Postgraduate and Research Department of Mathematics

Learning Outcome - Based Curriculum Framework (LOCF)

(w.e.f 2024-2025)

Sem	Category	Course Code	Course Title	Hours/Wk.	Credits	Marks
1	CC	24PGM/PSM4501	Algebraic Structure	6	5	100
1	CC	24PGM/PSM4503	Real Analysis - I	6	5	100
1	CC	24PGM/PSM4405	Ordinary Differential Equations	5	4	80
1	CC	24PGM/PSM4307	Number Theory and Cryptography	5	3	60
1	DSE	24XXXNNNN	*Discipline Specific Elective - I*	4	3	60
1	GE	24XXXNNNN	*Generic Elective - I*	4	3	60
	Total			**30**	**23**	**460**
2	CC	24PGM/PSM4502	Advanced Algebra	6	5	100
2	CC	24PGM/PSM4504	Real Analysis - II	6	5	100
2	CC	24PGM/PSM4406	Partial Differential Equations	5	4	80
2	CC	24PGM/PSM4308	Classical Mechanics	5	3	60
2	DSE	24XXXNNNN	*Discipline Specific Elective - II*	4	3	60
2	GE	24XXXNNNN	*Generic Elective - II*	4	3	60
	Total			**30**	**23**	**460**
3	CC	24PGM/PSM5501	Topology	6	5	100
3	CC	24PGM/PSM5503	Complex Analysis	6	5	100
3	CC	24PGM/PSM5405	Probability Theory	5	4	80
3	CC	24PGM/PSM5307	Graph Theory	5	3	60
3	CC	24PGM/PSM5309	Measure Theory	4	3	60
3	DSE	24XXXNNNN	*Discipline Specific Elective - III*	4	3	60
3	IS	24PGM/PSM5233	Internship*	-	2	40
	Total			**30**	**25**	**500**
4	CC	24PGM/PSM5502	Functional Analysis	6	5	100
4	CC	24PGM/PSM5504	Operations Research	6	5	100
4	CC	24PGM/PSM5406	Mathematical Statistics	5	4	80
4	CC	24PGM/PSM5308	Differential Geometry	5	3	60
4	DSE	24XXXNNNN	*Discipline Specific Elective - IV*	4	3	60
4	CC	24PGM/PSM5300	Project	4	3	60
4	SEC	24PGM/PSM5244	Professional Competency Skill	-	2	40
	Total			**30**	**25**	**500**
			Grand Total	**120**	**96**	**1920**

* Internship - First Year Vacation (30 Hrs.)

Discipline Specific Elective (DSE)

Sem	Category	Course Code	Course Title	Hours/Wk.	Credits	Marks
1	DSE	24PGM/PSM4311	Fuzzy Mathematics	4	3	60
1	DSE	24PGM/PSM4313	Formal Languages and Automata Theory	4	3	60
2	DSE	24PGM/PSM4312	Combinatorics	4	3	60
2	DSE	24PGM/PSM4314	Fluid dynamics	4	3	60
3	DSE	24PGM/PSM5311	Numerical Methods with C ++	4	3	60
3	DSE	24PGM/PSM5313	Fractal Geometry	4	3	60
4	DSE	24PGM/PSM5312	Mathematical Python	4	3	60
4	DSE	24PGM/PSM5314	Statistical Data Analysis using R Programming	4	3	60

Generic Elective (GE)

Sem	Category	Course Code	Course Title	Hours/Wk.	Credits	Marks
1	GE	24PGM/PSM4321	Mathematics for Career Prospects	4	3	60
1	GE	24PGM/PSM4323	Office Automation	4	3	60
2	GE	24PGM/PSM4322	Mathematical Reasoning	4	3	60
2	GE	24PGM/PSM4324	Programming in C	4	3	60

Postgraduate and Research Department of Mathematics

Programme Specific Outcomes (PSOs)

On the successful completion of the Postgraduate programme, the students will be able to

PSO1 Disciplinary Knowledge	demonstrate intensive and extensive knowledge of Mathematics and understand one or more disciplines that form a part of a postgraduate programme of study.
PSO2 Communication Skills	communicate various mathematical concepts effectively using examples and geometrical visualizations, and clearly communicate long-standing unsolved problems in mathematics. Use mathematics as a precise language of communication in other branches of human knowledge.
PSO 3 Problem Solving & Analytical Reasoning	translate theoretical understanding into experimental knowledge and solve both concrete and abstract problems.
PSO 4 Critical Thinking	critically evaluate complex problems in domain-related and multidisciplinary issues.
PSO 5 Research Skills	formulate appropriate questions related to concepts in various fields of mathematics.
PSO 6 Digital Literacy	utilize domain-related advanced software resources, computational skills, and digital tools for data analysis, visualization, and interpretation.
PSO 7 Professional competencies	demonstrate managerial skills required to apply mathematical principles effectively in professional settings such as financial institutions, technology firms, or research organizations, ensuring efficient decision-making and problem-solving.
PSO 8 Moral and Ethical Awareness/Reasoning	identify unethical behaviour such as fabrication, falsification, or misrepresentation of data, and adopt objective, unbiased, and truthful actions in all aspects.
PSO 9 Multicultural Competence	reflect multicultural competencies by engaging with diverse linguistic and ethnic communities, providing opportunities to understand, accept, and appreciate individuals at local, national, and international levels. Develop a global perspective through contemporary curriculum, culture, and language.
PSO 10 Self-directed & Lifelong Learning	work independently and conduct in-depth studies of various mathematical concepts. Acquire knowledge and skills through logical reasoning and develop the habit of self-learning.

Mapping with POs

PGM/PSM	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
	3	3	3	3	2	3	2	2	2	2

Mapping of Courses with PSOs

Courses	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
24PGM/PSM4501	3	3	3	3	3	2	2	2	2	2
24PGM/PSM4503	3	3	2	2	2	2	2	1	2	1
24PGM/PSM4405	3	3	3	3	2	1	2	1	1	2
24PGM/PSM4307	3	3	3	3	3	3	3	1	1	2
24PGM/PSM4311/ 24PGM/PSM4313	3	3	3	3	3	2	3	2	2	2
24PGM/PSM4502	3	3	3	3	3	2	2	2	2	2
24PGM/PSM4504	3	3	2	2	2	2	2	1	2	1
24PGM/PSM4406	3	3	3	3	2	1	2	1	2	2
24PGM/PSM4308	3	3	3	3	3	2	2	1	1	2
24PGM/PSM4312/ 24PGM/PSM4314	3	3	3	3	2	3	3	2	2	1
24PGM/PSM5501	3	3	3	2	3	2	2	2	2	2
24PGM/PSM5503	3	3	3	3	3	2	1	1	2	2
24PGM/PSM5405	3	3	3	3	2	1	2	1	1	1
24PGM/PSM5307	3	3	3	3	2	1	2	2	2	2
24PGM/PSM5309	3	3	3	2	3	2	2	2	2	2
24PGM/PSM5311/ 24PGM/PSM5313	3	3	3	3	2	3	2	2	1	2
24PGM/PSM5233	3	3	3	3	2	2	2	2	2	1
24PGM/PSM5502	3	3	3	2	3	2	2	2	2	2
24PGM/PSM5504	3	3	3	3	2	3	1	1	2	1
24PGM/PSM5406	3	2	3	3	3	2	3	2	3	2
24PGM/PSM5308	3	3	3	3	2	1	2	1	1	1
24PGM/PSM5312/ 24PGM/PSM5314	3	3	3	3	3	3	3	1	2	2
24PGM/PSM5300	3	3	3	3	3	3	3	3	3	2
24PGM/PSM5244	3	2	3	3	3	2	2	2	2	2
Average	3.0	2.9	2.9	2.8	2.5	2.0	2.2	1.6	1.8	1.7

Mapping of Courses with POs

Courses	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
24PGM/PSM4321/ 24PGM/PSM4323	3	3	3	3	2	3	2	1	2	2
24PGM/PSM4322/ 24PGM/PSM4324	3	3	3	3	3	3	3	2	2	3
Average	3	3	3	3	2.5	3	2.5	1.5	2	2.5

Course Code	Name of the Course	Category	Hours/Wk.	Credits
24PGM/PSM4501	Algebraic Structures	Core	6	5

An algebraic system can be described as a set of objects together with some operations for combining them. The Aim of the course is to introduce the concepts and to develop working knowledge on class equation, solvability of groups, finite abelian groups, linear transformations, real quadratic forms.

Course Outcomes:

At the end of the course, students will be able to

CO1: use counting technique by introducing equivalence relation in finite groups, and use Sylow's theorems in verifying converse of the Lagrange's theorem.

CO2: identify solvable groups and explore the properties of solvable groups, construct new groups (direct products) from old, understand the structure of finite abelian groups and modules.

CO3: explore the properties of similar transformations, invariant subspace, and triangular matrix, to explore the properties of nilpotent transformation relating nilpotence with invariants.

CO4: apply the concepts of Jordan and canonical form and find the characteristics polynomial of linear transformation.

CO5: find the trace and transpose of a matrix and explore the properties of Hermitian, Unitary and Normal Transformations.

Unit I **(18 Hours)**

Counting Principle - Class equation for finite groups and its applications - Sylow's theorems (For theorem 2.12.1, First proof only).

Unit II **(18 Hours)**

Solvable groups - Direct products - Finite abelian groups – Modules.

Unit III **(18 Hours)**

Linear Transformations: Canonical forms - Triangular form - Nilpotent transformations.

Unit IV **(18 Hours)**

Jordan form - rational canonical form.

Unit V **(18 Hours)**

Trace and transpose - Hermitian, unitary, normal transformations - real quadratic form.

Learning Resources:

Text Book(s)

1. I.N. Herstein. *Topics in Algebra (2nd Edition)*, Wiley Eastern Limited, New Delhi, 2017

   Unit I: Chapter 2 (Sec 2.11 and 2.12 (Omit Lemma 2.12.5))

   Unit II: Chapter 5 (Sec 5.7 (Lemma 5.7.1, Lemma 5.7.2, Theorem 5.7.1))

   Chapter 2 (Section 2.13 and 2.14 (Theorem 2.14.1 only))

   Chapter 4 (Sec 4.5)

   Unit III: Chapter 6 (Sec 6.4, 6.5)

   Unit IV: Chapter 6 (Sec 6.6 and 6.7)

   Unit V: Chapter 6 (Sec 6.8, 6.10 and 6.11)

References

1. M. Artin, *Algebra*, Prentice Hall of India, 1991.
2. P.B. Bhattacharya, S.K. Jain, and S.R. Nagpaul, *Basic Abstract Algebra* (II Edition) Cambridge University Press, 1997. (Indian Edition)
3. N. Jacobson, *Basic Algebra*, Vol. I & II W. H. Freeman (1980), Hindustan Publishing Company, New Delhi.
4. I.S. Luther and I.B.S. Passi, *Algebra* Vol. I Groups(1996); Vol. II Rings, Narosa Publishing House , New Delhi, 1999
5. D.S.Malik, J.N. Mordeson and M.K. Sen, *Fundamental of Abstract Algebra*, McGraw Hill (International Edition), New York, 1997.
6. Surjeeth Singh, and Quazi Zameeruddin, *Modern algebra*, vikas publishing house, 2006.

CO – PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO 1	3	3	3	3	3	2	2	2	2	2
CO 2	3	3	3	3	3	2	3	1	2	2
CO 3	3	3	3	3	3	2	2	2	2	1
CO 4	3	3	3	3	3	2	3	2	1	1
CO 5	3	3	3	3	3	2	2	1	2	2
Average	3	3	3	3	3	2	2.4	1.6	1.8	1.6

Strong – 3 Medium – 2 Low – 1

Course Code	Name of the Course	Category	Hours/Wk.	Credits
24PGM/PSM4503	Real Analysis - I	Core	6	5

The aim of the course is to present the elements and importance of Mathematical Analysis. It also enable students to work comfortably with functions of bounded variation, Riemann-Stieltjes Integration, convergence of infinite series, infinite product and uniform convergence and its interplay between various limiting operations.

Course Outcomes:

At the end of the course, students will be able to

CO1: analyze and evaluate functions of bounded variation and total variation.

CO2: describe the concept of Riemann - Stieltjes integral and its properties.

CO3: explain the concept of Riemann - Stieltjes integral as a limit of summation and its relevance in the context of derivative.

CO4: identify the convergence and divergence of infinite series and infinite products and introduce the concept of point wise converges and uniform converges.

CO5: exhibit the concept and properties of uniform convergence in continuity, differentiation and integration of various sequences of functions.

Unit I **(18 Hours)**

Properties of Monotonic Functions – Functions of Bounded Variation – Total Variation – Additive Property of Total Variation – Total Variation on [a, x] as a Function of x – Functions of Bounded Variation Expressed as the Difference of Two Increasing Functions - Continuous Functions of Bounded Variation. Infinite Series – Absolute and Conditional Convergence – Dirichlet's Test and Abel's Test – Rearrangement of Series – Riemann's Theorem on Conditionally Convergent Series.

Unit II **(18 Hours)**

Introduction to Riemann - Stieltjes Integral – Linear Properties – Integration by Parts – Change of Variable in a Riemann-Stieltjes Integral – Reduction to a Riemann Integral – Step Function as Integrators – Reduction of a Riemann-Stieltjes Integral to a finite Sum – Euler’s Summation Formula – Monotonically Increasing Integrators, Upper and Lower Integrals – Additive and Linearity Properties of Upper and Lower Integrals – Riemann's Condition – Comparison Theorems.

Unit III **(18 Hours)**

Integrators of Bounded Variation – Sufficient Conditions for the Existence of Riemann-Stieltjes integrals – Necessary Conditions for the Existence of Riemann-Stieltjes Integrals – Mean Value Theorems for Riemann-Stieltjes Integrals – The Integral as a Function of the Interval – Second Fundamental Theorem of Integral Calculus – Change of Variable in a Riemann Integral – Second Mean Value Theorem for Riemann Integral – Riemann-Stieltjes Integrals Depending on a Parameter – Differentiation Under Integral Sign – Interchanging the Order of Integration – Lebesgue's Criterion for Existence of Riemann Integrals.

Unit IV **(18 Hours)**

Double Sequences – Double Series – Rearrangement Theorem for Double Series – A Sufficient Condition for Equality of Iterated Series – Multiplication of Series – Cesaro Summability – Infinite Products – Pointwise Convergence of Sequences of Functions – Examples of Sequences of Real-Valued Functions – Uniform Convergence and Continuity.

