1 **(a)** Two of the SI base quantities are mass and time. State three other SI base quantities.

1. .....

2. .....

3. .....

[3]

(b) A sphere of radius r is moving at speed v through air of density ρ. The resistive force F acting on the sphere is given by the expression

$$F = Br^2\rho v^k$$

where B and k are constants without units.

(i) State the SI base units of F, ρ and v.

F .....

ρ .....

v .....

[3]

(ii) base units to determine the value of k.

$k =$ ..... [2]

(iii) determine the horizontal distance x.

x = ... m [2]

(b) The path of the ball in **(a)**, with an initial horizontal speed of $8.2\,m\,s^{-1}$, is shown again in Fig. 2.2.

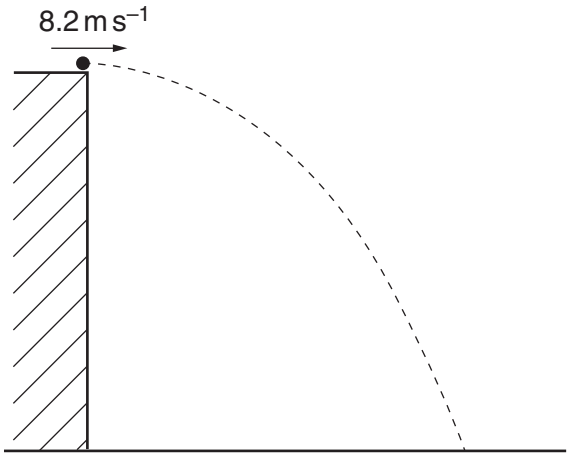


Fig. 2.2

On Fig. 2.2, sketch the new path of the ball for the ball having an initial horizontal speed

(i) greater than $8.2\,m\,s^{-1}$ and with negligible air resistance (label this path G), [2]

(ii) equal to $8.2\,m\,s^{-1}$ but with air resistance (label this path A). [2]

3 **(a)** State the relation between force and momentum.

..... [1]

(b) A rigid bar of mass 450 g is held horizontally by two supports A and B, as shown in Fig. 3.1.

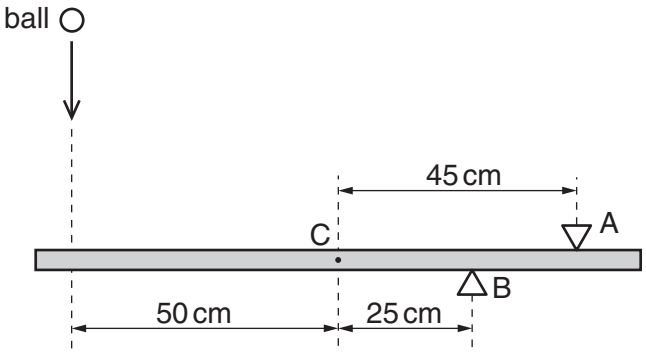


Fig. 3.1

The support A is 45 cm from the centre of gravity C of the bar and support B is 25 cm from C.

A ball of mass 140 g falls vertically onto the bar such that it hits the bar at a distance of 50 cm from C, as shown in Fig. 3.1.
The variation with time t of the velocity v of the ball before, during and after hitting the bar is shown in Fig. 3.2.

