

## 1.7 Energy, work and power continued

### 1.7.4 Power

#### Core

- 1 Define power as work done per unit time and also as energy transferred per unit time; recall and use the equations

$$(a) P = \frac{W}{t}$$

$$(b) P = \frac{\Delta E}{t}$$

#### Supplement

## 1.8 Pressure

#### Core

- 1 Define pressure as force per unit area; recall and use the equation

$$p = \frac{F}{A}$$

- 2 Describe how pressure varies with force and area in the context of everyday examples
- 3 Describe, qualitatively, how the pressure beneath the surface of a liquid changes with depth and density of the liquid

#### Supplement

- 4 Recall and use the equation for the change in pressure beneath the surface of a liquid

$$\Delta p = \rho g \Delta h$$

## 2 Thermal physics

### 2.1 Kinetic particle model of matter

#### 2.1.1 States of matter

#### Core

- 1 Know the distinguishing properties of solids, liquids and gases
- 2 Know the terms for the changes in state between solids, liquids and gases (gas to solid and solid to gas transfers are **not** required)

#### Supplement

## 2.1 Kinetic particle model of matter continued

### 2.1.2 Particle model

#### Core

- 1 Describe the particle structure of solids, liquids and gases in terms of the arrangement, separation and motion of the particles and represent these states using simple particle diagrams
- 2 Describe the relationship between the motion of particles and temperature, including the idea that there is a lowest possible temperature ( $-273^{\circ}\text{C}$ ), known as absolute zero, where the particles have least kinetic energy
- 3 Describe the pressure and the changes in pressure of a gas in terms of the motion of its particles and their collisions with a surface
- 4 Know that the random motion of microscopic particles in a suspension is evidence for the kinetic particle model of matter
- 5 Describe and explain this motion (sometimes known as Brownian motion) in terms of random collisions between the microscopic particles in a suspension and the particles of the gas or liquid

#### Supplement

- 6 Know that the forces and distances between particles (atoms, molecules, ions and electrons) and the motion of the particles affects the properties of solids, liquids and gases
- 7 Describe the pressure and the changes in pressure of a gas in terms of the forces exerted by particles colliding with surfaces, creating a force per unit area
- 8 Know that microscopic particles may be moved by collisions with light fast-moving molecules and correctly use the terms atoms or molecules as distinct from microscopic particles

### 2.1.3 Gases and the absolute scale of temperature

#### Core

- 1 Describe qualitatively, in terms of particles, the effect on the pressure of a fixed mass of gas of:
  - (a) a change of temperature at constant volume
  - (b) a change of volume at constant temperature
- 2 Convert temperatures between kelvin and degrees Celsius; recall and use the equation  $T \text{ (in K)} = \theta \text{ (in } ^{\circ}\text{C)} + 273$

#### Supplement

- 3 Recall and use the equation  $pV = \text{constant}$  for a fixed mass of gas at constant temperature, including a graphical representation of this relationship

## 2.2 Thermal properties and temperature

### 2.2.1 Thermal expansion of solids, liquids and gases

#### Core

- 1 Describe, qualitatively, the thermal expansion of solids, liquids and gases at constant pressure
- 2 Describe some of the everyday applications and consequences of thermal expansion

#### Supplement

- 3 Explain, in terms of the motion and arrangement of particles, the relative order of magnitudes of the expansion of solids, liquids and gases as their temperatures rise

### 2.2.2 Specific heat capacity

#### Core

- 1 Know that a rise in the temperature of an object increases its internal energy

#### Supplement

- 2 Describe an increase in temperature of an object in terms of an increase in the average kinetic energies of all of the particles in the object
- 3 Define specific heat capacity as the energy required per unit mass per unit temperature increase; recall and use the equation
 
$$c = \frac{\Delta E}{m\Delta\theta}$$
- 4 Describe experiments to measure the specific heat capacity of a solid and a liquid

### 2.2.3 Melting, boiling and evaporation

#### Core

- 1 Describe melting and boiling in terms of energy input without a change in temperature
- 2 Know the melting and boiling temperatures for water at standard atmospheric pressure
- 3 Describe condensation and solidification in terms of particles
- 4 Describe evaporation in terms of the escape of more-energetic particles from the surface of a liquid
- 5 Know that evaporation causes cooling of a liquid

