Revised Syllabi and Course of Study of Two Years Master Degree Programme in Mathematics (CBCS) University of Jammu.

The Master Degree Programme in Mathematics of University of Jammu is a two years CBCS programme consisting of four semesters and carries 88 credits with each Course of 4 Credits and the Dissertation in Semester IV shall carry 8 Credits. All courses in Semesters I and II are compulsory, In Semester III, first three courses are compulsory and students can choose any two courses out of rest of the given courses whereas in Semester IV, students can choose any three courses out of the given list of courses and there shall be a Dissertation of 8 credits. Students are required to earn 4 more credits each in Semester III and IV from a MOOC course from SWAYAM platform in Semester III and from an open course in Semester IV (given by different departments at the Campus as laid down in the CBCS guidelines of the University).

Titles of the Courses in each Semester

Semester-I

1. PSMATC101 Abstract Algebra
2. PSMATC102 Real Analysis
3. PSMATC103 First Course in Topology
4. PSMATC104 Differential and Integral Equations
5. PSMATC105 Fundamentals of Computers

Semester-II

1. PSMATC201 Rings and Modules
2. PSMATC202 Measure Theory
3. PSMATC203 Second Course in Topology
4. PSMATC204 Complex Analysis

5. PSMATC205 Differential Geometry

Semester-III

1. PSMATC301 Advance Complex Analysis
2. PSMATC302 Functional Analysis
3. PSMATC303 Linear Algebra
4. PSMATC304 Advance Measure Theory
5. PSMATC305 Complex Dynamics
6. PSMATC306 Partial Differential Equations
7. PSMATC307 Number Theory
8. PSMATC308 Multivariable Calculus
9. PSMATC309 Linear Programming and Optimization
10. PSMATC310 Numerical Methods
11. PSMATC311 Graph Theory

Semester-IV

1. PSMATC401 Analytic Function Spaces
2. PSMATC402 Advance Functional Analysis
3. PSMATC403 Operator Theory
4. PSMATC404 Normal Families in Complex Analysis
5. PSMATC405 Value Distribution of Meromorphic Functions
6. PSMATC406 Geometric Function Theory
7. PSMATC407 Complex Analysis in Several Variables
8. PSMATC408 Algebraic Topology
9. PSMATC409 Fourier Analysis
10. PSMATC410 Masters Dissertation
11. PSMATO411 Numerical Methods and Graph Theory

(This is an open course for students of other department)

SEMESTER III
(Examination to be held in December 2023, 2024, 2025)
Major Course

Course Code: PSMATC301
Course Title: Advanced Complex Analysis
Credits: 04
Total Number of Lectures: Theory: 45, Tutorials: 15
Maximum Marks: 100**,** **Theory:** 75**,** **Tutorial:** 25

Objectives: The main objective of this course is to study some advance topics in Complex Analysis.

Course Learning Outcomes: After studying this course the student will be able to

1. understand the basics of logarithmically convex function that helps in extending maximum modulus theorem.
2. be familiar with metric on spaces of analytic, meromorphic and analytic functions, Ascoli and related theorems, equi-continuity and normal families leading to Arzela.
3. know harmonic function theory on a disk and how it helps in solving Dirichlet's problem and the notion of Green's function.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration.

Unit-I

Harmonic Functions: Harmonic Conjugates, necessary and sufficient condition for the existence of harmonic conjugates, mean value property, Gauss Mean Value Theorem, Poisson Integral Formula, Dirichlet Problem on the open disk, characterization of harmonic functions, Schwarz Reflection Principle, analytic continuation, Monodromy Theorem.

Unit-II

Equicontinuous families of continuous functions, Arzela-Ascoli Theorem, normal subfamilies of continuous functions, Montel's Theorem, Riemann Mapping Theorem, The Schwarz-Christoffel Formula.

Unit-III

Normal families of meromorphic functions: Spherical derivative, Marty's Theorem, Zalcman's Lemma, Montel's Three value Theorem, Picard's Theorem. Applications of normality: Fatou and Julia sets of meromorphic functions and their basic properties.

Unit-IV

Runge's Theorem, the series of meromorphic functions, constructing meromorphic function: the Mittag-Leffer Theorem, the Weierstrass $\mathcal{P}$-function, infinite products, infinite products of functions, infinite products and analytic functions, the Weierstrass Factorization Theorem and its consequences.The Gamma function, the Riemann ζ- function and their properties, the Prime Number Theorem.

Text Books:

1. T. W. Gamelin, Complex Analysis, Springer-Verlag, 2001.

Reference Books:

1. Bruce P. Palka, *An Introduction to Complex Function Theory,* Springer-Business Media, 1991.
2. Lars V. Ahlfors, *Complex Analysis,* McGraw-Hill International Editions, 1979.
3. John B. Conway, *Functions of One Complex Variable,* Narosa Publishing House, 1990.
4. S. Ponnusamy and Herb Silverman, *Complex Variables with Applications,* Birkhauser, 2006.
5. Serge Lvovski, *Principles of Complex Analysis,* Springer, 2020.
6. Reinhold Remmert, *Theory of Complex Functions,* Springer, 1991.
7. Steven G. Krantz, *Complex Variables,* Chapman and Hall-CRC, 2008.
8. Joseph L. Taylor, *Complex Variables,* American Math. Soc., 2011.
9. Elias M. Stein and Rami Shakarchi, *Complex Analysis,* Princeton University Press, 2003.
10. Zeev Nihari, *Conformal Mappings,* Dover Publications Inc. New York, 1975.
11. Robert B. Ash and W. P. Woringer, *Complex Analysis,* Dover Publications, 2007.

Note There shall be three tests and the student shall be continuously evaluated on the basis of their performance as follows:

Note for paper setting of Major test:

1. There shall be two sections in the question paper, namely, Section A and Section B:

Theory	Syllabus to be covered in the examination	Time allotted for the examination	% weight age marks
Minor test-l (after 30 days)	Upto 25%	1 hour 30 min.	20
Minor test-ll (after 60 days)	Upto 50%	1 hour 30 min.	20
Major test (after 90 days)	Upto 100%	3 hour	60

(a) Section A shall have two questions equally distributed over Unit-I and Unit-II.

(a) Section B shall have three questions equally distributed over Unit-III and Unit-IV.

2. Each question shall be of the same weightage of 12 marks.

3. There shall be 100% internal choice.

MATHEMATICS SEMESTER III
(Examination to be held in December 2023, 2024, 2025)
Major Course

Course Code: PSMATC302
Course Title: Functional Analysis
Credits: 04
Total Number of Lectures: Theory: 45, Tutorials: 15
Maximum Marks: 100, **Theory:** 75, **Tutorial:** 25

Objectives: This course aims at familiarizing the students with the geometry of metric spaces, Banach Spaces and Hilbert spaces. Some fundamental theorems in functional analysis like Banach contraction Principle, Hahn-Banach Theorem, uniform boundedness principle are included in the syllabus. These theorems have immense applications in several branches of Mathematics and Mathematical physics. A preliminary knowledge of modern algebra, Real and Complex analysis, General topology and measure theory is essential for smooth sailing in this course.

Course Learning Outcomes: After studying this course the student will be able to

1. understand Banach contraction Principle and its applications to differential and integral equations, completion theorem, category theorem and its applications.
2. understand Hahn-Banach Theorem in real, Complex and linear spaces and applications, uniform boundedness principle, open mapping theorem, Bounded inverse-theorem, closed graph theorem.
3. understand the existence of orthonormal basis, Riesz representation theorem, the dimension of Hilbert spaces.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration.

Unit-I

Definition of metric spaces, convergence complete metric spaces, Banach contraction Principle and its applications to differential and integral equations, completion theorem, category theorem and its applications, compactness , Arzela-Ascoli's Theorem, Problems and examples based on these concepts.

Unit-II

Normed linear spaces and Banach spaces, examples, finite dimensional normed linear spaces, equivalent norms quotient spaces, F. Riesz's lemma , Bounded linear operators, examples, dual spaces, computation of duals of IR, $l_p, 1 \leq p < \infty$ and Co.

Unit-III

Hahn-Banach Theorem in real, Complex and linear spaces and applications, reflexive spaces, uniform boundedness principle, open mapping theorem, Bounded inverse-theorem, closed graph theorem.

Unit-IV

Inner product spaces, the Cauchy-Schwartz inequality, the Phythagorean Theorem, Hilbert spaces, examples of Hilbert spaces. Orthognal complement and direct sum, minimizing vector theorem, projection theorem, orthonormal sets, Bessel's inequality orthonormal basis, the existence of orthonormal basis Riez representation theorem, the dimension of Hilbert spaces. Adjoint of a linear operator, self adjoint, normal and unitary operators.

Text Books:

1. C. Goffman and G. Padrick, *First course in Functional Hall Analysis,* Prentice 1955.(for unit -1).
2. E. Kreyszig, *Introductory Functional Analysis with Applications*, John Wiley and Sons 1978. (For unit- II, III and IV)

Reference Books:

1. R. G. Douglas, *Banach Algebra Techniques in operator Theory,* Springer-Verlag, New York 1998.
2. J. B. Conway, *A course in Functional Analysis,* Springer Verlag, 1973.
3. B. V. Limaye, *Functional Analysis,* Wiley Eastern Ltd. 1981.

Note There shall be three tests and the student shall be continuously evaluated on the basis of their performance as follows:

Theory	Syllabus to be covered in the examination	Time allotted for the examination	% weight age marks
Minor test-l (after 30 days)	Upto 25%	1 hour 30 min.	20
Minor test-ll (after 60 days)	Upto 50%	1 hour 30 min.	20
Major test (after 90 days)	Upto 100%	3 hour	60

Note for paper setting of Major test:

1. There shall be two sections in the question paper, namely, Section A and Section B:
   (a) Section A shall have two questions equally distributed over Unit-I and Unit-II.
   (a) Section B shall have three questions equally distributed over Unit-III and Unit-IV.
2. Each question shall be of the same weightage of 12 marks.
3. There shall be 100% internal choice.

