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NEW JERSEY CENTER
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Algebra Based Physics

Work and Energy

2018-01-11

www.njctl.org

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https://www.njctl.org/video/?v=zFxiRGMN5RE

Conservation Principles, Systems and Energy

https://www.njctl.org/video/?v=gpIGt6ANfFU

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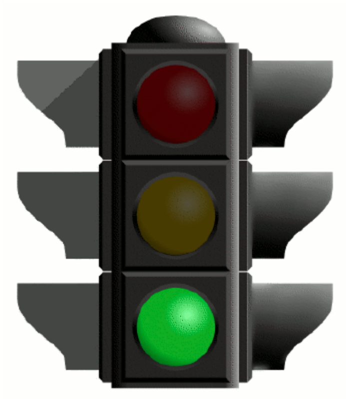
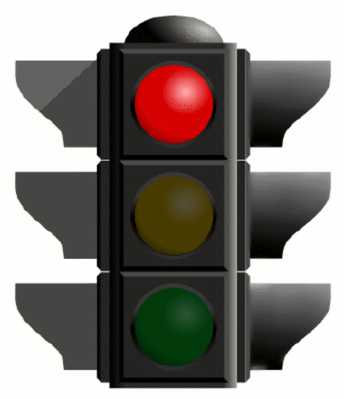
Conservation Principles

The most powerful concepts in science are called "conservation principles". These principles allow us to solve problems without worrying too much about the details of a process.

We just have to take a snapshot of a system initially and finally; by comparing those two snapshots we can learn a lot.





Conservation Principles

A good example is a bag of candy.

If you know that there are 50 pieces of candy at the beginning. And you know that none of the pieces have been taken out or added...you know that there must be 50 pieces at the end.

Conservation Principles

You can change the way you arrange them by moving them around...but you still will have 50 pieces.In that case we would say that the number of pieces of candy is conserved.

That is, we should always get the same amount, regardless of how they are arranged.

Conservation Principles

We also have to be clear about the system that we're talking about. If we're talking about a specific type of candy...we can't suddenly start talking about a different one and expect to get the same answers.

We must define the system whenever
we use a conservation principle.

Conservation Principles

But, what is a system?
And, how does it help us solve physics problems?

Let's discuss these two questions before we get back to Conservation Principles.
We'll start with why can we even solve physics problems?

Why Can We Solve Physics Problems?

You've learned about forces and solving physics problems.

But have you ever wondered how we can actually solve a problem? After all, every object we study is is in some way affected by a lot of other objects.

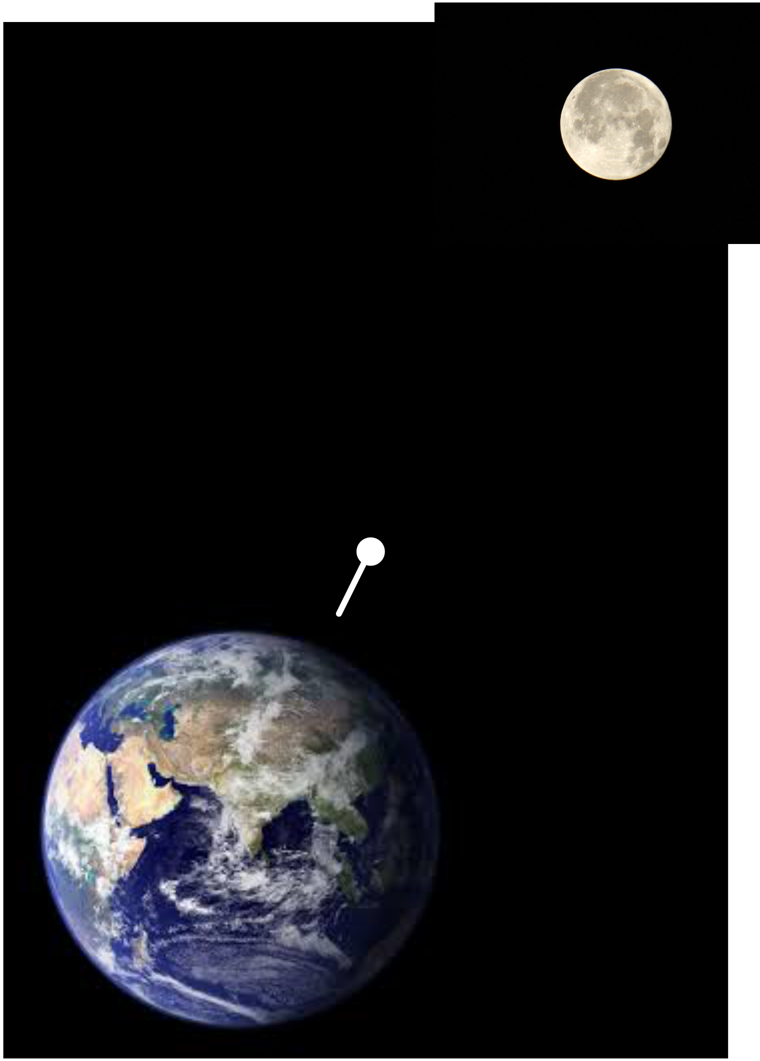
In fact, you could say that any object is affected by everything else in the Universe!

Why Can We Solve Physics Problems?

Here's an example.

We know that the moon exerts a gravitational force on the earth. So it must exert a force on every object on earth.

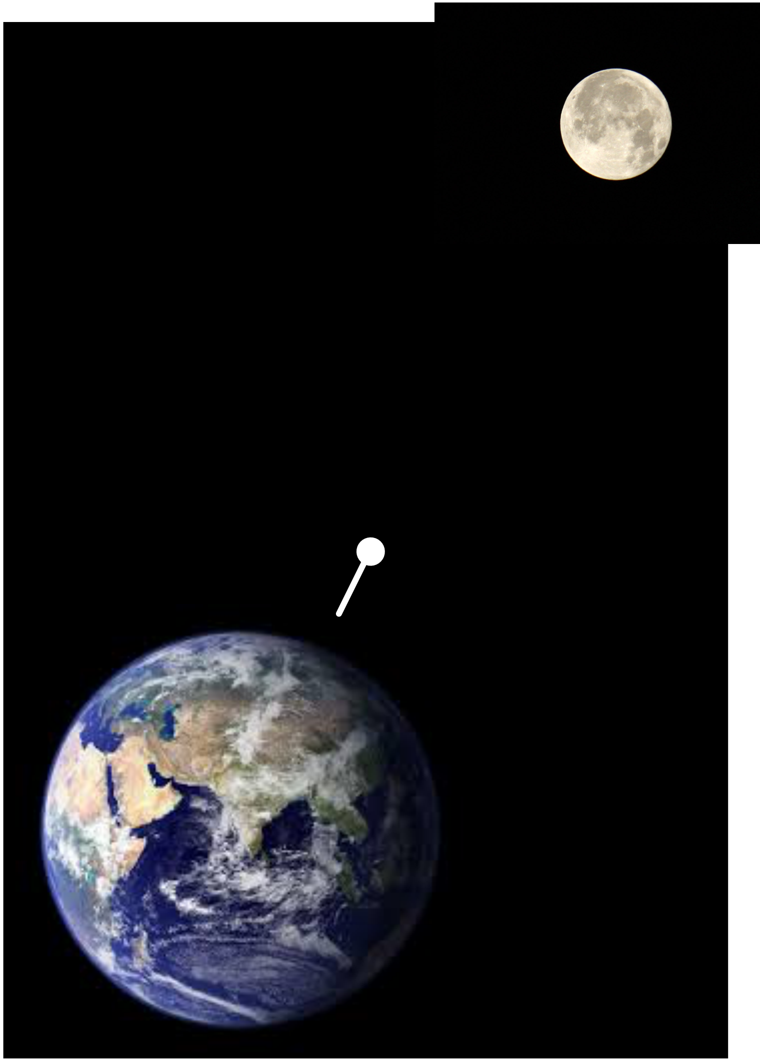
Why then, when we work out the motion of a dropped ball near the surface of the earth don't we take into account the affect of the moon's gravity? Or for that matter, the gravitational force from the sun... and all the other planets...and...



Why Can We Solve Physics Problems?

When we solve for the motion of a dropped ball, we only consider the gravitational pull of the earth, because...

