Shri Vile Parle Kelavani Mandal's

[ITHIBAI COLLEGE OF ARTS, CHAUHAN INSTITUTE OF SCIENCE & AMRUTBE

JIVANLAL COLLEGE OF COMMERCE AND ECONOMICS (AUTONOMOUS)

NAAC Reaccredited 'A' grade, CGPA: 3.57 (February 2016),

Granted under RUSA, FIST-DST & -Star College Scheme of DBT, Government of India,

Best College (2016-17), University of Mumbai

Affiliated to the

UNIVERSITY OF MUMBAI

Program: M.Sc. Mathematics

Course: Semester I

Choice Based Credit System (CBCS) with effect from the Academic year 2021- 2022

PSO1. Students should see a number of contrasting but complementary points of view in the topics continuous and discrete technique(algebraic and geometric) and approaches (theoretical and applied) to mathematician.

PSO2. Students will develop mathematical thinking, progressing from a computational understanding of mathematics to a broad understanding encompassing logical reasoning, generalization,abtraction and formal proof.

PSO3.Students will acquire sufficient knowelge and proficiency in the use of appropriate technology to assist in the learning and investigation of mathematics.

PSO4 Students will study of least one of mathematics in depth, drawing on ideas and tools from previous coursework to extend their understanding.

PSO5.Knowlege.Provide sufficient knowledge of principles, concepts and ideas and know how to use them for solving and interpreting.

PSO6, Reflecting the broad nature of the subject and developing mathematical tools for continuing further study in various ,fields of science.

PSO7.Enhancing students overall development and to equip them with mathematical ability ,problem solving skills, creative talent a power of communication necessary for various kinds of employment.

PSO8.A Student should be able to recall basic facts about mathematics and should be able to apply knowelge of numerical analysis and differential equation.

PSO9. A student should get a relational understanding of mathematical concepts and concerned complex problems.

PSO10. A student should get adequate exposure to global and local concerns that explore them many aspects of mathematical sciences.

Evaluation Pattern

The performance of the learner will be evaluated in two components. The first component will be a Continuous Assessment with a weightage of 25% of total marks per course. The second component will be a Semester end Examination with a weightage of 75% of the total marks per course. The allocation of marks for the Continuous Assessment and Semester end Examinations is as shown below:

a) Details of Continuous Assessment (CA)

25% of the total marks per course:

Continuous Assessment	Details	Marks
Component 1 (CA-1)	Class Test	15 marks
Component 2 (CA-2)	Assignment	10 marks

b) Details of Semester End Examination

75% of the total marks per course. Duration of examination will be two and half hours.

Question Number	Description	Marks	Total Marks
1	MODULE I	15	15
2	MODULE II	15	15
3	MODULE III	15	15
4	MODULE IV	15	15
5	MODULE I,II,III,IV	15	15
		Total Marks	**75**

SVKM's Mithibai College of Arts, Chauhan Institute of Science & Amrutben Jivanlal College of Commerce & Economics (AUTONOMOUS)

DEPARTMENT OF MATHEMATICS

M.Sc. SEMESTER I

SVKM's Mithibai College of Arts, Chauhan Institute of Science & Amrutben Jivanlal College of Commerce & Economics (AUTONOMOUS)

Program: M.Sc.(2021-22)					**Semester: I**
Course: ALGEBRA I					**Course Code: PSMAMT101**
Teaching Scheme				**Evaluation Scheme**	
Lecture (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks - 25)**	**Semester End Examinations (SEE) (Marks- 75 in Question Paper)**
4	NIL	1	5	25	75

Learning Objectives:

1] Students get the knowledge of basic concepts which they can use to solve various mathematical problems .

2] The students get the broad logical approach to formulate the mathematical model based on problem and analyze it to get the logical solution.

Course Outcomes:

After completion of the course, learners would be able to:

CO1: Understand the basic concepts related to finite dimensional vectorspace and its dual .(Understanding)

CO2: Get the knowledge to interpret the relation between linear transformation and its corresponding matrix (Understanding)

CO3: Calculate power of matrix, eigen values and eigenvectors of the matrix polynomial using Caley Hamilton theorem (Evaluate)

CO4: Apply knowledge of Jordan Canonical form to find minimal polynomial and geometric multiplicity of eigen vectors without using the matrix (Application)

CO5: Understand the relation between the linear operators – Self adjoint, Normal, Unitary operators which helps to analyze the properties of symmetric, skew symmetric, Hermitian , Skew Hermitian matrices (Analysis)

Outline of Syllabus: (per session plan)

Module	**Description**	**No of Hours**
1	Dual spaces	**15**
2	Determinants	**15**
3	Characteristic polynomial	**15**
4	Bilinear forms	**15**
	Total	**60**

PRACTICALS	

Unit	Topic	No. of Hours/Credits
Module 1	1. Vector spaces over a field, linear independence, basis for finite dimensional and infinite dimensional vector spaces and dimension. 2. Kernel and image, rank and nullity of a linear transformation, rank-nullity theorem (for finitedimensional vector spaces), relationship of linear transformations with matrices, invertible linear transformations. The following are equivalent for a linear map T : V −→V of a finite dimensional vector space V : 1. T is an isomorphism. 2. kerT = {0}. 3. Im(T) = V. 3. Linear functionals, dual spaces of a vector space, dual basis (for finite dimensional vectorspaces), annihilator W◦ in the dual space V ∗ of a subspace W of a vector space V and dimension formula, a k−dimensional subspace of an n− dimensional vector space is intersection of n − k many hyperspaces. Double dual V ∗∗of a Vector space V and canonical embedding of V into V ∗∗. V ∗∗ is isomorphic to V when V is of finite dimension. (ref:[1] Hoffman K and Kunze R) 4. Transpose Tt of a linear transformation T. For finite dimensional vector spaces: rank (Tt)=rank T, range(Tt) is the annihilator of kernel (T), matrix representing Tt a rank of a matrix. (ref:[1] Hoffman K and Kunze	**15**
Module 2	Determinants as alternating n-forms, existence and uniqueness , Laplace expansion of determinant, determinants of products and transposes, determinants and invertible linear transformations, determinant of a linear transformation. Reference for Unit II: [1] Hoffman K and Kunze R, Linear Algebra.	**15**
Module 3	Eigen values and Eigen vectors of a linear transformation, Characteristic polynomial, CayleyHamilton theorem, Minimal polynomial, Triangulable and diagonalizable linear operators, invariant subspaces and simple matrix representation (for finite dimension). (ref: [5] N.S. Gopalkrishnan & [3] Serge Lang) Nilpotent linear transformations on finite dimensional vector spaces, index of a Nilpotent linear transformation. Linear independence of {u,Nu,··· ,Nk−1u} where N is a nilpotent linear transformation of index k ≥ 2 of a vector space V and u ∈ V with Nu 6= 0. (Ref: [2] I.N.Herstein) For a nilpotent linear transformation N of a finite dimensional vector space V and for any subspace W of V which is invariant under N, there	**15**