SEMESTER III

(Examination to be held in December 2023, 2024, 2025)

Major Course

Course Code: PSMATC303
Course Title: Linear Algebra
Credits: 04
Total Number of Lectures: Theory: 45, Tutorials: 15
Maximum Marks: 100, **Theory:** 75, **Tutorial:** 25

Objectives:

1. Prove basic results in linear algebra using appropriate proof-writing techniques such as linear independence of vectors; properties of subspaces, etc.
2. Compute linear transformations, kernel and range, and inverse linear transformations, and find matrices of general linear transformations.
3. Create orthogonal and orthonormal bases, Gram-Schmidt process and use bases and orthonormal bases to solve application problems.
4. Understand various operators and their relationships understand the concept of invariant subspaces and their connections with nilpotent canonical forms.
5. Understand the concept of companion matrix, Jordan canonical form and Jordan blocks.

Course Learning Outcomes: After studying this course the student will be able to

1. understand linear independence, linear transformations, matrix representation of a linear transformation.
2. understand the relation between characteristic polynomial and minimal polynomial, Cayley-Hamilton theorem (statement and illustrations only), diagonalizability, necessary and sufficient condition for diagonalizability.
3. understand Cauchy Schwarz inequality, orthogonality and orthogonal complements, orthonormal basis, Gram-Schmidt process and adjoint of a linear transformation.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration.

Unit-I

Vector spaces, linear independence; linear transformations, matrix representation of a linear transformation; isomorphism between the algebra of linear transformations and that of matrices.

Unit-II

Similarity of matrices and linear transformations; trace of matrices and linear transformations, characteristic roots and characteristic vectors, characteristic polynomials, relation between characteristic polynomial and minimal polynomial; Cayley-Hamilton theorem (statement and illustrations only); diagonalizability, necessary and sufficient condition for diagonalizability.

Unit-III

Projections and their relation with direct sum decomposition of vector spaces; invariant subspaces; primary decomposition theorem, cyclic subspaces; companion matrices, a proof of Cayley-Hamilton theorem; triangulability; canonical forms of nilpotent transformations; Jordan canonical forms; rational canonical forms.

Unit-IV

Inner product spaces, properties of inner products and norms, Cauchy-Schwarz inequality; orthogonality and orthogonal complements, orthonormal basis, Gram-Schmidt process; adjoint of a linear transformation; Hermitian, unitary and normal transformations and their diagonalizations.

Text Books:

1. Hoffman, K., Kunze, R. *Linear Algebra* (2nd edition) Prentice Hall of India Pvt. Ltd., New Delhi.
2. Bhattacharya, P. B. Jain, S. K. and Nagpal, S. R. *First Course in Linear Algebra,* Wiley Eastern Ltd., New Delhi.

Reference Books:

1. I. N. Herstein, *Topics in Algebra* (4th edition), Wiley Eastern Limited, New Delhi, (2003).
2. G. E. Shilov, *Linear Algebra,* Prentice Hall Inc. (1998).
3. P. R. Halmos, *Finite Dimensional Vector Spaces,* D.VanNostrand Company Inc. (1965).
4. D. T. Finkbeiner, *Introduction to Matrices and Linear Transformations* (3rd edition) Dover Publications, (2011).
5. S. Kumaresan, *Linear Algebra: A Geometric Approach,* Prentice-Hall of India Pvt. Ltd., New Delhi. House, 2005.

Note There shall be three tests and the student shall be continuously evaluated on the basis of their performance as follows:

Note for paper setting of Major test:

Theory	Syllabus to be covered in the examination	Time allotted for the examination	% weight age marks
Minor test-l (after 30 days)	Upto 25%	1 hour 30 min.	20
Minor test-ll (after 60 days)	Upto 50%	1 hour 30 min.	20
Major test (after 90 days)	Upto 100%	3 hour	60

1. There shall be two sections in the question paper, namely, Section A and Section B:
   (a) Section A shall have two questions equally distributed over Unit-I and Unit-II.
   (a) Section B shall have three questions equally distributed over Unit-III and Unit-IV.
2. Each question shall be of the same weightage of 12 marks.
3. There shall be 100% internal choice.

SEMESTER III
(Examination to be held in December 2023, 2024, 2025)
Major Course

Course Code: PSMATC304
Course Title: Advanced Measure Theory
Credits: 04
Total Number of Lectures: Theory: 45, Tutorials: 15
Maximum Marks: 100, **Theory:** 75, **Tutorial:** 25

Objectives: The purpose of this paper is to study Borel measures, Riesz-Representation theorem, Differentiation of measure, Radon-Nikodym theorem and Fubini theorem. This is a second course in measure theory and the pre-requisite for this course is basic knowledge of algebra, topology, real and Complex Analysis.

Course Learning Outcomes: After studying this course the student will be able to

1. understand signed measures and complex measures, ability to use Hahn Nikodym theorem and recognized decomposition, Jordan decomposition, Radon singularity of measures.

2. verify conditions under which a measure defined on a semi-algebra or algebra is extendable to a sigma-algebra and to get the extended measure, and to prove the uniqueness up to multiplication by a scalar of Lebesgue measure as a translation invariant Borel measure.

3. to understand the concepts of Baire sets, Baire measures, regularity of measures on Markov representation theorem related to the locally compact spaces, Riesz representation of a bounded linear functional on the space of continuous functions.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration.

Unit-I

$C_c(X)$ and linear functional on this space. Riesz-representation theorem for positive linear Functional on $C_c(X)$ (only statement). Positive Borel Measures. Regularity properties of Borel measures. Lebesgue measure on IRn and its properties-Lusin's theorem. L_p-spaces, Holder's inequality and Minkowski's inequality. Completeness of Lp- spaces Approximation by continuous functions. Elementary exercises based on these topics.

Unit-II

Complex measure, Total variation, Absolute continuity, Lebesgue Radon-Nikodym theorem, Consequences of Radon-Nikodym theorem, Positive and negative variations, Hahn decomposition theorem, Bounded linear functional on

L_p(only statement), Riesz representation theorem for bounded linear functional on Co (X) (only statement), Elementary exercises based on these topics.

Unit-III

Derivatives of measure, Symmetric derivative, Maximal function, Lebesgue point, Radon Nikodym derivative in terms of symmetric derivative, Nicely shrinking sets, Lebesgue decomposition of a Complex Borel measure on IRn, Examples and elementary exercises based on these topics.

Unit-IV

Measurability on Cartesian products, product measures, Fubini theorem for product measures, Counter examples of Fubini theorem, Completion of product measures, Convolutions, Examples and elementary exercises based on these topics.

Text Books:

1. Walter Rudin, *Real and Complex analysis,* 3rd edition McGraw. Hill Book Company, 1987.
2. J.Yeh, *Lectures in Real Analysis,* World Scientific 2000.

Reference Books:

1. H .L. Royden, *Real Analysis,* The Mac- millan Company, New York, 1963.
2. M.E.Munroe, *Measure and Integration,* 2nd edition Addion-Wesley Publishing Company.

Note: There shall be three tests and the student shall be continuously evaluated on the basis of their performance as follows:

Theory	Syllabus to be covered in the examination	Time allotted for the examination	% weight age marks
Minor test-l (after 30 days)	Upto 25%	1 hour 30 min.	20
Minor test-ll (after 60 days)	Upto 50%	1 hour 30 min.	20
Major test (after 90 days)	Upto 100%	3 hour	60

Note for paper setting of Major test:

1. There shall be two sections in the question paper, namely, Section A and Section B:

    (a) Section A shall have two questions equally distributed over Unit-I and Unit-II.

    (a) Section B shall have three questions equally distributed over Unit-III and Unit-IV.

2. Each question shall be of the same weightage of 12 marks.

3. There shall be 100% internal choice.

SEMESTER III

(Examination to be held in December 2023, 2024, 2025)

Major Course

Course Code: PSMATC305
Course Title: Complex Dynamics
Credits: 04
Total Number of Lectures: Theory: 45, Tutorials: 15
Maximum Marks: 100, **Theory:** 75, **Tutorial:** 25

Objectives: This course is to introduce the concept of iterations of analytic function. The structure and properties of Julia and Fatou sets are also studied. A pre-requisite for this course is atleast one semester course in complex analysis.

Course Learning Outcomes: After studying this course the student will be able to

1. understand Iteration of Mobius transformation, attracting, repelling and indifferent fixed points, critical points, Riemann-Hurwitz relation, topology of rational functions.
2. understand Properties of Julia sets: Exceptional points, backward orbit, minimality property of the Julia set, expanding property of the Julia set.
3. understand Rieman Hurwitz formula for covering maps, maps between components of the Fatou set, the number of components of the Fatou set, components of the Julia set.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration.

Unit-I

Iteration of Mobius transformation, attracting, repelling and indifferent fixed points. Iteration of maps $z \to z^2, z \to z^2 + c, z \to z + \frac{1}{z}$, Newton's approximation. The Extended Complex Plane, chordal metric, spherical metric, rational maps, Lipschitz condition, conjugacy classes of rational maps, valency of a function, fixed points, critical points, Riemann-Hurwitz relation, topology of rational functions.

Unit-II

Equicontinuous functions, normality sets, Fatou sets and Julia sets, completely invariant sets, Normal families and equicontinuity.

Unit-III

Properties of Julia sets: Exceptional points, backward orbit, minimality property of the Julia set, expanding proprty of the Julia set, periodic points of a rational map, commuting rational maps and their Julia sets, rational maps with empty Fatou set.

Unit-IV

The structure of the Fatou set: The topology of the sphere, completely invariant components of the Fatou set, the Euler characteristic, the Rieman-Hurwitz formula for covering maps, maps between components of the Fatou set, the number of components of the Fatou set, components of the Julia set.

