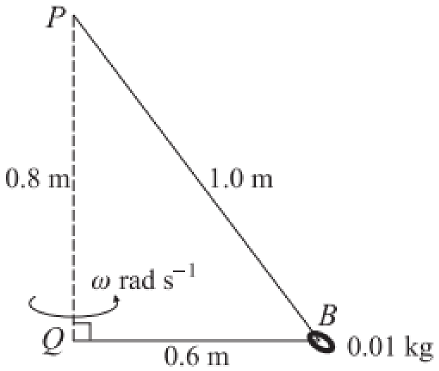
Horizontal Circular Motion (From OCR 4729)

Q1, (Jun 2005, Q3)



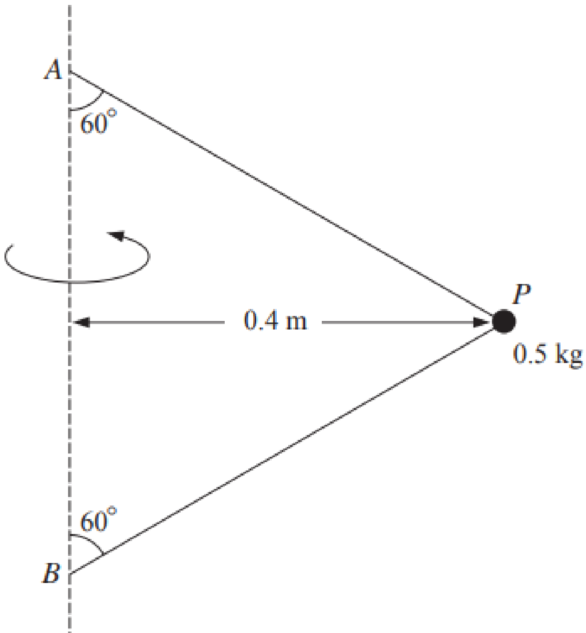
One end of a light inextensible string of length 1.6 m is attached to a point P. The other end is attached to the point Q, vertically below P, where $PQ = 0.8$ m. A small smooth bead B, of mass 0.01 kg, is threaded on the string and moves in a horizontal circle, with centre Q and radius 0.6 m. QB rotates with constant angular speed ω rad s^{-1} (see diagram).

(i) Show that the tension in the string is 0.1225 N. [3]

(ii) Find ω. [3]

(iii) Calculate the kinetic energy of the bead. [2]

Q2, (Jun 2008, Q6)



A particle P of mass 0.5 kg is attached to points A and B on a fixed vertical axis by two light inextensible strings of equal length. Both strings are taut and each is inclined at 60° to the vertical (see diagram). The particle moves with constant speed 3 m s^{-1} in a horizontal circle of radius 0.4 m.

(i) Calculate the tensions in the two strings. [7]

The particle now moves with constant angular speed ω rad s^{-1} and the string BP is on the point of becoming slack.

(ii) Calculate ω. [5]

Q3, (Jan 2006, Q8)

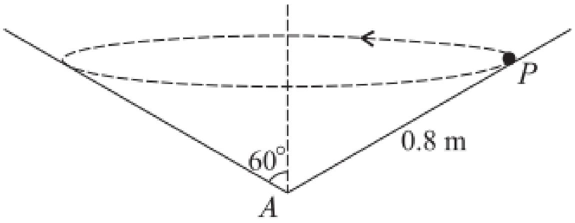


Fig. 1

A particle P of mass 0.1 kg is moving with constant angular speed ω rad s^{-1} in a horizontal circle on the smooth inner surface of a cone which is fixed with its axis vertical and its vertex A at its lowest point. The semi-vertical angle of the cone is 60° and the distance AP is 0.8 m (see Fig. 1).

(i) Calculate the magnitude of the force exerted by the cone on the particle. [3]

(ii) Calculate ω. [4]

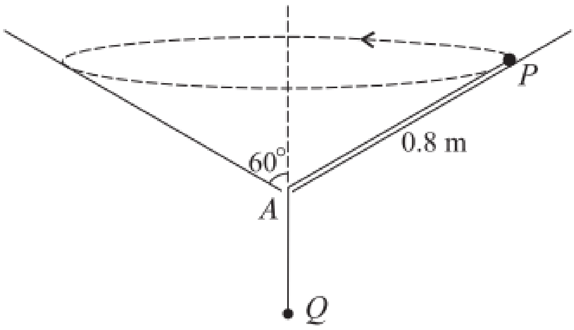


Fig. 2

The particle P is now attached to one end of a light inextensible string which passes through a small smooth hole at A. The lower end of the string is attached to a particle Q of mass 0.2 kg. Q is in equilibrium with the string taut and $AP = 0.8$ m. P moves in a horizontal circle with constant speed v m s^{-1} (see Fig. 2).

