

UNIVERSITY OF MADRAS
M.Sc. DEGREE PROGRAMME IN PHYSICS
SYLLABUS WITH EFFECT FROM 2023-2024

Paper-1 - MATHEMATICAL PHYSICS		I YEAR - FIRST SEMESTER						
Subject Code	Subject Name	Category	L	T	P	Credits	Inst. Hours	Marks
429C1A	MATHEMATICAL PHYSICS	Core				4	6	75

Pre-Requisites

Knowledge of Matrices, vectors, differentiation, integration, differential equations

Learning Objectives

- To equip students with the mathematical techniques needed for understanding theoretical treatment in different courses taught in their program
- To extend their manipulative skills to apply mathematical techniques in their fields
- To help students apply Mathematics in solving problems of Physics

UNITS	Course Details
UNITI: LINEAR VECTOR SPACE	Basic concepts – Definitions- examples of vector space – Linear independence - Scalar product- Orthogonality – Gram-Schmidt orthogonalization procedure – linear operators – Dual space- ket and bra notation – orthogonal basis – change of basis – Isomorphism of vector space – projection operator –Eigen values and Eigen functions – Direct sum and invariant subspace – orthogonal transformations and rotation
UNITII: COMPLEX ANALYSIS	Review of Complex Numbers -de Moivre's theorem-Functions of a Complex Variable- Differentiability -Analytic functions- Harmonic Functions- Complex Integration- Contour Integration, Cauchy – Riemann conditions – Singular points – Cauchy's Integral Theorem and integral Formula -Taylor's Series - Laurent's Expansion- Zeros and poles – Residue theorem and its Application: Potential theory - (1) Electrostatic fields and complex potentials - Parallel plates, coaxial cylinders and an annular region (2) Heat problems - Parallel plates and coaxial cylinders
UNITIII: MATRICES	Types of Matrices and their properties, Rank of a Matrix -Conjugate of a matrix - Adjoint of a matrix - Inverse of a matrix - Hermitian and Unitary Matrices - Trace of a matrix- Transformation of matrices - Characteristic equation - Eigen values and Eigen vectors - Cayley-Hamilton theorem –Diagonalization

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UNIT IV: FOURIER TRANSFORMS & LAPLACE TRANSFORMS	<p>Definitions -Fourier transform and its inverse - Transform of Gaussian function and Dirac delta function -Fourier transform of derivatives - Cosine and sine transforms - Convolution theorem. Application: Diffusion equation: Flow of heat in an infinite and in a semi - infinite medium - Wave equation: Vibration of an infinite string and of a semi - infinite string.</p> <p>Laplace transform and its inverse - Transforms of derivatives and integrals – Differentiation and integration of transforms - Dirac delta functions - Application - Laplace equation: Potential problem in a semi - infinite strip</p>
UNIT V: DIFFERENTIAL EQUATIONS	<p>Second order differential equation- Sturm-Liouville's theory - Series solution with simple examples - Hermite polynomials - Generating function - Orthogonality properties - Recurrence relations – Legendre polynomials - Generating function - Rodrigue formula – Orthogonality properties - Dirac delta function- One dimensional Green's function and Reciprocity theorem - Sturm-Liouville's type equation in one dimension & their Green's function.</p>
UNIT VI: PROFESSIONAL COMPONENTS	<p>Expert Lectures, Online Seminars - Webinars on Industrial Interactions/Visits, Competitive Examinations, Employable and Communication Skill Enhancement, Social Accountability and Patriotism</p>
TEXT BOOKS	<ol style="list-style-type: none"> 1. George Arfken and Hans J Weber, 2012, <i>Mathematical Methods for Physicists – A Comprehensive Guide</i> (7th edition), Academic press. 2. P.K. Chattopadhyay, 2013, <i>Mathematical Physics</i> (2nd edition), New Age, New Delhi 3. A W Joshi, 2017, <i>Matrices and Tensors in Physics</i>, 4th Edition (Paperback), New Age International Pvt.Ltd., India 4. B. D. Gupta, 2009, <i>Mathematical Physics</i> (4th edition), VikasPublishing House, New Delhi. 5. H. K. Dass and Dr. Rama Verma, 2014, <i>Mathematical Physics</i>, Seventh Revised Edition, S. Chand & Company Pvt. Ltd., New Delhi.
REFERENCEBOOKS	<ol style="list-style-type: none"> 1. E. Kreyszig, 1983, <i>Advanced Engineering Mathematics</i>, Wiley Eastern, New Delhi, 2. D. G. Zill and M. R. Cullen, 2006, <i>Advanced Engineering Mathematics</i>, 3rd Ed. Narosa, New Delhi. 3. S. Lipschutz, 1987, <i>Linear Algebra</i>, Schaum's Series, McGraw - Hill, New York 3. E. Butkov, 1968, <i>Mathematical Physics</i> Addison - Wesley, Reading, Massachusetts. 4. P. R. Halmos, 1965, <i>Finite Dimensional Vector Spaces</i>, 2nd Edition,

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	Affiliated EastWest, New Delhi. 5. C. R. Wylie and L. C. Barrett, 1995, Advanced Engineering Mathematics, 6 th Edition, International Edition, McGraw-Hill, New York
WEB SOURCES	1. www.khanacademy.org 2. https://youtu.be/LZnRIOA1_2I 3. http://hyperphysics.phy-astr.gsu.edu/hbase/hmat.html#hmath 4. https://www.youtube.com/watch?v=2jymuM7OUU&list=PLhkiT_RYTEU27vS_SIED56gNjVJGO2qaZ 5. https://archive.nptel.ac.in/courses/115/106/115106086/

COURSEOUTCOMES:

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

CO1	Understand use of bra-ket vector notation and explain the meaning of complete orthonormal set of basis vectors, and transformations and be able to apply them	K1, K2
CO2	Able to understand analytic functions, do complex integration, by applying Cauchy Integral Formula. Able to compute many real integrals and infinite sums via complex integration.	K2, K3
CO3	Analyze characteristics of matrices and its different types, and the process of diagonalization.	K4
CO4	Solve equations using Laplace transform and analyze the Fourier transformations of different function, grasp how these transformations can speed up analysis and correlate their importance in technology	K4, K5
CO5	To find the solutions for physical problems using linear differential equations and to solve boundary value problems using Green's function. Apply special functions in computation of solutions to real world problems	K2, K5
K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 – Evaluate		

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MAPPING WITH PROGRAM OUTCOMES:

Map course outcomes (**CO**) for each course with program outcomes (**PO**) and program specific outcomes (**PSO**) in the 3-point scale of STRONG(3), MEDIUM(2) and LOW(1).

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	3	3	3	3	2	3	2
CO2	2	3	3	3	3	3	3	2	2	2
CO3	3	3	3	2	2	3	3	2	3	2
CO4	3	3	3	3	2	3	3	2	2	2
CO5	3	2	3	3	2	3	3	2	2	3

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO1	3	3	3	3	3	3	3	2	3	2
CO2	2	3	3	3	3	3	3	2	2	2
CO3	3	3	3	2	2	3	3	2	3	2
CO4	3	3	3	3	2	3	3	2	2	2
CO5	3	2	3	3	2	3	3	2	2	3