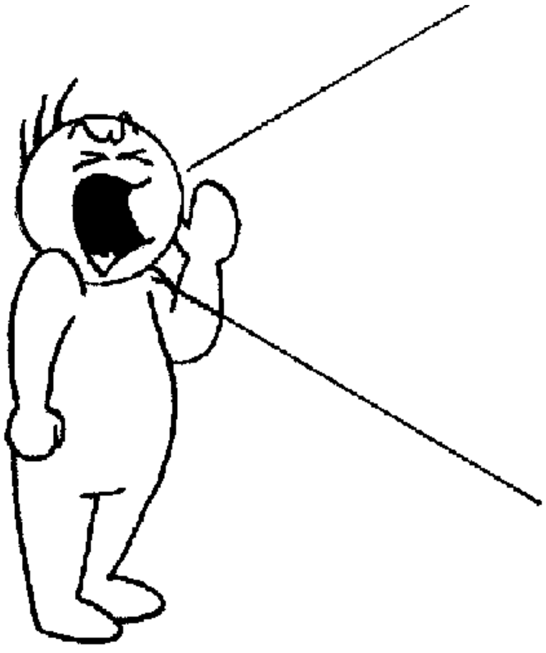
PHYSICS 2204
(Mr. J Fifield)

Unit 3: Work, Power and Energy

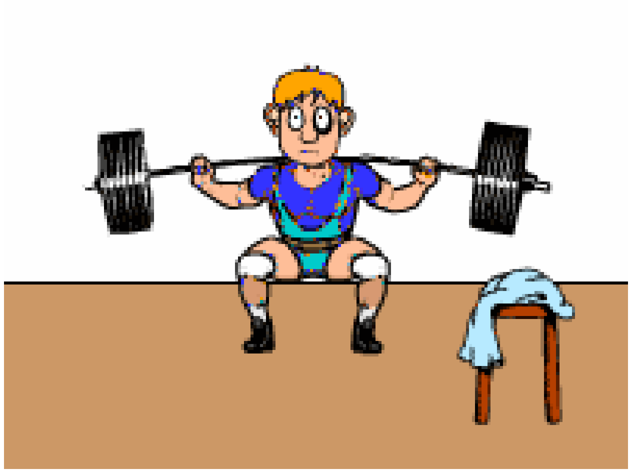


UNIT 3
Topic 1: Work

The Concept of Work

- Work is considered to be done when an object changes:

- position
- shape
- speed

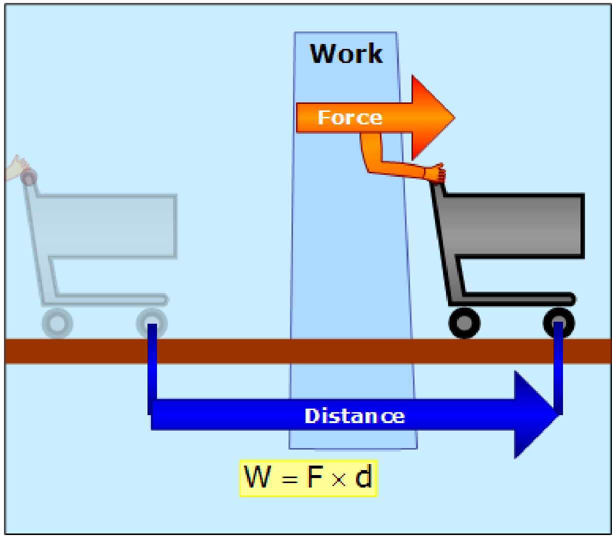


•Work is the amount if energy that placed in or taken out of a system

Formula For Calculating Work

Work is defined as a force acting upon an object to cause a displacement in the direction of the force.

