PX145-12 Physics Foundations

20/21

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

Description

Introductory description

This module looks at dimensional analysis, matter and waves. Often the qualitative features of systems can be understood (at least partially) by thinking about which quantities in a problem are allowed to depend on each other on dimensional grounds. Loosely speaking this is the requirement that "apples can only equal apples". Examples looked at include the size of an atom, the length scale on which a theory of gravity has to take account of quantum effects and the speed of a wave in a shallow channel. The module then covers thermodynamics which is the study of heat transfers and how they can lead to useful work. How much useful work can be extracted from a heat engine is determined by a quantity called the entropy. Even though the results are universal, the simplest way to introduce this topic is via the ideal gas, whose properties are discussed and derived in some detail.

The second half of the module covers waves. Waves are time-dependent variations about some time-independent (often equilibrium) state. For example, they can be variations in pressure (sound waves), variations in electric and magnetic fields (light waves) or variations in the height of water above the sea-bed (water waves). They carry energy, momentum and information and much of their behaviour is similar whatever their nature. The module revises the relation between the wavelength, frequency and velocity and the definition of the amplitude and phase of a wave. It also covers phenomena like the Doppler effect (this is the effect that the frequency of a wave changes as a function of the relative velocity of the source and observer), the reflection and transmission of

waves at boundaries and some elementary ideas about diffraction and interference patterns.

Module web page

Module aims

To introduce the style and content of physics at university and to cover ideas about waves, matter and thermodynamics.

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.

Introduction to University Physics:
Concepts - Mechanics, Fields and Thermal physics. Their use to predict and explain phenomena. The need for mathematics.

Dimensional Analysis:
Relation between dimensions and units. A physical law can always be written using dimensionless variables. Illustrative examples: wavespeed in a shallow channel and along a tight string; GI Taylor's t2/5 law for the spread of a fireball, the Planck length, period of a pendulum and the role of a second dimenionless variable.

Heat and Gases:
Thermal equilibrium, zero'th law. Temperature scales. Thermal expansion. Heat capacity. Phases of Matter. Kinetic theory of gases: equation of state and isotherms, kinetic model of gases, equipartition of energy. Heat capacity, compressibility. Particle interactions, van der Waal's equation, condensed phases. First law of thermodynamics. Thermodynamic systems and processes. Conservation of energy, heat is a form of energy. Internal energy and heat capacity. Adiabatic processes. Second law of thermodynamics. Reversible and irreversible processes. Carnot cycles, heat engines, refrigerators and heat pumps.

Waves:
Types of wave: sound waves in gases and solids, water waves, light waves. Different elastic moduli in solids. Description of a travelling wave and relation between speed, frequency and wavelength/wavenumber. Idea of a plane wave and use of complex numbers. Impedance, power and intensity. Reflection and transmission at a boundary, standing waves, normal modes and beats. Doppler effect. Nature of Light: wavefronts, reflection and refraction, refractive index, polarization. Huygens construction. Coherence. Interference: interference in thin films, interference of light waves from coherent sources. Two-slit experiment, intensity in interference pattern. Phase difference and path difference.

Learning outcomes

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

- Use dimensional analysis to establish how physical quantities can depend on each other

- Describe the solid, liquid and gas phases of matter
- Work with the kinetic theory of gases
- State and use the first and second laws of thermodynamics to solve problems involving heat transfers and work
- Solve wave problems involving: travelling and standing waves, the Doppler effect, boundary conditions and normal modes
- Describe the nature of light: its electromagnetic origin, its polarization and the role of the refractive index
- Describe interference effects using complex number notation

Indicative reading list

University Physics, Young and Freedman

View reading list on Talis Aspire

Subject specific skills

Knowledge of mathematics and physics. Skills in dimensional analysis, 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 B1

Assessment component	Weighting	Study time	Eligible for self-certification
In-person Examination Answer 4 questions	100%		No

Reassessment component is the same

Feedback on assessment

Personal tutor, group feedback

Past exam papers for PX145

Availability

Courses

This module is Core for:

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