Gravitational Potential and Kinetic Energy 1.7

A Level

P P P

A worker at ground level throws a $2.2\,\mathrm{kg}$ drinks bottle upwards to a thirsty colleague $3.2\,\mathrm{m}$ above the ground. It just reaches him, but he fails to catch it, and it falls into an excavated trench $1.6\,\mathrm{m}$ below ground level.

Part A Initial speed of bottle

At what speed did the worker need to throw the bottle if she threw it from the waist, $1.0\,\mathrm{m}$ above the ground?

Part B Impact speed

How fast was it moving when it struck the base of the trench?

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Physics. You work it out.

Gravitational Potential and Kinetic Energy 1.10

A Level

P P P

How high would a ball bounce if it struck an efficiency $\eta = 0.75$ surface at $13\,\mathrm{m\,s^{-1}}$?

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Gravitational, Elastic and Kinetic Energy 2.1

A Level
P P P

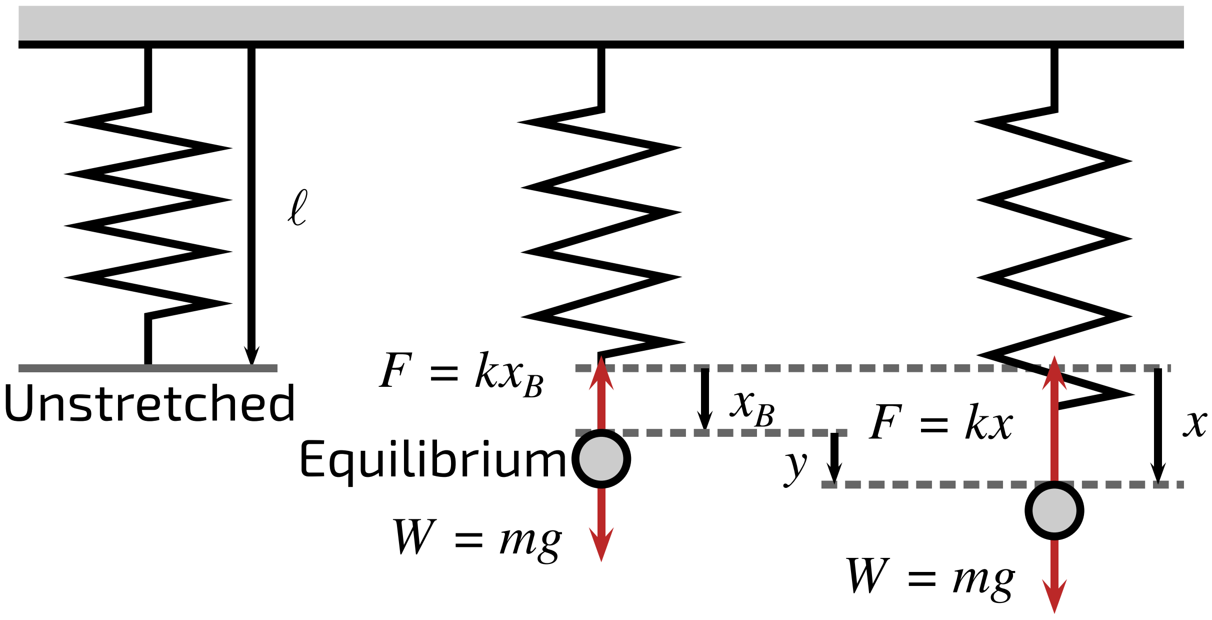

Figure 1: Objects suspended from a spring exchange stores of kinetic, elastic potential and kinetic energy as they move up and down.

Quantities:

x spring extension (m)
x_B equilibrium x (m)
v speed $(\mathrm{m\,s^{-1}})$
m mass (kg)
E_K kinetic energy (J)
E_T total energy (J)
F spring tension (N)

ℓ spring natural length (m)
y distance from equilibrium (m)
k spring constant $(\mathrm{N\,m^{-1}})$
g gravitational field strength $(\mathrm{N\,kg^{-1}})$
E_GP gravitational potential energy (J)
E_EP elastic potential energy (J)
W weight (N)

Equations:

$$E_\mathsf{K} = \frac{1}{2}mv^2 \qquad E_\mathsf{GP} = -mgx \qquad E_\mathsf{EP} = \frac{1}{2}kx^2 \qquad F = -kx$$

$$E_\mathsf{T} = E_\mathsf{K} + E_\mathsf{GP} + E_\mathsf{EP} \qquad W = mg \qquad y = x - x_\mathsf{B}$$

In the absence of air resistance, use the equations above to derive expressions for

Part A The total energy

Derive an expression for the total energy, E_{T}, in terms of x and v.

The following symbols may be useful: `E_B, E_EP, E_GP, E_T, g, k, m, v, x, x_B, y`

Part B The value of x where the forces balance

Derive an expression for the value of x where the forces balance (we will call this x_{B}).

