

PH4038 - Lagrangian and Hamiltonian Dynamics

Credits:	15.0	Semester:	2
Number of Lectures:		Lecturer:	Dr Bernd Braunecker
Academic Year:	2018-19		

Overview

The module covers the foundations of classical mechanics as well as a number of applications in various areas. Starting from the principle of least action, the Lagrangian and Hamiltonian formulations of mechanics are introduced. The module explains the connection between symmetries and conservation laws and shows bridges between classical and quantum mechanics. Applications include planetary motion, particle scattering and oscillators.

Aims & Objectives

To give students a solid grounding and sufficient training in Lagrangian and Hamiltonian techniques in classical mechanics and their applications, including

- the Principle of Least Action as the starting point of Lagrangian mechanics
- traditional applications of Lagrangian mechanics such as mechanical pendulums, planetary motion, collisions and some non-traditional ones
- appreciating the problem-solving power, generality and elegance of Lagrangian and Hamiltonian techniques
- understand the fundamental connection between symmetries and conservation laws (Noether theorem)

Learning Outcomes

By the end of the module, students will have a solid knowledge of the central concepts of Classical Mechanics and will have acquired and trained important problem-solving skills. They will be able to

- establish the Lagrangian, and to derive and solve the equations of motions for many systems subject to the Principle of Least Action
- calculate conserved quantities from symmetries
- calculate the Hamiltonian and establish the Hamilton equations
- be familiar with canonical transformations and Hamilton-Jacobi theory
- understand the concept of phase space and the conservation of phase-space density (Liouville's theorem)
- acquire a deep knowledge of the Hamiltonian formalism that is crucial for the formulation and understanding of quantum mechanics

Synopsis

Review of Newtonian mechanics.

Equations of Motion: The Principle of least action. The Euler-Lagrange equations. Free and interacting particles in non-relativistic mechanics. Introductory examples to illustrate the abstract concepts that follow in sections 2 and 3.

Conservation Laws: Energy, momentum, angular momentum, centre of mass. The Noether theorem.

Canonical formalism: Hamiltonian techniques. Canonical transformations. Liouville theorem (Hamilton-Jacobi theory).

Applications: Two-body problem. Kepler problem (planetary motion). Collisions.

Pre-requisites

PH3081 or PH3082 or (MT2506 and MT2507). Prior knowledge of vector calculus is required.

Anti-requisites

MT4507

Assessment

2-hour Written Examination = 75%, Coursework 25%

Additional information on continuous assessment etc.

Please note that the definitive comments on continuous assessment will be communicated within the module. This section is intended to give an indication of the likely breakdown and timing of the continuous assessment.

This module is typically taken in JH by theoretical physicists, and in SH by those doing an MPhys in other degree programmes in the School. It is sufficiently core to the programmes that it is included in the summary of deadlines etc on the School's Students and Staff web pages. Five tutorial sheets will be issued over the semester in two week intervals. They contain questions that will deepen the understanding of the current topics in the lectures, and they are required to be handed in for marking. This accounts for 25% of the module mark. Tutorials take the form of "whole class" tutorials where the solutions and underlying physics and problem-solving strategies can be discussed.

Accreditation Matters

This module may not contain material that is part of the IOP "Core of Physics", but does contribute to the wider and deeper learning expected in an accredited degree programme. The skills developed in this module, and others, contribute towards the requirements of the IOP "Graduate Skill Base".

Recommended Books

Please view University online record:

<http://resourcelists.st-andrews.ac.uk/modules/ph4038.html>

General Information

Please also read the general information in the School's honours handbook.