MATH20512 - 2012/2013

General Information

- Title: Classical Mechanics
- Unit code: MATH20512
- Credit rating: 10
- Level: 2
- Pre-requisite units: MATH20401 or MATH20411
- Co-requisite units:
- School responsible: Mathematics
- Members of staff responsible: Dr. James Montaldi

Unit specification

Aims

The course aims to develop an understanding of how Newton's laws of motion can be used to describe the motion of particles and to introduce the rudiments of wave mechanics.

Brief description

The first part of the unit concerns the general description and analysis of the motion of particles acted on by forces. Assuming a basic familiarity with Newton's laws of motion and their application in simple situations, we shall develop the advanced techniques necessary for the study of more complicated systems. We shall also consider the beautiful generalizations of Newton's equations due to Lagrange and Hamilton, which allow for simplified treatments of many interesting problems and which provide the foundation for the modern understanding of dynamics. The second theme within the course aims to characterise and elucidate some of the physical properties of important types of wave motions and their mathematical descriptions . Waves occur everywhere in the physical world: from the small scale (e.g. ultrasonic waves in biomedical imaging) to the very large (such as ocean waves). This introductory course discusses a number of basic ideas fundamental to wave dynamics and offers a range of simple applications. The course is a useful primer to third and fourth level course units in physical applied mathematics.

Intended learning outcomes

On completion of this unit successful students will be able to:

- model simple mechanical systems, both in inertial and rotating frames, using Lagrange's equations;
- analyze the dynamics of systems near equilibrium; find the normal modes of oscillation;
- relate the Hamiltonian and Lagrangian approaches;

- understand the basics of waves in infinite 1-dimensional domains; determine the group and phase velocities of such waves.

Future topics requiring this course unit

Third and fourth level course units in physical applied mathematics.

Syllabus

1. **Newtonian Mechanics of Systems of Particles**.
   Review of Newton's laws; centre of mass; basic kinematic quantities: momentum, angular momentum and kinetic energy; circular motion; 2-body problem; conservation laws; reduction to centre of mass frame. [5]
2. **Lagrangian formulation of mechanics**.
   Lagrange's equations and their equivalence to Newton's equations, generalized coordinates; constraints; cyclic variables; examples. [5]
3. **Potential wells and oscillations**.
   Particle in a potential well; coupled harmonic oscillators; normal modes; wave equation on a finite string and Fourier modes. [4]
4. **Rotating Frames and the Rigid Body**.
   Rotating frames in 2-D; centrifugal and Coriolis forces; moments of inertia, parallel axes theorem. Rotations in 3-D; free rigid body rotation, Euler's equations. [4]
5. **Hamiltonian formulation**.
   Hamilton's equations, equivalence with Lagrangian formulation; canonical transformations in one degree of freedom, equilibria; stability; conserved quantities. [4]

Textbooks

- Classical Mechanics, by R.D. Gregory, CUP.
- Classical Mechanics, by T.W.B. Kibble. F. H. Berkshire, Addison Wesley Publishing Company

Learning and teaching processes

Two lectures and one examples class each week In addition students should expect to do at least four hours private study for this course unit.

Assessment

Coursework (worth 20%) set over the Easter vacation
End of semester examination (worth 80%).

Arrangements