	exists a subspace V1 of V such that V = W ⊕ V1. (Ref:[2] I.N.Herstein) Computations of Minimum polynomials and Jordan Canonical Forms and rational canonical forms for 3×3- matrices through examples of matrices such as $\begin{pmatrix} 3 & 1 & -1 \\ 2 & 2 & -1 \\ 2 & 2 & 0 \end{pmatrix}, \begin{pmatrix} 1 & 1 & 1 \\ -1 & -1 & -1 \\ 1 & 1 & 0 \end{pmatrix}$ Morris W. Hirsch and Stephen Smale)	
Module 4	1. Inner product spaces, orthonormal basis. 2. Adjoint of a linear operator on an inner product space, unitary operators, self adjoint operators, normal operators, spectral theorem for a normal operator on a finite dimensional complex vector inner product space (ref:[1] Hoffman K and Kunze R). 3. Bilinear form, rank of a bilinear form, non-degenerate bilinear form and equivalent statements (ref:[1] Hoffman K and Kunze R). 4. Symmetric bilinear forms, orthogonal basis and Sylvester's Law, signature of a Symmetric bilinear form (ref:[4] Michael Artin). 5. Quadratic form – Positive definite ,negative definite and indefinite 6. Application of quadratic forms	**15**

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

Suggested Readings

Main Reference books

1. Hoffman K and Kunze Linear Algebra.
2. I.N.Herstein Linear Algebra.

Reference Books

[1 Serge Lang: *Linear Algebra*, Springer-Verlag Undergraduate Text in Mathematics.

[2] Michael Artin: *Algebra*, Prentice-Hall India.

[3] N.S. Gopalkrishnan: *University Algebra*, New Age International, third edition, 2015.

[4] Morris W. Hirsch and Stephen Smale, *Differential Equations, Dynamical Systems, Linear Algebra*, Elsevier.

Program: M.Sc . (2021-22)				**Semester: I**	
Course: Analysis I				**Course Code: PSMAMT 102**	
Teaching Scheme				**Evaluation Scheme**	
Lecture (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks - 25)**	**Semester End Examinations (SEE) (Marks- 75 in Question Paper)**
4	**0**	**1**	**5**	**25**	**75**

Learning Objectives:

(1) Give the students a sufficient knowledge of fundamental principles, and theorems on Euclidean space R^n

(2) Reflecting the broad nature of the subject and developing mathematical tools for continuing further study in various fields of science.

Course Outcomes:

After completion of the course, learners would be able to:

CO1: Knowledge about Inverse function theorem and Implicit function theorem will be gained (Understanding)

CO2 :Learn about compactness, connectedness and continuity. (Understanding)

CO3: Application of chain rule will be learned. (Application)

CO4: Student will learn to evaluate total derivative, partial derivative, Jacobian matrix(Evaluate).

CO5: Understand Mean value theorem, Taylors expansion theorem, Contraction mapping Theorem and apply them(Application).

CO6: Student will be able to understand concepts of Riemann Integration over a rectangle in R^n and calculate Riemann integration, apply Fubini's theorem. (Application)

Outline of Syllabus: (per session plan)

Module	**Description**	**No of Hours**
1	Euclidean space R^n	**15**
2	Riemann integration	**15**

3	Differentiable functions	**15**
4	Inverse function theorem, Implicit function theorem	**15**
	Total	**60**
PRACTICALS		

Unit	**Topic**	**No. of Hours/ Credits**
Module 1	Euclidean space R^n : inner product $\langle x, y\rangle = \sum_{j=1}^{n} x_j y_j$ of $x = (x_1, \cdots, x_n), y = (y_1, \cdots, y_n) \in \mathbb{R}^n$ and properties, norm $\|x\| = \sqrt{\sum_{j=1}^{n} x_j^2}$ of $x = (x_1, \cdots, x_n) \in \mathbb{R}^n$, Cauchy-Schwarz inequality, properties of the norm function $\|x\|$ on R^n Standard topology on R^n: open subsets of R^n, closed subsets of R^n, interior A° and boundary ∂A of a subset A of R^n. Operator norm $\|T\|$ of a linear transformation $T : R^n \longrightarrow R^m$ ($\|T\| = \sup\{\|T(v)\| : v \in R^n \& \|v\| \leq 1\}$) and its Properties such as For all linear maps $S, T : R^n \longrightarrow R^m$ and $R : R^m \longrightarrow R^k$ 1. $\|S + T\| \leq \|S\| + \|T\|$, 2. $\|R \circ S\| \leq \| R \|\|S\|$, and 3. $\|cT\| = \|c\|\|T\|$ $(c \in R)$. Compactness: Open cover of a subset of R^n, Compact subsets of R^n (A subset K of R^n is compact if every open cover of K contains a finite subcover), Heine-Borel theorem (statement only), the Cartesian product of two compact subsets of R^n is compact (statement only), every closed and bounded subset of R^n is compact. Bolzano-Weierstrass theorem: Any bounded sequence in R^n has a converging subsequence. Brief review of following three topics: 1. Functions and Continuity: Notation: $A \subset R^n$ arbitrary non-empty set. A function $f : A \longrightarrow R^m$ and its component functions, continuity of a function $(,\delta$ definition). A function $f : A \longrightarrow R^m$ is continuous if and only if for every open subset $V \subset R^m$ there is an open subset U of R^n such that $f^{-1}(V) = A \cap U$. 2. Continuity and compactness: Let $K \subset R^n$ be a compact subset and $f : K \longrightarrow R^m$ be any continuous function. Then f is uniformly continuous, and $f(K)$ is a compact subset of R^m. 3. Continuity and connectedness: Connected subsets of R are intervals. If $f : E \longrightarrow R$ is continuous where $E \subset R^n$ and E is connected, then $f(E) \subset R$ is connected.	**15**