#### Supplement

- 6 Describe the differences between boiling and evaporation
- 7 Describe how temperature, surface area and air movement over a surface affect evaporation
- 8 Explain the cooling of an object in contact with an evaporating liquid

## 2.3 Transfer of thermal energy

### 2.3.1 Conduction

#### Core

- 1 Describe experiments to demonstrate the properties of good thermal conductors and bad thermal conductors (thermal insulators)

#### Supplement

- 2 Describe thermal conduction in all solids in terms of atomic or molecular lattice vibrations and also in terms of the movement of free (delocalised) electrons in metallic conductors
- 3 Describe, in terms of particles, why thermal conduction is bad in gases and most liquids
- 4 Know that there are many solids that conduct thermal energy better than thermal insulators but do so less well than good thermal conductors

### 2.3.2 Convection

#### Core

- 1 Know that convection is an important method of thermal energy transfer in liquids and gases
- 2 Explain convection in liquids and gases in terms of density changes and describe experiments to illustrate convection

#### Supplement

### 2.3.3 Radiation

#### Core

- 1 Know that thermal radiation is infrared radiation and that all objects emit this radiation
- 2 Know that thermal energy transfer by thermal radiation does not require a medium
- 3 Describe the effect of surface colour (black or white) and texture (dull or shiny) on the emission, absorption and reflection of infrared radiation

#### Supplement

- 4 Know that for an object to be at a constant temperature it needs to transfer energy away from the object at the same rate that it receives energy
- 5 Know what happens to an object if the rate at which it receives energy is less or more than the rate at which it transfers energy away from the object
- 6 Know how the temperature of the Earth is affected by factors controlling the balance between incoming radiation and radiation emitted from the Earth's surface

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## 2.3 Transfer of thermal energy continued

### 2.3.3 Radiation continued

#### Core

#### Supplement

- 7 Describe experiments to distinguish between good and bad emitters of infrared radiation
- 8 Describe experiments to distinguish between good and bad absorbers of infrared radiation
- 9 Describe how the rate of emission of radiation depends on the surface temperature and surface area of an object

### 2.3.4 Consequences of thermal energy transfer

#### Core

#### Supplement

- 1 Explain some of the basic everyday applications and consequences of conduction, convection and radiation, including:
  - (a) heating objects such as kitchen pans
  - (b) heating a room by convection
- 2 Explain some of the complex applications and consequences of conduction, convection and radiation where more than one type of thermal energy transfer is significant, including:
  - (a) a fire burning wood or coal
  - (b) a radiator in a car

## 3 Waves

### 3.1 General properties of waves

#### Core

#### Supplement

- 1 Know that waves transfer energy without transferring matter
- 2 Describe what is meant by wave motion as illustrated by vibrations in ropes and springs, and by experiments using water waves
- 3 Describe the features of a wave in terms of wavefront, wavelength, frequency, crest (peak), trough, amplitude and wave speed
- 4 Recall and use the equation for wave speed  

$$v = f\lambda$$
- 5 Know that for a transverse wave, the direction of vibration is at right angles to the direction of propagation and understand that electromagnetic radiation, water waves and seismic S-waves (secondary) can be modelled as transverse

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**3.1 General properties of waves continued****Core**

- 6 Know that for a longitudinal wave, the direction of vibration is parallel to the direction of propagation and understand that sound waves and seismic P-waves (primary) can be modelled as longitudinal
- 7 Describe how waves can undergo:
  - (a) reflection at a plane surface
  - (b) refraction due to a change of speed
  - (c) diffraction through a narrow gap
- 8 Describe the use of a ripple tank to show:
  - (a) reflection at a plane surface
  - (b) refraction due to a change in speed caused by a change in depth
  - (c) diffraction due to a gap
  - (d) diffraction due to an edge

**Supplement**

- 9 Describe how wavelength and gap size affects diffraction through a gap
- 10 Describe how wavelength affects diffraction at an edge

**3.2 Light****3.2.1 Reflection of light****Core**

- 1 Define and use the terms normal, angle of incidence and angle of reflection
- 2 Describe the formation of an optical image by a plane mirror and give its characteristics, i.e. same size, same distance from mirror, virtual
- 3 State that for reflection, the angle of incidence is equal to the angle of reflection; recall and use this relationship

**Supplement**

- 4 Use simple constructions, measurements and calculations for reflection by plane mirrors