Major Subjects Syllabus
(Credits: Theory-03, Practical-01)

UPHYMAJ 11001 (Theory): Mathematical Physics-I
45 Lectures; 3 Credits

Unit 1: Vector Algebra [10 hours]
Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product. Scalar triple product and their interpretation in terms of area and volume, respectively. Scalar and Vector fields.

Unit 2: Vector Calculus [12 hours]
Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities. Vector Integration: Ordinary Integrals of Vectors. Multiple integrals. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of vector fields. Flux of a vector field. Gauss's divergence theorem, Green's and Stokes Theorems and their applications.

Unit 3: Orthogonal Curvilinear Coordinates [8 hours]
Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.

Unit 4: Differential Equations [15 hours]
First Order and Second Order Differential equations: First Order Differential Equations and Integrating Factor. Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of existence and Uniqueness Theorem for initial value problems.

Reference Books:

- Mathematical Methods for Physicists, G. B. Arfken, H. J. Weber, F. E. Harris, 2013, Elsevier.
- An introduction to ordinary differential equations, E. A. Coddington, 2009, PHI learning.
- Differential Equations, George F. Simmons, 2007, McGraw Hill.
- Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
- Mathematical methods for Scientists and Engineers, D. A. McQuarrie, 2003, Viva Book.
- Advanced Engineering Mathematics, D. G. Zill and W. S. Wright, Jones and Bartlett Learning.
- Mathematical Physics, Goswami, 1st edition, Cengage Learning.
- Engineering Mathematics, S. Pal and S. C. Bhunia, 2015, Oxford University Press.
- Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
- Essential Mathematical Methods, K. F. Riley & M. P. Hobson, 2011, Cambridge Univ. Press.
- Mathematical methods in the Physical Sciences, M. L. Boas, 2005, Wiley.

UPHYMAJ 11001 (Practical): Mathematical Physics-I Lab
30 Lectures; Credit-1

Errors and Error Analysis in scientific computing:
Floating point numbers, single and double precision arithmetic, underflow & overflow. Truncation and round-off errors, Absolute and relative errors.

Introduction to programming in Python:
Introduction to programming: constants, variables and data types, dynamical typing, operators and expressions, modules, I/O statements, iterables, compound statements, indentation in python, the if-elif-else block, for and while loops, nested compound statements, lists, tuples, dictionaries and strings, basic file handling, basic ideas of object oriented programming.

Basic Programs in Python along with algorithms: (Without using any library function)

- Input a list of numbers and obtain their sum & average
- Finding odd/even from a list of numbers
- Find the largest / smallest number of the list and its location in the list
- Sorting a list of numbers in ascending and descending order
- Finding sum and product of a series (e.g. $\sum_n \quad n^2, \sum_i \quad x^i, \prod_n \quad x^n$, etc.)
- Simple problems in matrix: Addition, subtraction, multiplication, equality, etc.
- Dot product, cross product, triple product of vectors
- Verify vector identities
- Print the Fibonacci sequence, Factorial of Number
- Find the frequency of each element in an array, etc.
- Sort words in alphabetical order, Remove punctuation from a string, Reverse a string
- Convert list to string, Concatenate two strings

File handling tools may also be used for the above programs

Reference Books:

- Introduction to Numerical Analysis, S. S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
- Learning with Python-how to think like a computer scientist, J. Elkner, C. Meyer, and A. Downey, 2015, Dreamtech Press.
- Introduction to computation and programming using Python, J. Guttag, 2013, Prentice Hall India.
- Effective Computation in Physics- Field guide to research with Python, A. Scopatz and K. D. Huff, 2015, O'Rielly.
- A first course in Numerical Methods, U. M. Ascher & C. Greif, 2012, PHI Learning.
- Elementary Numerical Analysis, K. E. Atkinson, 3 rd Edn., 2007, Wiley India Edition.
- Numerical Methods for Scientists & Engineers, R. W. Hamming, 1973, Courier Dover Pub.
- An Introduction to Computational Physics, T. Pang, 2nd Edn., 2006,Cambridge Univ. Press.
- Computational Physics, Darren Walker, 1st Edn., 2015, Scientific International Pvt. Ltd.

