Physical Quantities & Units

Question paper 3

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Physical Quantities & Units
Sub Topic	
Paper Type	Theory
Booklet	Question paper 3

Time Allowed: **84 minutes**

Score: **/70**

Percentage: **/100**

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 **(a)** The current in a wire is I. Charge Q passes one point in the wire in time t. State

(i) the relation between I, Q and t,

..... [1]

(ii) which of the quantities I, Q and t are base quantities.

.....

..... [2]

(b) The current in the wire is due to electrons, each with charge q, that move with speed v along the wire. There are n of these electrons per unit volume.
For a wire having a cross-sectional area S, the current I is given by the equation

$$I = nSqv^k,$$

where k is a constant.

(i) State the units of I, n, S, q and v in terms of the base units.

I .....

n .....

S .....

q .....

v .....
[3]

(ii) By considering the homogeneity of the equation, determine the value of k.

k = ... [2]

2 Make reasonable estimates of the following quantities.

(a) the frequency of an audible sound wave

frequency = ... Hz [1]

(b) the wavelength, in nm, of ultraviolet radiation

wavelength = ... nm [1]

(c) the mass of a plastic 30 cm ruler

mass = ... g [1]

(d) the density of air at atmospheric pressure

density = ... kg m^{-3} [1]

3 **(a)** Derive the SI base unit of force.

SI base unit of force = ... [1]

(b) A spherical ball of radius r experiences a resistive force F due to the air as it moves through the air at speed v. The resistive force F is given by the expression

$$F = crv,$$

where c is a constant.

Derive the SI base unit of the constant c.

SI base unit of c = ... [1]

(c) The ball is dropped from rest through a height of 4.5 m.

(i) Assuming air resistance to be negligible, calculate the final speed of the ball.

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

(ii) The ball has mass 15 g and radius 1.2 cm.

The numerical value of the constant c in the equation in **(b)** is equal to 3.2×10^{-4} when measured using the SI system of units.

Show quantitatively whether the assumption made in **(i)** is justified.

[3]

4 Make estimates of the following quantities.

(a) the speed of sound in air

speed = ... [1]

(b) the density of air at room temperature and pressure

density = ... [1]

(c) the mass of a protractor

mass = ... [1]

(d) the volume, in cm^3, of the head of an adult person

volume = ... cm^3 [1]

5 **(a)** State the difference between a scalar quantity and a vector quantity.

scalar: .....

.....

vector: .....

..... [2]

(b) Two forces of magnitude 6.0 N and 8.0 N act at a point P. Both forces act away from point P and the angle between them is 40°.
Fig. 1.1 shows two lines at an angle of 40° to one another.

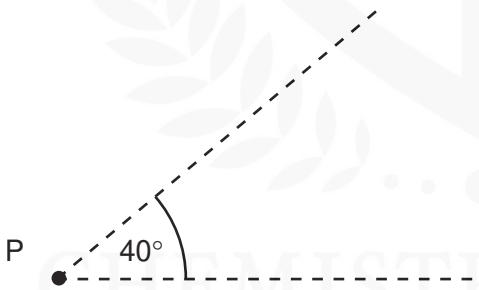

Fig. 1.1

On Fig. 1.1, draw a vector diagram to determine the magnitude of the resultant of the two forces.

magnitude of resultant = ... N [4]

6 Complete Fig. 1.1 to show each quantity and its unit. [4]

quantity	*unit*
speed	ms-1
density	.....
.....	s-1
electric field strength	.....
.....	kgms-1

Fig.1.1

7 **(a)** **(i)** Define *density*.

.....

.....

(ii) State the base units in which density is measured.

.....
[2]

(b) The speed v of sound in a gas is given by the expression

$$v = \sqrt{\left(\frac{\gamma p}{\rho}\right)},$$

where p is the pressure of the gas of density ρ. γ is a constant.

Given that p has the base units of $\mathrm{kg\,m^{-1}\,s^{-2}}$, show that the constant γ has no unit. [3]

8 **(a)** Define *speed* and *velocity* and use these definitions to explain why one of these quantities is a scalar and the other is a vector.

speed: .....

velocity: .....

.....

.....

[2]

(b) A ball is released from rest and falls vertically. The ball hits the ground and rebounds vertically, as shown in Fig. 2.1.

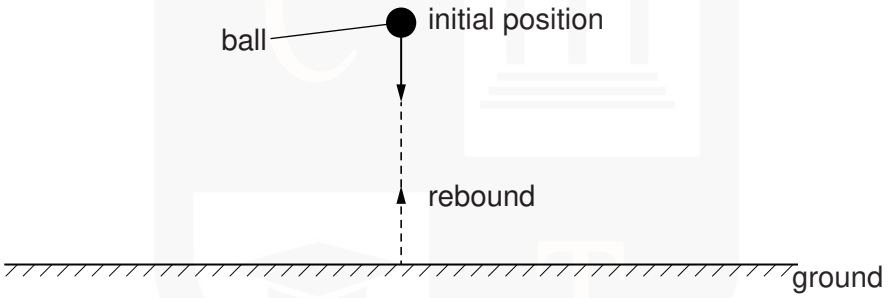

Fig. 2.1

The variation with time t of the velocity v of the ball is shown in Fig. 2.2.

