Equations of Motion

Question paper 3

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Kinematics
Sub Topic	Equations of Motion
Paper Type	Theory
Booklet	Question paper 3

Time Allowed: **78 minutes**

Score: **/65**

Percentage: **/100**

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

1 **(a)** A student walks from A to B along the path shown in Fig. 2.1.

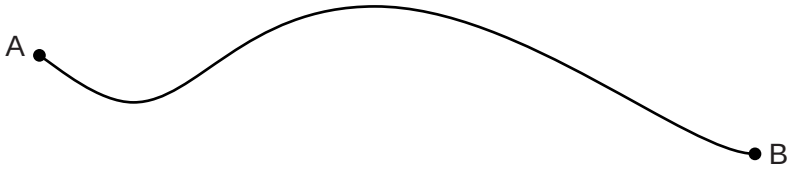

Fig. 2.1

The student takes time *t* to walk from A to B.

(i) State the quantity, apart from *t*, that must be measured in order to determine the average value of

1. speed,

.....

..... [1]

2. velocity.

.....

..... [1]

(ii) Define *acceleration*.

..... [1]

(b) A girl falls vertically onto a trampoline, as shown in Fig. 2.2.

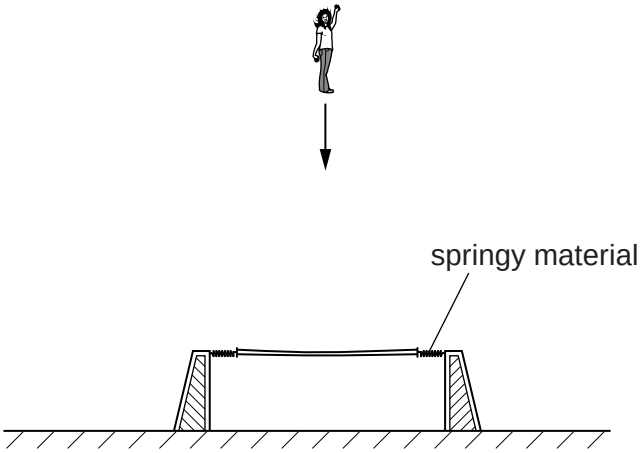

Fig. 2.2

The trampoline consists of a central section supported by springy material. At time t = 0 the girl starts to fall. The girl hits the trampoline and rebounds vertically. The variation with time t of velocity v of the girl is illustrated in Fig. 2.3.

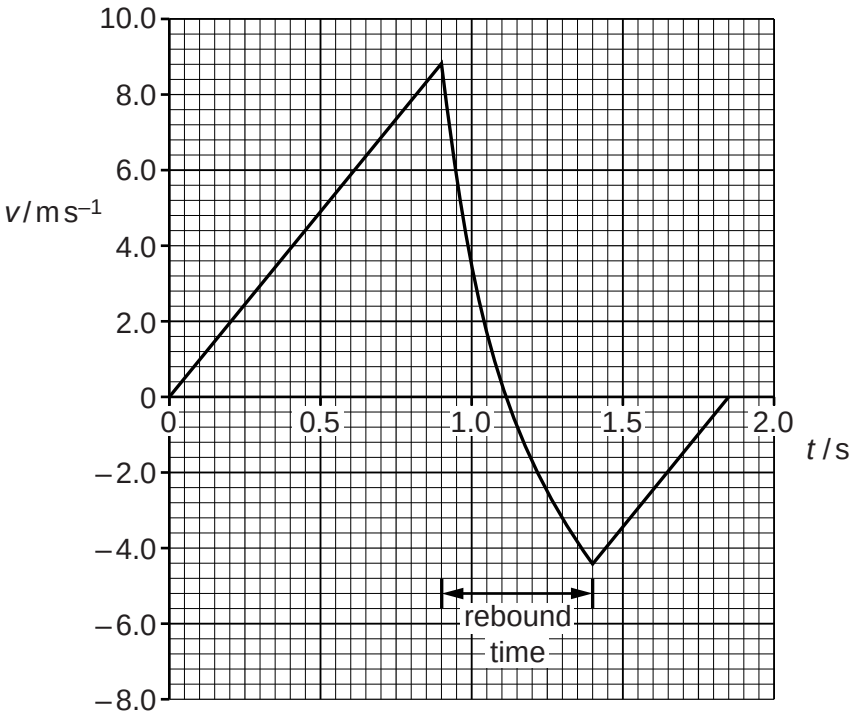

Fig. 2.3

For the motion of the girl, calculate

(i) the distance fallen between time t = 0 and when she hits the trampoline,

distance = ... m [2]

(ii) the average acceleration during the rebound.

