Gravitational Potential and Kinetic Energy 1.1

A Level
P P P

Quantities:

h_0 starting height (m)
h_1 final height (m)
m mass (kg)
E_{K} kinetic energy (J)
η efficiency (no unit)

v_0 starting speed $(\mathrm{m\,s^{-1}})$
v_1 final speed $(\mathrm{m\,s^{-1}})$
g gravitational field strength $(\mathrm{N\,kg^{-1}})$
E_{GP} gravitational potential energy (J)
E_{T} total energy (J)

Equations:

$$E_{\mathsf{K}} = \frac{1}{2}mv^2 \qquad E_{\mathsf{GP}} = mgh \qquad E_{\mathsf{T}} = E_{\mathsf{K}} + E_{\mathsf{GP}} \qquad E_{\mathsf{T,after}} = \eta E_{\mathsf{T,before}}$$

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

Part A Speed on the ground for a dropped object

the speed v_1 at the ground if an object was dropped from h_0.

The following symbols may be useful: `E_GP, E_K, E_T, eta, g, h_0, h_1, m, v_0, v_1`

Part B Speed for an object with initial speed v_0

the speed v_1 at a height h_1 if an object had speed v_0 at h_0.

The following symbols may be useful: `E_GP, E_K, E_T, eta, g, h_0, h_1, m, v_0, v_1`

Part C Greatest height starting from the ground

the greatest height h_1 for an object projected up from the ground with speed v_0.

The following symbols may be useful: `E_GP, E_K, E_T, eta, g, h_0, h_1, m, v_0, v_1`

Part D Greatest height reached starting from h_0

the greatest height h_1 for an object projected up from a height h_0 with speed v_0.

The following symbols may be useful: `E_GP, E_K, E_T, eta, g, h_0, h_1, m, v_0, v_1`

Part E Greatest height after a bounce

the greatest height h_1 above a hard surface reached by an object dropped from a height h_0 if the efficiency of the bounce is η.

The following symbols may be useful: `E_GP, E_K, E_T, eta, g, h_0, h_1, m, v_0, v_1`

Part F Speed after a bounce

the speed v_1 just after a bounce from a hard surface if the speed just before was v_0.

The following symbols may be useful: `E_GP, E_K, E_T, eta, g, h_0, h_1, m, v_0, v_1`

All materials on this site are licensed under the **Creative Commons license**, unless stated otherwise.

Physics. You work it out.

Gravitational Potential and Kinetic Energy 1.7

A Level

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?

Gameboard:

STEM SMART Physics 22 - Combining Energies

All materials on this site are licensed under the **Creative Commons license**, unless stated otherwise.

Gravitational Potential and Kinetic Energy 1.10

A Level

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

Gameboard:

STEM SMART Physics 22 - Combining Energies

All materials on this site are licensed under the **Creative Commons license**, unless stated otherwise.

isaac Physics. You work it out.

