Subject: Physics
Semester: Four
Course Name: Mathematical Physics
Existing Base Syllabus: HS Mathematics
Course Level: PHY254
Syllabus showing each unit against class number and marks

Unit no.	Unit content	No. of classes	Marks/Credit
Theory			
Unit I: Partial Differential Equations	Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. Wave equation and its solution for vibrational modes of a stretched string, rectangular and circular membranes.	10	Credit - 3
Unit II: Fourier Series	Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Complex representation of Fourier series. Application to square and triangular waves.	7	
Unit III: Complex Analysis	Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles and branch points, order of singularity. Integration of functions with complex variable. Cauchy's Integral theorem and Cauchy's Integral formula. Simply and multiply connected regions. Laurent and Taylor's series expansions. Residue Theorem with application.	17	
Unit IV: Tensor Algebra	Introduction to tensor, Transformation of co-ordinates, Einstein's summation convention. Contravariant, covariant and mixed tensors. Symmetric and antisymmetric tensors, Kronecker delta, LeviCivita tensor. Quotient law of tensors. Rules of combination of tensors: addition, subtraction, outer multiplication, contraction and inner multiplication.	6	
Unit V: Introduction to Probability	Independent random variables: Probability distribution functions; binomial, Gaussian and Poisson, with examples. Mean and variance.	5	
Laboratory			

<u>At least four from the following:</u>

<div align="right">Credit-1</div>

1. Solve the differential equations

   $\frac{dy}{dx} = e^x$ with $y = 0$ for $x = 0$

   $$\frac{dy}{dx} + e^{-x}y = x^2$$

   $$\frac{d^2y}{dx^2} + 2\frac{dy}{dx} = -y$$

   $$\frac{d^2y}{dx^2} + e^{-x}\frac{dy}{dx} = -y$$

2. Perform the multiplication of two 3×3 matrices.

3. Compute the eigenvalues and eigenvectors of the following matrices.

   $$\begin{bmatrix} 4 & 3 & 7 \\ 1 & 2 & 7 \\ 2 & 0 & 4 \end{bmatrix}, \quad \begin{bmatrix} 1 & -i & 3+4i \\ i & 2 & 4 \\ 3-4i & 4 & 3 \end{bmatrix},$$

   $$\begin{bmatrix} 2 & -i & 2i \\ i & 4 & 3 \\ -2i & 3 & 5 \end{bmatrix}$$

4. Using random number compute the areas of circle, square, volume of sphere and value of pi (π).

5. Evaluate trigonometric functions e.g. *sinθ; cosθ; tanθ* etc. using Interpolation by Newton Gregory Forward and Backward difference formula.

6. Find the solution of Partial Differential Equations: (a) Wave equation (b) Heat equation.

7. Evaluate the integral *I*,where,

   $I = \frac{1}{\sqrt{2\pi\sigma^2}} \int exp\left[\frac{(x-2)^2}{2\sigma^2}\right](x+3)dx$ for $\sigma = 1.0, 0.1, 0.01$ and show that $I \to 5$

8. Compute the *n*th roots of unity for $n = 2, 3,$ and 4.

9. Find the two square roots of $5 + 12i$.

Reading list

1. Mathematical Physics; H K Dass and R Verma, S Chand and Company limited.
2. Mathematical methods for Physics and Engineering; K. F Riley, M. P Hobson, S.J Bence, Cambridge University Press.
3. Graduate Mathematical Physics (With Mathematica Supplement); J J Kelly, Willey-VCH VerlagGmbH and Co. KGaA.
4. Mathematical Methods for Physicists; G. B. Arfken, H. J. Weber and F.E. Harris, Elsevier.
5. Ordinary and Partial Differential equations; M. D Raisinghania, S. Chand and Company Ltd.
6. Complex Variables; M R Spiegel,S Lipschutz, J J Schiller and D Spellman, Schaum's Outline Series, McGraw Hill Education.
7. Complex variables Demystified (A self-teaching guide); D McMahan, McGraw Hill Education.
8. A Student's Guide to vectors and Tensors; D A Fleisch, Cambridge University Press.
9. Vector analysis and an introduction to Tensor analysis; S Lipschutz, D Spellman, M R Spiegel, Schaum's Outline Series, McGraw Hill Education.
10. Tensors and applications with Scilab Programs; N D Soni, I.K International Publishing House Pvt. Limited.
11. Probability and Statistics; M R Spiegel, J J Schiller and R A Srinivasan, Schaum's Outline Series, McGraw Hill Education.

Graduate Attributes

i. Course Objective

➢ To solve partial differential equations using separation of variables, including Laplace's equation and the wave equation.
➢ To apply Fourier series expansion to represent periodic functions using sine and cosine functions.
➢ To understand complex analysis principles, including analytic functions, integration and residue theorem.
➢ To develop proficiency in tensor algebra, covering transformations, contravariant and covariant tensors and tensor algebra.
➢ To gain a preliminary knowledge to probability theory, focusing on independent random variables, probability distributions, and mean and variance calculations.

ii. Learning outcome

On successful completion of the course, the students will be equipped with the techniques related to solving partial differential equations using separation of variables method, application of Fourier series analysis, solving complex integrations, dealing with tensors and probability distributions which are relevant while dealing with wave mechanics, electrodynamics, quantum mechanics, theory of relativity and experimental physics.

Theory Credit: 03 (Three)

Practical Credit: 01 (One)

No. of Required Classes: 45

No. of Contact Classes: 45

No. of Non-Contact Classes:

Particulars of Course Designer (Name, Institution, email id):

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