Module 2	Riemann Integration over a rectangle in R^n, Riemann Integrable functions, Continuous functions are Riemann integrable, Measure zero sets, Lebesgues Theorem (statement only), Fubini's Theorem and applications.	**15**
Module 3	Differentiable functions on R^n, the *total derivative* $(Df)_p$ of a differentiable function $f : U \longrightarrow R^m$ at $p \in U$ where U is open in R^n, uniqueness of total derivative, differentiability implies continuity. Chain rule. Applications of chain rule such as: 1. Let γ be a differentiable curve in an open subset U of R^n. Let $f : U \longrightarrow R$ be a differentiable function and let $g(t) = f(\gamma(t))$. Then $g^0(t) = h(\nabla f)(\gamma(t)),\gamma^0(t)i$. 2. Computation of total derivatives of real valued functions such as (a) the determinant function $\det(X)$, $(X \in M_n(R))$, (b) the Euclidean inner product function hx,yi, $((x,y) \in R^n \times R^n)$. Results on total derivative: 1. If $f : R^n \longrightarrow R^m$ is a constant function, then $(Df)_p = 0 \ \forall \ p \in R^n$. 2. If $f : R^n \longrightarrow R^m$ is a linear map, then $(Df)_p = f \ \forall \ p \in R^n$. 3. A function $f = (f_1,f_2,\cdots,f_m) : R^n \longrightarrow R^m$ is differentiable at $p \in R^n$ if and only if each f_j is differentiable at $p \in R^n$, and $(Df)_p = ((Df_1)_p,(Df_2)_p,\cdots,(Df_m)_p)$. Partial derivatives, directional derivative $(D_uf)(p)$ of a function f at p in the direction of the unit vector, Jacobian matrix, Jacobian determinant. Results: 1. If the total derivative of a map $f = (f_1,\cdots,f_m) : U \longrightarrow R^m$ (U open subset of R^n) exists at $p \in U$, then all the partial derivatives $\frac{\partial f_i}{\partial x_j}$ exist at p. 2. If all the partial derivatives $\frac{\partial f_i}{\partial x_j}$ of a map $f = (f_1,\cdots,f_m) : U \longrightarrow R^m$ (U open subset of R^n) exist and are continuous on U, then f is differentiable. Derivatives of higher order, C^k-functions, C^∞-functions.	**15**
Module 4	Theorem (Mean Value Inequality): Suppose $f : U \longrightarrow R^m$ is differentiable on an open subset U of R^n and there is a real number such that $\|(Df)_x\| \le M \ \forall \ x \in U$. If the segment $[p,q]$ is contained in U, then $\|f(q) - f(p)\| \le M\|q - p\|$. Mean Value Theorem: Let $f : U \longrightarrow R^m$ is differentiable on an open subset U of R^n. Let $p,q \in U$ such that the segment $[p,q]$ is contained in U. Then for every vector v $\in R^n$ there is a point $x \in [p,q]$ such that $hv,f(q) - f(p)i = hv,(Df)_x(q - p)i$. If $f : U \longrightarrow R^m$ is differentiable on a connected open subset U of R^n and $(Df)_x = 0 \ \forall \ x \in U$, then f is a constant map. Taylor expansion for a real valued C^m-function defined on an open subset of R^n, stationary points (critical points), maxima, minima, saddle points, second derivative test for extrema at a stationary point of a real valued C^2-function defined on an open subset of R^n.	15

	Contraction mapping theorem. Inverse function theorem , Implicit function theorem.	

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

Suggested Readings

Main Reference books

1.W. Rudin: Principles of Mathematical Analysis, Mcgraw-Hill India

2. M. Spivak: Calculus on Manifolds, Harper –Collins Publishers

Reference Books

1 C.C.Pugh : Real Mathematical analysis, Springer UTM.

2 A. Browder: Mathematical Analysis, An Introduction, Springer

3 T. Apostol: Mathematical Analysis, Narosa

Program: M.Sc. (2021-22)				**Semester: I**	
Course: Complex Analysis				**Course Code: PSMAMT 103**	
Teaching Scheme				**Evaluation Scheme**	
Lecture (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks - 25)**	**Semester End Examinations (SEE) (Marks- 75 in Question Paper)**
4	Nil	1	5	25	75

Learning Objectives:

(1) Give the students a sufficient knowledge of course fundamentals, methods and a clear perception of immense power of mathematical ideas and tools and know how to use them by modelling, solving and interpreting.

(2) Reflecting the broad nature of the subject and developing mathematical tools for continuing further study in various fields of science.

Course Outcomes:

After completion of the course, learners would be able to:

CO1: Conceive the concepts of analytic functions and will be familiar with the elementary complex functions and their properties

CO2: Understand more about analytic functions by the way of power series.

CO3: Understand the basic methods of complex integration and its application in contour integration.

CO4: Evaluate integrals by observing the properties of functions using several results given by Cauchy.

CO5: Identify functions completely on complex plane by using several interesting results by Liouville's.

CO6: Locate and count zeros of polynomials of higher degree using Rouche's Theorem.

CO7: Apply Residue Calculus in evaluating complex Integrals.

CO8: Learn about Mobius transformations and its applications in Complex Analysis.

Outline of Syllabus: (per session plan)

Module	Description	No of Hours
1	Holomorphic functions	**15**
2	Contour integration, Cauchy-Goursat theorem	**15**
3	Properties of holomorphic functions	**15**
4	Residue Calculus and Mobius transformations	**15**
	Total	**60**
PRACTICALS		

Unit	Topic	No. of Hours/Credits
Module 1	**1.** Review: Complex Numbers, Geometry of the complex plane, Riemann sphere, Complex sequences and series, Sequences and series of functions in C, , Weierstrass's M-test, Uniform convergence, Complex differentiable functions, Cauchy-Riemann equations (no questions be asked). **2.** Ratio test and root test for convergence of a series of complex numbers. Complex Power series, radius of convergence of a power series, Cauchy-Hadamard formula for radius of convergence of a power series. **3.** Examples of convergent power series such as exponential series, cosine series and sine series, and the basic properties of the functions	**15**

	4. Abel's theorem & Applications of Abel's theorem such as exp0(z) = expz, cos (z) = −sinz,sin (z) = cosz,(z ∈ C). Chain Rule.	
Module 2	**1.** Contour integration, Cauchy-Goursat Theorem for a rectangular region or a triangular region. Primitives. **2.** Existence of primitives: If f is holomorphic on a disc U, then it has a primitive on U and the integral of f along any closed contour in U is 0. **3.** Local Cauchy's Formula for discs (without proof), **4.** Power series representation of holomorphic functions (without proof). **5.** Cauchy's estimates	**15**
Module 3	**1.** Entire functions, Liouville's theorem, Morera's theorem, the Fundamental theorem of Algebra. Cauchys theorem (homotopy version or homology version) **2.** Simply connected region. The index (winding number) of a closed curve, Cauchy integral formula. **3.** Zeros of holomorphic functions, Identity theorem. Counting zeros; Open Mapping Theorem, Maximum modulus theorem, Schwarz's lemma. **4.** Every automorphism of unit disc with center 0 in C is a rotation. Schwarz ' s pick lemma.	**15**
Module 4	1. Isolated singularities: removable singularities and Removable singularity theorem, poles and essential singularities. Laurent Series development. Casorati-Weirstrass's theorem. 2. Residue Theorem and evaluation of standard types of integrals by the residue calculus method. Argument principle. Rouch´e's theorem. Conformal mappings. 3. Properties of fractional linear transformation. Any Mobius transformation which fixes three distinct points is necessarily the identity map. 4. Riemann Mapping theorem (only statement). Cross ratio (z1,z2,z3,z4) of four points z1,z2,z3,z4 and properties relating to Mobius transformation	**15**

