GIVE FEEDBACK

CONTINUE >

Dynamic systems involve the movement of more than one component and the interaction of these components.

The **work-energy method** is an approach that can be used to analyse systems of dynamically interacting bodies.

In some problems the system will comprise two distinctly separate components constrained to move together. In others the influence of one part of the system on another will be expressed as work input or as work done against some form of resistance.

The work-energy method uses the changes in the total energy to obtain mathematical relationships between the elements of a dynamic system.

< BACK GIVE FEEDBACK OK

The work-energy method of solving problems involving a system of bodies

The analysis of a dynamic system can be achieved by considering changes in the total energy possessed by a component or a system of two interacting components when influenced by energy input or output in the form of work.

Mathematically, this principle can be generalised as follows:

$$\text{initial energy} \pm \text{work} = \text{final energy}$$

This approach to problem-solving in mechanics is referred to as the work-energy method.

GIVE FEEDBACK

OK

Type your answer in the box.

The work-energy method allows analysis of a dynamic system by considering changes in the
[ ] energy when influenced by energy input or output in the form of
[ ].

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Type your answer in the box.

The work-energy method of solving problems in mechanics can be expressed as:

________ energy ± ________ = final ________

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Which of the following is the correct mathematical statement of the work-energy method of solving problems in mechanics?

Click the correct answer.

- initial energy $\pm$ work = final energy
- $\dfrac{\text{initial energy}}{\text{final energy}} = \text{work}$
- $\dfrac{\text{initial energy}}{\text{work}} = \text{final energy}$
- initial energy $\pm$ final energy = work

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Forms of energy included in the work-energy method

For a mechanical component or system of components, the work-energy method for dynamic systems will consider all forms of mechanical energy which may include potential energy, kinetic energy and strain energy.

GIVE FEEDBACK

OK

Type your answer in the box.

For a mechanical component or system of components, the work-energy method will consider all forms of mechanical energy which may include ________ energy, ________ energy and ________ energy.

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Which of the following includes the forms of energy that are included in the work-energy method of analysis of dynamic systems?

Click the correct answer.

- Gravitational potential energy, kinetic energy and strain energy
- Chemical energy, kinetic energy and strain energy
- Gravitational potential energy, kinetic energy and electrical energy
- Gravitational potential energy, sound energy and strain energy
- Heat energy, strain energy and gravitational potential energy

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Which of the following forms of energy are included in the work-energy method of analysis of dynamic systems?

Check all that apply.

- [ ] Gravitational potential energy
- [ ] Kinetic energy
- [ ] Strain energy
- [ ] Sound energy
- [ ] Chemical energy
- [ ] Heat energy

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Mathematical formula for work-energy calculations (without strain energy)

The conservation of energy principle can be extended to situations where the external work done on a body and the work done against friction cannot be neglected and must be included in the analysis.

if we let:

$PE_1 + KE_1$ = the initial total energy of the body

$PE_2 + KE_2$ = the final total energy of the body

$\pm W$ = the net work done on the body

Then the final energy of the body is equal to the initial energy of the body increased by the amount of net work done on the body:

$$PE_1 + KE_1 \pm W = PE_2 + KE_2$$

GIVE FEEDBACK

OK

Match each of the symbols from the equation $PE_1 + KE_1 \pm W = PE_2 + KE_2$ with the correct description.

Drag statements on the right to match the left.

PE_1	The initial potential energy
KE_1	The initial kinetic energy
W	The work done
PE_2	The final potential energy
KE_2	The final kinetic energy

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Which of the following is the correct mathematical description of the work-energy method for a dynamic system that includes potential energy and kinetic energy?

Click the correct answer.

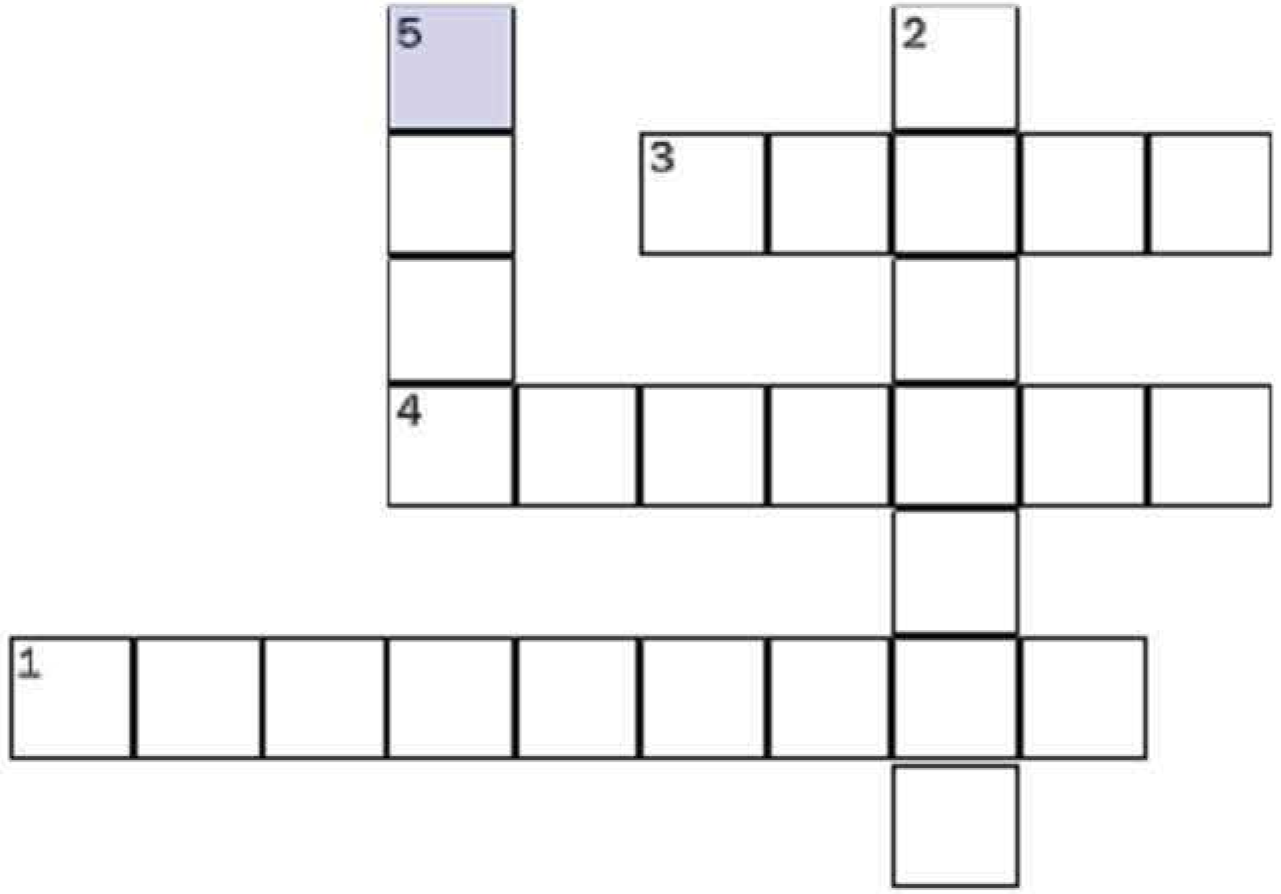
- $PE_1 + KE_1 \pm W = PE_2 + KE_2$
- $PE_1 - KE_1 = PE_2 - KE_2$
- $PE_1 + KE_2 \pm W = PE_2 + KE_1$
- $PE_2 + KE_1 = PE_1 + KE_2$
- $\frac{PE_1}{KE_1} \pm W = \frac{PE_2}{KE_2}$