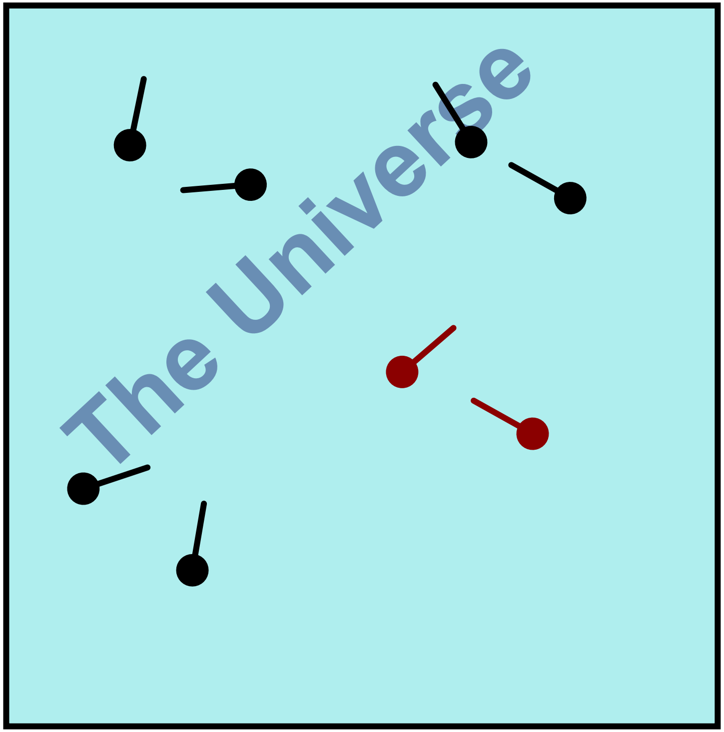
The earth's gravitational force on the ball is so much bigger than the gravitational force of the moon (and everything else) on the ball that we can ignore everything but the ball and the earth when solving the problem.



The Universe

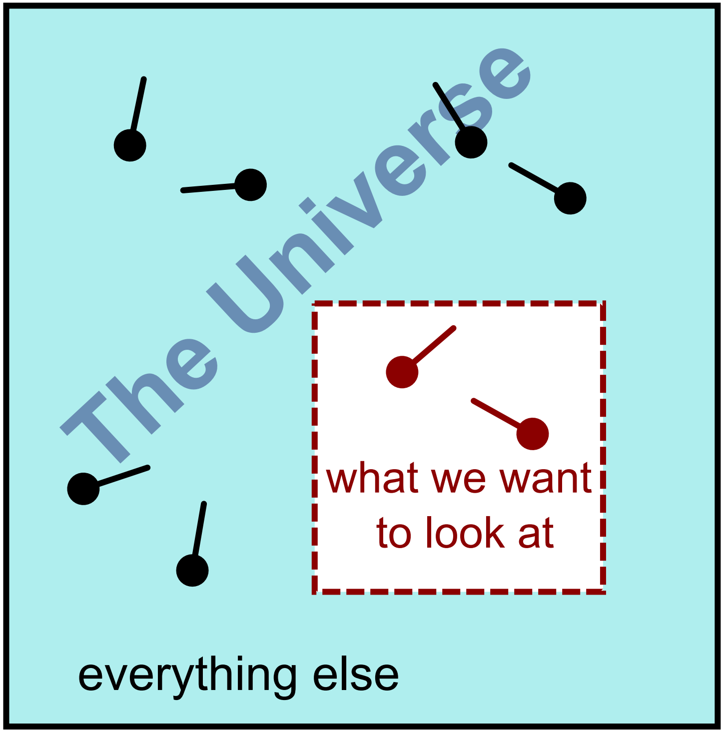
So... even though every object in the universe can affect every other object in the universe, most of the effects on any on any one object are too tiny to care about.

Often we can just consider one or a small number of objects, and ignore everything else.



System and Environment

To solve problems, we divide the universe into what we want to look at and everything else.



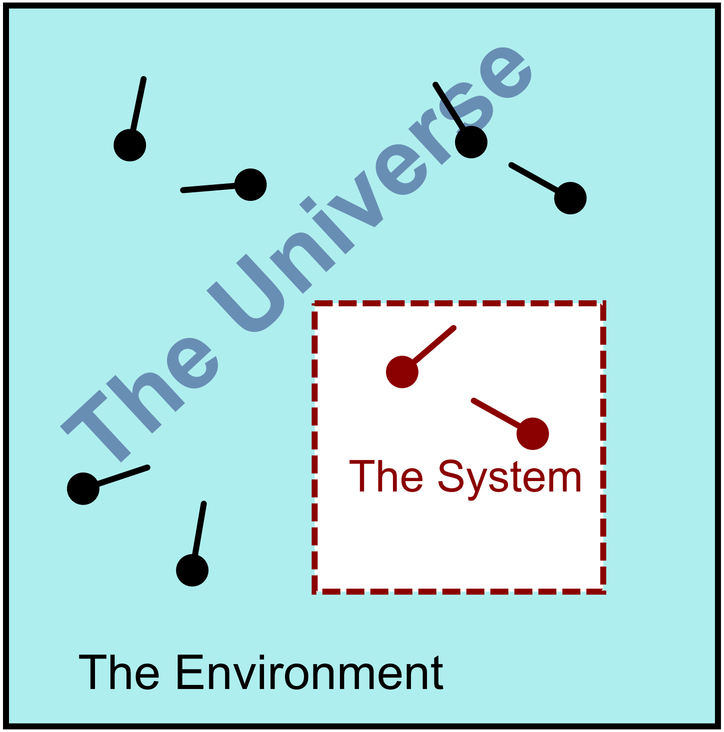
System and Environment

The little piece of the universe that we look at when we solve a specific problem is called the system.

A system may consist of one or more objects, or an amount of material, in a region of space.

We put an imaginary boundary or picture frame around the system.

Everything else - some or all of the universe outside the system boundary - is called the environment.

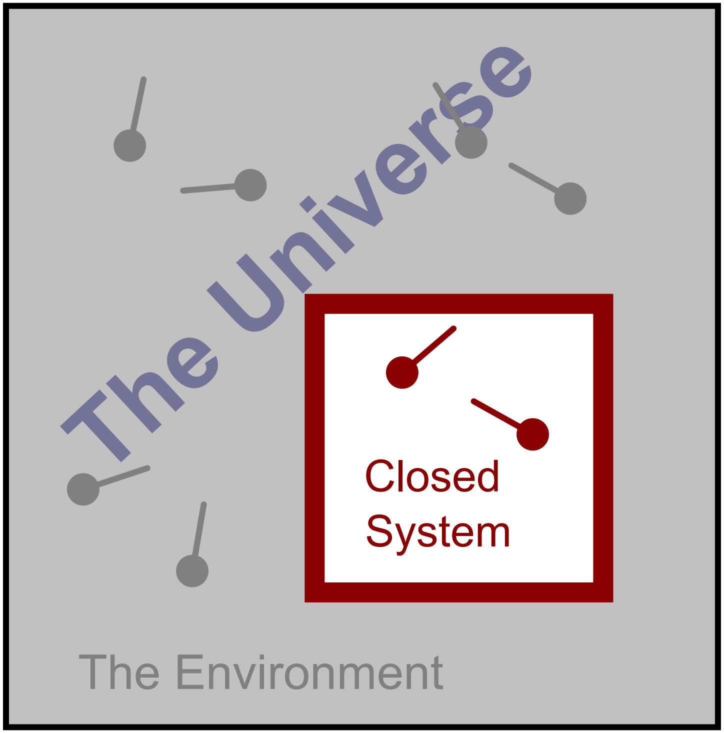


Systems Can Be Closed or Open

When a system is unaffected by anything in the environment, we call it a closed system.

It's as if the system was in a universe by itself.

- The objects can't leave.
- No other object can get in.
- No outside forces affect anything in the system.

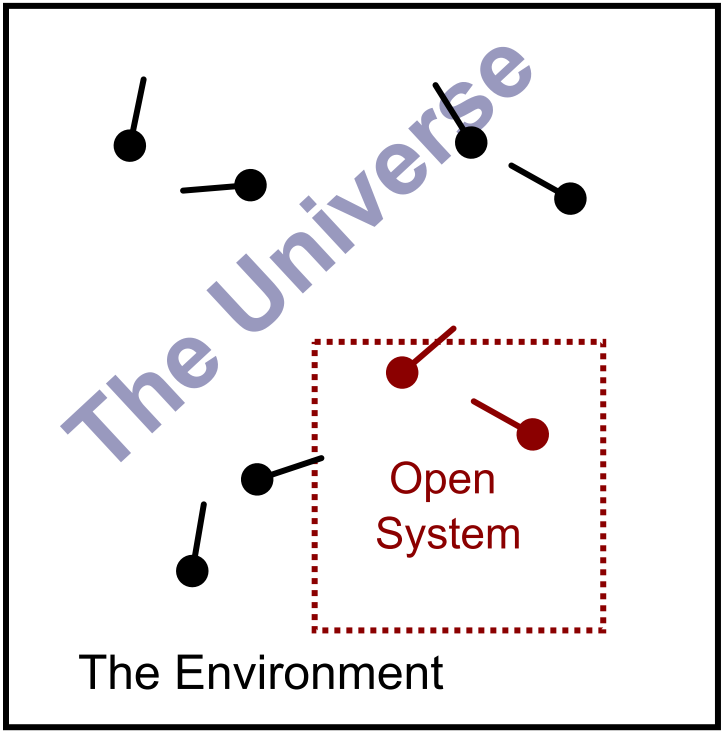


Systems Can Be Closed or Open

When a system can be affected by the environment, we call it an open system.

While we are focused on the objects in the system, they are affected by the environment.

- Objects might be able to leave.
- Other objects might get in.
- Some outside forces affect the objects in the system.



Systems and Forces

By separating the system from the environment, we can make a problem solvable.

