

- 1 (a) In terms of velocity and acceleration, describe uniform circular motion of an object.

.....

.....

..... [2]

- (b) Fig. 1.1 shows the view from above of a polystyrene ball undergoing horizontal circular motion of radius R .

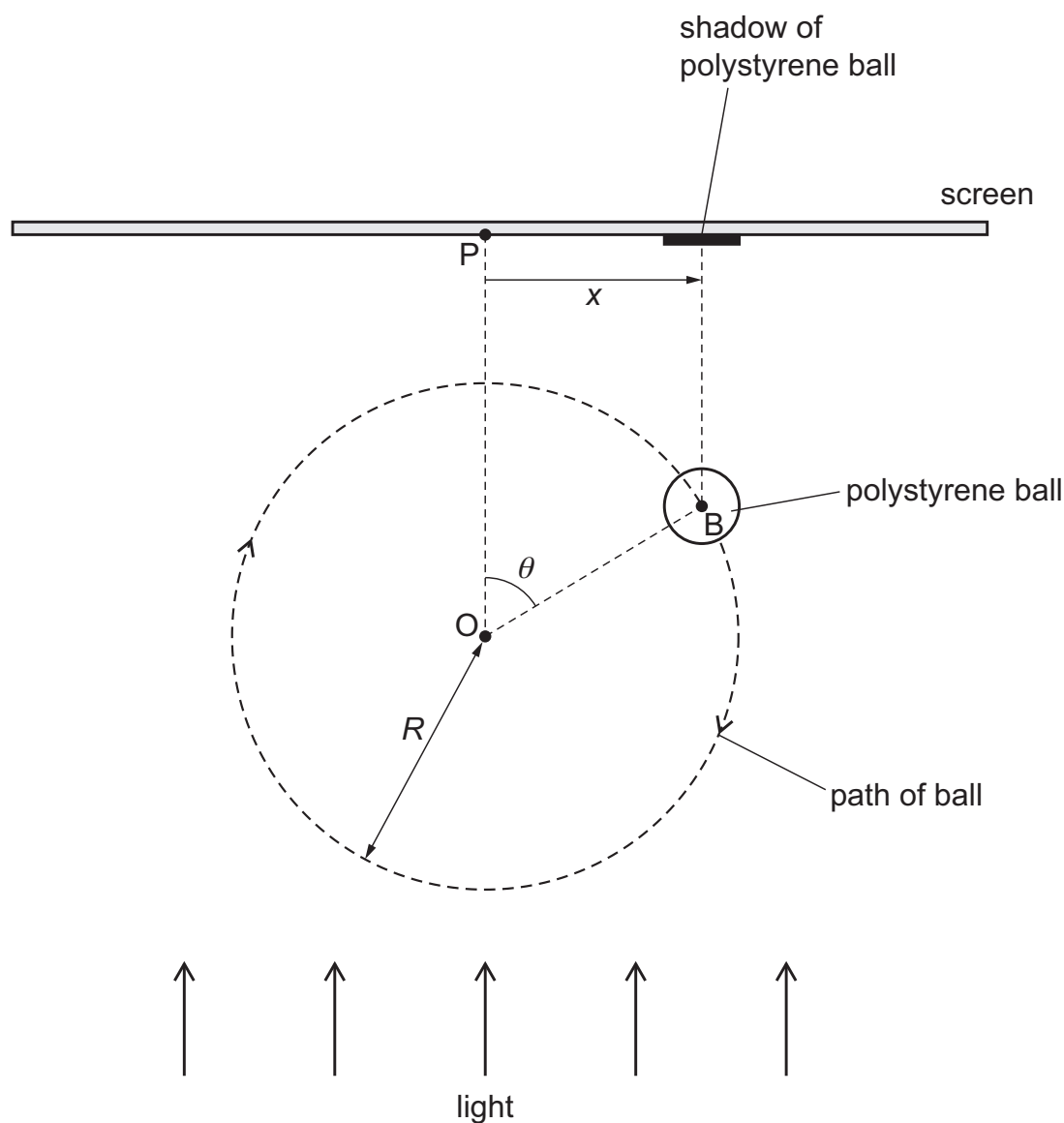


Fig. 1.1

The ball is illuminated by parallel light so that a shadow of the ball forms on a screen placed on the opposite side of the ball from the light source.