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

The work-energy method equation

1



Complete the crossword based on the mathematical expression of the work-energy method.

1) The symbol PE refers to ______ energy.

2) The subscript 1 refers to the ______ value.

3) The subscript 2 refers to the ______ value.

4) The symbol KE refers to ______ energy.

5) The symbol W refers to ______.

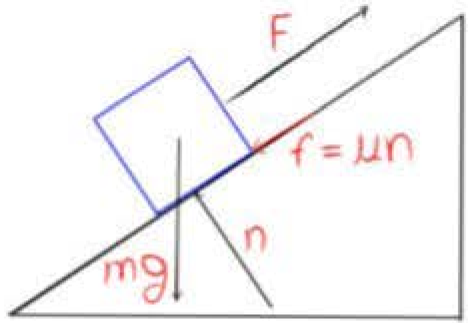
Done Hint Challenge

Remember that the work done is equal to the force multiplied by the distance.

Net work done on the body

The net work is the difference between positive work done on the body by forces acting in the direction of motion and negative work done by forces, such as friction, which are opposing the motion.

Weight should not be included when determining the external work since its effect has been allowed for in terms of potential energy.



GIVE FEEDBACK

OK

Type your answer in the box.

The ________ work is the difference between ________ work done on the body by forces acting in the direction of motion and negative work done by forces, such as friction, which are ________ the motion.

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

What is the term that is used to describe the difference between positive work done on a body by forces acting in the direction of motion and negative work done by forces which are opposing the motion?

Click the correct answer.

- Net work
- Work differential
- Gross work
- Energy deficit
- Energy content

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Which of the following is the correct description of net work?

Click the correct answer.

- The difference between positive work done on the body by forces acting in the direction of motion and negative work done by forces which are opposing the motion
- The difference between negative work done on the body by forces acting in the direction of motion and positive work done by forces which are opposing the motion
- The sum of negative work done on the body by forces acting in the direction of motion and positive work done by forces which are opposing the motion
- The sum of positive work done on the body by forces acting in the direction of motion and negative work done by forces which are opposing the motion

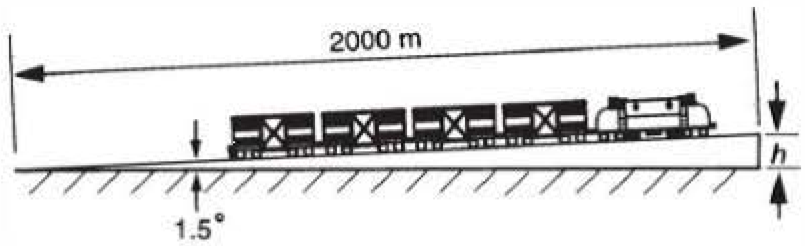
Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Calculate energy levels for a mechanical component or system of components

A 180 t train climbs an incline of 1.5° for 2 km. Its initial velocity before the climb is 90 km/h. The tractive effort exerted by the engine is 53.2 kN and tractive resistance is 95 N/t.

Identify and calculate all appropriate energy terms for this dynamic system.



Example	Potential energy	Kinetic energy

GIVE FEEDBACK

OK

Initial potential energy:

$$PE_1 = 0$$

The final elevation:

$$h = 2{,}000\ \text{m} \times \sin 1.5^\circ$$
$$= 52.35\ \text{m}$$

Final potential energy:

$$PE_2 = m\,g\,h$$
$$= 180{,}000\ \text{kg} \times 9.81\,\frac{\text{N}}{\text{kg}} \times 52.35\ \text{m}$$
$$= 92.45\ \text{MJ}$$

Example	Potential energy	Kinetic energy

GIVE FEEDBACK

OK

Calculate energy levels for a mechanical component or system of components

Initial velocity:

$$\begin{aligned} v_1 &= 90\ \text{km/h} \\ &= 25\ \text{m/s} \end{aligned}$$

Initial kinetic energy:

$$\begin{aligned} KE_1 &= \frac{1}{2} m v^2 \\ &= \left(\frac{1}{2}\right)(180{,}000\ \text{kg})(25\ \text{m/s})^2 \\ &= 56.25\ \text{MJ} \end{aligned}$$

Example	Potential energy	Kinetic energy

GIVE FEEDBACK

OK

A 12,000 kg truck climbs an incline of 5° for 1 km.

Its initial velocity before the climb is 72 km/h.

SMALL MEDIUM LARGE

Type your answer in the box.

The energy terms that must be included in the work-energy analysis of this problem are the ________ energy and the ________ energy of the truck.

These energy terms must be considered in the initial and final conditions.

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

A 12,000 kg truck climbs an incline of 5° for 1 km.

