two Server Model: M/M(a,b)/2 – The M/M(1,b)/c Model. **Network of Queues:** Network of Markovian Queues – Channels in Series or Tandem Queues – Jackson Network – Closed Markovian Network – Cyclic Queue – BCMP Networks.

(Textbook 1- Chapter: 4 and 5)

Unit IV

Inventory Theory: Components of Inventory Models – Deterministic Continuous Review Models – A Deterministic Periodic Review Model.

(Textbook 2 - Chapter: 19 (19.2-19.4))

Unit V

A Stochastic Continuous Review Model – A Stochastic Single Period Model for Perishable Products – Stochastic Periodic Review Models.

(Textbook 2 - Chapter: 19 (19.5-19.7))

Text Book:

- 1) Medhi J, Stochastic Models in Queuing Theory, Academic Press, Second Edition, 2003.
- 2) Frederick S. Hillier, Gerald J. Lieberman., Introduction to Operations Research, McGraw-Hill Higher Education, Seventh Edition, 2001

E-Learning sources:

1. <https://www.youtube.com/watch?v=xGkpXk-AnWU>

NEURAL NETWORKS

(Course Code: 26PMTEC8)

ECC (Self Study)

Credits - 3

Course Outcomes: By the end of the course the student will be able to

- | | | |
|------------|---|------|
| CO1 | Discuss the important concepts and theories of artificial neural networks | (K2) |
| CO2 | Apply simpler models as a component to build up feed forward neural network architectures | (K3) |
| CO3 | Analyse how ANNs can be designed and trained | (K4) |
| CO4 | Evaluate simple examples of ANNs | (K5) |
| CO5 | Compare real-valued states and continuous dynamics | (K5) |
| CO6 | Develop synchronous and asynchronous networks | (K6) |

UNIT - I:

Neural Computation – Artificial Neural Networks - Networks of Functions.

(Chapter 1: 1.1, 1.3, Chapter 2: 2.1)

UNIT - II:

Synthesis of Boolean functions – Equivalent Networks - Recurrent Networks – Harmonic Analysis of Logical Functions.

(Chapter 2: 2.2 - 2.5)

UNIT - III:

Perceptron and Parallel Processing – Implementation of Logical Functions - Learning Algorithms for Neural Networks.

(Chapter 3: 3.1- 3.2, Chapter 4: 4.1)

UNIT - IV:

Synchronous and Asynchronous networks - Definition of Hopfield networks - Converge to stable states - Equivalence of Hopfield and Preceptron learning - Parallel Combinatorics.

(Chapter 13: 13.1 -13.5)

UNIT - V:

Variations of the Hopfield model- Stochastic systems - Learning algorithms and applications

(Chapter 14: 14.1 -14.3))

Activity:

Assignment on solving TSP using parallel combinatorics

Text Book:

R. Rojas, Neural Networks, A Systematic Introduction, Springer-Verlag Berlin Heidelberg New York, 1996.

E-Learning sources:

1. <https://www.youtube.com/watch?v=xbYgKoG4x2g&list=PL53BE265CE4A6C056>

TENSOR ANALYSIS AND RELATIVITY

(Course Code: 26PMTEC9)

ECC (Self Study)

Credits - 3

Course Outcomes: By the end of the course the students will be able to

- | | | |
|------------|--|------|
| CO1 | Explain the concepts of tensors and algebra of tensor | (K3) |
| CO2 | Analyze quotient law of tensors, reciprocal tensor and relative tensor | (K4) |
| CO3 | Describe the Riemann Christoffel theorem | (K2) |
| CO4 | Analyze covariant differentiation of tensors | (K4) |
| CO5 | Evaluate the relativistic kinematics: Lorentz transformation equation and its related problems | (K5) |
| CO6 | Compute Lagrangian and Hamiltonian formulations | (K5) |

UNIT - I:

Tensor Algebra : Systems of Different orders – Summation Convention – Kronecker Symbols - Transformation of coordinates in S_n - Invariants – Covariant and Contravariant vectors - Tensors of Second Order – Mixed Tensors – Zero Tensor – Tensor Field – Algebra of Tensors – Equality of Tensors – Symmetric and Skew-symmetric tensors - Outer multiplication, Contraction and Inner Multiplication – Quotient Law of Tensors – Reciprocal Tensor – Relative Tensor – Cross Product of Vectors.

(Text Book: 1, Chapter I : I.1 – I.3, I.7 and I.8 and Chapter II : II.1 – II.19)

UNIT - II:

Tensor Calculus: Riemannian Space – Christoffel Symbols and their properties.

(Text Book: 1, Chapter III: III.1 and III.2)

UNIT - III:

Tensor Calculus (contd): Covariant Differentiation of Tensors – Riemann–Christoffel Curvature Tensor.

(Text Book: 1, Chapter III: III.3 – III.4)

UNIT - IV:

Special Theory of Relativity : Galilean Transformations – Maxwell's equations – The ether Theory – The Principle of Relativity. Relativistic Kinematics: Lorentz Transformation equations – Events and simultaneity – Example – Einstein Train – Time dilation – Longitudinal Contraction - Invariant Interval - Proper time and Proper distance - World line - Example – twin paradox – addition of velocities – Relativistic Doppler effect.

(Text Book: 2, Chapter 7 : Sections 7.1 and 7.2)

UNIT - V:

Relativistic Dynamics : Momentum – Energy – Momentum – energy four vector – Force - Conservation of Energy – Mass and energy – Example – inelastic collision – Principle of equivalence – Lagrangian and Hamiltonian formulations.

(Text Book: 2, Chapter 7 : Section 7.3)

Text books:

1. U.C. De, Absos Ali Shaikh and JoydeepSengupta, Tensor Calculus, Narosa Publishing House, New Delhi, 2004.
2. D.Greenwood, Classical Dynamics, Prentice Hall of India, New Delhi, 1985.

Reference books:

1. J.L.Synge and A.Schild, Tensor Calculus, Toronto, 1949.
2. A.S.Eddington. The Mathematical Theory of Relativity, Cambridge University Press, 1930.
3. P.G.Bergman, An Introduction to Theory of Relativity, Newyor, 1942.
4. C.E.Weatherburn, Riemannian Geometry and the Tensor Calculus, Cambridge, 1938.

E-Learning sources:

1. <https://www.youtube.com/watch?v=NmYdDE7b-bc&list=PLMdnA49lASokRJHnH6Hm1A6ZzmQCS2f1D>