PX148-12 Classical Mechanics & Special Relativity

21/22

Department
  Physics
Level
  Undergraduate Level 1
Module leader
  Thomas Marsh
Credit value
  12
Module duration
  10 weeks
Assessment
  100% exam
Study location
  University of Warwick main campus, Coventry

Description

Introductory description

By 1905, there was a successful theory (Newton's laws) describing the motion of massive bodies and there was a successful theory of light waves (Maxwell's equations of electromagnetism). But the two theories are inconsistent: in mechanics objects only move relative to each other, whereas light appears to move relative to nothing at all (the vacuum). Physicists (including Maxwell himself) had therefore assumed that there had to be some background 'ether', through which light propagated. But all attempts to detect this ether had failed. Einstein realised that there was nothing wrong with Maxwell's equations and that there was no need for an ether. Newtonian mechanics itself was the problem. He proposed that the laws of classical mechanics had to be consistent with just two postulates, namely that the speed of light is a constant and that all frames of reference are equivalent. These postulates forced Einstein to reject previous ideas of space and time and led directly to the special theory of relativity.

This module studies Newtonian mechanics emphasizing the conservation laws inherent in the theory. These have a wider domain of applicability than classical mechanics (for example they also apply in quantum mechanics). It also looks at the classical mechanics of oscillations and of rotating bodies. It then explains why the failure to find the ether was such an important experimental result and how Einstein constructed his theory of special relativity. The module covers some of the consequences of the theory for classical mechanics and some of the predictions it makes, including: the relation between mass and energy, length-contraction, time-dilation and the twin paradox.

Module web page

Module aims

To revise A-level classical mechanics and to develop the theory using vector notation and calculus. To introduce special relativity. To cover material required for future physics modules.

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.

Forces, interactions and Newton's Laws of Motion
Applying Newton's Laws - equilibrium, dynamics of particles, friction and dynamics of circular motion
Work and kinetic energy.
Potential energy and energy conservation.
Conservation of momentum, elastic collisions, centre of mass
Rotation of rigid bodies - angular velocity and acceleration
Dynamics of rotational motion, conservation of angular momentum
Hooke's law, equation of motion for a mass attached to a spring on a frictionless plane. Solutions for shm. Energy in shm. The pendulum, departures from shm for large amplitude. Complex notation. Damping: critical and under-/over-damping. Forced oscillations.
Motion as seen by different observers. Galilean Transformation of Velocities. Inertial frames of reference
The Michelson Morley experiment. The universality of the speed of light. The meaning of simultaneity.
Einstein's postulates: Lorentz transformation, Inverse Lorentz transformation and invariants.
Length Contraction and Time Dilation, Doppler Effect.
Einstein' energy and mass relation, energy and momentum of elementary particles.
Minkowski diagrams - graphical representation of past/present/future

Learning outcomes

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

- Solve F=dp/dt for a variety of cases
- Work with the concepts of kinetic and potential energy
- Recognise and solve the equations of forced and damped harmonic motion;
- Solve problems involving torque and angular momentum
- Explain the transformation between inertial frames of reference (Lorentz transformation) and work through illustrative problems

Indicative reading list

University Physics, Young and Freedman

[View reading list on Talis Aspire]

Interdisciplinary

This module is taken by students within Mathematical Sciences (mainly Maths and Physics). Mechanics is largely about the use of calculus to describe motion and stability. Calculus is the mathematics co-invented by Newton to describe physical systems.

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	30 sessions of 1 hour (25%)
Private study	90 hours (75%)
Total	120 hours

Private study description

Working through lecture notes, solving problems, wider reading, discussing with others taking the module, revising for 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 4 questions		

Feedback on assessment

Personal tutor, group feedback

[Past exam papers for PX148](#)

Availability

Courses

This module is Core for:

- Year 1 of UPXA-FG33 Undergraduate Mathematics and Physics (BSc MMathPhys)
- UPXA-GF13 Undergraduate Mathematics and Physics (BSc)
  - Year 1 of GF13 Mathematics and Physics
  - Year 1 of GF13 Mathematics and Physics
- UPXA-FG31 Undergraduate Mathematics and Physics (MMathPhys)
  - Year 1 of FG31 Mathematics and Physics (MMathPhys)
  - Year 1 of FG31 Mathematics and Physics (MMathPhys)
- UPXA-F300 Undergraduate Physics (BSc)
  - Year 1 of F300 Physics
  - Year 1 of F300 Physics
  - Year 1 of F300 Physics
- UPXA-F303 Undergraduate Physics (MPhys)
  - Year 1 of F300 Physics
  - Year 1 of F303 Physics (MPhys)
- Year 1 of UPXA-F3N1 Undergraduate Physics and Business Studies
- UPXA-F3F5 Undergraduate Physics with Astrophysics (BSc)
  - Year 1 of F3F5 Physics with Astrophysics
  - Year 1 of F3F5 Physics with Astrophysics
- Year 1 of UPXA-F3FA Undergraduate Physics with Astrophysics (MPhys)
- Year 1 of UPXA-F3N2 Undergraduate Physics with Business Studies

This module is Optional for:

- Year 1 of USTA-G300 Undergraduate Master of Mathematics,Operational Research,Statistics and Economics
- USTA-GG14 Undergraduate Mathematics and Statistics (BSc)
  - Year 1 of GG14 Mathematics and Statistics
  - Year 1 of GG14 Mathematics and Statistics
- USTA-Y602 Undergraduate Mathematics,Operational Research,Statistics and Economics

    - Year 1 of Y602 Mathematics,Operational Research,Stats,Economics
    - Year 1 of Y602 Mathematics,Operational Research,Stats,Economics

This module is Option list B for:

- UMAA-G100 Undergraduate Mathematics (BSc)
    - Year 1 of G100 Mathematics
    - Year 1 of G100 Mathematics
    - Year 1 of G100 Mathematics
- UMAA-G103 Undergraduate Mathematics (MMath)
    - Year 1 of G100 Mathematics
    - Year 1 of G103 Mathematics (MMath)
    - Year 1 of G103 Mathematics (MMath)
- Year 1 of UMAA-G106 Undergraduate Mathematics (MMath) with Study in Europe
- Year 1 of UMAA-G1NC Undergraduate Mathematics and Business Studies
- Year 1 of UMAA-G1N2 Undergraduate Mathematics and Business Studies (with Intercalated Year)
- Year 1 of UMAA-GL11 Undergraduate Mathematics and Economics
- Year 1 of UECA-GL12 Undergraduate Mathematics and Economics (with Intercalated Year)
- UMAA-GV17 Undergraduate Mathematics and Philosophy
    - Year 1 of GV17 Mathematics and Philosophy
    - Year 1 of GV17 Mathematics and Philosophy
    - Year 1 of GV17 Mathematics and Philosophy
- UMAA-GV18 Undergraduate Mathematics and Philosophy with Intercalated Year
    - Year 1 of GV18 Mathematics and Philosophy with Intercalated Year
    - Year 1 of GV18 Mathematics and Philosophy with Intercalated Year
- Year 1 of UMAA-G101 Undergraduate Mathematics with Intercalated Year