Its initial velocity before the climb is 72 km/h.

SMALL MEDIUM LARGE

Type your answer in the box.

The initial potential energy is ______ J.

The initial kinetic energy is ______ MJ (correct to two decimal places).

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

A 12,000 kg truck climbs an incline of 5° for 1 km.

Its initial velocity before the climb is 72 km/h.

SMALL MEDIUM LARGE

Type your answer in the box.

The truck's final height above the datum is ______ m (correct to two decimal places).

The truck's final potential energy is ______ MJ (correct to two decimal places).

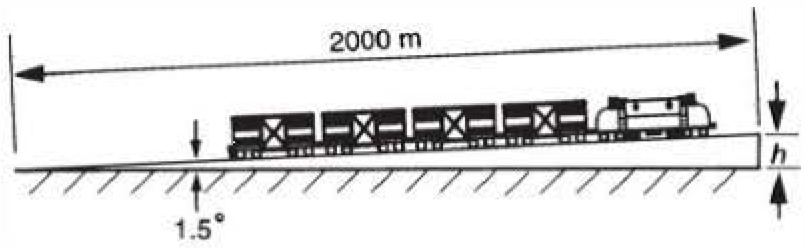
Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Calculate appropriate work inputs or outputs

A 180 t train climbs an incline of 1.5° for 2 km. Its initial velocity before the climb is 90 km/h. The tractive effort exerted by the engine is 53.2 kN and tractive resistance is 95 N/t.

Identify and calculate all appropriate work inputs or outputs for this dynamic system.



Example	Positive work	Negative work	Net work

GIVE FEEDBACK

OK

Calculate appropriate work inputs or outputs

Positive work:

$$\text{Effort} \times \text{distance} = 53{,}200\ \text{N} \times 2{,}000\ \text{m}$$
$$= 106.4\ \text{MJ}$$

Example	Positive work	Negative work	Net work

GIVE FEEDBACK

OK

Calculate appropriate work inputs or outputs

Tractive resistance:

$$95 \frac{N}{t} \times 180\ t = 17{,}100\ N$$

Negative work:

$$\text{Resistance} \times \text{distance} = 17{,}100\ N \times 2{,}000\ m$$
$$= 34.2\ MJ$$

Example	Positive work	Negative work	Net work

GIVE FEEDBACK

OK

Calculate appropriate work inputs or outputs

Net work:

$$\begin{aligned} W &= \text{positive } W - \text{negative } W \\ &= 106.4 - 34.2 \\ &= 72.2 \text{ MJ} \end{aligned}$$

Example	Positive work	Negative work	Net work

GIVE FEEDBACK

OK

A 12,000 kg truck climbs an incline of 5° for 1 km.

Its initial velocity before the climb is 72 km/h.

The tractive effort exerted by the engine is 14 kN and the total resistance force is 5.54 kN.

SMALL MEDIUM LARGE

Type your answer in the box.

The positive work done by the truck is [ ] MJ (correct to two decimal places).

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

A 12,000 kg truck climbs an incline of 5° for 1 km.

Its initial velocity before the climb is 72 km/h.

The tractive effort exerted by the engine is 14 kN and the total resistance force is 5.54 kN.

SMALL MEDIUM LARGE

Type your answer in the box.

The negative work done by the truck is [ ] MJ (correct to two decimal places).

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

A 12,000 kg truck climbs an incline of 5° for 1 km.

Its initial velocity before the climb is 72 km/h.

The tractive effort exerted by the engine is 14 kN and the total resistance force is 5.54 kN.

SMALL MEDIUM LARGE

Type your answer in the box.

The net work done by the truck is ______ MJ (correct to two decimal places).

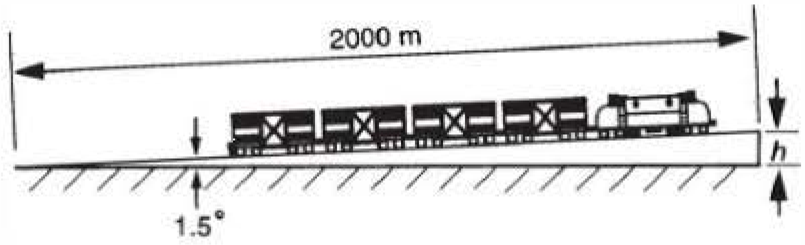
Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Calculating an unknown distance, velocity or elevation for linear motion

A 180 t train climbs an incline of 1.5° for 2 km. Its initial velocity before the climb is 90 km/h. The tractive effort exerted by the engine is 53.2 kN, and tractive resistance is 95 N/t.

Determine the final speed after the climb.



Example	Potential Energy	Work	Kinetic Energy	Solution

GIVE FEEDBACK

OK

Calculating an unknown distance, velocity or elevation for linear motion

Initial potential energy:

$$PE_1 = 0$$

The final elevation:

$$\begin{aligned} h &= 2{,}000 \text{ m} \times \sin 1.5° \\ &= 52.35 \text{ m} \end{aligned}$$

Final potential energy:

$$\begin{aligned} PE_2 &= m\, g\, h \\ &= 180{,}000 \text{ kg} \times 9.81 \frac{\text{N}}{\text{kg}} \times 52.35 \text{ m} \\ &= 92.45 \text{ MJ} \end{aligned}$$

Example	Potential Energy	Work	Kinetic Energy	Solution

GIVE FEEDBACK

OK

Positive work:

$$\begin{aligned} \text{Effort} \times \text{distance} &= 53{,}200 \text{ N} \times 2{,}000 \text{ m} \\ &= 106.4 \text{ MJ} \end{aligned}$$

Tractive resistance:

$$95 \frac{\text{N}}{\text{t}} \times 180 \text{ t} = 17{,}100 \text{ N}$$

Negative work:

$$\begin{aligned} \text{Resistance} \times \text{distance} &= 17{,}100 \text{ N} \times 2{,}000 \text{ m} \\ &= 34.2 \text{ MJ} \end{aligned}$$

Net work:

$$\begin{aligned} W &= \text{pos. } W - \text{neg. } W \\ &= 106.4 - 34.2 \\ &= 72.2 \text{ MJ} \end{aligned}$$

