Angular Motion

2013 Revised AH Physics

Marks

1. A stunt driver is attempting to "loop the loop" in a car as shown in Figure 1. Before entering the loop the car accelerates along a horizontal track.

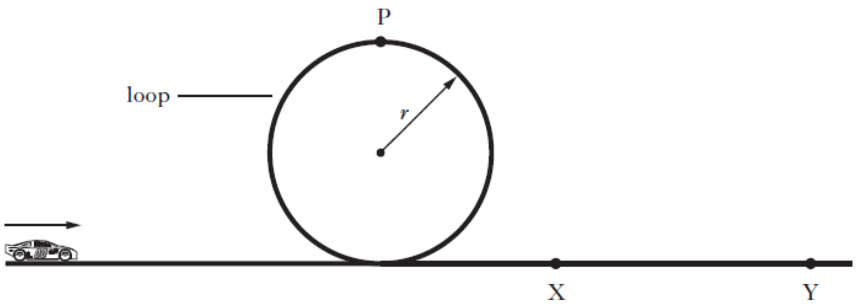


Figure 1

The radius r of the circular loop is 6·2 m.
The total mass of the car and driver is 870 kg.

(*a*) Show that the car must have a minimum speed of 7·8 m s^{-1} at point P to avoid losing contact with the track. **2**

(*b*) During one attempt the car is moving at a speed of 9·0 m s^{-1} at point P.

(i) Draw a labelled diagram showing the vertical forces acting on the car at point P. **1**

(ii) Calculate the size of each force. **3**

Marks

3. On a trip to a theme park, a student described what happened in the fairground spinner shown in Figure 3.

"You get thrown outwards by centrifugal force – you can feel it – it pushes you into the wall."

Figure 3

Use your knowledge of physics to discuss this statement. **(3)**

2. (a) An ideal conical pendulum consists of a mass moving with constant speed in a circular path, as shown in Figure 2A.

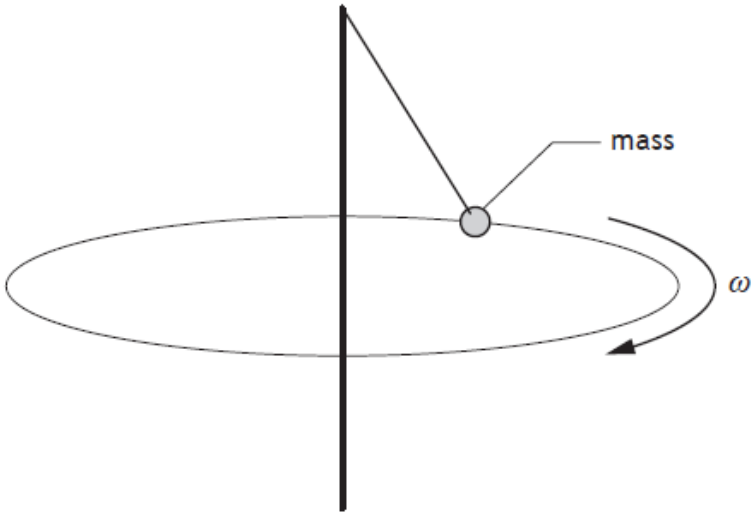


Figure 2A

(i) Explain why the mass is accelerating despite moving with constant speed. 1

(ii) State the direction of this acceleration. 1

(b) Swingball is a garden game in which a ball is attached to a light string connected to a vertical pole as shown in Figure 2B.

The motion of the ball can be modelled as a conical pendulum.

The ball has a mass of 0·059 kg.

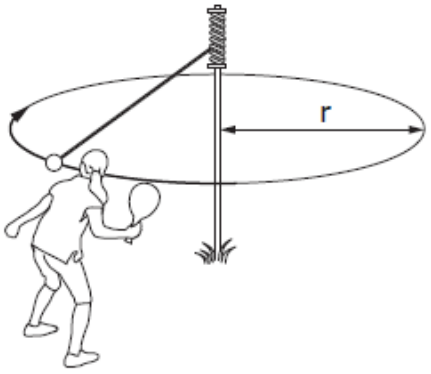


Figure 2B

(i) The ball is hit such that it moves with constant speed in a horizontal circle of radius 0·48 m.

The ball completes 1·5 revolutions in 2·69 s.

