1 **(a)** **(i)** Define *power*.

.....

.....[1]

(ii) Show that the SI base units of power are $kg\,m^2\,s^{-3}$.

[1]

(b) All bodies radiate energy. The power P radiated by a body is given by

$$P = kAT^4$$

where T is the thermodynamic temperature of the body,
A is the surface area of the body
and k is a constant.

(i) Determine the SI base units of k.

base units .....[2]

(ii) On Fig. 1.1, sketch the variation with T^2 of P. The quantity A remains constant.

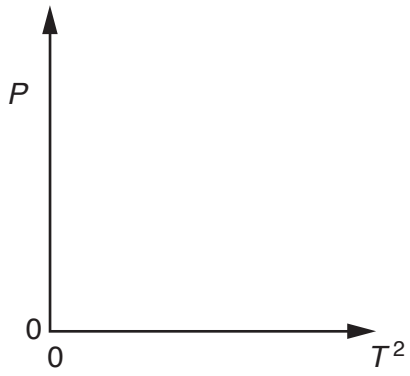


Fig. 1.1

[1]

[Total: 5]

2 A liquid of density ρ fills a container to a depth h, as shown in Fig. 2.1.

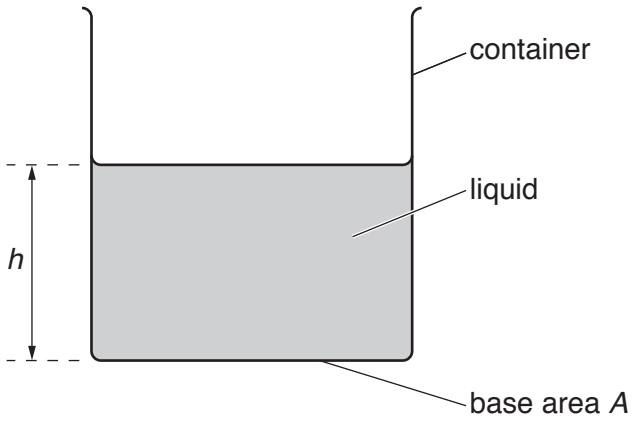


Fig. 2.1

The base of the container has area A.

(a) Derive, from the definitions of pressure and density, the equation

$$p = \rho g h$$

where p is the pressure exerted by the liquid on the base of the container and g is the acceleration of free fall.

[3]

(b) A small solid sphere falls with constant velocity through the liquid.

(i) State

1. the names of the three forces acting on the sphere,

.....

.....

2. a word equation that relates the magnitudes of these forces.

.....

[2]

(ii) State and explain the changes in energy that occur as the sphere falls.

.....

.....

.....

.....[2]

(c) The liquid in the container is liquid L. Liquid M is now added to the container. The two liquids do not mix. The total depth of the liquids is 0.17 m.

Fig. 2.2 shows how the pressure p inside the liquids varies with height x above the base of the container.

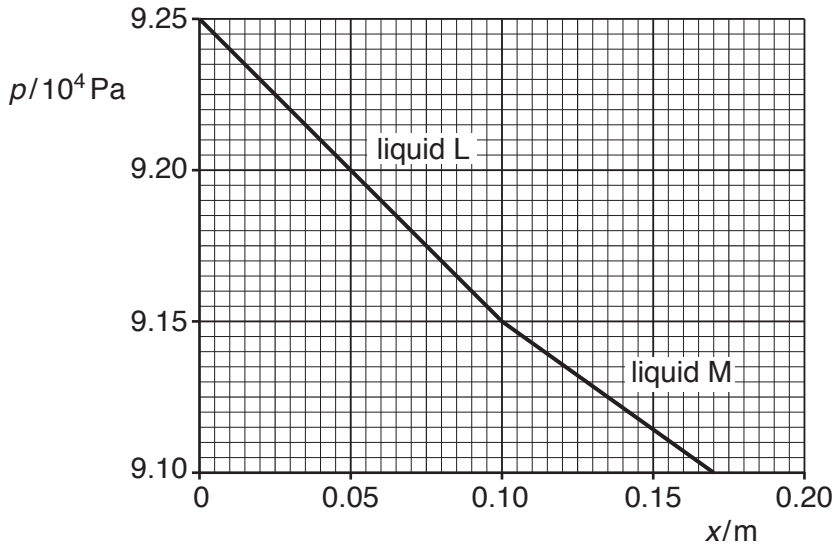


Fig. 2.2

Fig. 2.2 to

(i) state the value of atmospheric pressure,

atmospheric pressure = ... Pa [1]