UPHYMAJ 12002 (Theory): Mechanics -I

45 Lectures; 3 Credits

Unit 1: Fundamentals of Dynamics [9 hours]

Reference frames. Inertial frames – Review of Newton's laws of motion. Galilean transformations; Galilean invariance. Momentum of variable-mass system: motion of rocket. Dynamics of a system of particles – conservation of linear momentum, Centre of mass. Conservative and non-conservative forces. Potential energy. Stable and unstable equilibrium. Force as gradient of potential energy. Law of conservation of energy.

Unit 2: Rotational dynamics [10 hours]

Rotation about a fixed axis – Moment of Inertia, Kinetic energy, Angular momentum and Torque. Conservation of angular momentum. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. Motion involving both translation and rotation.

Unit 3: Elasticity [6 hours]

Hooke's law, Stress-strain diagram, Elastic moduli – relation between elastic constants, Poisson's ratio – expression of Poisson's ratio in terms of elastic constants. Work done in stretching and twisting a wire.

Unit 4: Gravitation and Central Force Motion [12 hours]

Law of gravitation. Gravitational potential energy, self-energy. Inertial and gravitational mass. Potential and field due to spherical shell and solid sphere. Motion of a particle under the central force field. Two-body problem, its reduction to one-body problem and its solution. Effective potential of a particle in gravitational field, Trajectory of a particle in inverse-square force potential. Kepler's laws. Escape velocity, satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness.

Unit 5: Non-Inertial Systems [8 hours]

Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of physics in rotating coordinate systems. Centrifugal force. Coriolis force and its applications. Components of Velocity and Acceleration in Cylindrical and Spherical Coordinate Systems.

Reference Books:

- An introduction to mechanics, D. Kleppner, R. J. Kolenkow, 1973, McGraw-Hill.
- Mechanics, Berkeley Physics, Vol.1, C. Kittel, W. Knight, et.al. 2007, Tata McGraw-Hill.
- Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
- Analytical Mechanics, G. R. Fowles and G. L. Cassiday. 2005, Cengage Learning.
- Feynman Lectures, Vol. I, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education
- Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.
- University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
- Mechanics, D. S. Mathur, S. Chand and Company Limited, 2000
- University Physics, F. W Sears, M. W Zemansky, H. D. Young 13/e, 1986, Addison Wesley

- Physics for scientists and Engineers with Modern Phys., J. W. Jewett, R. A. Serway, 2010, Cengage Learning
- Theoretical Mechanics, M. R. Spiegel, 2006, Tata McGraw Hill.

UPHYMAJ 12002 (Practical): Mechanics-I Lab

30 Lectures; Credit-1

1. Measurements of volume of a hollow cylinder using Vernier calipers, Screw gauge and Traveling microscope.
2. To determine the height of a building using a Sextant.
3. To study the motion of a spring and calculate (a) Spring Constant (b) Value of g.
4. To determine the Moment of Inertia of a Flywheel.
5. To determine g and velocity for a freely falling body using Digital Timing Technique.
6. To determine the moment of inertia of a) cylindrical, b) rectangular bar about an axis passing through its C.G. using static method.
7. To determine the moment of inertia of a) cylindrical, b) rectangular bar about an axis passing through its C.G. using dynamic method.
8. To determine the value of g by Bar Pendulum.
9. To determine the value of g by Kater's Pendulum.
10. Determination of rigidity modulus of the material of a wire by static method.
11. Determination of rigidity modulus of the material of a wire by dynamic method.
12. To determine the modulus of rigidity of a wire by Maxwell's needle.
13. To determine the Young's Modulus of a wire by Optical Lever method.
14. To determine the elastic constants of a wire by Searle's method.

Reference Books:

- Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
- Engineering Practical Physics, S. Panigrahi & B. Mallick,2015, Cengage Learning India Pvt. Ltd.
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
- Physics through experiments, B. Saraf, Vikas Publications, 2013
- A lab manual of Physics for undergraduate classes, 1st Edition, Vikas Publications.
- B.Sc. Practical Physics Revised Ed, C. L. Arora, S. Chand & Co. 2007