1. Nov/2020/Paper_41/No.3

A pendulum consists of a metal sphere P suspended from a fixed point by means of a thread, as illustrated in Fig. 3.1.

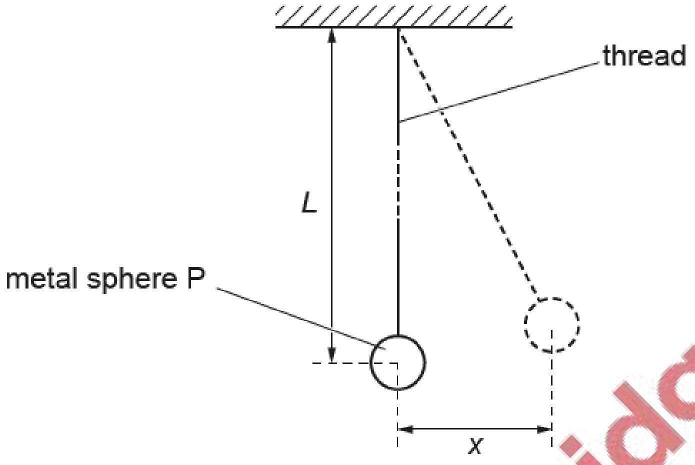

Fig. 3.1

The centre of gravity of sphere P is a distance L from the fixed point.

The sphere is pulled to one side and then released so that it oscillates. The sphere may be assumed to oscillate with simple harmonic motion.

(a) State what is meant by *simple harmonic motion*.

....

....

.... [2]

(b) The variation of the velocity v of sphere P with the displacement x from its mean position is shown in Fig. 3.2.

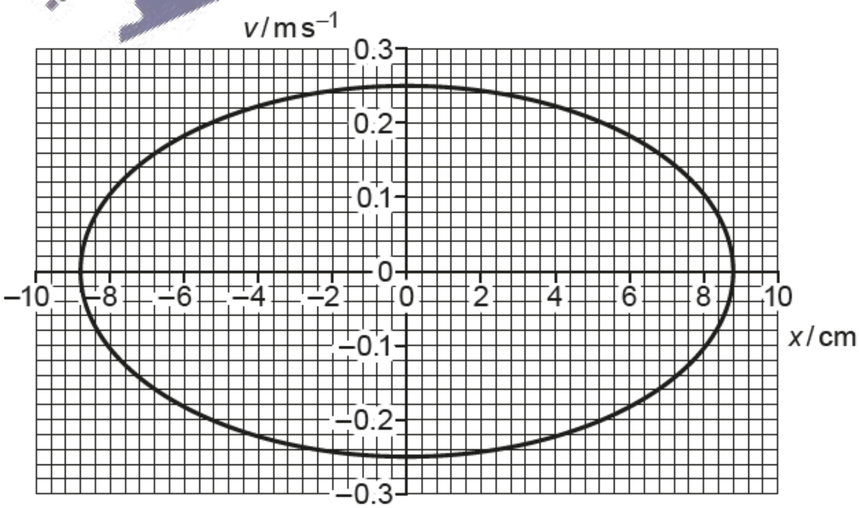

Fig. 3.2

Use Fig. 3.2 to determine the frequency *f* of the oscillations of sphere P.

f = ... Hz [3]

(c) The period *T* of the oscillations of sphere P is given by the expression

$$T = 2\pi\sqrt{\left(\frac{L}{g}\right)}$$

where *g* is the acceleration of free fall.

Use your answer in **(b)** to determine the length *L*.

L = ... m [2]

(d) Another pendulum consists of a sphere Q suspended by a thread. Spheres P and Q are identical. The thread attached to sphere Q is longer than the thread attached to sphere P.

Sphere Q is displaced and then released. The oscillations of sphere Q have the same amplitude as the oscillations of sphere P.

On Fig. 3.2, sketch the variation of the velocity *v* with displacement *x* for sphere Q. [2]

[Total: 9]

2. Nov/2020/Paper_42/No.3

A simple pendulum consists of a metal sphere suspended from a fixed point by means of a thread, as illustrated in Fig. 3.1.