Text Books:

1. A.F. Beardon, *Iteration of Rational functions*, Springer-Verlag, New York, 1991.

Reference Books:

1. L. Carlson and T.W Gamelin, *Complex Dynamics,* Springer-Verlag, New York 1993.
2. S. Morosawa, Y. Nishimura, M. Taniguchi, T. Ueda, *Holomorphic Dynamics,* Cambridge University Press, 2000
3. X. H. Hua, C.C. Yang,*Dynamics of transcendental functions,* Gordon and Breach Science Pub. 1998.

Note: There shall be three tests and the student shall be continuously evaluated on the basis of their performance as follows:

Theory	Syllabus to be covered in the examination	Time allotted for the examination	% weight age marks
Minor test-I (after 30 days)	Upto 25%	1 hour 30 min.	20
Minor test-II (after 60 days)	Upto 50%	1 hour 30 min.	20
Major test (after 90 days)	Upto 100%	3 hour	60

Note for paper setting of Major test:

1. There shall be two sections in the question paper, namely, Section A and Section B:
   (a) Section A shall have two questions equally distributed over Unit-I and Unit-II.
   (a) Section B shall have three questions equally distributed over Unit-III and Unit-IV.

2. Each question shall be of the same weightage of 12 marks.
3. There shall be 100% internal choice.

SEMESTER III
(Examination to be held in December 2023, 2024, 2025)
Major Course

Course Code: PSMATC306
Course Title: Partial Differential Equations
Credits: 04
Total Number of Lectures: Theory: 45, Tutorials: 15
Maximum Marks: 100**, Theory:** 75**, Tutorial:** 25

Objectives: A large number of physical phenomena occurring in Physics, Engineering Sciences, Elascitity's Mechanics, etc. when formulated mathematically give rise to mathematical model in the form of Partial Differential Equations with boundary conditions. So, solving a physical situation is equivalent to solving a Partial Differential Equation.

Course Learning Outcomes: After studying this course the student will be able to

1. understand Partial Differential Equation of 2nd and Higher order, classification examples of Partial Differential Equations, Partial Differential Equations relevant to industrial problems, Solutions of elliptic, hyperbolic and parabolic equations.

2. understand Transport Equation: Initial value Problem, Non homogeneous Equation. Laplace equation-Fundamental solution Mean Value Formulas, Properties of Harmonic functions, Green's Function, Energy methods .

3. understand Heat Equation: Fundamental solution, Mean Value Formulas, Properties of solutions, Energy Methods, Wave Equation: Solution by Spherical means, Non-Homogeneous equation.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration.

Unit-I

Partial Differential Equation of 2nd and Higher order, classification examples of Partial Differential Equations, Partial Differential Equations relevant to industrial problems, Solutions of elliptic, hyperbolic and parabolic equations.

Unit-II

Transport Equation : Initial value Problem, Non homogeneous Equation. Laplace equation-Fundamental solution Mean Value Formulas, Properties of Harmonic functions, Green's Function, Energy methods .

Unit-III

Heat Equation: Fundamental solution, Mean Value Formulas, Properties of solutions, Energy Methods, Wave Equation: Solution by Spherical means, Non-Homogeneous equations.

Unit-IV

Repesentation of solutions-Similarlity solutions (plane and travelling waves) Seperation of variables, Fourier and Laplace transform. Hopfcole Transform, Legender's transform, potential functions, power series (non-characteristics surface).

Text Books:

1. I.N.Sneddon, *Partial Differential Equations,* McGraw Hill

Reference Books:

1. L.C. Evans,*Partial Differential Equations,* Graduate studies in mathematics, Vol.19, AMS-1998
2. H.Goldstein,*Classical Mechanics,* Narosa Publishing House, New Delhi.
3. I. M. Gelfand, *Calculus of Variations,* Prentice Hall and S.V.Fomin
4. T. Amarnath, *Partial Differential Equations,* Prentice Hall.

Note: There shall be three tests and the student shall be continuously evaluated on the basis of their performance as follows:

Theory	Syllabus to be covered in the examination	Time allotted for the examination	% weight age marks
Minor test-l (after 30 days)	Upto 25%	1 hour 30 min.	20
Minor test-ll (after 60 days)	Upto 50%	1 hour 30 min.	20
Major test (after 90 days)	Upto 100%	3 hour	60

Note for paper setting of Major test:

1. There shall be two sections in the question paper, namely, Section A and Section B:
   (a) Section A shall have two questions equally distributed over Unit-I and Unit-II.

(a) Section B shall have three questions equally distributed over Unit-III and Unit-IV.

2. Each question shall be of the same weightage of 12 marks.

3. There shall be 100% internal choice.

SEMESTER III

(Examination to be held in December 2023, 2024, 2025)

Major Course

Course Code: PSMATC307
Course Title: Number Theory
Credits: 04
Total Number of Lectures: Theory: 45, Tutorials: 15
Maximum Marks: 100, **Theory:** 75, **Tutorial:** 25

Course Learning Outcomes: After studying this course the student will be able to

1. understand Farey sequences, Rational Approximations, Euclidean Algorithm, Uniqueness, Infinite Continued Fractions, The Geometry of Numbers.
2. understand Elementary Prime Number Estimates, Dirichlet Series, Estimates of Arithmetic Functions, Primes in Arithmetic Progressions.
3. understand Partitions, Ferrers Graphs, Formal Power Series, Generating Functions, and Euler's Identity, Euler's Formula, Bounds on p(n), Jacobi's Formula, Divisibility Property.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration.

Unit-I

Farey sequences, Rational Approximations, The Euclidean Algorithm, Uniqueness, Infinite Continued Fractions, The Geometry of Numbers.

Unit-II

Irrational Numbers, Approximations to Irrational Numbers, Best Possible Approximations, Periodic Continued Fractions, Pell's equations, Minkowski's theorem in Geometry of Numbers and its applications.

Unit-III

Elementary Prime Number Estimates, Dirichlet Series, Estimates of Arithmetic Functions, Primes in Arithmetic Progressions.

Unit-IV

Partitions, Ferrers Graphs, Formal Power Series, Generating Functions, and Euler's Identity, Euler's Formula; Bounds on $p(n)$, Jacobi's Formula , A Divisibility Property.

Text Books:

1. David, M. Burton,*Elementary Number Theory,* 2nd Edition (UBS Publishers).

2. Niven, Zuckerman and Montgomer, *Introduction to Theory of Numbers,* 5th Edition (John Wiley and Sons).

3. T. M. Apostol, *Introduction to Analytic Number Theory*(Springer-Verlag).

4. H. Davenpart, *Higher Arithmetic*(Camb. Univ. Press).

5. Hardy and Wright, *Number Theory*(Oxford Univ. Press).

6. J. B. Dence and T. P. Dence, *Elements of the Theory of Numbers* (Academic Press).

Note: There shall be three tests and the student shall be continuously evaluated on the basis of their performance as follows:

Theory	Syllabus to be covered in the examination	Time allotted for the examination	% weight age marks
Minor test-l (after 30 days)	Upto 25%	1 hour 30 min.	20
Minor test-ll (after 60 days)	Upto 50%	1 hour 30 min.	20
Major test (after 90 days)	Upto 100%	3 hour	60

Note for paper setting of Major test:

1. There shall be two sections in the question paper, namely, Section A and Section B:
   (a) Section A shall have two questions equally distributed over Unit-I and Unit-II.
   (a) Section B shall have three questions equally distributed over Unit-III and Unit-IV.
2. Each question shall be of the same weightage of 12 marks.
3. There shall be 100% internal choice.

SEMESTER III

(Examination to be held in December 2023, 2024, 2025)

Major Course

Course Code: PSMATC308
Course Title: Multivariable Calculus
Credits: 04
Total Number of Lectures: Theory: 45, Tutorials: 15
Maximum Marks: 100, **Theory:** 75, **Tutorial:** 25

Objectives:

1. To provide students with a good understanding of the concepts and methods of multivariate calculus, described in detail in the syllabus.

2. To help the students develop the ability to solve problems using multivariate calculus.

3. To develop abstract and critical reasoning by studying proofs as applied to multivariate calculus.

Course Learning Outcomes: After studying this course the student will be able to

1. understand Limits and Continuity of functions defined on Euclidean Spaces, Real-valued functions of several variables, Vector valued functions of several variables.

2. understand Differentiation, Partial derivatives , Gradient, directional derivatives, Chain Rule. Euler's Theorem, Mean Value Theorem and Taylor's Theorem for functions of several variables.

3. understand First and Second Fundamental Theorems of Calculus for Line Integrals. Green's Theorem and its applications to evaluation of line integrals, Surface Integrals: Parameterized surfaces.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration.

Unit-I

Limits and Continuity of functions defined on Euclidean Spaces: Review of vector algebra in $\mathbb{R}^n$, Real-valued functions of several variables, Level sets (level curves, level surfaces, etc.), Vector valued functions of several variables, Sequences in $\mathbb{R}^n$ and their limits, Neighborhoods in $\mathbb{R}^n$, Limits and continuity of scalar and vector-valued functions of several variables.

Unit-II

Differentiation: Partial derivatives. Differentiability of a real-valued function of several variables, the concept of (total) derivative. Gradient and directional derivatives. Chain Rule. Euler's Theorem. Higher order partial derivatives. Mixed Derivative Theorem. Mean Value Theorem and Taylor's Theorem for functions of several variables. Review of quadratic forms. Hessian matrix. Local maxima/minima and saddle points. Constrained maxima and minima of real-valued functions of several variables. Differentiation of vector-valued functions of several variables. Jacobians, Chain Rule. Contraction principle in $\mathbb{R}^n$. Implicit function theorem, Inverse function theorem.

Unit-III

Multiple Integrals: Definition of double (resp: triple) integral of a function defined and bounded on a rectangle (resp: box). Geometric interpretation. Basic properties of double and triple integrals. Iterated integrals, Fubini's Theorem. Integrability and the integral over arbitrary bounded domains. Change of variables formula (Statement only). Polar, cylindrical and spherical coordinates and integration using these coordinates.