(ii) determine the density of liquid M.

density = ... $kg\,m^{-3}$ [2]

[Total: 10]

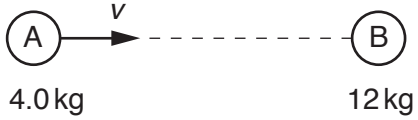
3 **(a)** State the principle of conservation of momentum.

.....

.....

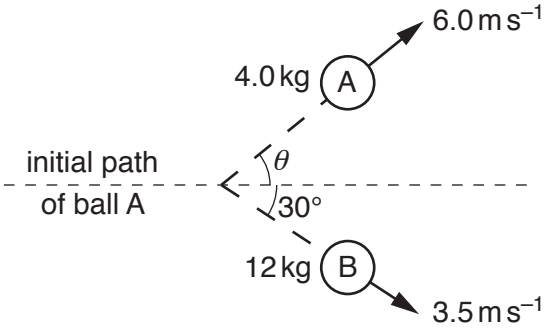
.....[2]

(b) Ball A moves with speed v along a horizontal frictionless surface towards a stationary ball B, as shown in Fig. 3.1.



before collision

Fig. 3.1



after collision

Fig. 3.2 (not to scale)

Ball A has mass 4.0 kg and ball B has mass 12 kg.
The balls collide and then move apart as shown in Fig. 3.2.
Ball A has velocity 6.0 m s^{-1} at an angle of θ to the direction of its initial path.
Ball B has velocity 3.5 m s^{-1} at an angle of 30° to the direction of the initial path of ball A.

(i) By considering the components of momentum at right-angles to the direction of the initial path of ball A, calculate θ.

θ = ... ° [3]

(ii) your answer in **(i)** to show that the initial speed v of ball A is $12\,m\,s^{-1}$.
Explain your working.

[2]

(iii) By calculation of kinetic energies, state and explain whether the collision is elastic or inelastic.

.....

.....[3]

[Total: 10]

4 **(a)** By reference to the direction of propagation of energy, explain what is meant by a *longitudinal* wave.

.....

.....[1]

(b) A car horn emits a sound wave of frequency 800 Hz. A microphone and a cathode-ray oscilloscope (c.r.o.) are used to analyse the sound wave. The waveform displayed on the c.r.o. screen is shown in Fig. 4.1.

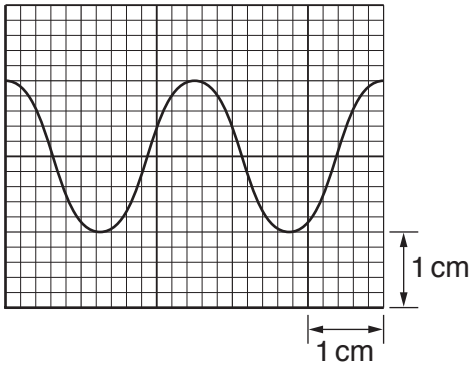


Fig. 4.1

Determine the time-base setting, in $s\,cm^{-1}$, of the c.r.o.

time-base setting = ... $s\,cm^{-1}$ [3]

(c) The intensity I of the sound at a distance r from the car horn in **(b)** is given by the expression

$$I = \frac{k}{r^2}$$

where k is a constant.

Fig. 4.2 shows the car in **(b)** on a road.

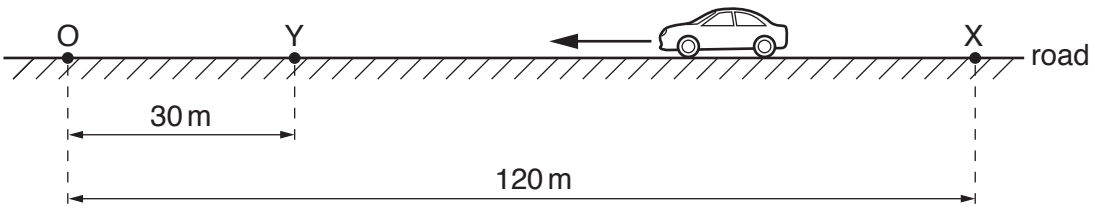


Fig. 4.2

An observer stands at point O. Initially the car is parked at point X which is 120 m away from point O. The car then moves directly towards the observer and stops at point Y, a distance of 30 m away from O.
The car horn continuously emits sound when the car is moving between points X and Y.

