PERIYAR UNIVERSITY

Re-accredited with 'A' grade by the NAAC

PERIYAR PALKALAI NAGAR

SALEM - 11

M.Sc. Branch – I (B): Mathematics

(SEMESTER PATTERN)

(Under Choice Based Credit System)

(For University Department & PG Center, Dharmapuri)

REGULATIONS AND SYLLABUS

(For candidates admitted from 2018-2019 onwards)

PERIYAR UNIVERSITY, SALEM –11

M.Sc. BRANCH 1(B) - MATHEMATICS - CHOICE BASED CREDIT SYSTEM (CBCS)

REGULATIONS AND SYLLABUS

(For the candidates admitted from 2018-2019)

1. PROGRAMME OBJECTIVES:

- To provide a wide and strong foundation in pure and applied mathematics.
- To enhance the logical and analytical thinking through mathematical proofs.
- To motivate students for independent research in mathematics.
- To apply mathematics to real life situations and help in problem solving.

Program Outcome: At the time of graduation, students will be able to:

PO1	gain knowledge in the fundamental subjects of pure and applied mathematics
PO2	explain the mathematical concepts with good understanding and clarity
PO3	conduct research independently with strong mathematics background
PO4	crack lectureship/fellowship exams like CSIR – NET/JRF, GATE, NBHM, SET, TRB etc.
PO5	apply the acquired mathematical techniques to solve the socio-economic and industrial problems
PO6	obtain career in the field of education/research/industry

2. DURATION OF THE PROGRAMME

The two-year postgraduate programme in M.Sc. Mathematics consists of four semesters under Choice Based Credit System.

3. ELIGIBILITY

A candidate who has passed B.Sc. Degree Examination in Branch I- Mathematics and Mathematics (CA) of this University or an examination of some other university accepted by the syndicate as equivalent there to shall be permitted to appear and qualify for the M.Sc. Mathematics (CBCS) Degree Examination of this university after a course of two academic years in the Department of Mathematics of Periyar University.

4. DISTRIBUTION OF CREDIT POINTS AND MARKS

The minimum credit requirement for a two year Master's programme shall be **90 Credits**. The break-up of credits for the programme is as follows:

- Core Courses : Minimum 62 credits
- Elective Courses : Minimum 16 credits
- Supportive Courses : Minimum 06 credits
- Project : 05 credits
- Soft skills : 02 credits
- Human Rights : 02 credits
- SWAYAM/MOOC/NPTEL : 08 credit

EXTRA CREDITS COURSES

(A) Compulsory

- *Human Rights with 2 extra credits offered in the II-semester as add on course.*
- *Soft skills **(Practical Only)** with 2 extra credits offered in the III-semester*

(B) Non Compulsory

- *SWAYAM/MOOC/NPTEL online Courses will be offered in the II & III semesters with 4 extra credits each as add on courses.*

4. COURSE OF STUDY

The courses of study for the degree shall be in Branch I (B) - Mathematics (Choice Based Credit System) with internal assessment according to syllabi prescribed from time to time. The **Internal Assessment** is distributed to tests, seminar, assignment and attendance as **10**, **05, 05** and **05** marks, respectively.

	Marks			No. of Subjects	Total Marks	Credits
	External	Internal	Total			
For Each Paper	75	25	100	23	2300	99
Dissertation + Viva Voce	25+25	25+25	100	01	100	05
	Grand Total			24	2400	104

Dissertation : **100** (Internal Valuation 25 + External Valuation 25 and Joint Viva Voce 25 + 25 Marks]

5. STRUCTURE OF THE COURSE

S.No	COURSE CODE	TITLE OF THE COURSE	CREDITS	MARKS
		I SEMESTER		
1.	18UPMAT1C01	Linear Algebra	5	100
2.	18UPMAT1C02	Real Analysis – I	5	100
3.	18UPMAT1C03	Ordinary Differential Equations	5	100
4.	18UPMAT1C04	Mechanics	5	100
5.		Elective Course – I	4	100
		II SEMESTER		
6.	18UPMAT1C05	Abstract Algebra	5	100
7.	18UPMAT1C06	Real Analysis – II	5	100
8.	18UPMAT1C07	Partial Differential Equations	5	100
9.		Elective Course – II	4	100
10.		Supportive Course – I	3	100
11.	06PHR01	Human Rights (Compulsory with extra credit)	2	100
12.		Swayam – I (Non Compulsory with extra credit)	4	100
		III SEMESTER		
13.	18UPMAT1C08	Topology	5	100
14.	18UPMAT1C09	Measure Theory and Integration	5	100
15.	18UPMAT1C10	Graph Theory	5	100
16.		Elective Course – III	4	100
17.		Supportive Course – II	3	100
18.		Swayam – II (Non Compulsory with extra credit)	4	100
19.		Soft Skills (**Practical only**) (Compulsory with extra credit)	2	100
		VI SEMESTER		
20.	18UPMAT1C11	Complex Analysis	5	100
21.	18UPMAT1C12	Functional Analysis	5	100
22.	18UPMAT1C13	Numerical Analysis	5	100
23.		Elective Course – IV	4	100
24.		Dissertation	5	100
			104	**2400**

ELECTIVE COURSES OFFERED

S.No	COURSE CODE	TITLE OF THE COURSE	CREDITS
1.	18UPMAT1E01	Discrete Mathematics	4
2.	18UPMAT1E02	Analytic Number Theory	4
3.	18UPMAT1E03	Difference Equations	4
4.	18UPMAT1E04	Probability Theory	4
5.	18UPMAT1E05	Methods of Applied Mathematics	4
6.	18UPMAT1E06	Optimization Techniques	4
7.	18UPMAT1E07	Combinatorial Mathematics	4
8.	18UPMAT1E08	Fuzzy Sets and their Applications	4
9.	18UPMAT1E09	Representation Theory of Finite Groups	4
10.	18UPMAT1E10	Non Commutative Algebra	4
11.	18UPMAT1E11	Commutative Algebra	4
12.	18UPMAT1E12	Control Theory	4
13.	18UPMAT1E13	Stochastic Differential Equations	4
14.	18UPMAT1E14	Number Theory	4
15.	18UPMAT1E15	Differential Geometry	4
16.	18UPMAT1E16	Advanced Partial Differential Equations	4
17.	18UPMAT1E17	Nonlinear Differential Equations	4
18.	18UPMAT1E18	Mathematical Biology	4
19.	18UPMAT1E19	Fluid Dynamics	4
20.	18UPMAT1E20	Financial Mathematics	4
21.	18UPMAT1E21	Multivariable Calculus	4
22.	18UPMAT1E22	Algebraic Geometry	4
23.	18UPMAT1E23	Algebraic Topology	4

SUPPORTIVE COURSES

S.No	COURSE CODE	TITLE OF THE COURSE	CREDITS
1.	18UPMAT1S01	Applied Mathematics – I	3
2.	18UPMAT1S02	Applied Mathematics – II	3
3.	18UPMAT1S03	Numerical and Statistical Methods	3
4.	18UPMAT1S04	Discrete Mathematics	3
5.	18UPMAT1S05	Integral Transforms	3

SOFT SKILL ELECTIVE COURSES
(PRACTICAL ONLY)

S.No	COURSE CODE	TITLE OF THE COURSE	CREDITS
1.	18UPMAT1SS1	Matlab	2
2.	18UPMAT1SS2	Mathematica	2
3.	18UPMAT1SS3	Latex	2

ELECTIVE COURSES OFFERED (SEMESTER-WISE)

S.No	TITLE OF THE COURSE	CREDITS
	SEMESTER I	
1.	Discrete Mathematics	4
2.	Difference Equations	4
3.	Number Theory	4
4.	Optimization Techniques	4
5.	Fuzzy Sets and their Applications	4
	SEMESTER II	
6.	Methods of Applied Mathematics	4
7.	Analytic Number Theory	4
8.	Mathematical Biology	4
9.	Representation Theory of Finite Groups	4
10.	Nonlinear Differential Equations	4
	SEMESTER III	
11.	Probability Theory	4
12.	Advanced Partial Differential Equations	4
13.	Fluid Dynamics	4
14.	Differential Geometry	4
15.	Mathematical Finance	4
16.	Noncommutative Algebra	4
17.	Multivariable Calculus	4
	SEMESTER IV	
18.	Combinatorial Mathematics	4
20.	Control Theory	4
21.	Stochastic Differential Equations	4
22.	Commutative Algebra	4
23.	Algebraic Geometry	4
24.	Algebraic Topology	4

6. EXAMINATION

For the purpose of uniformity, particularly for interdepartmental transfer of credits, there shall be a uniform pattern of examination to be adopted by all the teachers offering courses. There shall be three tests, one seminar and one assignment for internal evaluation and End semester examination during each semester.

The distribution of marks for internal evaluation and End Semester Examination shall be 25 marks and 75 marks, respectively. Further, distribution of internal marks shall be 10 marks for test, 5 marks for seminar, 5 marks for assignment and 5 marks for attendance, respectively. The average of the highest two test marks out of the three internal tests should be taken for Internal Assessment.

7. QUESTION PAPER PATTERN

(a) Question paper pattern for Theory Examination

Time: 3 Hours **Maximum Marks:** 75

Part – A (20 X 1 = 20 Marks)

Objective Type questions

Answer **ALL** Questions

(Four questions from each unit)

Part – B (3 X 5 = 15 Marks)

Analytical Type questions (Problems only)

Answer any **THREE** questions out of **FIVE** questions

(One question from each unit)

Part – C (5 X 8 = 40 Marks)

Descriptive Type questions

Answer **ALL** Questions

(One question from each unit with internal choice)

(b) Question paper pattern for Practical Examination

Time: 3 Hours Maximum: **100 (**Internal: 40 + External: 60) Marks

The components of 40 marks are

Periodical assessment	- 20 marks
Test (best 2 out of 3)	- 10 marks
Record	- 10 marks

The components of 60 marks are

Experiments	- 40 marks
Viva-voce	- 10 marks
Record	- 10 marks

Passing Minimum : **30 Marks** (Aggregate of Experiments, Viva-voce and Record)
(No passing minimum for records)

There will be one question with or without subsections to be asked for the practical examination. Every question should be chosen from the question bank prepared by the examiner(s). A question may be used for at most three students in a batch.

8. PASSING MINIMUM

A candidate who has secured a minimum of 50% marks in all the courses (including practical) prescribed in the programme and earned a minimum of **90 credits** will be considered to have passed the Master's programme.

For the Practical paper, a minimum of 30 marks out of 60 marks in the University examination and the record notebook taken together is necessary for a pass. There is no passing minimum for the record notebook. However submission of record notebook is a must.

For the Project work and viva-voce, a candidate should secure 50% of the marks for pass. The candidate should attend viva-voce examination to secure a pass in the Project.

9. COMMENCEMENT OF THIS REGULATION

These regulations shall take effect from the academic year 2018-19, that is, for students who are admitted to the first year of the programme during the academic year 2018-19 and thereafter.

10. PROJECT AND EDUCATIONAL TOUR:

For M.Sc Mathematics students, the project is individual and compulsory. In order to choose their topics/titles for the project, the students may like to visit the Libraries at the Universities/Indian Institute of Technology/Institute of Mathematical Sciences etc. So, the Department of Mathematics may arrange an Educational Tour either at the end of III semester or in the beginning of IV semester, for the students to visit the Libraries.

(a) Dissertation Topic:

The topic of the dissertation shall be assigned to the candidate at the beginning of third semester and a copy of the same should be submitted to the University for approval.

(b) No. of copies of dissertation:

Students should prepare three copies of dissertation and submit the same for the evaluation by Examiners. After evaluation one copy is to be retained in the University Library, one in the Department Library and one with the student.

(c) Format for the preparation of the dissertation:

(a) Title page

(b) Bonafide Certificate

(c) Acknowledgement

(d) Table of contents

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Chapter No.	Title	Page No.
1.	Introduction	
2.	Review of Literature	
3.	Summary	
4.	Results	
5.	References	

Format of the Title Page

TITLE OF THE DISSERTATION

Dissertation submitted in partial fulfillment of the requirements for the award of the

Degree of Master of Science in

MATHEMATICS

(Under Choice Based Credit System)

Submitted to

Department of Mathematics

Periyar University, Salem – 636 011.

By

Students Name	:
Register Number	:
Department	:
Year	:

Format of the Certificate

<u>CERTIFICATE</u>

This is to certify that the dissertation entitled ....submitted in partial fulfillment of the requirements for the award of the Degree of Master of Science in **MATHEMATICS (Under Choice Based Credit System)** to the Periyar University, Periyar Palkalai Nagar, Salem is a record of bonafide research work carried out by .... under my supervision and guidance and that no part of the dissertation has been submitted for the award of any degree, diploma, fellowship or other similar titles or prizes and that the work has not been published in part or full in any scientific or popular journals or magazines.

Date:

Place:

Signature of the Guide   Signature of the Head of the Department

18UPMAT1C01	LINEAR ALGEBRA	L	T	P	C
		4	1	0	5

OBJECTIVE: The objective of this course is to develop a strong foundation in linear algebra that provide a basic for advanced studies not only in mathematics but also in other branches like engineering, physics and computers, etc. Particular attention is given to canonical forms of linear transformations, diagonalizations of linear transformations, matrices and determinants.

UNIT I: Linear transformations

Linear transformations – Isomorphism of vector spaces – Representations of linear transformations by matrices – Linear functionals

UNIT II: Algebra of polynomials

The algebra of polynomials –Polynomial ideals - The prime factorization of a polynomial - Determinant functions.

UNIT III: Determinants

Permutations and the uniqueness of determinants – Classical adjoint of a (square) matrix – Inverse of an invertible matrix using determinants – Characteristic values – Annihilating polynomials.

UNIT IV: Diagonalization

Invariant subspaces – Simultaneous triangulations – Simultaneous diagonalization – Direct-sum decompositions – Invariant direct sums – Primary decomposition theorem.

UNIT V: The Rational and Jordan forms

Cyclic subspaces – Cyclic decompositions theorem (Statement only) – Generalized Cayley – Hamilton theorem - Rational forms – Jordan forms.

TEXT BOOK:

Kenneth M Hoffman and **Ray Kunze**, Linear Algebra, 2nd Edition, Prentice-Hall of India Pvt. Ltd, New Delhi, 2013.

UNIT	Chapter(s)	Sections
I	3	3.1 – 3.5
II	4 & 5	4.1, 4.2, 4.4, 4.5 and 5.1, 5.2
III	5 & 6	5.3, 5.4 and 6.1 – 6.3
IV	6	6.4 – 6.8
V	7	7.1 – 7.3

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **M. Artin**, *"Algebra"*, Prentice Hall of India Pvt. Ltd., 2005.
2. **S.H. Friedberg, A.J. Insel** and **L.E Spence**, *"Linear Algebra"*, 4th Edition, Prentice-Hall of India Pvt. Ltd., 2009.
3. **I.N. Herstein**, *"Topics in Algebra"*, 2nd Edition, Wiley Eastern Ltd, New Delhi, 2013.
4. **J.J. Rotman**, *"Advanced Modern Algebra"*, 2nd Edition, Graduate Studies in Mathematics, Vol. 114, AMS, Providence, Rhode Island, 2010.
5. **G. Strang**, *"Introduction to Linear Algebra"*, 2nd Edition, Prentice Hall of India Pvt. Ltd, 2013.

COURSE OUTCOMES: After the successful completion of the course students will be able to

CO	Statements	Knowledge level
CO1	Discuss the kernel and image of linear of a linear transformation in terms of nullity and rank of a matrix.	K1
CO2	Compute the eigen values and eigen vectors of a square matrix and determine the dimension of the corresponding eigen spaces.	K4
CO3	Determine whether a square matrix is diagonalizable, and compute its diagonalization.	K2
CO4	Find the minimal polynomial and the rational forms of a real square matrix.	K3
CO5	Find the numbers of possible Jordan forms are there for a 6x6 complex matrix with the given characteristic polynomial.	K5

MAPPING WITH PROGRAMME OUTCOME(S):

CO /PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓	✓

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18UPMAT1C02	REAL ANALYSIS - I	L	T	P	C
		4	1	0	5

OBJECTIVE: The course will develop a deeper and more rigorous understanding of calculus including defining terms and proving theorems about functions, sequences, series, limits, continuity and derivatives. The course will develop specialized techniques in problem solving.

UNIT I: Basic Topology

Finite, Countable and Uncountable Sets – Metric Spaces – Compact Sets – Connected Sets (Perfect sets - Omitted).

Unit II: Numerical Sequences and Series

Convergent sequences – Subsequences – Cauchy sequences - Upper and lower limits - Some special sequences – Series – Series of nonnegative terms - The number *e* - The root and ratio tests.

Unit III: Rearrangements of Series

Power series - Summation by parts - Absolute convergence - Addition and multiplication of series – Rearrangements.