By defining an appropriate system, we can isolate the forces that are within the system from the forces that act on the system from the environment.

Energy Change in Systems

If the system is open, external forces can do work on the system. That is $W \neq 0$ and

$$E_o + W = E_f \quad \text{(the energy of the system will change)}$$

If the system is closed, there is no work done on the system by outside forces $W = 0$. That is

$$E_o = E_f \quad \text{(the energy of the system doesn't change)}$$

This is called Conservation of Energy.

But what is work?
How does it relate to changes in energy?
Both questions will be answered in the next section.

1 A system is defined as:

- A everything in the universe.
- B the part of the universe that contains the objects we are interested in
- C everything in the universe except the objects we are interested in
- D a boundary that prevents the universe from affecting the objects we are interested in

Answer

2 The environment is defined as:

- A the part of the universe that contains no forces
- B the part of the universe that contains the objects we are interested in
- C the part of the universe that is the source of internal forces on the system.
- D the part of the universe that does not contain the objects we are interested in

Answer

3 A closed system

- A allows objects to enter and leave
- B is unaffected by external forces
- C is the universe
- D is unaffected by internal forces

Answer

Conservation of Energy

Energy is a conserved property of nature. It is not created or destroyed. Therefore in a closed system we will always have the same amount of energy.

The only way the energy of a system can change is if it is open to the outside...this means that energy has been added or taken away.

What is Energy?

It turns out that energy is so fundamental, like space and time, that there is no good answer to this question. However, just like space and time, that doesn't stop us from doing very useful calculations with energy.

We may not be able to define energy, but because it is a conserved property of nature, it's a very useful idea.

Conservation of Energy

If we call the amount of energy that we start with "E_o" and the amount we end up with as "E_f" then we would say that if no energy is added to or taken away from a system that

$$E_o = E_f$$

It turns out there are only two ways to change the energy of a system. One is with heat (which we won't deal with here) the other is with Work, "W".

If we define positive work as that work which increases the energy of a system our equation becomes:

$$E_o + W = E_f$$

Work

Work can only be done to a system by an external force; a force from something that is not a part of the system.

So if our system is a plane on an aircraft carrier and we come along and push the plane, we can increase the energy of the plane…

We are essentially doing work on the plane.

Work

The amount of work done, and therefore the amount of energy increase that the system will experience is given by the equation:

$$W = Fd_{parallel}$$

Meaning, work is the product of the force applied which moves the object a parallel displacement

There are some important points to understand about this equation.

Work

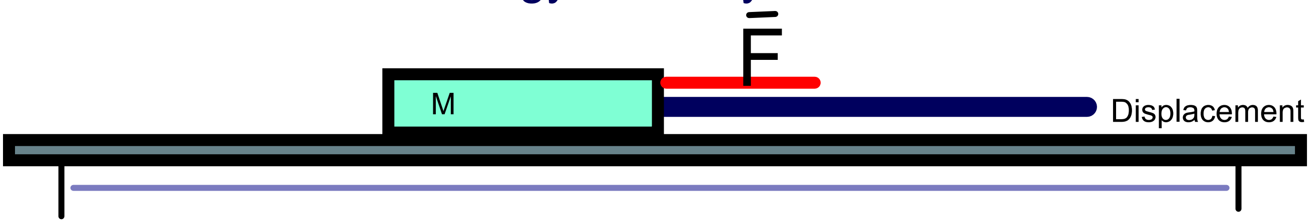
If the object that is experiencing the force does not move (if $d_{parallel} = 0$) then no work is done.

The energy of the system is unchanged; a state of equilibrium.

Positive Work

If the object moves in the same direction as the direction of the force
(for instance if force and displacement are in the same direction)
then the work is positive: W > 0.

The energy of the system is increased.

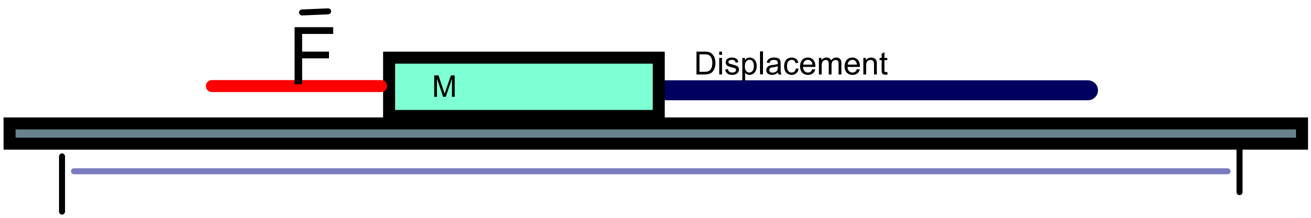


Acceleration occurs due to the unbalanced force.
Work is the ability to cause change.

Negative Work

If the object moves in the direction opposite the direction of the force (for instance if force and displacement are in opposite directions) then the work is negative: W < 0.

The energy of the system is reduced.

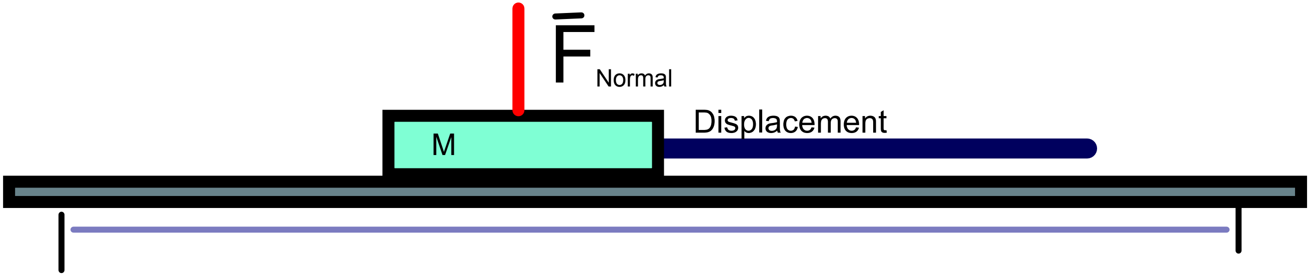


Acceleration occurs due to the unbalanced force.
Work is the ability to cause change.

Zero Work

If the object moves in the direction perpendicular the direction of the force (for instance if force and displacement are at right angles) then the work is negative: W = 0.

The energy of the system is unchanged.



No acceleration occurs due to the fact that no component of force acts in the direction of displacement.
In this case, no work is done by the normal force and/or the force of gravity.

Units of Work and Energy

$$W = Fd_{parallel}$$

This equation gives us the units of work. Since force is measured in Newtons (N) and displacement is measured in meters (m) the unit of work is the Newton-meter (N-m). And since N = kg-m/s^2; a N-m also equals a kg-m^2/s^2.

However, in honor of James Joule, who made critical contributions in developing the idea of energy, the unit of energy is also know as a Joule (J).

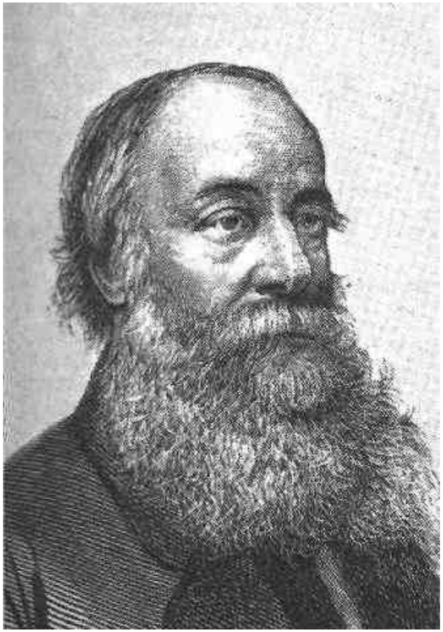
J	=	N-m	=	kg-m^2/s^2
Joule		*Newton-meter*		*kilogram-meter^2/second^2*

Units of Work and Energy

$$E_o + W = E_f$$

Since the work changed the energy of a system: the units of energy must be the same as the units of work

The units of both work and energy are the Joule.



James Joule

4 A +24 N force is applied to an object that moves 10 m in the same direction during the time that the force is applied. How much work is done to the object?

- -60 J
- -120 J
- 240J
- 360 J
- I need help

https://www.njctl.org/video/?v=63FEFi-w9qg

Answer

5 A +24 N force is applied to an object that moves 10 m in the opposite direction during the time that the force is applied. How much work is done to the object?

- A -240 J
- B -120 J
- C 120 J
- D 60 J
- E I need help

Answer

https://www.njctl.org/video/?v=6XIm1Mwjp4g

6 A +24 N force is applied to an object that is stationary during the time that the force is applied. How much work is done to the object?

