

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

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..... [2]

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

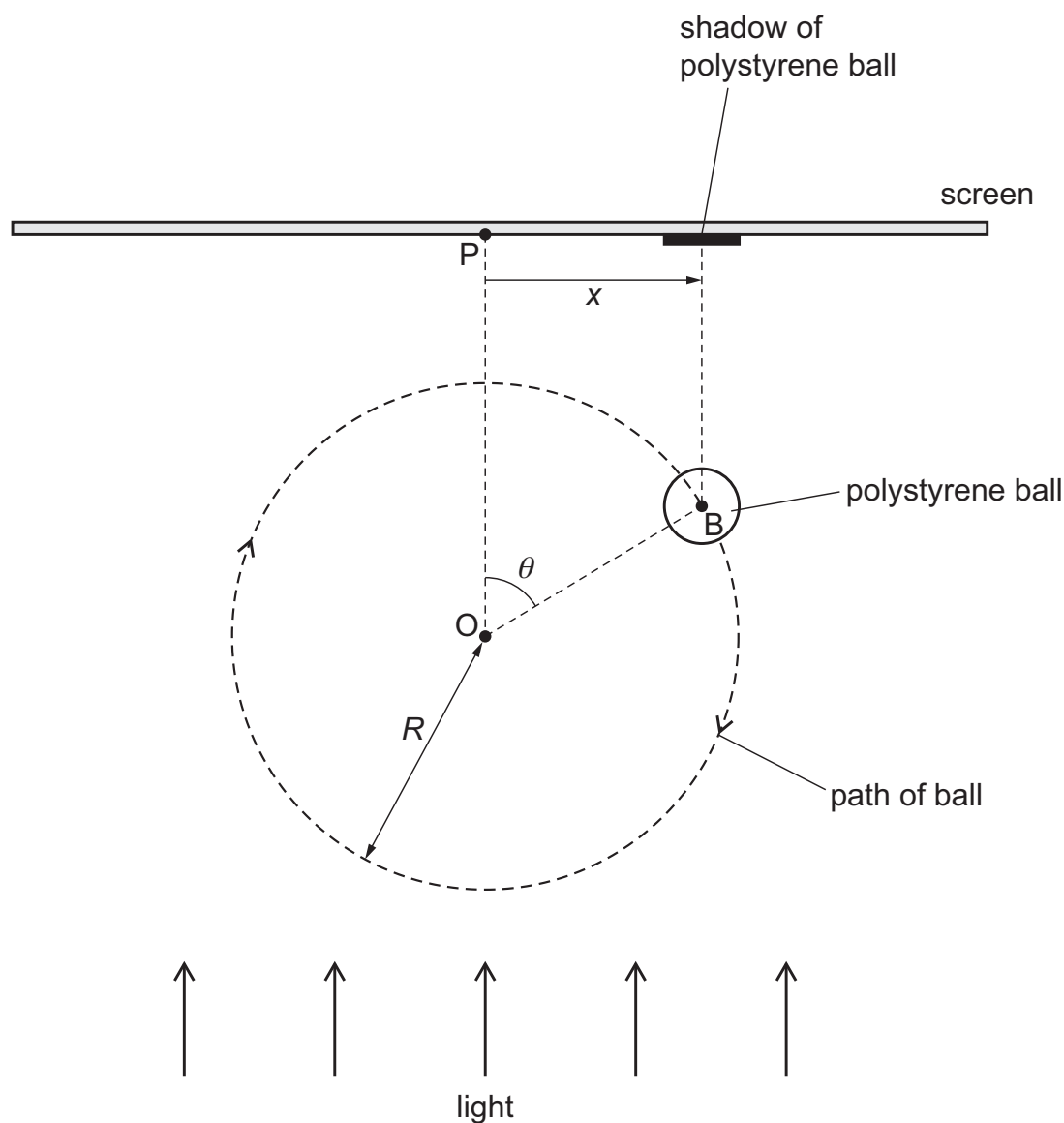


Fig. 1.1

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.