Unit-IV

Line Integrals: Paths (parameterized curves) in $\mathbb{R}^n$, Smooth and piecewise smooth paths. Closed paths. Equivalence and orientation preserving equivalence of paths. Definition of the line integral of a vector field over a piecewise smooth path. Basic properties of line integrals. First and Second Fundamental Theorems of Calculus for Line Integrals. Green's Theorem (proof only in the case of rectangular domains) and its applications to evaluation of line integrals. Surface Integrals: Parameterized surfaces. Smoothly equivalent parameterizations. Area of such surfaces. Definition of surface integral. Curl and divergence of a vector field. Stokes Theorem (proof assuming the general form of Green's Theorem), Gauss Divergence Theorem (proof only in the case of cubical domains) and their applications.

Reference Books:

1. T. Apostol, *Calculus*, Vol. 2, Second Ed., John Wiley, New York, 2002.
2. S. R. Ghorpade and B.V. Limaye, *A Course in Multivariable Calculus and Analysis*, Springer 2010.
3. C.H. Edwards, *Advanced calculus of several variables*, Dover Publications Inc., 1995.
4. T. Apostol, *Mathematical Analysis*, Second Ed., Narosa, New Delhi, 1974.

Note: There shall be three tests and the student shall be continuously evaluated on the basis of their performance as follows:

Note for paper setting of Major test:

Theory	Syllabus to be covered in the examination	Time allotted for the examination	% weight age marks
Minor test-l (after 30 days)	Upto 25%	1 hour 30 min.	20
Minor test-ll (after 60 days)	Upto 50%	1 hour 30 min.	20
Major test (after 90 days)	Upto 100%	3 hour	60

1. There shall be two sections in the question paper, namely, Section A and Section B:
   (a) Section A shall have two questions equally distributed over Unit-I and Unit-II.
   (a) Section B shall have three questions equally distributed over Unit-III and Unit-IV.
2. Each question shall be of the same weightage of 12 marks.
3. There shall be 100% internal choice.

SEMESTER III
(Examination to be held in December 2023, 2024, 2025)
Major Course

Course Code: PSMATC309
Course Title: Linear Programming and Optimization Techniques
Credits: 04
Total Number of Lectures: Theory: 45, Tutorials: 15
Maximum Marks: 100**,** **Theory:** 75**,** **Tutorial:** 25

Objectives: The main objective of the course is to formulate mathematical models and to understand solution methods for real life optimal decision problems. The emphasis will be on basic study of linear programming problem, Integer programming problem, Transportation problem, Two person zero sumgames with economic applications.

Course Learning Outcomes: After studying this course the student will be able to

1. understand Convex sets, Basic properties, Differentiable convex functions, Generalization of convex functions.
2. understand Linear Programming: Geometry of linear programming, Graphical method, Linear programming in standard form, Solution of L_P by simplex method.
3. understand Transportation and Assignment Problem: Initial basic feasible solutions of balanced and unbalanced transportation/assignment problems, Optimal solutions. Game Theory: Two person zero-sum game, Game with mixed strategies.

Outcome of the Course: Upon Completion of this course, the students would be able to

1. formulate and solve linear programming problems.
2. solve the transportation and assignment problems.
3. solve two person zero-sum games.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration.

Unit-I

Sequences and Subsequences, Mapping and functions, Continuous functions-Infimum and Supremum of functions, Minima and maxima of functions, Differentiable functions, Vectors and vector spaces, Matrices, Linear transformation, Quadratic forms, Definite quadratic forms, Linear equations, Solution of a set of linear equations, Basic solution and degeneracy.

Unit-II

Convex sets and Convex cones, Introduction and preliminary definition, Convex sets and properties, Convex Hulls, Extreme point, Separation and support of convex sets, Convex Polytopes and Polyhedra Convex cones, Convex and concave functions, Basic properties, Differentiable convex functions, Generalization of convex functions.

Unit-III

Linear Programming: Geometry of linear programming, Graphical method, Linear programming (LP) in standard form, Solution of LP by simplex method, Two phase method, Big M method, Exceptional cases in L_P, Duality theory, Dual simplex method. Integer Programming: Branch and bound technique.

Unit-IV

Transportation and Assignment Problem: Initial basic feasible solutions of balanced and unbalanced transportation/assignment problems, Optimal solutions, Travelling salesman problem. Game Theory: Two person zero-sum game, Game with mixed strategies, Graphical method and solution by linear programming.

Text Books:

1. K. Swarup Gupta, P. K. Manmohan, *Operations Research,* Sultan Chand and Sons, (2010).

2. H. A. Taha, *Operations Research*, An Introduction, PHI (2007).

3. S. S. Rao, *Engineering Optimization, Theory and Practice* Revised 3rd Edition, New Age International Publishers, New Delhi.

Reference Books:

1. B. S. Grewal, *Higher Engineering Mathematics,* Khanna Publishers 44th edition.

2. G. Hadley, *Linear Programming,* Addison Wesley.

3. N. S. Kambo, *Mathematical Programming Techniques,* East West Press, 1991.

4. S. Chandra, Jayadeva, A. Mehra, *Numerical Optimization and Applications,* Narosa Publishing House, (2013).

Note: There shall be three tests and the student shall be continuously evaluated on the basis of their performance as follows:

Note for paper setting of Major test:

Theory	Syllabus to be covered in the examination	Time allotted for the examination	% weight age marks
Minor test-l (after 30 days)	Upto 25%	1 hour 30 min.	20
Minor test-ll (after 60 days)	Upto 50%	1 hour 30 min.	20
Major test (after 90 days)	Upto 100%	3 hour	60

1. There shall be two sections in the question paper, namely, Section A and Section B:
    (a) Section A shall have two questions equally distributed over Unit-I and Unit-II.
    (a) Section B shall have three questions equally distributed over Unit-III and Unit-IV.
2. Each question shall be of the same weightage of 12 marks.
3. There shall be 100% internal choice.

SEMESTER III
(Examination to be held in December 2023, 2024, 2025)
Major Course

Course Code: PSMATC310
Course Title: Numerical Methods
Credits: 04
Total Number of Lectures: Theory: 45, Tutorials: 15
Maximum Marks: 100**,** **Theory:** 75**,** **Tutorial:** 25

Objectives: The objective of this course is to teach basics of Computer programming in $\mathbb{C}$. Some numerical methods which are extremely useful for many problems in engineering, sciences and social sciences are included for skill development in programming.

Course Learning Outcomes: After studying this course the student will be able to

1. understand Transcendental and algebraic equations: Bisection method, Regula-Falsi method, Newton-Raphson method, Secant method, Rate of convergence of these methods.
2. understand System of linear algebraic equations; Direct methods: Gaussian Elimination and Gauss Jordan methods, Iterative methods, Gauss Jacobi method, Gauss Seidel method and their convergence analysis.
3. understand Interpolation: Finite differences, Divided differences, Newton Gregory Forward and Backward formula, Lagrange's formula. Numerical Integration: Trapezoidal rule, Simpson's rules.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration.

Unit-I

Programming in $\mathbb{C}$: Historical development of $\mathbb{C}$, Character set, constants, variables, $\mathbb{C}$-key words, Instructions, Hierarchy of operations, Operators, Simple C programs, Control structures: The if, if-else, nested if-else, unconditional go to, switch structure, Logical and conditional operators, while, do-while and for loops, Break and continue statements, Arrays, Functions, recursion, Introduction to pointers.

Unit-II

Convergence; Errors: Relative, Absolute, Round off, Truncation; Transcendental and algebraic equations: Bisection method, Regula-Falsi method, Newton-Raphson method, Secant method, Rate of convergence of these methods.

Unit-III

System of linear algebraic equations; Direct methods: Gaussian Elimination and Gauss Jordan methods; Iterative methods: Gauss Jacobi method; Gauss Seidel method and their convergence analysis.

Unit-IV

Interpolation: Finite differences, Divided differences, Newton Gregory Forward and Backward formula, Lagrange's formula. Numerical Integration: Trapezoidal rule, Simpson's $\frac{1}{3}$ rule, Simpsons $\frac{3}{8}$th rule, Boole's Rule, Weddle rule. Ordinary Differential Equations: First order IVP; Single step methods-Taylor series method, Euler's method, Picard's method. Runge-Kutta methods of orders two and four.

Practical

Writing Programmes in $\mathbb{C}$ for the problems based on the numerical methods studied in theory and run them on PC.

Practical file(5) and Viva-Voce (5).

Text Books:

1. S. S. Shastry, *Introductory Methods of Numerical Analysis*, PHI, 2005.

Reference Books:

1. C. Xavier: $\mathbb{C}$ *Language and Numerical Methods,* New Age Int. Ltd., 2007.
2. Y. Kanetkar, *Let us* $\mathbb{C}$, BPB Publications, 2007.
3. M. K. Jain, S. R. K. Iyengar and R. K. Jain, *Numerical Methods for Scientific and Engineering Computation,* 6th Ed., New age International Publisher, India, 2019.
4. C. F. Gerald and P. O. Wheatley, *Applied Numerical Analysis*, Pearson Education, India, 2008

Note: There shall be three tests and the student shall be continuously evaluated on the basis of their performance as follows:

Note for paper setting of Major test:

1. There shall be two sections in the question paper, namely, Section A and Section B:
   (a) Section A shall have two questions equally distributed over Unit-I and Unit-II.
   (a) Section B shall have three questions equally distributed over Unit-III and Unit-IV.
2. Each question shall be of the same weightage of 12 marks.
3. There shall be 100% internal choice.