Unit V **(18 Hours)**

Cauchy Condition for Uniform Convergence – Uniform Convergence of Infinite Series of Functions – Uniform Convergence and Riemann - Stieltjes Integration – Non-Uniform Convergence and Term-by-term Integration – Uniform – Convergence and Differentiation – Sufficient Condition for Uniform Convergence of a Series – Mean Convergence.

Learning Resources:

Text Book(s)

1. M. Apostol, *Mathematical Analysis*, Addison Wesley Publishing house, 2010.
   - **Unit I :** Chapter 6 (Sec 6.1 to 6.8); Chapter 8 (Sec 8.8, 8.15, 8.17 to 8.18)
   - **Unit II :** Chapter 7 (Sec 7.1 to 7.14)
   - **Unit III :** Chapter 7 (Sec 7.15 to 7.26)
   - **Unit IV :** Chapter 8 (Sec 8.20 to 8.26); Chapter 9 (Sec 9.1 to 9.4)
   - **Unit V :** Chapter 9 (Sec 9.5, 9.6, 9.8 to 9.13)

References

1. R.G .Bartle, *Real Analysis*, John Wiley and Sons Inc., 1976.
2. B.R.Gelbaum and J. Olmsted, *Counter Examples in Analysis*, Holden day, San Francisco, 1964.

3. S.C. Malik and Savita Arora, *Mathematical Analysis*, Wiley Eastern Limited. New Delhi, 1991.
4. W. Rudin. *Principles of Mathematical Analysis*, 3rd Edition. McGraw Hill Company, New York, 1976.
5. Sanjay Arora and Bansi Lal, *Introduction to Real Analysis*, Satya Prakashan, New Delhi, 1991.

CO – PSO Mapping

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO 1	3	3	3	3	3	2	3	1	2	1
CO 2	3	3	3	2	2	2	3	1	2	1
CO 3	3	2	2	2	2	2	2	1	2	1
CO 4	3	3	2	2	2	2	2	1	2	1
CO 5	3	2	2	2	2	2	2	1	2	1
Average	3	2.6	2.4	2.2	2.2	2	2.4	1	2	1

Strong – 3 Medium – 2 Low – 1

Course Code	Name of the Course	Category	Hours/Wk.	Credits
24PGM/PSM4405	Ordinary Differential Equations	Core	5	4

To develop strong background on finding solutions to linear differential equations with constant and variable coefficients and also with singular points, to study existence and uniqueness of the solutions of first order differential equations.

Course Outcomes:

At the end of the course, students will be able to

CO1: recall the basic concepts of ordinary differential equations and differentiate homogeneous and non-homogeneous equations.

CO2: solve the initial value problems for the homogeneous equations and hence evaluate its independency using Wronskian.

CO3: compute the power series solution for the Legendre and Hermite equations.

CO4: identify the regular singular points for the second order ordinary differential equations hence solve them and compute Bessel's function.

CO5: analyse solutions using appropriate methods and derive the Lipchitz condition.

Unit I **(15 Hours)**

Homogeneous and non-homogeneous equation of order n – Initial value problems – Annihilator method to solve non-homogeneous equation – Algebra of constant coefficient operators.

Unit II **(15 Hours)**

Initial value problems – Existence and uniqueness theorems – Solutions to solve a non-homogeneous equation – Wronskian and linear independence – Reduction of the order of a homogenous equation – Homogenous equations with analytic Coefficients.

Unit III **(15 Hours)**

Non-homogeneous equations – Homogeneous equation with analytic coefficients – The Legendre equation – Hermite equation.

Unit IV **(15 Hours)**

The Euler equation - Second order equations with regular singular points–The exceptional cases– Bessel function.

Unit V **(15 Hours)**

Equations with variables separated – Exact equation–Method of successive approximations– The Lipschitz condition– Convergence of the successive approximations and the existence theorem.

Text Book(s)

1. E. A. Coddington, *An introduction to ordinary differential equations*, Prentice Hall of India Ltd., New Delhi, 2004

    Unit I **:** Chapter 2 (Sec 7 to 12)

    Unit II **:** Chapter 3 (Sec 1 to 5)

    Unit III **:** Chapter 3 (Sec 6 to 8)

    Unit IV **:** Chapter 4 (Sec 1 to 4 and 6 to 8)

    Unit V **:** Chapter 5 (Sec 1 to 6)

References

1. S. G. Deo and V. Raghavendra, *Ordinary differential equations and stability theory*, 1996.
2. M.D. Raisinghania, *Advanced Differential Equations*, S.Chand& Company Ltd. New Delhi 2001.
3. B.Rai, D.P.Choudary and H.I.Freedman, *A course in Ordinary Differential Equations*, Narosa Publishing House, New Delhi, 2002.
4. W.T. Reid, *Ordinary Differential Equations*, John Wiley and Sons, New York, 1971
5. G. F. Simmons, *Differential equations with applications and historical notes*,Tata McGraw Hill, 1995.
6. Williams E. Boyce and Richard C. DiPrima, *Elementary differential equations and boundary value problems*, John Wiley and sons, New York, 1967.

CO – PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO 1	3	3	3	2	1	1	1	1	1	1
CO 2	3	3	3	3	2	1	1	1	1	2
CO 3	3	2	3	3	2	1	2	1	1	2
CO 4	3	3	3	3	2	1	2	1	1	2
CO 5	3	3	3	3	3	1	2	1	1	2
Average	3	2.8	3	2.8	2	1	1.6	1	1	1.8

Strong – 3 Medium – 2 Low – 1

Course Code	Name of the Course	Category	Hours/Wk.	Credits
24PGM/PSM4307	Number Theory and Cryptography	Core	5	3

To introduce the basic rules of arithmetic and making students get exposed to a list of arithmetical functions. To instil skills adequate to find estimate of arithmetical functions and apply the knowledge gained to cryptosystems. The course deals with the divisibility properties of integers, properties of arithmetic functions, properties and results in congruences, and basic principles of cryptosystems.

Course Outcomes:

At the end of the course, students will be able to

CO1: describe the concept of divisibility of integers, prime numbers and Euler's totient function.

CO2: define Dirichlet product, apply Mobius inversion formula and find the inverse of a completely multiplicative function.

CO3: define the derivative of arithmetic function, to find the average order of number of divisors function.

CO4: recall the basic properties of congruences, to prove standards theorems involving integer congruences, to define Legendre symbol and to prove standard theorems related to existence of quadratic residues.

CO5: elucidate the basic notions of cryptosystems, digraph transformations, and to explore the affine enciphering transformations.

Unit I **(15 Hours)**

Divisibility: Greatest Common Divisor – Prime Numbers – The Euclidean algorithm – Arithmetical functions: Mobius function – Euler totient function.

Unit II **(15 Hours)**

Dirichlet product of arithmetical functions: Dirichlet inverses and the Mobius inversion formula – Mangoldt function – Multiplicative functions and Dirichlet multiplication – The inverse of a completely multiplicative function.

Unit III **(15 Hours)**

Liouville's function – The divisors functions – Derivatives of arithmetic functions – The Selberg identity – The big oh notation – Euler's summation formula – The average order of number of divisors function.

Unit IV **(15 Hours)**

Basic properties of congruences – Euler-Fermat Theorem – Lagrange's Theorem – Wilson's Theorem – Wolstenholme's Theorem – Chinese Remainder Theorem – Quadratic residues: Euler's criterion – Gauss Lemma – Quadratic reciprocity law.

Unit V **(15 Hours)**

Some simple cryptosystems: Basic notions – Digraph transformations – Enciphering matrices: Review of Linear algebra – Linear algebra modulo **N** – Affine enciphering transformations.

Learning Resources:

Text Book(s)

1. Tom M. Apostol, *Introduction to Analytic Number Theory*, Springer New York, 2013

   Unit I: Chapter 1 (Sec 1.2 to 1.5, 1.7); Chapter 2 (Sec 2.2 to 2.5).

   Unit II: Chapter 2 (Sec 2.6 to 2.11).

   Unit III: Chapter 2 (Sec 2.12, 2.13, 2.18, 2.19); Chapter 3 (Sec 3.2 to 3.5).

   Unit IV: Chapter 5 (Sec 5.1, 5.4 to 5.7); Chapter 9 (Sec 9.1 to 9.5).
2. Neal Koblitz, *A Course in Number Theory and Cryptography*, Springer – Verlag New York, Second Edition, 2015.

   Unit V: Chapter 3 (Sec 1, 2).

References

1. I. Niven, H. S. Zuckerman, H. L. Montgomery, *An Introduction to the Theory of Numbers*, Wiley India Edition, Fifth Edition (2012 reprint)
2. David M. Burton, *Elementary Number Theory*, Mc-Graw-Hill, 1996.
3. Oystein Ore, *Number Theory and Its History*, Dover Publication Inc., 1998.
4. Gareth A. Jones, J. Mary Jones, *Elementary Number Theory*, Springer-Verlag, Berlin, Second Edition, 1998.

CO – PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO 1	3	3	3	3	3	2	3	1	1	2
CO 2	3	2	3	3	3	2	2	1	1	2
CO 3	3	3	3	2	3	3	3	1	1	2
CO 4	3	3	3	3	3	3	3	1	1	2
CO 5	2	3	3	3	3	3	3	1	1	2
Average	2.8	2.8	3	2.8	3	2.6	2.8	1	1	2

Strong – 3 Medium – 2 Low – 1

Course Code	Name of the Course	Category	Hours/Wk.	Credits
24PGM/PSM4502	Advanced Algebra	Core	6	5

The study of field theory finds applications in number theory and theory of equations. The aim of the course is to introduce the concept of field extension, roots of polynomials, Galois Theory, finite fields, division rings and solvability by radicals, and to develop computational skill in abstract algebra.

Course Outcomes:

At the end of the course, students will be able to

CO1: use algebraic reasoning to demonstrate theorems.

CO2: drive the relationship between roots of a polynomial and characteristic of a field, and find the splitting field of a polynomial.

CO3: characterize normal extension of a field in terms of splitting field of a polynomial, and establish one-one correspondence between subfields of a splitting field of a polynomial and the subgroups of Galois group of the polynomial.

CO4: bring out insight into Abstract Algebra with a focus on axiomatic theories.

CO5: demonstrate knowledge through the understanding of fundamental concepts of fields and extension fields.

Unit I **(18 Hours)**

Extension fields – Transcendence of e.

Unit II **(18 Hours)**

Roots of Polynomials. – More about roots.

Unit III **(18 Hours)**

Elements of Galois Theory.

Unit IV **(18 Hours)**

Finite fields – Wedderburn's theorem on finite division rings.

Unit V **(18 Hours)**

Solvability by radicals – A theorem of Frobenius – Integral Quaternions and the Four-Square theorem.

Learning Resources:

Text Book(s)

1. I.N. Herstein, *Topics in Algebra* (2nd Edition), Wiley Eastern Limited, New Delhi, 1975.

   Unit I: Chapter 5 (Sec 5.1 and 5.2)

   Unit II: Chapter 5 (Sec 5.3 and 5.5)

   Unit III: Chapter 5 (Sec 5.6)

   Unit IV: Chapter 7 (Sec 7.1 and 7.2 (Theorem 7.2.1 only))

   Unit V: Chapter 5 (Sec 5.7 (omit Lemma 5.7.1, Lemma 5.7.2 and Theorem 5.7.1))
   Chapter 7 (Sec 7.3 and 7.4)

References

1. M.Artin, *Algebra*, Prentice Hall of India, 1991.
2. P.B.Bhattacharya, S.K.Jain, and S.R.Nagpaul, *Basic Abstract Algebra* (2nd Edition) Cambridge University Press, 1997. (Indian Edition)
3. N.Jacobson, *Basic Algebra,* Vol. I & II W.H.Freeman (1980); also published by Hindustan Publishing Company, New Delhi.
4. I.S.Luther and I.B.S.Passi, *Algebra,* Vol.I Groups (1996); Vol. II Rings, Narosa Publishing House, New Delhi, 1999.
5. D.S.Malik, J.N. Mordeson and M.K.Sen, *Fundamental of Abstract Algebra*, McGraw Hill (International Edition), New York. 1997.
6. Surjeeth Singh, and Quazi Zameeruddin, *Modern algebra*, Vikas publishing house, 2006.

CO – PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO 1	3	3	3	3	3	2	2	1	2	2
CO 2	3	3	3	3	3	2	3	1	1	2
CO 3	3	3	3	3	3	2	2	2	2	2
CO 4	3	3	3	3	3	2	3	2	2	1
CO 5	3	3	3	3	3	2	2	2	1	2
Average	3	3	3	3	3	2	2.4	1.6	1.6	1.8

Strong – 3 Medium – 2 Low – 1

Course Code	Name of the Course	Category	Hours/Wk.	Credits
24PGM/PSM4504	Real Analysis - II	Core	6	5

This course aims to explore equi continuous families of function, Power series, Fourier series and Integrals. It also enable the students to study the theory of derivatives of a function of several variables.

Course Outcomes:

At the end of the course, students will be able to

CO1:discuss on the importance of Stone-Weierstrass theorem as a polynomial approximation of continuous function.

CO2: explain the idea of power series of functions.

CO3: categorize different special functions as a consequence of series of functions.

CO4: analyze and perform various forms of partial derivative and mixed partial derivatives.

CO5: demonstrate higher level multivariable real valued functions and their properties.

Unit I **(18 Hours)**

Equi Continuous Families of Function – Arzelo Ascoli Theorem – Stone-Weierstrass Theorem.

Unit II **(18 Hours)**

Power Series – Multiplication of Power Series – The Substitution Theorem – Reciprocal of Power Series – The Real Power Series – The Taylor's Series Generated by a Function – Bernstein's Theorem – The Binomial Series – Abel's Limit Theorem – Tauber's Theorem.

Unit III **(18 Hours)**

Fourier Series and Fourier Integrals – Introduction – Orthogonal System of Functions – The Theorem on Best Approximation – The Fourier Series of a Function Relative to an Orthonormal System – Properties of Fourier Coefficients – The Riesz-Fischer Theorem – The Convergence and Representation Problems for Trigonometric Series – The Riemann - Lebesgue Lemma – The Dirichlet Integrals – An Integral Representation for the Partial Sums of Fourier Series – Riemann's Localization Theorem.

Sufficient Conditions for Convergence of a Fourier Series at a Particular Point – Cesaro Summability of Fourier Series – Consequences of Fejes's Theorem.