Initial velocity:

$$\begin{aligned} v_1 &= 90 \text{ km/h} \\ &= 25 \text{ m/s} \end{aligned}$$

Initial kinetic energy:

$$\begin{aligned} KE_1 &= \frac{1}{2} m\, v^2 \\ &= \left(\frac{1}{2}\right)(180{,}000 \text{ kg})(25 \text{ m/s})^2 \\ &= 56.25 \text{ MJ} \end{aligned}$$

Example	Potential Energy	Work	Kinetic Energy	Solution

GIVE FEEDBACK

OK

Substitute into:

$$(PE_1 + KE_1) \pm W = (PE_2 + KE_2)$$
$$0 + 56.25 + 72.2 = 92.45 + KE_2$$

Hence, final kinetic energy is:

$$KE_2 = 36 \text{ MJ}$$

Final velocity can now be calculated:

$$\frac{1}{2} m v^2 = 36 \text{ MJ} = 36 \times 10^6 \text{ J}$$

Solving for v:

$$v = 20 \text{ m/s or } 72 \text{ km/h}$$

Therefore the train's speed at the top of the climb is 72 km/h.

Example	Potential Energy	Work	Kinetic Energy	Solution

GIVE FEEDBACK

OK

A 12000 kg truck climbs an incline of 5° for 1 km.

Its initial velocity before the climb is 72 km/h.

The tractive effort exerted by the engine is 14 kN, and the total resistance force is 5.54 kN.

SMALL MEDIUM LARGE

Type your answer in the box.

The initial potential energy is [ ] MJ (correct to two decimal places).

The final potential energy is [ ] MJ (correct to two decimal places).

The initial kinetic energy is [ ] MJ (correct to two decimal places).

The net work done is [ ] MJ (correct to two decimal places).

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

A 12000 kg truck climbs an incline of 5° for 1 km.

Its initial velocity before the climb is 72 km/h.

The tractive effort exerted by the engine is 14 kN, and the total resistance force is 5.54 kN.

SMALL MEDIUM LARGE

Type your answer in the box.

The final kinetic energy can be determined using work-energy analysis ($PE_1 + KE_1 \pm W = PE_2 + KE_2$).

The final kinetic energy is [ ] joules.

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

A 12000 kg truck climbs an incline of 5° for 1 km.

Its initial velocity before the climb is 72 km/h.

The tractive effort exerted by the engine is 14 kN, and the total resistance force is 5.54 kN.

SMALL MEDIUM LARGE

Type your answer in the box.

The speed of the truck at the top of the hill is ______ m/s, which is equal to ______ km/h.

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Calculating an unknown distance, velocity and elevation for rotational motion

The work-energy method can be applied to rotational as well as linear motion.

It can also be used successfully when more than one moving component is involved.

The energy of a system of connected bodies, whose motions are related, is equal to the sum of the energies of the separate bodies.

Introduction	Example	Potential energy	Kinetic energy	Solution

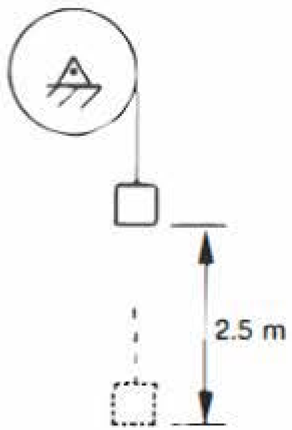
GIVE FEEDBACK

OK

Calculating an unknown distance, velocity and elevation for rotational motion

A block of mass 10 kg is attached to a cord which is wrapped around a drum of diameter 800 mm and the mass moment of inertia is 15 $kg.m^2$.

After the block is released and has dropped a distance of 2.5 m, its velocity is 2 m/s. Determine the magnitude of the bearing-friction torque which resists rotation.



Introduction	Example	Potential energy	Kinetic energy	Solution

GIVE FEEDBACK

OK

Calculating an unknown distance, velocity and elevation for rotational motion

Using the lowest position of the block as a datum:

$$\begin{aligned} PE_1 &= m\,g\,h_1 \\ &= 245.3\ \text{J} \end{aligned}$$

$$PE_2 = 0$$

Introduction	Example	Potential energy	Kinetic energy	Solution

GIVE FEEDBACK

OK

Calculating an unknown distance, velocity and elevation for rotational motion

$$KE_{1_{(block)}} = 0$$
$$KE_{1_{(drum)}} = 0$$

$$KE_{2_{(block)}} = \frac{1}{2} m\, v^{2} = \left(\frac{1}{2}\right)(10)(2^{2}) = 20\ \text{J}$$

Final angular velocity of the drum:

$$\omega_2 = \frac{v_2}{r} = \frac{2}{0.4} = 5\ \text{rad/s}$$

$$KE_{2_{(drum)}} = \frac{1}{2} I\, \omega^{2} = \left(\frac{1}{2}\right)(15)(5^{2}) = 187.5\ \text{J}$$

Introduction	Example	Potential energy	Kinetic energy	Solution

GIVE FEEDBACK

OK

Substitute into:

$$(PE_1 + KE_{1\,(block)} + KE_{1\,(drum)}) + W = (PE_2 + KE_{2\,(block)} + KE_{2\,(drum)})$$
$$245.3 + 0 + 0 + W = 0 + 20 + 187.5$$
$$\therefore W = -37.8 \text{ J}$$

This is negative work done by resistance torque equal to $W = T \times \theta$ where:

$$\theta = \frac{S}{r} = \frac{2.5 \text{ m}}{0.4 \text{ m}} = 6.25 \text{ rad}$$

Substitute:

$$37.8 = T \times 6.25$$
$$\therefore T = 6.05 \text{ N.m}$$

Hence bearing friction torque T is 6.05 N.m.

A block of mass 12 kg is attached to a cord which is wrapped around a drum of diameter 600 mm and the mass moment of inertia is $14\,\mathrm{kg\,m^2}$.

After the block is released and has dropped a distance of 3 m, its velocity is 1.8 m/s.

SMALL MEDIUM LARGE

Type your answer in the box.

Using the lowest position of the block as a datum, the final potential energy is ______ J and the initial potential energy is ______ J (correct to two decimal places).