Theory	Syllabus to be covered in the examination	Time allotted for the examination	% weight age marks
Minor test-l (after 30 days)	Upto 25%	1 hour 30 min.	20
Minor test-ll (after 60 days)	Upto 50%	1 hour 30 min.	20
Major test (after 90 days)	Upto 100%	3 hour	60

SEMESTER III

(Examination to be held in December 2023, 2024, 2025)

Major Course

Course Code: PSMATC311
Course Title: Graph Theory
Credits: 04
Total Number of Lectures: Theory: 45, Tutorials: 15
Maximum Marks: 100, **Theory:** 75, **Tutorial:** 25

Objectives: The primary objective of this course is to introduce:

1. Problem-solving techniques using various concepts of graph theory.
2. Various properties like planarity and chromaticity of graphs.
3. Several applications of these concepts in solving practical problems.

Course Learning Outcomes: After studying this course the student will be able to

1. understand Graphs and their representation, Pseudographs, Subgraphs, Degree sequence, Euler's theorem, Isomorphism of graphs, Paths and circuits, Connected graphs.
2. understand Kruskal's algorithm, Prim's algorithm, Acyclic digraphs and Bellman's algorithm. Planar graphs, Euler's formula, Kuratowski theorem.
3. understand Graph coloring, Applications of graph coloring, Circuit testing and facilities design, Flows and cuts, Max flow-min cut theorem, Matchings, Hall's theorem.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration.

Unit-I

Graphs and their representation, Pseudographs, Subgraphs, Degree sequence, Euler's theorem, Isomorphism of graphs, Paths and circuits, Connected graphs, Euler trails and circuits, Hamiltonian paths and cycles, Adjacency matrix, Weighted graphs.

Unit-II

Travelling salesman problem, Dijkstra's algorithm, The Chinese postman problem; Digraphs, Bellman-Ford algorithm, Tournaments, Directed network, Scheduling problem; Trees and their properties, Spanning trees.

Unit-III

Kruskal's algorithm, Prim's algorithm, Acyclic digraphs and Bellman's algorithm. Planar graphs, Euler's formula, Kuratowski theorem.

Unit-IV

Graph coloring, Applications of graph coloring, Circuit testing and facilities design, Flows and cuts, Max flow-min cut theorem, Matchings, Hall's theorem.

Text Books:

1. Goodaire, G. Edgar, Parmenter, M. Michael, *Discrete Mathematics with Graph Theory* Pearson Education Pvt. Ltd. Indian Reprint.

2. J. A. Bondy and Murty, *Graph Theory with Applications*, Springer, U.S.R. (2008).

Reference Books:

1. Chartrand, Gary and P. Zhang, *A First Course in Graph Theory*, Dover Publications, (2012).

2. R. Diestel, *Graph Theory (Graduate Texts in Mathematics)*, Springer Verlag,(1997).

3. West, B. Douglas,*Introduction to graph theory* (2nd ed.), Pearson India, (2001).

Note: There shall be three tests and the student shall be continuously evaluated on the basis of their performance as follows:

Note for paper setting of Major test:

1. There shall be two sections in the question paper, namely, Section A and Section B:

Theory	Syllabus to be covered in the examination	Time allotted for the examination	% weight age marks
Minor test-l (after 30 days)	Upto 25%	1 hour 30 min.	20
Minor test-ll (after 60 days)	Upto 50%	1 hour 30 min.	20
Major test (after 90 days)	Upto 100%	3 hour	60

(a) Section A shall have two questions equally distributed over Unit-I and Unit-II.

(a) Section B shall have three questions equally distributed over Unit-III and Unit-IV.

2. Each question shall be of the same weightage of 12 marks.

3. There shall be 100% internal choice.

SEMESTER IV
(Examination to be held in May 2024, 2025, 2026)
Major Course

Course Code: PSMATC401
Course Title: Analytic Function Spaces
Credits: 04
Total Number of Lectures: Theory: 45, Tutorials: 15
Maximum Marks: 100**,** **Theory:** 75**,** **Tutorial:** 25

Objectives: The purpose of this paper is to study Hardy Spaces over the disk and the upper-half-plane. The pre-requisites for this course are courses in Complex Analysis, Functional Analysis, Measure Theory and Basic Topology.

Course Learning Outcomes: After studying this course the student will be able to

1. understand Review of Fourier series, Fourier transforms and its properties.
2. understand Poisson Kernel and its properties, Poisson integral of a measure, Boundary behaviour of poisson integral.
3. understand Hardy space $H_p(+)$ over the upper half plane, Poisson integral formula, Cauchy Integral formula, Boundary behaviour of functions in $H_p(+)$, Canonical factorization, $H_p(+)$ as Banach Space.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration.

Unit-I

Review of Fourier series, Fourier transforms and its properties, Inversion theorem. Plancherel's Theorem, Translation-invariant subspaces of L^2, Examples and exercises.

Unit-II

An abstract approach to Poisson integral, Poisson Kernel and its properties. Poisson integrals of L^2 function. Harnack's Theorem, Mean-Value property. Poisson integral of a measure, Boundary behaviour of poisson integral. Approach regions. Maximal Functions. Non-tangential limits, Representation theorems. Examples and exercises.

Unit-III

Subharmonic functions. Hardy space $H^P(U)$ in $H^P(n)$ as a Banach space, Blaschke product and its properties, Navanlinna Space N., Theorem of F. and M. Riesz, Inner and outer functions, Factorization, Examples and excercises.

Unit-IV

Subharmonic functions in the upper half plane, Hardy space $H^p(+)$ over the upper half plane, Poisson integral formula, Cauchy Integral formula, Boundary behaviour of functions in $H^p(+)$, Canonical factorization, $H^p(+)$ as Banach Space, Paley-Wiener theorem, Examples and exercises.

Text Books:

1. Walter Rudin,*Real and Complex Analysis*(3rd Ed.), Mc Graw Hill Book Co.(for first 3 units)
2. P. L. Duren, *Theory of H^P Spaces,* Academic press.

Reference Books:

1. J. B. Carnett, *Bounded analytic functions*, Academic Press.
2. K. Hoffman, *Banach spaces of analytic functions*, Prentice-Hall, Eaglewood Cliffs, New Jersay.

Note: There shall be three tests and the student shall be continuously evaluated on the basis of their performance as follows:

Theory	Syllabus to be covered in the examination	Time allotted for the examination	% weight age marks
Minor test-l (after 30 days)	Upto 25%	1 hour 30 min.	20
Minor test-ll (after 60 days)	Upto 50%	1 hour 30 min.	20
Major test (after 90 days)	Upto 100%	3 hour	60

Note for paper setting of Major test:

1. There shall be two sections in the question paper, namely, Section A and Section B:
   (a) Section A shall have two questions equally distributed over Unit-I and Unit-II.
   (a) Section B shall have three questions equally distributed over Unit-III and Unit-IV.
2. Each question shall be of the same weightage of 12 marks.
3. There shall be 100% internal choice.

SEMESTER IV
(Examination to be held in May 2024, 2025, 2026)
Major Course

Course Code: PSMATC402
Course Title: Advanced Functional Analysis
Credits: 04
Total Number of Lectures: Theory: 45, Tutorials: 15
Maximum Marks: 100**,** **Theory:** 75**,** **Tutorial:** 25

Objectives: This is an advanced course in Analysis, An interplay of Algebra, Topology and Analysis is exhibited in this course, A course in Topology, a course in Algebra and a couple of courses in Analysis are pre-requisites for this course.

Course Learning Outcomes: After studying this course the student will be able to

1. understand balanced and absorbing sets, Minkowski functional, normable and metrizable topological vector spaces, complete topological vector spaces and Frechet space.
2. understand Dual spaces, finite dimensional topological vector spaces and Geometric form of Hahn Banach Theorem.
3. understand Duality, Polar, Bipolar theorem, Montel spaces, Schwarz spaces. Quasi completeness inverse limit and inductive limit of locally convex spaces.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration.

Unit-I

Definitions and examples of vector spaces, convex, balanced and absorbing sets and their properties. Minkowski functional, subspaces, product spaces and quotient spaces of Topological Vector Spaces, locally convex topological vector spaces, normable and metrizable topological vector spaces, complete topological vector spaces and Frechet spaces. Examples and exercises based on these concepts.

Unit-II

Linear transformations, linear functional and their continuity. Dual spaces, finite dimensional topological vector spaces. Linear Varieties and Hyperplanes. Geometric form of Hahn Banach Theorem. Examples and exercises.

Unit-III

Uniform boundedness principle. Open mapping theorem and closed graph theorem for Frechet spaces, Banach Analouge theorem, extreme points and external sets Krein- Milman's theorem. Examples and exercises based on these concepts.

Unit-IV

Duality, Polar, Bipolar theorem Barelled and Bornological Spaces Semi Reflexive and Reflexive topological vector spaces. Montel spaces and Schwarz spaces. Quasi completeness inverse limit and inductive limit of locally convex spaces. Distributions. Examples and exercises based on these concepts.

Text Books:

1. Laurent Schwarz,*Functional Analysis*, Courant Institute of Mathematcal Sciences.

Reference Books:

1. R. Larsen, *Functonal Analysis,* Marcel Dekker, 1972
2. F. Treves, *Topological Vector Spaces,* Distributions and Kernels, Academic Press, 1967.
3. G. Grothendick, *Topological Vector Spaces trend,* Gorden and Breach Science Publishers, New York, 1973.
4. G. Kothe, *Topological Vector Spaces-II,* Springer Verlag New York 1976.
5. Walter Rudin,*Functional Analysis,* Tata McGraw Hill, 1973.

Note: There shall be three tests and the student shall be continuously evaluated on the basis of their performance as follows:

Theory	Syllabus to be covered in the examination	Time allotted for the examination	% weight age marks
Minor test-l (after 30 days)	Upto 25%	1 hour 30 min.	20
Minor test-ll (after 60 days)	Upto 50%	1 hour 30 min.	20
Major test (after 90 days)	Upto 100%	3 hour	60

Note for paper setting of Major test:

1. There shall be two sections in the question paper, namely, Section A and Section B:
   (a) Section A shall have two questions equally distributed over Unit-I and Unit-II.
   (a) Section B shall have three questions equally distributed over Unit-III and Unit-IV.
2. Each question shall be of the same weightage of 12 marks.
3. There shall be 100% internal choice.

