FM1 (Year 2) - Hooke's Law Exam Questions (Edexcel)

Q1.
One end A of a light elastic string AB, of modulus of elasticity mg and natural length a, is fixed to a point on a rough plane inclined at an angle θ to the horizontal. The other end B of the string is attached to a particle of mass m which is held at rest on the plane. The string AB lies along a line of greatest slope of the plane, with B lower than A and $AB = a$. The coefficient of friction between the particle and the plane is μ, where $\mu < \tan\theta$. The particle is released from rest.

(a) Show that when the particle comes to rest it has moved a distance $2a(\sin\theta - \mu\cos\theta)$ down the plane.

(6)

(b) Given that there is no further motion, show that $\mu \geq \frac{1}{3}\tan\theta$.

(5)

(Total 11 marks)

(Q05 6679/01/R, June 2014)

Q2.
A particle P of mass 0.5 kg is attached to one end of a light elastic spring, of natural length 2 m and modulus of elasticity 20 N. The other end of the spring is attached to a fixed point A. The particle P is held at rest at the point B, which is 1 m vertically below A, and then released.

(a) Find the acceleration of P immediately after it is released from rest.

(4)

The particle comes to instantaneous rest for the first time at the point C.

(b) Find the distance BC.

(6)

(Total 10 marks)

(Q04 6679/01/R, June 2013)

Q3.
A particle P of mass 1.5 kg is attached to the mid-point of a light elastic string of natural length 0.30 m and modulus of elasticity λ newtons. The ends of the string are attached to two fixed points A and B, where AB is horizontal and $AB = 0.48$ m. Initially P is held at rest at the mid-point, M, of the line AB and the tension in the string is 240 N.

(a) Show that $\lambda = 400$

(3)

The particle is now held at rest at the point C, where C is 0.07 m vertically below M. The particle is released from rest at C.

(b) Find the magnitude of the initial acceleration of P.

(6)

(c) Find the speed of P as it passes through M.

(6)

(Total 15 marks)

(Q04 6679/01, Jan 2013)

Q4.

A particle P of mass m is attached to one end of a light elastic string of natural length l and modulus of elasticity $3mg$. The other end of the string is attached to a fixed point O on a rough horizontal table. The particle lies at rest at the point A on the table, where $OA = \frac{7}{6}l$. The coefficient of friction between P and the table is μ.

(a) Show that $\mu \geq \frac{1}{2}$.

(4)

The particle is now moved along the table to the point B, where $OB = \frac{3}{2}l$, and released from rest. Given that $\mu = \frac{1}{2}$, find

(b) the speed of P at the instant when the string becomes slack,

(5)

(c) the total distance moved by P before it comes to rest again.

(3)

(Total 12 marks)

(Q06 6679/01, June 2011)

Q5.

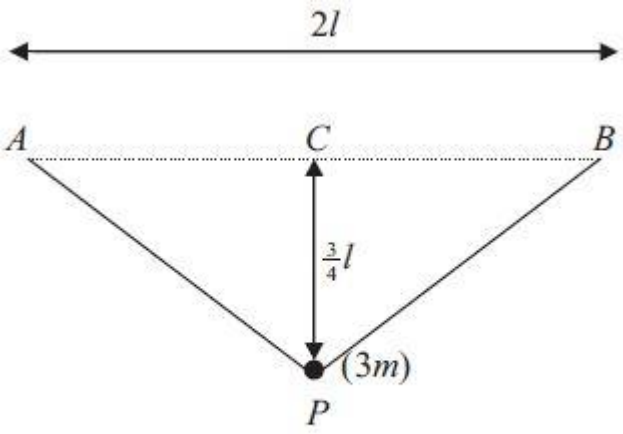

Figure 4

A small ball of mass $3m$ is attached to the ends o two light elastic strings AP and BP, each of natural length l and modulus of elasticity kmg. The ends A and B of the strings are attached to fixed points on the same horizontal level, with $AB = 2l$. The mid-point of AB is C. The ball hangs in equilibrium at a distance $\frac{3}{4}l$ vertically below C as shown in Figure 4.

(a) Show that $k = 10$

(7)

The ball is now pulled vertically downwards until it is at a distance $\frac{12}{5}l$ below C.
The ball is released from rest.

(b) Find the speed of the ball as it reaches C.

(6)

(Total 13 marks)

(Q04 6679/01, Jan 2011)

Q6.

A particle P of mass 2 kg is attached to one end of a light elastic string of natural length 1.2 m. The other end of the string is attached to a fixed point O on a rough horizontal plane. The coefficient of friction between P and the plane is $\frac{2}{5}$. The particle is held at rest at a point B on the plane, where $OB = 1.5$ m. When P is at B, the tension in the string is 20 N. The particle is released from rest.

(a) Find the speed of P when $OP = 1.2$ m.

(7)

The particle comes to rest at the point C.

(b) Find the distance BC.

(2)

(Total 9 marks)

(Q04 6679/01, June 2013)

Q7.

