STELLA MARIS COLLEGE (AUTONOMOUS), CHENNAI - 600086

M.Sc. DEGREE: BRANCH III- PHYSICS

SYLLABUS
(Effective from the academic year 2019–2020)

MATHEMATICAL PHYSICS I

CODE:19PH/PC/MP14 **CREDITS:4**
L T P:4 1 0
TOTAL TEACHING HOURS:65

OBJECTIVES OF THE COURSE

- The foundations to various mathematical techniques and tools like numerical methods, transform techniques and special functions which forms the back bone of all higher physics is introduced.

COURSE LEARNING OUTCOMES

On successful completion of the course, students will be able to

- Explain the main mathematical methods used in physics.
- Understand the fundamentals of Numerical and Complex Analysis
- Be familiar with important special functions in mathematical physics including Legendre Polynomial and Bessel function
- Master the tools from vector and tensor analysis that are important prerequisites for other theoretical physics courses like electrodynamics or continuum mechanics.
- Demonstrate accurate and efficient use of specific mathematical physics techniques

Unit 1

Numerical analysis **(13 Hours)**

Finite differences – Newton Gregory formula – Interpolation and extrapolation – Numerical differentiation - Numerical integration –Simpson's one third rule - Solution of ordinary differential equations: Euler method - Euler modified method – Runge - Kutta method (2^{nd} order) – Newton Raphson method – method of iterations (forward and backward iterations) – method of Least squares.

Unit 2

Complex Analysis **(13 Hours)**

Functions of a complex variable - Analytic function - Cauchy - Riemann equations - Laplace equation and harmonic function - Line integral in complex plane - Cauchy's theorem - multiply connected regions - Cauchy integral formula - Derivatives of analytic function - Taylor and Laurent series - Singularities - Residue theorem

Unit 3

Linear vector Space **(13 Hours)**

Basic concepts – Expansion theorem – Inner product and unitary spaces – Orthonormal sets – Schmidt orthogonalization procedure – Completeness – Applications to Hydrodynamics , Heat flow in solids, Gravitation and Electromagnetic field – Dual space: ket and bra notation – basis – orthogonal basis –

change of basis – Isomorphism of vector spaces – projection operator – Eigen values and eigen functions – Direct sum and invariant subspaces – orthogonal transformations and rotations

Unit 4

Tensor Analysis **(13 Hours)**

Tensors in Physics - Notation and conventions - Contra and covariant tensors of rank one and two - Algebra of tensors - outer and inner products - Contraction - Symmetric and anti symmetric tensors - Quotient law - Conjugate tensors - Metric tensor - Raising and lowering of indices Cartesian tensors - Rotation and translation – Orthogonal transformations - Transformation of divergence and curl of vectors - Stress, strain and Hooke's law – Tensors in dynamics, in elasticity and in rigid bodies - Moment of inertia tensor

Unit 5

Special Functions – I **(13 Hours)**

Series solution with simple examples - Gamma and Beta functions - Properties - Legendre polynomial and function - Generating function - Rodrigue formula – Orthogonality property - Associated Legendre function - Recurrence relations - spherical harmonics - Graphs of Legendre functions - Bessel function - Generating function – Hankel function - Recurrence relations - Spherical Bessel function - Graphs - Orthonormality relation

BOOKS FOR STUDY:

H.K.Dass, *Mathematical Physics*, S. Chand & Company Limited (2010) (Unit 1 Ch 13 and Unit 2 and 3)

Sathyaprakash, *Mathematical Physics with Classical Mechanics* Sultan Chand & Sons 2014 (Unit 4 and 5)

BOOKS FOR REFERENCE

Louis Albert Pipes, Lawrence R. Harvill, *Applied mathematics for engineers and physicist*, 3rd Edition, McGraw - Hill (1970)

Greenberg, *Advanced Engineering Mathematics*, 2nd Edition, Pearson Education India (1998)

Isaac A. Thangapandi Somasundaram A. Arumugam S, .*Engineering mathematics*, Vol I - III, 1st edition - Scitech Publications (India) Pvt. Ltd

George Arfken, Hans-Jurgen Weber, *Mathematical Methods for Physicists*, 6th Edition, Academic Press, (2003)

K. F. Riley, M. P. Hobson, S. J. Bence, *Mathematical Methods for Physics and Engineering: A Comprehensive Guide*, 3rd Edition, Cambridge University Press(2006)

Mary L. Boas, *Mathematical Methods in the Physical Sciences*, 3rd Edition, Wiley, (2006)

Nikolaĭ Nikolaevich Lebedev, *Special Functions and Their Applications*, Courier Dover Publications, (1972)

PATTERN OF ASSESSMENT

Continuous Assessment Test: Total Marks: 50 Duration: 90 minutes
Section A – 5 x 3 =15
Section B – 4x5 = 20 (4 out of 6 to be answered)
Section C – 1x15 = 15 (1 out of 2 to be answered)

Other Components:
Presentation/Assignments/Problem solving/Quiz

End-Semester Examination: Total Marks: 100 Duration: 3 hours
Section A – 10 x 3 = 30 Marks (All questions to be answered)
Section B – 5 x 5 = 25 Marks (5 out of 7 to be answered)
Section C – 3 x 15 = 45 Marks (3 out of 5 to be answered)

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M.Sc. DEGREE: BRANCH III- PHYSICS

SYLLABUS

(Effective from the academic year 2019–2020)

MATHEMATICAL PHYSICS II

CODE:19PH/PC/MP24 **CREDITS:4**

L T P:4 1 0

TOTAL TEACHING HOURS:65

OBJECTIVES OF THE COURSE

- Advanced mathematical tools essential for various theoretical models in all branches of physics are introduced with aim to enable students solve problems.