SEMESTER IV
(Examination to be held in May 2024, 2025, 2026)
Major Course

Course Code: PSMATC403
Course Title: Operator Theory
Credits: 04
Total Number of Lectures: Theory: 45, Tutorials: 15
Maximum Marks: 100**,** **Theory:** 75**,** **Tutorial:** 25

Objectives: Theory of operators on Hilbert spaces has been developed in the course using Banach Algebra Techniques. This course could be useful for persons working in integral equations. Boundary-value problems, ergodic theory and mathematical physics.

Course Learning Outcomes: After studying this course the student will be able to

1. understand Banach Algebra, Multiplicative Functionals Gelfand-Mazur theorem, spectral mapping theorem, Spectral Radius formula.
2. understand Spectrum, point spectrum and approximate points, Spectrum of Unilateral shift.
3. understand Finite rank operators, compact operators and their ideals, Approximation of compact-operators, Fredholm operators and Volterra integral operators.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration.

Unit-I

Banach Algebra and examples, Multiplicative Functionals Gelfand-Mazur theorem, spectral mapping theorem, Spectral Radius formula, Examples and exercises based on these concepts.

Unit-II

$\mathbb{C}^*$- algebra, examples and elementary properties of $\mathbb{C}^*$-algebra, commutative Gelfand-Naimark theorem, Problems and examples.

Unit-III

Spectral theory of operators on a Hilbert space, Spectral theorem, functional calculus, square root of a positive operator, partial isometrics, Polar decomposition, Spectrum, point spectrum and approximate points, Spectrum of Unilateral shift and invariant and reducing subspaces of unilateral shift and multiplication operators, Examples and exercises.

Unit-IV

Weak, strong and uniform operator topologies on $B(H)$, Finite rank operators, compact operators and their ideals, Approximation of compact-operators, integral operators, the Calkin Algebras, Fredholm operators, Volterra integral operators, Elementary properties of composition operators on L_p-spaces. Problems and examples on these concepts.

Text Books:

1. R. G. Douglas,*Banach Algebra techniques in opearator theory,* A.P. 1972 (for Unit-I,III and IV).
2. S. K. Berbarian,*Lectures in Functional analysis and operator theory*, Springer-Verlag, 1973 (for Unit-II).

Reference Books:

1. J. B. Conway, *A course in functional analysis,* Springer-Verlag, 1985.
2. N. Dunford and J. Schwartz, *Linear operators,* Wiley(1958, 1963 Vol.I, II and 1971 I, Vol.III).
3. P. R. Halmos, *A Hilbert space problem Book,* Wps, 1978.
4. P. R. Halmos and V. S. Sunder,*Bounded integral operators on L_2- spaces*, Springer-Verlag, 1978.
5. H. P. Radjavi, *Invariant subspaces,* Springer-Verlag 1973.
6. R. Schatten, *Norm ideals of completely continuous operators*, Springer-Verlag, 1960.

Note: There shall be three tests and the student shall be continuously evaluated on the basis of their performance as follows:

Theory	Syllabus to be covered in the examination	Time allotted for the examination	% weight age marks
Minor test-l (after 30 days)	Upto 25%	1 hour 30 min.	20
Minor test-ll (after 60 days)	Upto 50%	1 hour 30 min.	20
Major test (after 90 days)	Upto 100%	3 hour	60

Note for paper setting of Major test:

1. There shall be two sections in the question paper, namely, Section A and Section B:
   (a) Section A shall have two questions equally distributed over Unit-I and Unit-II.
   (a) Section B shall have three questions equally distributed over Unit-III and Unit-IV.
2. Each question shall be of the same weightage of 12 marks.
3. There shall be 100% internal choice.

SEMESTER IV

(Examination to be held in May 2024, 2025, 2026)

Major Course

Course Code: PSMATC404
Course Title: Normal Families in Complex Analysis
Credits: 04
Total Number of Lectures: Theory: 45, Tutorials: 15
Maximum Marks: 100, **Theory:** 75, **Tutorial:** 25

Objectives: This course aims at developing a theory of normal families of meromorphic functions which has enormous applications in other areas of mathematics besides direct applications in Complex Dynamics.

Course Learning Outcomes: After studying this course the student will be able to

1. understand Montel's theorem, Vitali-Porter theorem, zeros of normal families, Riemann mapping theorem, fundamental normality test, Julia theorem.

2. understand Zalcman's lemma, Robinson-Zalcman heuristic principle, Bloch's principle, the converse of Bloch's principle, counterexamples to Bloch's principle and its converse.

3. understand a generalization of Montel's theorem, new composition and its consequences, zero-free families of analytic functions and a new normality criterion.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration.

Unit-I

Spherical and hyperbolic metrices, definition and examples of normal families of analytic functions, Montel's theorem, Vitali-Porter theorem, zeros of normal families, Riemann mapping theorem, fundamental normality test, Julia theorem.

Unit-II

Definition and examples of normal families of meromorphic functions, Montel's theorem, fundamental normality test, Vitali-Porter theorem, Marty's criterion of normality, Poles of normal families, Invariant normal families.

Unit-III

Zalcman's lemma and its applications, Robinson-Zalcman heuristic principle, extended fundamental normality test, Bloch's principle, the converse of Bloch's principle, counterexamples to Bloch's principle and its converse, Minda's formalization.

Unit-IV

Reformulation of Montel's theorem, normality of F iff the normality of F_n fundamental normality test, a generalization of Montel's theorem, a new composition and its consequences, zero-free families of analytic functions and a new normality criterion.

Text Books:

1. J. L. Schiff, *Normal families,* Springer-Verlag, 1993.

Reference Books:

1. Chi-Tai Chuang, *Normal Families of Meromorphic Functions,* World Scientific, 1993.
2. Norbert Steinmetz, *Nevanlinna Theory, Normal Families, and Algebraic Differential Equations,* Springer, 2017.
3. T. W. Gamelin, *Complex Analysis,* Springer, 2001.
4. L. V. Ahlfors, *Complex Analysis*, 3rd edition, McGraw-Hill Inc., 1970.
5. B. P. Palka, *An Introduction to Complex Function Theory,* Springer-Verlag, 1991.

Note: There shall be three tests and the student shall be continuously evaluated on the basis of their performance as follows:

Theory	Syllabus to be covered in the examination	Time allotted for the examination	% weight age marks
Minor test-l (after 30 days)	Upto 25%	1 hour 30 min.	20
Minor test-ll (after 60 days)	Upto 50%	1 hour 30 min.	20
Major test (after 90 days)	Upto 100%	3 hour	60

Note for paper setting of Major test:

1. There shall be two sections in the question paper, namely, Section A and Section B:
   (a) Section A shall have two questions equally distributed over Unit-I and Unit-II.

(a) Section B shall have three questions equally distributed over Unit-III and Unit-IV.

2. Each question shall be of the same weightage of 12 marks.

3. There shall be 100% internal choice.

SEMESTER IV
(Examination to be held in May 2024, 2025, 2026)
Major Course

Course Code: PSMATC405
Course Title: Value Distribution Theory of Meromorphic Functions
Credits: 04
Total Number of Lectures: Theory: 45, Tutorials: 15
Maximum Marks: 100, **Theory:** 75, **Tutorial:** 25

Objectives: The objective of this course is to take the theory of functions beyond holomorphic functions and study the growth of meromorphic functions as introduced by Rolf Nevanlinna in early 1920s.

Course Learning Outcomes: After studying this course the student will be able to

1. understand Poison-Jensen formula, Nevanlinna's first fundamental theorem, the Cartan's identity and convexity theorem, growth of meromorphic functions, order and type of meromorphic functions.
2. understand fundamental inequality, the estimation of the error term $S(r)$, conditions for $S(r)$ to be small, Nevanlinna's theory of deficient values, second fundamental theorem of Nevanlinna.
3. understand Milloux theory: Milluox's basic results, exceptional values of meromorphic functions and their derivatives.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration.

Unit-I

The Poison-Jensen formula, characteristic function, Nevanlinna's first fundamental theorem, the Cartan's identity and convexity theorem, growth of meromorphic functions, order and type of meromorphic functions, comparative growth of Nevanlinna's characteristic function $T(r)$ and the logarithm of the maximum modulus $M(r)$.

Unit-II

The fundamental inequality, the estimation of the error term $S(r)$, conditions for $S(r)$ to be small, Nevanlinna's theory of deficient values, second fundamental theorem of Nevanlinna.

Unit-III

Deficient functions, functions taking the same values at the same point, fixed points of integral functions, a theorem of Polya, if f and g are integral functions and $\phi = f(g)$ has finite order, then either f is a polynomial or g has zero order.

Unit-IV

Milloux theory: Milluox's basic results, exceptional values of meromorphic functions and their derivatives, Tumura-Clunie theorem.

Text Books:

1. W. K. Hayman, *Meromorphic Functions,* Oxford University Press, 1964.

Reference Books:

1. R. Nevanlinna, *Analytic Functions,* Springer-Verlag, 1970.
2. Yang Lo, *Value Distribution Theory,* Springer, 1993.
3. J. Zheng, *Value Distribution of Meromorphic Functions,* Springer-Verlag, 2010.
4. I. Laine, *Nevanlinna Theory and Complex Differential Equations,* De Gruyter Studies in Mathematics, 1993..
5. W. Cherry and Z. Ye, *Nevanlinna Theory of Value Distribution,* Springer, 2010.
6. L. A. Rubel, *Entire and Meromorphic Functions,* Springer, 1996.
7. Chi-Tai Chuang and C. C. Yang, *Fix-points and Factorization of Meromorphic Functions,* World Scientific Pub. Co., 1990.
8. A. S. B Holland, *Introduction to the Theory of Entire Functions,* Academic Press, 1973.