Gravitational, Elastic and Kinetic Energy 2.1

A Level
P P P

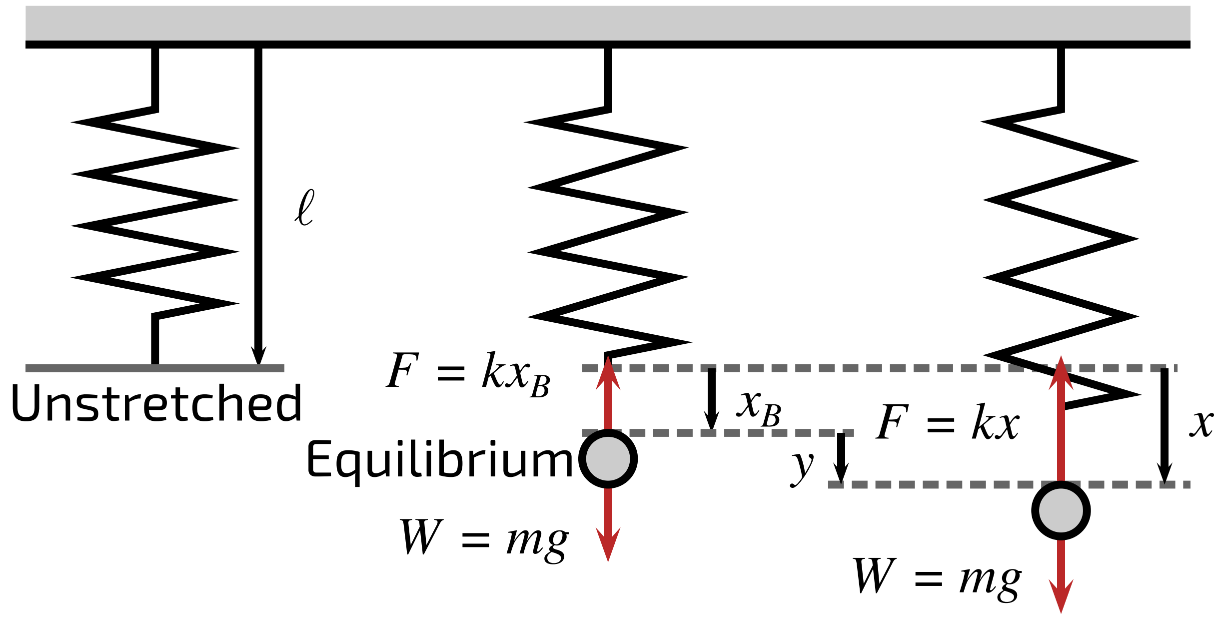

Figure 1: Objects suspended from a spring exchange stores of kinetic, elastic potential and kinetic energy as they move up and down.

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

Derive an expression for the value of $E_{\mathrm{GP}} + E_{\mathrm{EP}}$ in terms of $y = x - x_{\mathrm{B}}$. 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`

Gameboard:

STEM SMART Physics 22 - Combining Energies

All materials on this site are licensed under the **Creative Commons license**, unless stated otherwise.

Gravitational, Elastic and Kinetic Energy 2.2

A Level

P P P

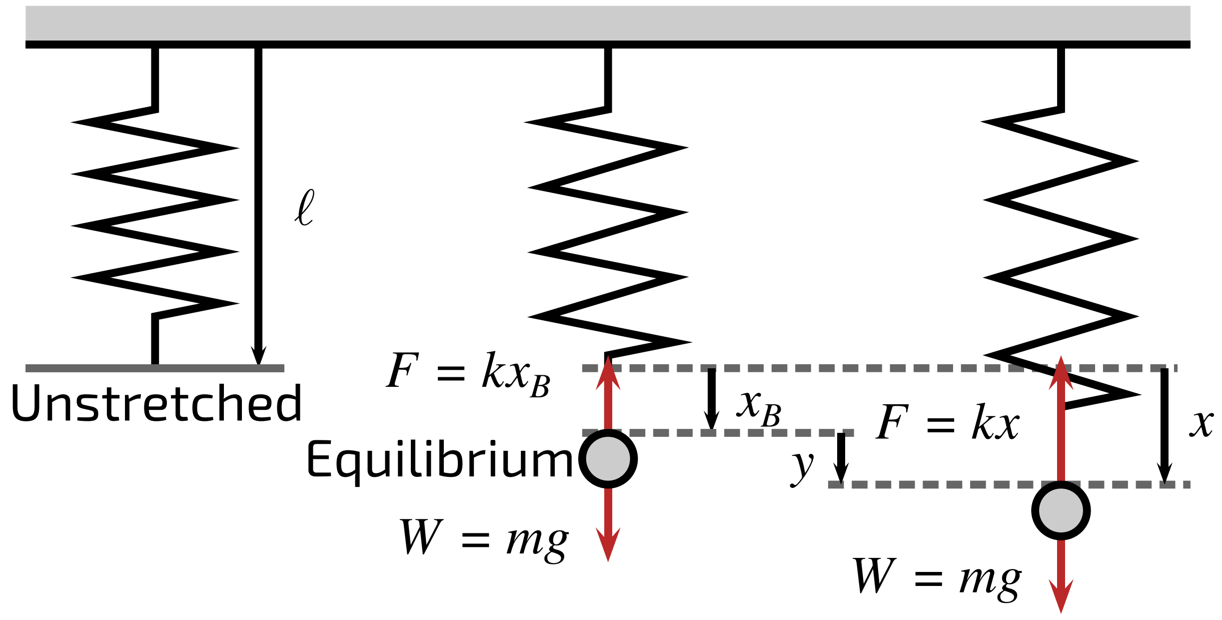

Figure 1: Objects suspended from a spring exchange stores of kinetic, elastic potential and kinetic energy as they move up and down.

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

Part A Calculate E_{GP}

Calculate the gravitational potential energy E_{GP} 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 B Calculate E_{EP}

Calculate the elastic potential energy E_{EP} 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 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 $k = 600\,\mathrm{N\,m^{-1}}$.

Gameboard:

STEM SMART Physics 22 - Combining Energies

All materials on this site are licensed under the **Creative Commons license**, unless stated otherwise.

Physics. You work it out.