Unit IV **(18 Hours)**

Multivariable Differential Calculus – Introduction – The Directional Derivative – Directional Derivative and Continuity – The Total Derivative – The Total Derivative Expressed in Terms of Partial Derivatives – The Matrix of Linear Function – The Jacobian Matrix – The Chain Rule – Matrix Form of Chain Rule – The Mean Value Theorem for Differentiable Functions – A Sufficient Condition for Differentiability – A Sufficient Condition for Equality of Mixed Partial Derivatives – Taylor's Theorem for Functions of R^n to R^1.

Unit V **(18 Hours)**

Implicit Functions and Extremum Problems – Introduction – Functions with Non-Zero Jacobian Determinants – The Inverse Function Theorem – The Implicit Function Theorem – Extrema of Real Valued Functions of One Variable – Extrema of Real Valued Functions of Severable Variables – Extremum Problems with Side Conditions.

Learning Resources:

Text Book(s)

1. W. Rudin, *Principles of Mathematical Analysis*, McGraw Hill, 2004.
   Unit I : Chapter 7 (Sec 7.6, 7.7)
2. M. Apostol, *Mathematical Analysis*, Addison Wesley Publishing house, 2010.
   Unit II : Chapter 9 (Sec 9.14 to 9.23)
   Unit III : Chapter 11 (Sec 11.1 to 11.14)
   Unit IV : Chapter 12 (Sec 12.1 to 12.14)
   Unit V : Chapter 13 (Sect 13.1 to 13.7**)**

References

1. J.C. Burkill, *The Lebesgue Integral*, Cambridge University Press, 1951.
2. S.C. Malik, and Savita Arora, *Mathematical Analysis*, Wiley Eastern Limited, New Delhi, 1991.
3. H.L. Roydon., *Real Analysis*, Macmillan Pub. Company, New York, 1988.
4. Sanjay Arora and Bansi Lal, *Introduction to Real Analysis*, Satya Prakashan, New Delhi, 1991.

CO – PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO 1	3	3	3	3	3	2	3	2	2	2
CO 2	3	3	3	2	2	2	2	1	2	1
CO 3	3	3	2	2	2	2	2	1	2	1
CO 4	3	2	2	2	3	2	2	1	2	1
CO 5	3	2	2	2	2	2	2	1	2	1
Average	3	2.6	2.4	2.2	2.4	2	2.2	1.2	2	1.2

Strong – 3 Medium – 2 Low – 1

Course Code	Name of the Course	Category	Hours/Wk.	Credits
24PGM/PSM4406	Partial Differential Equations	Core	5	4

To classify the second order partial differential equations and to study Cauchy problem, method of separation of variables, boundary value problems.

Course Outcomes:

At the end of the course, students will be able to

CO1: classify second order equations and find general solutions.
CO2: analyse and solve wave equations using Cauchy problems.
CO3: solve Vibrating string problem, Heat conduction problems.
CO4: apply maximum and minimum principle's and solve Dirichlet problems for various boundary conditions.
CO5: apply Green's function and solve Dirichlet, Laplace problems, to apply Helmholtz operation.

Unit I **(15 Hours)**

Classical equations – Vibrating string – Vibrating membrane – Conduction of heat in solids – Second order equations in two independent variables – Canonical forms – Equations with constant coefficients – General solution.

Unit II **(15 Hours)**

The Cauchy problem – Cauchy-Kowalewskaya theorem – Homogeneous wave equations – Initial Boundary value problems – Non-homogeneous boundary conditions – Finite string with fixed ends – Non-homogeneous wave equations – The Riemann method.

Unit III **(15 Hours)**

Separation of variable – Vibrating string problem – Existence and uniqueness of solution of vibrating string problem – Heat conduction problem – Existence and uniqueness of solution of heat conduction problem.

Unit IV **(15 Hours)**

Boundary value problems – Maximum and minimum principles – Uniqueness and continuity theorems – Dirichlet Problem for a circle , a circular annulus, a rectangle – Dirichlet problem involving Poisson equation.

Unit V **(15 Hours)**

The Delta function – Properties of Green's function – Method of Green's function – Dirichlet Problem for the Laplace and Helmholtz operator.

Learning Resources:

Text Book(s)

1. TynMyint-U and Lokenath Debnath, *Partial Differential Equations for Scientists and Engineers* (Fourth Edition), North Hollan, New York, 2007.

Unit I **:** Chapter 3 (Sec 3.1, 3.2, 3.3, 3.5)
Chapter 4 (Sec 4.1 to 4.4)

Unit II **:** Chapter 5 (Sec 5.1 to 5.8)

Unit III **:** Chapter 7 (Sec 7.1 to 7.6)

Unit IV **:** Chapter 9 (Sec 9.1 to 9.5, 9.7, 9.8)

Unit V **:** Chapter 11 (Sec 11.1 to 11.6)

References

1. R. Dennemeyer, *Introduction to Partial Differential Equations and Boundary Value Problems*, McGraw Hill, New York, 1968.
2. M.D. Raisinghania, *Advanced Differential Equations*, S.Chand& Company Ltd., New Delhi, 2001.
3. S, SankarRao, *Partial Differential Equations*, 2nd Edition, Prentice Hall of India, New Delhi. 2004
4. M.M.Smirnov, *Second Order partial Differential Equations*, Leningrad, 1964.
5. I.N.Sneddon, *Elements of Partial Differential Equations*, McGraw Hill, New Delhi, 1983.

CO – PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO 1	3	2	3	2	1	1	1	1	1	1
CO 2	3	3	3	2	2	1	1	1	2	2
CO 3	3	2	3	3	2	1	2	1	2	2
CO 4	3	3	3	3	2	1	2	1	1	2
CO 5	3	3	3	3	2	1	2	1	2	2
Average	3	2.6	3	2.6	1.8	1	1.6	1	1.6	1.8

Strong – 3 Medium – 2 Low – 1

Course Code	Name of the Course	Category	Hours/Wk.	Credits
24PGM/PSM4308	Classical Mechanics	Core	5	3

The objective of this course is to enable the students to know the basic principles of classical mechanics and its applications. This course demonstrate knowledge and understanding of the following fundamental concepts in the mechanics of system of particles, motions of the rigid body and the equations of motion for complicated mechanical systems using Lagrangian and Hamiltonian formulation of classical mechanics.

Course Outcomes:

At the end of the course, students will be able to

CO1: take on board the basic principles in mechanics.
CO2: apply complex and difficult problems of classical mechanics in a systematic way.
CO3: analysis the variation principle for real physical situations.
CO4: classify the concept of Euler angles and the Cayley – Klein parameters.
CO5: create problem solving skills of classical mechanics in various contexts such as mechanical engineering, astrophysics and biophysics.

Unit I **(15 Hours)**

Introductory concepts: Mechanical system – Generalized coordinates – Constraints – Virtual work – Energy and Momentum.

Unit II **(15 Hours)**

Lagrange's Equations: Derivations of Lagrange's Equations – Examples – Integrals of motion.

Unit III **(15 Hours)**

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

Unit IV **(15 Hours)**

The Euler angles – The Cayley – Klein Parameters and related quantities – Euler's theorem on the motion of a rigid body – Finite rotations – The rigid body equations of motion – Angular momentum and Kinetic energy of motion about a point.

Unit V **(15 Hours)**

Canonical transformations: Differential forms and generating functions – Lagrange and Poisson brackets.

Learning Resources:

Text Book(s)

1. Donald T. Greenwood, *Classical Dynamics*, Dover Publications, New York, 1997.

   Unit I **:** Chapter 1

   Unit II **:** Chapter 2 (Sec 2.1 to 2.3)

   Unit III **:** Chapter 4 (Sec 4.1 to 4.3)

   Unit V **:** Chapter 6 (Sec 6.1 to 6.3)

2. H. Goldstein, *Classical Mechanics*, Addison Wesley, Second edition, 2007.

   Unit IV **:** Chapter 4 (Sec 4.4 to 4.7); Chapter 5 (Sec 5.1)

References

1. J. L. Synge and B. A. Grifith, *Principle of Mechanics*, McGraw Hill, 1949.
2. D. E. Rutherford, *Classical Mechanics*, Oliver Boyd Ltd., 1964.
3. David Morin, *Introduction to Classical Mechanics*, Cambridge Press, 2008.

CO – PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO 1	3	3	3	3	3	1	2	1	1	2
CO 2	3	2	3	2	3	1	2	1	1	2
CO 3	3	3	2	3	2	1	3	1	1	2
CO 4	2	3	3	3	3	3	3	1	1	2
CO 5	3	2	2	3	3	2	2	1	1	2
Average	2.8	2.6	2.6	2.8	2.8	1.6	2.4	1	1	2

Strong – 3 Medium – 2 Low – 1

Course Code	Name of the Course	Category	Hours/Wk.	Credits
24PGM/PSM5501	Topology	Core	6	5

To study topological spaces, continuous functions, connectedness, compactness, countability and separation axioms.

Course Outcomes:

At the end of the course, students will be able to

CO1: define a topological space, correlate the relation between basis and sub basis, use the basis and sub basis for creation of new topologies, extend the concept called continuity to topological spaces.

CO2: distinguish between connectedness and path connectedness and its ramifications. Demarcate a metric space from a topological space.

CO3: familiarize himself/herself with compactness and related concepts. Learn the technique of compactification of topological spaces.

CO4: envision more intrinsic and inherent properties like countability axioms, separation axioms and separability.

CO5: gain knowledge on metrization of topological spaces and compactness of product spaces.

Unit I **(18 Hours)**

Topological Spaces – Basis for a Topology – The Order Topology – The Product Topology – The Subspace Topology– Metric topology –Closed Sets and Limit Points – Closure and Interior – Continuous Functions.

Unit II **(18 Hours)**

The Product Topology – The Metric Topology – Connected Spaces – Connected Subspaces of the Real Line – Components and Local Connectedness.

Unit III **(18 Hours)**

Compact Spaces – Compact Subspaces of the Real Line – Limit Point Compactness – Local Compactness.

Unit IV **(18 Hours)**

The Countability Axioms – The Separation Axioms – First Countable and Second Countable Spaces – Separable and Lindelof Spaces – Normal Spaces.

Unit V **(18 Hours)**

The Uryzohn Lemma – Uryzohn Metrization Theorem – The Tietz Extension Theorem – The Tychonoff Theorem.

Learning Resources:

http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics,
http://www.opensource.org , http://en.wikipedia.org

Learning Resources:

Text Book(s)

1. James R. Munkres**,** *Topology*, a first course, Prentice Hall of India, 2007.

   Unit I: Chapter 2 (Sec 12 to 18)

   Unit II: Chapter 2 (Sec 19 to 21); Chapter 3 (Sec 23 to 25)

   Unit III: Chapter 3 (Sec 26 to 29)

   Unit IV: Chapter 4 (Sec 30 to 32)

   Unit V: Chapter 4 (Sec 33, 34, 35, 37)

References

1. K.D.Joshi, *Introduction to general topology,* Wiley Eastern, 1983.
2. J.L. Kelly, *General Topology*, Van Nostrand, Reinhold Co., New York.
3. G.F.Simmons, *Introduction to topology and modern analysis*, McGraw Hill,1963.
4. L.Steen and J.Subhash, *Counter Examples in Topology*, Holt, Rinehart and Winston, New York, 1970.

CO – PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO 1	3	3	3	3	3	2	3	2	2	3
CO 2	3	3	3	3	3	3	3	2	2	2
CO 3	3	2	3	3	3	2	2	3	2	3
CO 4	3	3	3	2	3	2	2	2	2	2
CO 5	3	3	3	2	3	2	2	2	2	2
Average	3	2.8	3	2.4	3	2.2	2.4	2.2	2	2.4

Strong – 3 Medium – 2 Low – 1

Course Code	Name of the Course	Category	Hours/Wk.	Credits
24PGM/PSM5503	Complex Analysis	Core	6	5

This course is designed to Study Cauchy integral formula, local properties of analytic functions, general form of Cauchy's theorem and evaluation of definite integral and harmonic functions.

Course Outcomes:

At the end of the course, students will be able to

CO1: analyze and evaluate local properties of analytical functions and definite integrals.
CO2: describe the concept of definite integral and harmonic functions.
CO3: demonstrate the concept of the general form of Cauchy's theorem.
CO4: develop Taylor and Laurent Series.
CO5: explain the infinite products, canonical products and Jensen's formula.

Unit I **(18 Hours)**

Cauchy's Integral Formula: The Index of a point with respect to a closed curve – The Integral formula – Higher derivatives. Local Properties of analytical Functions: Removable Singularities-Taylor's Theorem – Zeros and poles – The local Mapping – The Maximum Principle.

Unit II **(18 Hours)**

The general form of Cauchy's Theorem: Chains and cycles- Simple Connectivity- Homology - The General statement of Cauchy's Theorem - Proof of Cauchy's theorem - Locally exact differentials- Multiply connected regions – The Calculus of Residues: The Residue theorem - The argument principle.

Unit III **(18 Hours)**

Evaluation of Definite Integrals and Harmonic Functions: Evaluation of definite integrals - Definition of Harmonic function and basic properties - The Mean-value property - Poisson formula.

Unit IV **(18 Hours)**

Harmonic Functions and Power Series Expansions: Schwarz theorem - The reflection principle – Weierstrass's theorem – The Taylor Series – The Laurent Series.

Unit V **(18 Hours)**

Partial Fractions and Entire Functions: Partial fractions - Infinite products – Canonical products – Gamma Function- Jensen's formula – Hadamard's Theorem.

Learning Resources:

Text Book(s)

1. Lars V. Ahlfors, *Complex Analysis, (3rd edition)* McGraw Hill Co., New York, 1979

Unit I : Chapter 4 (Sec 2.1 to 2.3); Chapter 4 (Sec 3.1 to 3.4)

Unit II : Chapter 4 (Sec 4.1 to 4.7); Chapter 4 (Sec 5.1 and 5.2)

Unit III : Chapter 4 (Sec 5.3); Chapter 4 (Sec 6.1 to 6.3)

Unit IV : Chapter 4 (Sec 6.4 and 6.5); Chapter 5 (Sec 1.1 to 1.3)

Unit V : Chapter 5 (Sec 2.1 to 2.4); Chapter 5 (Sec 3.1 and 3.2)

References

1. H.A. Presfly, *Introduction to complex Analysis*, Clarendon Press, oxford, 1990.
2. J.B. Conway, *Functions of one complex variables*, Springer - Verlag, International student Edition, Naroser Publishing Co. 1978.
3. E. Hille, *Analytic function Theory* (2 vols.), Gonm& Co, 1959.
4. M.Heins, *Complex function Theory*, Academic Press, New York, 1968.