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

Suggested Readings

Main Reference books

1. A. R. Shastri: An introduction to complex analysis, Macmillan.
2. S.Ponnusamy Foundation of complex analysis Narosa
3. Dennis Zill and Patrick Shanahan: First course in complex analysis

Reference Books

1. J. B. Conway, Functions of one Complex variable, Springer.
2. L. V. Ahlfors: Complex analysis, McGraw Hill .
3. R. Remmert: Theory of complex functions, Springer
4. Serge Lang: Complex Analysis.
5. E.M Stein and R Shakarchi: Complex Analysis, Princeton University 2003

Program: M.Sc . (2021-22)				**Semester: I**	
Course: Discrete Mathematics I				**Course Code: PSMAMT 104**	
Teaching Scheme				**Evaluation Scheme**	
Lecture (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks - 25)**	**Semester End Examinations (SEE) (Marks- 75 in Question Paper)**
4	NIL	1	5	25	75

Learning Objectives:

Student will be able to

1 Learn Diphantine Equations
2.Understand combinatorics proofs
3 Generate Recurrence equations
4 Solve generating equations

Course Outcomes:

After completion of the course, learners would be able to:

CO1: Learn concept related to counting.

CO2: Introduction to advanced counting.
CO3: Apply Pigeonhole Principle to general (practical) examples
CO4: Understand counting principle, principle of inclusion and exclusion

CO5: Apply Sterling numbers of second kind to solve

Outline of Syllabus: (per session plan)

Module	Description	No of Hours
1	Number Theory	**15**
2	Advanced Counting	**15**
3	Recurrence relations	**15**
4	Polya's theory of counting	**15**
	Total	**60**
PRACTICALS		

Unit	Topic	No. of Hours/Credits
Module 1	Divisibility, Linear Diophantine equations, Cardano's Method, Congruences, Quadratic residues, Arithmetic functions, Types of occupancy problems, distribution of distinguishable and indistinguishable objects into distinguishable and indistinguishable boxes (with condition on distribution) Stirling numbers of second and first kind. Selections with Repetitions. Unit	**15**
Module 2	Pigeon-hole principle, generalized pigeon-hole principle and its applications, Erdos- Szekers theorem on monotone subsequences, A theorem of Ramsey. Inclusion Exclusion Principle and its applications. Derangement. Permutations with Forbidden Positions, Restricted Positions and Rook Polynomials	**15**
Module 3	The Fibonacci sequence, Linear homogeneous recurrence relations with constant coefficient. Proof of the solution in	**15**

	case of distinct roots and statement of the theorem giving a general solution (in case of repeated roots), Iteration and Induction. Ordinary generating Functions, Exponential Generating Functions, algebraic manipulations with power series, generating functions for counting combinations with and without repetitions, exponential generating function for bell numbers, applications to counting, use of generating functions for solving recurrence relations.	
Module 4	Equivalence relations and orbits under a permutation group action. Orbit stabiliser theorem, Burnside Lemma and its applications, Cycle index, Polyas Formula, Applications of Polyas Formula	**15**

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

Suggested Readings

Main Reference books

1. D. M. Burton, Introduction to Number Theory, McGraw-Hill. 2. Nadkarni and Telang, Introduction to Number Theory
2. Richard A. Brualdi: Introductory Combinatorics, Pearson.

3.Kenneth Rosen: Discrete Mathematics and its applications, Tata McGraw Hills.

Reference books

1.V. Krishnamurthy:Combinatorics: Theory and applications, Affiliated East-West Press.

2.Tucker: Applied Combinatorics, John Wiley & Sons.
3. Norman L. Biggs: Discrete Mathematics, Oxford University Press

4.Sharad S. Sane, Combinatorial Techniques, Hindustan Book Agency, 2013.

Program: M.Sc . (2021-22)	**Semester: I**
Course: Ordinary Differential Equations	**Course Code: PSMAMT106**
Teaching Scheme	**Evaluation Scheme**

Lecture (Hours per week)	Practical (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks - 25)	Semester End Examinations (SEE) (Marks- 75 in Question Paper)
4	NIL	NIL	4	25	75

Learning Objectives:

(1) Give the students a sufficient knowledge of fundamental principles, methods and a clear perception of immense power of mathematical ideas and tools and know how to use them by modelling, solving and interpreting.

(2) Reflecting the broad nature of the subject and developing mathematical tools for continuing further study in various fields of science.

Course Outcomes:

After completion of the course, learners would be able to:

CO1: Understand Existence and Uniqueness of solutions to initial value problem of first order ODE

CO2: Find approximation to solutions of ODE using Picard's Theorem

CO3: Correlate between n-th order ODE and system of n - first order ODEs

CO4: Discover that solutions to a homogenous ODE form a vector space and hence connect linear algebra with Differential Equations

CO5: Understand the role of Wronskian Matrix in Differential equations

CO6: Express solutions of specific second order linear differential equations in the form of power series

CO7: Use Sturm - Liouville Theory to find properties of solutions of ODE without solving ODE

CO8: Understand Eigenvalues and Eigen functions of Sturm-Liouville Boundary Value Problem

CO9: Apply Fourier Series concept to ODE and express solution in Fourier Series

Outline of Syllabus: (per session plan)

Module	Description	No of Hours
1	Picard's Theorem	**15**
2	Ordinary Differential Equations- Higher Order	**15**
3	Series solutions and Sturm-Liouville theory	**15**
4	Fourier series	**15**
	Total	**60**