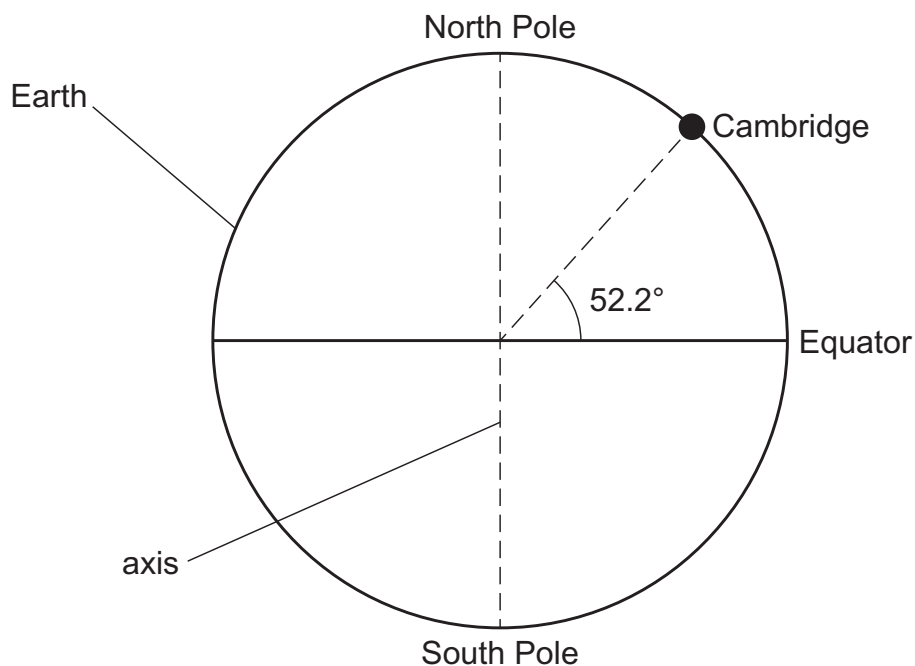


Fig. 1.1

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.

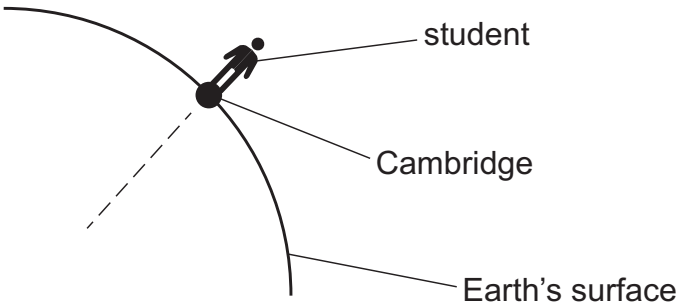


Fig. 1.2 (not to scale)

[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).

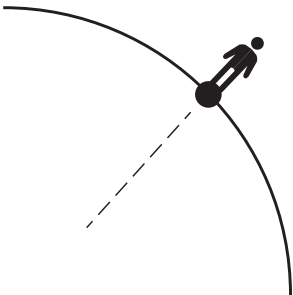


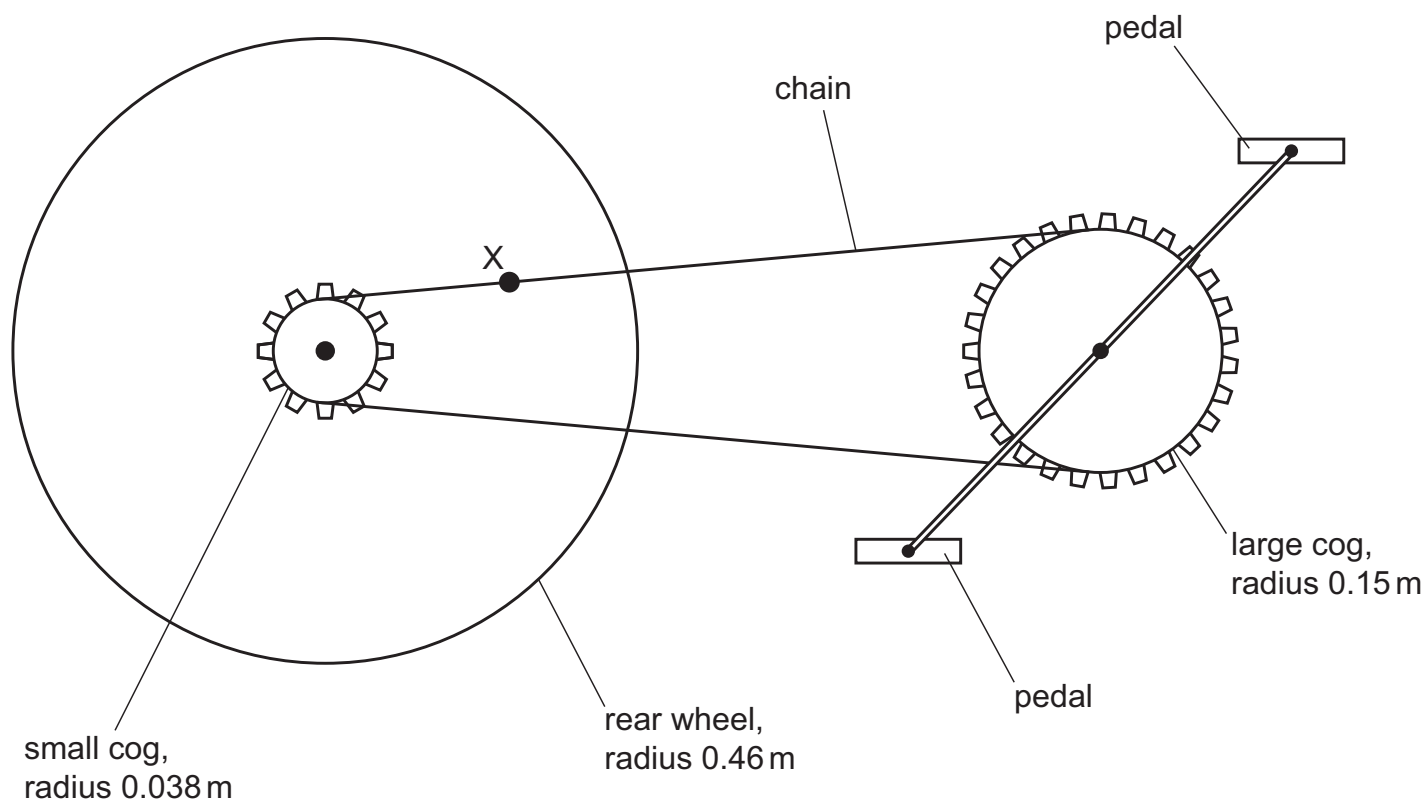
Fig. 1.3 (not to scale)

[2]

[Total: 9]

1 (a) Define the radian.