The line joining points O and P is perpendicular to the screen.

The angular speed of the circular motion is ω .

(i) State an expression, in terms of R and ω , for the speed v of the ball.

$v = \dots\dots\dots$ [1]

(ii) Determine an expression, in terms of v and ω , for the centripetal acceleration of the ball.

centripetal acceleration = $\dots\dots\dots$ [2]

(c) The ball in (b) is in the position shown in Fig. 1.1, such that line OB is at an angle θ to the line OP.

(i) Determine an expression, in terms of R and θ , for the displacement x of the shadow from P.

$x = \dots\dots\dots$ [1]

(ii) The value of θ is zero at time $t = 0$.

State an expression for θ in terms of ω and t .

$\theta = \dots\dots\dots$ [1]

(iii) Use your answers in (c)(i) and (c)(ii) to show that x is given by

$x = R \sin \omega t.$

[1]

(iv) Explain, with reference to the equation in (c)(iii), why the motion of the shadow of the ball on the screen may be modelled as simple harmonic.

- (d) The circular motion of the ball in Fig. 1.1 has a diameter of 0.46 m and an angular speed of 1.9 rad s^{-1} .

For the simple harmonic motion of the shadow of the ball in Fig. 1.1, calculate:

- (i) the amplitude

amplitude = m [1]

- (ii) the period

period = s [2]

- (iii) the maximum acceleration.

maximum acceleration = m s^{-2} [2]

- (e) On Fig. 1.1, draw, and label with the letter A, the position of the shadow on the screen when the shadow has its maximum positive acceleration. [1]

[Total: 15]

- 1 The Earth may be considered as a uniform sphere of radius $6.37 \times 10^6 \text{ m}$.

Cambridge is at a point on the Earth's surface that has a latitude of 52.2° north of the Equator, as shown in Fig. 1.1.

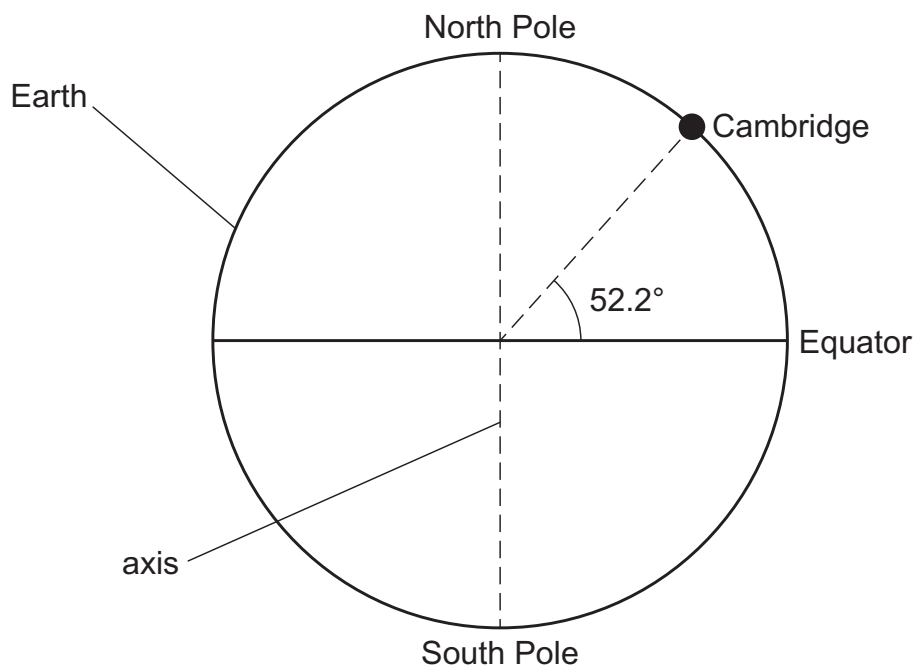


Fig. 1.1

As the Earth spins on its axis, Cambridge moves in a circle that is parallel to the Equator but with a smaller radius.

