Uniform Motion in a Circle

Question Paper 4

Level	International A Level
Subject	Maths
Exam Board	CIE
Topic	Uniform Motion in a Circle
Sub Topic	
Booklet	Question Paper 4

Time Allowed: **62 minutes**

Score: **/51**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 Particles P and Q, of masses 0.8 kg and 0.5 kg respectively, are attached to the ends of a light inextensible string which passes through a small hole in a smooth horizontal table of negligible thickness. P moves with constant angular speed 6.25 rad s^{-1} in a circular path on the surface of the table.

(i) It is given that Q is stationary and that the part of string attached to Q is vertical. Calculate the radius of the path of P, and find the speed of P. [4]

(ii) It is given instead that the part of string attached to Q is inclined at 60° to the vertical, and that Q moves in a horizontal circular path below the table, also with constant angular speed 6.25 rad s^{-1}. Calculate the total length of the string. [6]

2

A small sphere S of mass m kg is moving inside a fixed smooth hollow cylinder whose axis is vertical. S moves with constant speed in a horizontal circle of radius 0.4 m and is in contact with both the plane base and the curved surface of the cylinder (see diagram).

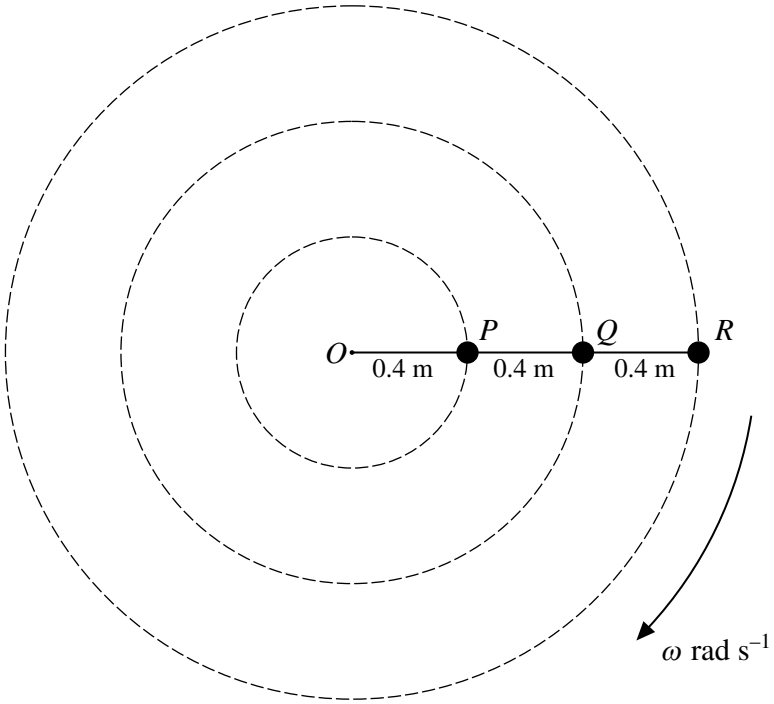
(i) Given that the horizontal and vertical forces exerted on S by the cylinder have equal magnitudes, calculate the speed of S. [3]

S is now attached to the centre of the base of the cylinder by a horizontal light elastic string of natural length 0.25 m and modulus of elasticity 13 N. The sphere S is set in motion and moves in a horizontal circle with constant angular speed ω rad s^{-1} and is in contact with both the plane base and the curved surface of the cylinder.

(ii) It is given that the magnitudes of the horizontal and vertical forces exerted on S by the cylinder are equal if $\omega = 8$. Calculate m. [3]

(iii) For the value of m found in part **(ii)**, find the least possible value of ω for the motion. [2]

