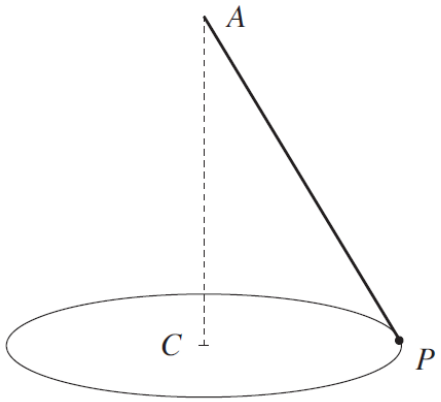
Old Exam Questions – Old Course

Motion in a Horizontal Circle

(M2 Haf 2006)

7. The diagram shows a small body P, of mass 3 kg, attached by means of a light inextensible string, of length 1·3 m, to a fixed point A. The point C is vertically below A, and P describes a horizontal circle, with centre C and radius 0·5 m, with a uniform angular speed of ω radians per second about C.



(a) Find the tension in the string. [3]

(b) Calculate, correct to two decimal places, the value of ω. [4]

(M2 Haf 2007)

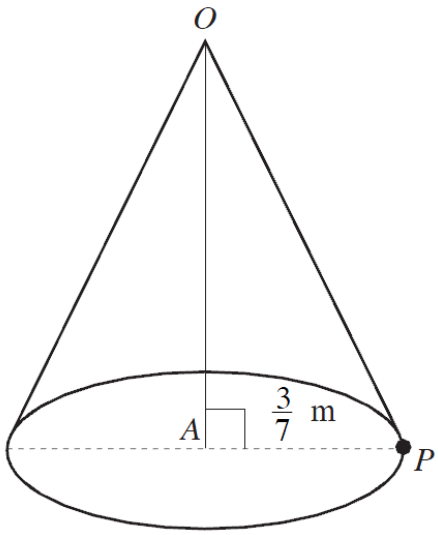
6. A particle of mass 0·8 kg is attached to one end of a light inextensible string of length 0·4 m. The other end of the string is fixed to a point O of a smooth horizontal surface. The particle moves on the surface with constant speed 3 ms^{-1} in a horizontal circle with centre O.

(a) Find the angular velocity about O of the particle. [2]

(b) Calculate the tension in the string. [2]

(M2 Haf 2008)

8. A particle P, of mass 4 kg, is tied to one end of a light inextensible string and the other end of the string is fastened to a fixed point O. The particle P moves with a uniform speed of 2 ms^{-1} in a horizontal circle with centre A and radius $\frac{3}{7}$ m, as shown in the diagram.



(a) Find the size of $A\hat{O}P$. [6]

(b) Calculate the tension in the string. [1]

(c) Determine the length of the string. [1]

(M2 Haf 2009)

7. A car, of mass 1000 kg, is travelling in a horizontal circle of radius 250 m on a track which is banked at an angle α to the horizontal. When the car is travelling at 28 ms^{-1}, it has no tendency to slip sideways. Calculate the value of α. [7]

(M2 Haf 2010)

6. An athlete is cycling at a constant speed v ms^{-1} in a horizontal circle, of radius 40 m, on a track that is banked at an angle of 30° to the horizontal. The combined mass of the bicycle and the athlete is 60 kg and the coefficient of friction between the bicycle tyres and the track is $\frac{1}{4}$. Find, correct to three significant figures, the greatest possible value of v. [7]

(M2 Haf 2011)

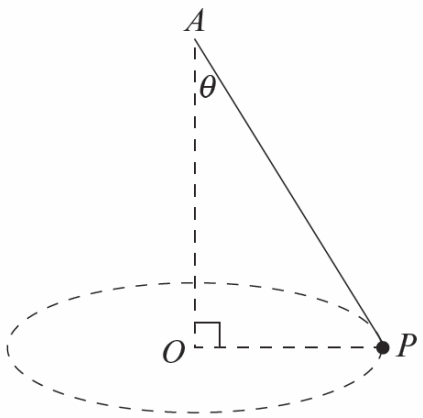
2. A particle of mass 0·5 kg is attached to one end of a light inextensible string of length 0·6 m. The other end of the string is fixed at a point O on a smooth horizontal surface. The particle moves on the surface in a circle with centre O, so that the string is taut and the angular velocity of the particle about O is 5 radians per second.

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

(b) Find the tension in the string. [2]

(M2 Haf 2012)

7. One end of a light inextensible string is attached to a fixed point A. The other end is attached to a particle P of mass 3 kg. The point O is vertically below A and P moves in a horizontal circle of centre O with a uniform angular speed of 2·8 radians per second. The tension in the string is 88·2 N and $O\hat{A}P$ is θ.