UNIT III: Continuity

Limit of Functions – Continuous functions - Continuity and Compactness – Continuity and Connectedness – Discontinuities – Monotonic functions – Infinite limits and Limits at infinity.

UNIT IV: Differentiation

The derivative of a real function – Mean value theorems – The continuity of the Derivative – L' Hospital's Rule – Derivatives of Higher order – Taylor's theorem – Differentiation of Vector–valued functions.

TEXT BOOK:

Walter Rudin, *"Principles of Mathematical Analysis"*, 3rd Edition, McGraw Hill Book Co., Kogaskusha, 1976.

UNIT	Chapter(s)	Pages
I	2	24 - 40, 42 – 46
II	3	47 – 68
III	3	69 – 82
IV	4	83 – 102
V	5	103 – 119

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **Tom M. Apostol**, *"Mathematical Analysis"*, Narosa Publishers, New Delhi, 2002.
2. **R. G. Bartle** and **D.R. Sherbert,** "Introduction to Real Analysis", John Wiley & Sons, New York, 1982.
3. **W.J. Kaczor** and **M.T. Nowak, "**Problems in Mathematical Analysis I – Real Numbers , Sequences and Series", American Mathematical Society, 2000.
4. **W.J. Kaczor** and **M.T. Nowak, "**Problems in Mathematical Analysis II – Continuity and Differentiation", American Mathematical Society, 2000.
5. **Steven G. Krantz,** Real Analysis and Foundations**,** 4th Edition, CRC Press, 2017.
6. **H.H.Sohrab,** *"Basic Real Analysis"*, Springer International Edition, India, 2006.

COURSE OUTCOMES: On completion of this course, students will be able to

CO	Statements	Knowledge level
CO1	Recall the concepts related to metric spaces, such as continuity, compactness, completeness and connectedness	K1
CO2	Evaluate the limit and continuity, derivative of a function at a point	K5
CO3	Understand and perform simple proofs in analysis	K2
CO4	Apply mean value theorems for differentiable functions	K3
CO5	Construct rigorous mathematical proofs in analysis	K6

MAPPING WITH PROGRAMME OUTCOME(S):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓		✓	✓	
CO2	✓	✓		✓	✓	✓
CO3	✓	✓	✓			
CO4	✓	✓		✓		
CO5	✓	✓	✓			

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18UPMAT1C03	ORDINARY DIFFERENTIAL EQUATIONS	L	T	P	C
		4	1	0	5

OBJECTIVE: The objective of this course is to equip the students with knowledge of some advanced concepts related to ordinary differential equations and to understand the concepts related to the solution of ordinary differential equations.

UNIT I: Linear Equations with Constant Coefficients

The second order homogeneous equation - Initial value problems for second order equations - Linear dependence and independence – A formula for Wronskian.

UNIT II:

Linear Equations with Constant Coefficients: The non-homogeneous equation of order two – The homogeneous equation of order n -– A special method for solving the non-homogeneous equation.

Linear Equations with Variable Coefficients: Reduction of the order of a homogeneous equation – The Legendre Equation.

UNIT III: Linear Equations with Regular Singular Points

The Euler equation - Second order equations with regular singular points – The Bessel Equation - The Bessel Equation (continued).

UNIT IV: Existence and Uniqueness of Solutions to First Order Equations

Equations with variables separated - Exact equations – The method of successive approximations – The Lipschitz condition- Convergence of the successive approximations

UNIT V: Boundary Value Problems

Sturm-Liouville problem – Green's functions.

TEXT BOOK:

1. **Earl A. Coddington**, *"An Introduction to Ordinary Differential Equations"*, Prentice Hall of India, New Delhi, 2011.
2. **S. G. Deo, V. Lakshmikantham** and **V. Raghavendra,** "Textbook of Ordinary Differential Equations", Tata McGraw-Hill, New Delhi, 1997.

UNIT	Chapters	Sections
I	2 of [1]	1 – 5
II	2 of [1]	6, 7, 11
	3 of [1]	5, 8

III	**4 of [1]**	1, 2, 3, 7, 8
IV	**5 of [1]**	1-6
V	**7 of [2]**	7.1 – 7.3

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES

1. **R.P. Agarwal** and **R. C. Gupta**, *"Essentials of Ordinary Differential Equation*", McGraw Hill, New York, 1991.
2. **A. K. Nandakumaran, P.S. Satti** and **Raju K. George,** *"Ordinary Differential Equations: Principles and Applications*", Cambridge University Press, 2017.
3. **D. Rai, D.P. Choudhury** and **H.I. Freedman**, *"A Course in Ordinary Differential Equations*", Narosa Publ. House, Chennai, 2004.
4. **Tyn Myint-U,** "Ordinary Differential Equations", Elsevier Science, 1977.
5. **Martin Braun,** "Differential Equations and Their Applications: An Introduction to Applied Mathematics", Springer, 4th Edition, 1992.

COURSE OUTCOMES: At the end of the course, the student will be able to:

CO	**Statements**	**Knowledge level**
CO1	Understand and solve problems based on linear differential equations.	K1
CO2	Solve the second order differential equations using various methods	K2
CO3	Enhancing the students to explore some of the basic theory of linear equations with regular singular points	K2
CO4	Learn various methods of first order differential equations with their solution	K3
CO5	Understand the concepts of differential equations and their use in solving boundary value problems	K4

MAPPING WITH PROGRAMME OUTCOME(S):

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	✓	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓	✓

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18UPMAT1C04	MECHANICS	L	T	P	C
		4	1	0	5

OBJECTIVE: The objective of this course is to understand the Lagrangian and Hamiltonian equations for dynamical systems.

UNIT I: Mechanical Systems

The Mechanical system – Generalized coordinates – Constraints – Virtual work – Energy and Momentum.

UNIT II : Lagrange's Equations

Derivation of Lagrange's Equations – Examples – Integrals of the motion.

UNIT III: Hamilton's Equations

Hamilton's Principle – Hamilton's Equations – Other variational principles.

UNIT IV: Hamilton – Jacobi Theory

Hamilton Principle Function – Hamilton-Jacobi Equation – Separability.

UNIT V: Canonical Transformation

Differential forms and Generating Functions – Special Transformations – Lagrange and Poisson Brackets.

TEXT BOOK:

D.T. Greenwood, *"Classical Dynamics"*, Prentice Hall of India, New Delhi, 1985.

UNIT	Chapter	Sections
I	1	1.1 to 1.5
II	2	2.1 to 2.3
III	4	4.1 to 4.3
IV	5	5.1 to 5.3
V	6	6.1 to 6.3

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **H. Goldstein**, *"Classical Mechanics"*, 2nd Edition, Narosa Publishing House, New Delhi.
2. **R.D. Gregory**, *"Classical Mechanics"*, Cambridge University Press, 2006
3. J.**L.Synge** and **B.A.Griffth**, *"Principles of Mechanics"*, 3rd Edition, McGraw Hill Book Co., New York, 1970.

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

CO	Statement	Knowledge level
CO1	Define the mechanical system of generalized coordinates, virtual work , energy and momentum	K1
CO2	Explain the Derivation of Lagrange's equation and the concept of the Integrals of the motion	K2
CO3	Classify the Hamilton's equations and Modified Hamilton's principle	K3
CO4	Determine the Hamilton form of the equation of motion and find the solutions of integral of equation by the Hamilton's Jacobi theory	K4
CO5	Analyze the Principle function of the generating function for canonical transformation, namely, Special Transformations, Lagrange and Poisson Brackets.	K5

MAPPING WITH PROGRAMME OUTCOME(S):

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓	✓		✓
CO2	✓	✓				✓
CO3	✓	✓	✓	✓		✓
CO4	✓	✓			✓	✓
CO5	✓	✓			✓	✓

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18UPMAT1C05	ABSTRACT ALGEBRA	L	T	P	C
		4	1	0	5

OBJECTIVE: The objective of this course is to introduce the basic ideas of counting principle, Sylow subgroups, finite abelian groups, field theory and Galois Theory and to see its application to the solvability of polynomial equations by radicals.

UNIT I: Sylow's Theorem

Another Counting Principle – 1st, 2nd and 3rd parts of Sylow's Theorems – double coset – the normalizer of a group.

UNIT II: Finite Abelian Groups

External and Internal direct Products – structure theorem for finite abelian groups – non iso-morphic abelian groups - polynomial rings.

UNIT III: Splitting Field

Polynomials over rational fields – the Eisenstein criterion - extension fields – roots of polynomials – splitting fields.

UNIT IV: Galois Theory

More about roots – simple extension – separable extension – fixed fields – symmetric rational functions – normal extension - Galois group – fundamental theorem of Galois theory.

UNIT V: Solvability by radicals

Solvable group – The commutator subgroup – Solvability by radicals - finite fields.

TEXT BOOK:

I.N. Herstein, Topics in Algebra, Second Edition, John Wiley and Sons, New York, 1975.

UNIT	Chapter(s)	Sections
I	**2**	2.11 & 2.12
II	**2 & 3**	2.13, 2.14, 3.9
III	**3 & 5**	3.10, 5.1, 5.3
IV	**5**	5.5 & 5.6
V	**5 & 7**	5.7, 7.1

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **S. Lang**, *"Algebra"*, 3rd Edition, Addison-Wesley, Mass, 1993.
2. **John B. Fraleigh**, *"A First Course in Abstract Algebra"*, Addison Wesley, Mass, 1982.
3. **M. Artin**, *"Algebra"*, Prentice-Hall of India, New Delhi, 1991.
4. **V. K. Khanna** and **S.K. Bhambri,** *"A Course in Abstract Algebra"*, Vikas Publishing House Pvt Limited, 1993.

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

CO	Statement	Knowledge Level
CO1	List all conjugate classes in a finite group	K1
CO2	Give examples to determine the number of Sylow subgroups and the number of nonisomorphic abelian groups	K2
CO3	Apply Eisenstein criterion to check the irreducibility of a given polynomial	K3
CO4	Associate a Galois group to the given polynomial through its splitting field	K4
CO5	Determine whether the given polynomial is solvable by radicals or not	K4

MAPPING WITH PROGRAMME OUTCOME(S):

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓	✓		✓
CO2	✓	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓		✓
CO4	✓	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓	✓

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18UPMAT1C06	REAL ANALYSIS - II	L	T	P	C
		4	1	0	5

OBJECTIVE: The course will develop a deeper and more rigorous understanding of calculus including defining terms and proving theorems about sequence and series of functions, integration, special functions and multivariable calculus. The course will develop specialized techniques in problem solving.

UNIT I: Riemann – Stieltjes Integral

Definition and Existence of the Integral – Properties of the Integral – Integration and Differentiation – Integration of Vector–valued functions – Rectifiable curves.

UNIT II: Sequences and Series of Functions

Discussion of main problem – Uniform Convergence - Uniform Convergence and Continuity - Uniform Convergence and Integration – Uniform Convergence and Differentiation.

Unit III: Sequences and Series of Functions (contd...)

Equicontinuous families of functions – Stone-Weierstrass Theorems – Algebra of complex valued functions.

Unit IV: Some special functions

Power series – The Exponential and Logarithmic functions – Trigonometric Functions – Fourier series - The Gamma functions (Algebraic completeness of the complex field - omitted).

Unit V: Functions of several variables

Linear transformations – Differentiation – The contraction principle - The inverse function theorem – The implicit function theorem.

TEXT BOOK:

Walter Rudin, *"Principles of Mathematical Analysis"*, 3rd Edition, McGraw Hill Book Co., Kogaskusha, 1976.

UNIT	Chapter(s)	Pages
I	**6**	120 – 142
II	**7**	143 – 154
III	**7**	155 – 171
IV	**8**	172 – 203 (Theorem 8.8 omitted)
V	**9**	204 – 228

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **T.M. Apostol**, *"Mathematical Analysis"*, Narosa Publishers, New Delhi,1985.
2. **W.J.Kaczor** and **M.T.Nowak, "**Problems in Mathematical Analysis III - Integration", American Mathematical Society, 2000.
3. **A. Browder, "***Mathematical Analysis, an Introduction"*, Springer-Verlag, New York, 1996.
4. **K.A. Ross,** *"Elementary Analysis: The Theory of Calculus",* 2nd Edition, Springer, New York, 2013.
5. **M. Stoll,** *"Introduction to Real Analysis",* 2nd Edition, Addison-Wesley Longman Inc, 2001.

COURSE OUTCOMES: At the end of this course, students will be able to

CO	Statement	Knowledge Level
CO1	Determine the Riemann integrability and the Riemann-Stieltjes integrability of a bounded function and prove a selection of theorems concerning integration,	K1
CO2	Recognize the difference between pointwise and uniform convergence of a sequence of functions and llustrate the effect of uniform convergence on the limit function with respect to continuity, differentiability, and integrability,	K2
CO3	Determine the limit point of a series of functions	K2
CO4	Know the fundamental theorem of calculus, integration by parts, Gamma function	K1
CO5	Understand the concepts of Functions of several variables, inverse function theorem and implicit function theorem.	K4

MAPPING WITH PROGRAMME OUTCOME(S):

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓
CO3	✓	✓	✓			
CO4	✓	✓				
CO5	✓	✓	✓			

*****

18UPMAT1C07	PARTIAL DIFFERENTIAL EQUATIONS	L	T	P	C
		4	1	0	5

OBJECTIVE: The objective of this course is to enable the students to understand the concepts related to the solution of partial differential equations arising in various fields.

UNIT I: Partial differential equations of first order

Origin of First-order Partial Differential Equations – Cauchy's Problem for First-Order -Nonlinear partial differential equations of the first order – Cauchy's method of characteristics – Compatible systems of first order equations – Charpit's method- Special types of first order equations – Jacobi's method.

UNIT II: Partial differential equations of second order

Linear partial differential equations with constant coefficients – Equations with variable coefficients – The solution of linear hyperbolic equations – Separation of variables

UNIT III: Laplace's Equation

Elementary solution of Laplace's equation – Families of equipotential surfaces – Boundary value problems – Separation of variables

UNIT IV: The wave equation

Elementary solutions of the one-dimensional wave equation – Vibrating membranes: Applications of the calculus of variations – Three dimensional problems

UNIT V: The Diffusion Equation

Elementary solutions of the diffusion equation – Separation of variables – The use of Green's functions

TEXT BOOK:

I.N. Sneddon, Elements of Partial Differential Equations, Dover, Singapore, 2006.

UNIT	Chapter	Sections
I	2	2, 3, 7 – 11, 13
II	3	4, 5, 8, 9
III	4	2 – 5
IV	5	2, 4, 5
V	6	3, 4, 6

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **D. Colton**, *"Partial Differential Equations: An Introduction"*, Dover Publishers, New York, 1988.
2. **H. Hattori**, *"Partial Differential Equations: Methods, Applications and Theories"*, World Scientific, Singapore, 2013.
3. **Y. Pinchover** and **J. Rubinstein,** *"An Introduction to Partial Differential Equations",* Cambride University Press, 2005.
4. **M.D.Raisinghania**, *"Advanced Differential Equations*", S. Chand & Company, New Delhi, 2013.
5. **K. Sankara Rao**, *"Introduction to Partial Differential Equations"*, Second Edition, Prentice – Hall of India, New Delhi, 2006.

COURSE OUTCOMES: At the end of the course, the student will be able to:

CO	Statement	Knowledge Level
CO1	Understand fundamental concepts of partial differential equations of first order, second order etc.	K1
CO2	Classify second order PDE and solve standard PDE using separation of variable method	K2
CO3	Know surfaces and curves in two dimensional space	K3
CO4	Learn various methods to solve linear and non linear partial differential equations	K4
CO5	Solve various real life problems by formulating them into partial differential equations	K5

MAPPING WITH PROGRAMME OUTCOME(S):

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓	✓

*****

		L	T	P	C
18UPMAT1C08	**TOPOLOGY**	4	1	0	5

OBJECTIVE: Topology is the mathematical study of the properties that are preserved through deformations like bending, twisting and stretchings of objects. The aim of studying this course is

- To define what a topological space is, and to introduce the concepts like open sets, closed sets, limit points and continuous functions of topological spaces as natural generalizations of the corresponding ideas for the real line and Euclidean space
- To introduce different kinds of topologies
- To learn the concepts of Connectedness and Compactness for arbitrary topological spaces
- To introduce the countability and separation axioms, and to study the Urysohn Metrization Theorem

UNIT I: Topological Spaces

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

UNIT II: Continuous Functions

Continuous functions – The product topology – The metric topology.

UNIT III: Connectedness

Connected spaces- connected subspaces of the real line – Components and local connectedness.

UNIT IV: Compactness

Compact spaces – Compact subspaces of the real line – Limit point compactness – Local compactness.

UNIT V: Countability and Separation Axioms

The countability axioms – The separation axioms – Normal spaces – The Urysohn lemma – The Urysohn metrization theorem - The Tietz extension theorem.