3



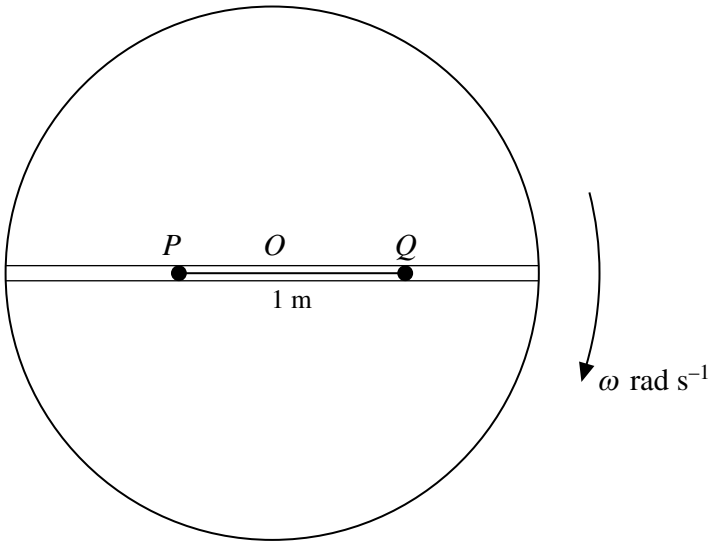
One end of a light inextensible string of length 1.2 m is attached to a fixed point O on a smooth horizontal surface. Particles P, Q and R are attached to the string so that $OP = PQ = QR = 0.4$ m. The particles rotate in horizontal circles about O with constant angular speed ω rad s^{-1} and with O, P, Q and R in a straight line (see diagram). R has mass 0.2 kg, and the tensions in the parts of the string attached to Q are 6 N and 10 N.

(i) Show that $\omega = 5$. [2]

(ii) Calculate the mass of Q. [3]

(iii) Given that the kinetic energy of P is equal to the kinetic energy of R, calculate the tension in the part of the string attached to O. [4]

4



A narrow groove is cut along a diameter in the surface of a horizontal disc with centre O. Particles P and Q, of masses 0.2 kg and 0.3 kg respectively, lie in the groove, and the coefficient of friction between each of the particles and the groove is μ. The particles are attached to opposite ends of a light inextensible string of length 1 m. The disc rotates with angular velocity ω rad s^{-1} about a vertical axis passing through O and the particles move in horizontal circles (see diagram).

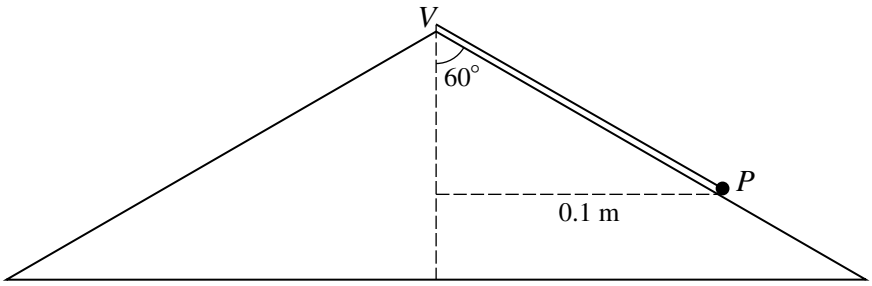
(i) Given that $\mu = 0.36$ and that both P and Q move in the same horizontal circle of radius 0.5 m, calculate the greatest possible value of ω and the corresponding tension in the string. [6]

(ii) Given instead that $\mu = 0$ and that the tension in the string is 0.48 N, calculate

(a) the radius of the circle in which P moves and the radius of the circle in which Q moves, [3]

(b) the speeds of the particles. [3]

5

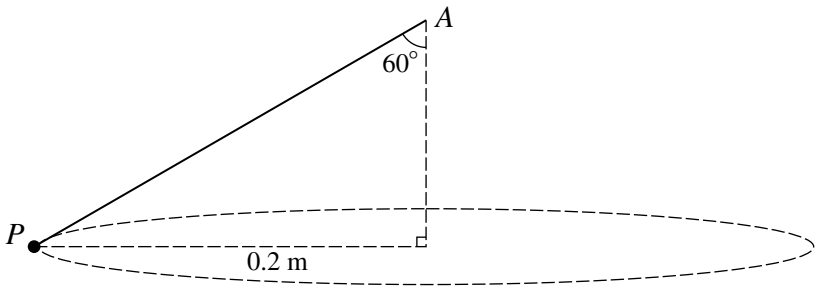


A particle P of mass 0.5 kg is attached to the vertex V of a fixed solid cone by a light inextensible string. P lies on the smooth curved surface of the cone and moves in a horizontal circle of radius 0.1 m with centre on the axis of the cone. The cone has semi-vertical angle 60° (see diagram).

(i) Calculate the speed of P, given that the tension in the string and the contact force between the cone and P have the same magnitude. [4]

(ii) Calculate the greatest angular speed at which P can move on the surface of the cone. [4]

6



A particle P of mass 0.4 kg is attached to a fixed point A by a light inextensible string. The string is inclined at 60° to the vertical. P moves with constant speed in a horizontal circle of radius 0.2 m. The centre of the circle is vertically below A (see diagram).

(i) Show that the tension in the string is 8 N. [2]

(ii) Calculate the speed of the particle. [2]