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

(c) **(i)** Use Fig. 2.3 to compare, without calculation, the accelerations of the girl before and after the rebound. Explain your answer.

.....

.....

..... [2]

(ii) Use Fig. 2.3 to compare, without calculation, the potential energy of the girl at $t = 0$ and $t = 1.85\,s$. Explain your answer.

.....

.....

..... [2]

2 **(a)** Explain what is meant by *work done*.

.....

..... [1]

(b) A car is travelling along a road that has a uniform downhill gradient, as shown in Fig. 2.1.

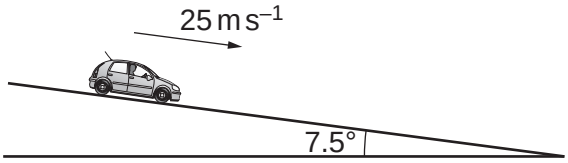

Fig. 2.1

The car has a total mass of 850 kg. The angle of the road to the horizontal is 7.5°.

Calculate the component of the weight of the car down the slope.

component of weight = ... N [2]

(c) The car in **(b)** is travelling at a constant speed of 25 m s^{-1}. The driver then applies the brakes to stop the car. The constant force resisting the motion of the car is 4600 N.

(i) Show that the deceleration of the car with the brakes applied is 4.1 m s^{-2}.

[2]

(ii) Calculate the distance the car travels from when the brakes are applied until the car comes to rest.

distance = ... m [2]

(iii) Calculate

1. the loss of kinetic energy of the car,

loss of kinetic energy = ... J [2]

2. the work done by the resisting force of 4600 N.

work done = ... J [1]

(iv) The quantities in **(iii) part 1** and in **(iii) part 2** are not equal. Explain why these two quantities are not equal.

.....

..... [1]

3 **(a)** Distinguish between *scalar* quantities and *vector* quantities.

.....

.....

..... [2]

(b) In the following list, underline **all** the scalar quantities.

acceleration force kinetic energy mass wer eight [1]

(c) A stone is thrown with a horizontal velocity of 20 m s^{-1} from the top of a cliff 15 m high. The path of the stone is shown in Fig. 1.1.

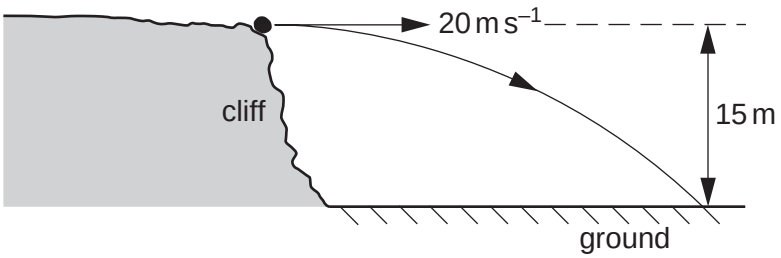

Fig. 1.1

Air resistance is negligible.

For this stone,

(i) calculate the time to fall 15 m,

time = ... s [2]

(ii) calculate the magnitude of the resultant velocity after falling 15 m,

resultant velocity = ... m s^{-1} [3]

(iii) describe the difference between the displacement of the stone and the distance that it travels.

.....

.....

..... [2]

4 A student takes measurements to determine a value for the acceleration of free fall. Some of the apparatus used is illustrated in Fig. 4.1.

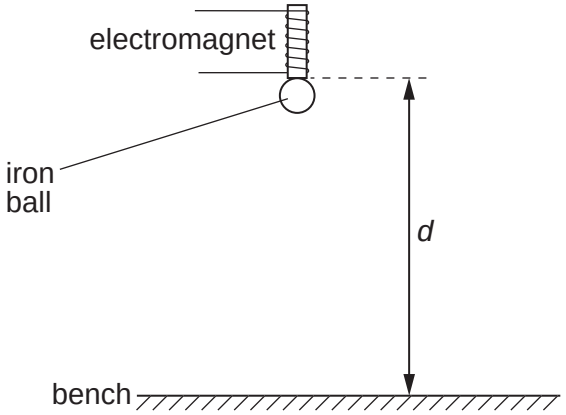

Fig. 4.1

The student measures the vertical distance d between the base of the electromagnet and the bench. The time t for an iron ball to fall from the electromagnet to the bench is also measured.
Corresponding values of t^2 and d are shown in Fig. 4.2.