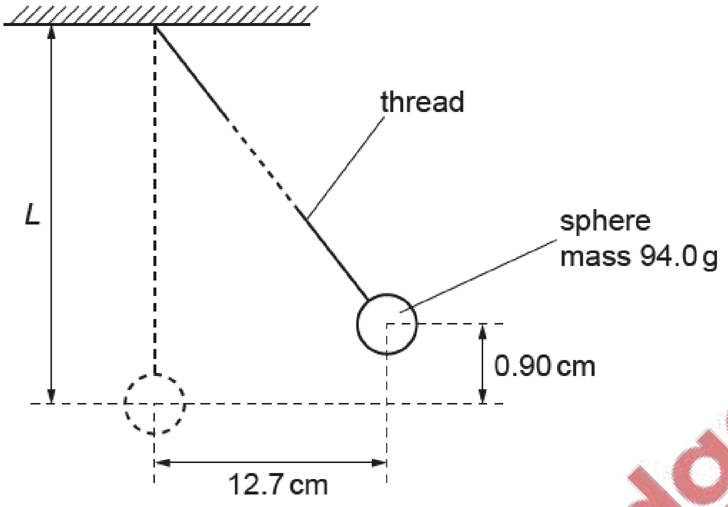

Fig. 3.1 (not to scale)

The sphere of mass 94.0 g is displaced to one side through a horizontal distance of 12.7 cm. The centre of gravity of the sphere rises vertically by 0.90 cm.

The sphere is released so that it oscillates. The sphere may be assumed to oscillate with simple harmonic motion.

(a) State what is meant by *simple harmonic motion*.

....

....

....[2]

(b) **(i)** State the kinetic energy of the sphere when the sphere returns to the displaced position shown in Fig. 3.1.

kinetic energy = ... J [1]

(ii) Calculate the total energy E_T of the oscillations.

E_T = ... J [2]

(iii) Use your answer in **(ii)** to show that the angular frequency ω of the oscillations of the pendulum is $3.3\,\text{rad}\,\text{s}^{-1}$.

[2]

(c) The period T of oscillation of the pendulum is given by the expression

$$T = 2\pi\sqrt{\left(\frac{L}{g}\right)}$$

where g is the acceleration of free fall and L is the length of the pendulum.

Use data from **(b)** to determine L.

L = ... m [3]

[Total: 10]

3. June/2020/Paper_41/No.3

The piston in the cylinder of a car engine moves in the cylinder with simple harmonic motion. The piston moves between a position of maximum height in the cylinder to a position of minimum height, as illustrated in Fig. 3.1.

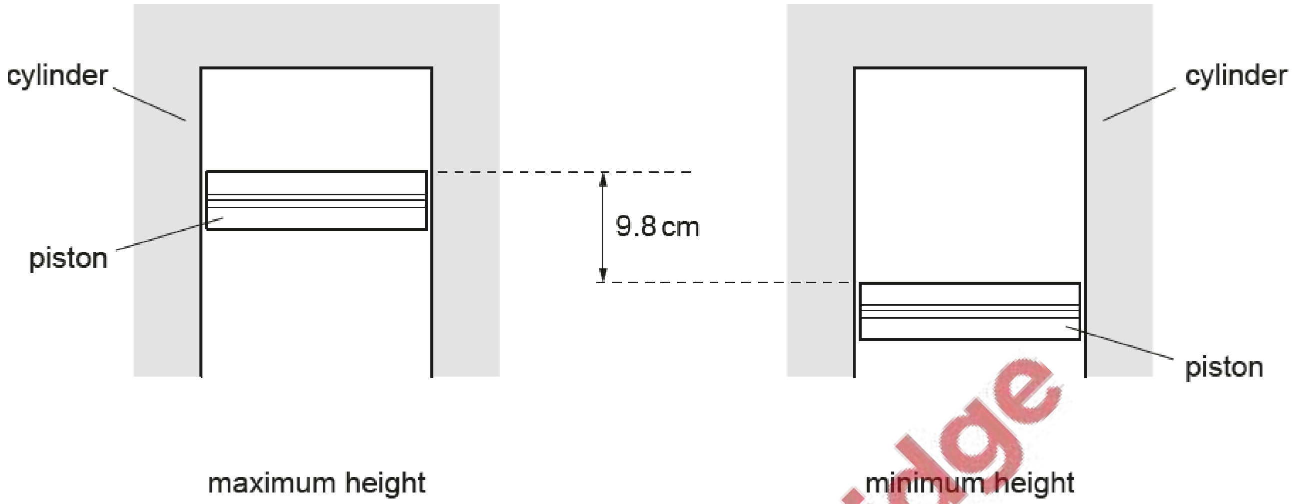

Fig. 3.1

The distance moved by the piston between the positions shown in Fig. 3.1 is 9.8 cm.

The mass of the piston is 640 g.

At one particular speed of the engine, the piston completes 2700 oscillations in 1.0 minute.

(a) For the oscillations of the piston in the cylinder, determine:

(i) the amplitude

amplitude = ... cm [1]

(ii) the frequency

frequency = ... Hz [1]

(iii) the maximum speed

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

(iv) the speed when the top of the piston is 2.3 cm below its maximum height.

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

(b) The acceleration of the piston varies.

Determine the resultant force on the piston that gives rise to its maximum acceleration.

force = ... N [3]

[Total: 9]

4. June/2020/Paper_42/No.4

A dish is made from a section of a hollow glass sphere.