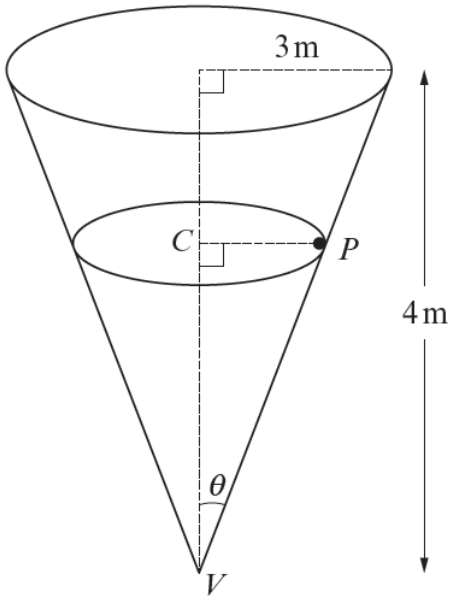


(a) Find the value of θ. [3]

(b) Calculate the length of the string. [5]

(M2 Haf 2013)

4. The diagram shows a hollow cone, of base radius 3 m and height 4 m, which is fixed with its axis vertical and vertex V downwards. A particle P, of mass M kg, moves in the horizontal circle with centre C on the smooth inner surface of the cone with constant speed $\sqrt{\frac{8g}{3}}$ ms^{-1}, where g ms^{-2} is the acceleration due to gravity.



(a) Show that the normal reaction of the surface of the cone on the particle is $\frac{5Mg}{3}$ N. [4]

(b) Calculate the length of CP and hence determine the height of C above V. [5]

(M2 Haf 2015)

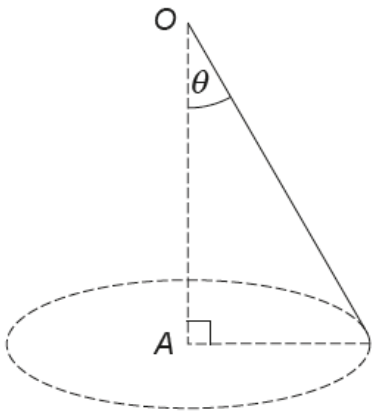
7. A car of mass 1200 kg is moving in a horizontal circle of radius 80 m on a road banked at an angle of 12° to the horizontal.
When the car is moving with a constant speed of v ms^{-1}, there is no tendency to sideslip. Calculate the normal reaction of the road on the car and find the value of v. [5]

(M2 Haf 2016)

8. A rough circular plate rotates horizontally about a smooth fixed vertical axis through its centre O. A point A on the plate moves with constant speed v ms^{-1}, where OA is 1·6 m. A particle of mass m kg lies on the point A on the plate. The coefficient of friction between the particle and the plate is 0·72. Given that the particle remains at the point A, find the greatest possible value of v. Hence write down the greatest possible value of the angular velocity of the particle. State clearly your units for the angular velocity. [7]

(M2 Haf 2017)

7. A particle of mass 2 kg is suspended from a fixed point O by means of an elastic string of natural length 3 m and modulus of elasticity λ N. The particle describes a horizontal circle with constant angular speed ω rad s^{-1}, with the string being of constant length l m, where $l > 3$. The centre of the circle A is vertically below O and the angle between the string and the downward vertical is θ.



(a) Show that $\cos\theta = \dfrac{g}{l\omega^2}$. [6]

(b) Given that the tension in the string is $20g$ N and $\omega^2 = 3g$,

(i) find the value of $\cos\theta$,

(ii) show that $l = \dfrac{10}{3}$,

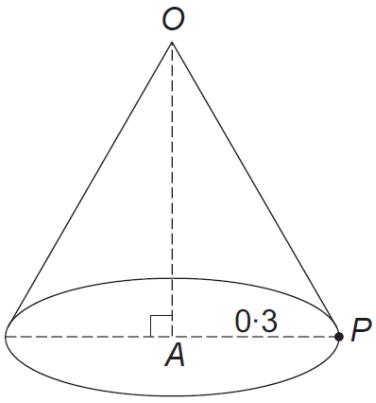
(iii) calculate the value of λ,

(iv) find the elastic energy in the string. [8]

(M2 Haf 2018)

4. A rough circular plate rotates horizontally, with constant angular velocity ωrad s^{-1}, about a fixed smooth vertical axis through its centre. An object of mass $m$kg lies on the plate at a distance 0·25 m from the axis and is connected to the axis by a light horizontal spring of natural length 0·2 m and modulus $3mg$N. The coefficient of friction between the object and the plate is 0·4. Find the greatest and the least value of ω if the object is to remain at rest on the plate. [10]

7. A particle P, of mass 3 kg, 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 P moves with a uniform angular velocity of 4 rad s^{-1} in a horizontal circular path with centre A and radius 0·3 m, as shown in the diagram.



(a) Find,

(i) the angle AOP,

(ii) the tension in the string. [7]

(b) Determine the length of the string. [1]