- A -240 J
- B -120 J
- C 0 J
- D 120 J
- E I need help

Answer

https://www.njctl.org/video/?v=nL796_NH6_A

7 How much force must be applied to an object such that it gains 100J of energy over a distance of 20 m?

- 0 N
- 5 N
- 100 N
- 2000N
- I need help

Answer

https://www.njctl.org/video/?v=aptcYGHAFYI

8 Over what distance must a 400 N force be applied to an object such that it gains 1600 J of energy?

- A 4 m
- B 16 m
- C 40 m
- D 160 m
- E I need help

https://www.njctl.org/video/?v=3uNVVUJ3fZk

Answer

9 A boy rides a bike at a constant speed 3 m/s by applying a force of 100 N. How much work will be done during 100 seconds?

- A 1 J
- B 300 J
- C 10,000 J
- D 30,000 J
- E I need help

Answer

https://www.njctl.org/video/?v=tYBse2UZgrU

10 A horse pulls a sleigh at a constant speed 1.2 m/s by applying a force of 350 N. How much work will be done during 100 seconds?

- A 120 J
- B 700 J
- C 35,000 J
- D 42,000 J
- E I need help

Answer

https://www.njctl.org/video/?v=Qzug247XyYU

11 A book is held at a height of 2.0 m for 20 s. How much work is done on the book?

- A 0 J
- B 10 J
- C 40 J
- D 400 J
- E I need help

Answer

https://www.njctl.org/video/?v=1Uid0dPj5pY

12 A barbell of mass "m" is lifted vertically upwards, at a constant velocity, to a distance "h" by an outside force. How much work does that outside force do on the barbell?

- A mg
- B -mgh
- C mgh
- D -mg
- E I need help

Hint: Do a free body diagram to determine a formula for the outside force (F_{app}); then use the formula for work: $W = Fd_{parallel}$.

https://www.njctl.org/video/?v=F-9K5YIPoZk

Answer

Forces and Potential Energy

https://www.njctl.org/video/?v=fLAvXHPXPUo

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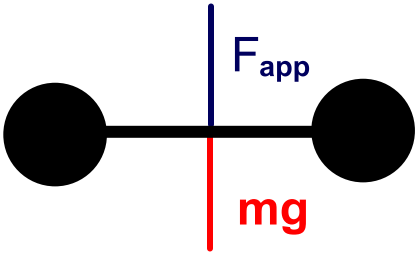
Gravitational Potential Energy

A barbell of mass "m" is lifted vertically upwards a distance "h" by an outside force. How much work does that outside force do on the barbell?



$W = Fd_{parallel}$

Since $a = 0$, $F_{app} = mg$

$W = (mg)\, d_{parallel}$

Since F and d are in the same direction ...and $d_{parallel} = h$

$W = (mg)\, h$

$$W = mgh$$

Gravitational Potential Energy

But we know that in general,
$E_o + W = E_f$.

If our barbell had no energy to begin with ($E_o = 0$), then $W = E_f$

But we just showed that we did $W=mgh$ to lift the barbell... so $mgh=E_f$

The energy of a mass is increased by an amount mgh when it is raised by a height "h".

Gravitational Potential Energy

The name for this form of energy is
Gravitational Potential Energy (GPE).

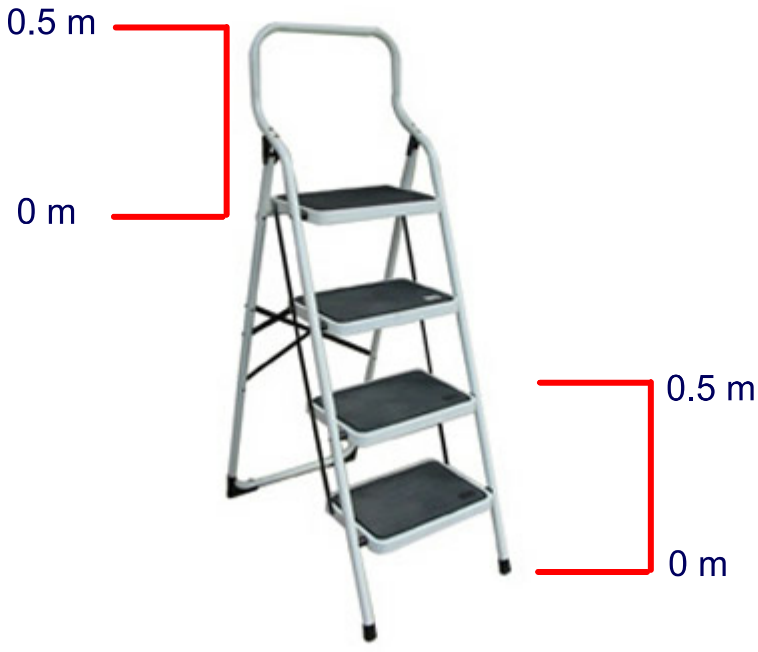
$$GPE = mgh$$

One important thing to note is that while changes in gravitational potential energy are important, their absolute value is not.

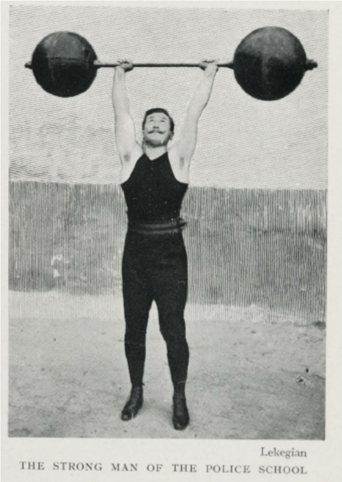
Gravitational Potential Energy

You can define any height to be the zero for height...and therefore the zero for GPE.

But whichever height you choose to call zero, changes in heights will result in changes of GPE. For example, the floor level can be considered zero energy or the ladder level can be zero.



13 What is the change of GPE for a 5.0 kg object which is raised from the floor to a final height of 2.0m above the floor?



- A 10 J
- B 49 J
- C 98 J
- D 190 J
- E I need help

Answer

https://www.njctl.org/video/?v=eEDh2sD-Pzs

14 As an object falls downward, its GPE always _____.

- A increases
- B decreases
- C stays the same
- D I need help

Answer

https://www.njctl.org/video/?v=5BOfc00McQs

15 What is the change of GPE for a 8.0 kg object which is lowered from an initial height of 2.0 m above the floor to a final height of 1.5m above the floor?

- -77 J
- -39 J
- -4.5 J
- 15 J
- I need help

Answer

16 What is the change in GPE for a 10.0 kg object which is raised from an initial height of 1.0 m above the floor to a final height of 10.0 m above the floor?

- A +88 J
- B +100 J
- C +440 J
- D +882 J
- E I need help

Answer

https://www.njctl.org/video/?v=HRfzm-3alJs

17 What is the change in height of a 2.0 kg object which gained 16 J of GPE?

- 0.82 m
- 1.6 m
- 4.0 m
- 8.0 m
- I need help

Answer

https://www.njctl.org/video/?v=o9ZE8qxf4vo

18 What is the change in height of a 0.50 kg object which lost 20 J of GPE?

- A 4.1 m
- B 8.2 m
- C 24 m
- D 41 m
- E I need help

https://www.njctl.org/video/?v=m2Grf6ZpXcU

Answer

Kinetic Energy

Imagine an object of mass "m" at rest at a height "h". If dropped, how fast will it be traveling just before striking the ground?

Use your kinematics equations to get a formula for v^2.

$$v^2 = v_o^2 + 2a\Delta x$$

Since $v_o = 0$, $\Delta x = h$, and $a = g$

$$v^2 = 2gh$$

We can solve this for "gh"

$$gh = v^2 / 2$$

We're going to use this result later.

https://www.njctl.org/video/?v=AjT9BMKfze0

Kinetic Energy

In this example, we dropped an object. While it was falling, its energy was constant...but changing forms.

It only had gravitational potential energy, GPE, at beginning, because it had height but no velocity.

Just before striking the ground (or in the example on the right, before hitting the hand) it only had kinetic energy, KE, as it had velocity but no height.

In between, it had some of both.

Kinetic Energy

Now let's look at this from an energy perspective.

No external force acted on the system so its energy is constant. Its original energy was in the form of GPE, which is "mgh".

W = 0 and E_o = mgh

$E_o + W = E_f$

$mgh=E_f$

Divide both sides by m

Solving for gh yields

$gh=E_f/m$

Now let's use our result from kinematics

($gh = v^2/2$)

$v^2/2=E_f/m$

$E_f=(1/2)mv^2$

This is the energy an object has by virtue of its motion: its kinetic energy

$$KE = \frac{1}{2}mv^2$$

Kinetic Energy

The energy an object has by virtue of its motion is called its kinetic energy. The symbol we will be using for kinetic energy is KE.

Like all forms of energy, it is measured in Joules (J).

The amount of KE an object has is given by:

$$KE = 1/2\ mv^2$$

19 As an object falls, its KE always ______.

- A decreases
- B increases
- C stays the same.
- D changes direction
- E I need help

Answer

https://www.njctl.org/video/?v=mcuU9nMfPdU

20 A ball falls from the top of a building to the ground below. How does the kinetic energy (KE) compare to the potential energy (PE) at the top of the building?

