1 **(a)** **(i)** State the SI base units of volume.

base units of volume .... [1]

(ii) Show that the SI base units of pressure are $kg\,m^{-1}\,s^{-2}$.

[1]

(b) The volume V of liquid that flows through a pipe in time t is given by the equation

$$\frac{V}{t} = \frac{\pi P r^4}{8 C l}$$

where P is the pressure difference between the ends of the pipe of radius r and length l. The constant C depends on the frictional effects of the liquid.

Determine the base units of C.

base units of C .... [3]

2 A ball is thrown vertically down towards the ground with an initial velocity of $4.23\,m\,s^{-1}$. The ball falls for a time of 1.51 s before hitting the ground. Air resistance is negligible.

(a) **(i)** Show that the downwards velocity of the ball when it hits the ground is $19.0\,m\,s^{-1}$.

[2]

(ii) Calculate, to three significant figures, the distance the ball falls to the ground.

distance = ... m [2]

(b) The ball makes contact with the ground for 12.5 ms and rebounds with an upwards velocity of $18.6\,m\,s^{-1}$. The mass of the ball is 46.5 g.

(i) Calculate the average force acting on the ball on impact with the ground.

magnitude of force = ... N

direction of force ....

[4]

(ii) conservation of energy to determine the maximum height the ball reaches after it hits the ground.

height = ... m [2]

(c) State and explain whether the collision the ball makes with the ground is elastic or inelastic.

....

....

....[1]

3 One end of a spring is fixed to a support. A mass is attached to the other end of the spring. The arrangement is shown in Fig. 3.1.

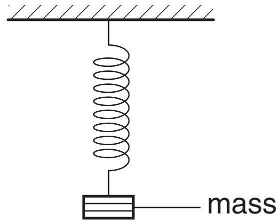

Fig. 3.1

(a) The mass is in equilibrium. Explain, by reference to the forces acting on the mass, what is meant by equilibrium.

....

....

.... [2]

(b) The mass is pulled down and then released at time $t = 0$. The mass oscillates up and down. The variation with t of the displacement of the mass d is shown in Fig. 3.2.

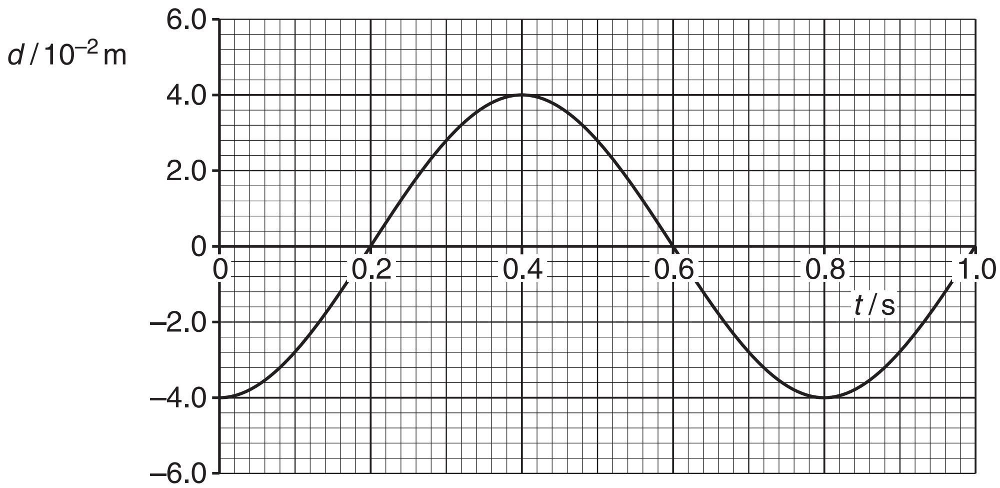

Fig. 3.2

Fig. 3.2 to state a time, one in each case, when

(i) the mass is at maximum speed,

time = ... s [1]

(ii) the elastic potential energy stored in the spring is a maximum,

time = ... s [1]

(iii) the mass is in equilibrium.

time = ... s [1]

(c) The arrangement shown in Fig. 3.3 is used to determine the length l of a spring when different masses M are attached to the spring.

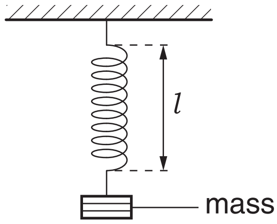

Fig. 3.3

The variation with mass M of l is shown in Fig. 3.4.

