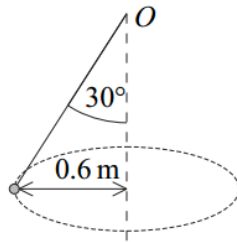


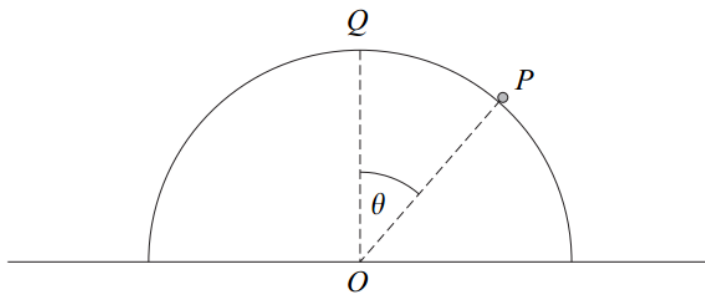
Mechanics 2 Circular Motion

- 2 A particle, of mass 2 kg, is attached to one end of a light inextensible string. The other end is fixed to the point O . The particle is set into motion, so that it describes a horizontal circle of radius 0.6 metres, with the string at an angle of 30° to the vertical. The centre of the circle is vertically below O .



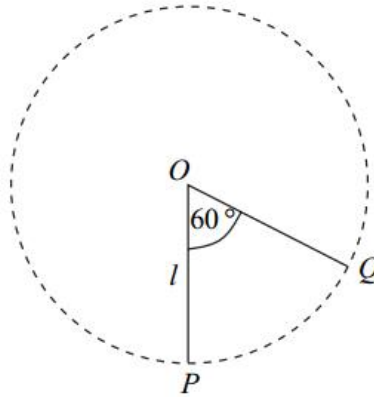
- (a) Show that the tension in the string is 22.6 N, correct to three significant figures. (3 marks)
- (b) Find the speed of the particle. (4 marks)
-

- 7 A particle P , of mass m kg, is placed at the point Q on the top of a smooth upturned hemisphere of radius 3 metres and centre O . The plane face of the hemisphere is fixed to a horizontal table. The particle is set into motion with an initial horizontal velocity of 2 m s^{-1} . When the particle is on the surface of the hemisphere, the angle between OP and OQ is θ and the particle has speed $v \text{ m s}^{-1}$.



- (a) Show that $v^2 = 4 + 6g(1 - \cos \theta)$. (4 marks)
- (b) Find the value of θ when the particle leaves the hemisphere. (5 marks)
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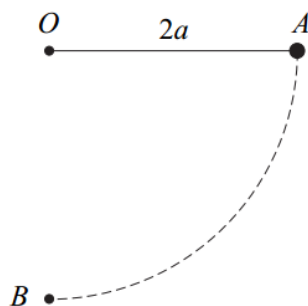
- 4 A particle of mass m is suspended from a fixed point O by a light inextensible string of length l . The particle hangs in equilibrium at the point P vertically below O . The particle is then set into motion with a horizontal velocity U so that it moves in a complete vertical circle with centre O . The point Q on the circle is such that $\angle POQ = 60^\circ$, as shown in the diagram.



- (a) Find, in terms of g , l and U , the speed of the particle at Q . (4 marks)
- (b) Find, in terms of g , l , m and U , the tension in the string when the particle is at Q . (5 marks)
- (c) Find, in terms of g , l , m and U , the tension in the string when the particle returns to P . (2 marks)
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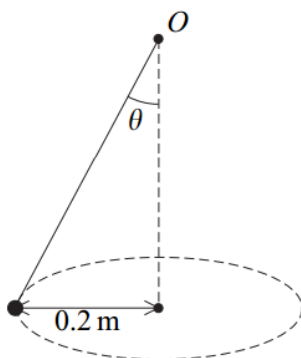
- 6 A car of mass 1200 kg travels round a roundabout on a horizontal, circular path at a constant speed of 14 m s^{-1} . The radius of the circle is 50 metres . Assume that there is no resistance to the motion of the car and that the car can be modelled as a particle.
- (a) A friction force, directed towards the centre of the roundabout, acts on the car as it moves. Show that the magnitude of this friction force is 4704 N . (4 marks)
- (b) The coefficient of friction between the car and the road is μ . Show that $\mu \geq 0.4$. (3 marks)
-

- 3 A light inextensible string has length $2a$. One end of the string is attached to a fixed point O and a particle of mass m is attached to the other end. Initially, the particle is held at the point A with the string taut and horizontal. The particle is then released from rest and moves in a circular path. Subsequently, it passes through the point B , which is directly below O . The points O , A and B are as shown in the diagram.



- (a) Show that the speed of the particle at B is $2\sqrt{ag}$. (3 marks)
- (b) Find the tension in the string as the particle passes through B . Give your answer in terms of m and g . (3 marks)
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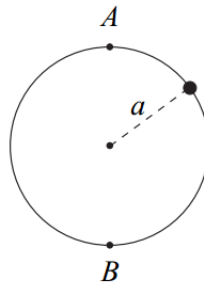
- 6 A particle is attached to one end of a light inextensible string. The other end of the string is attached to a fixed point O . The particle is set into motion, so that it describes a horizontal circle whose centre is vertically below O . The angle between the string and the vertical is θ , as shown in the diagram.



- (a) The particle completes 40 revolutions every minute.
- Show that the angular speed of the particle is $\frac{4\pi}{3}$ radians per second. (2 marks)
- (b) The radius of the circle is 0.2 metres.
- Find, in terms of π , the magnitude of the acceleration of the particle. (2 marks)

- (c) The mass of the particle is m kg and the tension in the string is T newtons.
- Draw a diagram showing the forces acting on the particle. (1 mark)
 - Explain why $T \cos \theta = mg$. (1 mark)
 - Find the value of θ , giving your answer to the nearest degree. (5 marks)
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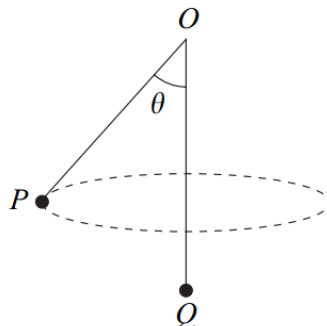
- 5 A bead of mass m moves on a smooth circular ring of radius a which is fixed in a vertical plane, as shown in the diagram. Its speed at A , the highest point of its path, is v and its speed at B , the lowest point of its path, is $7v$.



- Show that $v = \sqrt{\frac{ag}{12}}$. (5 marks)
 - Find the reaction of the ring on the bead, in terms of m and g , when the bead is at A . (4 marks)
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- 8 A particle, P , of mass 3 kg is attached to one end of a light inextensible string. The string passes through a smooth fixed ring, O , and a second particle, Q , of mass 5 kg is attached to the other end of the string. The particle Q hangs at rest vertically below the ring and the particle P moves with speed 4 m s^{-1} in a horizontal circle, as shown in the diagram.

The angle between OP and the vertical is θ .



- Explain why the tension in the string is 49 N. (2 marks)
- Find θ . (3 marks)
- Find the radius of the horizontal circle. (4 marks)