(i) The sound wave at point O has amplitude A_X when the car is at X and has amplitude A_Y when the car is at Y.

Calculate the ratio $\frac{A_Y}{A_X}$.

ratio = ...[3]

(ii) When the car is parked at X, the frequency of the sound from the horn that is detected by the observer is 800 Hz. As the car moves from X to Y, the maximum change in the detected frequency is 16 Hz. The speed of the sound in air is 330 m s^{-1}.

Determine, to two significant figures,

1. the minimum wavelength of the sound detected by the observer,

wavelength = ... m [2]

2. the maximum speed of the car.

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

[Total: 11]

5 **(a)** Define *electric field strength*.

.....

.....[1]

(b) Two parallel metal plates in a vacuum are separated by 0.045 m. A potential difference V is applied between the plates, as shown in Fig. 5.1.

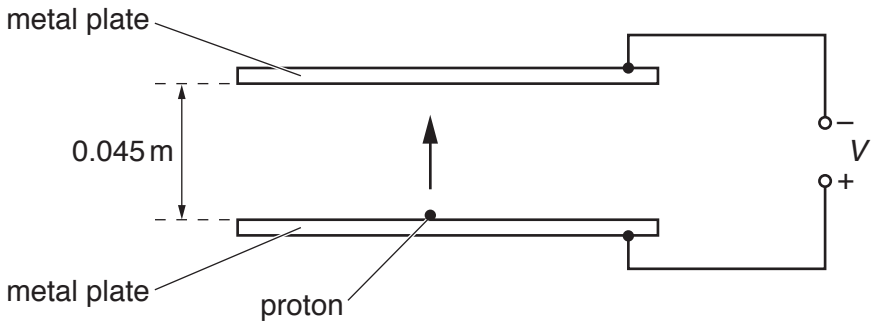


Fig. 5.1

A proton is initially at rest on the surface of the positive plate. The proton in the uniform electric field takes a time of 1.5×10^{-7} s to reach the negative plate.

(i) Show that the acceleration of the proton is $4.0 \times 10^{12}\,m\,s^{-2}$.

[2]

(ii) Calculate the electric force on the proton.

force = ... N [1]

(iii) your answer in **(ii)** to determine

1. the electric field strength,

field strength = ... NC^{-1} [2]

2. the potential difference V between the plates.

V = ... V [2]

(c) An α particle is now accelerated between the two metal plates in **(b)** by the electric field.

Calculate the ratio

$$\frac{\text{acceleration of } \alpha \text{ particle}}{\text{acceleration of proton}}.$$

ratio = ...[2]

[Total: 10]

6 A filament lamp is rated as 30 W, 120 V. A potential difference of 120 V is applied across the lamp.

(a) the filament wire of the lamp, calculate

(i) the current,

current = ... A [2]

(ii) the number of electrons passing a point in 3.0 hours.

number = ...[2]

(b) Show that the resistance of the filament wire is 480 Ω.

[2]

(c) The filament wire has an uncoiled length of 580 mm and is made of metal. The metal has resistivity $6.1 \times 10^{-7}\,\Omega\,m$ at the operating temperature of the lamp.

Calculate the diameter of the wire.

diameter = ... m [3]

(d) The potential difference across the lamp is now reduced. State and explain the effect, if any, on the resistance of the filament wire.

.....

.....[1]

[Total: 10]

7 **(a)** A nucleus X decays by emitting a β^+ particle to form a new nucleus, $^{23}_{11}Na$.

State the number of nucleons and the number of neutrons in nucleus X.

number of nucleons = ...

number of neutrons = ...
[2]

(b) State one similarity and one difference between a β^+ particle and a β^- particle.

similarity: .....

difference: .....
[2]

[Total: 4]