- A KE = PE
- B KE > PE
- C KE < PE
- D It is impossible to tell.
- E I need help

Answer

https://www.njctl.org/video/?v=v_e84J2poGA

21 What is the kinetic energy of a 12 kg object with a velocity of 10 m/s?

- A 12 J
- B 60 J
- C 120 J
- D 600 J
- E I need help

Answer

https://www.njctl.org/video/?v=bdSb4Fqh9vg

22 What is the kinetic energy of a 20 kg object with a velocity of 5 m/s?

- 4 J
- 100 J
- 250 J
- 500 J
- I need help

Answer

https://www.njctl.org/video/?v=UCqXbehZqNE

23 What is the mass of an object which has 2400 J of KE when traveling at 6.0 m/s?

- A 63 kg
- B 130 kg
- C 270 kg
- D 400 kg
- E I need help

Answer

https://www.njctl.org/video/?v=E5IzqESi0O0

24 What is the mass of an object which has 2000 J of KE when traveling at 10 m/s?

- A 20 kg
- B 40 kg
- C 50 kg
- D 200 kg
- E I need help

Answer

https://www.njctl.org/video/?v=7SyvJO1aU4I

25 A 3.0 kg object has 45 J of kinetic energy. What is its velocity?

- 5.5 m/s
- 6.9 m/s
- 12 m/s
- 16 m/s
- I need help

Answer

https://www.njctl.org/video/?v=XMqEio3puV0

26 A 10 kg object has 100 J of kinetic energy. What is its velocity?

- A 1.1 m/s
- B 3.7 m/s
- C 4.5 m/s
- D 8.7 m/s
- E I need help

https://www.njctl.org/video/?v=XgU_jLP3LEU

Answer

27 If the speed of a car is doubled, the KE of the car is:

- A quadrupled
- B quartered
- C halved
- D doubled
- E I need help

Answer

https://www.njctl.org/video/?v=QuLGUEmsN7c

28 If the speed of a car is halved, the KE of the car is:

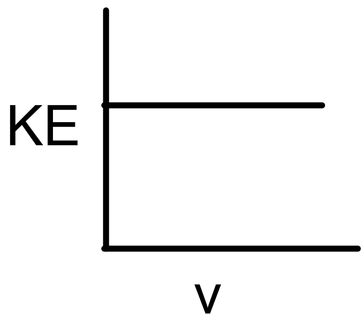
- A quadrupled
- B quartered
- C halved
- D doubled
- E I need help

Answer

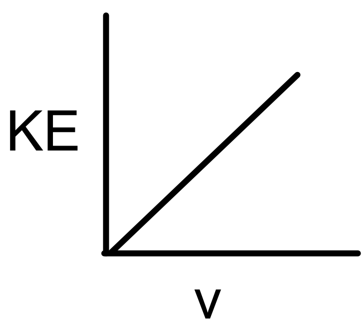
https://www.njctl.org/video/?v=ISOCvADZWtc

29 Which graph best represents the relationship between the KE and the velocity of an object accelerating in a straight line?

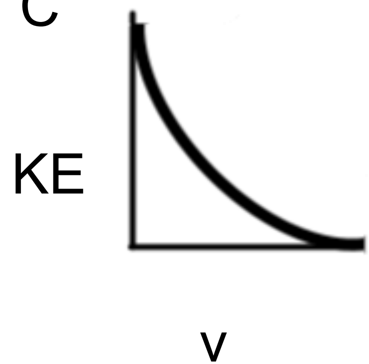
○ A



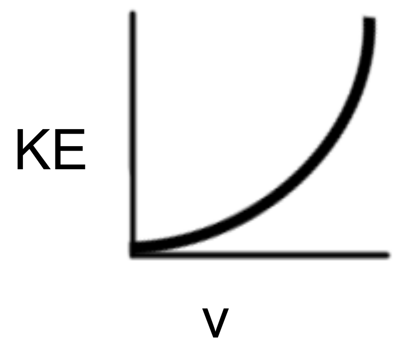
○ B



○ C



○ D



Answer

https://www.njctl.org/video/?v=c9d-rhr5pCY

30 The data table below lists mass and speed for 4objects. Which 2 have the same KE?

- A A and D
- B B and D
- C A and C
- D B and C
- E I need help

Data Table

Objects	Mass (kg)	Speed (m/s)
A	1.0	4.0
B	2.0	2.0
C	0.5	4.0
D	4.0	1.0

Answer

https://www.njctl.org/video/?v=Dw91asRRhSk

Elastic Potential Energy

Energy can be stored in a spring, this energy is called Elastic Potential Energy.

Robert Hooke first observed the relationship between the force necessary to compress a spring and how much the spring was compressed.

https://www.njctl.org/video/?v=V7FjkmolSZk

Elastic Potential Energy

It was common for scientists to establish riddles to prove ownership of new ideas in order prevent others for taking credit of new models.

Robert Hooke first reported his findings of how springs function in anagram form.

ceiiinosssttuv

Can you unscramble this?
see the next page for the answer.

Elastic Potential Energy

ceiiinosssttuv
Can you unscramble this?

The answer.
ut tensio, sic vis

Latin;
as the tension, so the force

Hooke's Law

$$F_{spring} = -kx$$

k represents the spring constant and is measured in N/m.

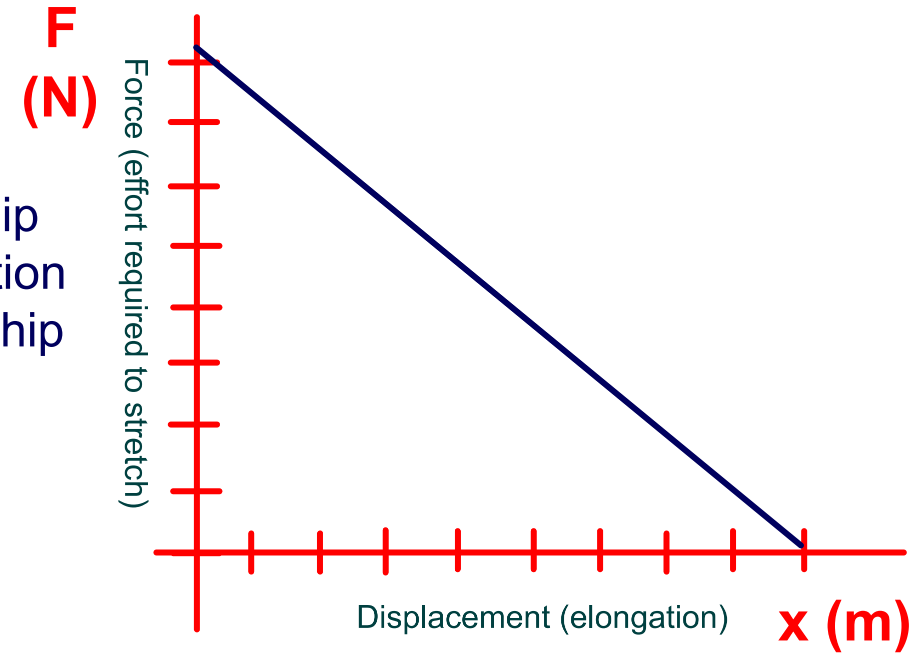
x represents how much the spring is compressed and is measured as you would expect, in meters.

The - sign tells us that this is a restorative force.
(if you let the spring go once it is compressed, it will go back to its original position)

Hooke's Law

$F_{spring} = -kx$

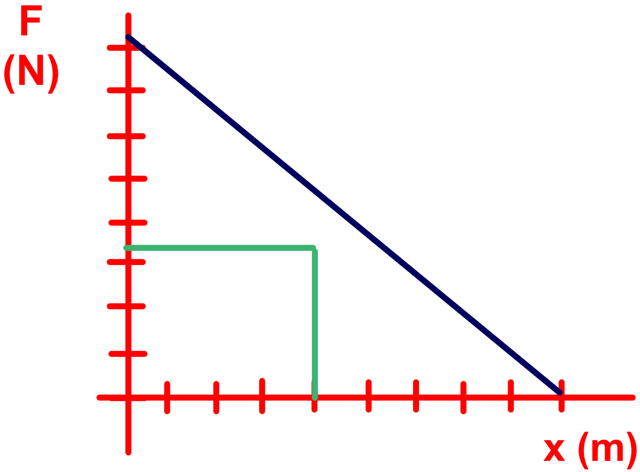
If we graph the relationship between force and elongation the mathematical relationship can be experimentally confirmed.