(iii) State the tension in the string. [1]

(iv) Find v. [6]

Q4, (Jun 2012, Q5)

A particle P, of mass 2 kg, is attached to fixed points A and B by light inextensible strings, each of length 2 m. A and B are 3.2 m apart with A vertically above B. The particle P moves in a horizontal circle with centre at the mid-point of AB.

(i) Find the tension in each string when the angular speed of P is 4 rad s^{-1}. **[7]**

(ii) Find the least possible speed of P. **[6]**

Q5, (Jun 2006, Q6)

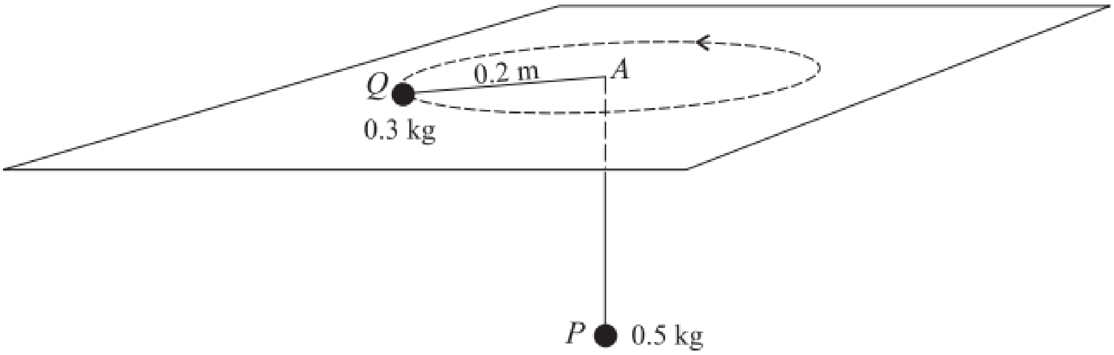


Fig. 1

A light inextensible string of length 1 m passes through a small smooth hole A in a fixed smooth horizontal plane. One end of the string is attached to a particle P, of mass 0.5 kg, which hangs in equilibrium below the plane. The other end of the string is attached to a particle Q, of mass 0.3 kg, which rotates with constant angular speed in a circle of radius 0.2 m on the surface of the plane (see Fig. 1).

(i) Calculate the tension in the string and hence find the angular speed of Q. [4]