- (a) (i) Show that the radius of the circle around which Cambridge moves is $3.90 \times 10^6 \text{ m}$.

[1]

- (ii) Calculate the speed at which Cambridge moves around the circle.

speed = ms^{-1} [3]

- (b) A student of mass 58.6 kg stands on horizontal ground in Cambridge.
- (i) Determine the magnitude of the resultant force that acts to cause the circular motion of the student.

resultant force = N [2]

- (ii) On Fig. 1.2, draw an arrow to show the direction of the resultant force that acts on the student.

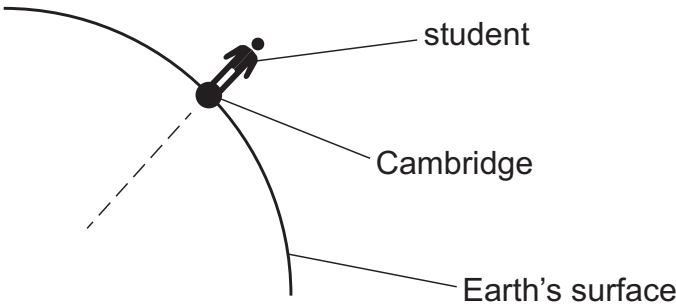


Fig. 1.2 (not to scale)

[1]

- (iii) On Fig. 1.3, draw labelled arrows from the student to show the directions of the forces that act on the student to cause the resultant force in (b)(ii).

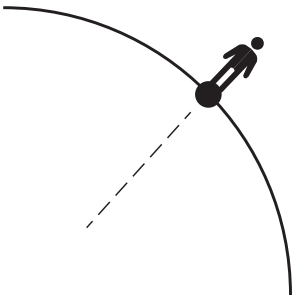


Fig. 1.3 (not to scale)

[2]

[Total: 9]

1 Fig. 1.1 shows a horizontal turntable.

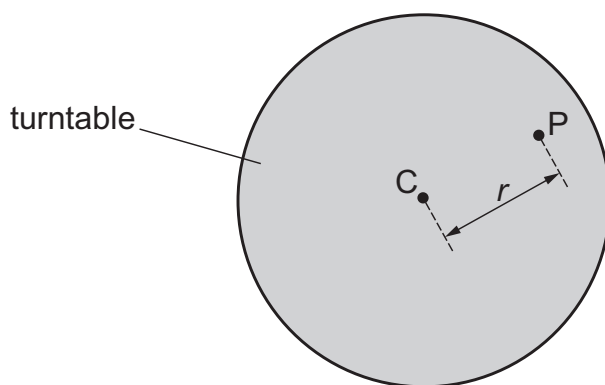


Fig. 1.1

Point C is at the centre of the turntable. Point P is a distance r from the centre.

Fig. 1.2 shows a side view of a d.c. motor attached to the turntable with a belt.



Fig. 1.2

The motor is used to rotate the turntable at frequency f_0 . The motor is switched off and the turntable continues to rotate at frequency f_0 .

A sphere of adhesive putty of mass m is dropped onto the turntable at point P. The frequency of the turntable is now f .

It is suggested that f is related to m by the relationship

$$\frac{Kf_0}{f} = \beta K + mr^2$$

where β and K are constants.

Plan a laboratory experiment to test the relationship between f and m .

Draw a diagram showing the arrangement of your equipment.

Explain how the results could be used to determine values for β and K .

In your plan you should include:

- the procedure to be followed
- the measurements to be taken
- the control of variables
- the analysis of the data
- any safety precautions to be taken.

Diagram

7.

[illegible]