CO – PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO 1	3	3	3	3	3	2	1	1	2	2
CO 2	3	3	3	3	3	2	1	1	2	2
CO 3	3	3	3	3	3	2	2	1	2	2
CO 4	3	3	3	3	3	2	2	1	2	2
CO 5	3	3	3	3	3	2	1	1	2	2
Average	3	3	3	3	3	2	1.4	1	2	2

Strong – 3 Medium – 2 Low – 1

Course Code	Name of the Course	Category	Hours/Wk.	Credits
24PGM/PSM5405	Probability Theory	Core	5	4

To introduce axiomatic approach to probability theory, to study some statistical characteristics, discrete and continuous distribution functions and their properties, characteristic function and basic limit theorems of Probability.

Course Outcomes:

At the end of the course, students will be able to

CO1: define Random Events, Random Variables, describe Probability, apply Bayes, define Distribution Function, find Joint Distribution function, find Marginal Distribution and Conditional Distribution function, solve functions on random variables.

CO2: solve Expectation, Moments and Chebyshev inequality, solve Regression of the first and second types.

CO3: analyze Characteristic functions, define distribution function, solve problems applying characteristic functions.

CO4: define One point, two-point, Binomial distributions, solve problems of Hypergeometric and Poisson distributions, define Uniform, normal, gamma, Beta distributions.

CO5: discuss Stochastic convergence, Bernaulli law of large numbers, elaborate Convergence of sequence of distribution functions, prove Levy-Cramer Theorems and de Moivre-Laplace Theorems, explain Poisson's & Chebyshev's law of large numbers.

Unit I **(15 Hours)**

Random events – Probability axioms – Combinatorial formulae – conditional probability – Bayes Theorem – Independent events – Random Variables – Distribution Function – Joint Distribution – Marginal Distribution – Conditional Distribution – Independent random variables – Functions of random variables

Unit II **(15 Hours)**

Expectation- Moments – The Chebyshev Inequality – Absolute moments – Order parameters – Moments of random vectors – Regression of the first and second types.

Unit III **(15 Hours)**

Properties of characteristic functions – Characteristic functions and moments – semi invariants – Characteristic function of the sum of the independent random variables – Determination of distribution function by the Characteristic function.

Unit IV **(15 Hours)**

One point, two point, Binomial – Polya – Hypergeometric distributions – Poisson (discrete) distributions – Uniform – Normal- Gmma – Beta distributions.

Unit V **(15 Hours)**

Stochastic convergence – Bernaulli law of large numbers – Convergence of sequence of distribution functions – Levy-Cramer Theorem – De-Moivre-Laplace Theorem – Poisson's, Chebyshev's law of large numbers.

Learning Resources:

Text Book(s)

1. M. Fisz, *Prbability Theory and Mathematical Statistics*, John Wiley and Sons, New York, 1963.

   Unit I : Chapter 1 (Sec 1.1 to 1.7); Chapter 2(Sec 2.1 to 2.9)

   Unit II : Chapter 3 (Sec 3.1 to 3.8)

   Unit III : Chapter 4 (Sec 4.1 to 4.5)

   Unit IV : Chapter 5 (Sec 5.1 to 5.9)

   Unit V : Chapter 6 (Sec 6.1 to 6.4, 6.6, 6.7 & 6.11)

References

1. V.K.Rohatgi, *An Introduction to Probability Theory and Mathematical Statistics*, Wiley Eastern Ltd., New Delhi, 1988(Third Print).
2. R.B. Ash, *Real Analysis and Probability*, Academic Press, New york, 1972
3. K.L.Chung, *A course in Probability*, Academic Press, New York,1974.
4. R.Durrett, *Probability : Theory and Examples*, (Second Edition) Duxbury Press, New York, 1996.
5. S.I.Resnick, *A Probability Path*, Birhauser, Berlin,1999.
6. B.R.Bhat, *Modern Probability Theory* (Third Edition), New Age International (P) Ltd, New Delhi, 1999.
7. Robert V.Hogg and Allen T.Craig, *Introduction to Mathematical Statistics* (sixth edition), Pearson Education International, 2005.

CO – PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO 1	3	3	2	3	3	1	2	1	2	2
CO 2	3	2	3	2	2	1	2	1	1	1
CO 3	3	2	3	3	2	1	2	1	1	1
CO 4	3	2	3	3	2	1	3	1	1	2
CO 5	3	2	2	3	1	1	1	1	1	1
Average	3	2.5	2.6	2.8	2	1	2	1	1.2	1.4

Strong – 3 Medium – 2 Low – 1

Course Code	Name of the Course	Category	Hours/Wk.	Credits
24PGM/PSM5307	Graph Theory	Core	5	3

Graph Theory is an important branch of Mathematics which has plenty of applications in almost all other fields such as Physics, Chemistry, Operations Research, Management, Sociology, Linguistics, Computer Engineering, Electrical Engineering, etc. This course covers all the basic concepts in Graph Theory namely trees, Eulerian and Hamiltonian graphs, matching, vertex and edge coloring, planar graphs and applications of Graph Theory in various fields. The objective of the course is to give a complete introduction to Graph Theory so that interested students can continue their research in this area.

Course Outcomes:

At the end of the course, students will be able to

CO1: absorb precise mathematical definitions of objects in graph theory.
CO2: apply the properties of trees and cut vertices concept in graphs.
CO3: identify Eulerian/Hamiltonian graphs and apply algorithms to construct Eulerian trails in graphs.
CO4: apply the matching concept and enumerate edge chromatic properties.
CO5: validate and critically assess the vertex coloring and planarity.

Unit I **(15 Hours)**

Graphs and Simple Graphs – Graphs Isomorphism – The Incidence and Adjacency Matrix – Sub Graphs – Vertex Degrees – Paths and Connection – Cycles – Applications.

Unit II **(15 Hours)**

Trees – Cut Edges and Bonds – Cut Vertices – Cayle's Formula – Applications.

Unit III **(15 Hours)**

Connectivity – Blocks – Euler Tours – Hamiltonian Cycles – Application of the Chinese Postman Problem.

Unit IV **(15 Hours)**

Matchings – Matchings and Coverings in Bipartite Graphs – Perfect Matchings– Edge Chromatic Number – Vizing's Theorem – Independent Sets – Turan's Theorem.

Unit V **(15 Hours)**

Chromatic Number – Brook's Theorem – Vertex Colorings and Upper Bounds – Brooks' Theorem – Chromatic Polynomials – Plane and Planar graphs – Dual Graphs – Euler's Formula.

Learning Resources:

Text Book(s)

1. J. A. Bondy and U. S. R. Murty, *Graph Theory with Applications*, Macmillan Co, 1976

   Unit I : Chapter 1 (Sec 1.1 to 1.8)

   Unit II : Chapter 2 (Sec 2.1 to 2.5)

   Unit III : Chapter 3 (Sec 3.1 and 3.2); Chapter 4 (Sec 4.1 to 4.3)

   Unit IV : Chapter 5 (Sec 5.1 to 5.3); Chapter 6 (Sec 6.1 and 6.2); Chapter 7 (Sec 7.1 and 7.3)

   Unit V : Chapter 8 (Sec 8.1, 8.2 and 8.4); Chapter 9 (Sec 9.1 to 9.3)

References

1. R. Balakrishnan and K.Ranganathan ,*A text Book of Graph Theory*, Springer Verlag, 2000.
2. G. Chartrand and O. R. Oellerman, *Applied and Algorithmic Graph Theory*, Mcgraw Hill, 1993.
3. G. Chartrand and P. Zhang, *A First Course in Graph Theory*, Dover Publications, 2012
4. F. Harary, *Graph Theory*, Addison Wesley publishing house, 1972.
5. M. Murugan, *Topics in Graph Theory and Algorithms*, Mudali publishing house, 2003.
6. Narasingh Deo, *Graph Theory with Applications to Engineering and Computer science*, Prentice Hall of India, 1984.
7. K. R. Parthasarathy, *Basic Graph Theory*, Tata Mcgraw Hill, 1994.
8. D. B. West, *Introduction to Graph Theory*, Prentice Hall of India, 2001.

CO – PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO 1	3	3	3	3	2	2	1	2	2	1
CO 2	3	3	3	3	2	2	1	2	2	2
CO 3	3	3	3	3	2	1	2	2	2	1
CO 4	3	3	2	3	3	1	2	2	2	2
CO 5	3	3	3	3	3	1	2	2	2	2
Average	3	3	2.8	3	2.4	1.4	1.6	2	2	1.6

Strong – 3 Medium – 2 Low – 1

Course Code	Name of the Course	Category	Hours/Wk.	Credits
24PGM/PSM5309	Measure Theory	Core	4	3

The aim of the course is to enable the student to understand the basic ideas of measure theory. This course deals with the concepts abstract measure spaces, abstract integration, Lebesgue measure, Lebesgue integration and the relation with Riemann integration and various types of convergence of sequence of measurable functions. Both ideas from real analysis and topology are needed to understand measure theory.

Course Outcomes:

At the end of the course, students will be able to

CO1: apprehend the fundamental concepts of Lebesgue outer measure and its properties also distinguish between Borel and Lebsegue measurability.

CO2: distinguish between Riemann and Lebesgue integrations and the ramifications on convergent sequence of functions.

CO3: analyse the four derivates and its properties.

CO4: apprehend and analyse an abstract measure and a measure space.

CO5: analyse the completion of measure and evaluate integration with respect to measure.

Unit I **(12 Hours)**

Introduction – Lebesgue outer measure – Measurable sets – Regularity – Measurable functions – Borel and Lebesgue measurability.

Unit II **(12 Hours)**

Integration of non-negative functions – Lebesgue integral – Fatou's lemma – Lebesgue monotone convergence theorem –The general integral– Lebesgue dominated convergence theorem – Riemann and Lebesgue integrals.

Unit III **(12 Hours)**

The four derivates –Continuous Non– differentiable functions– Functions of bounded variation - Lebesgue's differentiation theorem.

Unit IV **(12 Hours)**

Measures and outer measures – Extension of a measure – Uniqueness of the extension.

Unit V **(12 Hours)**

Completion of Measure - Measure spaces – Integration with respect to Measure.

Learning Resources:

Text Book(s)

1. G. De Barra, *Measure Theory and Integration*, New Age International, 2013.

   Unit 1: Chapter 2 (except sec 2.6)

   Unit 2: Chapter 3 (except sec 3.3)

   Unit 3: Chapter 4 (except sec 4.5 & 4.6)

   Unit 4: Chapter 5 (Sec 5.1 to 5.3)

   Unit 5: Chapter 5 (Sec 5.4 to 5.6)

References

1. P.R. Halmos, *Measure theory*, Springer international student edition, 1981
2. Royden, *Real analysis*, Macmillan, 1988.
3. W. Rudin, *Real and complex analysis*, Tata MC Graw Hill, 1966.
4. Munroe, M. E., *Introduction to measure and integration* –Addison Wesley, 1953.
5. I. K.Rana, *An Introduction to measure and integration*, Narosa Publishing House, 1997.

CO – PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO 1	3	3	3	3	3	2	3	2	2	3
CO 2	3	3	3	3	3	3	3	2	2	2
CO 3	3	2	3	3	3	2	2	3	2	3
CO 4	3	3	3	2	3	2	2	2	2	2
CO 5	3	3	3	2	3	2	2	2	2	2
Average	3	2.8	3	2.4	3	2.2	2.4	2.2	2	2.4

Strong – 3 Medium – 2 Low – 1

Course Code	Name of the Course	Category	Hours	Credits
24PGM/PSM5233	Internship	IS	30*	2

This course aims to enable the students to have hands-on training in their subject specialization of choice, and to convert the theoretical knowledge into practical skills.

Course Outcomes:

At the end of the course, students will be able to

CO1: demonstrate the ability to apply theoretical concepts and principles learned during coursework to solve real-world problems.

CO2: develop professional skills through hands-on experience in the field.

CO3: exhibit ethical behavior and professionalism in interactions with peers, supervisors and stakeholders.

CO4: demonstrate proficiency in communication, teamwork and time management.

CO5: reflect critically on personal learning and professional development during the internship.

CO – PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO 1	3	3	3	3	2	2	2	2	2	1
CO 2	2	3	2	3	2	2	3	2	2	2
CO 3	3	3	3	2	1	2	3	3	2	1
CO 4	3	3	2	2	2	2	2	3	3	1
CO 5	2	2	3	3	1	2	2	3	2	2
Average	2.6	2.8	2.6	2.6	1.6	2	2.4	2.6	2.2	1.4

Strong – 3 Medium – 2 Low – 1

*****First Year Vacation (30 Hrs.)

Course Code	Name of the Course	Category	Hours/Wk.	Credits
24PGM/PSM5502	Functional Analysis	Core	6	5

To provide students with a strong foundation in functional analysis, focusing on spaces, operators and fundamental theorems. To develop student's skills and confidence in mathematical analysis and proof technique.

Course Outcomes:

At the end of the course, students will be able to

CO1: be aware of the concept of Normed linear spaces and demonstrate the relevance of Open mapping theorem and closed graph theorem in the context of Normed linear spaces.

CO2: describe the Hilbert spaces, orthogonal complements, orthonormal sets, operators and projections.

CO3: discuss the finite dimensional spectral theory and the spectrum of an operator.

CO4: analyze regular and singular elements, the spectrum, the radical and semi- simplicity.

CO5: outline the structure of commutative Banach algebras and demonstrate the Gelfand-Neumark theorem.

Unit I **(18 Hours)**

Banach Spaces: The definition and some examples – Continuous linear transformations – The Hahn-Banach theorem – The natural imbedding of N in N^{**} – The open mapping theorem – The conjugate of an Operator.

Unit II **(18 Hours)**

Hilbert Spaces: The definition and some simple properties – Orthogonal complements – Orthonormal sets – The conjugate space H^* - The adjoint of an operator – Self-adjoint operators – Normal and unitary operators – Projections.

Unit III **(18 Hours)**

Finite-Dimensional Spectral Theory: Matrices – Determinants and the spectrum of an operator – The spectral theorem.

Unit IV **(18 Hours)**

General Preliminaries on Banach Algebras: The definition and some examples – Regular and singular elements – Topological divisors of zero – The spectrum – The formula for the spectral radius – The radical and semi-simplicity.

Unit V **(18 Hours)**

The Structure of Commutative Banach Algebras: The Gelfand mapping – Application of the formular $r(x) = lim\|x^n\|^{1/n}$ – Involutions in Banach Algebras – The Gelfand-Neumark theorem.