The dish, fixed to a horizontal table, contains a small solid ball of mass 45 g, as shown in Fig. 4.1.

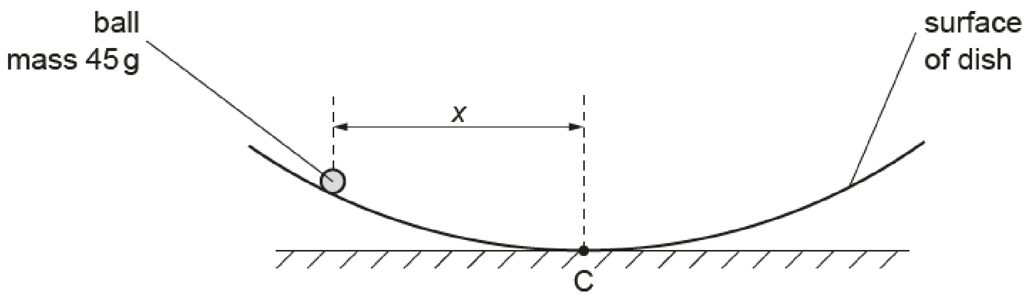

Fig. 4.1

The horizontal displacement of the ball from the centre C of the dish is *x*.

Initially, the ball is held at rest with distance *x* = 3.0 cm.

The ball is then released. The variation with time *t* of the horizontal displacement *x* of the ball from point C is shown in Fig. 4.2.

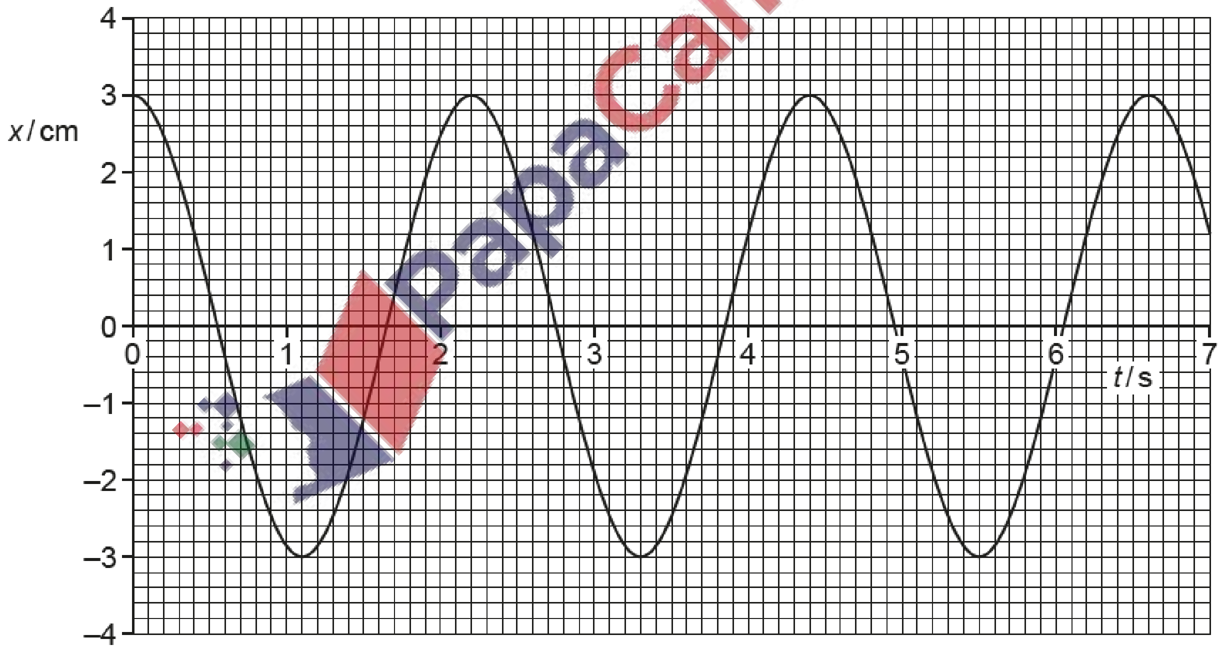

Fig. 4.2

The motion of the ball in the dish is simple harmonic with its acceleration *a* given by the expression

$$a = -\left(\frac{g}{R}\right)x$$

where *g* is the acceleration of free fall and *R* is a constant that depends on the dimensions of the dish and the ball.

(a) Use Fig. 4.2 to show that the angular frequency ω of oscillation of the ball in the dish is $2.9\,\text{rad}\,\text{s}^{-1}$.

[1]

(b) Use the information in **(a)** to:

(i) determine *R*

R = ... m [2]

(ii) calculate the speed of the ball as it passes over the centre C of the dish.