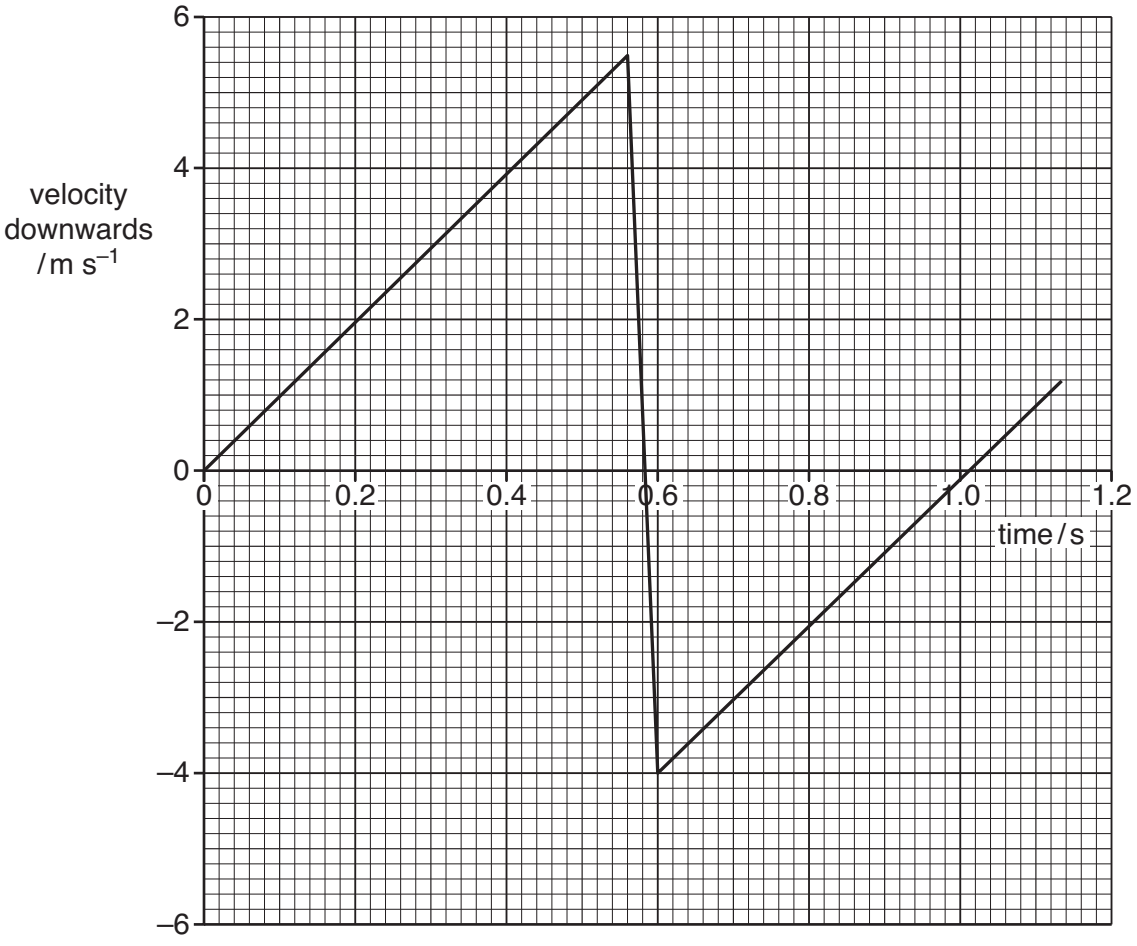


Fig. 3.2

the time that the ball is in contact with the bar, use Fig. 3.2

(i) to determine the change in momentum of the ball,

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

(ii) to show that the force exerted by the ball on the bar is 33 N.

[1]

(c) the time that the ball is in contact with the bar, use data from Fig. 3.1 and **(b)(ii)** to calculate the force exerted on the bar by

(i) the support A,

force = ... N [3]

(ii) the support B.

force = ... N [2]

4 **(a)** A uniform wire has length L and constant area of cross-section A.
The material of the wire has Young modulus E and resistivity ρ.
A tension F in the wire causes its length to increase by ΔL.

this wire, state expressions, in terms of L, A, F, ΔL and ρ for

(i) the stress σ,

..... [1]

(ii) the strain ε,

..... [1]

(iii) the Young modulus E,

..... [1]

(iv) the resistance R.

..... [1]

(b) One end of a metal wire of length 2.6 m and constant area of cross-section $3.8 \times 10^{-7}\,m^2$ is attached to a fixed point, as shown in Fig. 4.1.