PRACTICALS

Unit	Topic	No. of Hours/Credits
Module 1	Existence and Uniqueness of solutions to initial value problem of first order ODE- both autonomous, non-autonomous (Picard's Theorem) Picard's scheme of successive Approximations, system of first order linear ODE with constant coefficients and variable coefficients Reduction of an n-th order linear ODE to a system of first order ODE..	**15**
Module 2	Existence and uniqueness results for an n-th order linear ODE with constant coefficients and variable coefficients linear dependence and independence of solutions of a homogeneous n-th order linear ODE Wronskian matrix, Lagrange's Method (variation of parameters) Algebraic properties of the space of solutions of a non-homogeneous n-th order linear ODE.	**15**
Module 3	Solutions in the form of power series for second order linear equations of Legendre and Bessel, Legendre polynomials, Bessel functions. Sturm- Liouville Theory: Sturm-Liouville Separation and comparison Theorems, Oscillation properties of solutions.	**15**
Module 4	Eigenvalues and eigen functions of Sturm-Liouville Boundary Value Problem, the vibrating string. Orthogonality of eigen value functions,Dirichlet's conditions Fourier series expansion of periodic functions(period of 2p π and arbitrary period) Complex form of Fourier series,Half range Fourier series,Nth partial sum of Fourier series Bessel's inequality,Parseval's identity (over complex field)	**15**

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

Suggested Readings

Main Reference books

1. Robert R. Stoll: Set theory and logic, Freeman & Co.

2. James Munkres: Topology, Prentice-Hall India;

Reference books

1 J. F. Simmons, Introduction to Topology and real analysis.
2.Richard A. Brualdi: Introductory Combinatorics, Pearson
3. Kenneth Rosen: Discrete Mathematics and its applications, Tata McGraw Hills.
4. Larry J. Gerstein: Introduction to mathematical structures and proofs, Springer.
5. Joel L. Mott, Abraham Kandel, Theodore P. Baker: Discrete mathematics for Computer scientists and mathematicians, Prentice-Hall India.
6.Robert Wolf: Proof, logic and conjecture, the mathematicians toolbox, W. H. Freemon.

Shri Vile Parle Kelavani Mandal's

ITHIBAI COLLEGE OF ARTS, CHAUHAN INSTITUTE OF SCIENCE & AMRUTBE JIVANLAL COLLEGE OF COMMERCE AND ECONOMICS (AUTONOMOUS)

NAAC Reaccredited 'A' grade, CGPA: 3.57 (February 2016),
Granted under RUSA, FIST-DST & -Star College Scheme of DBT, Government of India,
Best College (2016-17), University of Mumbai

Affiliated to the

UNIVERSITY OF MUMBAI

Program: M.Sc. Mathematics

Course: Semester II

Choice Based Credit System (CBCS) with effect from the Academic year 2021- 2022

PSO1. Students should see a number of contrasting but complementary points of view in the topics continuous and discrete technique(algebraic and geometric) and approaches (theoretical and applied) to mathematician.

PSO2. Students will develop mathematical thinking, progressing from a computational understanding of mathematics to a broad understanding encompassing logical reasoning, generalization,abtraction and formal proof.

PSO3.Students will acquire sufficient knowelge and proficiency in the use of appropriate technology to assist in the learning and investigation of mathematics.

PSO4 Students will study of least one of mathematics in depth, drawing on ideas and tools from previous coursework to extend their understanding.

PSO5.Knowlege.Provide sufficient knowledge of principles, concepts and ideas and know how to use them for solving and interpreting.

PSO6, Reflecting the broad nature of the subject and developing mathematical tools for continuing further study in various ,fields of science.

PSO7.Enhancing students overall development and to equip them with mathematical ability ,problem solving skills, creative talent a power of communication necessary for various kinds of employment.

PSO8.A Student should be able to recall basic facts about mathematics and should be able to apply knowelge of numerical analysis and differential equation.

PSO9. A student should get a relational understanding of mathematical concepts and concerned complex problems.

PSO10. A student should get adequate exposure to global and local concerns that explore them many aspects of mathematical sciences.

Evaluation Pattern

The performance of the learner will be evaluated in two components. The first component will be a Continuous Assessment with a weightage of 25% of total marks per course. The second component will be a Semester end Examination with a weightage of 75% of the total marks per course. The allocation of marks for the Continuous Assessment and Semester end Examinations is as shown below:

a) **Details of Continuous Assessment (CA)**
25% of the total marks per course:

Continuous Assessment	Details	Marks
Component 1 (CA-1)	Class Test	15 marks
Component 2 (CA-2)	Assignment	10 marks

b) **Details of Semester End Examination**
75% of the total marks per course. Duration of examination will be two and half hours.

Question Number	Description	Marks	Total Marks
1	MODULE I	15	15
2	MODULE II	15	15
3	MODULE III	15	15
4	MODULE IV	15	15
5	MODULE I,II,III,IV	15	15
		Total Marks	**75**

SVKM's Mithibai College of Arts, Chauhan Institute of Science & Amrutben Jivanlal College of Commerce & Economics (AUTONOMOUS)

DEPARTMENT OF MATHEMATICS

M.Sc. SEMESTER II

Program:M.Sc.(2021-22)				**Semester: II**	
Course: ALGEBRA II				**Course Code: PSMAMT201**	
Teaching Scheme				**Evaluation Scheme**	
Lecture (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks - 25)**	**Semester End Examinations (SEE) (Marks- 75 in Question Paper)**
4	NIL	1	5	25	75

Learning Objectives:

(1) Give the students a sufficient knowledge of fundamental principles, mathematical ideas and how to use them to study pure theory

(2) Develop the logical thought process which can be applied in various streams

Course Outcomes:

After completion of the course, learners would be able to:

CO1: Recall the definitions of groups ,rings, functions and also examples of groups and rings (Understanding)

CO2:apply Sylow theorem ,class equation and Cauchy theorem to derive the logical solution which lead to properties of Abelian and nonabelian group (Application)

CO3:Examine the properties of Ideals-Maximal and Prime ideals to evaluate the properties of quotient rings and field (Evaluation)

CO4:develop the concepts of ordered integral domains and Unique Factorization Domains (Understanding)

CO5:inter relate Orbit theory of groups (groups acting on set) with application of probability theory (Application)

CO6:explore the ideas which relates vector spaces over the field with extension field (Analysis)

Outline of Syllabus: (per session plan)

Module	**Description**	**No of Hours**
1	Groups, group Homomorphisms	**15**
2	Groups acting on sets, Sylow theorems	**15**
3	Rings, Fields	**15**
4	Divisibility in integral domains	**15**
	Total	**60**

