PX267-7.5 Hamiltonian Mechanics

23/24

Department
Physics
Level
Undergraduate Level 2
Module leader
Matthew Turner
Credit value
7.5
Assessment
100% exam
Study location
University of Warwick main campus, Coventry

Description

Introductory description

This module introduces the Hamiltonian formulation of classical mechanics. This elegant theory has provided the natural framework for several important developments in theoretical physics including quantum mechanics. The module starts by covering the general "spirit" of the theory and then goes on to introduce the details.

The module uses a lot of examples. Many of these should be familiar from earlier studies of mechanics while others, which would be much harder to deal with using traditional techniques, can be dealt with quite easily using the language and methods of Hamiltonian mechanics.

Module web page

Module aims

To revise the key elements of Newtonian mechanics and use this to motivate and then develop Lagrangian and Hamiltonian mechanics

Outline syllabus

This is an indicative module outline only to give an indication of the sort of topics that may be covered. Actual sessions held may differ.

1. Introduction. Analogy with optics and constructive interference; principle of least action;

examples of L: T-V, $-mc^2/\gamma$

2. Euler Lagrange Equations. 1-d trajectory, T-V case, worked examples; T+V as a constant of the motion; multiple coordinates with examples
3. Generalised coordinates and canonical momenta. Polar coordinates; angular momentum; moment of inertia of rigid bodies; treatment of constraints; examples
4. Symmetry and Conservation Laws
5. Hamiltonian formulation. Hamilton's equations, phase space, examples
6. Normal Modes and Small Oscillations. Inertial and stiffness matrices, diatomic and triatomic molecules

Learning outcomes

By the end of the module, students should be able to:

- Explain the significance of the Lagrangian and Hamiltonian
- Derive and solve the Euler-Lagrange equations for simple models
- Find the canonical momenta in a mechanical system and construct the Hamiltonian function
- Derive and solve Hamilton's equations for simple systems
- Explain the role of (and relations between) constraints, conserved quantities and generalised coordinates

Indicative reading list

A good text going well beyond the module is H Goldstein, Classical Mechanics;
A helpful reference for the beginning of the module is: Feynmann, Leighton & Sands, The Feynmann Lectures on Physics, Vol 2, Chapter 19

[View reading list on Talis Aspire]

Interdisciplinary

The Hamiltonian and Lagrangian formulations of mechanics use ideas from mathematics - variational methods and symplectic structures. These mathematical methods can lead to valuable conceptual understanding as well as more elegant methods for solving (and approximately solving) problems in mechanics. This module is taken by many mathematics and physics students.

Subject specific skills

Knowledge of mathematics and physics. Skills in modelling, reasoning, thinking

Transferable skills

Analytical, communication, problem-solving, self-study

Study

Study time

Type	Required
Lectures	20 sessions of 1 hour (100%)
Total	20 hours

Private study description

Working through lecture notes, solving problems, wider reading, discussing with others taking the module, revising for the exam, practising on past exam papers

Costs

No further costs have been identified for this module.

Assessment

You must pass all assessment components to pass the module.

Assessment group B2

	Weighting	Study time
In-person Examination	100%	
Answer 2 questions		

- Answerbook Green (8 page)
- Students may use a calculator

Feedback on assessment

Personal tutor, group feedback

Past exam papers for PX267

Availability

Courses

This module is Option list A for:

- Year 2 of UPXA-FG33 Undergraduate Mathematics and Physics (BSc MMathPhys)
- Year 2 of UPXA-F3N1 Undergraduate Physics and Business Studies