Learning Resources:

Text Book(s)

1. G.F.Simmons, *Introduction to Topology and Modern Analysis*, McGraw Hill Education (India) Private Limited, New Delhi, 1963.

   Unit I : Chapter 9 (Sec 46 to 51)

   Unit II: Chapter 10 (Sec 52 to 59)

   Unit III: Chapter 11 (Sec 60 to 62)

   Unit IV: Chapter 12 (Sec 64 to 69)

   Unit V: Chapter 13 (Sec 70 to 73).

References

1. C. Goffman and G. Pedrick, *First course in Functional Analysis*, Prentice Hall of India, NewDelhi,1987.
2. E. Kreyszig, *Introductory Functional Analysis with Applications*, John Wiley & Sons, New York, 1978.
3. B.V. Limaye, *Functional Analysis*, New Age International, 1996.
4. W.Rudin, *Functional Analysis*, McGraw Hill Education (India) Private Limited, New Delhi, 1973.
5. M. Thamban Nair, *Functional Analysis*, A First course, Prentice Hall of India, New Delhi, 2002.

Websites/ e-Learning Resources

http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org, http://en.wikiepedia.org

CO – PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO 1	3	3	3	3	3	2	3	2	2	3
CO 2	3	3	3	3	3	3	3	2	2	2
CO 3	3	2	3	3	3	2	2	3	2	3
CO 4	3	3	3	2	3	2	2	2	2	2
CO 5	3	3	3	2	3	2	2	2	2	2
Average	3	2.8	3	2.4	3	2.2	2.4	2.2	2	2.4

Strong – 3 Medium – 2 Low – 1

Course Code	Name of the Course	Category	Hours/Wk.	Credits
24PGM/PSM5504	Operations Research	Core	6	5

This course deals with network models, dynamic and integer programming, and queuing theory. Additionally the idea about nonlinear programming and provide the mathematical basis behind these techniques. The aim of this course is to help the students to understand and apply some of the widely used techniques of Operations Research.

Course Outcomes:

At the end of the course, students will be able to

CO1: analyse and solve integer programming problem.
CO2: interpret and solve network models.
CO3: analyse and solve queuing models.
CO4: analyse and solve classical optimization theory.
CO5: measure and solve non linear programming problems.

Unit I **(18 Hours)**

Integer programming problem (Pure & mixed)- formulation- branch and bound method & cutting plane method. Dynamic programming- Capital budgeting problem -shortest route problem- knapsack problem.

Unit II **(18 Hours)**

Network models- minimum spanning tree problem- shortest route problem- maximal flow problem- minimum cost capacitated problem.

Unit III **(18 Hours)**

Queuing theory- Queuing models-Basic characteristic of queueing system-Steady state solution of morkovian queuing models-M/M/1, M/M/C with limited waiting space, M/G/1 Queuing models.

Unit IV **(18 Hours)**

Determining points of extrema for unconstrained and constrained functions (Optimality conditions)-Jacobian method- Lagrangian multiplier techniques- Kuhn Tucker optimality conditions.

Unit V **(18 Hours)**

Non linear programming problem. - Quadratic programming problem.

Learning Resources:

Text Book(s)

1. H.A.Taha, *Operations Research an introduction*, Prentice Hall of India, 10th edition, 2019.

   Unit I: Chapter 9 (Sec 9.2); Chapter 12 (Sec 12.1, 12.2, 12.3.1)

   Unit II: Chapter 6 (Sec 6.1 to 6.4 (except 6.4.3))

   Unit III: Chapter 18 (Sec 18.1, 18.2, 18.5, 18.6.1 to 18.6.3, 18.7)

   Unit IV: Chapter 20 (Sec 20.1.1, 20.2)

   Unit V: Chapter 21 (Sec 21.1, 21.2.1 & 21.2.2)

References

1. F.S.Hillier and G.J.Liebermann, *Introduction to Operations research*, Mcgraw hill, 1995.
2. F.S.Hillier and G.J.Liebermann, *Introduction to Mathematical programming*, McGraw Hill, 1995
3. S.S.Rao, *Optimization theory and applications*, Wiley eastern, 1977.

CO – PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO 1	3	3	3	3	1	2	1	1	2	1
CO 2	3	3	3	3	2	2	1	1	2	1
CO 3	3	3	3	3	2	2	1	1	2	1
CO 4	3	3	3	3	2	2	1	1	2	1
CO 5	3	3	3	3	2	2	1	1	2	1
Average	3	3	3	3	1.8	2.6	1	1	2	1

Strong – 3 Medium – 2 Low – 1

Course Code	Name of the Course	Category	Hours/Wk.	Credits
24PGM/PSM5406	Mathematical Statistics	Core	5	4

This course intends to develop statistical inference (estimation and testing) based on likelihood methods, to study measures of quality of estimators and its properties, optimal tests of hypotheses and non-parametric statistics.

Course Outcomes:

At the end of the course, students will be able to

CO1: compute maximum likelihood estimation.

CO2: enlist different measures of quality estimators.

CO3: discuss exponential class of distribution, functions of parameter & relation between completeness.

CO4: illustrate with examples of different likelihood test.

CO5: analyse non-parametric statistics.

Unit I **(15 Hours)**

Maximum likelihood estimation - Rao-cramer lower bound and efficiency – Maximum Likelihood Tests - Multi parameter Case- Estimation &Testing.

Unit II **(15 Hours)**

Measures of Quality of Estimators – A Sufficient Statistic for a Parameter - Properties of Sufficient Statistic - Completeness and Uniqueness.

Unit III **(15 Hours)**

The Exponential Class of Distributions - Functions of Parameter - Minimal sufficiency and Ancillary Statistics - Sufficiency Completeness and Independence.

Unit IV **(15 Hours)**

Most powerful tests – Uniformly Most Powerful Tests - Likelihood Ratio tests - The Sequential Probability Ratio Test.

Unit V **(15 Hours)**

Location Models – Sample Median and Sign Test – Signed – Rank Wilcoxon – Mann – Whitney – Wilcoxon Procedure.

Learning Resources:

Text Book(s)

1. Robert V. Hogg, Joseph W. McKean and Allen T. Craig, *Introduction to Mathematical Statistics* (sixth edition), Pearson Education International, 2005.

   Unit I : Chapter 6 (Sec 6.1 to 6.5)

   Unit II : Chapter 7 (Sec 7.1 to 7.4),

   Unit III : Chapter 7 (Sec 7.5,7.6, 7.8 & 7.9)

   Unit IV : Chapter 8 (Sec 8.1 to 8.4)

   Unit V : Chapter 10 (Sec 10.1 to 10.4)

References

1. M. Fisz, *Probability Theory and Mathematical Statistics*, John Wiley and Sons, New York, 1963.
2. E.J. Dudeiczn and S.N. Mishra, *Modern Mathematical Statistics*, John Wiley & sons, New York , 1988.
3. V.K.Rohatgi, *An Introduction to Probability Theory and Mathematical Statistics*, Wiley Eastern Ltd., New Delhi, 1988.

CO – PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO 1	3	2	3	3	2	2	2	3	3	2
CO 2	3	2	3	3	3	2	3	2	3	2
CO 3	3	2	3	3	3	2	3	2	3	3
CO 4	3	2	3	3	3	2	2	2	3	3
CO 5	3	2	3	2	3	2	3	2	3	2
Average	3	2	3	2.8	2.8	2	2.6	2.1	3	2.4

Strong – 3 Medium – 2 Low – 1

Course Code	Name of the Course	Category	Hours/Wk.	Credits
24PGM/PSM5308	Differential Geometry	Core	5	3

This course introduces space curves and their intrinsic properties of a surface and geodesics. Further the non-intrinsic properties of surface and the differential geometry of surfaces are explored.

Course Outcomes:

At the end of the course, students will be able to

CO1: explain space curves, tangent, normal, binormal, curvature and torsion.
CO2: find the involute, evolute and intrinsic equations of some curves.
CO3: evaluate these concepts with related examples.
CO4: compose problems on geodesics.
CO5: recognize applicability of developable.

Unit I **(15 Hours)**

Space curves – Definition of a space curve – Arc length – tangent – normal and binormal – curvature and torsion.

Unit II **(15 Hours)**

Contact between curves and surfaces – tangent surface – involutes and evolutes – Intrinsic equations – Fundamental Existence Theorem for space curves – Helices.

Unit III **(15 Hours)**

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 IV **(15 Hours)**

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

Unit V **(15 Hours)**

Non Intrinsic properties of a surface – The second fundamental form – Principle curvature – Lines of curvature – Developable – Developable associated with space curves and with curves on surface – Minimal surfaces – Ruled surfaces.

Learning Resources:

Text Book(s)

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

   Unit I: Chapter I (Sec 1 to 5)

   Unit II: Chapter I (Sec 6 to 9)

   Unit III: Chapter II (Sec 1 to 9)

   Unit IV: Chapter II (Sec 10 to 18)

   Unit V: Chapter III (Sec 1 to 8)

References

1. Dirk J. Struik, Lectures *on Classical Differential Geometry*, Addison – Wesley, Mass. 1950.
2. S.Kobayashi and K.Nomizu, *Foundations of Differential Geometry*, Inter science Publishers, 1963.
3. D.Somasundaram, *"Differential Geometry: A first course"*, Narosa Publishing House, New - Delhi, India, 2005.
4. Thorpe J.A, *Elementary topics in Differential Geometry*, Under- graduate Texts in Mathematics, Springer - Verlag 1979.
5. Wilhelm Klingenberg, *A course in Differential Geometry*, Graduate Texts in Mathematics, Springer-Verlag 1978.

CO – PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO 1	3	3	3	3	1	1	1	1	1	1
CO 2	3	3	3	3	2	1	1	1	1	1
CO 3	3	2	3	3	2	1	2	1	1	1
CO 4	3	3	3	3	2	1	2	1	1	2
CO 5	3	3	3	3	3	1	2	1	2	2
Average	3	2.8	3	3	2	1	1.6	1	1.2	1.4

Strong – 3 Medium – 2 Low – 1

Course Code	Name of the Course	Category	Hours/Wk.	Credits
24PGM/PSM5300	Project	Core	4	3

The aim of this course is to train the students in literature collection and to gain experience for research. Students are encouraged to take it as a challenge, so that the result of the project shall be approved for publication in leading scientific journals.

Course Outcomes:

At the end of the course, students will be able to

CO1: compile and write dissertation based on their experiences as a researcher by understanding the need of research.

CO2: use the modern gadgets and exploit the digital data for an enhanced accuracy and reliability.

CO3: develop critical analysis and understanding on issues handled in the project as a mathematical model imitating the real time problem.

CO4: use the mathematical techniques for solving real time issues.

CO5: make them sensitive to social issues, mould them as socially upright citizen, and enhance their communication skill through meticulous interactions.

Guidelines & Instructions:

- A candidate may, however, in certain cases, be permitted to work on projects in an Industrial/Research Organization, on the recommendations of the Head of the Department. In such cases, the Project work shall be jointly supervised by a supervisor of the department and an expert, as a joint supervisor from the organization.
- The student shall be instructed to meet the supervisor periodically and to attend the review committee meetings for evaluating the progress.
- The Project work for M.Sc Mathematics shall be pursued for a minimum of 12 weeks during the final semester.
- The deadline for submission of final Project Report is the last working day of the semester in which project / thesis / dissertation is done.
- In case of candidates of M.Sc. Programmes not completing of project work successfully, the candidates can undertake again in the subsequent semester.

Evaluation:

The PG-Head of the Department and the supervisor shall constitute the review committee for each branch of study. The evaluation of Project Work for M.Sc. Mathematics shall be done independently in the respective semesters and marks shall be allotted as per the weightages given in tabular column. There shall be two reviews (each 10 Marks) during the semester by the review committee. The student shall make presentation on the progress made by him / her before the committee. The total marks obtained in the two reviews will be 20 Marks. The internal (Guide) will assess for 30 marks (Including the regular discussion, attendance and participation in Seminars/Workshops/Conferences). The project report (thesis / dissertation) shall carry a maximum 10 marks. The viva-voce examination shall carry 40 marks. (Marks are awarded to each student of the project group based on the individual performance in the viva –voce Examination).

Internal Assessment (50Marks)			**End Semester Examination (50 Marks)**			
Review -I	**Review -II**	**Internal (Guide)**	**Evaluation (10 Marks)**	**Viva – Voce (40 Marks)**		
			Internal (Guide)	**Examiner I**	**Examiner II**	**Examiner III**
10	10	30	10	40		

Review Committee members:

1. PG - Head of the Department
2. Supervisor/Guide.

CO – PSO Mapping

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO 1	3	3	3	3	3	3	3	3	3	2
CO 2	3	3	3	3	3	3	3	3	3	2
CO 3	3	3	3	3	3	3	3	3	3	2
CO 4	3	3	3	3	3	3	3	3	3	2
CO 5	3	3	3	3	3	3	3	3	3	2
Average	3	3	3	3	3	3	3	3	3	2

Strong – 3 Medium – 2 Low – 1

Course Code	Name of the Course	Category	Hours/Wk.	Credits
24PGM/PSM4311	Fuzzy Mathematics	DSE	4	3

The objective of this course is to introduce to the students all the basic ideas of fuzzy mathematics. The course deals with types of fuzzy sets, operations on fuzzy sets, fuzzy number, fuzzy interval, fuzzy logic, fuzzy relations and various connectives in fuzzy sets.

Course Outcomes:

At the end of the course, students will be able to

CO1: recall the basic concept of crisp sets and develop analogous patterns in fuzzy sets using alpha cuts and decomposition theorems.

CO2: characterize fuzzy complement and t-norm.

CO3: characterize t-co norm and develop relationship between fuzzy complement, t-norm and t-co norm.

CO4: identify and characterize fuzzy numbers and realize real number as a special case of fuzzy number, illustrate arithmetic operation on fuzzy numbers and solve fuzzy equations.

CO5: compare and contrast fuzzy relations with crisp relations.

Unit I **(12 Hours)**

Introduction – Crisp sets – Fuzzy sets – Basic concepts – Properties of α–cuts – Representations of fuzzy sets –Decomposition theorems – Extension Principle for fuzzy sets.

Unit II **(12 Hours)**

Fuzzy complements – First Characterization Theorem of Fuzzy complements – Second Characterization Theorem of Fuzzy complements – Fuzzy intersections (t – norms).