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

A block of mass 12 kg is attached to a cord which is wrapped around a drum of diameter 600 mm and the mass moment of inertia is $14\,\mathrm{kg\,m^2}$.

After the block is released and has dropped a distance of 3 m, its velocity is 1.8 m/s.

SMALL MEDIUM LARGE

Type your answer in the box.

The initial kinetic energy of the block is ______ J.

The final kinetic energy of the block is ______ J (correct to two decimal places).

The initial kinetic energy of the drum is ______ J.

The final kinetic energy of the drum is ______ J.

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

A block of mass 12 kg is attached to a cord which is wrapped around a drum of diameter 600 mm and the mass moment of inertia is $14\,\mathrm{kg\,m^2}$.

After the block is released and has dropped a distance of 3 m, its velocity is 1.8 m/s.

SMALL MEDIUM LARGE

Type your answer in the box.

Using the work-energy method ($PE_1 + KE_1 \pm W = PE_2 + KE_2$), the work done is – ______ J (correct to two decimal places).

This is negative work done by resistance torque which is equal to $W = T\,\theta$, therefore the bearing friction torque is ______ Nm (correct to two decimal places).

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

A block of mass 8 kg is attached to a cord which is wrapped around a drum of diameter 1 m and the mass moment of inertia is $10\,\mathrm{kg\,m^2}$.

After the block is released and has dropped a distance of 1.91 m, its velocity is 1.5 m/s.

SMALL MEDIUM LARGE

Type your answer in the box.

Using the lowest position of the block as a datum, the final potential energy is ______ J and the initial potential energy is ______ J (correct to the nearest joule).

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

A block of mass 8 kg is attached to a cord which is wrapped around a drum of diameter 1 m and the mass moment of inertia is $10\,\mathrm{kg\,m^2}$.

After the block is released and has dropped a distance of 1.91 m, its velocity is 1.5 m/s.

SMALL MEDIUM LARGE

Type your answer in the box.

The initial kinetic energy of the block is ______ J.

The final kinetic energy of the block is ______ J.

The initial kinetic energy of the drum is ______ J.

The final kinetic energy of the drum is ______ J.

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

A block of mass 8 kg is attached to a cord which is wrapped around a drum of diameter 1 m and the mass moment of inertia is $10\,\mathrm{kg\,m^2}$.

After the block is released and has dropped a distance of 1.91 m, its velocity is 1.5 m/s.

SMALL MEDIUM LARGE

Type your answer in the box.

Using the work-energy method ($PE_1 + KE_1 \pm W = PE_2 + KE_2$), the work done is - [ ] J.

This is negative work done by resistance torque which is equal to $W = T\,\theta$, therefore the bearing friction torque is [ ] Nm (correct to two decimal places).

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Mathematical formula for work-energy calculations (with strain energy)

The conservation of energy principle can be extended to situations where the external work done on a body and the work done against friction cannot be neglected and must be included in the analysis.

The total mechanical energy of a system that involves springs includes the gravitational potential energy, the kinetic energy and the elastic strain energy.

if we let:

$PE_1 + KE_1 + SE_1$ = the initial total energy of the body

$PE_2 + KE_2 + SE_2$ = the final total energy of the body

$\pm W$ = the net work done on the body

Then the final energy of the body is equal to the initial energy of the body increased by the amount of net work done on the body:

$$PE_1 + KE_1 + SE_1 \pm W = PE_2 + KE_2 + SE_2$$

GIVE FEEDBACK

OK

Match each of the symbols from the equation $PE_1 + KE_1 + SE_1 \pm W = PE_2 + KE_2 + SE_2$ with the correct description.

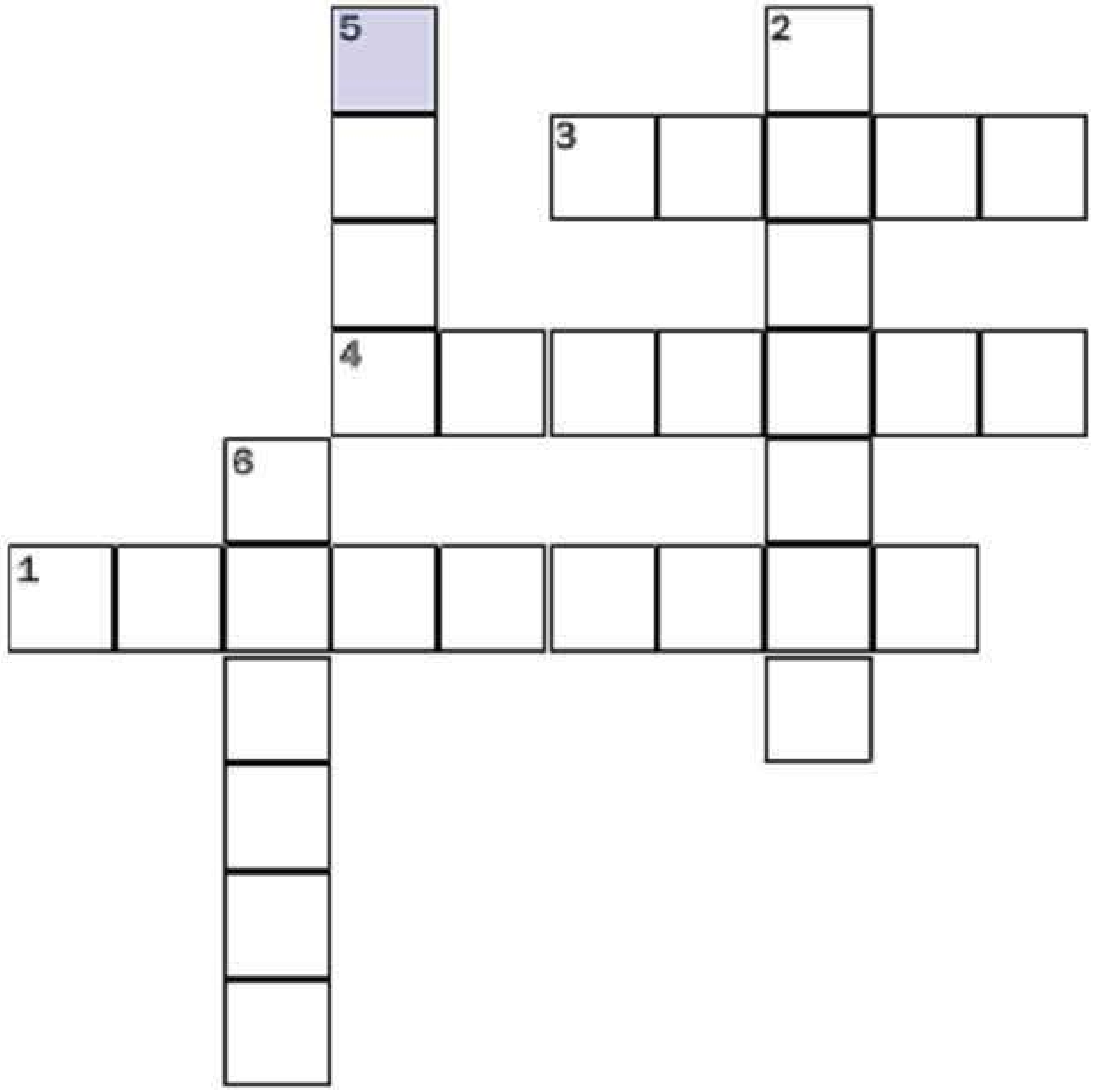
Drag statements on the right to match the left.