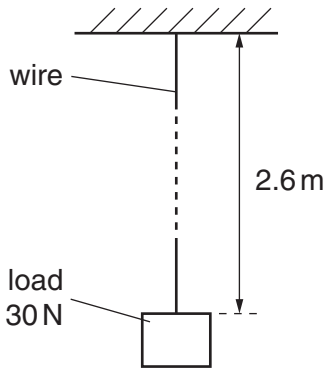


Fig. 4.1

The Young modulus of the material of the wire is 7.0×10^{10} Pa and its resistivity is $2.6 \times 10^{-8}\,\Omega$ m.
A load of 30 N is attached to the lower end of the wire. Assume that the area of cross-section of the wire does not change.
this load of 30 N,

(i) show that the extension of the wire is 2.9 mm,

[1]

(ii) calculate the change in resistance of the wire.

change = ... Ω [2]

(c) The resistance of the wire changes with the applied load.
Comment on the suggestion that this change of resistance could be used to measure the magnitude of the load on the wire.

.....

.....

..... [2]

5 **(a)** State what is meant by the *diffraction* of a wave.

.....

.....

..... [2]

(b) Plane wavefronts are incident on a slit, as shown in Fig. 5.1.

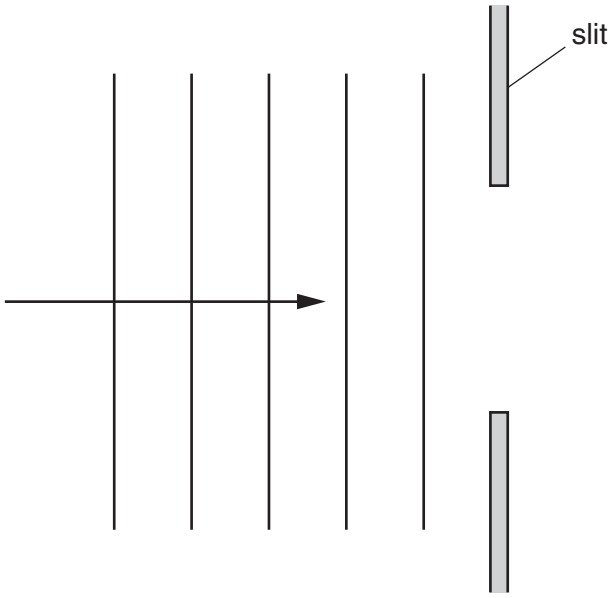


Fig. 5.1

Complete Fig. 5.1 to show four wavefronts that have emerged from the slit. [2]

(c) Monochromatic light is incident normally on a diffraction grating having 650 lines per millimetre, as shown in Fig. 5.2.

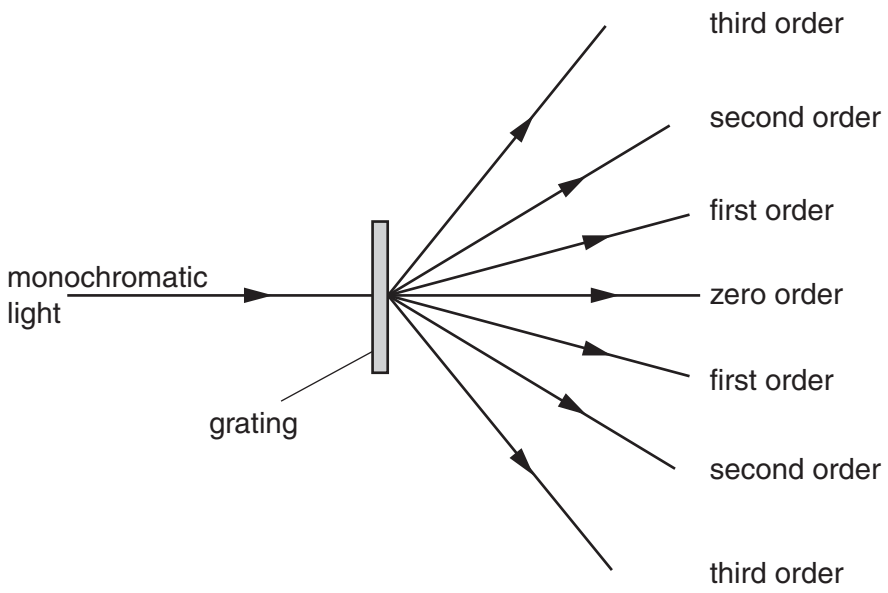


Fig. 5.2

An image (the zero order) is observed for light that has an angle of diffraction equal to zero.

incident light of wavelength 590 nm, determine the number of orders of diffracted light that can be observed on each side of the zero order.

number = ... [3]

(d) The images in Fig. 5.2 are viewed, starting with the zero order and then with increasing order number.
State how the appearance of the images changes as the order number increases.