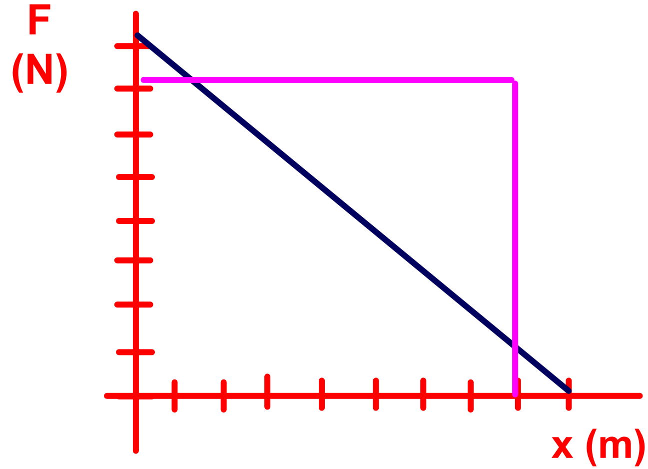
Hooke's Law

$F_{spring} = -kx$

Varying the displacement/elongation (x)



small elongations require small forces

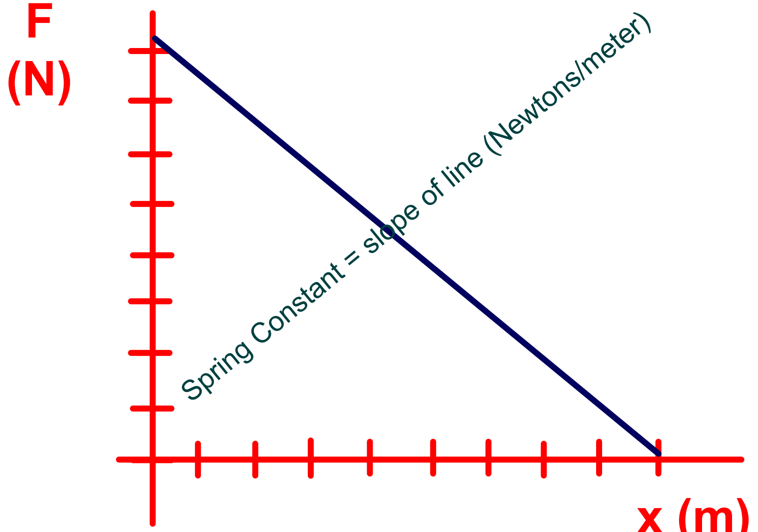


large elongations require large forces

Hooke's Law

$F_{spring} = -kx$

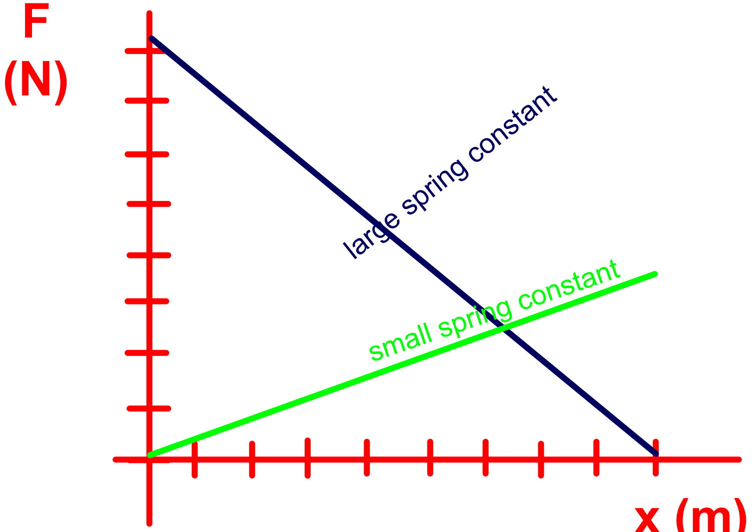
Varying the spring constant k (the stiffness of the spring)
The spring constant is related to the slope the line.



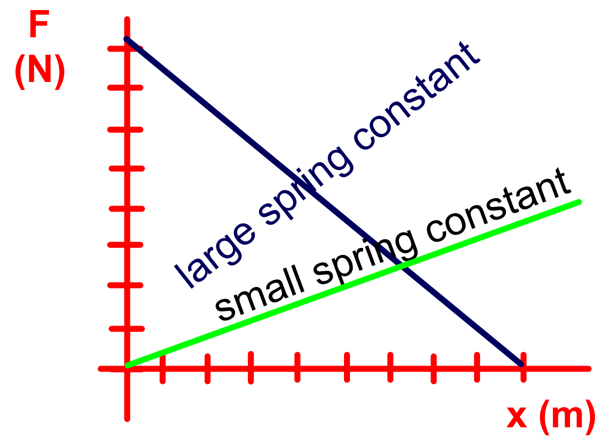
Hooke's Law

$F_{spring} = -kx$

Varying the spring constant k (the stiffness of the spring)
The spring constant is related to the slope the line.



31 Which spring requires a greater force to stretch?



- A blue
- B green
- C the same force is required
- D no force is required
- E I need help

Answer

https://www.njctl.org/video/?v=V7FjkmolSZk

32 An ideal spring has a spring constant of 25 N/m. Determine the force required to elongate/displace the spring by 2.0 meters.

- A 13 N
- B 25 N
- C 50 N
- D 130 N
- E I need help

https://www.njctl.org/video/?v=7tvI8d7Pd4A

Answer

33 An ideal spring is requires 30 Newtons of force in order to stretch 5.0 meters. Determine the spring constant (k).

- A 0.17 N/m
- B 6.0 N/m
- C 75 N/m
- D 150 N/m
- E I need help

Answer

https://www.njctl.org/video/?v=35F-UAObaz4

34 A force of 100 Newtons is applied to a spring with a constant of 25 N/m. Determine the resulting displacement/elongation.

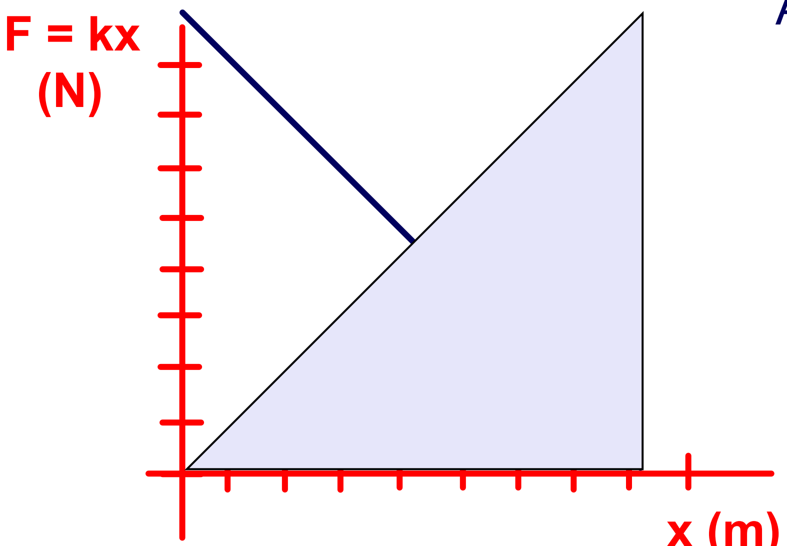
- A 0.25 m
- B 0.50 m
- C 4.0 m
- D 12 m
- E I need help

https://www.njctl.org/video/?v=5fjk6d14nXw

Answer

Elastic Potential Energy

The work needed to compress a spring is equal to the area under its force vs. distance curve.



Area of a triangle = 1/2 b h

$W = 1/2\,(x)(F)$

$W = 1/2\,(x)(kx)$

$W = 1/2kx^2$

Work = EPE

https://www.njctl.org/video/?v=nwaX5D0W1GU

Elastic Potential Energy

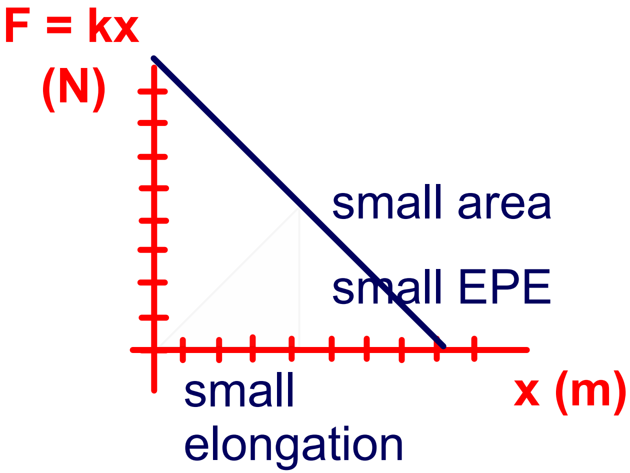
The energy imparted to the spring by this work must be stored in the Elastic Potential Energy (EPE) of the spring:

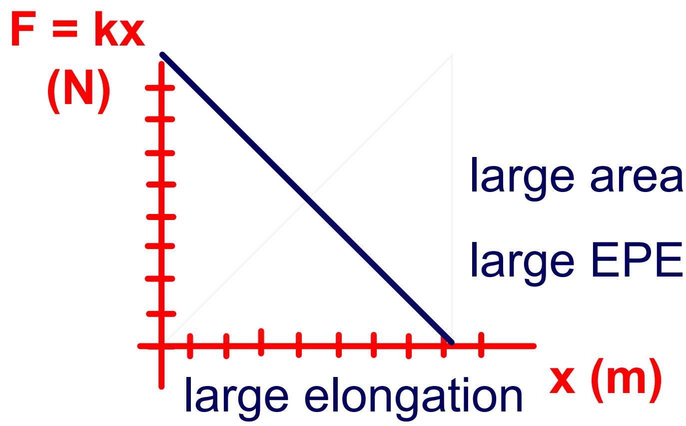
$$EPE = 1/2kx^2$$

Like all forms of energy, it is measured in Joules (J).

