1 **(a)** Make estimates of:

(i) the mass, in g, of a new pencil

mass = ... g [1]

(ii) the wavelength of ultraviolet radiation.

wavelength = ... m [1]

(b) The period T of the oscillations of a mass m suspended from a spring is given by

$$T = 2\pi\sqrt{\frac{m}{k}}$$

where k is the spring constant of the spring.

The manufacturer of a spring states that it has a spring constant of $25\,\mathrm{N\,m^{-1}} \pm 8\%$. A mass of $200 \times 10^{-3}\,\mathrm{kg} \pm 4 \times 10^{-3}\,\mathrm{kg}$ is suspended from the end of the spring and then made to oscillate.

(i) Calculate the period T of the oscillations.

T = ... s [1]

(ii) Determine the value of T, with its absolute uncertainty, to an appropriate number of significant figures.

T = ... ± .... s [3]

[Total: 6]

2 A small charged glass bead of weight 5.4×10^{-5} N is initially at rest at point A in a vacuum. The bead then falls through a uniform horizontal electric field as it moves in a straight line to point B, as illustrated in Fig. 2.1.

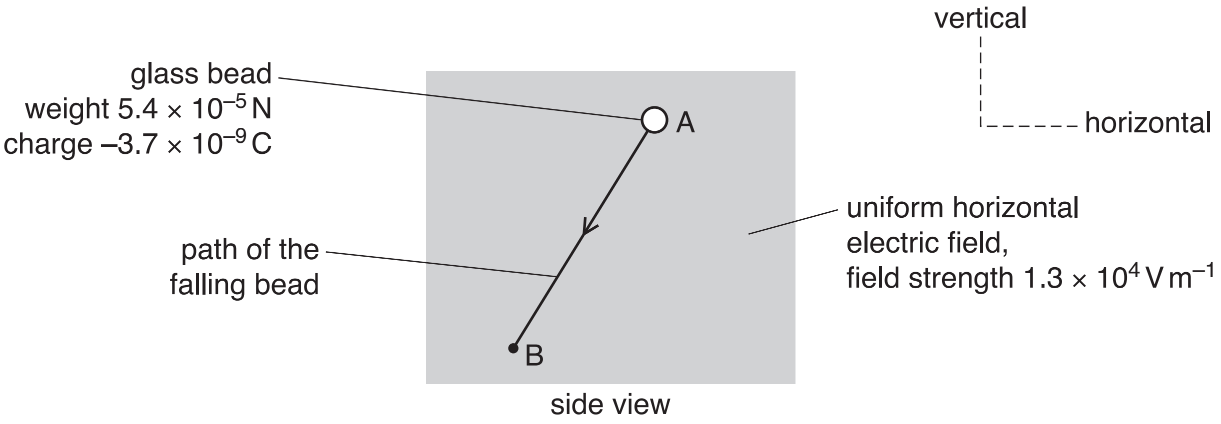

Fig. 2.1 (not to scale)

The electric field strength is 1.3×10^{4} V m^{-1}. The charge on the bead is -3.7×10^{-9} C.

(a) Describe how two metal plates could be used to produce the electric field. Numerical values are not required.

....

....

.... [2]

(b) Determine the magnitude of the electric force acting on the bead.

electric force = ... N [2]

(c) your answer in **(b)** and the weight of the bead to show that the resultant force acting on it is 7.2×10^{-5} N.

[1]

(d) Explain why the resultant force on the bead of 7.2×10^{-5} N is constant as the bead moves along path AB.

....

....

....

.... [2]

(e) **(i)** Calculate the magnitude of the acceleration of the bead along the path AB.

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

(ii) The path AB has length 0.58 m.

your answer in **(i)** to determine the speed of the bead at point B.

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

[Total: 11]

3 A small remote-controlled model aircraft has two propellers, each of diameter 16 cm. Fig. 3.1 is a side view of the aircraft when hovering.

