1 **(a)** State what is meant by a *scalar* quantity and by a *vector* quantity.

scalar: ....

....

vector: ....

....
[2]

(b) Complete Fig. 1.1 to indicate whether each of the quantities is a vector or a scalar.

quantity	vector or scalar
power	
temperature	
momentum	

Fig. 1.1

[2]

(c) An aircraft is travelling in wind. Fig. 1.2 shows the velocities for the aircraft in still air and for the wind.

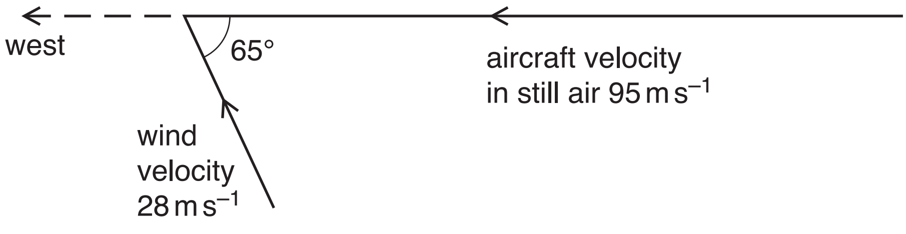

Fig. 1.2

The velocity of the aircraft in still air is 95 m s^{-1} to the west.
The velocity of the wind is 28 m s^{-1} from 65° south of east.

(i) On Fig. 1.2, draw an arrow, labelled R, in the direction of the resultant velocity of the aircraft. [1]

(ii) Determine the magnitude of the resultant velocity of the aircraft.

magnitude of velocity = ... $m\,s^{-1}$ [2]

[Total: 7]

2 **(a)** State Newton's first law of motion.

....

....[1]

(b) A block of weight 15 N hangs by a wire from a remotely controlled aircraft, as shown in Fig. 2.1.

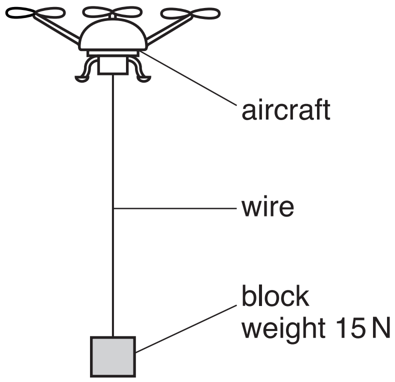

Fig. 2.1

The aircraft is used to move the block only in a vertical direction. The force on the block due to air resistance is negligible.

The variation with time t of the vertical velocity v of the block is shown in Fig. 2.2.
The velocity is taken to be positive in the upward direction.

