# 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 $6\,\mathrm{m\,s^{-1}}$. 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]

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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]

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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 $5\,\mathrm{m\,s^{-1}}$. The extension of the string is $e$ m when the speed of the particle is $2\,\mathrm{m\,s^{-1}}$ for the first time.

**(ii)** Find $e$. [4]

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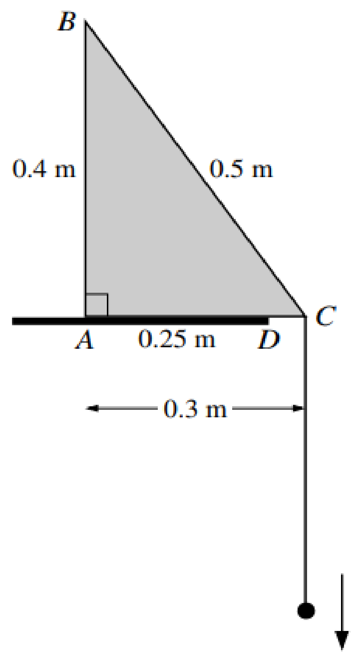
Q4.




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]

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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 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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# Hooke's Law 1

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 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]

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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 m s$^{-1}$.

**(ii)** Find the distance $AP$ when the speed of $P$ is 3.5 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]

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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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# Hooke's Law 1

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]

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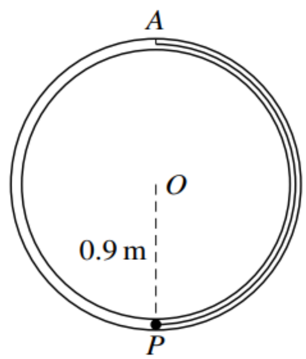
Q10.




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]

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