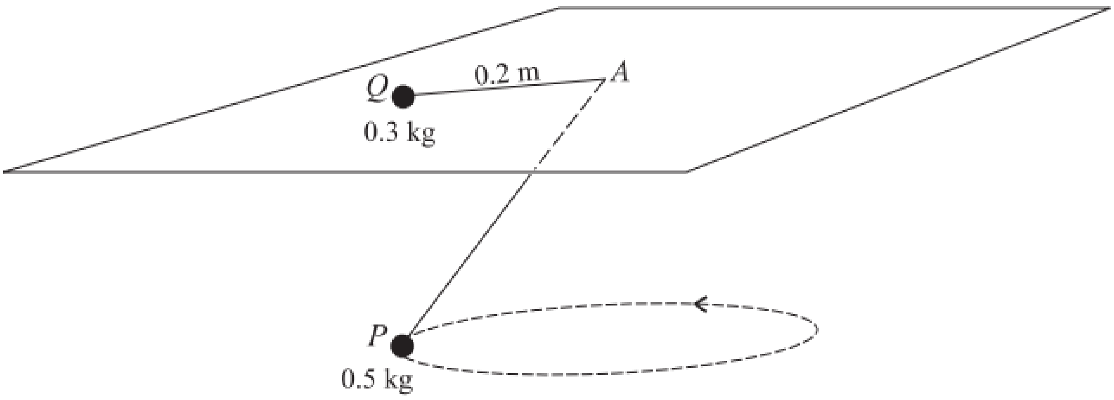


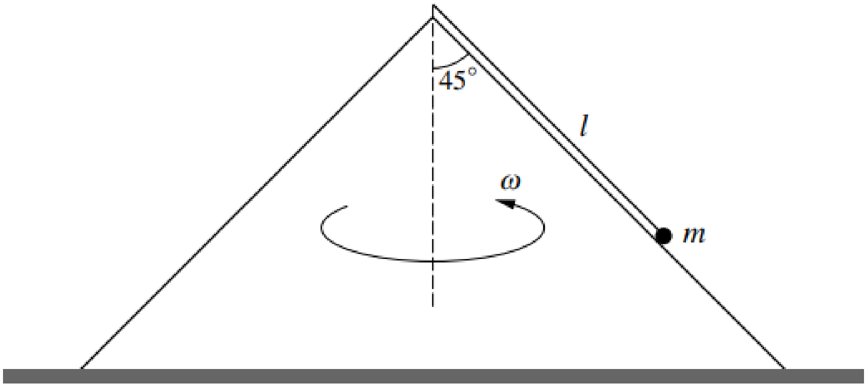
Fig. 2

The particle Q on the plane is now fixed to a point 0.2 m from the hole at A and the particle P rotates in a horizontal circle of radius 0.2 m (see Fig. 2).

(ii) Calculate the tension in the string. [4]

(iii) Calculate the speed of P. [3]

Q6, (Jun 2010, Q5)

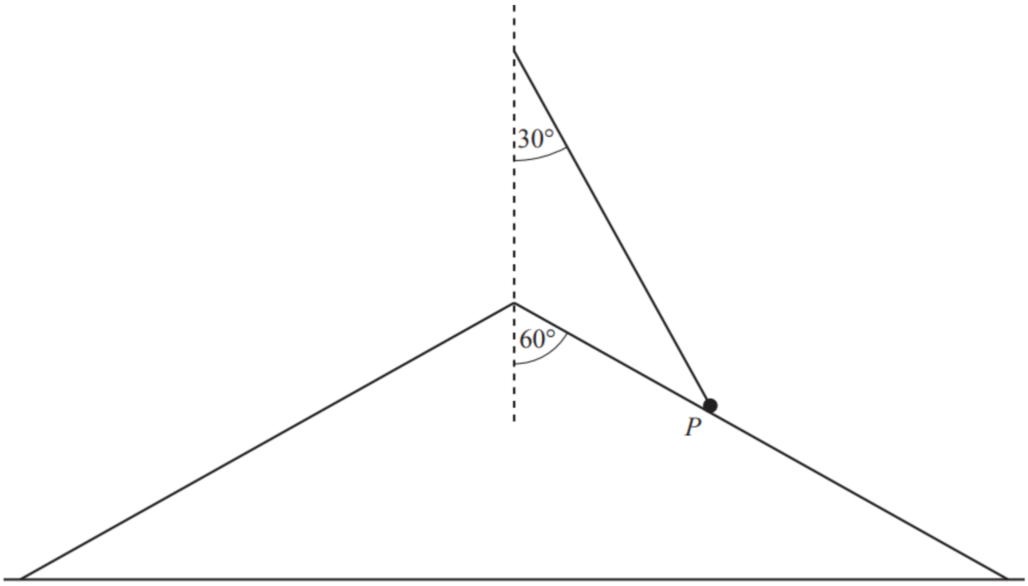


One end of a light inextensible string of length l is attached to the vertex of a smooth cone of semi-vertical angle 45°. The cone is fixed to the ground with its axis vertical. The other end of the string is attached to a particle of mass m which rotates in a horizontal circle in contact with the outer surface of the cone. The angular speed of the particle is ω (see diagram). The tension in the string is T and the contact force between the cone and the particle is R.

(i) By resolving horizontally and vertically, find two equations involving T and R and hence show that $T = \frac{1}{2}m(\sqrt{2}g + l\omega^2)$. **[6]**

(ii) When the string has length 0.8 m, calculate the greatest value of ω for which the particle remains in contact with the cone. **[4]**

Q7, (Jun 2016, Q4)

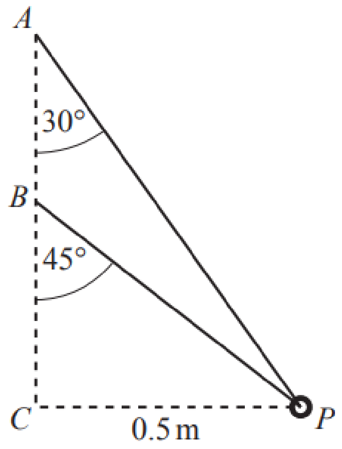


A smooth solid cone of semi-vertical angle 60° is fixed to the ground with its axis vertical. A particle P of mass m is attached to one end of a light inextensible string of length a. The other end of the string is attached to a fixed point vertically above the vertex of the cone. P rotates in a horizontal circle on the surface of the cone with constant angular velocity ω. The string is inclined to the downward vertical at an angle of 30° (see diagram).