Unit III **(12 Hours)**

Fuzzy union (t-conorms) – Characterization theorem of t-norms, t-conorms – Combinations of operations**.**

Unit IV **(12 Hours)**

Fuzzy Numbers – Linguistic variables – Arithmetic Operations on intervals – Arithmetic Operations on Fuzzy numbers – Lattice of fuzzy numbers – Fuzzy Equations.

Unit V **(12 Hours)**

Crisp and fuzzy relations – Projections and Cylindrical extensions – Binary fuzzy relations – Binary relations on a single set – Fuzzy equivalence relations.

Learning Resources:

Text Book(s)

1. George J. Klir and Bo Yuan, *Fuzzy sets and fuzzy logic, theory and applications*, Prentice Hall of India, 2005.

   Unit I : Chapter 1 (Sec 1.1 to 1.5), Chapter 2 (Sec 2.1 to 2.3)

   Unit II : Chapter 3 (Sec 3.1 to 3.3)

   Unit III : Chapter 3 (Sec 3.4 to 3.5)

   Unit IV : Chapter 4 (Sec 4.1 to 4.6)

   Unit V : Chapter 5 (Sec 5.1 to 5.5)

References

1. G. J. Klir and T. A. Folger, *Fuzzy sets, uncertainty and information*, Prentice Hall of India, 2001.
2. H.T. Nguyen and E.T. Walker, *A first course in fuzzy logic*, Chapman and Hall, 1999.
3. H.J. Zimmermann, *Fuzzy set theory and its applications*, Allied publishers, 1996.

CO – PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO 1	3	2	3	2	1	1	1	1	1	1
CO 2	3	3	3	2	2	1	1	1	2	2
CO 3	3	2	3	3	2	1	2	1	2	2
CO 4	3	3	3	3	2	1	2	1	1	2
CO 5	3	3	3	3	2	1	2	1	2	2
Average	3	2.6	3	2.6	1.8	1	1.6	1	1.6	1.8

Strong – 3 Medium – 2 Low – 1

Course Code	Name of the Course	Category	Hours/Wk.	Credits
24PGM/PSM4313	Formal Languages and Automata Theory	DSE	4	3

A theoretical area of computer science and mathematics is automata theory. It is the study of abstract machines and how to use them to solve computational issues. The primary goal in offering the automata theory is to create techniques for characterizing and evaluating the dynamic behavior of discrete systems.

Course Outcomes:

At the end of the course, students will be able to

CO1: appreciate the structural concepts of grammar and languages.
CO2: differentiate DFA and NFA.
CO3: obtain knowledge in the relationship between regular expression and associated DFA.
CO4: simplify context free grammar and demonstrate the notion of normal forms.
CO5: analyze the relationship between context free languages and pushdown automaton

Unit I **(12 Hours)**

Alphabets and languages – Introduction to parsing – formal notion of a Grammar – types of grammars.

Unit II **(12 Hours)**

Finite state machines – Non Deterministic Finite Automata – Finite Automata with ϵ-moves.

Unit III **(12 Hours)**

Regular expressions– finite automata with output – pumping lemma for regular sets – closure properties of regular sets.

Unit IV **(12 Hours)**

Derivation trees– simplification of context free grammar – Chomsky Normal Form – Greibach Normal form.

Unit V **(12 Hours)**

Pushdown Automata – Pushdown Automata and Context Free Languages.

Learning Resources:

Text Book(s)

1. Rani Sironmoney, *Formal Languages and Automata Theory*, Manohar Printers, Tambaram, 1973

   Unit I: chapter 1 and 2 (Use notations in text book 2)

2. John E. Hopcroft and Jeffrey D. Ullman, *Introduction to Automata theory, Languages, and Computation*, Narosa Publishing House, 1990.

   Unit II: Chapter 2 (Sec 2.1 to 2.4)

   Unit III: Chapter 2 (Sec 2.5, 2.7)

   Chapter 3 (Sec 3.1, 3.2)

   Unit IV: Chapter 4 (Sec 4.2 to 4.6)

   Unit V: Chapter 5 (Sec 5.1 to 5.3)

References

1. William A Barrett, Rodney M Bates, David A Gustafson, John D Couch, *Compiler Construction, Theory and Practice*, Galgotia Publications Pvt. Ltd., New Delhi, 1988.
2. J P Tremblay and R. Manohar, *Discrete Mathematical Structures with Applications*, Tata McGraw-Hill (Indian Edition), 2008
3. Michael Sipser, *Introduction to the Theory of Computation*, Thomson Course Technology, 2006.

CO – PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO 1	3	3	2	3	2	2	3	2	3	2
CO 2	3	3	3	3	3	3	3	2	2	2
CO 3	3	3	3	3	3	3	3	2	3	2
CO 4	3	3	3	3	2	3	3	2	2	2
CO 5	3	3	3	3	3	3	3	2	2	2
Average	3	3	2.8	3	2.6	2.8	3	2	2.4	2

Strong – 3 Medium – 2 Low – 1

Course Code	Name of the Course	Category	Hours/Wk.	Credits
24PGM/PSM4312	Combinatorics	DSE	4	3

Combinatorics is the branch of Mathematics studying the enumeration, combination, and permutation of sets of elements and the mathematical relations that characterize their properties. The objective is to introduce large variety of applications and how algorithmic approach can be applied to solve a combinatorial problem. This course will also initiate interest in the students in higher studies and research in applicable mathematics.

Course Outcomes:

At the end of the course, students will be able to

CO1: identify and apply the rules of sum and product in Combinatorics.

CO2: discuss the distributions of distinct objects, identical objects and its application in counting principle.

CO3: use generating function as a tool for solving counting problems.

CO4: formulate recurrence relation for counting problems and solve them using known techniques including the generating functions.

CO5: outline the principle of inclusion and exclusion and solve counting problems.

Unit I **(12 Hours)**

Two basic counting principles – Simple arrangement and selections – Arrangement and selection with repetitions.

Unit II **(12 Hours)**

Distributions – distribution of distinct objects – Distribution of identical objects – Binomial identities.

Unit III **(12 Hours)**

Generating functions – Calculating coefficients of generating functions – Partitions – Exponential generating functions.

Unit IV **(12 Hours)**

Recurrence relation – Solution of linear recurrence relations – Solutions of inhomogeneous recurrence relations.

Unit V **(12 Hours)**

Inclusion and exclusion formula – Derangement – Introduction to rook polynomial.

Learning Resources:

Text Book(s)

1. A.W. Tucker, *Applied Combinatorics*, Wiley, 2011.

    Unit I: Chapter 5: Section 5.1, 5.2, 5.3

    Unit II: Chapter 5: Section 5.4, 5.5

    Unit III: Chapter 6: Section 6.1, 6.2, 6.3, 6.4

    Unit IV: Chapter 7: Section 7.1, 7.3, 7.4, 7.5

    Unit V: Chapter 8: Section 8.2, 8.3 (page 335 to 341)

References

1. D.Cohen, *Combinatorics*, Wiley, 1978.
2. M.Hall, *Combinatorial Mathematics*, McGraw Hill, 1968.
3. C.L.Liu, *Introduction to Combinatorial Mathematics*, 1994.
4. H.J.Ryser, *Combinatorial Mathematics*, Carus Mathematical monograph, 1965.
5. Krishnamurthy, *Combinatorics*, PHI, 1998.

CO – PSO Mapping

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO 1	3	3	3	3	2	3	2	2	1	1
CO 2	3	2	3	3	2	3	2	3	2	1
CO 3	3	2	3	2	2	3	2	3	2	1
CO 4	3	2	3	3	2	2	2	3	1	2
CO 5	3	2	2	3	1	2	2	2	2	1
Average	3	2.2	2.8	2.8	1.8	2.6	2	2.6	1.6	1.2

Strong – 3 Medium – 2 Low – 1

Course Code	Name of the Course	Category	Hours/Wk.	Credits
24PGM/PSM4314	Fluid Dynamics	DSE	4	3

Fluid dynamics is the branch of applied science that is concerned with the movement of liquids and gases. This course develops, the concepts of fluid motion, the Bernoulli's equation which derives from the motion equation, evaluate the stream function and complex potential for two-dimensional flows.

Course Outcomes:

At the end of the course, students will be able to

CO1: learn the concepts of fluid motion, its properties and the equation of continuity.
CO2: derive Euler's & Bernoulli's equations and the conservation of mass to determine velocities, pressures, and accelerations.
CO3: describe two-dimensional vortex behavior.
CO4: acquire the knowledge of sinks and doublets and evaluate the stream function.
CO5: evaluate the complex potential for two-dimensional flows.

Unit I **(12 Hours)**

Kinetics of Fluids in motion- Stream lines and path lines – The velocity potential – The vorticity vector – The equation of continuity – General analysis of Fluid motion.

Unit II **(12 Hours)**

Equations of a motion of a fluid- Pressure at a point in a moving fluid – Euler's equations of motion – Bernoulli's equation and related problems – Steady motion under conservative body forces-Some potential theorem.

Unit III **(12 Hours)**

Equations of a motion of a fluid- Some flows involving axial symmetry- Some special two-dimensional flows-Aspects of vortex motion.

Unit IV **(12 Hours)**

Three dimensional flows- Sources, Sinks and doublets – Images in a rigid infinite plane – Stoke's stream function.

Unit V **(12 Hours)**

Two-Dimensional flows- The stream function-The Complex potential for Incompressible flow-complex velocity potential & related problems.

Learning Resources:

Text Book(s)

1. Charlton, *Text Book of Fluid Dynamics*, CBS Publications, 1981.

Unit I : Chapter 2 (section 2.1 to 2.11)

Unit II : Chapter 3 (section 3.1 to 3.8)

Unit III : Chapter 3 (section 3.9 & 3.12)

Unit IV : Chapter 4 (section 4.1 to 4.3 & 4.5)

Unit V : Chapter 5 (section 5.3 to 5.6)

References

1. R. Von Mises & K.O. Fredricks, *Fluid Dynamics*, Springer International students Edition, Narosa publishing house, 1988.
2. Dr.J.K. Goyal & K.P.Gupta, *Fluid Dynamics*, published by K.K.Mittal for Pragati Prakashan,Second Edition 1986-87.

Websites/ e-Learning Resources

1. https://youtu.be/ycgJvnm24ks?si=nGernI4moydC2sjp
2. https://youtu.be/towu4x8qI4c?si=yJagNYYYEZEGPRi7
3. https://youtu.be/8wXWEsHR47A?si=uIAMWZbMu--nkFaD

CO – PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO 1	3	3	3	3	3	2	3	2	2	1
CO 2	3	3	3	3	3	2	3	2	2	1
CO 3	3	3	3	2	3	2	3	2	2	1
CO 4	3	2	2	2	2	2	2	2	1	1
CO 5	3	2	3	2	2	2	2	2	1	1
Average	3	2.6	2.8	2.4	2	2.6	2.6	1	1.6	1

Strong – 3 Medium – 2 Low – 1

Course Code	Name of the Course	Category	Hours/Wk.	Credits
24PGM/PSM5311	Numerical Methods with C++	DSE	4	3

This course introduces the basic concepts and techniques of solving algebraic, transcendental equations and system of simultaneous linear equations numerically. Also, it covers interpolation, numerical integration, and methods for solving differential equations. Also, this course is designed to develop programming skills in solving numerical analysis problems using C++.

Course Outcomes:

At the end of the course, students will be able to

CO1: solve transcendental and polynomial equations.

CO2: recall the procedure to solve system of linear algebraic equations and develop C++ programs.

CO3: identify various interpolating polynomials.

CO4: apply numerical methods to find the integrals of functions.

CO5: solve and compare the solutions of given ordinary differential equations with exact solutions using C++.

Unit I **(12 Hours)**

Roots of Algebraic and Transcendental Equations: Bisection Method – Method of False Position – Iterative Method – Newton-Raphson Method – Related programs in C++.

Unit II **(12 Hours)**

Solution of simultaneous linear algebraic equations: Gauss Elimination Method – Gauss Jordan Method – Gauss-Jacobi Method – Gauss-Seidel Method – Related programs in C++.

Unit III **(12 Hours)**

Interpolation: Finite Differences – Newton Forward & Backward Interpolation Formula – Gauss Forward & Backward Interpolation Formula – Lagrange formula – Related programs in C++.

Unit IV **(12 Hours)**

Numerical Integration: Trapezoidal Rule – Simpson's 1/3 Rule – Simpson's 3/8 Rule – Boole and Weddle Rule – Programs in C++ to find Numerical Integration.

Unit V **(12 Hours)**

Solution of Ordinary Differential Equations: Euler Formula – Modified Euler Formula – Runge-Kutta Method – Related programs in C++.

Learning Resources:

Text Book(s)

1. Nita H. Shah, *Numerical Methods with C++ programming, for Scientific and Engineering Computation*, PHI Learning Private Limited, New Delhi, 2009.

   Unit I **:** Chapter 2 (Sec 2.2 to 2.5, 2.11.1 to 2.11.7)

   Unit II **:** Chapter 3 (Sec 3.3, 3.4, 3.7, 3.8, 3.15.1, 3.15.2, 3.15.5, 3.15.6)

   Unit III **:** Chapter 5 (Sec 5.0, 5.1, 5.7 to 5.10, 5.17, 5.23.1 to 5.23.3)

   Unit IV **:** Chapter 6 (Sec 6.6 to 6.9, 6.16.3)

   Unit V **:** Chapter 7 (Sec 7.4 to 7.6, 7.11.1 to 7.11.4)

References

1. S. Balachandra Rao and C.K. Shantha, *Numerical Methods with Programs in BASIC, FORTRAN, Pascal and C++*, Universities Press (India) Private Limited, 2004.
2. E. Balagurusamy, *Object Oriented Programming with C++*, Seventh Edition, The McGraw–Hill Company Ltd, New Delhi, 2019.
3. B. S. Grewal, *Numerical Methods in Engineering & Science with Programs in C, C++ & MATLAB*, Khanna Publishers, New Delhi, 2015.
4. Pallab Ghosh, *Numerical Methods with Computer Programs in C++*, Prentice Hall of India Private Limited, 2006.
5. Samuel D. Conte and Carl De Boor, *Elementary Numerical Analysis: An Algorithmic Approach*, Third Edition, Tata McGraw- Hill Edition, New Delhi, 2009.
6. RM. Somasundaram and RM. Chandrasekaran, *Numerical Methods with C++ Programming*, Prentice Hall of India Private Limited, New Delhi, 2005.
7. Steve Oualline, *Practical C++ Programming*, Second Edition, O'Reilly Media Inc, United States of America, 2002.