Note: There shall be three tests and the student shall be continuously evaluated on the basis of their performance as follows:

Theory	Syllabus to be covered in the examination	Time allotted for the examination	% weight age marks
Minor test-l (after 30 days)	Upto 25%	1 hour 30 min.	20
Minor test-ll (after 60 days)	Upto 50%	1 hour 30 min.	20
Major test (after 90 days)	Upto 100%	3 hour	60

Note for paper setting of Major test:

1. There shall be two sections in the question paper, namely, Section A and Section B:
   (a) Section A shall have two questions equally distributed over Unit-I and Unit-II.
   (a) Section B shall have three questions equally distributed over Unit-III and Unit-IV.
2. Each question shall be of the same weightage of 12 marks.
3. There shall be 100% internal choice.

SEMESTER IV

(Examination to be held in May 2024, 2025, 2026)

Major Course

Course Code: PSMATC406
Course Title: Geometric Functions Theory
Credits: 04
Total Number of Lectures: Theory: 45, Tutorials: 15
Maximum Marks: 100, **Theory:** 75, **Tutorial:** 25

Course Learning Outcomes: After studying this course the student will be able to

1. understand Harmonic, Subharmonic function, Green function and Univalent functions.
2. understand classes of univalent functions, Bieberbach conjucture, Littlewood's theorem, Lowner's theory and its applications.
3. understand Exponentiation and Reformulation of the Grunsky inequalities, Logarithmic coefficients, Littlewood's subordination theorem and Sharpened form of the Schwarz Lemma.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration.

Unit-I

Harmonic and Subharmonic function, Green function, Statement of Green theorem, Positive Harmonic functions, Univalent functions, Class S, Area theorem, Bieberbach's theorem, Koebe One-Quarter theorem, Growth and distortion theorems.

Unit-II

Coefficient estimates for univalent functions and special classes of univalent functions, Statement of Bieberbach conjucture, Littlewood's theorem, Lowner's theory and its applications, outline of de-Banges proof of Bieberbach conjecture.

Unit-III

Generalization of the area principle, The Grunsky inequalities, Inequalities of Goluzin and Lebedev.

Unit-IV

Exponentiation of the Grunsky inequalities, Reformulation of the Grunsky inequalities, Logarithmic coefficients, Subordination, Littlewood's subordination theorem and Sharpened form of the Schwarz Lemma.

Text Books:

1. P. Duren, *Univalent Functions,* Springer, New York, 1983. A. W. Goodman, Univalent Functions I II, Mariner, Florida, 1983.

Reference Books:

1. Ch. Pommerenke, *Univalent Functions,* Van den Hoek and Ruprecht, Gottingen, 1975.
2. M. Rosenblum and J. Rovnyak, *Topics in Hardy Classes and Univalent Functions,* Birkhauser Verlag, 1994.
3. D. J. Hallenbeck and T. H. MacGregor, *Linear Problems and Convexity Techniques in Geometric Function Theory,* Pitman Adv. Publ. Program, Boston-London-Melbourne, 1984.
4. I. Graham and G. Kohr,*Geometric Function Theory in One and Higher Dimensions,* Marcel Dekker, New York, 2003.

Note: There shall be three tests and the student shall be continuously evaluated on the basis of their performance as follows:

Theory	Syllabus to be covered in the examination	Time allotted for the examination	% weight age marks
Minor test-l (after 30 days)	Upto 25%	1 hour 30 min.	20
Minor test-ll (after 60 days)	Upto 50%	1 hour 30 min.	20
Major test (after 90 days)	Upto 100%	3 hour	60

Note for paper setting of Major test:

1. There shall be two sections in the question paper, namely, Section A and Section B:
   (a) Section A shall have two questions equally distributed over Unit-I and Unit-II.
   (a) Section B shall have three questions equally distributed over Unit-III and Unit-IV.
2. Each question shall be of the same weightage of 12 marks.
3. There shall be 100% internal choice.

SEMESTER IV
(Examination to be held in May 2024, 2025, 2026)
Major Course

Course Code: PSMATC407
Course Title: Complex Analysis in Several Variables
Credits: 04
Total Number of Lectures: Theory: 45, Tutorials: 15
Maximum Marks: 100**,** **Theory:** 75**,** **Tutorial:** 25

Objectives: This course aims at extending Complex Analysis from one variable to several complex variables. **Course Learning Outcomes:** After studying this course the student will be able to

1. understand holomorphic functions in several complex variables, Partially holomorphic functions, Cauchy-Riemann differential equations and Cauchy Integral Formula.

2. understand Power series, Taylor series, Laurent series and theoretic interpretation of the Laurent series.

3. understand Riemann Mapping Problem and Cartan's Uniqueness Theorem. Elementary properties of Analytic sets, Riemann Removable Singularity Theorem.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration.

Unit-I

Geometry of $C^{''}$, holomorphic functions in several complex variables, definition and basic properties, Partially holomorphic functions and the Cauchy-Riemann differential equations, The Cauchy Integral Formula.

Unit-II

The Space of Holomorphic Functious as a Topological Space, Locally convex spaces, the compact-open topology on the space of continuous mappings on an open set in $\mathbb{C}$ and the Theorems of Arzela-Ascoli and Montel.

Unit-III

Power series and Taylor series, Summable families in Banach spaces, Power series, Reinhardt domains and Laurent series, Holomorphic continuation, Representation-theoretic interpretation of the Laurent series, Hartogs Kugelsatz-special case.

Unit-IV

Biholomorphic maps, the Inverse Function Theorem and Implicit Functions. The Riemann Mapping Problem and Cartan's Uniqueness Theorem. Analytic Sets: Elementary properties of Analytic sets, the Riemann Removable Singularity Theorem.

Text Books:

1. V. Scheidemann, *Introduction to Complex Analysis in Several Vari- ables,* Birkhauser, 2005.

Reference Books:

1. P. M. Gautheir, *Lectures on Several Complex Variables,* Birkhauser, 2014.
2. Klaus Fritzsche and Hans Grauert, *From Holomorphic Functions to Complex Manifolds,* Springer, 2002.
3. Raghavan Narasimhan, *Several Complex variables*, (Chicago Lectures in Mathematics), The University of Chicago Press, 1971.
4. Raghavan Narasimhan and Yves Nievergelt, *Complex Analysis in One Variable* (Second Edition), Springer Science Bussiness Media, New York, 2001.
5. B. A. Fulks, *Theory of Analytic Functions of Several Complex Variables,* Amer. Math. Soc. 1963.
6. Lars Hormander, *An Introduction to Complex Analysis in Several Variables* (third Edition), Elsevier, 1988.

Note: There shall be three tests and the student shall be continuously evaluated on the basis of their performance as follows:

Theory	Syllabus to be covered in the examination	Time allotted for the examination	% weight age marks
Minor test-l (after 30 days)	Upto 25%	1 hour 30 min.	20
Minor test-ll (after 60 days)	Upto 50%	1 hour 30 min.	20
Major test (after 90 days)	Upto 100%	3 hour	60

Note for paper setting of Major test:

1. There shall be two sections in the question paper, namely, Section A and Section B:
   (a) Section A shall have two questions equally distributed over Unit-I and Unit-II.
   (a) Section B shall have three questions equally distributed over Unit-III and Unit-IV.
2. Each question shall be of the same weightage of 12 marks.
3. There shall be 100% internal choice.

SEMESTER IV
(Examination to be held in May 2024, 2025, 2026)
Major Course

Course Code: PSMATC408
Course Title: Algebraic Topology
Credits: 04
Total Number of Lectures: Theory: 45, Tutorials: 15
Maximum Marks: 100**,** **Theory:** 75**,** **Tutorial:** 25

Objectives: This course aims at extending Complex Analysis from one variable to several complex variables. **Course Learning Outcomes:** After studying this course the student will be able to

1. understand Geometric Simplexes, Geometric complexes, Polyhedra, Triangulable Spaces, Simplicial maps and Simplicial Approximation.
2. understand Computation of Simplicial homology groups of geometric complexes, structure of zero-dimensional homology groups, Induced homomorphisms of simplicial maps, Beti number, Euler-Pioncare Theorem.
3. understand Subdivison chain map, topological invariance of homology groups, Homotopy invariance, Invariance of dimensions, Brower's Fixed point theorem, Degree of a map, Degree of the antipodal map.

Structure of the Course: This is one of the basic course of Modern Mathematics. The pre requisite are basic topology, algebra and Homological algebra.

Unit-I

Geometric Simplexes, Geometric complexes, Polyhedra, Triangulable Spaces, Examples of Triangulable Spaces, Simplicial maps, Simplicial Approximation, Barycentric Subdivision.

Unit-II

Mesh of Geometric complex, Simplicial Approximation Theorem, Orientation of a geometric simplex, incidence number, Boundary Homomorphism, Oriented Simplicial Chain complex, Simplicial Homology groups.

Unit-III

Computation of Simplicial homology groups of geometric complexes, structure of zero-dimensional homology groups, Induced homomorphisms of simplicial maps, Beti number, Euler-Pioncare Theorem, Euler theorem, Psuedo manifold, Orientable Pseudomanifolds, Homology groups of S_n.

Unit-IV

Subdivison chain map, chain homotopic chain mappings, Homomorphism induced by continuous maps, topological invariance of homology groups, Homotopy invariance, Invarience of dimensions, retraction theorem, Brower's Fixed point theorem, Degree of a map, Degree of the antipodal map. Tangent vector field, Brower's Poincare theorem.

Text Books:

1. S. Deo, *Algebraic Topology,* A Primer, Hindustan Book Agency (2003).

Reference Books:

1. F. H. Croom,*Basic concepts of algebraic topology,* Springer Verlag (1970).
2. W. S. Massey,*Algebraic topology*, Springer Verlag (1977).
3. C. R. F. Maunder,*Algebraic Topology*, Cambridge Univ. Press.
4. M. A. Armstrong,*Basic Topology,* Springer Verlag.
5. M. K. Agoston, *Algebraic Topology A First Course,* Marcel Dekker, I. N. C.