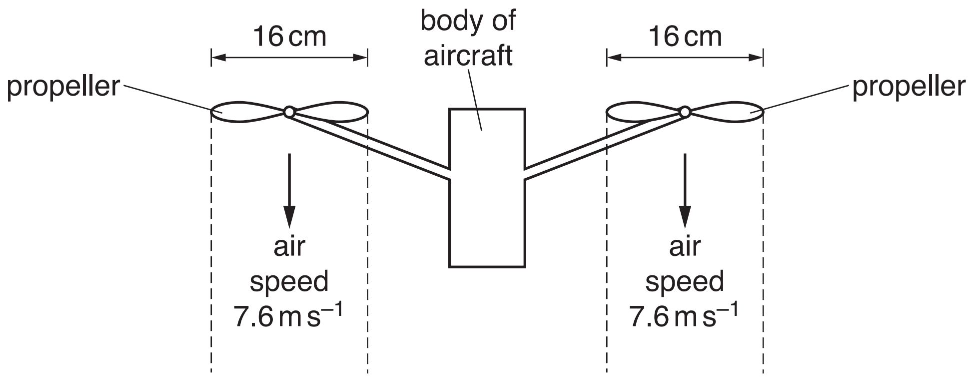

Fig. 3.1

Air is propelled vertically downwards by each propeller so that the aircraft hovers at a fixed position. The density of the air is $1.2\,kg\,m^{-3}$. Assume that the air from each propeller moves with a constant speed of $7.6\,m\,s^{-1}$ in a uniform cylinder of diameter 16 cm. Also assume that the air above each propeller is stationary.

(a) Show that, in a time interval of 3.0 s, the mass of air propelled downwards by **one** propeller is 0.55 kg.

[3]

(b) Calculate:

(i) the increase in momentum of the mass of air in **(a)**

increase in momentum = ... Ns [1]

(ii) the downward force exerted on this mass of air by the propeller.

force = ... N [1]

(c) State:

(i) the upward force acting on **one** propeller

force = ... N [1]

(ii) the name of the law that explains the relationship between the force in **(b)(ii)** and the force in **(c)(i)**.

.... [1]

(d) Determine the mass of the aircraft.

mass = ... kg [1]

(e) In order for the aircraft to hover at a very high altitude (height), the propellers must propel the air downwards with a greater speed than when the aircraft hovers at a low altitude. Suggest the reason for this.

....

.... [1]

(f) When the aircraft is hovering at a high altitude, an electric fault causes the propellers to stop rotating. The aircraft falls vertically downwards. When the aircraft reaches a constant speed of $22\,\mathrm{m\,s^{-1}}$, it emits sound of frequency 3.0 kHz from an alarm. The speed of the sound in the air is $340\,\mathrm{m\,s^{-1}}$.

Determine the frequency of the sound heard by a person standing vertically below the falling aircraft.

frequency = ... Hz [2]

[Total: 11]

4 The variation with extension x of the force F applied to a spring is shown in Fig. 4.1.

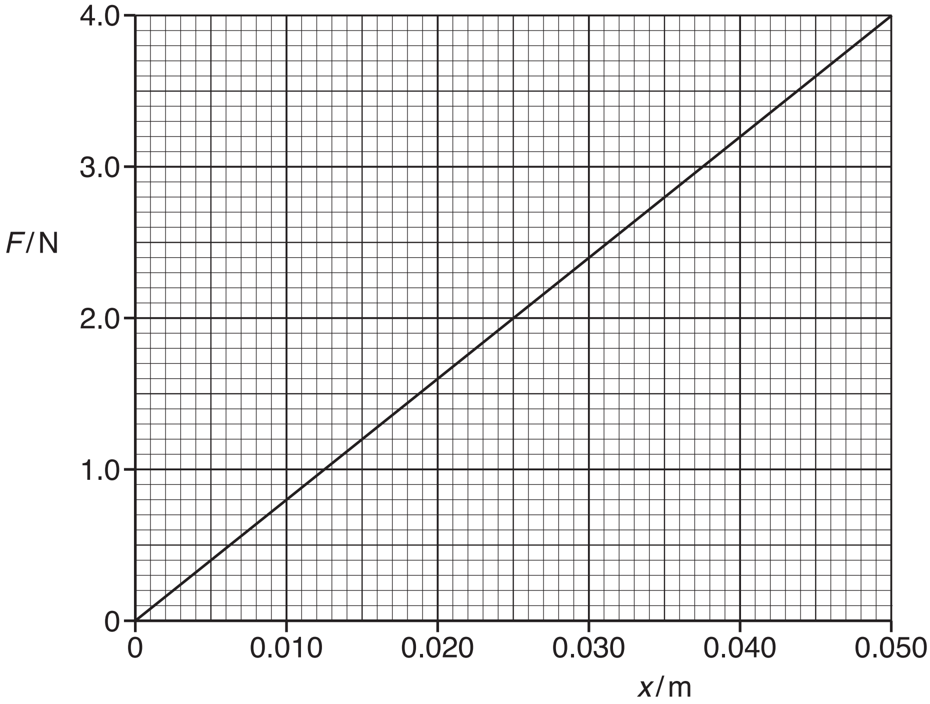

Fig. 4.1

The spring has an unstretched length of 0.080 m and is suspended vertically from a fixed point, as shown in Fig. 4.2.