TEXT BOOK:

J. R. Munkres, *"Topology"*, 2nd Edition, Prentice Hall of India Pvt. Ltd., 2009.

UNIT	Chapter	Sections
I	2	12 – 17
II	2	18 – 21
III	3	23 – 25
IV	3	26 – 29
V	4	30 – 35

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **J. Dugundji,** *"Topology"*, Prentice Hall of India, New Delhi, 1975.
2. **G.F.Simmons, "***Introduction to Topology and Modern Analysis"*, Tata McGraw-Hill Book Co., New Delhi, 2004.
3. **J.L. Kelly,** *"General Topology"*, Springer-Verlag, New York, 1975.

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

CO	Statement	Knowledge Level
CO1	Define what a topological space is, and to identify the concepts like open sets, closed sets, limit points and continuous functions of topological spaces as natural generalizations of the corresponding ideas for the real line and Euclidean space	K1
CO2	Explain various properties of continuous functions, and how to construct continuous functions from one topological space to another	K2
CO3	Create new connected spaces as well as compact spaces from existing ones	K6
CO4	Determine the conditions under which a topological space is metrizable	K4
CO5	Examine the relationship between the countability and separation axioms	K4

MAPPING WITH PROGRAMME OUTCOME(S):

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓	✓		✓
CO2	✓	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓		✓

CO4	✓	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓		✓

*****

		L	T	P	C
18UPMAT1C09	**MEASURE THEORY AND INTEGRATION**	4	1	0	5

OBJECTIVES: The objectives of this course are

- To gain understanding of the abstract measure theory and main properties of the Lebesgue integral.
- To make the students acquire basic knowledge of measure theory needed to understand probability theory, statistics and functional analysis.
- To get ability to differentiate and integrate the Lebesgue integral.

UNIT I: Lebesgue Measure

Introduction – Outer measure - Measurable sets and Lebesgue measure – Measurable functions - Littlewood's three principles.

UNIT II: Lebesgue integral

The Riemann integral - Lebesgue integral of bounded functions over a set of finite measure - The integral of a nonnegative function - The general Lebesgue integral.

UNIT III: Differentiation and Integration

Differentiation of monotone functions - Functions of bounded variation - Differentiation of an integral - Absolute continuity.

UNIT IV: General Measure and Integration

Measure spaces – Measurable functions – Integration - General convergence theorems – Signed Measure – The Radon - Nikodym theorem.

UNIT V: Measure and Outer Measure

Outer measure and measurability – The Extension theorem – Product measures.

TEXT BOOK:

H.L. Royden, "Real Analysis", 3rd Edition, Macmillan Publishing Company, New York, 1988.

UNIT	Chapter	Sections
I	3	1 – 3, 5 & 6
II	4	1 – 4
III	5	1 – 4
IV	11	1 – 3, 5, 6
V	12	1, 2, 4

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **Robert G. Bartle**, The Elements of Integration and Lebesgue Measure, 2nd Edition, Wiley-Blackwell, 1995.
2. **G. De Barra**, Measure Theory and Integration, 2nd Edition, Horwood, Publishing, 2003.
3. **W.Rudin**, Real and Complex Analysis, 3rd Edition, Tata McGraw-Hill Education, New Delhi, 2013.

COURSE OUTCOMES: On the successful completion of the course, students will be able to

CO	Statement	Knowledge Level
CO1	Know the meaning of outer and inner measures with their basic properties and know the meaning with examples of algebras, sigma-algebras, measurable sets, measurable space and measure space..	K1
CO2	Understand the concept of Lebesgue integration both on the general measure space and the real line and know the basic theory of integration and convergence, with the application in evaluating integrals..	K2
CO3	Develop the concepts of Differentiation of monotone functions, Functions of bounded variation, Differentiation of an integral, Absolute continuity	K6
CO4	Study the Radon-Nikodym theorem and its applications. Understand the concepts of Convergence in Measure and Lebesgue Integrability	K3
CO5	Demonstrate understanding of the statements of the main results on integration on product spaces and an ability to apply these in examples.	K4

MAPPING WITH PROGRAMME OUTCOME(S):

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓	✓		✓
CO2	✓	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓		✓
CO4	✓	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓		✓

***

18UPMAT1C10	GRAPH THEORY	L	T	P	C
		3	1	0	4

OBJECTIVE: The objective of the course is to introduce students with the fundamental concepts in graph theory, with a sense of some its modern applications. They will be able to use these methods in subsequent courses in the design and analysis of algorithma, computability theory, software engineering and computer systems.

UNIT I: Basic Concepts:

Graphs and Digraphs.

UNIT II:

Connectivity and trees

UNIT III:

Independent sets, Matchings and Cycles.

UNIT IV:

Graphs colorings.

UNIT V:

Planar Graphs.

TEXT BOOK:

R. Balakrishnan and **K. Ranganathan**, "*A Textbook of Graph Theory*" (2nd edition), Springer, New York, 2012.

UNIT	Chapter	Sections
I	1 & 2	1.1 – 1.7, 2.1 – 2.4
II	3 & 4	3.1, 3.2, 4.1, 4.2
III	5	5.1 – 5.3, 6.1, 6.2
IV	7	7.1, 7.2, 8.1, 8.2, 8.4
V	9	9.1 – 9.3, 9.6

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. J.Clark and D.A.Holton, A First look at Graph Theory, Allied Publishers, New Delhi, 1995.
2. R.J.Wilson and J.J.Watkins, Graphs: An Introductory Approach, John Wiley and Sons, New York, 1989.
3. S.A.Choudum, A First Course in Graph Theory, MacMillan India Ltd. 1987.
4. J.A.Bondy and U.S.R. Murty, Graph Theory and Applications, Macmillan, London, 1976.

COURSE OUTCOMES: After the successful completion of the course students will be able to

CO	Statements	Knowledge level
CO1	Understand the basic concepts of graphs, directed graphs, and able to present a graph by matrices.	K1
CO2	Understand the properties of trees and able to find a minimal spanning tree for a given weighted graph.	K2
CO3	Understand Eulerian and Hamiltonian graphs which makes the model of optimal communication systems.	K3
CO4	Apply shortest path algorithm to solve Chinese Postman problem.	K4
CO5	Apply the knowledge of graphs to solve the real life problem.	K6

MAPPING WITH PROGRAMME OUTCOME(S):

CO /PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓		✓	✓
CO2	✓	✓	✓		✓	✓
CO3	✓	✓	✓		✓	✓
CO4	✓	✓	✓		✓	✓
CO5	✓	✓	✓		✓	✓

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18UPMAT1C11	COMPLEX ANALYSIS	L	T	P	C
		3	1	0	4

OBJECTIVES: The objectives of this course are

- To know the algebraic and topological properties of complex numbers.
- To provide understanding the analytic functions of a complex variable and their role in modern mathematics.
- To demonstrate ability to think knowledge of integration in complex analysis.

Unit I:

The spherical representation of complex numbers – Introduction to the concept of analytic functions - Elementary theory of power series – The Exponential and Trigonometric functions.

Unit II:

Conformality - Linear transformations - Elementary conformal mappings.

Unit III:

Fundamental theorems - Cauchy's integral formula –Local properties of analytic functions.

Unit IV:

The general form of Cauchy's theorem - Calculus of residues.

Unit V:

Harmonic functions – Power series expansions.

TEXT BOOK:

L.V. Ahlfors, *"Complex Analysis"*, 3rd Edition, McGraw-Hill Education, New Delhi, 1979.

UNIT	Chapter(s)	Section(s)
I	1	2, 4
	2	1 – 3
II	3	2 – 4
III	4	1 – 3
IV	4	4 & 5
V	4	6
	5	1

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **J.B. Conway,** *"Functions of One Complex Variable",* 2nd Edition, Springer-Verlag, New York, 1978.
2. **S. Lang,** *"Complex Analysis"*, 4th Edition, Springer-Verlag, New York, 1999.
3. **S. Ponnusamy,** "*Foundations of Complex Analysis*", 2nd Edition, Alpha Science International, 2005.

COURSE OUTCOMES: On the successful completion of the course, students will be able to

CO	Statement	Knowledge Level
CO1	Find the harmonic conjugate to a harmonic function; express analytic functions in terms of power series and Laurent series	K1
CO2	Construct conformal mappings between many kinds of domain. Use conformal mapping to solve the Dirichlet problem in a region.	K2
CO3	Find parameterizations of curves, and compute line integrals directly. Use Cauchy's integral theorem or formula to compute line integrals.	K4
CO4	Find the number of zeroes and poles within a given curve using the argument principle or Rouche's theorem and determine residues. Use the residue theorem to compute several kinds of real integrals.	K3
CO5	Find Laurent series about isolated singularities. Determine whether a sequence of analytic functions converges uniformly on compact sets.	K6

MAPPING WITH PROGRAMME OUTCOME(S):

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓	✓

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18UPMAT1C12	FUNCTIONAL ANALYSIS	L	T	P	C
		4	1	0	5

OBJECTIVES:

The main aim of this course is to provide basic concepts of functional analysis to facilities the study of advanced mathematical structures arising in the natural sciences and the engineering sciences and to grasp the newest technical and mathematical literature.

UNIT I: Banach Spaces

Definition and some examples – Continuous linear transformations – The Hahn-Banach theorem.

UNIT II: Banach Spaces (Cont…)

The natural imbedding of N in N** - Open mapping theorem – conjugate of an operator

UNIT III: Hilbert Spaces

Definition and some simple properties - Orthogonal complements – Orthonormal sets - Conjugate space H*

UNIT IV: Hilbert spaces (Cont…)

Adjoint of an operator - Self-adjoint operators – Normal and unitary operators – Projections.

UNIT V: General Preliminaries on Banach Algebras

Definition and some examples – Regular and singular elements – Topological divisors of zero – Spectrum – The formula for the spectral radius – the radical and semi-simplicity.

TEXT BOOK:

G. F. Simmons, "Introduction to Topology and Modern Analysis", Tata McGraw -Hill Publishing Company, New Delhi, 2004.

UNIT	Chapter(s)	Sections
I	9	46 – 48
II	9 & 10	49 – 51, 52
III	10	53 – 56
IV	10	57 – 59
V	12	64 - 69

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **G. Bachman** and **L. Narici**, *"Functional Analysis"*, Academic Press, New York, 1966.
2. **H.C. Goffman** and **G. Fedrick,** *"First Course in Functional Analysis*", Prentice Hall of India, New Delhi, 1987.
3. **E.Kreyszig**, *"Introductory Functional Analysis with Applications*", John Wiley & Sons, New York, 1978.
4. **E.S.Suhubi**, *"Functional Analysis*", Springer International Edition, India, 2009.

COURSE OUTCOMES: After the successful completion of the course students will be able to

CO	Statements	Knowledge level
CO1	Understand the concepts of Banach and Hilbert spaces and to learn to classify the standard examples. In particular, spaces of sequences and functions.	K2
CO2	Apply properly the specific techniques for bounded operators over normal and Hilbert spaces.	K3
CO3	Know the properties of a Hilbert spaces, including orthogonal complements, orthonormal sets, complete orthonormal sets together with the identities and inequalities.	K4
CO4	Familiar with the theory of linear operators on a Hilbert space, including adjoint operators, self adjoint and unitary operators with their spectra.	K5
CO5	Construct Banach algebras through Banah spaces.	K6

MAPPING WITH PROGRAMME OUTCOME(S):

CO /PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓	✓

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18UPMAT1C13	NUMERICAL ANALYSIS	L	T	P	C
		3	1	0	4

OBJECTIVES: The objectives of this course are

- to make the students familiarize with the ways of solving complicated mathematical problems numerically.
- To provide numerical methods for solving the non-linear equations, interpolation, differentiation, integration, ordinary and partial differential equations.
- Describing and understanding error analysis in numerical methods.

Unit I: Solutions of Equations in One Variable

Newton's Method and its Extensions – Error Analysis for Iterative Methods – interpolation and Polynomial Approximation - Interpolation and the Lagrange Polynomial – Hermite Interpolation – Cubic Spline Interpolation.

Unit II: Numerical Differentiation and Integration

Numerical Differentiation – Elements of Numerical Integration – Romberg Integration.

Unit III: Initial Value Problems for Ordinary Differential Equations

Elementary Theory of Initial Value Problems – Euler's Method – Taylor Method – Runge-Kutta Methods.

Unit IV: Initial Value Problems for Ordinary Differential Equations (Continued)

Multistep Methods – Higher-Order Equations and Systems of Differential Equations – Stability.

Unit V: Numerical Solutions to Partial Differential Equations

Elliptic Partial Differential Equations – Parabolic Partial Differential Equations - Hyperbolic Partial Differential Equations.

TEXT BOOK:

R. L. Burden and **J.D. Faires**, *"Numerical Analysis"*, 9th Edition, Thomson Learning. Inc., Stanford, Connecticut, 2011.

UNIT	Chapter(s)	Sections
I	2 & 3	2.3, 2.4, 3.1, 3.4, 3.5
II	4	4.1, 4.3, 4.5
III	5	5.1, 5.2, 5.4
IV	5	5.6, 5.9, 5.10
V	12	12.1 – 12.3
Algorithms are not included in the syllabus		

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **C.F. Gerald and P.O. Wheatley**, "*Applied Numerical Analysis*" Sixth Edition, Addison-Wesley, Reading, 1998.
2. **M.K. Jain,** "*Numerical Methods for Scientific and Engineering Computation*" New Age International, 2003.

COURSE OUTCOMES: At the end of the course, the student will be able to:

CO	Statements	Knowledge level
CO1	Apply numerical methods to obtain approximate solutions to mathematical problems.	K1
CO2	Understand how to approximate the functions using interpolating polynomials	K2
CO3	Perform error analysis for various methods	K3
CO4	Learn numerical solution of ordinary and partial differential equations with an understanding of convergence, stability and consistency.	K4
CO5	Analyze and evaluate the accuracy of common numerical methods	K5

MAPPING WITH PROGRAMME OUTCOME(S):

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓
CO3		✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓	✓

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18UPMAT1E01	DISCRETE MATHEMATICS	L	T	P	C
		3	1	0	4

OBJECTIVE: The objective of this course is to understand the basic ideas of logic, proof methods and strategy, the growth of functions, counting techniques, pigeonhole principle, recurrence relations, solving recurrences using generating functions, Boolean functions, apply Boolean algebra to circuits and gatting networks, use finite state-machines to model computer operations.

UNIT I: The Foundation of Logic

Logic – Propositional equivalence – Predicates and quantifiers – Proof Methods and Strategy – The growth of functions.

UNIT II: Counting

Basics of counting – The pigeonhole principle – permutations and combinations – Generalized permutations and combinations – Generating permutations and combinations.

UNIT III: Advanced counting techniques

Recurrence relation – Solving recurrence relations – Generating functions.

UNIT IV: Boolean Algebra

Boolean functions – Representing Boolean functions – Logic Gates – Minimization of circuits.

UNIT V: Modeling Computations

Finite – state machines with output, finite – State machines with no output – Turing machines

TEXT BOOK:

Kenneth H. Rosen, "Discrete Mathematics and its Applications"**,** 7th Edition, WCB/ McGraw Hill Publications, New Delhi, 2011.

UNIT	Chapter(s)	Sections
I	1 & 3	1.1 – 1.3, 1.8, 3.2
II	5	5.1 – 5.6
III	6	6.1, 6.2, 6.4
IV	10	10.1 – 10.4
V	12	12.2, 12.3, 12.5

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **Edward A. Bender** and **S. Gill Williamson**, *"A Short Course in Discrete Mathematics",* Dover Publications, 2006.
2. **M.O. Albertson** and **J.P. Hutchinson**, *"Discrete Mathematics with Algorithms*", John Wiley & Sons, 2008.
3. **Rajendra Akerkar** and **Rupali Akarkar**, *"Discrete Mathematics*", Pearson Education Pvt. Ltd, Singapore, 2004.
4. **J.P. Trembley** and **R. Manohar**, *"Discrete Mathematical Structures*", Tata McGraw Hill, New Delhi, 1997.
5. **Martin Aigner**, *"A Course in Enumeration"*, Springer-Verlag, Heidelberg, 2007.
6. **J.H. Van Lint** and **R.M. Wilson**, *"A Course in Combinatorics"*, 2nd Edition, Cambridge University Press, Cambridge, 2001.

COURSE OUTCOMES: After the successful completion of the course students will be able to

CO	Statements	Knowledge level
CO1	Express a logic sentence interms of predicates, quantifiers and logical connectives.	K2
CO2	Apply the rules of inference and methods of proof including direct and indirect proof forms, proof by contradiction and mathematical induction.	K3
CO3	Solve discrete mathematics problems that involve permutations and combinations of a set, fundamental enumeration principles.	K4
CO4	Evaluate Boolean functions and simplify Boolean expressions using the properties of Boolean algebra.	K5
CO5	Simplify Boolean function using circuits with different type of gates.	K6

MAPPING WITH PROGRAMME OUTCOME(S):

CO /PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓		✓	✓
CO2	✓	✓	✓		✓	✓
CO3	✓	✓	✓		✓	✓
CO4	✓	✓	✓		✓	✓
CO5	✓	✓	✓		✓	✓

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18UPMAT1E02	ANALYTIC NUMBER THEORY	L	T	P	C
		3	1	0	4

OBJECTIVE: The aim of this course is to teach the students about the basics of elementary number theory starting with the fundamental theorem of arithmetic, arithmetic functions, multiplicative functions, some equivalent forms of prime number theorem.