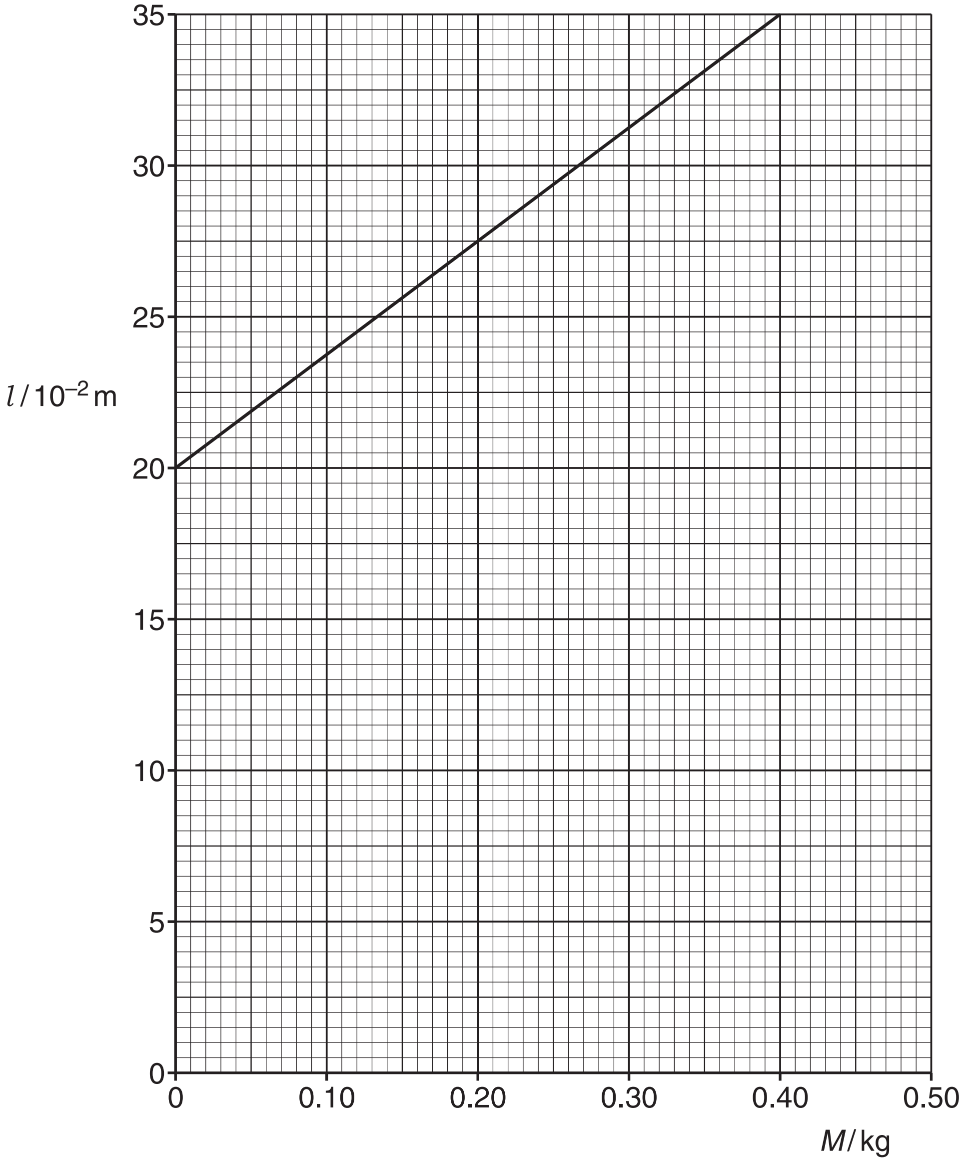

Fig. 3.4

(i) State and explain whether the spring obeys Hooke's law.

....

....

....[2]

(ii) Show that the force constant of the spring is $26\,\mathrm{N\,m^{-1}}$.

[2]

(iii) A mass of $0.40\,\mathrm{kg}$ is attached to the spring. Calculate the energy stored in the spring.

energy = ... J [3]

4 **(a)** The output of a heater is 2.5 kW when connected to a 220 V supply.

(i) Calculate the resistance of the heater.

resistance = ... Ω [2]

(ii) The heater is made from a wire of cross-sectional area $2.0 \times 10^{-7}\,m^2$ and resistivity $1.1 \times 10^{-6}\,\Omega\,m$.

your answer in **(i)** to calculate the length of the wire.

length = ... m [3]

(b) The supply voltage is changed to 110 V.

(i) Calculate the power output of the heater at this voltage, assuming there is no change in the resistance of the wire.

power = ... W [1]

(ii) State and explain quantitatively **one** way that the wire of the heater could be changed to give the same power as in **(a)**.

....

....

.... [2]

5 **(a)** **(i)** State Kirchhoff's second law.

....

.... [1]

(ii) Kirchhoff's second law is linked to the conservation of a certain quantity. State this quantity.

.... [1]

(b) The circuit shown in Fig. 5.1 is used to compare potential differences.