Unless otherwise indicated, whenever a numerical value of g is required, take $g = 9.8$ ms^{-2} and give your answer to either 2 significant figures or 3 significant figures.

A particle P of mass m is attached to one end of a light elastic string of natural length a and modulus of elasticity $3mg$.

The other end of the string is attached to a fixed point O on a ceiling.

The particle hangs freely in equilibrium at a distance d vertically below O.

(a) Show that $d = \frac{4}{3}a$.

(3)

The point A is vertically below O such that $OA = 2a$.

The particle is held at rest at A, then released and first comes to instantaneous rest at the point B.

(b) Find, in terms of g, the acceleration of P immediately after it is released from rest.

(3)

(c) Find, in terms of g and a, the maximum speed attained by P as it moves from A to B.

(5)

(d) Find, in terms of a, the distance OB.

(3)

(Total for question = 14 marks)

(Q07 9FM0/3C-4C, Specimen papers)

Q8.

A particle P of mass 0.5 kg is attached to one end of a light elastic spring, of natural length 1.2 m and modulus of elasticity λ newtons. The other end of the spring is attached to a fixed point A on a ceiling. The particle is hanging freely in equilibrium at a distance 1.5 m vertically below A.

(a) Find the value of λ.

(3)

The particle is now raised to the point B, where B is vertically below A and $AB = 0.8$ m. The spring remains straight. The particle is released from rest and first comes to instantaneous rest at the point C.

(b) Find the distance AC.

(4)

(Total for question = 7 marks)

(Q04 6679/01, June 2015)

Q9.

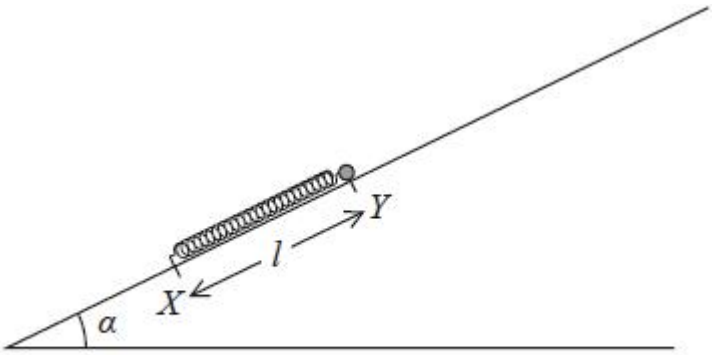

Figure 2

A light elastic spring has natural length $3l$ and modulus of elasticity $3mg$.

One end of the spring is attached to a fixed point X on a rough inclined plane.

The other end of the spring is attached to a package P of mass m.

The plane is inclined to the horizontal at an angle α where $\tan\alpha = \frac{3}{4}$

The package is initially held at the point Y on the plane, where $XY = l$. The point Y is higher than X and XY is a line of greatest slope of the plane, as shown in Figure 2.

The package is released from rest at Y and moves up the plane.

The coefficient of friction between P and the plane is $\frac{1}{3}$

By modelling P as a particle,

(a) show that the acceleration of P at the instant when P is released from rest is $\frac{17}{15}g$

(5)

(b) find, in terms of g and l, the speed of P at the instant when the spring first reaches its natural length of $3l$.

(6)

(Total for question = 11 marks)

(Q06 9FM0/03C, Oct 2021)

Q10.

A light elastic string has natural length $2a$ and modulus of elasticity $4mg$.
One end of the elastic string is attached to a fixed point O. A particle P of mass m is attached to the other end of the elastic string.
The particle P hangs freely in equilibrium at the point E, which is vertically below O

(a) Find the length OE.

(4)

Particle P is now pulled vertically downwards to the point A, where $OA = 4a$, and released from rest. The resistance to the motion of P is a constant force of magnitude $\frac{1}{4}mg$.

(b) Find, in terms of a and g, the speed of P after it has moved a distance a.

(7)

Particle P is now held at O
Particle P is released from rest and reaches its maximum speed at the point B.

The resistance to the motion of P is again a constant force of magnitude $\frac{1}{4}mg$.

(c) Find the distance OB.

(4)

(Total for question = 15 marks)

(Q04 9FM0/03C, June 2023)

Q11.

A spring of natural length a has one end attached to a fixed point A. The other end of the spring is attached to a package P of mass m.
The package P is held at rest at the point B, which is vertically below A such that $AB = 3a$.
After being released from rest at B, the package P first comes to instantaneous rest at A.
Air resistance is modelled as being negligible.

By modelling the spring as being light and modelling P as a particle,

(a) show that the modulus of elasticity of the spring is $2mg$

(5)

(b) (i) Show that P attains its maximum speed when the extension of the spring is $0.5a$

(ii) Use the principle of conservation of mechanical energy to find the maximum speed, giving your answer in terms of a and g.

(6)

In reality, the spring is not light.

(c) State one way in which this would affect your energy equation in part (b).

(1)

(Total for question = 12 marks)

(Q07 9FM0/03C, June 2022)