.....

..... [1]

6 **(a)** A lamp is rated as 12V, 36W.

(i) Calculate the resistance of the lamp at its working temperature.

resistance = ... Ω [2]

(ii) On the axes of Fig. 6.1, sketch a graph to show the current-voltage (I–V) characteristic of the lamp. Mark an appropriate scale for current on the y-axis.

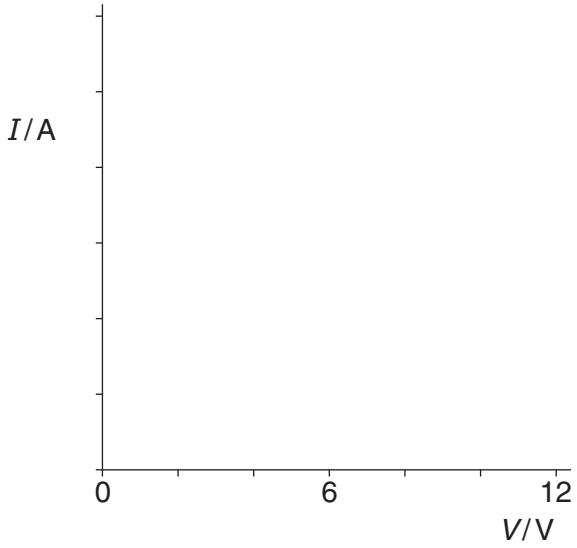


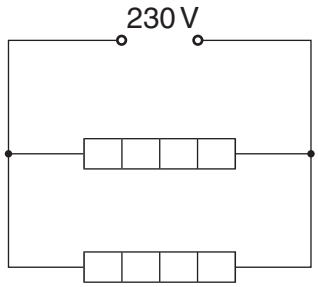
Fig. 6.1

[3]

(b) Some heaters are each labelled 230 V, 1.0 kW. The heaters have constant resistance.

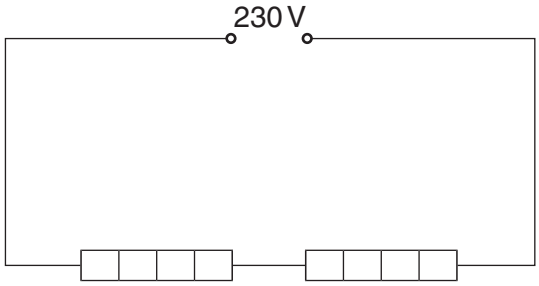
Determine the total power dissipation for the heaters connected as shown in each of the diagrams shown below.

(i)



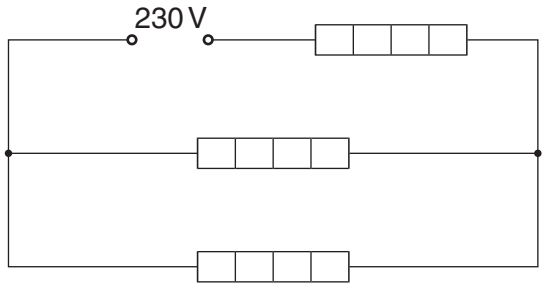
power = ... kW [1]

(ii)



power = ... kW [1]

(iii)



power = ... kW [2]

7 **(a)** Uranium (U) has at least fourteen isotopes.
Explain what is meant by *isotopes*.

.....

.....

..... [2]

(b) One possible nuclear reaction involving uranium is

$$^{235}_{92}\text{U} + {}^{1}_{0}\text{n} \longrightarrow {}^{141}_{56}\text{Ba} + {}^{92}_{Z}\text{Kr} + x\,{}^{1}_{0}\text{n} + \text{energy.}$$

(i) State three quantities that are conserved in a nuclear reaction.

1. .....

.....

2. .....

.....

3. .....

.....
[3]

(ii) this reaction, determine the value of

1. Z,

$Z =$ ..... [1]

2. x.

$x =$ ..... [1]