PE_1	The initial potential energy
KE_1	The initial kinetic energy
SE_1	The initial strain energy
W	The work done
PE_2	The final potential energy
KE_2	The final kinetic energy
SE_2	The final strain energy

Do you know the answer?

The work-energy method equation

1



Complete the crossword based on the mathematical expression of the work-energy method.

1) The symbol PE refers to ______ energy.
2) The subscript 1 refers to the ______ value.
3) The subscript 2 refers to the ______ value.
4) The symbol KE refers to ______ energy.
5) The symbol W refers to ______.
6) The symbol SE refers to ______ energy.

Done   Hint   Challenge

Which of the following is the correct mathematical description of the work-energy method for a dynamic system that includes potential energy, kinetic energy and strain energy?

Click the correct answer.

- $PE_1 + KE_1 + SE_1 \pm W = PE_2 + KE_2 + SE_2$
- $PE_1 - KE_1 - SE_1 = PE_2 - KE_2 - SE_2$
- $PE_1 + KE_2 + SE_1 \pm W = PE_2 + KE_1 + SE_2$
- $PE_2 + KE_1 + SE_2 = PE_1 + KE_2 + SE_1$
- $\dfrac{PE_1}{KE_1 + SE_1} \pm W = \dfrac{PE_2}{KE_2 + SE_2}$

Do you know the answer?

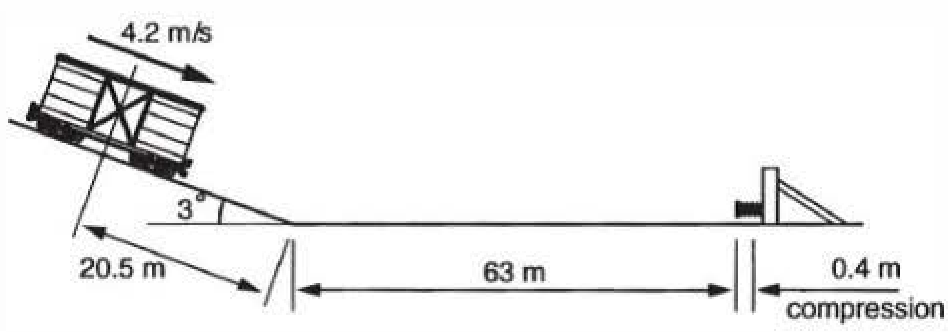
I KNOW IT | THINK SO | UNSURE | NO IDEA

Calculate energy levels for a mechanical component or system of components

A railway truck of mass 8 t rolls 20.5 m down a 3° incline, starting with an initial velocity of 4.2 m/s, and continues on a level track for 63 m before striking a spring buffer.

The spring stiffness is unknown and the spring is compressed by 400 mm.

Identify and calculate all appropriate energy levels for this system of components.



Example	Potential energy	Kinetic energy	Strain energy

GIVE FEEDBACK

OK

Calculate energy levels for a mechanical component or system of components

Initial potential energy:

$$\begin{aligned} PE_1 &= m\,g\,h \\ &= (8{,}000)(9.81)(20.5 \sin 3^\circ) \\ &= 84{,}200 \text{ J} \end{aligned}$$

Final potential energy:

$$PE_2 = 0$$

Example	Potential energy	Kinetic energy	Strain energy

GIVE FEEDBACK

OK

Calculate energy levels for a mechanical component or system of components

Initial kinetic energy:

$$KE_1 = \frac{1}{2} m\, v^2$$
$$= \left(\frac{1}{2}\right)(8{,}000\ \text{kg})(4.2\ \text{m/s})^2$$
$$= 70{,}560\ \text{J}$$

Final kinetic energy:

$$KE_2 = 0$$

Example	Potential energy	Kinetic energy	Strain energy

GIVE FEEDBACK

OK

Initial strain energy:

$$SE_1 = 0$$

(the spring is not compressed at this stage).

Final strain energy:

$$\begin{aligned} SE_2 &= \frac{1}{2}k\,x^2 \\ &= \left(\frac{1}{2}\right)k\,(0.4\ \mathrm{m})^2 \\ &= 0.08\,k \end{aligned}$$

where k is the unknown spring constant.

Example	Potential energy	Kinetic energy	Strain energy

A railway truck of mass 6.4 t rolls 35 m down a 2° incline, starting with an initial velocity of 4.7 m/s, and continues on a level track for 64.7 m before striking a spring buffer.

The total tractive resistance is 1200 N.

The spring is compressed by 300 mm.

SMALL MEDIUM LARGE

Type your answer in the box.

The energy terms that must be included in the work-energy analysis of this problem are the ______ energy, the ______ energy and the ______ energy of the truck.

These energy terms must be considered in the initial and final conditions.