(A) Show that the angular velocity of the ball is 3·5 rad s^{-1}. 2

Space for working and answer

(B) Calculate the magnitude of the centripetal force acting on the ball. 3

Space for working and answer

2. (b) (i) **(continued)** MARKS

(C) The horizontal component of the tension in the string provides this centripetal force and the vertical component balances the weight of the ball.

Calculate the magnitude of the tension in the string. 3

Space for working and answer

(ii) The string breaks whilst the ball is at the position shown in Figure 2C.

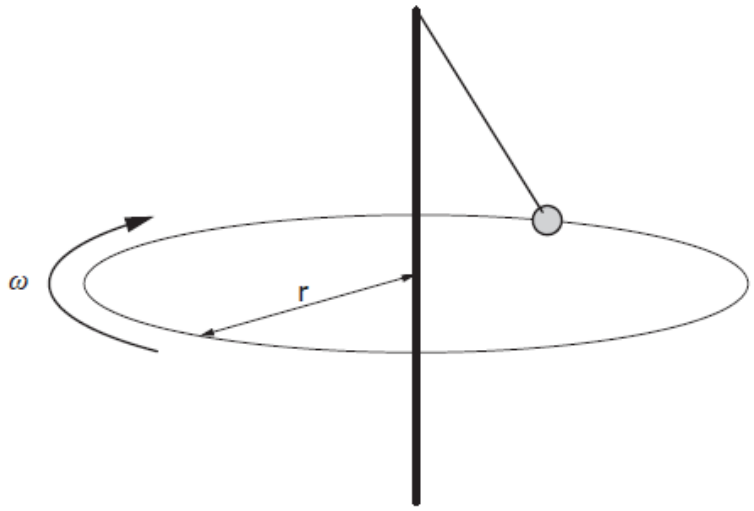


Figure 2C

On Figure 2C, draw the direction of the ball's velocity **immediately** after the string breaks. 1

(An additional diagram, if required, can be found on *Page 39*.)

2. (a) As part of a lesson, a teacher swings a sphere tied to a light string as shown in Figure 2A. The path of the sphere is a vertical circle as shown in Figure 2B.

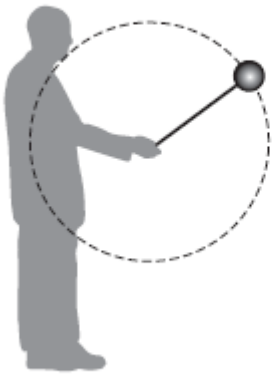


Figure 2A

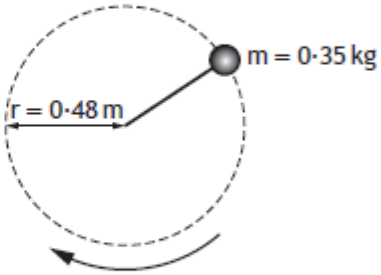


Figure 2B

(i) On Figure 2C, show the forces acting on the sphere as it passes through its highest point.

You must name these forces and show their directions. 1

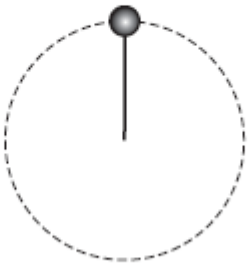


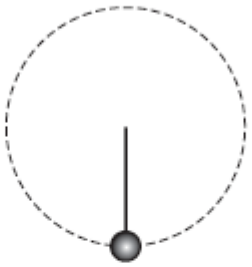
Figure 2C

2. (a) (continued)

(ii) On Figure 2D, show the forces acting on the sphere as it passes through its lowest point.

You must name these forces and show their directions. 1

Figure 2D



(iii) The sphere of mass 0·35 kg can be considered to be moving at a constant speed.

The centripetal force acting on the sphere is 4·0 N.

Determine the magnitude of the tension in the light string when the sphere is at:

(A) the highest position in its circular path; 2

Space for working and answer

(B) the lowest position in its circular path. 1

Space for working and answer

2. (continued)

(b) The speed of the sphere is now gradually reduced until the sphere no longer travels in a circular path.

Explain why the sphere no longer travels in a circular path. 2

SQA Exemplar paper

2. A motorised model plane is attached to a light string anchored to a ceiling. The plane follows a circular path of radius 0·35 m as shown in Figure 2.