Websites/ e-Learning Resources

https://nptel.ac.in

https://mathonline.wikidot.com

CO – PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO 1	3	3	3	1	2	3	2	1	1	3
CO 2	3	2	3	2	2	3	2	1	1	3
CO 3	3	3	3	3	3	3	3	2	2	3
CO 4	3	2	3	3	2	3	3	2	2	3
CO 5	3	3	3	3	3	3	3	2	1	2
Average	3	2.6	3	2.4	2.4	3	2.6	1.6	1.4	2.8

Strong – 3 Medium – 2 Low – 1

Course Code	Name of the Course	Category	Hours/Wk.	Credits
24PGM/PSM5313	Fractal Geometry	DSE	4	3

This course aims to learn the concept of geometry in Nature and emerging applications in Analysis.

Course Outcomes:

At the end of the course, students will be able to

CO1: discuss the space of fractals and its properties.
CO2: distinguish between compact sets and connected Sets.
CO3: construct contraction mappings and generate Fractal models.
CO4: analyze the addresses of points on fractals and attractors of fractals.
CO5: determine the Fractal Dimension.

Unit I **(12 Hours)**

Introduction to Fractal Geometry – Spaces of Fractals – Code Spaces – Metric Spaces – Cauchy Sequences – Limit Points – Closed Sets – Perfect Sets and Complete Metric Spaces – Compact Sets – Bounded Sets – Open Sets – Interiors and Boundaries – Connected Sets – Disconnected Sets and Path wise Connected Sets.

Unit II **(12 Hours)**

The Completeness of the Space of Fractals – Additional Theorems about Metric Spaces.

Unit III **(12 Hours)**

Transformations on the Real Line – Affine Transformations in the Euclidean Plane – Mobius Transformations on the Riemann Sphere – Analytic Transformations – How to Change Coordinates – The Contraction Mapping Theorem – Contraction Mappings on the Space of Fractals – Two Algorithms for Computing Fractals from Iterated Function Systems – Condensation Sets – How to Make Fractal Models with the Help of the Collage Theorem.

Unit IV **(12 Hours)**

The Addresses of Points on Fractals – Continuous Transformations from Code Space to Fractals – Introduction to Dynamical Systems.

Unit V **(12 Hours)**

Fractal Dimension – The Theoretical Determination of the Fractal Dimension – The Experimental Determination of the Fractal Dimension.

Learning Resources:

Text Book(s)

1. M.F.Branslay, *Fractals Everywhere*, 2nd Edition, 1998.

Unit I : Chapter 2 (sec 2.1 – 2.5)

Unit II : Chapter 2 (sec 2.6 – 2.7)

Unit III : Chapter 3 (sec 3.1 – 3.10)

Unit IV : Chapter 4 (sec 4.1 – 4.3)

Unit V : Chapter 5 (sec 5.1 – 5.3)

References

1. Gilbert Helmberg, *Getting Acquainted with Fractals*, Walter de Gruyter GmbH & Co.KG, Germany. 2006.
2. Paul S Addison, *Fractals and Chaos*, IOP Publishing ltd, 2nd Edition, 2024.

CO – PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO 1	3	3	3	3	1	2	1	1	1	1
CO 2	3	3	3	3	2	2	1	1	1	1
CO 3	3	3	3	3	2	2	1	1	1	1
CO 4	3	3	3	3	2	2	1	1	1	1
CO 5	3	3	3	3	2	2	1	1	1	1
Average	3	3	3	3	1.8	2	1	1	1	1

Strong – 3 Medium – 2 Low – 1

Course Code	Name of the Course	Category	Hours/Wk.	Credits
24PGM/PSM5312	Mathematical Python	DSE	4	3

This course aims to learn the concept in building the Python programming skill to understand and implement in research work.

Course Outcomes:

At the end of the course, students will be able to

CO1: differentiate and express the data types of Python and express various usage of operators.

CO2: execute the types of loops and different Python statements and interpret Python Modules, Classes and Objects.

CO3: create the syntax of functions and comprehend Time functions and Random Function.

CO4: discuss the object class and operator overloading in Python.

CO5: identify the data types and assign Values of Data Frame, renaming and combining Data.

Unit I **(12 Hours)**

Introduction to Python Data types – Assigning Values to Variables – Multiple Assignment – Naming Rules – Python's Standard Data Types – Data Type Conversion – Introduction to statements, Expressions and Operators – Statements and Expressions – Operators and Operands – Arithmetic Operators – Relational Operators – Assignment – Operators – Bitwise Operators – Logical Operators – Membership Operators – Identity Operators – Precedence and Associativity of Python Operators.

Unit II **(12 Hours)**

The Completeness of the Space of Fractals – Additional Theorems about Metric Spaces. Introduction to Python's Flow Control Tools – *if* statement – *if...else* statement – *if...else....else* statement – *for* loop – *while* loop – *break* and *continue* loop – *pass* statement – Introduction to Python Modules – *import* statement – Import by Renaming *from ... import* statement – importing all names in a Module – Module Search Path – Reloading Modules – *dir* () function – Packages – Importing Modules from Packages.

Unit III **(12 Hours)**

Introduction to Functions in Python – Standard Mathematical Functions – Time Functions – Random Functions – Reasons to write your own Functions – Functions Basics.

Unit IV **(12 Hours)**

Introduction to Python Classes and Objects – Introduction to Object Oriented Programming – *Object* Class – Operator Overloading in Python.

Unit V **(12 Hours)**

Introduction to Pandas – Creating, Reading and Writing – Indexing , Selecting and Assigning – Summarizing Functions and Maps – Grouping and Sorting – Data Types and Missing values –Renaming and Combining.

Text Book(s)

1. Mohd.Abdul Hameed, *Python for Data Science*, Wiley India Ltd, 2021.
   Unit I : Chapter 1 (sec 1.1 to 1.7); Chapter 2 (sec 2.1 to 2.11)
   Unit II : Chapter 3 (sec 3.1 to 3.8); Chapter 5 (sec 5.1 to 5.10)
   Unit III : Chapter 4 (sec 4.1 to 4.6)
   Unit IV : Chapter 6 (sec 6.1 to 6.4)
   Unit V : Chapter 9 (sec 9.1 to 9.7)

References

1. Ashok Namdev Kamthane and Amit Ashok Kamthane, *Programming and Problem Solving with Python* , McGraw Hill Education India, 2018.
2. James Tudor, *Python Programming for Beginners: Learn the basics of Python Programming,* Amazon Digital Services LLC, KDP Print, US, 2019.

CO – PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO 1	3	3	3	3	3	3	3	1	2	1
CO 2	3	3	3	3	3	3	3	1	2	1
CO 3	3	3	3	3	3	3	3	1	2	1
CO 4	3	3	3	3	3	3	3	1	2	1
CO 5	3	3	3	3	3	3	3	1	2	1
Average	3	3	3	3	3	3	3	1	2	1

Strong – 3 Medium – 2 Low – 1

Course Code	Name of the Course	Category	Hours/Wk.	Credits
24PGM/PSM5314	Statistical Data Analysis using R Programming	DSE	4	3

This course introduces the basic concepts and techniques of R Programming and enables the students to perform statistical analysis using built – in functions.

Course Outcomes:

At the end of the course, students will be able to

CO1: recall the basics of R Language.
CO2: apply various concepts to write programs in R.
CO3: analyse the data and use appropriate plots, charts, and diagrams for all kinds of data.
CO4: predict the data and take decisions through R programming.
CO5: write and execute the code for multivariate analysis.

Unit I **(12 Hours)**

Introduction to R programming: What is R? – Installing R and R Studio – R Studio Overview – Packages in R – Working in the Console –Essentials of R: Arithmetic Operators – Logical Operations – Using Functions – Getting Help in R and Quitting R Studio – Installing and loading packages. Data structures, Variables, and Data types in R: Creating Variables – Numeric, Character and Logical Data – Vectors.

Unit II **(12 Hours)**

Data Frames – Factors – Sorting Numeric, Character, and Factor Vectors – Special Values, conditional statements – Functions.

Unit III **(12 Hours)**

Descriptive Statistics and Graphics: Scatter Plots – Box Plots – Scatter Plots and Box and – histograms – Customize plot axes, labels, add legends, and add colours.

Unit IV **(12 Hours)**

Probability functions – Normal distribution – The Chi – squared distribution – The Gamma distribution – The Bernoulli distribution – The Binomial distribution – The Poisson distribution.

Unit V **(12 Hours)**

Analysis of Variance – One – way ANOVA – Calculations in one – way ANOVA – Assumptions of ANOVA – Plots for interpreting one – way ANOVA – Factorial experiments – Multiple comparisons – Multivariate analysis of variance.

Text Book(s)

1. M.J .Crawley., *The R Book*, John Wiley and Sons Private Ltd., NY, 2007.

Unit I **:** Chapter 1 (Sec 1.1 to 1.3, 1.5 to 1.8);
Chapter 2 (Sec 2.1 to 2.2, 2.6, 2.15, 2.16)

Unit II **:** Chapter 4 (Sec 4.1 to 4.4)

Unit III : Chapter 5 (Sec 5.1 to 5.2, 5.6 to 5.7)

Unit IV : Chapter 7 (Sec 7.2 to 7.4)

Unit V **:** Chapter 11 (Sec11.1 to 11.2, 11.6 to 11.7)

References

1. M. Gardener, *Beginning R: The Statistical Programming Language*, Wiley Publications, 2012.
2. W. J Braun., D. J Murdoch., *A First Course in Statistical Programming with R*, Cambridge University Press, New York, 2007.
3. M. J Crawley., *Statistics – An introduction using R*, John Wiley, London, 2006.
4. S.G Purohit., S.D Gore., and S.R Deshmukh., *Statistics using R*, second edition, Narosa Publishing House, New Delhi, 2015.
5. P. Dalgaard., *Introductory Statistics with R*, Second Edition, Springer, 2008.

Websites/ e-Learning Resources

https://onlinecourses.nptel.ac.in/

CO – PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO 1	2	2	2	1	2	3	2	1	2	2
CO 2	3	3	3	3	2	3	2	1	1	2
CO 3	3	3	3	3	2	3	2	1	2	2
CO 4	3	2	3	3	2	3	3	1	1	2
CO 5	3	3	3	3	2	3	3	1	1	2
Average	3	2.6	3	2.6	2	3	2.4	1	1.4	2

Strong – 3 Medium – 2 Low – 1

Course Code	Name of the Course	Category	Hours/Wk.	Credits
24PGM/PSM4321	Mathematics for Career Prospects	GE	4	3

This course enhances the problem solving skills and provides strategies and methods to solve problems in mathematical section of any competitive examination.

Course Outcomes:

At the end of the course, students will be able to

CO1: solve problems on numbers.
CO2: identity and find average, percentage, profit / loss and ratios.
CO3: interpret and find solution from the given data.
CO4: solve problems involving time, permutations and combinations.
CO5: find simple and compound interest, true discount and determine the probability.

Unit I **(12 Hours)**

Number System – HCF and LCM of numbers – Fractions – Simplification.

Unit II **(12 Hours)**

Average – Percentage – Profit and Loss – Ratio and Proportion.

Unit III **(12 Hours)**

Data Interpretation: Tabulation – Bar Graphs – Pie Chart – Line Graphs.

Unit IV **(12 Hours)**

Time and Work – Time and Distance – Problems on Trains – Permutations and Combinations.

Unit V **(12 Hours)**

Simple Interest – Compound Interest –True Discount – Probability.

Learning Resources:

Text Book(s)

1. Dr. R.S. Aggarwal, *Quantitative Aptitude for Competitive Examinations*, S. Chand and Company Limited, Reprint (2020).
   Unit I: Section I: 1 to 4
   Unit II: Section I: 6, 11, 12, 13

Unit III: Section II: 36 to 39

Unit IV: Section I: 17, 18, 20, 30

Unit V: Section I: 22, 23, 31, 32

References

1. Abhijit Guha, *Quantitative Aptitude*, McGraw Hill India, 2020.
2. R.K. Tyagi, *Quantitative Aptitude for Competitive Examination*, MTG Learning Media 2018.

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3	3	3	3	1	2	2	1	1	2
CO 2	3	3	3	3	1	2	2	1	1	2
CO 3	3	3	3	3	2	2	3	2	2	2
CO 4	3	3	3	3	2	2	2	1	2	2
CO 5	3	3	3	3	2	2	1	1	1	2
Average	3	3	3	3	1.6	1.6	2.2	1.4	1.6	2

Strong – 3 Medium – 2 Low – 1

Course Code	Name of the Course	Category	Hours/Wk.	Credits
24PGM/PSM4323	Office Automation	GE	4	3

The objective of the course is to facilitate the students to introduce the basic tools in computer software.

Course Outcomes:

At the end of the course, students will be able to

CO1: perform basic computer operations.
CO2: prepare documents, letters and do necessary formatting of the document.
CO3: apply basic formulas and functions.
CO4: create and print charts.
CO5: manipulate slides to enhance the look of the slides as well as whole presentation by inserting a picture, objects, formatting etc..

Unit I **(12 Hours)**

Introduction to MS Office 2019 – Selecting and Editing Data – Modifying Pictures and Drawing on Documents.

Unit II **(12 Hours)**

Introduction to MS Office - MS Word - Working with Documents - Formatting Documents – Setting Page Style – Creating Tables – Drawing – Tools – Printing Documents.

Unit III **(12 Hours)**

Introduction to MS Office – MS Excel – Spreadsheet and its Applications – Entering & Deleting Data – Formatting Spreadsheets.

Unit IV **(12 Hours)**

Playing with Formulas – Working with Sheets – Creating Charts – Printing.

Unit V **(12 Hours)**

Introduction to MS Office – MS Power Point – Creating a presentation – Formatting a Presentation – Adding Effects to the Presentation – Printing Handouts.

Learning Resources:

Text Book(s)

1. Wallace Wang, *Microsoft Office 2019 for Dummies*, John Wiley & Sons, Inc., 2019.

   Unit I **:** Chapters 1 to 3

   Unit II **:** Chapters 5 to 7

   Unit III **:** Chapter 8

   Unit IV **:** Chapters 9 to 10

   Unit V **:** Chapters 11 to 13

References

1. Lalit Mali, *Microsoft Office 2016 Word, Excel, One Note Book - Vol 1*, Notion Press, 2016.
2. P.K. Sinha, *Computer Fundamentals*, BPB Publications, 2020.
3. Tittel Ed, *Computer Networking*, Schaum's Outlines, MC Graw Hill, 2006.