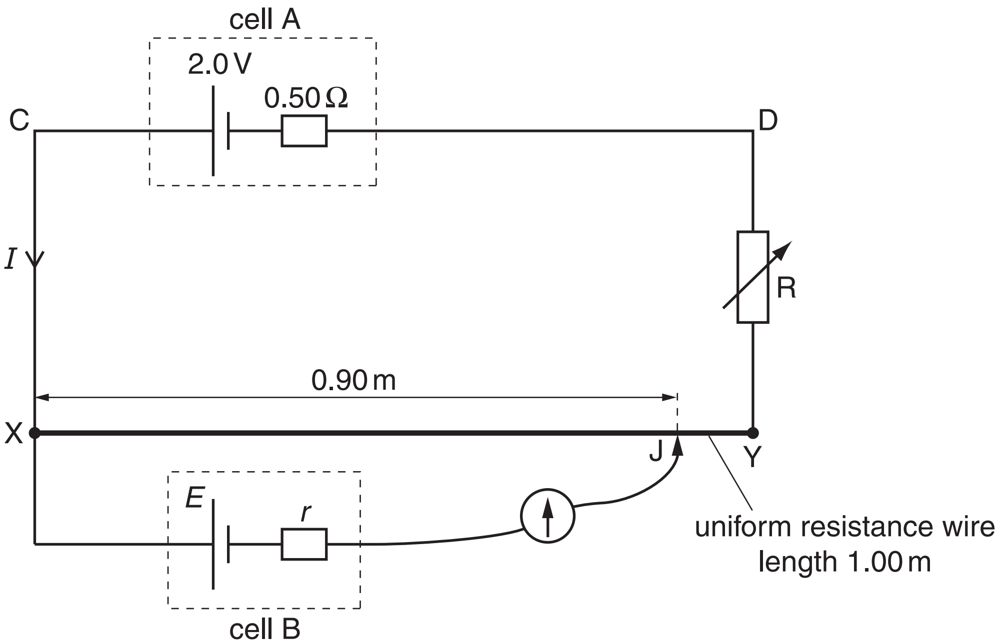

Fig. 5.1

The uniform resistance wire XY has length 1.00 m and resistance 4.0 Ω. Cell A has e.m.f. 2.0 V and internal resistance 0.50 Ω. The current through cell A is I. Cell B has e.m.f. E and internal resistance r.

The current through cell B is made zero when the movable connection J is adjusted so that the length of XJ is 0.90 m. The variable resistor R has resistance 2.5 Ω.

(i) Apply Kirchhoff's second law to the circuit CXYDC to determine the current I.

I = ... A [2]

(ii) Calculate the potential difference across the length of wire XJ.

potential difference = ... V [2]

(iii) your answer in **(ii)** to state the value of *E*.

E = ... V [1]

(iv) State why the value of the internal resistance of cell B is not required for the determination of *E*.

....

....[1]

6 **(a)** A laser is used to produce an interference pattern on a screen, as shown in Fig. 6.1.

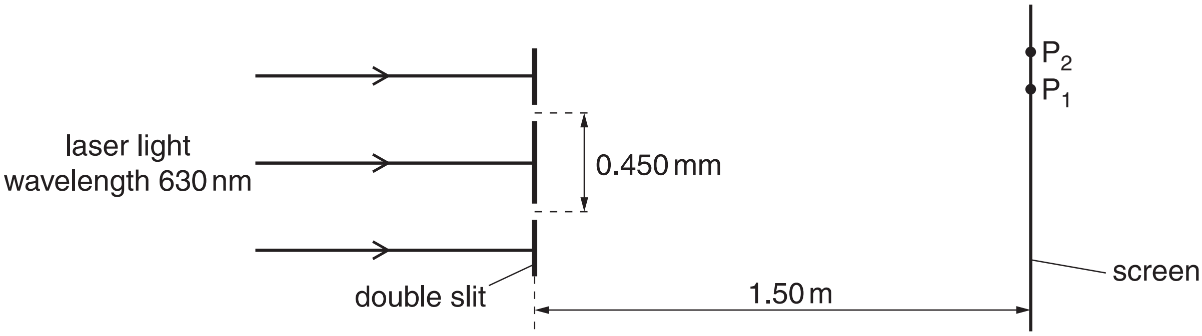

Fig. 6.1 (not to scale)

The laser emits light of wavelength 630 nm. The slit separation is 0.450 mm. The distance between the slits and the screen is 1.50 m. A maximum is formed at P_1 and a minimum is formed at P_2.
Interference fringes are observed only when the light from the slits is coherent.

(i) Explain what is meant by *coherence*.

....

....

.... [2]

(ii) Explain how an interference maximum is formed at P_1.

....

.... [1]

(iii) Explain how an interference minimum is formed at P_2.

....

.... [1]

(iv) Calculate the fringe separation.

fringe separation = ... m [3]

(b) State the effects, if any, on the fringes when the amplitude of the waves incident on the double slits is increased.

....

....

....

....[3]

7 **(a)** The spontaneous decay of polonium is shown by the nuclear equation

$$^{210}_{84}\text{Po} \rightarrow ^{206}_{82}\text{Pb} + \text{X}.$$

(i) State the composition of the nucleus of X.

....

....[1]

(ii) The nuclei X are emitted as radiation. State two properties of this radiation.

1. ....

....

2. ....

....

[2]

(b) The mass of the polonium (Po) nucleus is greater than the combined mass of the nuclei of lead (Pb) and X. a conservation law to explain qualitatively how this decay is possible.

....

....

....[3]