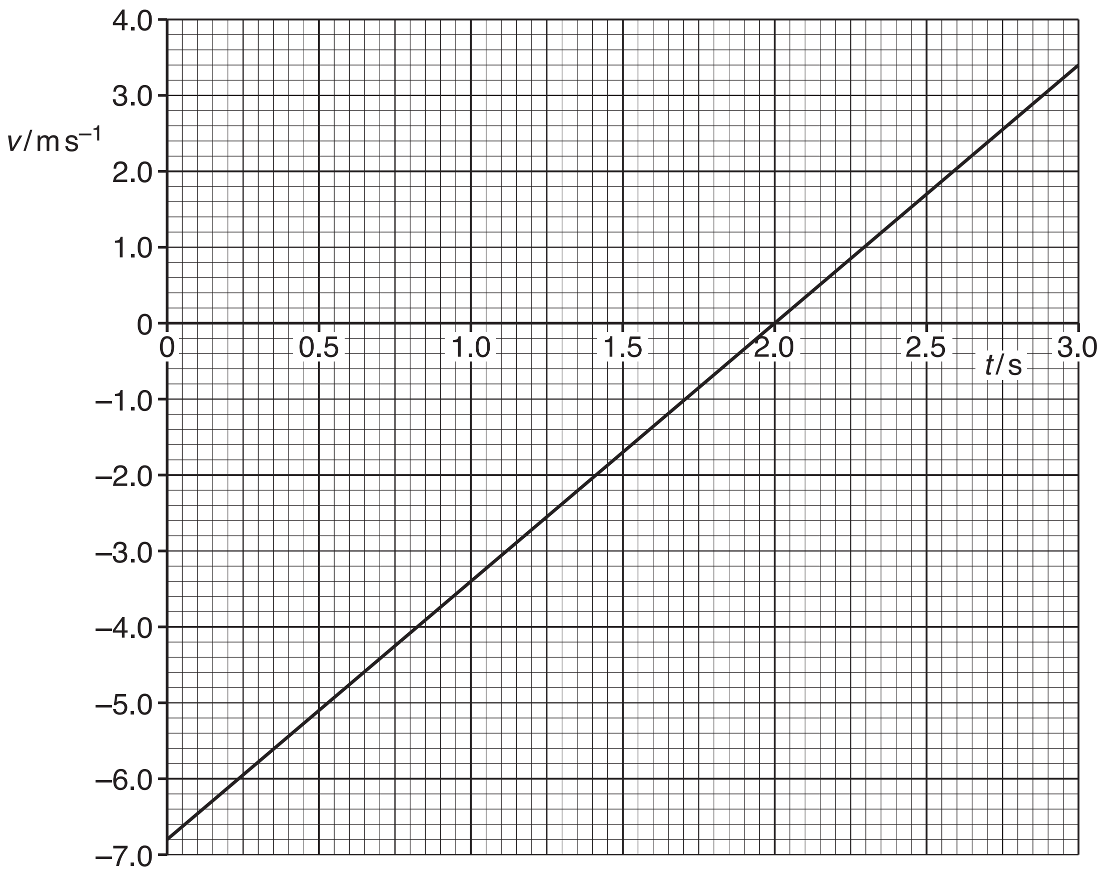

Fig. 2.2

(i) Determine, for the block,

1. the displacement from time $t = 0$ to $t = 3.0\,s$,

magnitude of displacement = ... m

direction of displacement ....
[3]

2. the change in gravitational potential energy from time $t = 0$ to $t = 3.0\,s$.

change in gravitational potential energy = ... J [2]

(ii) Calculate the magnitude of the acceleration of the block at time $t = 2.0\,s$.

acceleration = ... $m\,s^{-2}$ [2]

(iii) your answer in **(b)(ii)** to show that the tension T in the wire at time $t = 2.0\,s$ is 20 N.

[2]

(iv) The wire has a cross-sectional area of $2.8 \times 10^{-5}\,m^2$ and is made from metal of Young modulus 1.7×10^{11} Pa. The wire obeys Hooke's law.

Calculate the strain of the wire at time $t = 2.0$ s.

strain = ... [3]

(v) At some time after $t = 3.0$ s the tension in the wire has a constant value of 15 N.

State and explain whether it is possible to deduce that the block is moving vertically after $t = 3.0$ s.

....

....

....

....[2]

3 **(a)** State what is meant by the *mass* of a body.

....

....[1]

(b) Two blocks travel directly towards each other along a horizontal, frictionless surface. The blocks collide, as illustrated in Fig. 3.1.

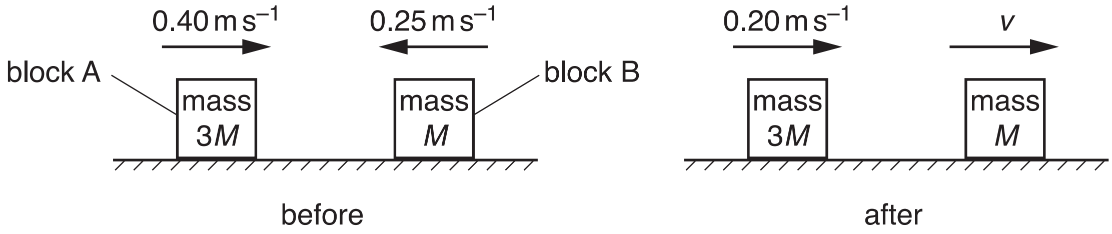

Fig. 3.1

Block A has mass 3*M* and block B has mass *M.*
Before the collision, block A moves to the right with speed $0.40\,\mathrm{m\,s^{-1}}$ and block B moves to the left with speed $0.25\,\mathrm{m\,s^{-1}}$.
After the collision, block A moves to the right with speed $0.20\,\mathrm{m\,s^{-1}}$ and block B moves to the right with speed *v*.

(i) Newton's third law to explain why, during the collision, the change in momentum of block A is equal and opposite to the change in momentum of block B.

....

....

....

....[2]

(ii) Determine speed *v*.

v = ... $\mathrm{m\,s^{-1}}$ [3]

(iii) Calculate, for the blocks,

1. the relative speed of approach,

relative speed of approach = ... $m\,s^{-1}$

2. the relative speed of separation.

relative speed of separation = ... $m\,s^{-1}$
[2]

(iv) your answers in **(b)(iii)** to state and explain whether the collision is elastic or inelastic.