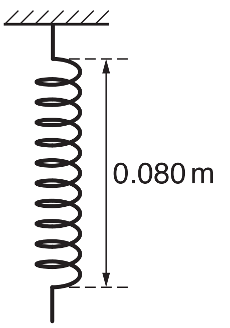

Fig. 4.2

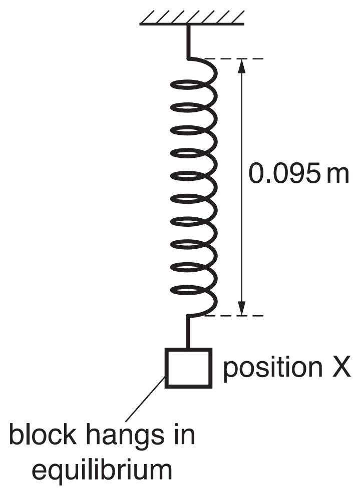

Fig. 4.3

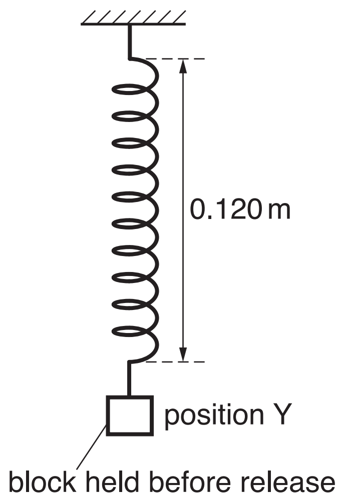

Fig. 4.4

A block is attached to the lower end of the spring. The block hangs in equilibrium at position X when the length of the spring is 0.095 m, as shown in Fig. 4.3.

The block is then pulled vertically downwards and held at position Y so that the length of the spring is 0.120 m, as shown in Fig. 4.4. The block is then released and moves vertically upwards from position Y back towards position X.

(a) Fig. 4.1 to determine the spring constant of the spring.

spring constant = ... N m^{-1} [2]

(b) Fig. 4.1 to show that the decrease in elastic potential energy of the spring is 0.055 J when the block moves from position Y to position X.

[2]

(c) The block has a mass of 0.122 kg. Calculate the increase in gravitational potential energy of the block for its movement from position Y to position X.

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

(d) the decrease in elastic potential energy stated in **(b)** and your answer in **(c)** to determine, for the block, as it moves through position X:

(i) its kinetic energy

kinetic energy = ... J [1]

(ii) its speed.

speed = ... m s^{-1} [2]

[Total: 9]

5 A ripple tank is used to demonstrate the interference of water waves.
Two dippers D1 and D2 produce coherent waves that have circular wavefronts, as illustrated in Fig. 5.1.

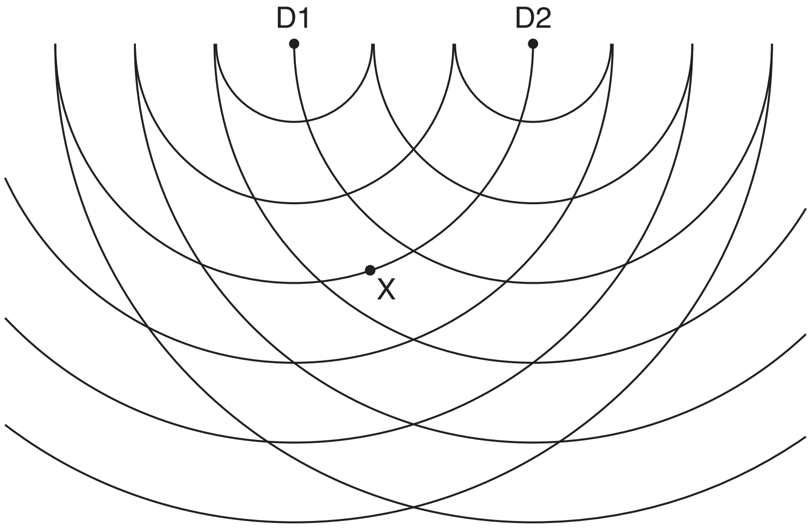

Fig. 5.1

The lines in the diagram represent crests. The waves have a wavelength of 6.0 cm.