Unit	Topic	No. of Hours/Credits
Module 1	Review: Groups, subgroups, normal subgroups, center Z(G) of a group. The kernel of a homomorphism is a normal subgroup. Cyclic groups. Lagrange's theorem. The product set HK := {hk |h ∈ H & k ∈ K} of two subgroups of a group G. Examples of groups such as Permutation groups, Dihedral groups, Matrix groups, Un−the group of units of Zn (no questions be asked). Quotient groups. First Isomorphism Theorem and the following two applications (reference: Algebra by Michael Artin) 1. Let C∗ be the multiplicative group of non-zero complex numbers and R>0 be the multiplicative group of positive real numbers. Then the quotient group C∗/U is isomorphic to R>0. 2. The quotient group GLn(R)/SLn(R) is isomorphic to the multiplicative group of non-zero real numbers R∗. Second and third isomorphism theorems for groups, applications. Product of groups. The group Zm × Zn is isomorphic to Zmn if and only if the g.c.d. of m and n is 1. Internal direct product (A group G is an internal direct product of two normal subgroups H,K if G = HK and every g ∈ G can be written as g = hk where h ∈ H,k ∈ K in a unique way). If H,K are two finite subgroups of a group, then are two normal subgroups of a group G such that H ∩ K = {e} and HK = G, then G is internal direct product of H and K. If a group G is an internal direct product of two normal subgroups H and K, then G is isomorphic to H × K. (Ref: Algebra by Michael Artin) Automorphisms of a group. If G is a group, then A (G), the set of all automorphisms of G, is a group under composition. If G is a finite cyclic group of order r, then A (G) is isomorphic to Ur, the groups of all units of Zr under multiplication modulo r. For the infinite cyclic group Z, A (Z) is isomorphic to Z2. Inner automorphisms of a group. Topics in Algebra by I.N.Herstein). Structure theorem of Abelian groups(statement only) and applications (ref: A first Course in Abstract Algebra by J. B. Fraleigh,)	**15**
Module 2	Center of a group, centralizer or normalizer N(a) of an element a ∈ G, conjugacy class C(a) of a in G. In finite group G, |C(a)| = o(G)/o(N(a)) and where the summation is over one element in each conjugacy class, applications such as: (1) If G is a group of order pn where p is a prime number, then Z(G) 6= {e}. (2) Any group of order p2, where p is a prime number, is Abelian (Reference: Topics in Algebra by	**15**

	I.N.Herstein). Groups acting on sets, Class equation, Cauchy's theorem: If p is a prime number and p|o(G) where G is finite group,then G has an element of order p. (Reference: Topics in Algebra by I.N.Herstein). p-groups, Syllow's theorems and applications: 1. There are exactly two isomorphism classes of groups of order 6. 2. Any group of order 15 is cyclic (Reference for Syllow's theorems and applications: Algebra by Michael Artin).	
Module 3	Review: Rings (with unity), ideals, quotient rings, prime ideals, maximal ideals, ring homomorphisms, characteristic of a ring, first and second Isomorphism theorems for rings, correspondence theorem for rings (If f : R−→R0 is a surjective ring homomorphism, then there is a 1−1 correspondence between the ideals of R containing the kerf and the ideals of R0). Integral domains, construction of the quotient field of an integral domain. (no questions be asked). For a commutative ring R with unity: 1. An ideal M of R is a maximal ideal if and only if the quotient ring R/M is a field. 2. An ideal N of R is a prime ideal if and only if the quotient ring R/M is an integral domain. 3. Every maximal ideal is a prime ideal. Definition of field, characteristic of a field, subfield of a field. A field contains a subfield isomorphic to Zp or Q. Polynomial ring F[X] over a field, irreducible polynomials over a field. Prime ideals, and maximal ideals of a Polynomial ring F[X] over a field F. A non-constant polynomial p(X) is irreducible in a polynomial ring F[X] over a field F if and only if the ideal (p(X)) is a maximal ideal of F[X]. Unique Factorization Theorem for polynomials over a field (statement only). Definition of field extension, algebraic elements, minimal polynomial of an algebraic element, extension of a field obtained by adjoining one algebraic element. Kronecker's theorem: Let F be any field and let f(X) ∈ F[X] be such that f(X) has no root in F. Then there exists a field E containing F as a subfield such that f has a root in E. Application of Kronecker's theorem: Let F be any field and let f(X) ∈ F[X]. Then there exists a field E containing F as a subfield such that f(X) factorises completely into linear factors in E[X]. (reference: Rings, fields and Groups, An Introduction to Abstract Algebra by R.B.J.T. Allenby). Finite fields: A finite field of characteristic p contains exactly pn elements for some n ∈ N. Existence result for finite fields: For every prime number p and positive integer n, there exists a filed with exactly pn elements (reference: Rings, fields and Groups, An Introduction to Abstract Algebra by R.B.J.T. Allenby).	**15**

Module 4	Prime elements, irreducible elements, Unique Factorization Domains, Principle Ideal Domains, Gauss's lemma, Z[X] is a UFD, irreducibility criterion, Eisenstein's criterion, Euclidean domains. $Z[\sqrt{-5}]$ is not a UFD. Reference for Unit IV:, Michael Artin: Algebra Prentice-Hall India.	15

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

Suggested Readings

Main Reference books

1. David Dummit, Richard Foot: *Abstract Algebra*, Wiley-India.

Reference books

1. Michael Artin: Algebra.
2. An Introduction to Abstract Algebra by R.B.J.T. Allenby
3 : A first Course in Abstract Algebra by J. B. Fraleigh,
4. R.B.J.T. Allenby: *Rings, fields and Groups, An Introduction to Abstract Algebra*, Elsevier (Indian edition).

<table>
<tr><td colspan="4">Program: M.Sc . (2021-22)</td><td colspan="2">Semester: II</td></tr>
<tr><td colspan="4">Course: Topology</td><td colspan="2">Course Code: PSMAMT 202</td></tr>
<tr><td colspan="4">Teaching Scheme</td><td colspan="2">Evaluation Scheme</td></tr>
<tr><td>Lecture (Hours per week)</td><td>Practical (Hours per week)</td><td>Tutorial (Hours per week)</td><td>Credit</td><td>Continuous Assessment (CA) (Marks - 25)</td><td>Semester End Examinations (SEE) (Marks- 75 in Question Paper)</td></tr>
<tr><td>4</td><td>0</td><td>1</td><td>5</td><td>25</td><td>75</td></tr>
<tr><td colspan="6">Learning Objectives:
(1) Give the students a sufficient knowledge of fundamental principles of Topology
(2) Reflecting the broad nature of the subject and developing mathematical tools for continuing further study in various fields of science.</td></tr>
</table>

Course Outcomes:

After completion of the course, learners would be able to:

CO1: Students will learn about Topological spaces , subspace topology, Basis of topological spaces .

CO2: Knowledge about connected topological spaces, path- connected topological spaces will be gained.

CO3: Understanding of Countability Axioms , Separation axioms, separable spaces , Lindeloff spaces , second countable spaces will be achieved.