The following symbols may be useful: `E_B, E_EP, E_GP, E_T, g, k, m, v, x, x_B, y`

Part C $E_{\mathrm{GP}} + E_{\mathrm{EP}}$ at the point where the forces balance

Derive an expression for $E_{\mathrm{GP}} + E_{\mathrm{EP}}$ at the point where the forces balance (we will call this E_{B}).

The following symbols may be useful: `E_B, E_EP, E_GP, E_T, g, k, m, v, x, x_B, y`

Part D The greatest value of x

Derive an expression for the greatest value of x if you hold the mass at $x = 0$ and let go.

The following symbols may be useful: `E_B, E_EP, E_GP, E_T, g, k, m, v, x, x_B, y`

Part E $E_{\mathsf{GP}} + E_{\mathsf{EP}}$ in terms of $y = x - x_{\mathsf{B}}$

Derive an expression for the value of $E_{\mathsf{GP}} + E_{\mathsf{EP}}$ in terms of $y = x - x_{\mathsf{B}}$. You may find it simplifies the algebra if you give your answer in the form $E_B + \ldots$

The following symbols may be useful: `E_B, E_EP, E_GP, g, k, m, y`

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Home Gameboard Physics Mechanics Dynamics Gravitational, Elastic and Kinetic Energy 2.2

Gravitational, Elastic and Kinetic Energy 2.2

A Level P P P

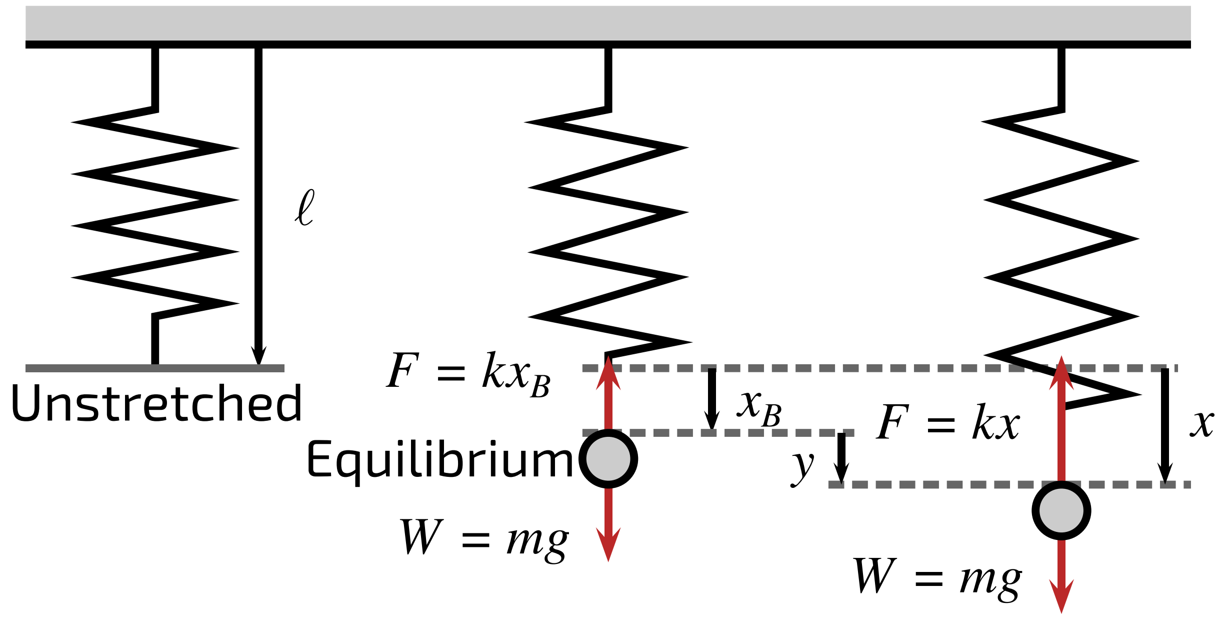

Figure 1: Objects suspended from a spring exchange stores of kinetic, elastic potential and kinetic energy as they move up and down.

Using the diagram above, calculate the energies E_{GP}, E_{EP}, E_{K} and E_{T} for a $2.5\,\text{kg}$ mass when $x = 0.055\,\text{m}$ and speed $v = 0.25\,\text{m}\,\text{s}^{-1}$ if $k = 600\,\text{N}\,\text{m}^{-1}$.

Part A Calculate E_{GP}

Calculate the gravitational potential energy E_{GP} for a $2.5\,\text{kg}$ mass when $x = 0.055\,\text{m}$ and $v = 0.25\,\text{m}\,\text{s}^{-1}$ if $k = 600\,\text{N}\,\text{m}^{-1}$.

Part B Calculate E_{EP}

Calculate the elastic potential energy E_{EP} for a $2.5\,\text{kg}$ mass when $x = 0.055\,\text{m}$ and $v = 0.25\,\text{m}\,\text{s}^{-1}$ if $k = 600\,\text{N}\,\text{m}^{-1}$.

Part C Calculate E_K

Calculate the kinetic energy E_K for a $2.5\,\mathrm{kg}$ mass when $x = 0.055\,\mathrm{m}$ and $v = 0.25\,\mathrm{m\,s^{-1}}$ if $k = 600\,\mathrm{N\,m^{-1}}$.