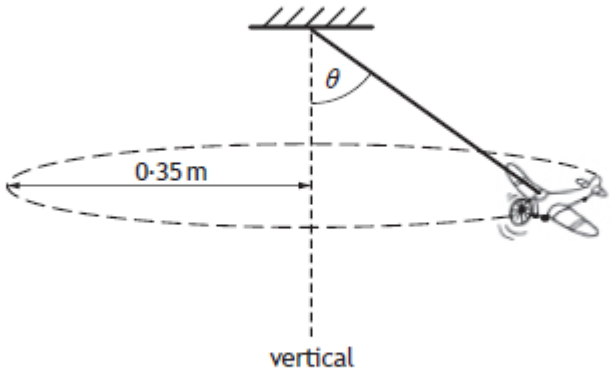


Figure 2

The plane has a mass of 0·20 kg and moves with a constant angular velocity of 6·0 rad s^{-1}.

(a) Calculate the central force acting on the plane. 3

Space for working and answer

(b) Calculate the angle θ of the string to the vertical. 3

Space for working and answer

2. (continued)

(c) State the effect a decrease in the plane's speed would have on angle θ. Justify your answer. 2

SQA Specimen Paper

1. Water is removed from clothes during the spin cycle of a washing machine. The drum holding the clothes has a maximum spin rate of 1250 revolutions per minute.

Figure 1A

(a) Show that the maximum angular velocity of the drum is 131 rad s^{-1}. 2

Space for working and answer

(b) At the start of a spin cycle the drum has an angular velocity of 7·50 rad s^{-1}. It then takes 12·0 seconds to accelerate to the maximum angular velocity.

(i) Calculate the angular acceleration of the drum during the 12·0 seconds, assuming the acceleration is uniform. 3

Space for working and answer

1. (b) (continued)

(ii) Determine how many revolutions the drum will make during the 12·0 seconds. 5

Space for working and answer

(c) When the drum is rotating at maximum angular velocity, an item of wet clothing of mass $1{\cdot}5 \times 10^{-2}$ kg rotates at a distance of 0·28 m from the axis of rotation as shown in Figure 1B.

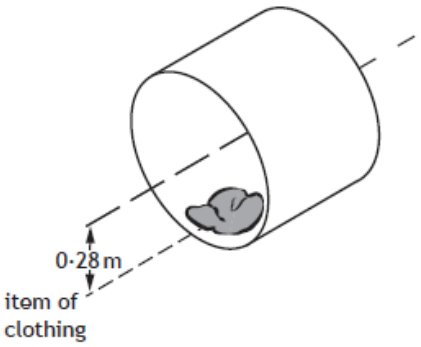


Figure 1B

Calculate the centripetal force acting on the item of clothing. 3

Space for working and answer

1. (continued) MARKS

(d) The outer surface of the drum has small holes as shown in Figure 1C. These holes allow most of the water to be removed.

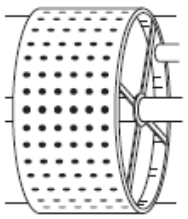


Figure 1C

(i) Explain why the water separates from the item of clothing during the spin cycle. 2

(ii) The drum rotates in an anticlockwise direction. Indicate on Figure 1D the direction taken by a water droplet as it leaves the drum. 1

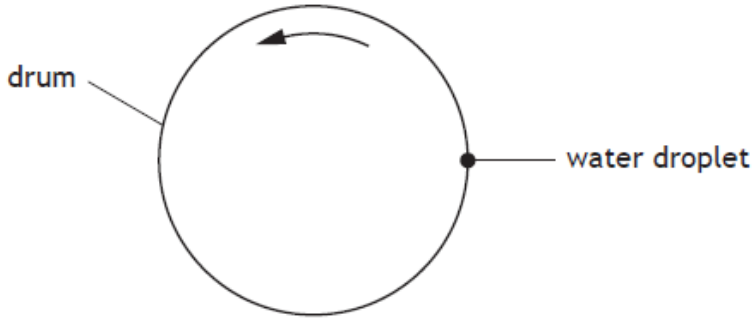


Figure 1D

(iii) Explain what happens to the value of the force on an item of clothing inside the drum as it rotates at its maximum angular velocity. 2