CO4: Learn about Compact spaces, Limit point compact spaces , Compactification

CO5: Students will be introduced to concepts such as Complete metric spaces, total boundedness

CO6:. Students will be able to apply concepts of Uniform Continuity , Lebesgue covering lemma.

Outline of Syllabus: (per session plan)

Module	Description	No of Hours
1	Topological spaces	**15**
2	Connected and compact topological spaces	**15**
3	Countability and separation axiom	**15**
4	Compact metric spaces, Complete metric spaces	**15**
	Total	**60**
PRACTICALS		

Unit	Topic	No. of Hours/Credits
Module 1	Topological spaces, basis, sub-basis, product topology (finite factors only), subspace topology, closure, interior, continuous functions, T_1,T_2 spaces, quotient spaces. Homeomorphism with illustration Topological properties of Pasting lemma, characterization of continuous function(closed set, closure and interior) Heredatary property	**15**

Module 2	Connected topological spaces, path-connected topological spaces, continuity and connectedness, Connected components of a topological space, Path components of a topological space. Compact spaces, limit point compact spaces, continuity and compactness, tube lemma, compactness and product topology (finite factors only), local compactness, one point compactification.	**15**
Module 3	Countability Axioms, Separation Axioms, Separable spaces, Lindeloff spaces, Second countable spaces. A compact T_2 space is regular and normal space.	**15**
Module 4	Complete metric spaces, Completion of a metric space, total boundedness , compactness in Metric spaces, sequentially compact metric spaces, uniform continuity, Lebesgue covering lemma. Arzela Ascoli theorem	**15**

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

Suggested Readings

Main Reference books

1. James Munkres: Topology, Pearson

Reference Books

2. George Simmons: Topology and Modern Analysis, Tata Mcgraw-Hill.
3. M.A.Armstrong: Basic Topology, Springer UTM.

SVKM's Mithibai College of Arts, Chauhan Institute of Science & Amrutben Jivanlal College of Commerce & Economics (AUTONOMOUS)

Program: M.Sc . (2021-22)					**Semester: II**
Course: Analysis II					**Course Code: PSMAMT 203**
Teaching Scheme				**Evaluation Scheme**	
Lecture (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks - 25)**	**Semester End Examinations (SEE) (Marks- 75 in Question Paper)**
4	0	1	5	25	75

Learning Objectives:

(1) Give the students a sufficient knowledge of fundamental principles of Measure theory

(2) Reflecting the broad nature of the subject and developing mathematical tools for continuing further study in various fields of science.

Course Outcomes:

After completion of the course, learners would be able to:

CO1:Student will understand concept of Lebesgue's outer measure , Measurable sets.

CO2 : Learn about Measurable functions , simple functions, properties of measurable functions.

CO3: Knowledge about integral of non-negative simple measurable function will be gained .

CO4: Student will learn to evaluate Lebesgue measure of various set.

CO5: Knowledge about various important theorems such as Dominated convergence theorem , Fatous lemma,

Monotone convergence theorem will be gained.

CO6: Understand the concepts of signed measures, Hann Decomposition Theorem, Radon- Nykodym Theorem.

Outline of Syllabus: (per session plan)

Module	**Description**	**No of Hours**
1	Measures	**15**
2	Measurable functions and integration of non-negative functions	**15**
3	Dominated convergence theorem and $L^1(\mu)$, $L^2(\mu)$ spaces	**15**
4	Signed measures, Radon-Nykodym theorem	**15**
	Total	**60**
PRACTICALS		

Unit	**Topic**	**No. of Hours/Credits**
Module 1	Outer measure μ^*on a set X, μ^*-measurable subsets of X (A subset E of a set X with outer measure μ^* is said to be μ^*-measurable if $\mu^*(A) = \mu^*(A \cap E) + \mu^*(A \cap (X \setminus E)$ $\forall A \subseteq X$ (definition due to Carath´eodory)), the collection Σ of all μ^*-measurable subsets of X form a σ-algebra, measure space (X,Σ,μ). Volume $\lambda(I)$ of any rectangle in R^d Lebesgue's Outer measure m^* in R^d and results: 1. Lebesgue's Outer measure m^* is translation invariant. 2. 2. Let A,B be any two subsets of R^d with $d(A,B) > 0$. Then $m^*(A\cup B) = m^*(A)+m^*(B)$. 3. For any bounded interval I = (a,b) of R, $m^*(I) = b - a$. 4. For any interval I of R^d, $m^*(I) = \lambda(I)$. The σ-algebra M of all Lebesgue measurable subsets of R^d, the Lebesgue measure $m = m^*\|^M$ and the measure space (R^d,M,m). Existence of a subset of R which is not Lebesgue measurable.	**15**
Module 2	Measurable functions on (X,Σ,μ), simple functions, properties of measurable functions. If $f \geq 0$ is a measurable function, then there exists a monotone increasing sequence (s_n) of non-negative simple measurable functions converging to pointwise to the function f. Integral $R_X\ sd\mu$ of a non-negative simple measurable function s defined on the measure space (X,Σ,μ) and properties, integral of a non-negative measurable function, Monotone convergence theorem. If $f \geq 0$ and $g\ \geq 0$ are measurable functions, then $R_{X(f+g)d\mu} = R_{X\,f\,d\mu} + R_X$ $g\ d\mu$.	**15**

Module 3	Integrable functions with respect to a measure μ (A measurable function f defined on the measure space (X,Σ,μ) is is integrable (or summable) if $\int_X f^+ d\mu < \infty$ and $\int_X f^- d\mu < \infty$) and linearity properties. Fatous lemma, Dominated convergence theorem, Completeness of $L^1(\mu)$,$L^2(\mu)$. Lebesgue and Riemann integrals: A bounded real valued function on $[a,b]$ is Riemann integrable if and only if it is continuous at almost every point of $[a,b]$; in this case, its Riemann integral and Lebesgue integral coincide.	**15**
Module 4	Borel σ- algebra of $\mathbb{R}^d$. Any closed subset and any open subset of $\mathbb{R}^d$ is Lebesgue measurable. Every Borel set in $\mathbb{R}^d$ is Lebesgue measurable. For any bounded Lebesgue measurable subset E of $\mathbb{R}^d$, given any any $\epsilon > 0$ there exist a compact set K and open set U in $\mathbb{R}^d$ such that $K \subseteq E \subseteq U$ and $m(U\backslash K) < \epsilon$. For any Lebesgue measurable subset E of $\mathbb{R}^d$, there exist Borel sets F,G in $\mathbb{R}^d$ such that $F \subseteq E \subseteq G$ & $m(E \setminus F) = 0 = m(G \setminus E)$ Complex valued Lebesgue measurable functions on $\mathbb{R}^d$, Lebesgue integral of complex valued measurable functions, Approximation of Lebesgue integrable functions by continuous functions with compact support. Signed measures, positive measurable sets and negatives measurable sets for a signed measure. Notion of Absolutely continuity $\nu << \mu$ of a signed measure ν with respect to a positive measure μ, Hahn Decomposition theorem, Jordan Decomposition of a signed measure, examples. Radon-Nykodym theorem and Radon-Nykodym derivative.	**15**

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester.