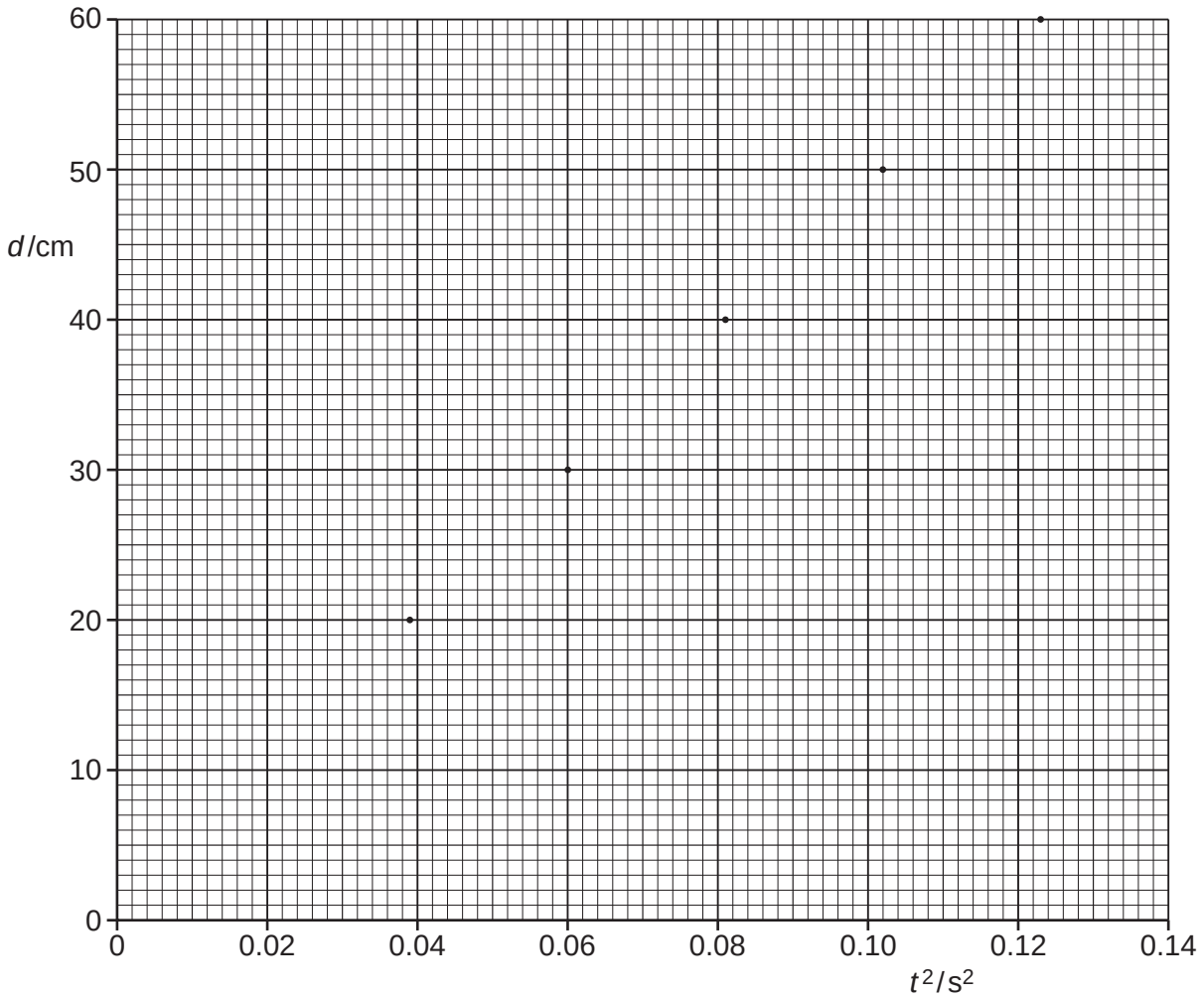

Fig. 4.2

(a) On Fig. 4.2, draw the line of best fit for the points. [1]

(b) State and explain why there is a non-zero intercept on the graph of Fig. 4.2.

.....

.....

..... [2]

(c) Determine the student's value for

(i) the diameter of the ball,

diameter = ... cm [1]

(ii) the acceleration of free fall.

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

5 Two vertical parallel metal plates are situated 2.50 cm apart in a vacuum. The potential difference between the plates is 350 V, as shown in Fig. 6.1.