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	2	3	2	1	1	2	1	1	1	1
CO 2	3	3	2	2	1	3	2	1	2	1
CO 3	3	3	3	3	1	3	2	1	2	1
CO 4	3	2	2	1	1	3	2	1	2	1
CO 5	3	3	3	2	2	3	2	1	2	1
Average	2.8	2.8	2.4	1.8	1.2	2.8	1.8	1	1.8	1

Strong – 3 Medium – 2 Low – 1

Course Code	Name of the Course	Category	Hours/Wk.	Credits
24PGM/PSM4322	Mathematical Reasoning	GE	4	3

This course aims at providing necessary logical reasoning part which is required of post graduates from arts and science disciplines, in order to get through in competitive exams like CSIR&UGC-NET/SET. This course includes arithmetic reasoning, logical reasoning, verbal and non-verbal reasoning ideas. The contents are put in order so that a student who had undergone this course will get enhanced with verbal and logical abilities.

Course Outcomes:

At the end of the course, students will be able to

CO1: solve verbal reasoning problems like series completion, alpha-numeric puzzle, coding and letter coding.

CO2: solve blood relations tests the analytical skills of the students and how one can approach the solution of logical problems

CO3: analyze and establish the relation between the given series of figures, arithmetic reasoning problems.

CO4: solve the problems in non-verbal reasoning.

CO5: relate the given statements and draw conclusions from it.

Unit I **(12 Hours)**

Verbal Reasoning: Number series – Alphabet series – Odd word – Odd number – Letter coding–Number/symbol Coding.

Unit II **(12 Hours)**

Blood Relation: Relation puzzle–Coded relations – Puzzle test–Classification type question–Family based puzzles.

Unit III **(12 Hours)**

Arithmetical Reasoning: Calculation based problems –Data based questions –Problems on ages –Venn diagram based questions.

Unit IV **(12 Hours)**

Non-verbal reasoning: Five figure series – Three and four figure series – Choosing the missing figure in a series – Choosing one element of a similarity related pair.

Unit V **(12 Hours)**

Logical reasoning: Two premise arguments – Three premise arguments – Statements and arguments – Statements and assumptions – Type1, Type2 deriving conclusions from passages.

Learning Resources:

Text Book(s)

1. R. S. Aggarwal, *A Modern Approach To Verbal and Non – Verbal Reasoning*, S.Chand and Company. Pvt. Ltd, 2020.

   Unit I : 1.3 to 1.18, 3.1 to 3.16, 3.23 to 3.27, 4.1 to 4.23.

   Unit II : 5.6 to 5.18, 6.1 to 6.12, 6.55 to 6.63.

   Unit III : 15.1 to 15.18.

   Unit IV : 1.3 to 1.10, 1.91 to 1.97, 1.118 to 1.125, 2.1 to 2.10

   Unit V : 1.3 to 1.20, 2.1 to 2.20, 3.1 to 3.30, 6.1 to 6.15.

References

1. R. S. Aggarwal, *A Modern Approach to Verbal Reasoning*, S.Chand and Company Pvt. Ltd 2006
2. R. S. Aggarwal, *A Modern Approach to Non – Verbal Reasoning*, S.Chand and Company Pvt. Ltd 2006
3. R. S. Aggarwal, *A Modern Approach to logical Reasoning*, S.Chand and Company Pvt. Ltd, 2013.

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3	3	3	3	3	2	3	2	3	2
CO 2	2	2	3	3	3	2	2	3	3	1
CO 3	3	3	3	3	2	2	2	2	2	2
CO 4	3	2	3	3	3	1	3	3	3	2
CO 5	3	2	3	3	3	2	2	3	3	2
Average	2.8	2.4	3	3	2.8	1.8	2.4	2.6	2.8	1.8

Strong – 3 Medium – 2 Low – 1

Course Code	Name of the Course	Category	Hours/Wk.	Credits
24PGM/PSM4324	Programming in C	GE	4	3

This course is mainly designed to use C to learn the art of programming, and to appreciate and understand the C language to creatively write a wide range of programmes and peep into the study of Data Structures.

Course Outcomes:

At the end of the course, students will be able to

CO1: explain the importance of C, Create and execute simple C programs.
CO2: develop a C program using operators and manage I/O operations.
CO3: construct C program with the help of branching statements.
CO4: recall the syntax and use loop statements in C program.
CO5: illustrate the uses of arrays and create C programs using arrays to compute and print the specified output.

Unit I **(12 Hours)**

Overview of C- basic structure – executing a C program - character sets – C tokens – keywords – identifiers - constants – variables – data types - declaration of variables.

Unit II **(12 Hours)**

Operators and expressions- arithmetic, relational, logical, assignment, increment and decrement, conditional, bitwise, special operators - managing input and output operations - formatted input and output.

Unit III **(12 Hours)**

Decision making and branching –simple if – if … Else- nested if – else if ladder – switch statement – Goto statement.

Unit IV **(12 Hours)**

Decision making and looping- while loop – for loop –do while loop – break, continue statements.

Unit V **(12 Hours)**

Arrays - introduction – declaration initialization of one dimensional arrays – initializing two

dimensional arrays - character arrays and strings – declaring and initializing string variables – string handling functions.

Learning Resources:

Text Book(s)

1. E. Balagurusamy, *Programming in ANSI C 6th edition*, Tata McGraw Hill, 2013.

   Unit 1: Chapter 1: (Sec 1.1 to 1.10); Chapter 2 (Sec 2.1 to 2.10)

   Unit 2: Chapter 3 (Sec 3.1 to 3.12); Chapter 4

   Unit 3: Chapter 5

   Unit 4: Chapter 6 (Sec 6.1 to 6.5)

   Unit 5: Chapter 7 (Sec 7.1 to 7.6); Chapter 8 (Sec 8.1 to 8.8)

References

1. P. Pandiyaraja, Programming in C, S. Viswanathan Pvt Ltd, 2005.
2. Herbert Schildt, Advanced C programming, Osborne McGraw Hill, 1990.
3. M. Tim Grady, Turbo C Programming Principles and Practices, McGraw Hill, 1990.

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3	2	2	3	2	3	3	1	1	3
CO 2	3	3	3	3	3	3	3	1	1	3
CO 3	3	3	2	3	3	3	3	1	1	2
CO 4	3	3	3	3	2	3	3	1	1	3
CO 5	3	3	3	2	3	3	3	1	1	3
Average	3	2.8	2.6	2.8	2.6	3	3	1	1	2.8

Strong – 3 Medium – 2 Low – 1

Course Code	Name of the Course	Category	Hours/Wk.	Credits
24PGM/PSM5244	Professional Competency Skill	SEC	-	2

Professional competency skills encompass a broad range of abilities and attributes that enable the students to perform effectively in their professional roles. These skills are crucial for their success across various disciplines, higher education and job functions.

Developing and refining the following professional competency skills can significantly enhance career prospects and contribute to professional growth and success in various organizational contexts.

Course Module & Outcome:

Questions selected from the core courses offered over the three semesters which are of immense importance. In Semester IV, an Online Test will be conducted to test their competency skill and grades will be awarded accordingly.

When it comes to testing mathematical knowledge as a professional competency skill, there are several key aspects to consider. The expected outcome of this test is as follows:

1. **Problem-solving Ability:** Assessing someone's capability to solve mathematical problems across various domains such as Algebra, Calculus, Statistics, etc. This involves not just computational skills but also the ability to understand the problem, formulate a solution approach, and execute it effectively.

2. **Mathematical Reasoning:** Evaluating how well an individual can apply logical reasoning to mathematical concepts and theories. This includes understanding mathematical principles, making connections between different concepts, and drawing conclusions based on mathematical evidence.

3. **Quantitative Analysis:** Testing proficiency in analyzing numerical data, interpreting results, and making data-driven decisions. This skill is crucial in fields such as finance, economics, engineering, and scientific research.

4. **Mathematical Modeling:** Assessing the ability to create mathematical models to represent real-world scenarios, predict outcomes, and optimize solutions. This involves translating

real-world problems into mathematical frameworks and using appropriate techniques to analyze them.

5. **Critical thinking in Mathematics:** Evaluating the capacity to critically evaluate mathematical arguments, identify flaws in reasoning, and construct valid proofs or justifications.

6. **Applied Mathematics:** Testing proficiency in applying mathematical concepts to practical problems or situations, such as in engineering designs, statistical analysis, or optimization problems.

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3	2	3	3	3	2	2	2	2	3
CO 2	3	2	3	3	3	3	3	2	2	3
CO 3	3	3	3	2	3	2	3	2	2	2
CO 4	3	2	3	3	3	2	2	3	2	2
CO 5	3	3	3	3	3	3	2	2	3	2
Average	3	2.4	3	2.8	3	2.4	2.4	2.2	2.2	2.4

Strong – 3 Medium – 2 Low – 1

Department of Mathematics (PG)

Value Added Courses

w.e.f. 2024-2025

Sem	Course Code	Course Title	Hours/Wk.	Credits
2	24PGM/PSM422V	Introduction to LaTeX	2	2
3	24PGM/PSM521V	Hacks and Tips for NET Paper I	2	2

Course Code	Name of the Course	Category	Hours/Wk.	Credits
24PGM/PSM422V	Introduction to LaTeX	Value Added Course	2	2

The main motive is to impart knowledge and understanding about the LaTeX system, explain the procedure of LaTeX typesetting, and familiarize the participants with various document formats of LaTeX, enabling them to prepare research articles, thesis, books, and presentations confidently.

Course Outcomes:

At the end of the course, students will be able to

CO1: typesetting of complex mathematical formulae using LaTeX.

CO2: use tabular and array environments within LaTeX.

CO3: create a journal articles, technical reports, books.

CO4: typesetting of Slide presentation in LaTeX.

CO5: automatic generation of a table of contents, bibliographies, and indexes.

Unit I **(6 Hours)**

Installation of MikTeX – Creating a Title-Sections – Command names – Arguments-Labelling – Table of Contents – Font Effects.

Unit II **(6 Hours)**

Lists, Tables – Figures – List of figures – Equations: Inserting Equations and Mathematical Symbols.

Unit III **(6 Hours)**

Inserting References: Inserting the Bibliography Styles – Technical Report: Writing Thesis/Project/Report, Classes: Article, Book, Report.

Unit IV **(6 Hours)**

Introduction to Beamer – Beamer slides – Main features: How to set the document class to beamer – Its title–subtitle – Author – Institute and Date information – Bold, Italics and Underlining – Highlighting important sentences/words – Customizing Presentation: Themes (rows) and Colour themes (columns) – Fonts and Columns.

Unit V **(6 Hours)**

Document Layout and Organization – Page Layout – Titles, Abstract Chapters, Sections, References, Equation References, Citation.

Learning Resources:

Text Book(s)

1. Helmut Kopka, Patrick W. Daly, *A Guide to LATEX and Electronic Publishing*, Fourth Edition, 2004.
2. Tobias Oetiker, Marcin Serwin, Hubert Partl, Irene Hyna, Elisabeth Schlegl, *The Not So Short Introduction to LATEX*, August 2023.
3. Sefan Kottwitz, *LATEX Beginners Guide*, 2011.

References

1. LATEX Tutorials, *A PRIMER Indian TEX Users Group*, Trivandrum, India, 2003.
2. Andre Heck, *Learning LATEX by Doing*, March 2005.

Websites/e-learning Resources

https://www.overleaf.com/learn/latex/LaTeX_video_tutorial_for_beginners_(video_1)

https://www.overleaf.com/learn/latex/LaTeX_video_tutorial_for_beginners_(video_2)

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3	1	1	3	3	1	3	1	1	3
CO 2	3	1	1	3	3	2	3	1	1	2
CO 3	3	1	1	3	3	2	3	1	1	2
CO 4	3	1	1	3	3	3	3	1	1	3
CO 5	3	1	1	3	3	2	3	1	1	3
Average	3	1	1	3	3	2	3	1	1	2.6

Strong – 3 Medium – 2 Low – 1

Course Code	Name of the Course	Category	Hours/Wk.	Credits
24PGM/PSM521V	Hacks and Tips for NET Paper I	Value Added Course	2	2

This course will enable the General Aptitude Training helps them to demonstrate various principles involved in solving mathematical problems and thereby reducing the time taken for performing and clearing NET Paper I.

Course Outcomes:

At the end of the course, students will be able to

CO1: crack the problems on numbers.

CO2: identify and demonstrate the use of ratio, Calendar and clocks.

CO3: solve the problems involving time and distance, permutation and combination.

CO4: enhance and find the solution from given data.

CO5: interpret the concepts of Reasoning Skills.

Unit I **(6 Hours)**

Numerical Ability: Number and Simplification – Averages.

Unit II **(6 Hours)**

Ratio – Calendar and Clocks.

Unit III **(6 Hours)**

Time and Distance – Permutations and Combinations.

Unit IV **(6 Hours)**

Data Interpretation: Bar Graph – Line Graph – Pie Chart.

Unit V **(6 Hours)**

Reasoning: Coding and Decoding – Ranking and Time Sequence test.

Learning Resources:

Text Book(s)

1. R.S. Aggarwal, *Quantitative Aptitude*, S. Chand and Company Ltd. 2017.
   Unit I : Chapter 1, 4 and 6
   Unit II : Chapter 13, 27 and 28
   Unit III : Chapter 18 and 30

Unit IV : Chapter 37 to 39

2. R.S. Aggarwal, *A. Modern Approach to Verbal and Non-verbal Reasoning*, S. Chand and Company Ltd. 2020.

Unit V : Section I (Chapter 4 and 11)

References

1. R. K. Tyagi, *Quantitative Aptitude for Competitive Examination*, MTG Learning Media, 2018.
2. Abhijit Guha, *Quantitative Aptitude for Competitive Examination*, Tata Mc-Graw Hill, Seventh Edition, 2020.

Websites/ e-Learning Resources

https://ifasonline.com/csir-net/csir-paper-1-previous-year-question-paper/6433b5b36f88433b504b4258/650f1605a623c3fc42fa3336

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3	3	3	3	1	3	2	2	1	2
CO 2	3	2	3	3	2	3	2	2	1	3
CO 3	3	3	3	2	1	2	2	2	2	2
CO 4	3	3	2	2	2	3	2	1	2	2
CO 5	3	3	3	3	3	3	2	1	2	2
Average	3	2.8	2.8	2.6	1.8	2.8	2	1.6	1.6	2.2

Strong – 3 Medium – 2 Low – 1