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.

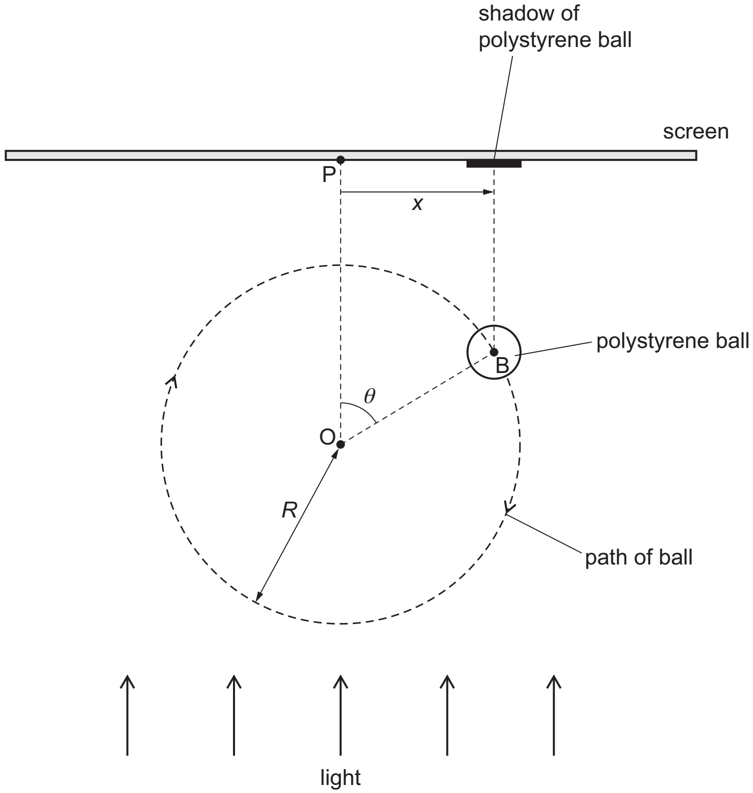

Fig. 1.1

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 = ... [1]

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

centripetal acceleration = ... [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 = ... [1]

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

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

θ = ... [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.

....

[1]

(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 6.37×10^6 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.

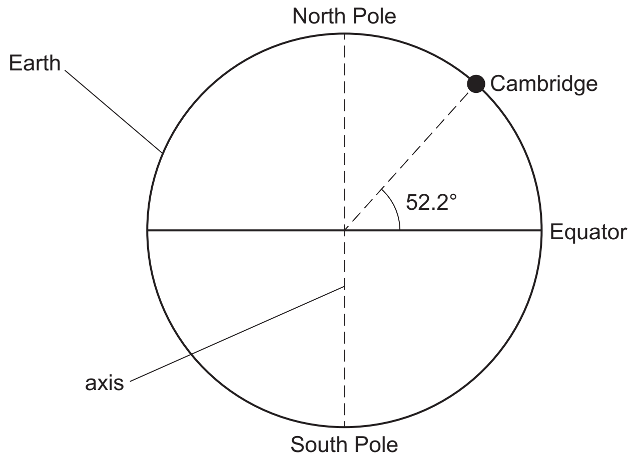

Fig. 1.1

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 3.90×10^6 m.

[1]

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

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

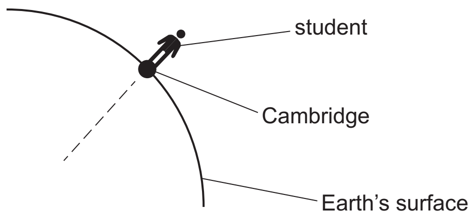

Fig. 1.2 (not to scale)

[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)**.

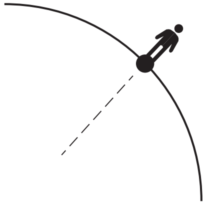

Fig. 1.3 (not to scale)

[2]

[Total: 9]

1 Fig. 1.1 shows a horizontal turntable.

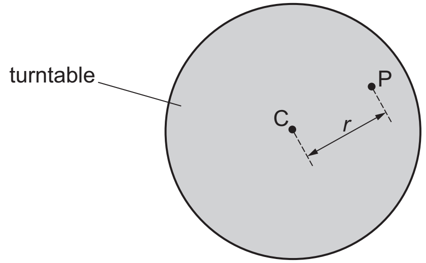

Fig. 1.1

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.

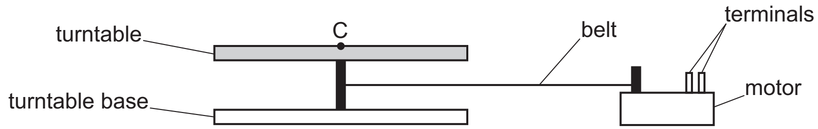

Fig. 1.2

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

[15]