(i) Show that the magnitude of the contact force between the cone and the particle is $\frac{1}{6}m(2\sqrt{3}g - 3a\omega^2)$. **[6]**

(ii) Given that $a = 0.5$ m and $m = 3.5$ kg, find, in either order, the greatest speed for which the particle remains in contact with the cone and the corresponding tension in the string. **[3]**

Q8, (Jun 2014, Q7)



A small smooth ring P of mass 0.4 kg is threaded onto a light inextensible string fixed at A and B as shown in the diagram, with A vertically above B. The string is inclined to the vertical at angles of 30° and 45° at A and B respectively. P moves in a horizontal circle of radius 0.5 m about a point C vertically below B.

(i) Calculate the tension in the string. **[3]**

(ii) Calculate the speed of P. **[3]**

The end of the string at B is moved so both ends of the string are now fixed at A.

(iii) Show that, when the string is taut, AP is now 0.854 m correct to 3 significant figures. **[2]**

P moves in a horizontal circle with angular speed 3.46 rad s^{-1}.

(iv) Find the tension in the string and the angle that the string now makes with the vertical. **[4]**

Q9, (Jan 2010, Q7)

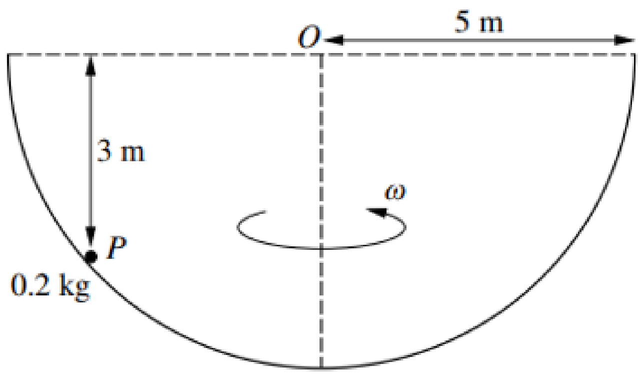


Fig. 1

A particle P of mass 0.2 kg is moving on the smooth inner surface of a fixed hollow hemisphere which has centre O and radius 5 m. P moves with constant angular speed ω in a horizontal circle at a vertical distance of 3 m below the level of O (see Fig. 1).

(i) Calculate the magnitude of the force exerted by the hemisphere on P. **[3]**

(ii) Calculate ω. **[4]**

[QUESTION CONTINUED ON NEXT PAGE]

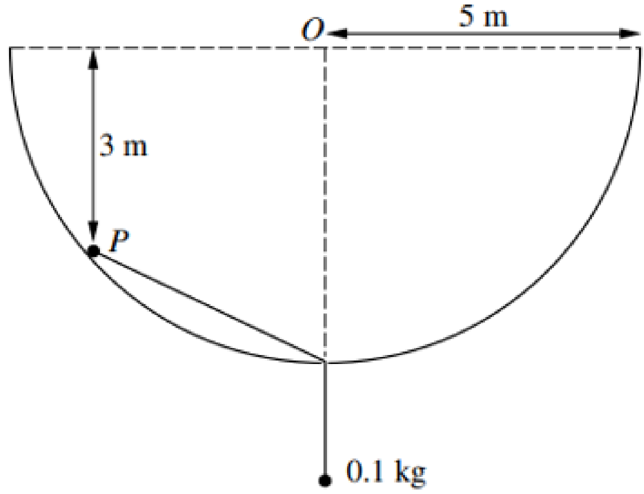


Fig. 2

A light inextensible string is now attached to P. The string passes through a small smooth hole at the lowest point of the hemisphere and a particle of mass 0.1 kg hangs in equilibrium at the end of the string. P moves in the same horizontal circle as before (see Fig. 2).

(iii) Calculate the new angular speed of P. **[8]**