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

(c) Some moisture collects on the surface of the dish so that the motion of the ball becomes lightly damped.

On the axes of Fig. 4.2, draw a line to show the lightly damped motion of the ball for the first 5.0 s after the release of the ball. [3]

[Total: 8]

5. March/2020/Paper_42/No.3

(a) A body undergoes simple harmonic motion.

The variation with displacement x of its velocity v is shown in Fig. 3.1.

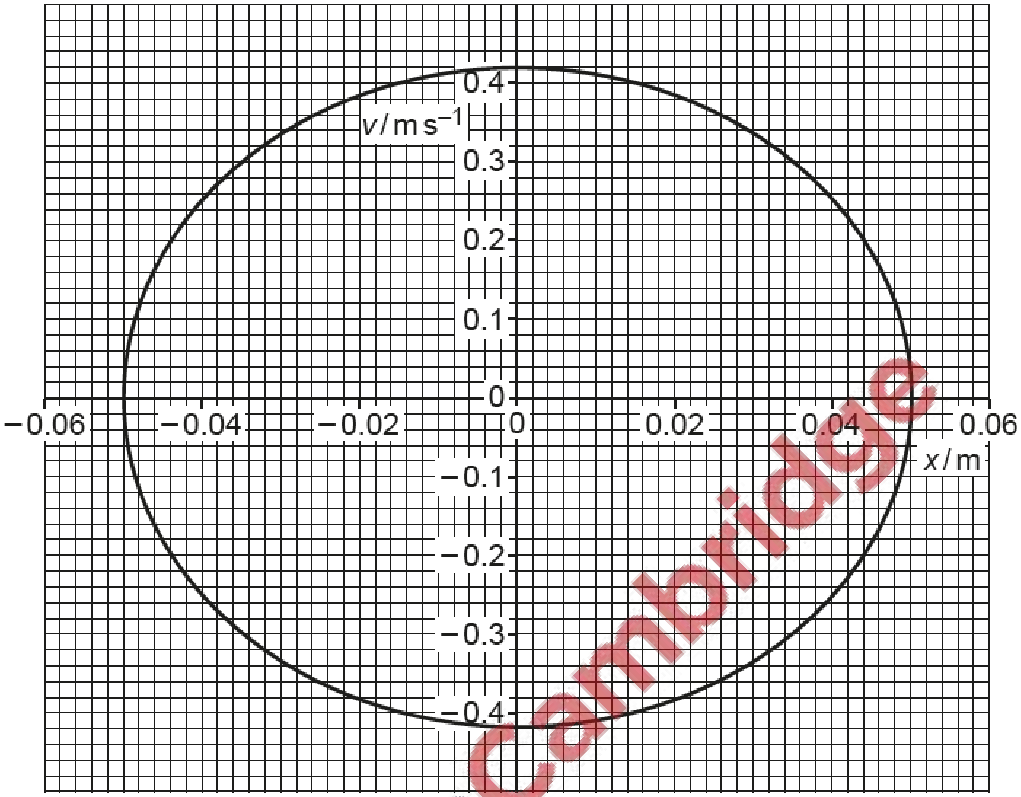

Fig. 3.1

(i) State the amplitude x_o of the oscillations.

x_o = ... m [1]

(ii) Calculate the period T of the oscillations.

T = ... s [3]

(iii) On Fig. 3.1, label with a P a point where the body has **maximum** potential energy. [1]

(b) A bar magnet is suspended from the free end of a spring, as shown in Fig. 3.2.

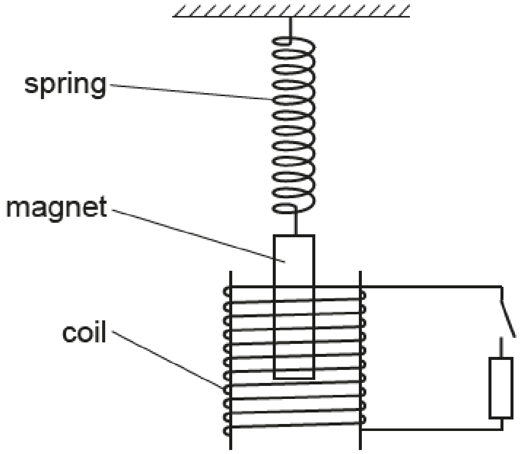

Fig. 3.2

One pole of the magnet is situated in a coil of wire. The coil is connected in series with a switch and a resistor. The switch is open.

The magnet is displaced vertically and then released. The magnet oscillates with simple harmonic motion.

(i) State Faraday's law of electromagnetic induction.

....

....

....

.... [2]

(ii) The switch is now closed. Explain why the oscillations of the magnet are damped.

....

....

....

....

....

.... [3]

[Total: 10]