COURSE LEARNING OUTCOMES

On successful completion of the course, students will be able to

- Express in depth understanding of the partial differential equations
- Be familiar with differential forms as tools that allow to solve physical problems with simplicity
- Acquire a basic knowledge of some advanced topics in Mathematical Physics, such as the elements of group theory
- Solve problems using special functions, such as Bessel functions and Legendre polynomials.
- Understand the applications of Fourier Transform in the field of Physics

Unit 1

Fourier Transform **(13 Hours)**

Fourier transform – properties – Convolution theorem - Transforms of derivatives – Finite Fourier transform - Laplace transform - properties Transforms of derivatives and integral - Periodic function - Special Function – Fourier Miller theorem – Convolution - Laplace transform and its inverse - Solution of differential equations.

Unit 2

Partial Differential Equations **(13 Hours)**

Introduction – Elliptic parabolic and hyperbolic equations - Solution of partial differential equations – Laplace equation – transformation – Solutions– Wave equation - Solutions involving boundary conditions – Two dimensional and Three dimensional equation - Wave equation in spherical and cylindrical coordinates – Heat conduction equation – One dimensional and Two dimensional equation with boundary conditions

Unit 3

Special Function – II **(13 Hours)**

Fuch's theorem – Hermite equations - Hermite polynomials - Generating function for $H_n(x)$ – Rodrique's formula for $H_n(x)$ – Bessel's equations – Recurrence formula for Bessel function - Orthogonality properties of Bessel function - Laguerre polynomials - Generating function for $L_n(x)$ - Rodrique's formula - Orthogonality properties - Recurrence relation

Unit 4

Group Theory **(13 Hours)**

Groups - Symmetry transformation of a square - Conjugate element and classes - multiplication of classes - Subgroups - cyclic group - Normal subgroups and factor groups - Direct product of groups - Isomorphism and homomorphism - Permutation groups – Distinct groups - representation theory of finite groups - Molecular point groups - irreducible representation of point groups – reducible representation - Schur's lemma and the orthogonality theorem - character of the representation - the example of C4V – irreducible representation and regular representation - Continuous groups and their representations - Lie groups - Axial rotation group SO (2) - Three dimensional rotation groups SO (3) and SU(2)

Unit 5

Probability **(13 Hours)**

Definitions - Laws of probability - Mean, Standard deviation – Poisson distribution - Binomial distribution - Normal distribution - Moments of distribution - Recurrence relations - Sampling of variables - Variance - The t-distribution - The Chi – Square distribution

BOOKS FOR STUDY:

A. B. Gupta *Fundamentals of Mathematical Physics,* Books & Allied Ltd 2013 Unit 2 (ch 5) Unit 3 (ch 8)

Sathyaprakash, *Mathematical Physics with Classical Mechanics,* Sultan Chand & Sons 2014 Unit 1 (ch 9) Unit 4 (ch 12)

Rao Sankara, *Introduction to Partial Differential Equations,* 2nd edition, Prentice – Hall of India(2005) (Unit 1 and 2)

Erwin Kreyszig, *Advanced Engineering Mathematics,* 10th Edition, John Wiley & Sons (2011)(partly for unit 1)

W. W. Bell, *Special functions for scientists and engineers*, Courier Dover Publications (2004)(Unit 3)

A.W. Joshi, *Elements of group theory for physicists,* 4th Edition, New Age International (2007) (Unit 4)

H.K.Dass, *Mathematical Physics*, S. Chand & Company Limited (2010) (Unit 5)

BOOKS FOR REFERENCE

Louis Albert Pipes, Lawrence R. Harvill, *Applied mathematics for engineers and physicists* 3rd Edition, McGraw - Hill (1970)

Greenberg, *Advanced Engineering Mathematics,* 2nd Edition, Pearson Education India (1998)

Isaac A. Thangapandi Somasundaram A. Arumugam S., *Engineering mathematics,* Vol I - III, 1st edition - Scitech Publications (India) Pvt. Ltd

Michael Tinkham, *Group theory and quantum mechanics,* Courier Dover Publications, Tata McGraw - Hill(2003)

George Arfken, Hans-Jurgen Weber, *Mathematical Methods for Physicists,* 6th Edition, Academic Press, (2003)

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Nikolaĭ Nikolaevich Lebedev, *Special Functions and Their Applications,* Courier Dover Publications, (1972)

Tulsi Dass, S.K. Sharma, *Mathematical Methods In Classical And Quantum Physics,* Universities Press,

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