Part D Calculate E_T

Calculate the total energy E_T for a $2.5\,\mathrm{kg}$ mass when $x = 0.055\,\mathrm{m}$ and $v = 0.25\,\mathrm{m\,s^{-1}}$ if $k = 600\,\mathrm{N\,m^{-1}}$.

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Gravitational, Elastic and Kinetic Energy 2.3

A Level

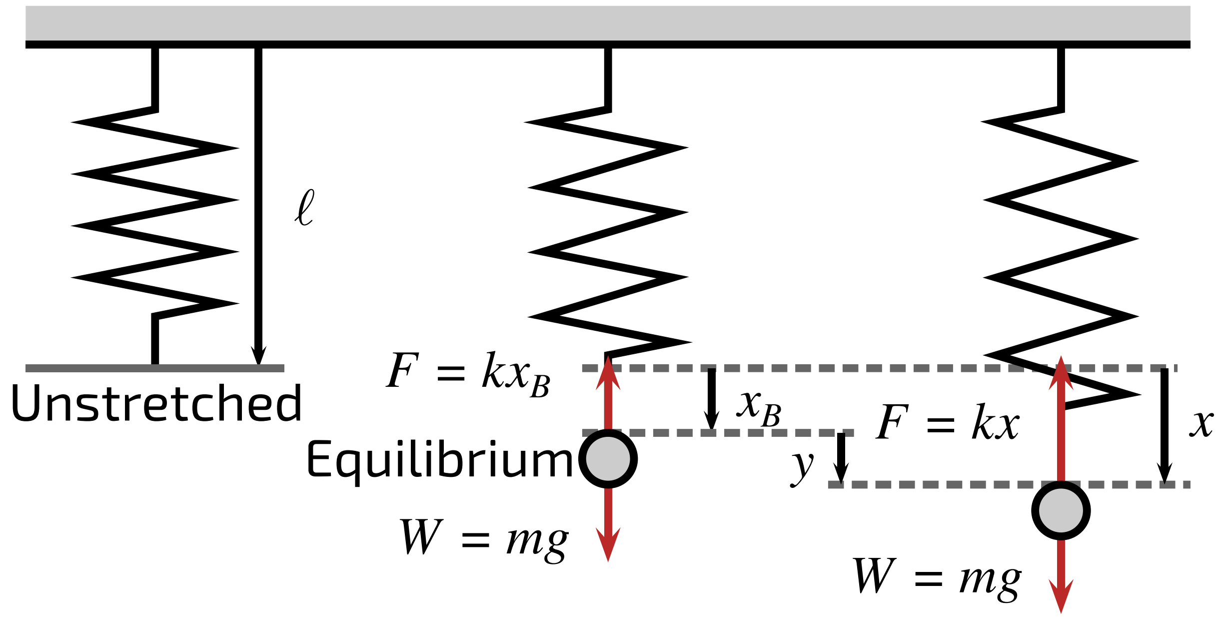

Figure 1: Objects suspended from a spring exchange stores of kinetic, elastic potential and kinetic energy as they move up and down.

Using the diagram above, calculate x_B (the extension of the spring at the equilibrium point) for a $100\,\mathrm{N}$ weight hanging from a $k = 5.0\,\mathrm{kN\,m^{-1}}$ spring.

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Home Gameboard Physics Mechanics Dynamics Gravitational, Elastic and Kinetic Energy 2.4

Gravitational, Elastic and Kinetic Energy 2.4

A Level
P P P

(This question is about the system shown in the Example in the notes page, which is shown below.)

A $60\,\mathrm{kg}$ bungee jumper falls $12\,\mathrm{m}$ before their bungee is taut. The spring constant $k = 200\,\mathrm{N\,m^{-1}}$.

Part A The bungee has stretched $5.0\,\mathrm{m}$

Calculate the speed of bungee jumper when the bungee has stretched $5.0\,\mathrm{m}$.

Part B The bungee becomes slack on the way up

Calculate the speed of bungee jumper when the bungee becomes slack on the way up.

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Gravitational, Elastic and Kinetic Energy 2.7

A Level

(This question is about the system shown in the Example in the notes page, which is shown below.)

A $60\,\mathrm{kg}$ bungee jumper falls $12\,\mathrm{m}$ before their bungee is taut. The spring constant $k = 200\,\mathrm{N\,m^{-1}}$.

Calculate how far the bungee jumper falls before they first come to rest. You may assume that the *total* potential energy of the jumper relative to the equilibrium position is given by $\frac{1}{2}ky^2$.

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Home Gameboard Physics Mechanics Dynamics Pop-up Toy

Pop-up Toy

A Level

A pop-up toy consists of a head and sucker of combined mass m stuck to the top of a light spring of natural length l_0 and spring constant k. The spring is compressed to length l_1 when the pop-up is stuck to the ground.

To what height above the ground does the bottom of the unstretched spring jump to when it is smoothly released?

The following symbols may be useful: `g, k, l_0, l_1, m`

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