....

....[1]

[Total: 9]

4 **(a)** a progressive wave, state what is meant by

(i) the *period*,

....

....[1]

(ii) the *wavelength*.

....

....[1]

(b) Fig. 4.1 shows the variation with time t of the displacement x of two progressive waves P and Q passing the same point.

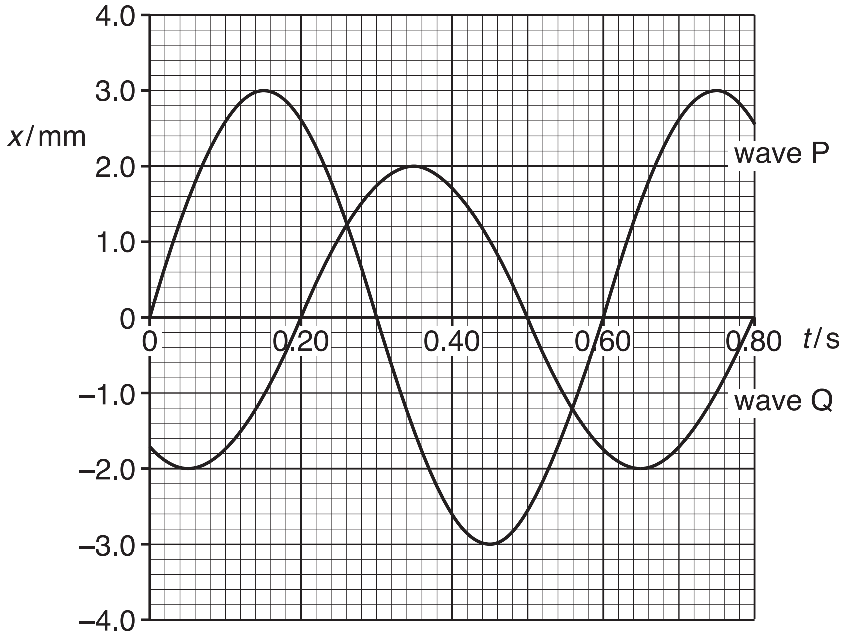

Fig. 4.1

The speed of the waves is $20\,\text{cm}\,\text{s}^{-1}$.

(i) Calculate the wavelength of the waves.

wavelength = ... cm [2]

(ii) Determine the phase difference between the two waves.

phase difference = ... ° [1]

(iii) Calculate the ratio

$$\frac{\text{intensity of wave Q}}{\text{intensity of wave P}}.$$

ratio = ... [2]

(iv) The two waves superpose as they pass the same point. Fig. 4.1 to determine the resultant displacement at time $t = 0.45\,\text{s}$.

displacement = ... mm [1]

[Total: 8]

5 **(a)** When monochromatic light is incident normally on a diffraction grating, the emergent light waves have been diffracted and are coherent.

Explain what is meant by

(i) *diffracted* waves,

....

....[1]

(ii) *coherent* waves.

....

....[1]

(b) Light consisting of only two wavelengths λ_1 and λ_2 is incident normally on a diffraction grating.

The third order diffraction maximum of the light of wavelength λ_1 and the fourth order diffraction maximum of the light of wavelength λ_2 are at the same angle θ to the direction of the incident light.

(i) Show that the ratio $\frac{\lambda_2}{\lambda_1}$ is 0.75.

Explain your working.

[2]

(ii) The difference between the two wavelengths is 170 nm.

Determine wavelength λ_1.

λ_1 = ... nm [1]

[Total: 5]

6 **(a)** Define the *volt*.

.... [1]

(b) A battery of electromotive force (e.m.f.) 4.5 V and negligible internal resistance is connected to two filament lamps P and Q and a resistor R, as shown in Fig. 6.1.

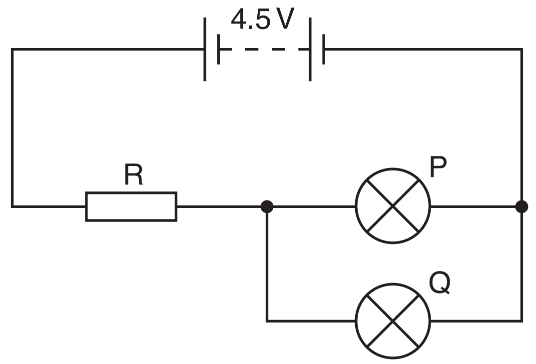

Fig. 6.1

The current in lamp P is 0.15 A.
The I–V characteristics of the filament lamps are shown in Fig. 6.2.

