A Level · Edexcel · Further Maths

48 mins 4 questions

Elastic Strings & Springs

Hooke's Law / Elastic Potential Energy / Problem Solving with Strings & Springs

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Total Marks **/48**

1 (a) 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.

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

(3 marks)

(b) 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.

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

(3 marks)

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

(5 marks)

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

(3 marks)

2 (a) A particle P, of mass m, is attached to one end of a light elastic spring of natural length a and modulus of elasticity kmg.

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

The point A is vertically below O such that $OA = 3a$.

The point B is vertically below O such that $OB = \frac{1}{2}a$.

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

Show that $k = \frac{4}{3}$.

(3 marks)

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

(3 marks)

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

(6 marks)

3 (a) A light elastic string with natural length l and modulus of elasticity kmg has one end attached to a fixed point A on a rough inclined plane. The other end of the string is attached to a package of mass m.

The plane is inclined at an angle θ to the horizontal, where $\tan\theta = \frac{5}{12}$.

The package is initially held at A. The package is then projected with speed $\sqrt{6gl}$ up a line of greatest slope of the plane and first comes to rest at the point B, where $AB = 3l$.

The coefficient of friction between the package and the plane is $\frac{1}{4}$.

By modelling the package as a particle,

show that $k = \frac{15}{26}$.

(6 marks)

(b) Find the acceleration of the package at the instant it starts to move back down the plane from the point B.

(5 marks)

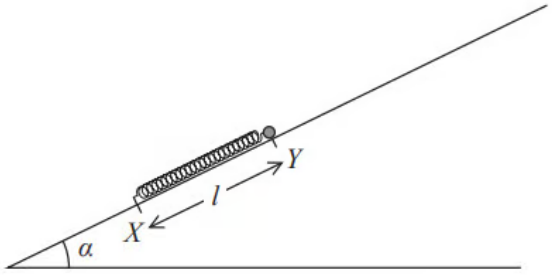

Figure 2

4 (a)

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

By modelling P as a particle,

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

(5 marks)

(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 marks)