Note: There shall be three tests and the student shall be continuously evaluated on the basis of their performance as follows:

Theory	Syllabus to be covered in the examination	Time allotted for the examination	% weight age marks
Minor test-l (after 30 days)	Upto 25%	1 hour 30 min.	20
Minor test-ll (after 60 days)	Upto 50%	1 hour 30 min.	20
Major test (after 90 days)	Upto 100%	3 hour	60

Note for paper setting of Major test:

1. There shall be two sections in the question paper, namely, Section A and Section B:
   (a) Section A shall have two questions equally distributed over Unit-I and Unit-II.
   (a) Section B shall have three questions equally distributed over Unit-III and Unit-IV.
2. Each question shall be of the same weightage of 12 marks.
3. There shall be 100% internal choice.

SEMESTER IV
(Examination to be held in May 2024, 2025, 2026)
Major Course

Course Code: PSMATC409
Course Title: Fourier Analysis
Credits: 04
Total Number of Lectures: Theory: 45, Tutorials: 15
Maximum Marks: 100, **Theory:** 75, **Tutorial:** 25

Objectives: The philosophy behind this course for students is to give them a large class of concrete examples which are essential for the proper understanding of the theory in the general context of topological groups and computational harmonic analysis .

Course Learning Outcomes: After studying this course the student will be able to

1. understand Banach space, continuous linear functionals, and the three key theorem, the closed graph, the Hahn-Banach, the uniform boundedness theorems.
2. understand order of magnitude of Fourier coefficents and their applications and estimates.
3. understand Fourier series of square summable sequence in Hilbert spaces, absolutely convergent Fourier series, Fourier coefficients of a functionals, Parseval's formula, Fourier-Stieltjes coefficients and Fourier-Stieltjes series.

Structure of the Course: This is one of the basic course of Modern Mathematics. The pre requisite are basic topology, algebra and Homological algebra.

Unit-I

A review of Lebesgue integration, Banach space, continuous linear functionals, and the three key theorem, the closed graph, the Hahn-Banach, the uniform boundedness theorems. The Hilbert spaces, Parseval's lemma. Trigonometric polynomial and trigonometric series on the unit circle, The Fourier Series, Fourier coefficients and Fourier Transform and their basic properties Fourier coefficients, convolution operation in $L^{'}(T)$ and their properties, convolution theorem, exercises and examples based on these concepts.

Unit-II

A summability kernel, their properties, Fejer's kernel, the definition of $Sn(f)$, the uniqueness theorem, the Riemann-Lebesgue Lemma, The de la Vallee Poisson kernel, The Poisson kernel and their properties, point-wise and a.e., convergence of s-sigma $n(f)$, Fejer's theorem, The order of magnitude of Fourier coefficients and their applications and estimates, exercises and examples based on these concepts.

Unit-III

Fourier series of square summable sequence in Hilbert spaces, absolutely convergent Fourier series and Bernstein theorem, The Fourier coefficients of a functionals, Parseval's formula, sequences of Fourier coefficients of linear functionals Fourier-Stieltjes coefficients, Fourier-Stieltjes series, exercises and examples based on these concepts.

Unit-IV

Fourier-Stieltjes coefficients , Fourier-Stieltjes series, Fourier-Stieltjes coefficients of positive measures as positive definite sequences Herglotz Theorem, Fourier-Stieltjes coeffcients as universal multipliers, The Poisson Integral, The conjugate function and their properties, distribution function, weak L^p-spaces, M. Riesz Theorem,The maximal function of Hardy and Littlewood, The Hardy spaces, exercises and examples based on these concepts.

Text Books:

1. Y. Katznelson, *An introduction to Harmonic Analysis,* John Wiley, 1968.

Reference Books:

1. Henry Helson, *Harmonic Analysis,* Addison-Wesley 1983, second edition,Hindustanpub. Corp., 1994.
2. E. Hewitt and K. A. Ross, *Abstract Harmonic Analysis* vol.1, 4th Edition, Springer-verleg, 1993.

Note: There shall be three tests and the student shall be continuously evaluated on the basis of their performance as follows:

Theory	Syllabus to be covered in the examination	Time allotted for the examination	% weight age marks
Minor test-l (after 30 days)	Upto 25%	1 hour 30 min.	20
Minor test-ll (after 60 days)	Upto 50%	1 hour 30 min.	20
Major test (after 90 days)	Upto 100%	3 hour	60

Note for paper setting of Major test:

1. There shall be two sections in the question paper, namely, Section A and Section B:
   (a) Section A shall have two questions equally distributed over Unit-I and Unit-II.
   (a) Section B shall have three questions equally distributed over Unit-III and Unit-IV.
2. Each question shall be of the same weightage of 12 marks.
3. There shall be 100% internal choice.

SEMESTER IV
(Examination to be held in May 2024, 2025, 2026)
Major Course

Course Code: PSMATC410
Course Title: Masters Dissertation
Credits: 08
Maximum Marks: 200

Dissertation work is considered an unique course involving applying knowledge in solving/ analyzing/ exploring a real-life situation/ complex problem/ data analysis. Dissertation work has the intention to provide research competencies at the postgraduate level. It enables the acquisition of special/ advanced knowledge through support study/a dissertation work. This course is applicable to students in 4th semester of postgraduate research program. The following mechanism shall be adopted for completion of the dissertation.

(1) The dissertation work shall be started in the beginning of the 4th semester and Supervisor/ mentors shall be allotted through DAC in the first week of the 4th semester.

(2) The dissertation carries 08 credits carrying 200 marks.

(3) The topics of the dissertation shall be allotted by the nominated Supervisor/ mentor and approved by DRC.

(4) The evaluation of the dissertation and viva-voce shall be carried out by DRC of the department with following weightage of marks:

   (i) Dissertation-150 marks.

   (ii) Viva-voce/ Presentation-50 marks.

SEMESTER IV
(Examination to be held in May 2024, 2025, 2026)
Major Course

Course Code: PSMATO411
Course Title: Numerical Methods and Graph Theory
Credits: 04
Total Number of Lectures: Theory: 45, Tutorials: 15
Maximum Marks: 100**,** **Theory:** 75**,** **Tutorial:** 25

Objectives: The objective of this course is to teach basics of Computer programming in $\mathbb{C}$ and Problem-solving techniques using various concepts of graph theory. Some numerical methods which are extremely useful for many problems in engineering, sciences and social sciences are included for skill development in programming.

Course Learning Outcomes: After studying this course the student will be able to

1. understand Transcendental and algebraic equations: Bisection method, Regula-Falsi method, Newton-Raphson method, Secant method, Rate of convergence of these methods.
2. understand Graphs and their representation, Pseudographs, Subgraphs, Degree sequence, Euler's theorem, Isomorphism of graphs, Paths and circuits, Connected graphs.
3. understand Dijkstra's algorithm, The Chinese postman problem; Digraphs, Bellman-Ford algorithm, Tournaments, Directed network.

Structure of the Course: This course is divided into four units of 15 class lectures each, wherein one lecture is of one hour duration.

Unit-I

Programming in $\mathbb{C}$: Historical development of $\mathbb{C}$, Character set, constants, variables, $\mathbb{C}$-key words, Instructions, Hierarchy of operations, Operators, Simple C programs, Control structures: The if, if-else, nested if-else, unconditional go to, switch structure, Logical and conditional operators, while, do-while and for loops, Break and continue statements, Arrays, Functions, recursion, Introduction to pointers.

Unit-II

Convergence; Errors: Relative, Absolute, Round off, Truncation; Transcendental and algebraic equations: Bisection method, Regula-Falsi method, Newton-Raphson method, Secant method, Rate of convergence of these methods.

Unit-III

Graphs and their representation, Pseudographs, Subgraphs, Degree sequence, Euler's theorem, Isomorphism of graphs, Paths and circuits, Connected graphs, Euler trails and circuits, Hamiltonian paths and cycles, Adjacency matrix, Weighted graphs.

Unit-IV

Travelling salesman problem, Dijkstra's algorithm, The Chinese postman problem; Digraphs, Bellman-Ford algorithm, Tournaments, Directed network, Scheduling problem; Trees and their properties, Spanning trees.

Text Books:

1. S. S. Shastry, *Introductory Methods of Numerical Analysis*, PHI, 2005.
2. Goodaire, G. Edgar, Parmenter, M. Michael, *Discrete Mathematics with Graph Theory* Pearson Education Pvt. Ltd. Indian Reprint.

Reference Books:

1. C. Xavier: $\mathbb{C}$ *Language and Numerical Methods,* New Age Int. Ltd., 2007.
2. Y. Kanetkar, *Let us* $\mathbb{C}$, BPB Publications, 2007.
3. C. Gary and P. Zhang, *A First Course in Graph Theory*, Dover Publications, (2012).
4. R. Diestel, *Graph Theory (Graduate Texts in Mathematics)*, Springer Verlag,(1997).

Note: There shall be three tests and the student shall be continuously evaluated on the basis of their performance as follows:

Theory	Syllabus to be covered in the examination	Time allotted for the examination	% weight age marks
Minor test-l (after 30 days)	Upto 25%	1 hour 30 min.	20
Minor test-ll (after 60 days)	Upto 50%	1 hour 30 min.	20
Major test (after 90 days)	Upto 100%	3 hour	60

Note for paper setting of Major test:

1. There shall be two sections in the question paper, namely, Section A and Section B:
   (a) Section A shall have two questions equally distributed over Unit-I and Unit-II.
   (a) Section B shall have three questions equally distributed over Unit-III and Unit-IV.
2. Each question shall be of the same weightage of 12 marks.
3. There shall be 100% internal choice.