UNIT I: The Fundamental Theorem of Arithmetic

Divisibility – greatest common divisor – prime numbers – the fundamental theorem of arithmetic – the series of reciprocals of the primes – the euclidean algorithm – the gcd of more than two numbers.

UNIT II: Arithmetic functions and Dirichlet Multiplication

The Möbius function μ(n) – the Eulertotient functionφ(n) – a relation connecting φandμ - a product formula for φ(n) – the Dirichlet product of arithmetical functions – Dirichlet inverse and the Möbius inversion formula – the Mangoldt function Λ(n).

UNIT III: Multiplicative functions

Multiplicative functions – multiplicative functions and Dirichlet multiplication – the inverse of a completely multiplicative function – Liouville's function – the divisor functions – generalized convolutions.

UNIT IV: Averages of Arithmetical Functions

Asymptotic equality of functions – Euler's summation formula – some elementary asymptotic formula – the average order of $d(n)$ – average order of the divisor functions the average order of $\varphi(n)$ – the average order of $\mu(n)$ and of $\Lambda(n)$.

UNIT V: Distribution of Prime Numbers

The partial sums of a Dirichlet product – applications to $\mu(n)$ and $\Lambda(n)$ - Chebyshev's functions $\psi(x)$ and $I(x)$ – relations connecting $I(x)$and $\pi(x)$.Some equivalent forms of the prime number theorem, inequalities for $\Lambda(n)$ and p_n.

TEXT BOOK:

Tom M. Apostol,*"Introduction to Analytic Number Theory",* Springer, International Student Edition, 2013.

UNIT	Chapter	Sections
I	**1**	**full**
II	**2**	**2.1 – 2.8**
III	**2**	**2.9 – 2.14**
IV	**3**	**3.1 – 3.9**
V	**3**	**3.10, 3.11**
	4	**4.1 – 4.5**

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **R.G. Ayoub**, "*An Introduction to the Analytic Theory of Numbers*", Mathematical Survays, No.10, Providence, R.I, AMS Publications, 1963.
2. **K. Chandrasekharan**, *"Introduction to Analytic Number Theory",*Springer Verlag, 1968.
3. **D.T. Newman,** "*Analytic Number Theory*" GTM Vol 177, Correeted Edition, Springer, 2000.
4. **HengHuat Chan,** "*Analytic Number Theory for undergraduate*" World Scientific, 2009.
5. **William Duke** and **Yuri Tschinkel,** "*Analysis Number Theory: A Tribute to Gauss and Dirichlet,Clay Mathematics"*Proceeding Vol. 7, AMS Publication, Providence, RI, 2007.
6. **H. Iwaniec,** and **E. Kowalski,** "*Analytic Number Theory*" AMS Colloquium Publications, Vol. 53, AMS, 2004.

COURSE OUTCOMES: After the successful completion of the course students will be able to

CO	Statements	Knowledge level
CO1	Know the definition and properties of Dirichlet product the Möbius inversion formula, the greatest integer function, Euler's phi-function.	K1
CO2	Analyze how analytical methods can be used to tackle problems in number theory. Famous examples include Prime Number Theorem about the asymptotic density of prime and Dtichlet theorem about prime numbers in arithmetic progressions.	K2
CO3	Analyze the interrelationships between various arithmetical functions.	K4
CO4	Understand some elementary identities involving $\mu(n)$ and $\Lambda(n)$. This will be used in studying the distribution of primes.	K2
CO5	Apply multiplicative functions to deal with Dirichet series as functions of a complex variable.	K3

MAPPING WITH PROGRAMME OUTCOME(S):

CO /PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓	✓

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18UPMAT1E03	DIFFERENCE EQUATIONS	L	T	P	C
		3	1	0	4

OBJECTIVE: Difference equations usually describe the evolution of certain phenomena over the course of time. The aim of studying this course is

- To introduce the difference calculus.
- To study linear difference equations and to know how to solve them.
- To know the stability theory for homogeneous linear system of difference equations.
- To study the asymptotic behavior of solutions of homogeneous linear difference equations.

UNIT I: Difference Calculus

Difference operator - Summation – Generating functions and approximate summation.

UNIT II: Linear Difference Equations

First order equations - General results for linear equations - Solving linear equations.

UNIT III: Linear Difference Equations

Equations with variable coefficients – The z -transform.

UNIT IV: Stability Theory

Initial value problems for linear systems – Stability of linear systems.

UNIT V: Asymptotic Methods

Introduction – Asymptotic analysis of sums – Linear equations.

TEXT BOOK:

W.G. Kelley and **A.C. Peterson,** *"Difference Equations"*, 2nd Edition, Academic Press, New York, 2001.

UNIT	Chapter	Sections
I	**2**	**2.1 – 2.3**
II	**3**	**3.1 – 3.3**
III	**3**	**3.5, 3.7**
IV	**4**	**4.1, 4.2**
V	**5**	**5.1 – 5.3**

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **R.P. Agarwal**, *"Difference Equations and Inequalities"*, 2nd Edition, Marcel Dekker, New York, 2000.
2. **S.N. Elaydi**, "*An Introduction to Difference Equations*", 3rd Edition, Springer, India, 2008.
3. **R. E. Mickens**, *"Difference Equations"*, 3rd Edition, CRC Press, 2015.

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

CO	Statement	Knowledge Level
CO1	Define a difference operator and to state the properties of difference operator	K1
CO2	Explain the computation of sums, the concept of generating function and the important Euler summation formula	K2
CO3	Solve linear difference equations by applying different methods, namely, annihilator method, z-transform method, etc.	K3
CO4	Examine the stability of linear system of difference equations using eigen value criteria	K4
CO5	Analyze the asymptotic behavior of solutions to linear difference equations by the theorems of Poincare and Perron	K4

MAPPING WITH PROGRAMME OUTCOME(S):

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓	✓		✓
CO2	✓	✓	✓			✓
CO3	✓	✓	✓		✓	✓
CO4	✓	✓	✓		✓	✓
CO5	✓	✓	✓		✓	✓

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18UPMAT1E04	PROBABILITY THEORY	L	T	P	C
		3	1	0	4

OBJECTIVE:

This course aim to provide an understanding of the basic concepts in probability, conditional probability and independent events. It will also focus on the random variable, mathematical expectation, and different types of distributions.

UNIT I: Probability

Introduction - Sample space - Probability axioms - Combinatorics: Probability on finite sample spaces – Conditional probability and Bayes theorem - Independence of events

UNIT II: Random Variables and their Probability Distributions

Introduction - Random variables - Probability distribution of a random variable - Discrete and continuous random variables - Functions of a random variable

UNIT III: Moments and Generating Functions

Introduction - Moments of a distribution function - Generating functions - Some moment inequalities

UNIT IV: Multiple Random Variables

Introduction - Multiple random variables - Independent random variables - Functions of several random variables - Covariance, correlation and moments - Conditional expectation

Unit V: Basic Asymptotics: Large Sample Theory

Introduction - Modes of convergence - Weak law of large numbers - Strong law of large numbers - Limiting moment generating functions - Central limit theorem

TEXT BOOK:

Vijay K. Rohatgi and **A. K. Md. Ehsanes Saleh**, An Introduction to Probability and Statistics, John Wiley and Sons, New Jersey, 2015.

UNIT	Chapter	Sections
I	1	1.1 – 1.6
II	2	2.1 – 2.5
III	4	4.1 – 4.7
IV	5	5.1 – 5.10
V	6	6.2 – 6.4, 6.6 – 6.9, 6.11, 6.12

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **R. Ash**, Probability and Measure Theory, Academic Press, 1999
2. **B.R. Bhat**, Modern Probability Theory, 3rd Edition, New Age International (P)Ltd, New Delhi, 1999.
3. **Y.S. Chow** and **H.Teicher**, Probability Theory, Springer Verlag. Berlin, 1988 (2nd Edition)
4. **K.L. Chung**, A course in Probability, Academic Press, New York, 1974.
5. **K.L. Chung** and **F. Aitshalia**, Elementary Probability Theory, Springer Verlag, 2006.
6. **R. Durrett**, Probability: Theory and Examples, 2nd Edition, Duxbury Press, New York, 1996.
7. **S.I. Resnick**, A Probability Path, Birhauser, Berlin, 1999.
8. **J.S. Rosenthal**, A First Look at Rigorous Probability Theory, 2nd Edition, World Scientific, 2006.

COURSE OUTCOMES: At the end of the course, students will be able to

CO	Statement	Knowledge Level
CO1	Calculate probabilities by applying probability laws and theoretical results.	K1
CO2	Understand the notion of convergence of random variables in the sense of probability and distribution	K2
CO3	Apply methods from algebra and calculus to derive the mean and variance for a range of probability distributions	K3
CO4	Apply the basic rules and theorems in probability including Baye's theorem and the central limit theorem	K3
CO5	Develop the techniques to accurately calculate probabilities.	K6

MAPPING WITH PROGRAMME OUTCOME(S):

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓			✓		
CO2		✓		✓		
CO3				✓	✓	
CO4					✓	
CO5			✓			

18UPMAT1E05	METHODS OF APPLIED MATHEMATICS	L	T	P	C
		3	1	0	4

OBJECTIVES: This course treats the foundations of calculus of variations and gives example on some applications within physics and engineering science: the Euler-Lagrange equation, the brachistochrone problem, minimal surfaces of revolution, Fermat's principle, Hamilton principle, Lagrange's and Hamilton's equations of motion, the Euler-Lagrange equation for several independent variables, vibrating strings and membranes, Ritz Optimisation, relation between differential and integral equations, the Green functions, Fredholm integral equations with separable kernels, classical Fredholm theory, the Neumann Series and resolvent kernels.

UNIT I: Calculus of variations

Maxima and Minima – The simplest case – Examples - Natural and transition boundary conditions – The variational notation – The more general case – Constraints and Lagranges multipliers – Variable end points – Sturm-Liouville problems.

UNIT II: Applications of Calculus of variations

Hamilton's principle – Lagrange's equation – Generalized dynamical entities – Constraints in dynamical systems – Small vibrations about equilibrium – Variational problems for deformable bodies – Rayleih – Ritz method.

UNIT III: Integral Equations

Integral equations – Relations between differential and integral equations – The Green's function – Fredholm equations with separable kernels – Example.

UNIT IV: Integral Equations

Hilbert – Schmidt theory – Iterative method for solving equations of the second kind – The Neumann Series – Fredholm theory – Singular integral equations.

UNIT V: Special devices

Special devices – Iterative approximation to characteristic functions – Approximation of Fredholm equations by sets of algebraic equations.

TEXT BOOK:

F.B. Hildebrand, *"Methods of Applied Mathematics"*, Prentice-Hall of India Pvt., New Delhi, 1968.

UNIT	Chapter	Sections
I	2	2.1 – 2.9
II	2	2.10 – 2.14, 2.16, 2.19
III	3	3.1 – 3 .3, 3.6, 3.7
IV	3	3.8 – 3.12
V	3	3.13 – 3.15

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **R.P. Kanwal,** "*Linear integral equation: Theory and Techniques*", 2nd Edition, Birkhäuser, 1996.
2. **A.S. Gupta**, *"Calculus of Variations with Application",* Prentice-Hall of India, New Delhi, 2005.
3. **L. Elsgolts**, *"Differential Equations and Calculus of Variations*", University Press of the Pacific, 2003.

COURSE OUTCOMES: After the successful completion of the course students will be able to

CO	Statements	Knowledge level
CO1	Give an account of the foundations of calculus of variations and of its applications in Mathematics and Physics.	K1
CO2	Describe the brachistochrone problem mathematically and solve it.	K2
CO3	Solve isoperimetric problems of standard type.	K3
CO4	Solve simple initial and boundary value problems by using several variable.	K4
CO5	Use the theory, methods and techniques of the course solve problems.	K6

MAPPING WITH PROGRAMME OUTCOME(S):

CO /PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓	✓

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18UPMAT1E06	OPTIMIZATION TECHNIQUES	L	T	P	C
		3	1	0	4

OBJECTIVES:

- To introduce the methods of optimization techniques.
- To understand the theory of optimization techniques for solving various types of optimization problems.
- To provide with basic skills and knowledge of optimization techniques and their applications.
- To make the students familiar in solving techniques, analysing the results and propose recommendations to the decision-making processes.

UNIT I: Linear Programming Problems

Dual Simplex – Revised Simplex - Illustrative Applications - Integer Programming Algorithms.

UNIT II: Decision Analysis and Games

Decision Making under certainty – Decision Making under Risk – Decision under uncertainty – Game Theory.

UNIT III: Inventory Models - Deterministic Models

Inventory Models - Probabilistic Models.

UNIT IV: Queuing Theory

Elements of a Queuing model – Role of Exponential Distribution – Pure Birth and Death Models – Generalized Poisson Queuing Model – Specialized Poisson Queues – (M/G/1): (GD/∞/∞) – Pollaczek - Khintchine (P-K) Formula.

UNIT V: Optimization Theory

Classical Optimization Theory – Unconstrained Problems – Constrained Problems.

TEXT BOOK:

Hamdy A Taha, "Operations Research: An Introduction", 7th Edition, Prentice – Hall of India, New Delhi, 2003.

UNIT	Chapter(s)	Sections
I	4 & 7	4.4, 7.2, 9.1, 9.2
II	14	14.1 – 14. 4
III	11 & 16	11.1 – 11.3, 16.1
IV	17	17.2 – 17.7 (Omit 17.6.4)
V	20	20.1, 20.2

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **F.S.Hillier** and **G.J.Lieberman**, *"Introduction to Operations Research,* 4th Edition, Mc Graw Hill Book Company, New York, 1989.
2. **D.T. Philips, A. Ravindra** and **J. Solberg,** *"Operations Research, Principles and Practice",* John Wiley and Sons, New York, 1991.
3. **B.E.Gillett,** *"Operations Research – A Computer Oriented Algorithmic Approach",* TMH Edition, New Delhi, 1976.

COURSE OUTCOMES: At the end of the course, students will be able to:

CO	Statements	Knowledge level
CO1	More knowledge on this topic in higher studies will help students to deal industrial models	K1
CO2	Understand the characteristics of different types of decision-making environments and the appropriate decision making approaches and tools to be used in each type.	K2
CO3	Apply the process of Stock Items-All inventory models	K3
CO4	Formulate Queuing models for service and manufacturing systems, and apply operations research techniques and algorithms to solve these Queuing problems.	K4
CO5	Solve various constrained and unconstrained problems in single variable as well as multivariable.	K5

MAPPING WITH PROGRAMME OUTCOME(S):

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓		✓

CO3	✓	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓		✓
CO5	✓	✓	✓	✓	✓	✓

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18UPMAT1E07	COMBINATORIAL MATHEMATICS	L	T	P	C
		3	1	0	4

OBJECTIVE: Combinatorial mathematics is the study of the arrangements of objects, according to prescribed rules, to count the number of possible arrangements or patterns, to determine whether a pattern of a specified kind exists and to find methods of constructing arrangements of a given type. The objective of this course is to acquaint the students with the concepts of permutations and combinatorics, generating functions, recurrence relations, the principle of inclusion and exclusion and Polya's theory of counting.

UNIT I: Permutations and Combinatorics

The Rules of sum and product – Permutations – Combinations – Distributions of distinct objects – Distribution of nondistinct objects – Stirling's formula

UNIT II: Generating Functions

Generating functions for combinations – Enumerators for permutations- Distributions of distinct objects into nondistinct cells – Partitions of integers – The Ferrers graph – Elementary relations.

UNIT III: Recurrence relations

Linear recurrence relations with constant coefficients – Solution by the technique of generating functions – A special class of nonlinear difference equations – Recurrence relations with two indices.

UNIT IV: The Principle of inclusion and exclusion

The Principle of inclusion and exclusion – The general formula – Derangements – Permutations with restrictions on relative positions – The rook polynomials – Permutations with forbidden positions.

UNIT V: Polya's theory of counting

Sets, relations and groups – Equivalence classes under a permutation group – Equivalence classes of functions – Polya's fundamental theorem – Generalization of Polya's theorem.

TEXT BOOK

C.L.Liu, *"Introduction to Combinatorial Mathematics",* McGraw Hill Book Company, New York, 1968.