(a) One condition that is required for an observable interference pattern is that the waves must be coherent.

(i) Describe how the apparatus is arranged to ensure that the waves from the dippers are coherent.

....

.... [1]

(ii) State one other condition that must be satisfied by the waves in order for the interference pattern to be observable.

....

.... [1]

(b) Light from a lamp above the ripple tank shines through the water onto a screen below the tank. Describe one way of seeing the illuminated pattern more clearly.

....

.... [1]

(c) The speed of the waves is $0.40\,\text{m}\,\text{s}^{-1}$. Calculate the period of the waves.

period = ... s [2]

(d) Fig. 5.1 shows a point X that lies on a crest of the wave from D1 and midway between two adjacent crests of the wave from D2.

the waves at point X, state:

(i) the path difference, in cm

path difference = ... cm [1]

(ii) the phase difference.

phase difference = ... ° [1]

(e) On Fig. 5.1, draw **one** line, at least 4 cm long, which joins points where only maxima of the interference pattern are observed. [1]

[Total: 8]

6 **(a)** Define *electric potential difference* (*p.d.*).

....

.... [1]

(b) The variation with potential difference V of the current I in a semiconductor diode is shown in Fig. 6.1.

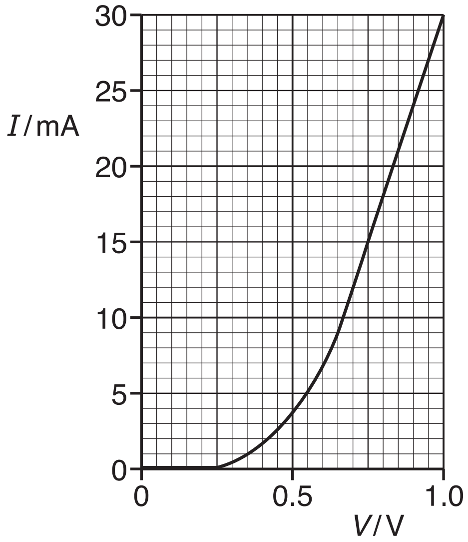

Fig. 6.1

Fig. 6.1 to describe qualitatively the variation of the resistance of the diode as V increases from 0 to 1.0 V.

....

....

....

.... [2]

(c) The diode in **(b)** is part of the circuit shown in Fig. 6.2.

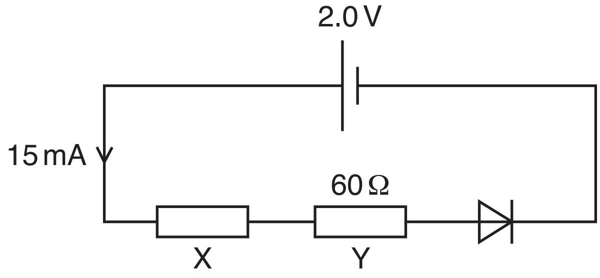

Fig. 6.2

The cell of electromotive force (e.m.f.) 2.0 V and negligible internal resistance is connected in series with the diode and resistors X and Y. The resistance of Y is 60 Ω. The current in the cell is 15 mA.

(i) Fig. 6.1 to determine the resistance of the diode.

resistance = ... Ω [3]

(ii) Calculate:

1. the resistance of X

resistance = ... Ω [3]

2. the ratio

$$\frac{\text{power dissipated in resistor Y}}{\text{total power produced by the cell}}.$$

ratio = ... [2]

[Total: 11]

7 **(a)** The decay of a nucleus $^{35}_{18}\text{Ar}$ by β^+ emission is represented by

$$^{35}_{18}\text{Ar} \longrightarrow \text{X} + \beta^+ + \text{Y}.$$

A nucleus X and two particles, β^+ and Y, are produced by the decay.

State:

(i) the proton number and the nucleon number of nucleus X

proton number = ...

nucleon number = ...
[1]

(ii) the name of the particle represented by the symbol Y.

.... [1]

(b) A hadron consists of two down quarks and one strange quark.

Determine, in terms of the elementary charge *e*, the charge of this hadron.

charge = ... [2]

[Total: 4]