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..... [1]

(b) The rear wheel and the pedals of a bicycle are connected by a chain that passes around two cogs (toothed wheels), as shown in Fig. 1.1.**Fig. 1.1** (not to scale)

The small cog has a radius of 0.038 m and is fixed to the rear wheel so that it rotates with it. The large cog has a radius of 0.15 m and is fixed to the pedals so that it rotates with them. The rear wheel has a radius of 0.46 m.

The bicycle is being pedalled so that it moves in a straight line at a constant speed of 17 m s^{-1} .

(i) Calculate the angular speed of the rear wheel.

angular speed = rad s^{-1} [2]

(ii) Calculate the period of rotation of the small cog.

period = s [2]

(iii) Show that the distance moved by point X on the chain during one full rotation of the small cog is 0.24 m.

[1]

(iv) Use the information in (b)(iii) to determine the angle through which the large cog rotates during one full rotation of the small cog.

angle = rad [2]

(c) The chain of the bicycle in (b) is moved onto a smaller cog fixed to the rear wheel. The speed of the bicycle does not change.

Explain, without calculation, the effect of this change on the angular speed of the pedals.

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..... [2]

[Total: 10]

- 1 A steel ball is placed on the inside surface of a hollow circular cone. The ball moves in a horizontal circle at constant speed, as shown in Fig. 1.1.

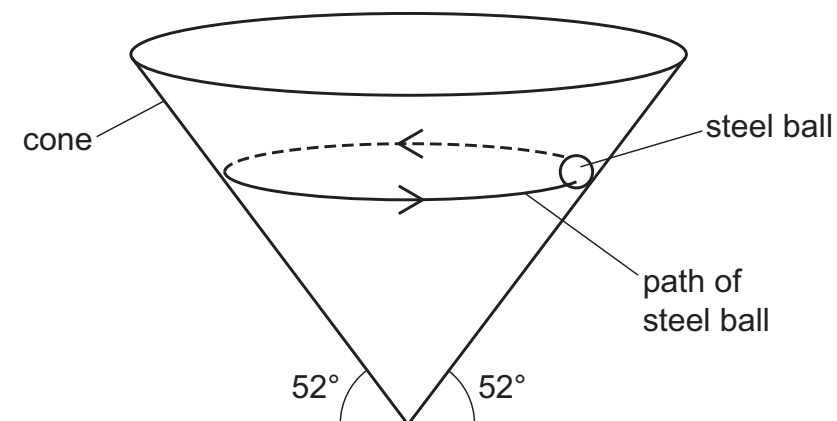


Fig. 1.1

The angle of the side of the cone to the horizontal is 52° . There is no friction between the ball and the cone.

- (a) Fig. 1.2 shows a cross-section through the cone and the steel ball.

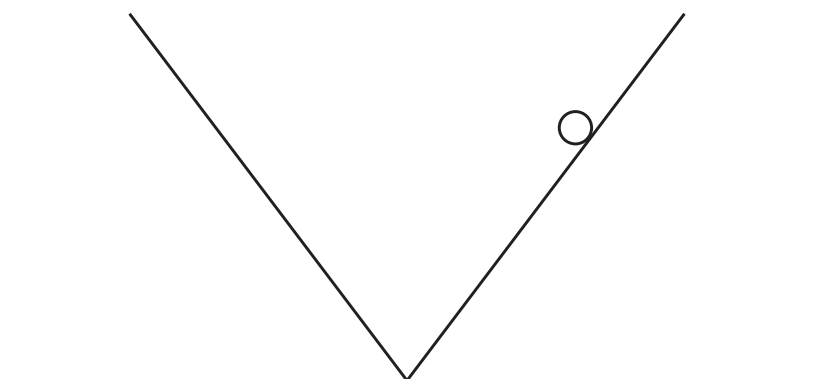


Fig. 1.2

On Fig. 1.2, draw labelled arrows to show the **two** forces acting on the ball.

[1]

- (b) Describe how the forces acting on the ball cause its acceleration to be centripetal.

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[2]

(c) The ball moves in a circle of radius 0.15 m.

Show that the speed of the ball is 1.4 m s^{-1} .

[3]

(d) Calculate the angular speed ω of the ball.

$\omega = \dots\dots\dots \text{ rad s}^{-1}$ [2]

(e) The speed of the ball is increased.

Explain why the radius of the circular path of the ball increases.

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..... [1]

[Total: 9]