UNIT	Chapter(s)	Sections
I	**1**	**1.1 – 1.7**
II	**2**	**2.1 – 2.7**
III	**3**	**3.1 – 3.5**
IV	**4**	**4.1 – 4.7**
V	**5**	**5.1 – 5.7**

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **Murray Edelberg** and **C. L. Liu,** *"Solutions to Problems in Introduction to Combinatorial Mathematics"*, MC Grow-Hill Book & Co., New York, 1968.
2. **R.P. Stanley**, *"Enumerative Combinatorics*", Volume I, 2nd Edition, Cambridge Studies in Advanced Mathematics (Book 49)s, Cambridge University Press, 1997.
3. **P.J. Cameron,** *"Combinatorics: Topics, Techniques, Algorithms*", Cambridge University Press, Cambridge, 1998.
4. **Miklos Bona**, *"A Walk through Combinatorics*", World Scientific Publishing Company, 2002.
5. **M. Aigner**, *"A Course in Enumeration*", Springer-Verlag, Heidelberg, 2007.
6. **J.H. Van Lint** and **R.M. Wilson**, *"A Course in Combinatorics*", 2nd Edition, Cambridge University Press, Cambridge, 2001.

COURSE OUTCOMES: After the successful completion of the course students will be able to

CO	Statements	Knowledge level
CO1	Use formulas for counting basic combinatorial outcomes to construct solutions to complete combinatorial enumeration problems: • permutation with and without repetitions; • combination with and without repetitions.	K1
CO2	Apply counting strategies to solve discrete probability problems.	K2
CO3	Use specialized techniques to solve combinatorial enumeration problems: • generating functions; • recurrence relations; • inclusion-exclusion principle.	K4
CO4	Understand the concepts of permutations with restrictions on relative positions and the rook polynomials.	K5
CO5	enumerate configuration using Polya's theory.	K3

MAPPING WITH PROGRAMME OUTCOME(S):

CO /PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓
CO4	✓	✓	✓		✓	✓
CO5	✓	✓	✓		✓	✓

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18UPMAT1E08	FUZZY SETS AND THEIR APPLICATIONS	L	T	P	C
		3	1	0	4

OBJECTIVE: The objective of this course is to introduce the basic ideas of Fuzzy Sets, Fuzzy sets versus crisp sets, operation on Fuzzy sets, Fuzzy arithmetic and methods of contracting fuzzy sets.

UNIT I: Fuzzy sets

Fuzzy sets – Basic types – basic concepts – Characteristics- Significance of the paradigm shift - Additional properties of $\alpha-$cuts.

UNIT II: Fuzzy sets versus crisp sets

Representation of Fuzzy sets- Extension principle of Fuzzy sets – Operation on Fuzzy Sets – Types of operation – Fuzzy complements.

UNIT III: Operations on Fuzzy sets

Fuzzy intersection – t-norms, Fuzzy unions – t conorms-Combinations of operations – Aggregation operations.

UNIT IV: Fuzzy Arithmetic

Fuzzy numbers – Linguistic variables – Arithmetic operation on intervals – Lattice of Fuzzy numbers.

UNIT V: Constructing Fuzzy Sets

Methods of construction: an overview – direct methods with one expert – direct method with multiple experts – indirect method with multiple experts and one expert- Construction from sample data.

TEXT BOOK:

G.J. Klir and **Bo Yuan,** *"Fuzzy Sets and Fuzzy Logic: Theory and Applications"*, Prentice Hall of India Ltd, New Delhi, 2005.

UNIT	Chapter(s)	Sections
I	1 & 2	1.3 – 1.5, 2.1
II	2 & 3	2.2, 2.3, 3.1, 3.2
III	3	3.3 – 3.6
IV	4	4.1 – 4.4
V	10	10.1 – 10.7

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **H.J.Zimmermann**, "*Fuzzy Set Theory and its Applications*", Allied Publishers, Chennai, 1996.
2. **A.Kaufman**, "*Introduction to the Theory of Fuzzy Subsets*", Academi Press, New York, 1975.
3. **V.Novak**, *"Fuzzy Sets and Their Applications"*, Adam Hilger, Bristol, 1969.

COURSE OUTCOMES: After the successful completion of the course students will be able to

CO	Statements	Knowledge level
CO1	distinguish between the crisp set and fuzzy set concepts.	K1
CO2	draw a parallelism between crisp set operations and fuzzy set operations through the use of characteristic and membership functions, respectively.	K2
CO3	define fuzzy sets using linguistic words and represent these sets by membership functions.	K1
CO4	know how to perform mapping of fuzzy sets by a function and also use α – level sets in such instances.	K3
CO5	Become aware of the use of fuzzy inference systems in the design of intelligent or humanistic systems.	K4

MAPPING WITH PROGRAMME OUTCOME(S):

CO /PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓		✓	✓
CO2	✓	✓	✓		✓	✓
CO3	✓	✓	✓		✓	✓
CO4	✓	✓	✓		✓	✓
CO5	✓	✓	✓		✓	✓

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18UPMAT1E09	REPRESENTATION THEORY OF FINITE GROUPS	L	T	P	C
		3	1	0	4

OBJECTIVE: Representation theory, the art of realizing a group in a concrete way, usually as a collection of matrices, is a fundamental tool for studying groups by means of linear algebra. The results of the theory of representations of finite groups play a fundamental role in many recent developments of mathematics and theoretical physics. The study of the representation theory of groups becomes a special case of the study of modules over rings. This course provides the concepts of the characters of groups and the basic properties of irreducible characters and their connection with the ring structure of group algebras.

UNIT I: Group representations

Group representations – FG Modules – FG - submodules and Reducibility- Group algebras.

UNIT II: Group algebra

FG-homomorphisms – Maschke's theorem – Consequences of Maschke's theorem – Schur's lemma – Irreducible modules and the group algebra.

UNIT III: More on the group algebra

More on the group algebra – The spaces of FG-homeomorphisms – Conjugacy classes - Conjugacy class sizes – Characters – The values of a character – The regular character.

UNIT IV: Irreducible characters

Inner product of characters – Applications – Decomposing CG-modules – Class functions – The number of irreducible characters.

UNIT V: Character tables

Character Tables and Orthogonality relations- Normal subgroups and Lifted characters- Some Elementary Character Tables.

TEXT BOOK:

G.James and **M.Liebeck**, "*Representations and Characters of Groups*", 2nd Edition, Cambridge University Press, London, 2001.

UNIT	Chapter(s)
I	3 – 6
II	7 – 10
III	11 – 13

IV	**14 – 15**
V	**16 – 18**

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **C.W. Curtis** and **I.Reiner**, *"Methods of Representation Theory with Applications to Finite Groups and Orders"*, Volume 1, Wiley – Interscience, New York, 1981.
2. **J.P. Serre**, *"Linear Representation of Finite Groups"*, Springer-Verlag, New York, 1977.
3. **W.Fulton** and **J. Harris**, *"Representation Theory – A First Course"*, Graduate Texts in Mathematics 129, Springer – Verlag, New York, 1991.

COURSE OUTCOMES: After the successful completion of the course students will be able to

CO	Statements	Knowledge level
CO1	Find the number of irreducible representations of a finite group	K2
CO2	Understand the special role played by the famous Maschke's Theorem	K3
CO3	Find a finite set of irreducible CG-modules such that every irreducible CG-module is isomorphic to one of them.	K4
CO4	Calculate the dimension of Hom(V,W) over CG.	K5
CO5	Find a method for decomposing a given CG-module as a direct sum of CG-sub modules, using characters.	K6

MAPPING WITH PROGRAMME OUTCOME(S):

CO /PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓		✓	✓
CO2	✓	✓	✓		✓	✓
CO3	✓	✓	✓		✓	✓
CO4	✓	✓	✓		✓	✓
CO5	✓	✓	✓		✓	✓

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		L	T	P	C
18UPMAT1E10	**NON COMMUTATIVE ALGEBRA**	3	1	0	4

OBJECTIVE: The objective of this course is to equip the students with knowledge of some advanced concepts namely decomposition of rings, Artinian rings, Noetherian rings, categories, functors, projective, injective and flat modules and homological dimensions. This course also provides the foundation required for more advanced study in Algebra.

UNIT I: Decompositions of Rings:

Modules and homomorphisms – Classical isomorphism theorems – direct sums and products – free modules – two sided Peirce decomposition of a ring – the Wedderburn – Artin theorem – finitely decomposable rings.

UNIT II: Artinian and Noetherian Rings:

The Jordan-Holder theorem – the Hilbert basis theorem – the radical of a module and a ring – the radical of an Artinian rings – Semiprimary rings.

UNIT III: Categories and Functors:

Exact sequences – direct sums and direct products – the Hom functors – tensor product functor – direct and inverse limits.

UNIT IV: Projectives, Injectives and Flats:

Projective modules – injective modules – essential extensions and injective hulls – flat modules – right hereditary and right semihereditary rings – Herstein-Small rings.

UNIT V: Homological Dimensions:

Complexes and homology, free solutions – Projective and Injective resolutions, Derived functors – the functors Tor, EXT__ , projective and injective dimensions – global dimensions.

TEXT BOOK:

M. Hazewinkel, N. Gubareni and **V.V. Kirichenko, "***Algebras, Rings and Modules", Volume I*, Springer International Edition, New Delhi, 2011.

UNIT	Chapter(s)	Sections
I	1 & 2	1.1 – 1.5, 2.1 – 2.4
II	3	3.1 – 3.7
III	4	4.1 – 4.7
IV	5	5.1 – 5.6
V	6	6.1 – 6.6

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **T.Y. Lam**, *"Lectures on Modules and Rings*", Graduate Texts in Mathematics, Vol. 189, Springer-Verlag, Berlin-Heidelberg, New York, 1999.
2. **J. Lambek,** *"Lectures on Rings and Modules*", 3rd Edition, AMS Chelsea Publishing, AMS, Providence, Rhode Island, 2009.
3. **D.S. Passman,** *"A Course in Ring Theory"*, AMS Chelsea Publishing, AMS, Providence, Rhode Island, 2004.

4. **L.R. Vermani,** *"An Elementary Approach to Homological Algebra"*, Chapman & Hall / CRC Monographs and Surveys in Pure and Applied Mathematics. Vol. 130, CRS Press, LLC, Florida, 2003.

COURSE OUTCOMES: After the successful completion of the course students will be able to

CO	Statements	Knowledge level
CO1	Find whether the given ring is decomposable or not? by using centrally primitive orthogonal idempotents,	K2
CO2	Know the properties of the radical of a module and a ring.	K2
CO3	Understand the role of the Hom and tensor product functors.	K3
CO4	Find whether the given module is injective or not? by using many structure theorems for injective modules.	K5
CO5	Calculate the homological dimensions of modules.	K6

MAPPING WITH PROGRAMME OUTCOME(S):

CO /PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓		✓	✓
CO2	✓	✓	✓		✓	✓
CO3	✓	✓	✓		✓	✓
CO4	✓	✓	✓		✓	✓
CO5	✓	✓	✓		✓	✓

		L	T	P	C
18UPMAT1E11	**COMMUTATIVE ALGEBRA**	3	1	0	4

OBJECTIVE: The objective of this course is to study modules, exact sequences, tensor product of modules, local properties, primary decomposition, Noetherian rings and Artinian rings. Also, another important class of Dedekind domain is studied.

Unit I: Rings and Ideals

Rings and ring homomorphism's – ideals – Extension and Contraction, modules and module homomorphism – exact sequences.

Unit II: Rings and Modules of Fractions

Tensor product of modules – Tensor product of algebra – Local properties – extended and contracted ideals in rings of fractions.

Unit III: Primary Decomposition

Primary Decomposition – Integral dependence – The going-up theorem – The going-down theorem – Valuation rings.

Unit IV: Noethorian rings

Chain conditions – Primary decomposition in Noetherian rings.

Unit V: Artin local rings

Artin rings – Discrete valuation rings – Dedekind domains – Fractional ideals.

TEXT BOOK:

S.M.Atiyah and **I.G.Macdonald**, *"Introduction to Commutative Algebra"*, Addison – Wesley Publication Company, Inc, 1969.

UNIT	Chapter(s)	Pages
I	1, 2	1 - 24
II	2, 3	24 - 49
III	4, 5	50 - 73
IV	6, 7	74 – 88
V	8, 9	89 – 99

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **N.S. Gopalakrishnan**, *"Commutative Algebra"*, Oxonian Press Pvt. Ltd, New Delhi, 2015.
2. **I. Kaplansky**, *"Commutative Rings"*, University of Chicago Press, Chicago, 1974.
3. **H. Matsumura,** *"Commutative Ring Theory"*, Cambridge University Press, 1986.

COURSE OUTCOMES: After the successful completion of the course students will be able to

CO	Statements	Knowledge level
CO1	Know the definition of commutative rings, local rings, prime and maximal ideals and modules over commutative rings.	K1
CO2	Understand the important properties and applications of exact sequences.	K2
CO3	Understand how to define tensor products of modules and the concept of flatness.	K2
CO4	Analyze about localize rings and modules, and the important applications of localization.	K1
CO5	Apply the notions of Noetherian and Artinian rings and modules, Hilbert basis theorem and the structure theorem for Artinian rings.	K3

MAPPING WITH PROGRAMME OUTCOME(S):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓	✓	✓	✓
CO2	✓	✓	✓		✓	✓
CO3	✓	✓	✓		✓	✓
CO4	✓	✓	✓		✓	✓
CO5	✓	✓	✓		✓	✓

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16UPMAT1E12	CONTROL THEORY	L	T	P	C
		3	1	0	4

OBJECTIVE: This is an introductory course in mathematical systems theory. The subject provides the mathematical foundation of modern control theory. The aim of the course is to acquire a systematic understanding of linear dynamical systems. The acquirement of such knowledge is useful in preparation for work on system analysis and design problems that appear in many engineering fields.

Unit-I: Observability

Linear Systems – Nonlinear Systems.

Unit-II: Controllability

Linear systems – Nonlinear systems.

Unit-III: Stability

Stability – Perturbed linear systems – Nonlinear systems.

Unit IV: Stabilizability

Stabilization via linear feedback control – The controllable subspace – Stabilization with restricted feedback.

Unit V: Optimal Control

Linear time varying systems – Linear time invariant systems – Nonlinear Systems.

TEXT BOOK

K.Balachandran and **J.P.Dauer**, *"Elements of Control Theory"*, 2nd Edition (revised), Alpha Science International Ltd, 2011.

UNIT	Chapter(s)	Sections
I	**2**	**2.1 – 2.3**
II	**3**	**3.1, 3.2**
III	**4**	**4.1 – 4.3, 4.5**
IV	**5**	**5.1 – 5.4**
V	**6**	**6.1 – 6.3**

Books for Supplementary Reading and References:

1. **R. Conti**, *"Linear Differential Equations and Control"*, Academic Press, London, 1976.
2. **R.F. Curtain** and **A.J.Pritchard**, *"Functional Analysis and Modern Applied Mathematics"*, Academic Press, New York, 1977.
3. **J. Klamka,** *"Controllability of Dynamical Systems"*, Kluwer Academic Publisher, Dordrecht, 1991.

COURSE OUTCOMES: At the end of the course, students will be able to

CO	Statements	Knowledge level
CO1	understand the building blocks of basic and modern control systems	K2
CO2	get an understanding of the basic ingredients of linear systems theory	K2
CO3	select appropriate methodologies for the analysis or design of feedback and open-loop control systems	K4
CO4	learn some basic notions and results in control theory, which are very useful for applied mathematicians	K1
CO5	take a research career in the area of differential equations and control theory	K6

MAPPING WITH PROGRAMME OUTCOME(S):

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓				
CO2	✓	✓				
CO3	✓	✓	✓			
CO4	✓	✓	✓		✓	✓
CO5	✓	✓			✓	✓

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16UPMAT1E13	STOCHASTIC DIFFERENTIAL EQUATIONS	L	T	P	C
		3	1	0	4

OBJECTIVE: Stochastic differential equations have been used extensively in many areas of application, including finance and social science as well as in physics, chemistry. This course develops the theory of Itô's calculus and stochastic differential equations.

Unit I: Mathematical Preliminaries and Itô Integrals

Probability Spaces – Random variables and Stochastic Processes – An Important Example: Brownian motion – Construction of the Itô Integral – Some Properties of the Itô Integral – Extensions of the Itô Integral.

Unit II: Itô Formula and Martingale Representation Theorem

The 1-dimensional Itô Formula - The Multi-dimensional Itô Formula – The Martingale Representation Theorem.

Unit III: Stochastic Differential Equations

Examples and Some Solution Methods – An Existence and Uniqueness Result – Weak and Strong Solutions.

Unit IV: The Filtering Problem

Introduction – The 1-Dimensional Linear Filtering Problem – The Multidimensional Linear Filtering Problem.

Unit V: Diffusions: Basic Properties

The Markov Property – The Strong Markov Property – The Generator of an Itô Diffusion – The Dynkin Formula – The Characteristic Operator.

TEXT BOOK:

B. Oksendal, "*Stochastic Differential Equations: An Introduction with Applications*", 6th Edition, Springer - Verlag, Heidelberg, 2003.