Elastic Potential Energy

Work done when varying the displacement/elongation (x).

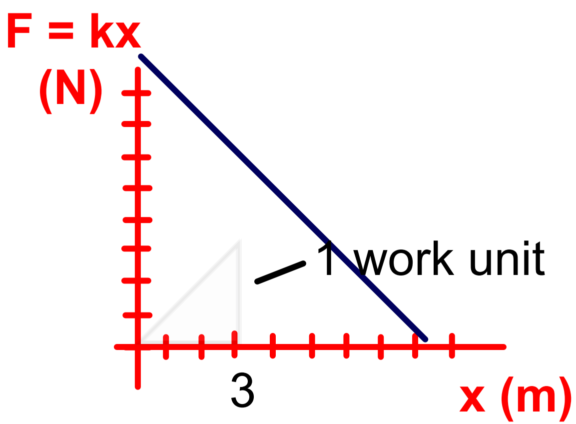


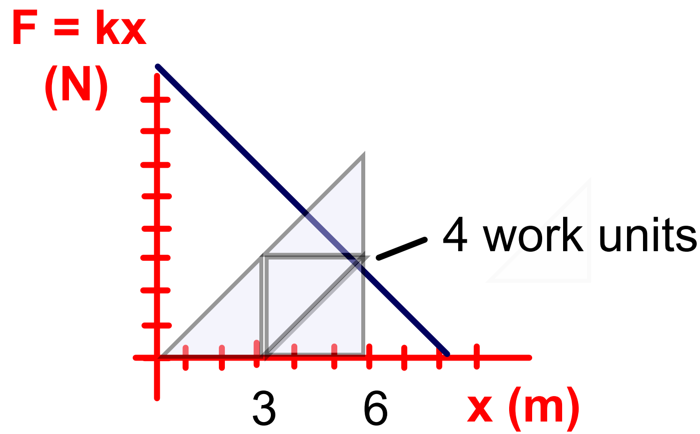


$$EPE = 1/2kx^2$$

Elastic Potential Energy

Work done when varying the displacement/enlongation(x).





$$EPE = 1/2kx^2$$

EPE is directly proportional to the square of the elongation.

Stretching the spring twice as far requires twice the force but four times the work.

Resistance Bands and EPE

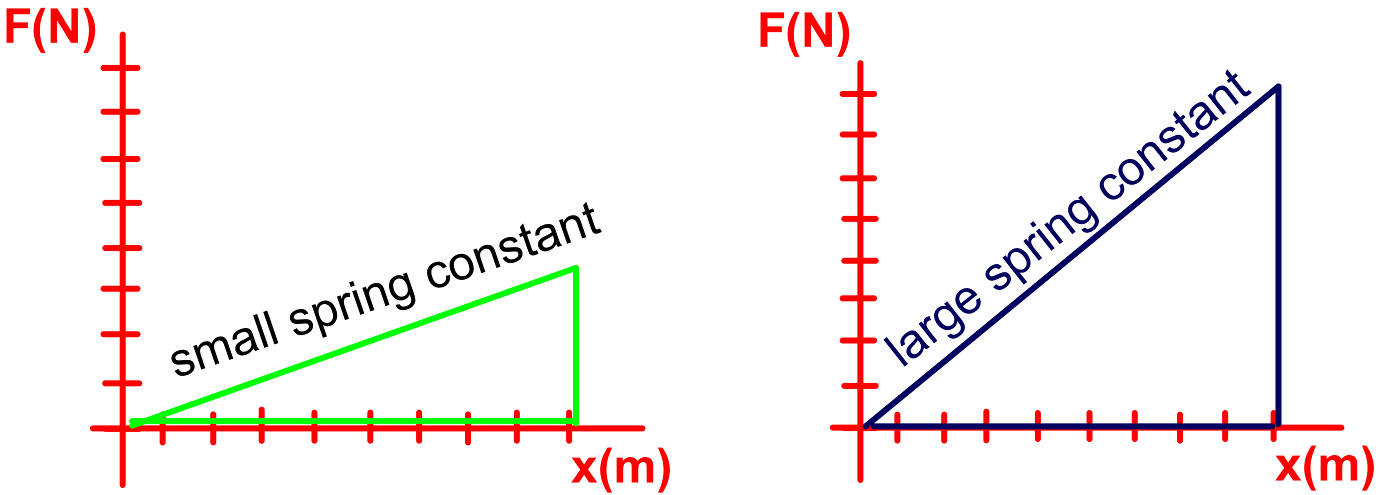
Resistance bands are used for resistance training.

These bands allow us to get a 'workout' them because stretching the bands requires AND expends energy.

Resistance bands are available in different tensions (spring constants) and are color coded accordingly.

Elastic Potential Energy

Work done when varying the spring constant (k).



$$EPE = 1/2kx^2$$

EPE is directly proportional to the value for the spring constant. Similar displacements require different amounts of work.

The large spring constant requires more work and stores more elastic potential energy with similar elongation.

35 Determine the elastic potential energy stored in a spring with a spring constant of 250 N/m that is compressed 8.0 cm.

- A 0.80 J
- B 1.6 J
- C 80 J
- D 160 J
- E I need help

https://www.njctl.org/video/?v=osLRYNZUXR8

Answer

36 Determine the elastic potential energy stored in a spring with a spring constant of 500 N/m that is compressed 24 cm.

- A 0.24 J
- B 14 J
- C 22 J
- D 1400 J
- E I need help

Answer

https://www.njctl.org/video/?v=cBjMdefah4A

37 What is the spring constant of a spring that is compressed 5.0 cm and has 0.65 J of elastic potential energy stored in it?

- A 0.15 N/m
- B 52 N/m
- C 260 N/m
- D 520 N/m
- E I need help

Answer

38 What is the spring constant of a spring that is compressed 10 cm and has 0.65 J of elastic potential energy stored in it?

- A 65 N/m
- B 130 N/m
- C 270 N/m
- D 300 N/m
- E I need help

https://www.njctl.org/video/?v=IEs4bsVzjXY

Answer

39 How much does a spring with a spring constant of 500 N/m need to be compressed in order to store 1.75 J of elastic potential energy?

- A 0.0400 m
- B 0.0800 m
- C 0.160 m
- D 0.480 m
- E I need help

Answer

40 How much does a spring with a spring constant of 500 N/m need to be compressed in order to store 7.0 J of elastic potential energy?

- A 0.16 m
- B 0.71 m
- C 1.2 m
- D 7.1 m
- E I need help

Answer

https://www.njctl.org/video/?v=rgGbQ-UCPwk

41 A 3.0 kg mass compresses a spring 2.5 cm. What is the spring constant?

- 340 N/m
- 420 N/m
- 870 N/m
- 1200 N/m
- I need help

Answer

https://www.njctl.org/video/?v=vjUcrTNdoNk

42 The same 3.0 kg mass compresses the same spring 2.5 cm. How much elastic potential energy is stored in the spring?

- A 0.13 J
- B 0.37 J
- C 4.4 J
- D 6.8
- E I need help

Answer

https://www.njctl.org/video/?v=tLJ9QAc3Abk

43 The same 3.0 kg mass compresses the same spring 5.0 cm. How much elastic potential energy is stored in the spring?

- A 1.5 J
- B 1.9 J
- C 2.3 J
- D 3.8 J
- E I need help

Answer

https://www.njctl.org/video/?v=C1OiuozklQg

Conservation of Energy

https://www.njctl.org/video/?v=GuIp7ja-J8E

Demo

Lab

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Conservation of Energy

A roller coaster is at the top of a track that is 80 m high. How fast will it be going at the bottom of the hill?

$E_o + W = E_f$

$E_o = E_f$ *W = 0*

GPE = KE *E_0 = GPE, E_f = KE*

mgh = 1/2mv2

Substitute GPE and KE equations

$v^2 = 2gh$

$v^2 = 2\ (9.8 m/s^2)\ 80 m$ *Solving for v yields*

v =39.6 m/s

44 A spring gun with a spring constant of 250 N/m is compressed 5.0 cm. How fast will a 0.025 kg dart move when it leaves the gun?

- A 0.13 m/s
- B 0.50 m/s
- C 1.5 m/s
- D 5.0 m/s
- E I need help

Answer

https://www.njctl.org/video/?v=qA9MABYv0uc

45 A spring gun with a spring constant of 250 N/m is compressed 15 cm. How fast will a 0.025 kg dart go when it leaves the gun?

- A 5.0 m/s
- B 10 m/s
- C 15 m/s
- D 20 m/s
- E I need help

Answer

https://www.njctl.org/video/?v=tLxezl4ohfg

46 A student uses a spring (with a spring constant of 180 N/m) to launch a marble vertically into the air. The mass of the marble is 0.0040 kg and the spring is compressed 0.030 m.

What is the maximum height the marble will reach?

- A 1.6 m
- B 2.1 m
- C 3.1 m
- D 3.8 m
- E I need help

Answer

https://www.njctl.org/video/?v=uCMQdPMV7SA

47 A student uses a spring (with a spring constant of 360 N/m) to launch a marble vertically into the air. The mass of the marble is 0.050 kg and the spring is compressed 0.10 m.