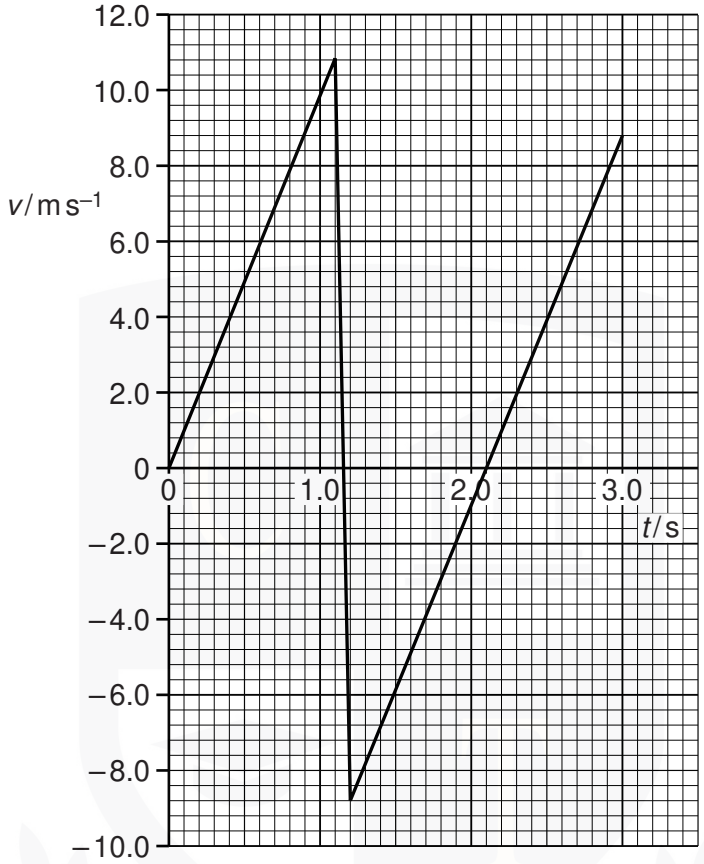

Fig. 2.2

Air resistance is negligible.

(i) Without calculation, use Fig. 2.2 to describe the variation with time t of the velocity of the ball from $t = 0$ to $t = 2.1$ s.

.....

.....

.....

.....

.....

.....[3]

(ii) Calculate the acceleration of the ball after it rebounds from the ground. Show your working.

acceleration = ... $m s^{-2}$ [3]

(iii) Calculate, for the ball, from $t = 0$ to $t = 2.1$ s,

1. the distance moved,

distance = ... m [3]

2. the displacement from the initial position.

displacement = ... m [2]

(iv) On Fig. 2.3, sketch the variation with t of the speed of the ball.

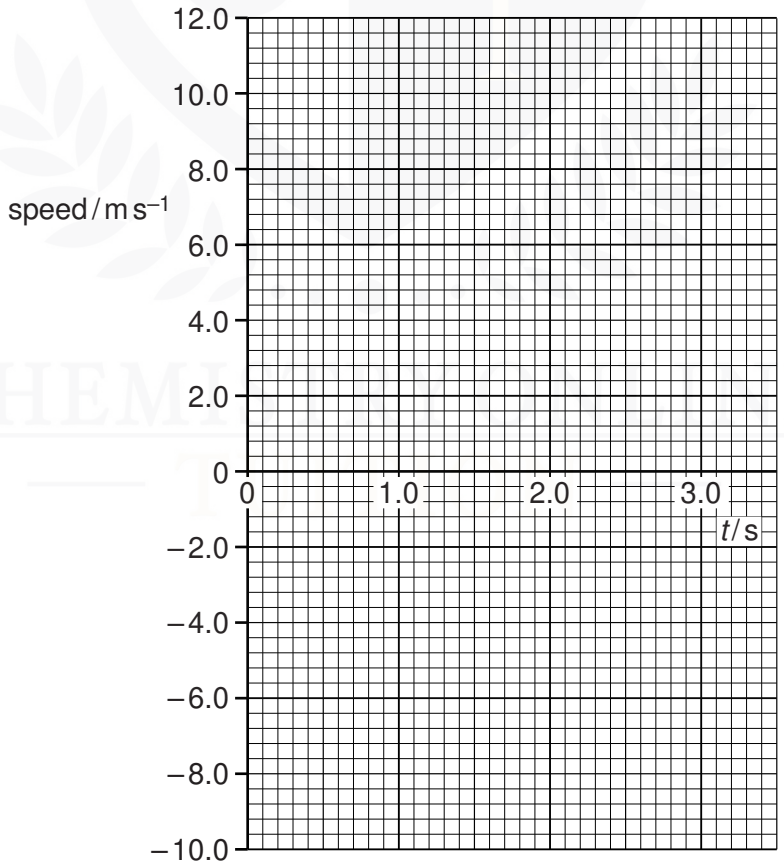

Fig. 2.3

[2]

9 Energy is stored in a metal wire that is extended elastically.

(a) Explain what is meant by *extended elastically*.

