Special/Select Topics in Classical Mechanics - Video course

COURSE OUTLINE

This course has grown out of the first course in Physics taught to engineering students at IIT-Madras. However, the contents are expanded to include the interests of students of basic sciences and a strong emphasis on the foundations of classical mechanics is aimed at.

Essentially, foundations of ‘classical mechanics’ would include a comprehensive introduction to Newtonian, Lagrangian and Hamiltonian Mechaincs, and include an introduction to mechanics of a system of particles, fluid mechanics, introduction to ‘chaos’, to the special theory of relativity and also to electrodynamics.

The course is designed as the first course students would take after high school, and the scope of some of the advanced topics that are introduced is therefore restricted. A comfortable introduction, adequately rigorous but not overly involved, to advanced applications is attempted. In this course, we emphasize that ‘observation’ and ‘measurements’ play a fundamental role in Physics.

We introduce mathematical methods as and where needed, but keep the focus o n physical principles. The course aims, even as it will provide a rigorous introduction to the foundations of classical mechanics, at discovering the romance in physics, beauty in its simplicity, and rigor in its formulation.

COURSE DETAIL

The curriculum will be covered in Eleven Units spread over about 40 lecture hours.

Unit No.	Topic/s	Lectures
Unit 1	Equations of Motion. Principle of Causality and Newton’s I & II Laws. Interpretation of Newton’s 3rd Law as ‘conservation of momentum’ and its determination from translational symmetry. Alternative formulation of Mechanics via ‘Principle of Variation’. Determination of Physical Laws from Symmetry Principles, Symmetry and Conservation Laws. Lagrangian/Hamiltonain formulation. Application to SHO.	Unit 1: 1(Course Overview)+5 Lectures: L1 to L6
Unit 2	Oscillations. Small oscillations. SHM. Electromechanical analogues exhibiting SHM. Damped harmonic oscillator, types of damping. Driven and damped & driven harmonic oscillator. Resonance, Quality Factor. Waves.	Unit 2: 4 Lectures: L7 to L10

NP-TEL

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Physics

Additional Reading:

1. P. Chaitanya Das, G. Srinivasa Murthy, Gopal Pandurangan and **P. C. Deshmukh** , The real effects of pseudo-forces Resonance, Vol. 9, Number 6, 74 -85 (2004).
2. P. Chaitanya Das, G. Srinivasa Murty, K. Satish Kumar, T A. Venkatesh and **P. C. Deshmukh** , Motion of Charged Particles in Electromagnetic Fields and Special Theory of Relativity Resonance, Vol. 9, Number 7, 77-85 (2004).

Coordinators:

Unit 3	Polar coordinate systems.	Unit 3: 2 Lectures: L11,L12
Unit 4	Kepler Problem. Laplace-Runge-Lenz vector, 'Dynamical' symmetry. Relationship between 'Conservation principle' and 'Symmetry'.	Unit 4: 2 Lectures: L13,L14
Unit 5	Inertial and non-inertial reference frames. Pseudo forces.	Unit 5: 4 Lectures: L15 to L18
Unit 6	Galilean & Lorentz transformations. Special Theory of Relativity.	Unit 6: 4 Lectures: L19 to L22
Unit 7	Physical examples of fields. Potential energy function. Gradient, Directional Derivative, Divergence of a vector field.	Unit 7: 3 Lectures: L23 to L25
Unit 8	Gauss' Law; Equation of Continuity. Hydrodynamics and Electrodynamics illustrations.	Unit 8: 3 Lectures: L26 to L28
Unit 9	Fluid Flow, Bernoulli's Principle. Equation of motion for fluid flow. Definition of curl, vorticity, Irrotational flow and circulation. Steady flow. Bernoulli's principle, some illustrations. Applications of Gauss' divergence theorem and Stokes' theorem in fluid dynamics.	Unit 9: 2 Lectures: L29,L30
Unit 10	Classical Electrodynamics and the special theory of relativity. Introduction to Maxwell's equations.	Unit 10: 4 Lectures: L31 to L34
Unit 11	'Chaos', bifurcation, strange attractors, fractals, self-similarity, Mandelbrot sets.	Unit 11: 5 Lectures: L35 to L39 L40: Scope and Limitations of Classical Mechanics
Ilustrative Problem Sets for Tutorials that can be used for this course are available at:		

Prof. P.C. Deshmukh
ProfessorDepartment of PhysicsIIT Madras

http://www.physics.iitm.ac.in/~labs/amp/homepage/courses.html

References:

No single text covers the vast range of topics and the novel treatment of the subject material dealt with in this course. A very large number of books and original literature in Physics education journals (such American Journal of Physics) has been referred to develop the course contents. Useful sources include the following:

1. Fundamentals of Physics, Volume 1 David Halliday, Robert Resnick, and Jearl Walker. Hardcover, Wiley (2007).

2. The Feynman Lectures on Physics, Vol. I & II Richard P. Feynman, Robert B. Leighton, Matthew Sands. Hardcover, Addison Wesley; 2 edition (2005).

3. Mechanics (Berkeley Physics Course, Vol. I) Charles Kittel, Walter D. Knight, Malvin A. Ruderman, and A. Carl Helmholz. Hardcover, McGraw-Hill (1973).

4. 'Analytical Mechanics' Grant R. Fowles and George L. Cassiday (Brooks Cole; 7 edition, 2004).

5. John R. Taylor 'Classical Mechanics' University Science Books (January 1, 2005).

6. James Gleick: Chaos - making a new science William Heinemann Ltd. (1988, Great Britain).

7. David R. Griffiths Introduction to Electrodynamics (3rd Edition) (Benjamin Cummings, 1999).