Home Gameboard Physics Mechanics Dynamics Gravitational, Elastic and Kinetic Energy 2.3

Gravitational, Elastic and Kinetic Energy 2.3

A Level

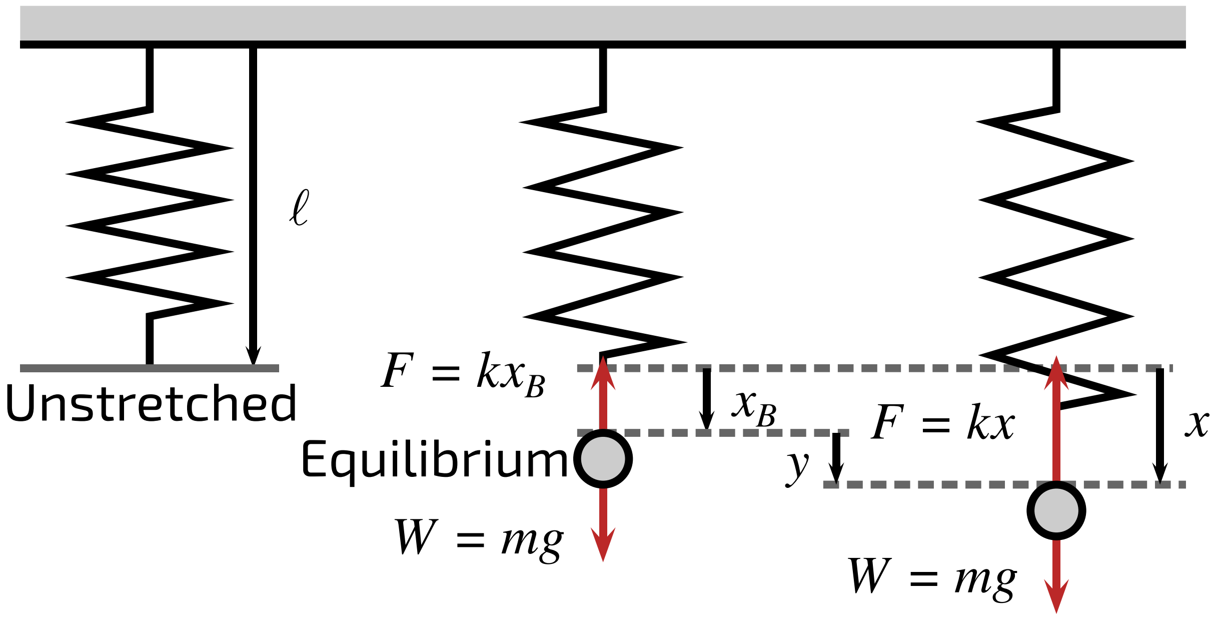

Figure 1: Objects suspended from a spring exchange stores of kinetic, elastic potential and kinetic energy as they move up and down.

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.

Gameboard:

STEM SMART Physics 22 - Combining Energies

All materials on this site are licensed under the **Creative Commons license**, unless stated otherwise.

Physics. You work it out.

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.

Gameboard:

STEM SMART Physics 22 - Combining Energies

All materials on this site are licensed under the **Creative Commons license**, unless stated otherwise.

Physics. You work it out.

Gravitational, Elastic and Kinetic Energy 2.6

A Level

P P P

Consider the motion of a $100\,\mathrm{N}$ weight ($m = 10.2\,\mathrm{kg}$), hanging from a $k = 5000\,\mathrm{N\,m^{-1}}$ spring, which is released from rest at extension $x = 0$. (The same system as in question 2.5)

Part A x where the total potential energy is at a minimum

Calculate the value of x where the total potential energy is at a minimum.

Part B The minimum total potential energy

Calculate the minimum total potential energy.

Part C The total potential energy

Calculate the total potential energy *relative to the minimum* when $y = 2.0\,\mathrm{cm}$.

Part D The energy required to stretch $2.0\,\mathrm{cm}$

Calculate the energy required to stretch a $k = 5000\,\mathrm{N\,m^{-1}}$ spring by $2.0\,\mathrm{cm}$.

Gameboard:

STEM SMART Physics 22 - Combining Energies

All materials on this site are licensed under the **Creative Commons license**, unless stated otherwise.

Physics. You work it out.

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 $\frac{1}{2}ky^2$.

Gameboard:
STEM SMART Physics 22 - Combining Energies

All materials on this site are licensed under the **Creative Commons license**, unless stated otherwise.

Physics. You work it out.

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`

All materials on this site are licensed under the **Creative Commons license**, unless stated otherwise.