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

A railway truck of mass 6.4 t rolls 35 m down a 2° incline, starting with an initial velocity of 4.7 m/s, and continues on a level track for 64.7 m before striking a spring buffer.

The total tractive resistance is 1200 N.

The spring is compressed by 300 mm.

SMALL MEDIUM LARGE

Type your answer in the box.

The initial potential energy is ______ J (correct to the nearest joule).

The final potential energy is ______ J.

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

A railway truck of mass 6.4 t rolls 35 m down a 2° incline, starting with an initial velocity of 4.7 m/s, and continues on a level track for 64.7 m before striking a spring buffer.

The total tractive resistance is 1200 N.

The spring is compressed by 300 mm.

SMALL MEDIUM LARGE

Type your answer in the box.

The initial kinetic energy is ______ J (correct to the nearest joule).

The final kinetic energy is ______ J.

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

A railway truck of mass 6.4 t rolls 35 m down a 2° incline, starting with an initial velocity of 4.7 m/s, and continues on a level track for 64.7 m before striking a spring buffer.

The total tractive resistance is 1200 N.

The spring is compressed by 300 mm.

SMALL MEDIUM LARGE

Type your answer in the box.

The initial strain energy is ______ J.

If the spring has a modulus of k, the final strain energy is ______ J.

Do you know the answer?

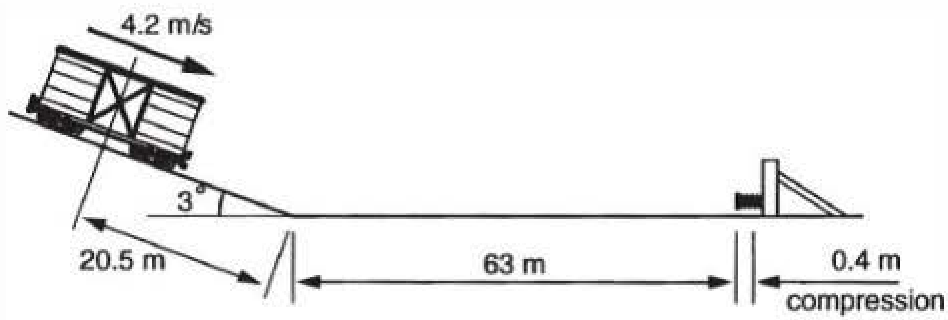
I KNOW IT | THINK SO | UNSURE | NO IDEA

Calculate appropriate work inputs or outputs

A railway truck of mass 8 t rolls 20.5 m down a 3° incline, starting with an initial velocity of 4.2 m/s, and continues on a level track for 63 m before striking a spring buffer.

The total tractive resistance is 1320 N.

What is the work done if the spring is compressed by 400 mm?



Example	Identify the source of work	Action distance	Work done	Discussion

GIVE FEEDBACK

OK

Calculate appropriate work inputs or outputs

The work is done by the railway truck moving against tractive resistance.

Example	Identify the source of work	Action distance	Work done	Discussion

GIVE FEEDBACK

OK

The total distance is the sum of the distance travelled down the hill, the distance travelled on the level track and the distance travelled in compressing the spring.

Therefore:

$$\begin{aligned}\text{Total distance} &= 20.5 + 63 + 0.4 \\ &= 83.9 \text{ m}\end{aligned}$$

Example	Identify the source of work	Action distance	Work done	Discussion

Calculate appropriate work inputs or outputs

The work done can be calculated using:

work = force x distance

Therefore:

$$
\begin{aligned}
W &= (1{,}200\ \text{N})(83.9\ \text{m}) \\
&= 110{,}750\ \text{J}
\end{aligned}
$$

Example	Identify the source of work	Action distance	Work done	Discussion

GIVE FEEDBACK

OK

Calculate appropriate work inputs or outputs

This work is negative, as it is done against frictional resistance and represents the amount of mechanical energy lost from the system.

Example	Identify the source of work	Action distance	Work done	Discussion

GIVE FEEDBACK

OK

A railway truck of mass 6.4 t rolls 35 m down a 2° incline, starting with an initial velocity of 4.7 m/s, and continues on a level track for 64.7 m before striking a spring buffer.

The total tractive resistance is 1200 N.

The spring is compressed by 300 mm.

SMALL MEDIUM LARGE

Type your answer in the box.

In this system the work is done against ____ resistance.

This force has a value of ____ N.

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

A railway truck of mass 6.4 t rolls 35 m down a 2° incline, starting with an initial velocity of 4.7 m/s, and continues on a level track for 64.7 m before striking a spring buffer.

The total tractive resistance is 1200 N.

The spring is compressed by 300 mm.

SMALL MEDIUM LARGE

Type your answer in the box.

The total distance travelled by the railway truck is the sum of the distance travelled down the _____, the distance travelled on the _____ track and the distance travelled in compressing the _____.

Therefore the total distance travelled is _____ m.

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

A railway truck of mass 6.4 t rolls 35 m down a 2° incline, starting with an initial velocity of 4.7 m/s, and continues on a level track for 64.7 m before striking a spring buffer.

The total tractive resistance is 1200 N.

The spring is compressed by 300 mm.

SMALL MEDIUM LARGE

Type your answer in the box.

The work done by the railway truck is ____ kJ.

Do you know the answer?

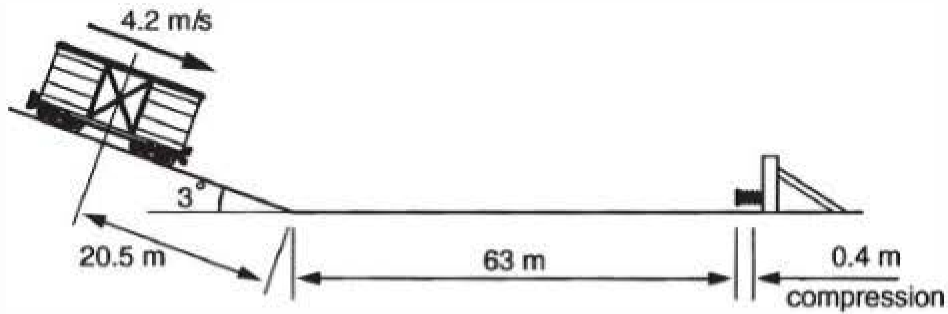
I KNOW IT | THINK SO | UNSURE | NO IDEA

Calculating an unknown distance, velocity, elevation or amount of compression in a spring

A railway truck of mass 8 t rolls 20.5 m down a 3° incline, starting with an initial velocity of 4.2 m/s, and continues on a level track for 63 m before striking a spring buffer.

