Hooke's Law (From OCR 4730)

Q1, (Jun 2006, Q6)

A bungee jumper of mass 70 kg is joined to a fixed point O by a light elastic rope of natural length 30 m and modulus of elasticity 1470 N. The jumper starts from rest at O and falls vertically. The jumper is modelled as a particle and air resistance is ignored.

(i) Find the distance fallen by the jumper when maximum speed is reached. [4]

(ii) Show that this maximum speed is $26.9\,\text{m s}^{-1}$, correct to 3 significant figures. [4]

(iii) Find the extension of the rope when the jumper is at the lowest position. [4]

Q2, (Jan 2009, Q7)

A particle of mass 0.8 kg is attached to one end of a light elastic string of natural length 2 m and modulus of elasticity 20 N. The other end of the string is attached to a fixed point O. The particle is held at rest at O and then released. When the extension of the string is x m, the particle is moving with speed $v\,\text{m s}^{-1}$.

(i) By considering energy show that $v^2 = 39.2 + 19.6x - 12.5x^2$. **[4]**

(ii) Hence find

(a) the maximum extension of the string, **[2]**

(b) the maximum speed of the particle, **[4]**

(c) the maximum magnitude of the acceleration of the particle. **[5]**

Q3, (Jan 2010, Q5)

A light elastic string of natural length 1.6 m has modulus of elasticity 120 N. One end of the string is attached to a fixed point O and the other end is attached to a particle P of weight 1.5 N. The particle is released from rest at the point A, which is 2.1 m vertically below O. It comes instantaneously to rest at B, which is vertically above O.

(i) Verify that the distance AB is 4 m. **[4]**

(ii) Find the maximum speed of P during its upward motion from A to B. **[7]**

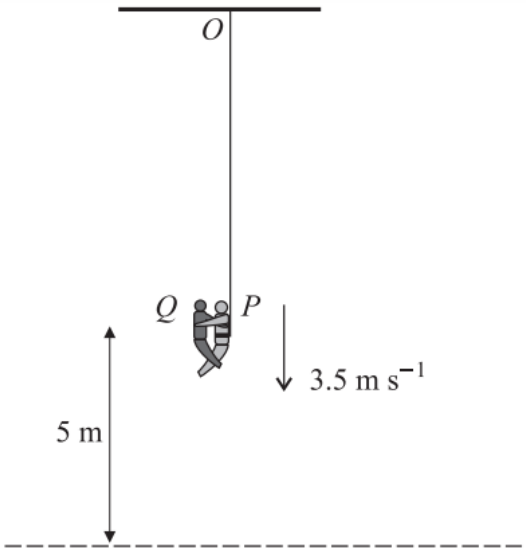
Q4, (Jan 2012, Q4)

One end of a light elastic string, of natural length 0.75 m and modulus of elasticity 44.1 N, is attached to a fixed point O. A particle P of mass 1.8 kg is attached to the other end of the string. P is released from rest at O and falls vertically. Assuming there is no air resistance, find

(i) the extension of the string when P is at its lowest position, **[4]**

(ii) the acceleration of P at its lowest position. **[4]**

Q5, (Jun 2007, Q6)



A circus performer P of mass 80 kg is suspended from a fixed point O by an elastic rope of natural length 5.25 m and modulus of elasticity 2058 N. P is in equilibrium at a point 5 m above a safety net. A second performer Q, also of mass 80 kg, falls freely under gravity from a point above P. P catches Q and together they begin to descend vertically with initial speed 3.5 m s^{-1} (see diagram). The performers are modelled as particles.

(i) Show that, when P is in equilibrium, $OP = 7.25$ m. [3]

(ii) Verify that P and Q together just reach the safety net. [5]

(iii) At the lowest point of their motion P releases Q. Prove that P subsequently just reaches O. [3]

(iv) State two additional modelling assumptions made when answering this question. [2]

Q6, (Jun 2012, Q7)

S_A and S_B are light elastic strings. S_A has natural length 2 m and modulus of elasticity 120 N; S_B has natural length 3 m and modulus of elasticity 180 N. A particle P of mass 0.8 kg is attached to one end of each of the strings. The other ends of S_A and S_B are attached to fixed points A and B respectively, on a smooth horizontal table. The distance AB is 6 m. P is released from rest at the point of the line segment AB which is 2.9 m from A.

(i) For the subsequent motion, show that the total elastic potential energy of the strings is the same when $AP = 2.1$ m and when $AP = 2.9$ m. Deduce that neither string becomes slack. **[3]**

(ii) Find, in terms of x, an expression for the acceleration of P in the direction of AB when $AP = (2.5 + x)$ m. **[3]**

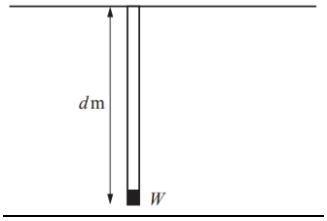
(iii) State, giving a reason, the type of motion of P and find the time taken between successive occasions when P is instantaneously at rest. **[3]**

For the instant 0.6 seconds after P is released, find

(iv) the distance travelled by P, **[3]**

(v) the speed of P. **[2]**

Q7, (Jun 2013, Q1)



A small object W of weight 100 N is attached to one end of each of two parallel light elastic strings. One string is of natural length 0.4 m and has modulus of elasticity 20 N; the other string is of natural length 0.6 m and has modulus of elasticity 30 N. The upper ends of both strings are attached to a horizontal ceiling and W hangs in equilibrium at a distance d m below the ceiling (see diagram). Find d. **[5]**

Q8, (Jun 2014, Q2)

One end of a light elastic string, of natural length 0.6 m and modulus of elasticity 30 N, is attached to a fixed point O. A particle P of weight 48 N is attached to the other end of the string. P is released from rest at a point d m vertically below O. Subsequently P just reaches O.

(i) Find d. **[4]**

(ii) Find the magnitude and direction of the acceleration of P when it has travelled 1.3 m from its point of release. **[4]**