What is the maximum height the marble will reach?

- A 1.9 m
- B 3.7 m
- C 4.1 m
- D 4.9 m
- E I need help

Answer

https://www.njctl.org/video/?v=1uBXRGEL8eA

48 A student uses a spring gun (with a spring constant of 120 N/m) to launch a marble vertically into the air. The mass of the marble is 0.0020 kg and the spring is compressed 0.040 m.

How fast will the marble be traveling when it leaves the gun?

- A 3.9 m/s
- B 5.7 m/s
- C 8.2 m/s
- D 9.8 m/s
- E I need help

https://www.njctl.org/video/?v=12z8LAx_9no

Answer

49 A roller coaster has a velocity of 25 m/s at the bottom of the first hill. How high was the hill?

- A 32 m
- B 35 m
- C 41 m
- D 56 m
- E I need help

Answer

https://www.njctl.org/video/?v=rN8dHTR4eL0

50 A roller coaster has a velocity of 50 m/s at the bottom of the first hill. How high was the hill?

- A 64 m
- B 87 m
- C 100 m
- D 130 m
- E I need help

Answer

https://www.njctl.org/video/?v=E2DxJB_v73k

51 A 5.0 kg rock is dropped a distance of 1.0 m onto the spring. The rock compresses the spring 2.0 cm. What is the spring constant?

- A 160,000 N/m
- B 220,000 N/m
- C 250,000 N/m
- D 330,000 N/m
- E I need help

Answer

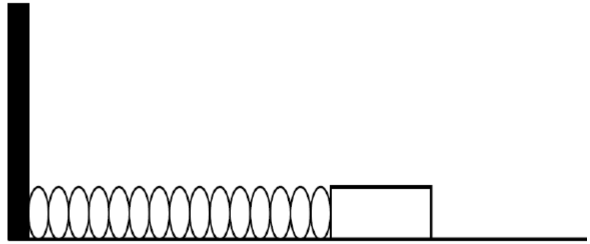
https://www.njctl.org/video/?v=VoEh8MYRY5g

52 A 20 kg rock is dropped a distance of 1.0 m onto the spring. The rock compresses the spring 2.0 cm. What is the spring constant?

- A 250,000 N/m
- B 490,000 N/m
- C 980,000 N/m
- D 1,900,000 N/m
- E I need help

https://www.njctl.org/video/?v=Wy_nBTfkjMc

Answer



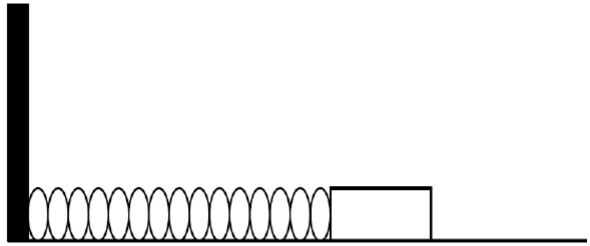
53 A student uses the lab apparatus shown above. A 5.0 kg block compresses a spring by 6.0 cm. The spring constant is 300 N/m.

What is the blocks velocity when the spring loses all of the stored elastic potential energy?

- A 0.31 m/s
- B 0.46 m/s
- C 0.59 m/s
- D 0.92 m/s
- E I need help

https://www.njctl.org/video/?v=pCFbGfs3FYg

Answer



54 A student uses the lab apparatus shown above. A 5.0 kg block compresses a spring 6.0 cm. The spring constant is 1200 N/m.

What is the block's velocity when the spring loses all of the stored elastic potential energy?

- A 1.8 m/s
- B 4.1 m/s
- C 8.8 m/s
- D 11 m/s
- E I need help

https://www.njctl.org/video/?v=UvjbCuJ46fY

Answer

55 How much work is done in stopping a 5.0 kg bowling ball rolling with a velocity of 10 m/s?

- A 50 J
- B 100 J
- C 130 J
- D 250 J
- E I need help

Answer

https://www.njctl.org/video/?v=jYIHIVoUs2M

56 How much work is done in stopping a 5.0 kg bowling ball rolling with a velocity of 20 m/s?

- 100 J
- -1,000 J
- 100 J
- 1,000 J
- I need help

Answer

https://www.njctl.org/video/?v=Ztw_l4pDiHg

57 How much work is done in compressing a spring with a 450 N/m spring constant a distance of 2 cm?

- A 0.06 J
- B 0.09 J
- C 6 J
- D 9 J
- E I need help

Answer

https://www.njctl.org/video/?v=dTCGGwafpIc

58 How much work is done in compressing a spring with a 900 N/m spring constant 11 cm?

- A 5.5 J
- B 6.9 J
- C 9.7 J
- D 12 J
- E I need help

https://www.njctl.org/video/?v=ZhlFBnWDQb4

Answer

Power

Lab

https://www.njctl.org/video/?v=BRuTWJSCRu8

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Power

It is often important to know not only if there is enough energy available to perform a task but also how much time will be required.

Power is defined as the rate that work is done (or energy is transformed) :

$$P = \frac{W}{t}$$

100 Watt light bulbs convert 100 Joules of electrical energy to heat and light every second.

Power

Since work is measured in Joules (J) and time is measured in seconds (s) the unit of power is Joules per second (J/s).

However, in honor of James Watt, who made critical contributions in developing efficient steam engines, the unit of power is also know as a Watt (W).

$$P = \frac{W}{t}$$

Power

$$P = \frac{W}{t}$$

Since $W = Fd_{parallel}$

$$P = \frac{Fd_{parallel}}{t}$$

$$P = (F)\frac{d_{parallel}}{t}$$

Since $v = d/t$

$$P = (F)v_{parallel}$$

So power can be defined as the product of the force applied and the velocity of the object parallel to that force.

Power

A third useful expression for power can be derived from our original statement of the conservation of energy principle.

$$P = \frac{W}{t}$$

Since $W = E_f - E_0$

$$P = \frac{E_f - E_0}{t}$$

So the power absorbed by a system can be thought of as the rate at which the energy in the system is changing.

59 A steam engine does 50 J of work in 12 s. What is the power supplied by the engine?

- 1.1 W
- 2.3 W
- 2.8 W
- 4.2 W
- I need help

Answer

https://www.njctl.org/video/?v=NXLuYIRc9F4

60 How long must a 350 W engine run in order to produce 720 kJ of work?

A 1,230 s

B 1,450 s

C 1,820 s

D 2,060 s

E I need help

Answer

https://www.njctl.org/video/?v=IR-YweBGBdI

61 How long must a 350 W engine run in order to produce 360 kJ of work?

- A 681 s
- B 804 s
- C 1,030 s
- D 1,440 s
- E I need help

Answer

https://www.njctl.org/video/?v=kTTY7D29nWM

62 A 12 kW motor runs a vehicle at a speed of 8.0 m/s. What is the force supplied by the engine?

- A 800 N
- B 1,000 N
- C 1,300 N
- D 1,500 N
- E I need help

Answer

https://www.njctl.org/video/?v=2O7vv19xrmo

63 A 24 kW motor runs a vehicle at a speed of 8 m/s. What is the force supplied by the engine?

- 1,100 B
- 1,200 N
- 1,500 N
- 3,000 N
- I need help

Answer

https://www.njctl.org/video/?v=tbzZMjWOUqE

64 An athlete pulls a sled with a force of 200 N burning 600 Joules of food/caloric energy every second. What is the velocity of the athlete?

- A 3 m/s
- B 4 m/s
- C 6 m/s
- D 12 m/s
- E I need help

Answer

https://www.njctl.org/video/?v=TiRXw1qIltg

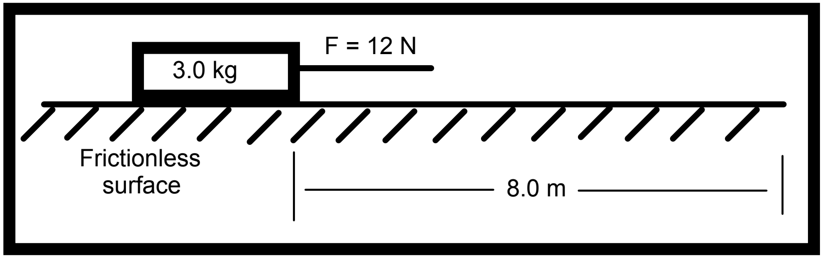
65 An athlete pulls a sled with a force of 100 N producing 200 Joules of thermal energy due to friction every second. What is the velocity of the athlete?

- A 2 m/s
- B 8 m/s
- C 12 m/s
- D 20 m/s
- E I need help

Answer

https://www.njctl.org/video/?v=FVtIpXNesTA

66 A 3.0 kg block is initially at rest on a frictionless, horizontal surface. The block is moved 8.0 m in 2.0 s by the application of a 12 N horizontal force, as shown in the diagram below. What is the power developed when moving the block?



- A 24 W
- B 32 W
- C 48 W
- D 96 W
- E I need help

https://www.njctl.org/video/?v=GotMGnt9Idw

Answer