The total tractive resistance is 1320 N.

What is the spring stiffness if the spring is compressed by 400 mm?



Example	Initial energy	Final energy	Work done	Work-energy analysis

GIVE FEEDBACK

OK

Initial potential energy:

$$PE_1 = m\,g\,h = (8{,}000)(9.81)(20.5 \sin 3^\circ) = 84{,}200 \text{ J}$$

Initial kinetic energy:

$$KE_1 = \frac{1}{2} m\,v^2 = \left(\frac{1}{2}\right)(8{,}000 \text{ kg})(4.2 \text{ m/s})^2 = 70{,}560 \text{ J}$$

Initial strain energy:

$SE_1 = 0$ (the spring is not compressed at this stage).

Example	Initial energy	Final energy	Work done	Work-energy analysis

GIVE FEEDBACK

OK

Calculating an unknown distance, velocity, elevation or amount of compression in a spring

Final potential energy:

$$PE_2 = 0$$

Final kinetic energy:

$$KE_2 = 0$$

Final strain energy:

$$SE_2 = \frac{1}{2} k\, x^2 = \left(\frac{1}{2}\right) k\, (0.4\ \mathrm{m})^2 = 0.08\, k$$

where k is the unknown spring constant.

Example	Initial energy	Final energy	Work done	Work-energy analysis

GIVE FEEDBACK

OK

The work done against tractive resistance is:

$$W = \text{force} \times \text{distance}$$
$$= 1{,}320 \times (20.5 + 63 + 0.4)$$
$$= 110{,}750 \text{ J}$$

Example	Initial energy	Final energy	Work done	Work-energy analysis

Calculating an unknown distance, velocity, elevation or amount of compression in a spring

We can now write the energy balance as follows:

$$PE_1 + KE_1 + SE_1 \pm W = PE_2 + KE_2 + SE_2$$

Substitution yields:

$$84{,}200 + 70{,}560 + 0 - 110{,}750 = 0 + 0 + 0.08\,k$$
$$\therefore k = 550 \text{ N/mm}$$

Hence the spring stiffness corresponding to maximum compression of 400 mm is $k = 550 \text{ N/mm}$.

Example	Initial energy	Final energy	Work done	Work-energy analysis

GIVE FEEDBACK

OK

A railway truck of mass 6.4 t rolls 35 m down a 2° incline, starting with an initial velocity of 4.7 m/s, and continues on a level track for 64.7 m before striking a spring buffer.

The total tractive resistance is 1200 N.

The spring is compressed by 300 mm.

SMALL MEDIUM LARGE

Type your answer in the box.

The initial potential energy is [ ] J (correct to the nearest joule).

The initial kinetic energy is [ ] J (correct to the nearest joule).

The initial strain energy is [ ] J (correct to the nearest joule).

The work done against tractive resistance is [ ] J (correct to the nearest joule).

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

A railway truck of mass 6.4 t rolls 35 m down a 2° incline, starting with an initial velocity of 4.7 m/s, and continues on a level track for 64.7 m before striking a spring buffer.

The total tractive resistance is 1200 N.

The spring is compressed by 300 mm.

SMALL MEDIUM LARGE

Type your answer in the box.

The final potential energy is ______ J (correct to the nearest joule).

The final kinetic energy is ______ J (correct to the nearest joule).

The final strain energy is ______ J (correct to the nearest joule).

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

A railway truck of mass 6.4 t rolls 35 m down a 2° incline, starting with an initial velocity of 4.7 m/s, and continues on a level track for 64.7 m before striking a spring buffer.

The total tractive resistance is 1200 N.

The spring is compressed by 300 mm.

SMALL MEDIUM LARGE

Type your answer in the box.

Using the work-energy method ($PE_1 + KE_1 + SE_1 \pm W = PE_2 + KE_2 + SE_2$), the spring modulus is equal to ______ N/mm (correct to the nearest N/mm).

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Determining whether work is positive or negative requires consideration of the energy of the system.

The difference between positive and negative work

The description of work as being either positive or negative is based on whether the work increases or decreases the energy of the system.

Positive work increases the energy of a system while negative work decreases the energy of a system.

GIVE FEEDBACK

OK

Which of the following are correct descriptions for positive and negative work?

Check all that apply.

- [ ] Positive work increases the energy of a system
- [ ] Negative work decreases the energy of a system
- [ ] Positive work increases the energy of a system and negative work decreases the energy of a system
- [ ] Negative work increases the energy of a system and positive work decreases the energy of a system
- [ ] Negative work increases the energy of a system
- [ ] Positive work decreases the energy of a system

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Which of the following is a correct description of positive and negative work?

Click the correct answer.

- Positive work increases the energy of a system and negative work decreases the energy of a system
- Negative work increases the energy of a system and positive work decreases the energy of a system
- Positive work decreases the energy of a system and negative work increases the energy of a system
- Negative work decreases the energy of a system and positive work decreases the energy of a system
- Positive work increases the energy of a system and negative work increases the energy of a system

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

Type your answer in the box.

Positive work [ ] the energy of a system and [ ] work decreases the energy of a system.

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA

The concept of negative work

Negative work decreases the energy of a system.

Examples of negative work include those where work is done against frictional resistance. In these cases energy loss occurs by virtue of the conversion of mechanical energy into heat. The heat is dissipated into the surroundings thus diminishing the amount of energy left in the system.

GIVE FEEDBACK

OK

Which of the following represent examples of negative work where work is done against frictional resistance?

Check all that apply.

- [ ] A car using its brakes to come to rest
- [ ] A box being dragged across a concrete floor
- [ ] An electric heater used to heat a room
- [ ] A box being lifted by hoist
- [ ] A spring stretching as it supports a vertical weight

Do you know the answer?

I KNOW IT | THINK SO | UNSURE | NO IDEA