UNIT	Chapter(s)	Pages
I	2 & 3	2.1, 2.2, 3.1 – 3.3
II	4	4.1 – 4.3
III	5	5.1 – 5.3
IV	6	6.1 – 6.3
V	7	7.1 – 7.5

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **A. Friedman**, *"Stochastic Differential Equations and Applications"*, Dover Publications, 2006.
2. **L. Arnold**, *"Stochastic Differential Equations: Theory and Applications"*, Dover Publications, 2011.
3. **D. Henderson** and **P. Plaschko**, *"Stochastic Differential Equations in Science and Engineering"*, World Scientific, 2006.

COURSE OUTCOMES: At the end of the course, students will be able to

CO	Statements	Knowledge level
CO1	Understand the basics of Ito calculus	K1
CO2	obtain solution to stochastic differential equations	K3
CO3	learn about general existence and uniqueness results for stochastic differential equations	K1
CO4	Apply Ito's Lemma to find SDEs arising in real-world applications	K3
CO5	take a research career in the area of stochastic differential equations	K6

MAPPING WITH PROGRAMME OUTCOME(S)::

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓				
CO2	✓	✓				
CO3	✓	✓	✓			
CO4	✓	✓			✓	
CO5	✓	✓				✓

*****

18UPMAT1E14	NUMBER THEORY	L	T	P	C
		3	1	0	4

OBJECTIVE: The aim of this course is to teach the students about the basics of elementary number theory starting with primes, congruences, quadratic residues, primitive roots, arithmetic functions and some Diophantine equations.

Unit I: Divisibility and Congruences

Divisibility – Primes – Congruences – Solutions of Congruences.

Unit II: Congruences

The Chinese Remainder Theorem – Prime Power Moduli – Prime Modulus - Primitive Roots and Power Residues – Congruencesof Degree Two, Prime Modulus.

Unit III: Quadratic Reciprocity and Quadratic Forms

Quadratic Residues – Quadratic Reciprocity – The Jacobi Symbol – Sums of Two Squares.

Unit IV: Some Functions of Number Theory

Greatest Integer Function – Arithmetic Functions – The Mobius Inversion Formula - Combinatorial Number Theory.

Unit V: Some Diophantine Equations

The Equation ax + by=c – Simultaneous Linear Equations – Pythagorean Triangles – Assorted Examples.

TEXT BOOK:

I. Niven, H. S. Zuckerman and **H. L. Montgomery, An Introduction to the Theory of Numbers**, 5thEdition, John Wiley & Sons, Inc., New York, 2004.

UNIT	Chapter(s)	Sections
I	1&2	1.2, 1.3, 2.1, 2.2
II	2	2.3, 2.6 – 2.9
III	3	3.1 – 3.3, 3.6
IV	4	4.1 – 4.3, 4.5
V	5	5.1 – 5.4

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **D.M. Burton**, *"Elementary Number Theory"*, Universal Book, Stall, New Delhi 2001.
2. **K. Ireland** and **M. Rosen**, *"A Classical Introduction to Modern Number Theory"*, Springer Verlag, New York, 1972.
3. **T.M. Apostol**, *"Introduction to Analytic Number Theory*", Narosa Publ. House, Chennai, 1980.

COURSE OUTCOMES: On the successful completion of the course, students will be able to

CO	Statement	Knowledge Level
CO1	Find quotients and remainders from integer division. Apply Euclid's algorithm and backwards substitution	K1
CO2	Understand the definitions of congruences, residue classes and least residues. Add and subtract integers, modulo n, multiply integers and calculate powers, modulo n.	K3

CO3	Analyze the Euler's function, applications of Euler's function algebraic structures and its behavior.	K3
CO4	Evaluate the quadratic residues, Legendre symbols and solve its problems.	K4
CO5	Solve certain types of Diophantine equations.	K3

MAPPING WITH PROGRAMME OUTCOME(S)::

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓		
CO3	✓	✓	✓	✓	✓	
CO4	✓	✓	✓	✓		
CO5	✓	✓	✓	✓		✓

18UPMAT1E15	DIFFERENTIAL GEOMETRY	L	T	P	C
		3	1	0	4

OBJECTIVE: This course gives students basic knowledge of classical differential geometry of curves and surfaces such as the catenary, the tractrix, the cycloid and the surfaces of constant Gaussian curvature and minimal surfaces. .

UNIT I: Space Curves

Definition of a space curve – Arc length – Tangent – Normal and binormal – Curvature and torsion – Contact between curves and surfaces – Tangent surface – Involutes and evolutes – Intrinsic equations – Fundamental existence theorem for space curves – Helics.

UNIT II: Intrinsic Properties of a Surface

Definition of a surface – Curves on a surface – Surface of revolution – Helicoids – Metric – Direction coefficients – Families of curves – Isometric correspondence – Intrinsic properties.

UNIT III: Geodesics

Geodesics – Canonical geodesic equations – Normal property of geodesics – Existence theorems – Geodesic parallels – Geodesics curvature- Gauss-Bonnet Theorem – Gaussian curvature – Surface of constant curvature.

UNIT IV: Non Intrinsic Properties of a Surface

The second fundamental form – Principal curvature – Lines of curvature – Developable - Developable associated with space curves and with curves on surface – Minimal surfaces – Ruled surfaces.

UNIT V: Differential Geometry of Surfaces

Compact surfaces whose points are umblics – Hilbert's lemma – Compact surface of constant curvature –Complete surface and their Characterization – Hilbert's Theorem – Conjugate points on geodesics.

TEXT BOOK:

T.J. Willmore, *"An Introduction to Differential Geometry"*, Oxford University press, (17th Impression), New Delhi, 2002. (Indian Print)

UNIT	Chapter(s)	Sections
I	I	1 – 9
II	II	1 – 9
III	II	10 – 18
IV	III	1 – 8
V	IV	1 – 8

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **D.T. Struik**, *"Lectures on Classical Differential Geometry"*, Addition –Wesley, Mass, 1950.
2. **S. Kobayashi** and **K. Nomizu,** *"Foundations of Differential Geometry"*, Interscience Publishers, 1963.
3. **W. Klingenberg,** *"A Course in Differential Geometry"*, Graduate Texts in Mathematics, Springer – Verlag 1979.
4. **C.E.Weatherburn**, *"Differential Geometry of Three Dimensions"*, University Press, Cambridge, 1930.

COURSE OUTCOMES: After the successful completion of the course students will be able to

CO	Statements	Knowledge level
CO1	Determine and calculate curvature of curves in different coordinate systems.	K2
CO2	Find the Osculating surface and Osculating curve at any point of a given curve.	K3
CO3	Calculate the first and the second fundamental forms of surface.	K3
CO4	Introduced to geodesics on a surface and their characterization and understand geodesics as distance minimizing curves on surfaces.	K1

CO5	Calculate the Gaussian curvature, the man curvature, the curvature lines, the asymptotic lines, the geodesics on various surfaces.	K5

MAPPING WITH PROGRAMME OUTCOME(S):

CO /PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓		✓	✓
CO2	✓	✓	✓		✓	✓
CO3	✓	✓	✓		✓	✓
CO4	✓	✓	✓		✓	✓
CO5	✓	✓	✓		✓	✓

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18UPMAT1E16	ADVANCED PARTIAL DIFFERENTIAL EQUATIONS	L	T	P	C
		3	1	0	4

OBJECTIVE: The objective is to

- ❖ develop an understanding of the theory and methods of solution for partial differential equations.
- ❖ provide an introduction to the study and solution methods for partial differential equations of first and second order.
- ❖ make the students to understand the characteristics of heat, wave, and Laplace's equations.
- ❖ provide the students a better understanding to the diffusion and wave equations and their applications.

Unit-I: Laplace Equation

Partial Differential Equations – Classifications – Examples - Fundamental solution – Mean-value formulas – Properties of harmonic functions – Green's functions – Energy methods.

UNIT II: Heat Equation

Fundamental solution – Mean-value formula – Properties of solutions – Energy methods.

UNIT III: Wave Equation

Solution by spherical means – Nonhomogeneous problem – Energy methods.

UNIT IV: Other ways to represent solutions

Separation of variables - Similarity solutions.

UNIT V: Other ways to represent solutions

Transform methods - Converting nonlinear into linear PDE.

TEXTBOOK:

L. C. EVANS, *"Partial Differential Equations",* American Mathematical Society, Indian Edition, 2009.

UNIT	Chapter(s)	Sections
I	1 & 2	1.1, 1.2, 2.2
II	2	2.3
III	2	2.4
IV	4	4.1, 4.2
V	4	4.3, 4.4

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **D. Colton**, *"Partial Differential Equations: An Introduction",* Dover Publishers, New York, 1988.
2. **F. John,** *"Partial Differential Equations"*, Applied Mathematical Science (Vol. 1), Springer, 1982.
3. **M. Renardy** and **R.C.Rogers,** *"An Introduction to Partial Differential Equations*", Springer, 2004.
4. **R. McOwen,** *"Partial Differential Equations: Methods and Applications*", 2nd Edition, Pearson Education, 2005.

COURSE OUTCOMES: At the end of the course, students will be able to

CO	Statements	Knowledge level
CO1	Obtain the fundamental solutions of Laplace's, Heat and Wave equations	K1
CO2	Derive the mean-value formula of Laplace's, Heat and Wave equations	K5
CO3	Enhance their mathematical understanding in representing solutions of partial differential equations.	K2
CO4	Understand the fundamental theory to take a research career in the area of partial differential equations	K2
CO5	Apply different methods to obtain solutions	K3

MAPPING WITH PROGRAMME OUTCOME(S):

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓					
CO2	✓				✓	✓

CO3	✓	✓	✓			
CO4	✓		✓			✓
CO5	✓		✓		✓	✓

*****

		L	T	P	C
18UPMAT1E17	**NONLINEAR DIFFERENTIAL EQUATIONS**	3	1	0	4

OBJECTIVE: The main objective of this course is

- to discuss nonlinear ordinary differential equations for their different behavior of the solutions.
- to study periodic solutions and averaging methods, perturbation methods and stability.
- to analyze some applications of nonlinear ordinary differential equations studied in the present work to some concrete problem of the other areas of mathematics.

UNIT I: Plane autonomous systems and linearization

The general phase plane - Some population models – Linear approximation at equilibrium points – Linear systems in matrix form.

UNIT II: Periodic Solutions and Averaging Methods

An energy balance method for limit cycles – Amplitude and frequency estimates – Slowly varying amplitudes; Nearly periodic solutions - Periodic solutions: Harmonic balance – Equivalent linear equation by harmonic balance – Accuracy of a period estimate.

UNIT III: Perturbation Methods

Outline of the direct method – Forced oscillations far from resonance- Forced oscillations near resonance with weak excitation – Amplitude equation for undamped pendulum – Amplitude perturbation for the pendulum equation – Lindstedt's method – Forced oscillation of a self – excited equation – The Perturbation method and Fourier series.

UNIT IV: Stability

Poincare stability – Paths and solution curves for general systems - Stability of time solutions: Liapunov stability - Liapunov stability of plane autonomous linear systems

UNIT V: Stability

Structure of the solutions of *n*-dimensional linear systems - Structure of *n*-dimensional inhomogeneous linear systems - Stability and boundedness for linear systems - Stability of linear systems with constant coefficients.

TEXT BOOK:

D.W.Jordan and P.Smith, *"Nonlinear Ordinary Differential Equations"*, 4th Edition, Oxford University Press, New York, 2007.

UNIT	Chapter	Sections
I	2	2.1 – 2.5
II	4	4.1 – 4.5
III	5	5.1 – 5.5, 5.8 – 5.11
IV	8	8.1 – 8.4
V	8	8.5 – 8.8

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **G.F. Simmons,** "*Differential Equations*", Tata McGraw-Hill, New Delhi, 1995.
2. **D.A. Sanchez,** "*Ordinary Differential Equations and Stability Theory*", Dover, New York, 1979.
3. **J.K. Aggarwal**, "*Notes on Nonlinear Systems*", Van Nostrand, 1972.

COURSE OUTCOMES: At the end of the course, students will be able to

CO	Statements	Knowledge level
CO1	Identify the concepts of population model with phase plane.	K1
CO2	derive the limit cycle via energy balance method	K5
CO3	Use perturbation method and Fourier series to solve Forced oscillations and Amplitude equation for undamped pendulum	K2
CO4	understand the stability through Liapunov function and Poincare stability	K2
CO5	apply stability theory to n-dimensional linear systems.	K3

MAPPING WITH PROGRAMME OUTCOME(S):

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓
CO3	✓	✓	✓		✓	✓
CO4	✓	✓	✓		✓	✓
CO5	✓	✓	✓		✓	✓

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18UPMAT1E18	MATHEMATICAL BIOLOGY	L	T	P	C
		3	1	0	4

OBJECTIVE: Biology is undergoing a quantitative revolution, generating vast quantities of data that are analysed using bioinformatics techniques and modelled using mathematics to give insight into the underlying biological processes. This module aims to give a flavour of how mathematical modelling can be used in different areas of biology.

UNIT I: Single Species Population Dynamics

Continuous time models – Growth models, Logistic model – Evolutionary Aspects – Delay models.

UNIT II: Two Species Population Dynamics

The Lotka-Volterra Prey-Predator equations – Modelling the predator functional response Competition – Ecosystems modeling.

UNIT III: Infectious Diseases

Simple epidemic and SIS diseases – SIR Epidemics – SIR Endemics.

UNIT IV: Biochemical Kinetics

Transitions between states at the molecular and populations level – Law of mass action – Enzyme kinetics.

UNIT V: Biochemical Kinetics

Simple models for polymer growth dynamics.

TEXT BOOK:

1. **N. Britton,** *"Essential Mathematical Biology",* Springer Science & Business Media, 2012.
2. **L.A. Segel** and **L. Edelstein-Keshet,** *"A Primer in Mathematical Models in Biology",* SIAM, Vol. 129, 2013.

UNIT	Chapter/ Text Book	Section(s)
I	1 of [1]	1.3 – 1.5, 1.7
II	2 of [1]	2.3 - 2.6
III	3 of [1]	3.1 - 3.4
IV	2 of [2]	2.1 - 2.4
V	2 of [2]	2.5

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **J.D. Murray, "***Mathematical Biology I: An Introduction*", Springer-Verlag, New York, 2002.
2. **A. D. Bazykin,** *"Nonlinear dynamics of interacting populations",* World Scientific, 1998.

3. **J.N.Kapur,** "*Mathematical Models in Biology and Medicine*", Affiliated East–West, New Delhi, 1985.

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

CO	Statement	Knowledge Level
CO1	Identify the concepts of Continuous time models, Growth models, Logistic model, Delay models.	K1
CO2	Understand the concepts of Lotka-Volterra Prey-Predator equations and modelling the predator functional response Competition.	K3
CO3	Develop the epidemic and SIS diseases, SIR Epidemics, SIR Endemics and its behavior.	K4
CO4	Analyze the Transitions between states at the molecular and populations level and Law of mass action.	K3
CO5	Apply the concepts of Simple models for polymer growth dynamics.	K3

MAPPING WITH PROGRAMME OUTCOME(S):

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓		✓	✓
CO2	✓	✓	✓		✓	✓
CO3	✓		✓		✓	✓
CO4	✓		✓		✓	✓
CO5	✓		✓		✓	✓

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18UPMAT1E19	FLUID DYNAMICS	L	T	P	C
		3	1	0	4

OBJECTIVE: The objective of this course is

- To give fundamental knowledge of fluid, its properties and behavior under various conditions of internal and external flows.
- To understand basic laws and equations used for analysis of static and dynamic fluids.
- To develop an appreciation for the properties of Newtonian fluids.
- To understand the dynamics of fluid flows and the governing non-dimensional parameters

Unit I: Inviscid Theory

Introductory Notions, velocity: Streamlines and paths of the particles-stream tubes and filaments-fluid body- Density – Pressure – Bernoulli's theorem. Differentiation with respect to time- Equation of continuity- Boundary conditions: kinematical and physical – Rate of change of linear momentum – The equation of motion of an inviscid fluid.

Unit II: Inviscid Theory (contd...)

Euler's momentum theorem- conservative forces – Lagrangian form of the equation of motion – Steady motion – The energy equation – Rate of change of circulation – Vortex motion – Permanence of vorticity.

Unit III: Two Dimensional Motion

Two dimensional functions: Stream function – Velocity potential – Complex potential – Indirect approach – Inverse function. Basic singularities: Source – Doublet – Vortex – Mixed flow – Method of images: Circle theorem – Flow past circular cylinder with circulation. The aerofoil: Blasius's theorem – Lift force.

Unit IV: Viscous Theory

The equations of motion for viscous flow: The stress tensor – The Navier-Stokes equations – Vorticity and circulation in a viscous fluid. Flow between parallel flat plates: Couette flow, Plane Poiseuille flow. Steady flow in pipes: Hagen-Poiseuille flow.