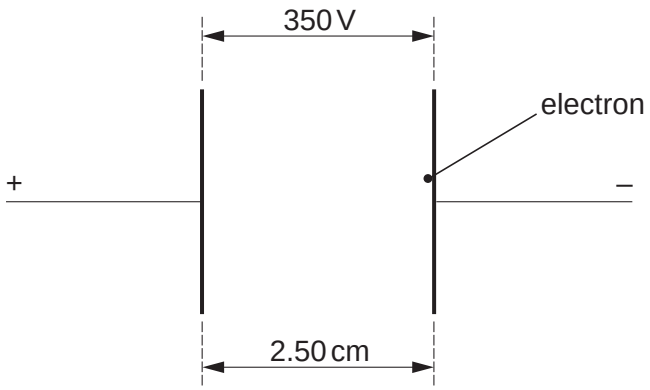

Fig. 6.1

An electron is initially at rest close to the negative plate and in the uniform electric field between the plates.

(a) (i) Calculate the magnitude of the electric field between the plates.

electric field strength = ... $N\,C^{-1}$ [2]

(ii) Show that the force on the electron due to the electric field is 2.24×10^{-15} N.

[2]

(b) The electron accelerates horizontally across the space between the plates. Determine

(i) the horizontal acceleration of the electron,

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

(ii) the time to travel the horizontal distance of 2.50 cm between the plates.

time = ... s [2]

(c) Explain why gravitational effects on the electron need not be taken into consideration in your calculation in **(b)**.

.....

.....

..... [2]

6 **(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]

7 **(a)** One of the equations of motion may be written as

$$v^2 = u^2 + 2as.$$

(i) Name the quantity represented by the symbol *a*.

.....

(ii) The quantity represented by the symbol *a* may be either positive or negative. State the significance of a negative value.

.....
[2]

(b) A student investigates the motion of a small polystyrene sphere as it falls from rest alongside a vertical scale marked in centimetres. To do this, a number of flash photographs of the sphere are taken at 0.1 s intervals, as shown in Fig. 1.1.

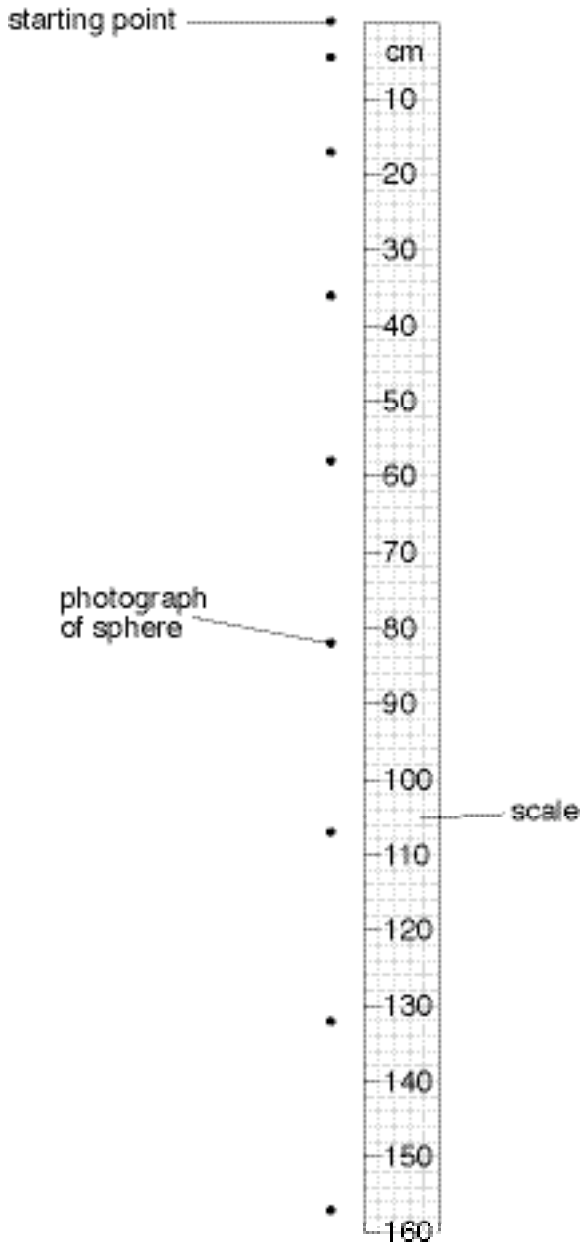

Fig. 1.1

The first photograph is taken at time $t = 0$.

By reference to Fig. 1.1,

(i) briefly explain how it can be deduced that the sphere reaches a constant speed,

.....

.....

(ii) determine the distance that the sphere has fallen from rest during a time of

1. 0.7 s,

distance = …… cm

2. 1.1 s.

distance = …… cm
[4]

(c) The student repeats the experiment with a lead sphere that falls with constant acceleration and does not reach a constant speed.

Determine the number of flash photographs that will be observed against the 160 cm scale.

Include in your answer the photograph obtained at time $t = 0$.

number = …… [3]