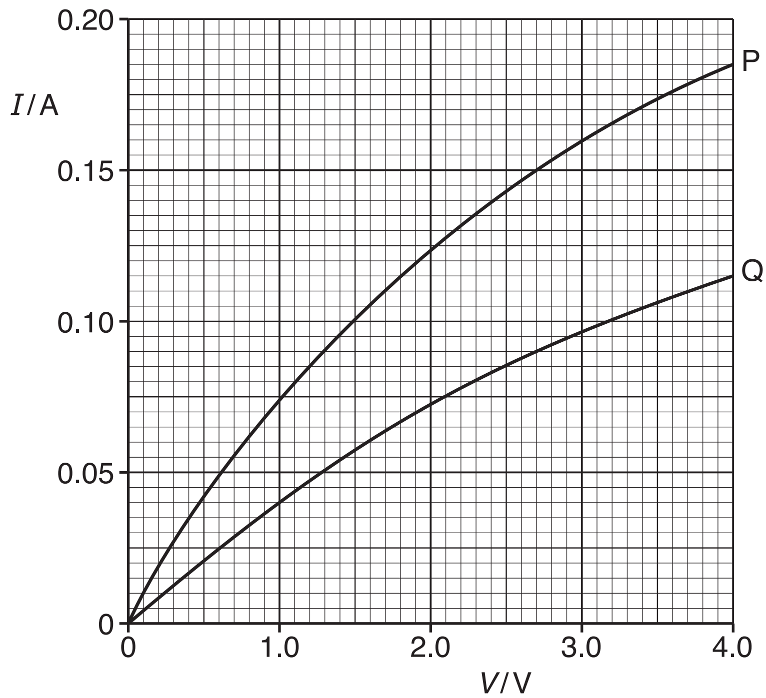

Fig. 6.2

(i) Fig. 6.2 to determine the current in the battery. Explain your working.

current = ... A [2]

(ii) Calculate the resistance of resistor R.

resistance = ... Ω [2]

(iii) The filament wires of the two lamps are made from material with the same resistivity at their operating temperature in the circuit. The diameter of the wire of lamp P is twice the diameter of the wire of lamp Q.

Determine the ratio

$$\frac{\text{length of filament wire of lamp P}}{\text{length of filament wire of lamp Q}}.$$

ratio = ... [3]

(iv) The filament wire of lamp Q breaks and stops conducting.

State and explain, qualitatively, the effect on the resistance of lamp P.

....

....

....

....[2]

[Total: 10]

7 A β^- particle from a radioactive source is travelling in a vacuum with kinetic energy 460 eV. The particle enters a uniform electric field at a right-angle and follows the path shown in Fig. 7.1.

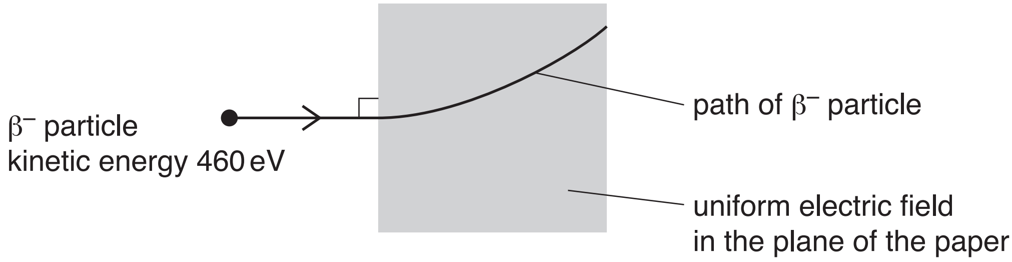

Fig. 7.1

(a) The direction of the electric field is in the plane of the paper.
On Fig. 7.1, draw an arrow to show the direction of the electric field. [1]

(b) Calculate the speed of the β^- particle before it enters the electric field.

speed = ... $m s^{-1}$ [3]

(c) Other β^- particles from the same radioactive source travel outside the electric field along the same incident path as that shown in Fig. 7.1.

State and briefly explain whether those β^- particles will all follow the same path inside the electric field.

....

....

....

....[2]

[Total: 6]