Unit V: Boundary Layer Theory

Boundary layer concept- Boundary layer equations in two dimensional flow- Boundary layer along a flat plate: Blasius solution – Shearing stress and boundary layer thickness – Momentum integral theorem for the boundary layer: The von Karman integral relation – von Karman integral relation by momentum law.

TEXT BOOKS:

1. **L.M. Milne Thomson**, "*Theoretical Hydrodynamics*", Dover, 1996.
2. **N. Curle** and **H.J. Davies**, "*Modern Fluid Dynamics Vol-I*" by, D Van Nostrand Company Ltd.,London, 1968.
3. **S.W. Yuan,** *"Foundations of Fluid Mechanics"* by Prentice- Hall of India, New Delhi, 1988.

UNIT	Chapter(s)	Sections
I	I & III of [1]	1.0 – 1.4, 3.10 – 3.31, 3.40, 3.41
II	III of [1]	3.42 – 3.45, 3.50 – 3.53
III	3 of [2]	3.2, 3.3, 3.5 - 3.5.1, 3.5.2, 3.7.4, 3.7.5
IV	5 of [2]	5.2.1- 5.2.3
	8 of [3]	8.3 – a,b, 8.4 – a
V	9 of [3]	9.1, 9.2, 9.3 – a,b, 9.5 – a,b

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **R.K. Bansal**, *"An Introduction to Fluid Dynamics"*, Firewall Media, 2005.

2. **G.K. Batchelor,** *"An Introduction to Fluid Dynamics",* Cambridge University Press, 2000.
3. **F. Chorlton,** *"Text Book of Fluid Dynamics*", CBS Publications, Delhi, 1985.
4. **D.E. Rutherford**, *"Fluid Dynamics",* Oliver and Boyd, 1959.

COURSE OUTCOMES: On the successful completion of the course, students will be able to

CO	Statement	Knowledge Level
CO1	Recognize and find the values of fluid properties	K1
CO2	The relationship between them and understand the principles of continuity, momentum, and energy as applied to fluid motions.	K2
CO3	Identify these principles written in form of mathematical equations.	K1
CO4	Application of The Navier-Stokes equations	K3
CO5	Apply dimensional analysis to predict physical parameters that influence the flow in fluid mechanics.	K3

MAPPING WITH PROGRAMME OUTCOME(S):

CO\ PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓		✓	✓
CO2	✓	✓	✓		✓	✓
CO3	✓		✓		✓	✓
CO4	✓		✓		✓	✓
CO5	✓		✓		✓	✓

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18UPMAT1E20	FINANCIAL MATHEMATICS	L	T	P	C
		3	1	0	4

UNIT – I: Portfolio Management and the Capital Asset Pricing Model

Portfolios, returns and risk – two-asset portfolios – Multi asset portfolios – stock options – the purpose of options – profit and Payoff curves – selling short.

UNIT – II: An Aperitif on Arbitage and more Discrete Probability

Background on forward contacts – the pricing of forward contracts – the put-call option parity formula – option prices – conditional probability – partitions and measurability – algebras – conditional expectation stochastic – processes – filtrations and martingales.

UNIT – III: Discrete – Time Pricing Models

Assumptions – positive random variables – the basic model by example – the basic model – portfolios and trading strategies – the pricing problem – arbitrage trading strategies – admissible – characterizing arbitrage – computing Martingale measures – the model – Martingale measures in the CRR model – pricing in the CRR model.

UNIT – IV: Continuous Probability

General probability spaces – probability measures on ℝ - distribution functions –density functions – types of probability measures on ℝ - random variables – the normal distribution – convergence in distribution – the central limit theorem – stock prices and Brownian motion – the CRR model in the limit – taking the limit as $\Delta t \rightarrow 0$.

UNIT – V: The Black – Scholes Option Pricing Formula and Optional Stopping

The natural CRR Model – the Martingale measure CRR model – more on the model from a different perspective – the Black – Scholes option pricing formula – how dividends affect the use of black – schools – the model – the payoffs – stopping times – stopping the payoff process – optimal stopping times and the Snell envelope – existence of optimal stopping times – optimal stopping times and the Doob decomposition – the smallest and the largest optimal stopping time.

TEXT BOOK

Steven Roman, *"Introduction to the Mathematics of Finance From Risk Management to Options Pricing"*, Springer International edition, India, 2010.

UNIT	Chapter	Section
I	2 & 3	2.1 – 2.3 & 3.1 - 3.4
II	4 & 5	4.1 – 4.4 & 5.1 - 5.6
III	6 & 7	6.1 - 6.10 & 7.1 - 7.4
IV	8 & 9	8.1 – 8.9 & 9.1 – 9.3
V	9 & 10	9.4 – 9.10 & 10.1 10.16

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **A. Etheridge**, A Course in Financial Calculus, Cambridge university press, Cambridge, 2002.
2. **H. Föllmer**, Stochastic Finance: An Introduction to Discrete Time, Walter de Gruyter, 2002.
3. **G. Kallianpur** and **R. Karamdikar**, Introduction to Option pricing Theory, Birkhouser, 1997.
4. **S. Ross**, An Introduction to Mathematical Finance: Options and Other Topics, Cambridge University Press, 1999.

5. **S. Ross**, An Elementary Introduction to Mathematical Finance, Cambridge University press, 2002.

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

CO	Statements	Knowledge level
CO1	Describe the main investment and risk characteristics of the standard asset classes available for investment purpose.	K2
CO2	Calculate the discounted mean term or volatility of an asset or liability and analyse whether an asset-liability position is matched or immunized.	K3
CO3	Demonstrate an understanding of the nature and use of simple stochastic interest rate models.	K4
CO4	Calculate the forward price and value of a forwarded contract using no-arbitrage pricing.	K5
CO5	Know about basic probability, random walks, central limit theorem, Brownian motion, Block schools theory of options.	K3

MAPPING WITH PROGRAMME OUTCOME(S):

CO /PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓		✓	✓
CO2	✓	✓	✓		✓	
CO3	✓	✓	✓		✓	✓
CO4	✓	✓	✓		✓	
CO5	✓	✓	✓		✓	✓

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18UPMAT1E21	MULTIVARIABLE CALCULUS	L	T	P	C
		3	1	0	4

OBJECTIVE: This course takes calculus from the two dimensional world of single variable functions into the three dimensional world, and beyond, of multivariable functions. This course includes the study of multivariable calculus; including partial derivatives, multiple integrals, and their applications; parametric curves and surfaces in 3-space; solid analytic geometry; and the calculus of vector-valued functions, including line integrals and flux integrals.

UNIT – I: Sequences, Continuity and Limits

Sequences in R^2 – Subsequences and Cauchy sequences – Closure, boundary and interior

Continuity – Composition of continuous functions – Characterizations of continuity – Continuity and boundedness – Continuity and monotonicity – Continuity and convexity – Continuity and Intermediate value property - Uniform continuity–– Limits and continuity.

UNIT – II: Partial and Total Differentiation

Partial and Directional Derivatives – Partial derivatives – Directional derivatives – Higher-order partial derivatives – Problems

UNIT – III: Partial and Total Differentiation (Contd…)

Differentiability – Differentiability and directives – Implicit differentiation – Taylor's theorem and Chain rule – Functions of three variables – Problems

UNIT IV: Applications of Partial Differentiation

Absolute extrema – Constrained extrema –Local extrema and saddle points – Linear and quadratic approximations

UNIT – V: Multiple Integration

Double integrals on rectangles – Basic inequality and criterion for integrability – Domain additivity on rectangles - Integrability of monotonic and continuous functions – Algebraic and order properties – Fundamental theorem of calculus – Fubini's theorem on rectangles -

TEXT BOOK

S.R. Ghorpade and **B. V. Limaye**, *"A Course in Multivariable Calculus and Analysis*, Springer, 2017.

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **Spivak**, Calculus on Manifolds, 5th Edition, CRC Press, 1965.
2. **J. L. Taylor**, Foundations of Analysis, American Mathematical Society, 2012.
3. **W. Rudin**, Principles of Mathematical Analysis, 3rd Edition, McGraw Hill Book Co., Kogaskusha, 1976.

UNIT	Chapter	Pages
I	2	43 – 52, 55 – 63, 67 – 71
II	3	83 – 99
III	3	101 – 124, 138 – 156
IV	4	157 – 184
V	5	185 – 225

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

CO1	Evaluate and interpret derivatives of functions of two or more variables	K5
CO2	Find and interpret the gradient and directional derivatives for a function at a given point.	K5
CO3	Find the total differential of a function of several variables and use it to approximate incremental change in the function.	K3
CO4	Optimize a function of two or more variables, organizing work into main steps, carefully justifying determination of critical points.	K6
CO5	Evaluate multiple integrals either by using iterated integrals or approximation methods.	K3

MAPPING WITH PROGRAMME OUTCOME(S):

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓				
CO2	✓	✓				
CO3	✓	✓	✓		✓	✓
CO4	✓	✓	✓			
CO5	✓	✓	✓		✓	✓

*****

		L	T	P	C
18UPMAT1E22	**ALGEBRAIC GEOMETRY**	3	1	0	4

OBJECTIVE: Algebraic geometry is the study of systems of polynomial equations. The solution set of a system of polynomial equations forms a geometric object called an algebraic variety. The aim of this course is to develop basic algebraic tools to explore the geometry of these varieties. We will build up a dictionary between geometric properties of varieties and numerical invariants of equations.

UNIT – I: Commutative Algebra

Nakayama lemma – Hilbert basis theorem – localization – Noetherian graded rings – Euler and Taylor identities – homogeneous localization – Krull and Chevally dimensions – Hilbert-Samuel polynomial – dimension theorem – Krull's principal ideal theorem – dimention of polynomial rings.

UNIT – II: Commutative Algebra (Contd....)

Generalities – going up theorem – Noether's normalization lemma – Hilbert's Nullstellensatz – regular ring and UFDs – criteria for normality – relative normalizations – towards Zariski's main theorem – Schmidt and Lüroth's theorems – elimination theory.

UNIT – III: Affine Varieties

Affine algebraic sets – regular functions – irreducible algebraic sets – affine varieties – complete intersections – finite sets and curves – surfaces and solids.

UNIT – IV: Affine Varieties (Contd...)

Linear varieties – determinantal varieties – group varieties – morphisms – rational morphisms – birational equivalence – products.

UNIT – V: Projective Varieties

Terminology – projective Algebraic sets – homogenisation / dehomogenisation – projective closures – morphisms – products – complete varieties.

TEXT BOOK

C. Musli, *"Algebraic Geometry for Beginners"*, Text and Readings in Mathematics Vol.20, Hindustan Book Agency (India), New Delhi, 2001.

UNIT	Chapter	Section
I	1	10 - 14
II	1	15 - 18
III	2	21 - 26.2
IV	2	26.3 – 28
V	3	31 - 37

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

4. **N. Bourbaki**, Commutative Algebra, Chapters 1-7, Springer, 1985.
5. **D. Bump**, Algebraic Geometry, World Scientific, Singapore, 1998.
6. **D. Eisenbud**, Commutative Algebra with a view towards Algebraic Geometry, GTM Vol. 150, Springer, 1995.
7. **J. Harris**, Algebraic Geometry – A First Coursc, GTM Vol. 52, Springer, 1992.

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

CO	Statements	Knowledge level
CO1	Know results in algebraic geometry connected to the Zariski topology, affine and projective varieties, their regular functions, rational functions and singularities, as well as morphisms and rational maps between varieties.	K2
CO2	Perform an elementary analysis of simple varieties, in particular answer questions on irreducible components and singularities.	K4
CO3	Know fundamental intersection theory and Veronese embedding theorem.	K5
CO4	Give an account of important connections between	K3

	geometry and commutative algebra.	
CO5	Produce the main ideas in the proofs of the most important results connected to the notions above.	K6

MAPPING WITH PROGRAMME OUTCOME(S):

CO /PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓		✓	✓
CO2	✓	✓	✓		✓	✓
CO3	✓	✓	✓		✓	✓
CO4	✓	✓	✓		✓	✓
CO5	✓	✓	✓		✓	✓

*****

<table>
<tr><td rowspan="2">18UPMAT1E23</td><td rowspan="2">ALGEBRAIC TOPOLOGY</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>1</td><td>0</td><td>4</td></tr>
</table>

OBJECTIVE: This is a basic course in algebraic topology where we introduce the notion of fundamental groups, covering spaces,methods for computing fundamental groups using Seifert Van Kampen theorem and some applications such as the Brouwer's fixed point theorem, Borsuk Ulam theorem,fundamental theorem of algebra. We discuss some classical groups and their fundamental groups.The second part of the course concerns singular homology theory and would cover all the standard machinery such as homotopy invariance of homology, relationship with the fundamental group, excision and the Mayer Vietoris sequence.
After discussing the relative versions, the course closes with the proof of the famous Jordan Brouwer separation theorem.

UNIT – I: Basic Topological Notions
Homotopy – convexity, contractibility and cones – paths and path connectedness – affine spaces - affine maps.

UNIT – II: The fundamental group

The fundamental groupoid – the functor π_1 - π_1 (S^1) – Holes and Green's theorem – free abelian groups – the singular complex and homology functors.

UNIT – III: Singular Homology

Dimension axiom and compact supports – the homotopy axiom – the Hurewicz theorem – the category **Comp**.

UNIT – IV: Long Exact Sequence

Exact homology sequences – reduced homology – simplicial complexes: definitions-simplicial approximation – abstract simplicial complexes – simplicial homology.

UNIT – V: Simplicial Complexes

Comparison with singular homology – calculations – fundamental groups of polyhedra – the Seifert – van Kampen theorem.

TEXT BOOK

J.J. Rotman, *"An Introduction to Algebraic Topology"*, GTM Vol.119, Springer International Edition, 1998.

UNIT	Chapter	Pages
I	1 and 2	14 - 38
II	3 and 4	39 - 68
III	4 and 5	68 - 93
IV	5 and 7	93 – 105, 131 - 147
V	7	147 - 179

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **J.F. Adams**, Algebraic Topology: A Students Guide, Cambridge University Press, Cambridge, 1972.
2. **E.Artin** and **H. Brawn**, Introduction to Algebraic Topology, Merril, Westerville, OH, 1969.
3. **J.R. Munkress**, Elements of Algebraic Topology, Addison-Wesley, Reading, MA, 1984.
4. **A. Hatcher**, Algebraic Topology, Cambridge University Press, Cambridge, 2002.

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

CO	Statements	Knowledge level
CO1	Compute algebraic invariants associated to topological spaces and maps between them.	K2
CO2	Know about the fundamental group and covering spaces.	K3
CO3	Understand the basic algebraic and geometric ideas that underpin homology and cohomology theory. These include the cup product and Poincare Duality for manifolds.	K4
CO4	Give the definition of simplicial complexes and their homology groups and a geometric understanding of what these groups measure.	K5
CO5	Give the extension to singular homology and develop a geometric understanding of how to use these groups in practice.	K6

MAPPING WITH PROGRAMME OUTCOME(S):

CO /PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	√	√	√		√	√
CO2	√	√	√		√	√
CO3	√	√	√		√	√
CO4	√	√	√		√	√
CO5	√	√	√		√	√

*****

18UPMAT1S01	APPLIED MATHEMATICS – I	L	T	P	C
		2	1	0	3

OBJECTIVE: The objective of this course is to provide a strong foundation for partial differential equation and obtaining its solutions using classical methods.

UNIT I: Ordinary Differential Equations

Second and higher order linear ODE – Homogeneous linear equations with constant and variable coefficients – Nonhomogeneous equations – Solutions by variation of parameters.

UNIT II: Functions of Several Variables

Partial derivatives – Total differential – Taylor's expansions – Maxima and Minima of functions – Differentiation under integral sign.

UNIT III: Partial Differential Equations

Formation of PDE by elimination of arbitrary constants and functions – Solutions – General and singular solution- Lagrange's Linear equation – Linear PDE of second and higher order with constant coefficients.

UNIT IV: Fourier Series

Dirichlet's conditions – General Fourier series – Half range Sine and Cosine series –Parseval's identity – Harmonic Analysis.

UNIT V: Boundary Value Problems

Classifications of PDE – Solutions by separation of variables - One dimensional heat and wave equation.

TEXT BOOK:

1. **B.S. Grewal,** *"Higher Engineering Mathematics*", 30th Eighth Edition, Khanna Publishers, Delhi, 2004.
2. **E. Kreyszig,** *"Advanced Engineering Mathematics"*, 8th Edition, John Wiley and Sons, (Asia), Singapore, 2000.

