Hooke's Law 1

Q1.

A particle P of mass 0.3 kg is attached to one end of a light elastic string of natural length 0.9 m and modulus of elasticity 18 N. The other end of the string is attached to a fixed point O which is 3 m above the ground.

(i) Find the extension of the string when P is in the equilibrium position. [2]

P is projected vertically downwards from the equilibrium position with initial speed $6\,\text{m}\,\text{s}^{-1}$. At the instant when the tension in the string is 12 N the string breaks. P continues to descend vertically.

(ii) **(a)** Calculate the height of P above the ground at the instant when the string breaks. [2]

(b) Find the speed of P immediately before it strikes the ground. [4]

Q2.

One end of a light elastic string of natural length 0.5 m and modulus of elasticity 30 N is attached to a fixed point O. The other end of the string is attached to a particle P which hangs in equilibrium vertically below O, with $OP = 0.8$ m.

(i) Show that the mass of P is 1.8 kg. [2]

The particle is pulled vertically downwards and released from rest from the point where $OP = 1.2$ m.

(ii) Find the speed of P at the instant when the string first becomes slack. [3]

Q3.

One end of a light elastic string of natural length 0.4 m and modulus of elasticity 20 N is attached to a fixed point A on a smooth plane inclined at 30° to the horizontal. The other end of the string is attached to a particle P of mass 0.5 kg which rests in equilibrium on the plane.

(i) Calculate the extension of the string. [2]

P is projected down the plane from the equilibrium position with speed $5\,\text{m}\,\text{s}^{-1}$. The extension of the string is e m when the speed of the particle is $2\,\text{m}\,\text{s}^{-1}$ for the first time.

(ii) Find e. [4]

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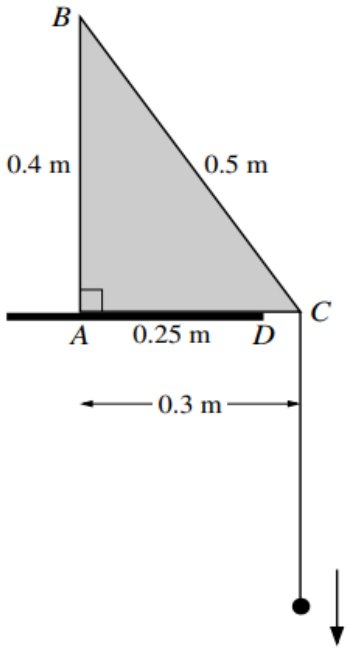
Q4.



A uniform triangular prism of weight 20 N rests on a horizontal table. ABC is the cross-section through the centre of mass of the prism, where $BC = 0.5$ m, $AB = 0.4$ m, $AC = 0.3$ m and angle $BAC = 90°$. The vertical plane ABC is perpendicular to the edge of the table. The point D on AC is at the edge of the table, and $AD = 0.25$ m. One end of a light elastic string of natural length 0.6 m and modulus of elasticity 48 N is attached to C and a particle of mass 2.5 kg is attached to the other end of the string. The particle is released from rest at C and falls vertically (see diagram).

(i) Show that the tension in the string is 60 N at the instant when the prism topples. [3]

(ii) Calculate the speed of the particle at the instant when the prism topples. [5]

Q5.

A particle P of mass 0.2 kg is attached to one end of a light elastic string of natural length 0.75 m and modulus of elasticity 21 N. The other end of the string is attached to a fixed point A which is 0.8 m vertically above a smooth horizontal surface. P rests in equilibrium on the surface.

(i) Find the magnitude of the force exerted on P by the surface. [2]

P is now projected horizontally along the surface with speed $3\ \text{m s}^{-1}$.

(ii) Calculate the extension of the string at the instant when P leaves the surface. [3]

(iii) Hence find the speed of P at the instant when it leaves the surface. [3]

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Q6.

A particle P of mass M kg is attached to one end of a light elastic string of natural length 0.8 m and modulus of elasticity 12.5 N. The other end of the string is attached to a fixed point A. The particle is released from rest at A and falls vertically until it comes to instantaneous rest at the point B. The greatest speed of P during its descent is $4.4\,\text{m s}^{-1}$ when the extension of the string is e m.

(i) Show that $e = 0.64M$. [2]

(ii) Find a second equation in e and M, and hence find M. [6]

(iii) Calculate the distance AB. [3]

Q7.

A particle P of mass 0.6 kg is attached to one end of a light elastic string of natural length 0.8 m and modulus of elasticity 24 N. The other end of the string is attached to a fixed point A, and P hangs in equilibrium.

(i) Calculate the extension of the string. [2]

P is projected vertically downwards from the equilibrium position with speed $4.5\,\text{m s}^{-1}$.

(ii) Find the distance AP when the speed of P is $3.5\,\text{m s}^{-1}$ and P is below the equilibrium position. [4]

(iii) Calculate the speed of P when it is 0.5 m above the equilibrium position. [3]

Q8.

A particle P is attached to one end of a light elastic string of natural length 1.2 m and modulus of elasticity 12 N. The other end of the string is attached to a fixed point O on a smooth plane inclined at an angle of 30° to the horizontal. P rests in equilibrium on the plane, 1.6 m from O.

(i) Calculate the mass of P. [2]

A particle Q, with mass equal to the mass of P, is projected up the plane along a line of greatest slope. When Q strikes P the two particles coalesce. The combined particle remains attached to the string and moves up the plane, coming to instantaneous rest after moving 0.2 m.

(ii) Show that the initial kinetic energy of the combined particle is 1 J. [4]

The combined particle subsequently moves down the plane.

(iii) Calculate the greatest speed of the combined particle in the subsequent motion. [5]

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Q9.

One end of a light elastic string of natural length 0.4 m is attached to a fixed point O. The other end of the string is attached to a particle of weight 5 N which hangs in equilibrium 0.6 m vertically below O.

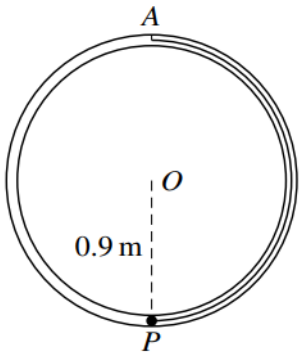
(i) Find the modulus of elasticity of the string. [2]

The particle is projected vertically upwards from the equilibrium position and comes to instantaneous rest after travelling 0.3 m upwards.

(ii) Calculate the speed of projection of the particle. [3]

(iii) Calculate the greatest extension of the string in the subsequent motion. [3]

Q10.



The diagram shows a smooth narrow tube formed into a fixed vertical circle with centre O and radius 0.9 m. A light elastic string with modulus of elasticity 8 N and natural length 1.2 m has one end attached to the highest point A on the inside of the tube. The other end of the string is attached to a particle P of mass 0.2 kg. The particle is released from rest at the lowest point on the inside of the tube. By considering energy, calculate

(i) the speed of P when it is at the same horizontal level as O, [4]

(ii) the speed of P at the instant when the string becomes slack. [3]