.....

..... [2]

(b) Show that the SI units of energy per unit volume are $kg\,m^{-1}\,s^{-2}$.

[2]

(c) For a wire extended elastically, the elastic energy per unit volume X is given by

$$X = C\varepsilon^2 E$$

where C is a constant,
ε is the strain of the wire,
and E is the Young modulus of the wire.

Show that C has no units.

[3]

10 **(a)** A stone of mass 56 g is thrown horizontally from the top of a cliff with a speed of $18\,m\,s^{-1}$, as illustrated in Fig. 4.1.

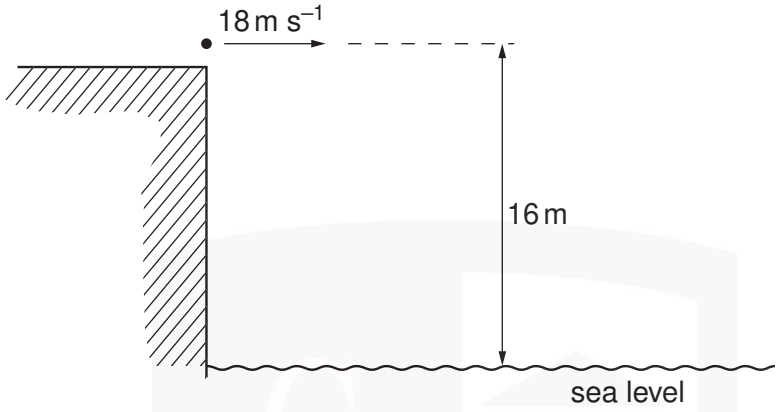

Fig. 4.1

The initial height of the stone above the level of the sea is 16 m. Air resistance may be neglected.

(i) Calculate the change in gravitational potential energy of the stone as a result of falling through 16 m.

change = ... J [2]

(ii) Calculate the total kinetic energy of the stone as it reaches the sea.

kinetic energy = ... J [3]

(b) Use your answer in **(a)(ii)** to show that the speed of the stone as it hits the water is approximately $25\,m\,s^{-1}$.

[1]

(c) State the horizontal velocity of the stone as it hits the water.

horizontal velocity = ...$m\,s^{-1}$ [1]

(d) **(i)** On the grid of Fig. 4.2, draw a vector diagram to represent the horizontal velocity and the resultant velocity of the stone as it hits the water. [1]

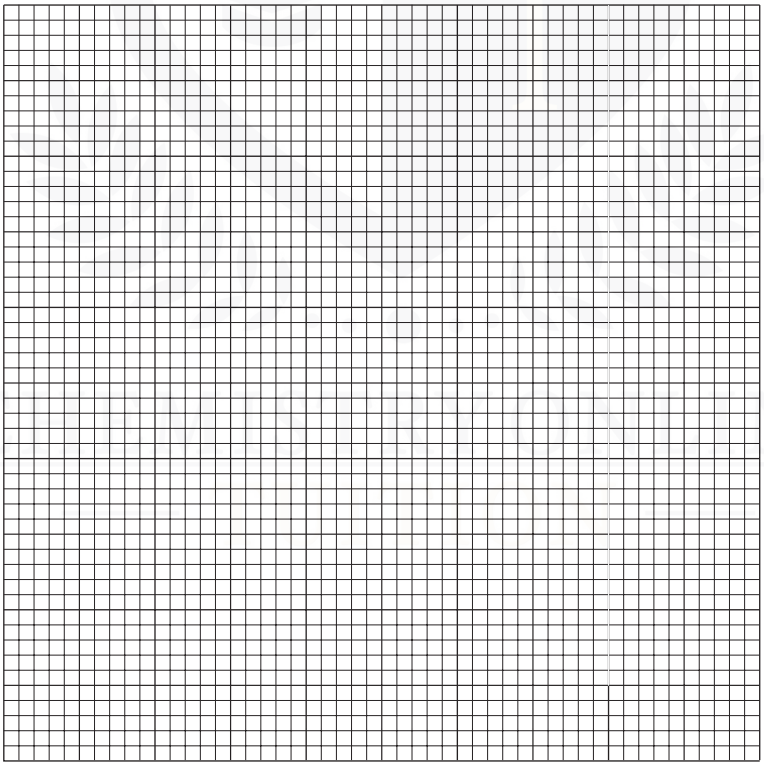

Fig. 4.2

(ii) Use your vector diagram to determine the angle with the horizontal at which the stone hits the water.

angle = ... ° [2]