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

CO	Statement	Knowledge level
CO1	Define the Differential equations and Equations of the first order and first degree	K1
CO2	Explain the numerical solution of ODE and concepts of Taylor's series method ,Runge – Kutta method and Eulers method	K2
CO3	Solve the Linear equations and Non linear equation in different methods by PDEs	K3
CO4	Examine the Clarity of linear systems of difference equations using Linear difference equation and simultaneous difference method	K4
CO5	Analyze the numerical solution of PDE , namely, Elliptic equations, Laplace equations and Poisson's equations	K5

MAPPING WITH PROGRAMME OUTCOME(S):

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	√	√	√	√		√
CO2	√	√		√	√	√
CO3	√	√	√	√		√
CO4	√	√	√	√	√	√
CO5	√	√	√	√	√	√

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18UPMAT1S02	APPLIED MATHEMATICS – II	L	T	P	C
		2	1	0	3

OBJECTIVE: The objective of this course is to provide the strong background of applicable mathematics

UNIT I: Laplace Transform

Transform of elementary functions – Transforms of derivatives and integrals – Initial and final value theorems – Inverse Laplace transform – Convolution theorem – Solutions of linear ODE with constant coefficients.

UNIT II: Fourier Transforms

Fourier integral theorem – Fourier transform pairs– Fourier Sine and Cosine transforms – Properties – Transforms of simple functions – Convolution theorem – Parseval's identity.

UNIT III: Multiple Integrals

Double integration – Cartesian and polar co-ordinates – Change of order of integration – Area as a double integral – Triple integration – Volume as a triple integral.

UNIT IV: Vector Calculus

Gradient, Divergence and Curl – Directional derivative – Irrotational and solenoid vector fields – Vector integration – Green's theorem, Gauss divergence theorem and Stoke's theorem.

UNIT-V: Numerical Solutions of ODEs

Solution by Taylor's series method – Euler's method – Modified Euler method, Runge-Kutta Method – Solving simultaneous equations.

TEXT BOOK:

1. **E. Kreyszig,** *"Advanced Engineering Mathematics"*, 10th Edition, John Wiley and Sons, Singapore, 2011.
2. **B.S. Grewal,** *"Higher Engineering Mathematics*", 30th Edition, Khanna Publishers, Delhi 2004.

COURSE OUTCOMES: After the successful of the course, students will be able to

CO	Statement	Knowledge level
CO1	Define the Applications of Leibnitz's theorem, Expansions of function's and Indeterminate forms	K1
CO2	Explain the Partial differentiation and its Application by Homogeneous functions and Jacobians.	K2
CO3	Solve the Numerical Differentiation and Integration, namely Trapezoidal rule, Simpson's one – Third rule etc..	K3
CO4	Examine the Clarity of linear systems of difference equations using Linear difference equation and simultaneous difference method	K4
CO5	Analyze the Numerical solutions of PDEs particularly Predictor – Corrector methods Milne's method and Adams – Bash forth method,	K5

MAPPING WITH PROGRAMME OUTCOME(S):

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	√	√	√	√	√	√
CO2	√	√		√	√	√

CO3	√	√	√			√
CO4	√	√	√	√	√	√
CO5	√	√	√	√	√	√

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		L	T	P	C
18UPMAT1S03	**NUMERICAL & STATISTICAL METHODS**	2	1	0	3

OBJECTIVE: The objective of this course is to provide the foundation for numerical methods and statistics.

UNIT I: Algebraic and Transcendental Equations

Bisection Method – Iteration Method – The Method of False Position – Newton- Raphson – Method

UNIT II: System of Linear Equation

Gauss Elimination, Gauss Jordon elimination – Triangularization method –Iterative Methods, Jacobi, Gauss-Seidal iteration, Iterative method for A^{-1}

UNIT III: Interpolation

Interpolation with equal intervals – Newton forward and backward formula – Central Difference Interpolation formula – Gauss forward and backward formula – Stirling's formula – Bessel's Formula - Numerical differentiation: Maximum and minimum values of a tabulated function. Numerical Integration: Trapezoidal Rule – Simpson's Rule – Numerical double Integration.

UNIT IV: Basic Distribution

Binominal distribution – Poisson distribution – Normal distribution – Properties and Applications.

UNIT V: Correlation and Regression

Correlation Coefficient – Rank correlation coefficient of determination – Linear regression –Method of least squares – Fitting of the curve of the form $ax+b$, ax^2+bx+c, ab^x and ax^b – Multiple and partial correlation (3-variable only).

TEXT BOOK:

1. **P. Kandasamy, K. Thilagavathy** and **K. Gunavathi**, "*Numerical Methods*", 3rd Edition, S. Chand, 2006.
2. **S.C. Gupta** and **V.K. Kapoor,** "*Fundamentals of Mathematical Statistics*", Sultan Chand & Sons, 1994.

UNIT	Chapter(s)	Sections
I	3 *of* [1]	3.1 to 3.4
II	4 of [1]	4.1 to 4.4, 4.8
III	8, 9 of [1]	8.1 to 8.8, 9.1 to 9.16
IV	7 of [2]	7.1 to 7.4
V	10 of [2]	10.1 to 10.7

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

1. **S. Kalavathy**, *"Numerical Methods"*, Vijay Nicole, Chennai, 2004.
2. **S.S. Sastry**, *"Introductory Methods of Numerical Analysis"*, Prentice Hall of India, Pvt Ltd., 1995.

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

CO	Statement	Knowledge level
CO1	Apply numerical methods to obtain approximate solutions to algebraic equations.	K3
CO2	Understand how to solve system of linear equation	K2
CO3	Application of numerical integration and differentation.	K3
CO4	Basic concepts of distribution	K1
CO5	Computation of correlation and regression	K5

MAPPING WITH PROGRAMME OUTCOME(S):

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓	✓

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18UPMAT1S04	DISCRETE MATHEMATICS	L	T	P	C
		2	1	0	3

OBJECTIVE: The focus of the module is on basic mathematical concepts in discrete mathematics and on applications of discrete mathematics.

UNIT – I: Mathematical logic

Statements and Notations – Connectives – Negation – Conjunction – Disjunction – Statement formulas and Truth table – Conditional and Bi- conditional – well formed formulas - Tautologies.

UNIT – II: Mathematical logic (Contd...)

Normal forms – Disjunctive Normal forms – Conjunctive Normal forms – Principal Disjunctive Normal forms – Principal conjunctive normal forms – ordering and uniqueness of normal forms – the theory of inference for the statement calculus – validity using truth tables – Rules of inference.

UNIT – III: Predicate Calculus

The predicate calculus – Predicates – The Statements function, Variables and quantifiers – Predicate formulas – Free and bound variables – The universe of discourse – inference theory of the predicate calculus – Valid formulas and Equivalence – some valid formulas over finite Universes – Special valid formulas involving quantifiers – Theory of inference for the predicate calculus.

UNIT – IV: Relations and ordering

Relations – Properties of binary relation in a set – Partial ordering – Partially ordered set: Representation and Associated terminology – Functions – Definition and introduction – Composition of functions – inverse functions – Natural numbers – Peano axioms – Mathematical Induction.

UNIT – V: Lattices and Boolean Algebra

Lattices partially ordered sets: Definition and Examples – Some properties of Lattices. Boolean Algebra: Definition and example – Sub algebra, Direct Product and homomorphism – Boolean Functions – Boolean forms and free Boolean algebra – values of Boolean expression and Boolean functions.

TEXT BOOK

J.P. Trembly, and **R. Manohar**, *“Discrete Mathematical Structure with Applications to Computer Science”*, Tata McGraw Hill, 2001.

UNIT	Chapter(s)	Sections
I	1	1.1, 1.2.1 to 1.2.4, 1.2.6 to 1.2.8

II	**1**	**1.3.1 to 1.3.5, 1.4.1 to 1.4.2**
III	**1**	**1.6.1 to 1.6.4**
IV	**2**	**2.3.1, 2.3.2, 2.3.8, 2.3.9, 2.4.1, 2.4.3, 2.5.1**
V	**4**	**4.1.1, 4.1.2, 4.2.1, 4.2.2, 4.3.1, 4.3.2**

BOOKS FOR SUPPLEMENTARY READING AND REFERENCES:

Dr. M.K.Sen and **Dr. B.C.Charraborthy**, *"Introduction to Discrete Mathematics",* Arunabha Sen Books & Allied Pvt. Ltd., Kolkata, Reprinted in 2016.

COURSE OUTCOMES: After the successful completion of the course students will be able to

CO	**Statements**	**Knowledge level**
CO1	Express a logic sentence interms of predicates, quantifiers and logical connectives.	K2
CO2	Apply the rules of inference and methods of proof including direct and indirect proof forms, proof by contradiction and mathematical induction.	K3
CO3	Solve discrete mathematics problems that involve permutations and combinations of a set, fundamental enumeration principles.	K4
CO4	Evaluate Boolean functions and simplify Boolean expressions using the properties of Boolean algebra.	K5
CO5	Simplify Boolean function using circuits with different type of gates.	K6

MAPPING WITH PROGRAMME OUTCOME(S):

CO /PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	√	√	√		√	√
CO2	√	√	√		√	√
CO3	√	√	√		√	√
CO4	√	√	√		√	√
CO5	√	√	√		√	√

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		L	T	P	C
18UPMAT1S05	**INTEGRAL TRANSFORMS**	2	1	0	3

OBJECTIVE: An integral transform maps the problem from its original domain into a new domain in which solution is easier. The solution is then mapped back to the original domain with the inverse of the integral transform. This module will provide a systematic mathematical treatment of the theory of integral transforms and its varied applications in applied mathematics and engineering.

UNIT I: Laplace Transforms

Laplace Transform – Transform of some elementary functions – Properties – Transforms of Periodic functions – Transforms of special functions – Evaluation of integrals by Laplace transform

UNIT II: Laplace Transform (Contd...)

Inverse Transforms – Method of partial fraction – Other methods for inverse transforms – Convolution theorem – Applications to differential equations – Unit step function – Unit impulse function -

UNIT III: Fourier Transforms

Definition - Fourier integral theorem – Fourier transforms – Properties – Convolution – Parseval's identity – Fourier transforms of the derivatives of a function –

UNIT IV: Fourier Transforms (Contd...)

Application of transforms to boundary value problems – Discrete and Fast Fourier transform

UNIT V – Z-Transform

Definition - Some standard Z-transforms - Linearity property - Damping rule – Some standard results - Shifting u_n to the right and to the left - Multiplication by n - Two Basic theorems - Some useful Z-transforms - Some useful inverse Z-transforms - Convolution theorems – Evaluation of inverse Z-transforms - Application to Difference equations

TEXT BOOK:

1. **B.S. Grewal,** *"Higher Engineering Mathematics*", 42nd Edition, Khanna Publishers, Delhi 2012.
2. **E. Kreyszig,** *"Advanced Engineering Mathematics"*, 10th Edition, John Wiley and Sons, Singapore, 2010.

COURSE OUTCOMES: After the successful completion of the course students will be able to

CO	Statement	Knowledge level
CO1	Basic concepts of Laplace Transform and properties of Laplace transform.	K1
CO2	Applications of Laplace Transform to differential equations	K3
CO3	Basic concepts of Fourier transforms and Properties	K1
CO4	Application of Fourier transforms to boundary value problems	K3
CO5	Basic concepts of Z-transforms and Properties Evaluation of inverse Z-transforms – Application of Z-transformation to Difference equations	K1, K3 & K5

MAPPING WITH PROGRAMME OUTCOME(S):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓	✓		✓
CO2	✓	✓	✓	✓		✓
CO3	✓	✓	✓			
CO4	✓	✓	✓		✓	
CO5	✓	✓	✓	✓	✓	

*****

		L	T	P	C
UPMAT1SS1	**MATLAB**				2

Objective:
This course provides basic fundamentals on MATLAB, primarily for numerical computing. To learn the characteristics of script files, functions and function files, two-dimensional plots and three-dimensional plots. To enhance the programming skills with the help of MATLAB and its features which allow to learn and apply specialized technologies.

Unit – I:
Starting with Matlab - Creating arrays - Mathematical operations with arrays.

Unit – II:
Script files - Functions and function files.

Unit – III:
Two-dimensional plots - Three-dimensional plots.

Unit – IV:
Programming in MATLAB.

Unit – V:
Polynomials, Curve fitting and interpolation - Applications in numerical analysis.

Text Book:
"MATLAB An Introduction with Application" by A. Gilat, John Wiley & Sons, Singapore, 2004.

UNIT	Chapter(s)	Sections
I	1, 2 & 3	-
II	4 & 6	-
III	5 & 9	-
IV	7	-
V	8 & 9	-

List of practical programs will be issued by course teacher.

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

CO1	Learning the basic windows in MATLAB and mathematical operations with arrays	K1
CO2	Creating scripts e functions file in MATLAB	K5
CO3	Understanding the various type of 2D&3D plots and animations	K2
CO4	Study the various type of loops in MATLAB	K3
CO5	Applications to numerical analysis like solving algebraic equation, curve fitting and interpolation	K5

MAPPING WITH PROGRAMME OUTCOME(S):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1					✓	✓
CO2					✓	✓
CO3					✓	✓
CO4					✓	✓
CO5	✓	✓	✓		✓	✓

*****

18UPMAT1SS2	MATHEMATICA	L	T	P	C
					2

Objective:

Numerical calculation, Compile notes, equations, sample calculations, graphics, references, and hyperlinks in a single document. Visualize data or functions with 2D/3D graphics and charts. Analyze real-world data with ready-to-use data sets. Mathematical functions – Algebraic manipulation – Numerical calculations of differential and integral Calculus.

Unit – I:

Running Mathematica - Numerical calculations – Building up calculations – Using the Mathematica system – Algebraic calculations - Symbolic mathematics - Numerical mathematics.

Unit – II:

Graphics and Sound - Files and External Operations

Unit – III:

Textual Input and Output - The Structure of Graphics and Sound

Unit – IV: ADVANCED MATHEMATICS IN MATHEMATICA

Numbers - Mathematical functions – Algebraic manipulation – Manipulating equations - Calculus.

Unit – V:

Series, limits and residues - Linear algebra.

Text Book:

"The Mathematica Book" by S. Wolfram, Fourth Edition, Cambridge University Press, Cambridge, 1999.

UNIT	Chapter(s)	Sections
I	1	1.0- 1.6
II	1	1.9- 1.11
III	2	2.9- 2.10
IV	3	3.1- 3.5
V	3	3.6- 3.7

List of practical programs will be issued by course teacher.

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

CO1	Start with Running mathematical- Basic Mathematical calculation with symbolic	K1
CO2	Understanding the graphics & sound in 2D and 3D	K2
CO3	Learning the output and input formation in mathematica	K1
CO4	Evaluate the mathematical functions and calculus in mathematica	K5
CO5	Applications to mathematical calculation like a series, limits, residue at Linear Algebra	K3

MAPPING WITH PROGRAMME OUTCOME(S):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1					✓	✓
CO2					✓	✓
CO3						✓
CO4	✓	✓	✓		✓	✓
CO5	✓	✓	✓		✓	✓

****

		L	T	P	C
18UPMAT1SS3	LATEX				2

Objective:

Typeset mathematical formulae using LaTeX. Use the preamble of LaTeX file to define document class and layout options. Use tabular and array environments within LaTeX document. Use various methods to either create or import graphics into a LaTeX document. Use Theorem, Corollary, and other environments. Use BibTeX to maintain bibliographic information and to generate a bibliography for a particular document.

Unit I:
Text formatting, TEX and its offspring, What's different in LATEX 2ϵ, Distinguishing LATEX 2ϵ , Basics of a LATEX file.

Unit II:
Commands and environments–Command names and arguments, Environments, Declarations, Lengths, Special Characters, Fragile Commands, Exercises.

Unit III:
Document layout and organization – Document class, Page style, Parts of the document, Table of contents, Fine – tuning text, Word division. Displayed text - Changing font, Centering and indenting, Lists, Generalized lists, Theorem–like declarations, Tabulator stops, Boxes.

Unit IV:
Tables, Printing literal text, Footnotes and marginal notes. Drawing pictures with LATEX.

Unit V:
Mathematical formulas – Mathematical environments, Main elements of math mode, Mathematical symbols, Additional elements, Fine–tuning mathematics.

Text Book:
"A Guide to LATEX" by H. Kopka and P.W. Daly, Third Edition, Addison – Wesley, London, 1999.

UNIT	Chapter(s)	Sections
I	1	1.1 - 1.3, 1.4.1, 1.5.
II	2	2.1 - 2.7.
III	3 & 4	3.1 - 3.6, 4.1 - 4.7
IV	4& 6	4.8 - 4.10, 6.1.
V	5	5.1 -5.5.

List of practical programs will be issued by course teacher.

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

CO1	Basic of LATEX and LATEX 2ϵ, LATEX file creation Tex formatting	K1
CO2	Discus the command, environments and creating special characters	K2
CO3	Formatting the document layout, page style part of document and Table of contents	K3
CO4	Creating the table and drawing pictures in LATEX	K2
CO5	Drive the mathematical environments mathematical symbol for typing thesis project and report	K5

MAPPING WITH PROGRAMME OUTCOME(S):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1						✓
CO2						✓
CO3						✓
CO4						✓
CO5						✓

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