Suggested Readings

Main Reference books

1. Andrew Browder, Mathematical Analysis, An introduction , Springer Undergraduate Texts in Mathematics.
2. H.L Royden, Real Analysis, PHI

Reference Books

3 Walter Rudin , Real and Complex Analysis, McGraw-Hill India ,1974.

4 Measure, Integral and Probability by M. Capinski and E.Kopp, Springer.

Program: M.Sc.				**Semester: II**	
Course: INTEGRAL TRANSFORM				**Course Code: PSMAMT 206**	
Teaching Scheme				**Evaluation Scheme**	
Lecture (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks - 25)**	**Semester End Examinations (SEE) (Marks- 75 in Question Paper)**
4	Nil	1	5	25	75

Learning Objectives:

1] Give the students ,sufficient knowledge of fundamental principles, methods and a clear perception of immense power of mathematical ideas and tools and know how to use them by modelling, solving and interpreting.

_2] It enables students to apply the various tools and techniques to solve ordinary and partial differential equation which has vast applications in electronics ,medical ,and social sciences etc.

Course Outcomes:

After completion of the course, learners would be able to:

CO1: Gain the knowledge of construction of various transforms like Laplace ,Fourier , Mellin and Z transform (Understanding)

CO2: Able to derive and analyze properties of transforms which can help to study the applications of it (Analysis).

CO3: Able to apply the tool, Fourier transforms to get the solution of initial and boundary value problems.(Application)

CO4: Able to apply the tool, Laplace and inverse Laplace transform to get the solutions of ODEs .(Application)

CO5: Able to compute the solutions of difference equations using Z-transform (Evaluation)

CO6: Understand and can explain the Relationship of Fourier and Laplace Transform .(Analysis)

Outline of Syllabus: (per session plan)

Module	**Description**	**No of Hours**

1	**Laplace Transform**	**15**
2	**Fourier Transform**	**15**
3	**Mellin Transform**	**15**
4	**Z-Transform**	**15**
	Total	**60**
PRACTICALS		

Unit	Topic	No. of Hours/Credits
Module 1	Definition of Laplace Transform, Laplace transforms of some elementary functions, Properties of Laplace transform, Laplace transform of the derivative of a function, Inverse Laplace Transform, Properties of Inverse Laplace Transform, Inverse Laplace Transform of derivatives, Convolution Theorem, Heaviside's expansion theorem, Application of Laplace transform to solutions of ODEs	**15**
Module 2	Fourier Integral theorem, Properties of Fourier Transform, Inverse Fourier Transform, Convolution Theorem, Fourier Transform of the derivatives of functions, Parseval's Identity, Relationship of Fourier and Laplace Transform, Application of Fourier transforms to the solution of initial and boundary value problems.	**15**
Module 3	Properties and evaluation of Mellin transforms, Convolution theorem for Mellin transform, Complex variable method and applications	**15**

Module 4	Definition of Z-transform, Inversion of the Z-transform, Solutions of difference equations using Z-transform	15

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

Suggested Readings

Main Reference books

1. Brian Davies, Integral transforms and their Applications, Springer.

2. L. Andrews and B. Shivamogg, Integral Transforms for Engineers,Prentice Hall of India.

Reference Books

1. I.N.Sneddon, Use of Integral Transforms, Tata-McGraw Hill.

2. R. Bracemell, Fourier Transform and its Applications, MacDraw hill.

Program: M.Sc (2021-22)				**Semester: II**	
Course: Probability Theory				**Course Code:PSMAMT 205**	
Teaching Scheme				**Evaluation Scheme**	
Lecture (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks - 25)**	**Semester End Examinations (SEE) (Marks- 75 in Question Paper)**
4	Nil	nil	4	25	75

Learning Objectives:

Student will be able to learn
1.Concept of probability and theorems
2 Field and sigma field
3.Conditional probability and Byes theorem
4.Random variable and expectations
5.Characteristics functions of probability distribution

Course Outcomes:

After completion of the course, learners would be able to:

- **CO1:** Recall the definition of probability and set functions
- **CO2:** Differentiate between probability and conditional probability and compute according to the requirement
- **CO3:** Understand the definition of random variables, their types and related concepts
- **CO4:** Detect the different probability distributions which are widely used
- **CO5:** Apply the techniques to prove the properties of probability and related distributions
- **CO6**: Analyze characteristic functions

Outline of Syllabus: (per session plan)

Module	Description	No of Hours
1	Basics of Probability	**15**
2	Probability measure	**15**
3	Random variables	**15**
4	Limit theorems	**15**
	Total	**60**
PRACTICALS		

Unit	Topic	No. of Hours/Credits
Module 1	Modelling Random Experiments: Introduction to probability, probability space, events. Classical probability spaces: uniform probability measure, fields, finite fields, finitely additive probability, Inclusion-exclusion principle, σ-fields, σ-fields generated by a family of sets, σ-field of Borel sets, Limit superior and limit inferior for a sequence of events.	**15**
Module 2	Probability measure, Continuity of probabilities, First Borel-Cantelli lemma, Discussion of Lebesgue measure on σ-field of Borel subsets of assuming its existence, Discussion of Lebesgue integral for non-negative Borel functions assuming its construction. Discrete and absolutely continuous probability measures, conditional probability, total probability formula, Bayes formula, Independent events.	**15**
Module 3	Random variables, simple random variables, discrete and absolutely continuous random variables, distribution of a random variable, distribution function of a random variable, Bernoulli, Binomial, Poisson and Normal distributions, Independent random variables, Expectation and variance of random variables both discrete and absolutely continuous.	**15**
Module 4	Conditional expectations and their properties, characteristic functions, examples, Higher moments examples, Chebyshev inequality, Weak law of large numbers, Convergence of random variables, Kolmogorov strong law of large numbers (statement only), Central limit theorem (statement only).	**15**

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

Suggested Readings

Main Reference Books

1. M. Capinski, Tomasz Zastawniak: Probability Through Problems.

Reference Books

1 J. F. Rosenthal: A First Look at Rigorous Probability Theory, World Scientific.
2. Kai Lai Chung, Farid AitSahlia: Elementary Probability Theory, Springer Verla