WORK = FORCE PARALLEL X DISPLACEMENT



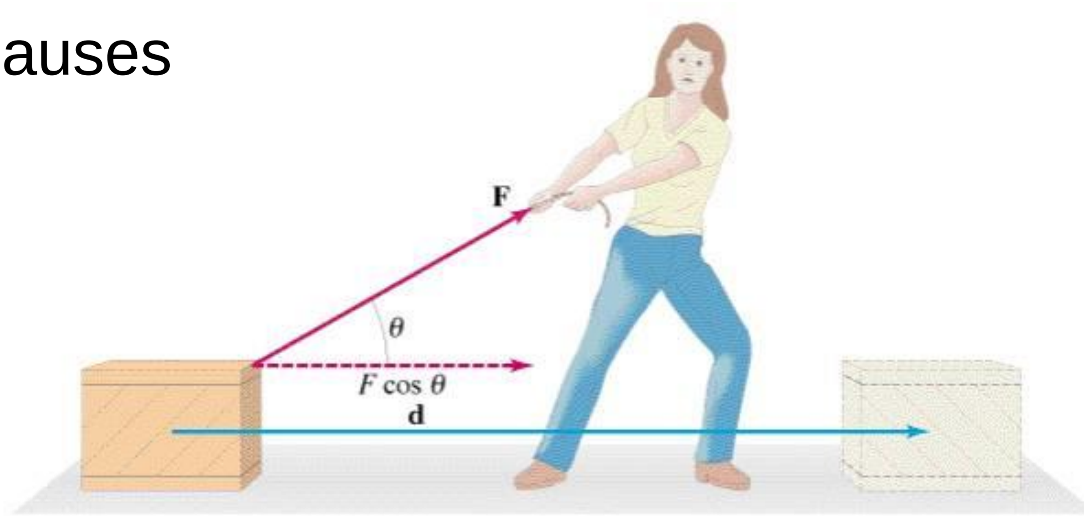
$$Work = \vec{F}_{\text{II}} \times \vec{D}$$

The unit for work is the **Joule** which is a N·m

Work: Force Applied At An Angle (θ)

$$W = \vec{F}_{\Pi} \bullet \vec{D}$$

Fx is the parallel force that causes displacement of the box



$$W = \vec{F}x \bullet \vec{D}$$

Remember **Fx = Fcosθ**

$$W = (\vec{F} \bullet \cos\theta) \bullet \vec{D}$$

The vertical component (FsinΘ) does NO work on the box because it is NOT parallel to the displacement.

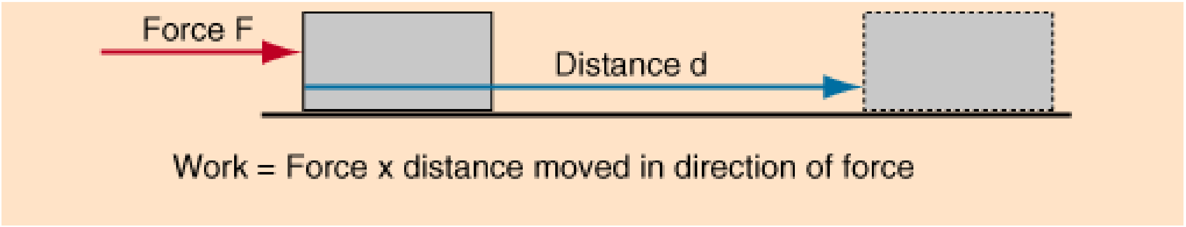
Rearrange the above formula:

$$W = (\vec{F} \bullet \cos\theta) \bullet \vec{D}$$

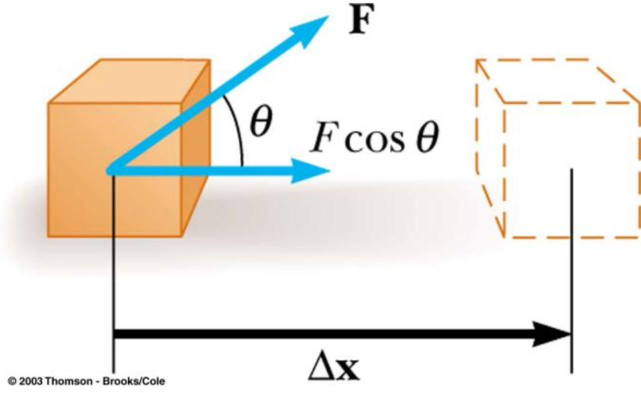
Conditions for doing work

1. **Force MUST cause the displacement**

2. **Displacement MUST happen parallel to the force**



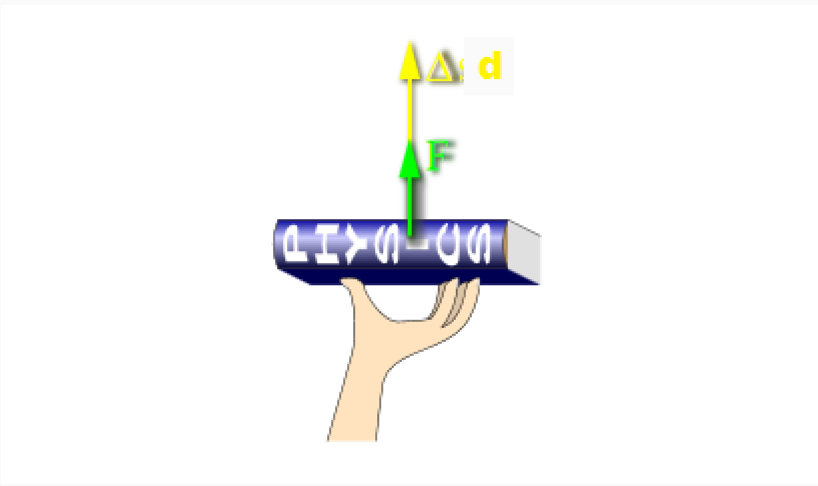
3. **The greater the angle between the direction of the force and the direction that the object moves, the smaller will be the work done on the object.**



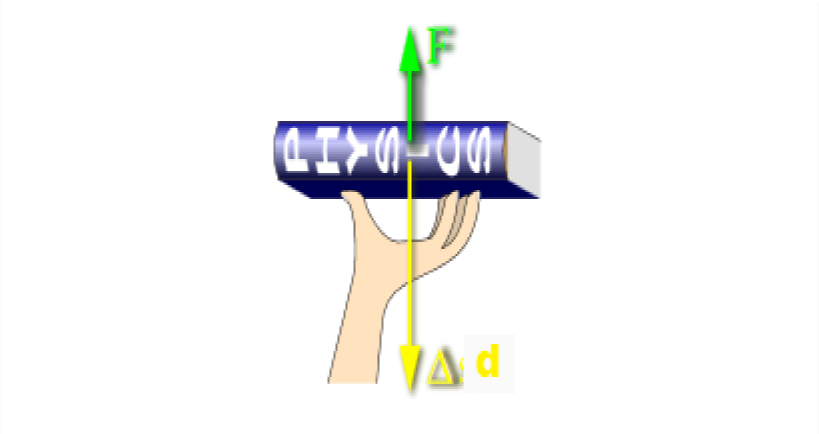
Work: Positive Vs Negative

Positive work is performed when the direction of the force and the direction of motion are the same

Negative work is performed when the direction of the force and the direction of motion are the *opposite*



Positive work is done on a textbook when it is raised vertically at a constant velocity.

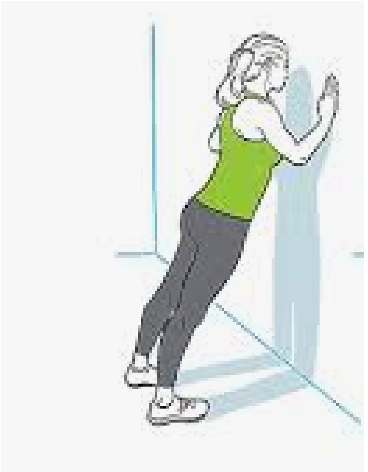


Negative work is also done on a textbook when it is lowered vertically at a constant velocity.

Example 1: Is Work Being Done!

A. A person applies a force to a wall and becomes exhausted.

No. The wall is not displaced.



B. A book falls off a table and free falls to the ground.

Yes! The is a downward force (gravity) which acts on the book to displace it.

C. A person carries a box on his shoulders across the room.

No. There is an upward force, and there is a horizontal displacement but the force does not cause displacement

D. A rocket accelerates through space.

Yes the expelled gas is the force which accelerates the rocket through space.

Example 2

A car accelerates to “highway speed” by using a net force of 2400. N, which is applied over a distance of 150.0 m. How much work is done?

Example 3:

Calculate the work done by a weightlifter in lifting a 150 kg barbell 1.6 m vertically at a constant velocity

Example 4:

A 75 kg boulder rolls off a cliff and falls to the ground below. If the force of gravity did 6.0×10^4 J of work on the boulder, how far did it fall?

Example 5:

A 1.1 kg physics book slides to the right on a table at a constant speed. The book encounters a rough patch where the coefficient of kinetic friction is 0.15 and slows down over a distance of 1.5 m. Calculate the work done by friction.

Example 6:

A boy pulls a wagon a distance of 1.2 km. An applies force of 28N is directed at an angle of 40^{O} above the horizontal. How much work is done?

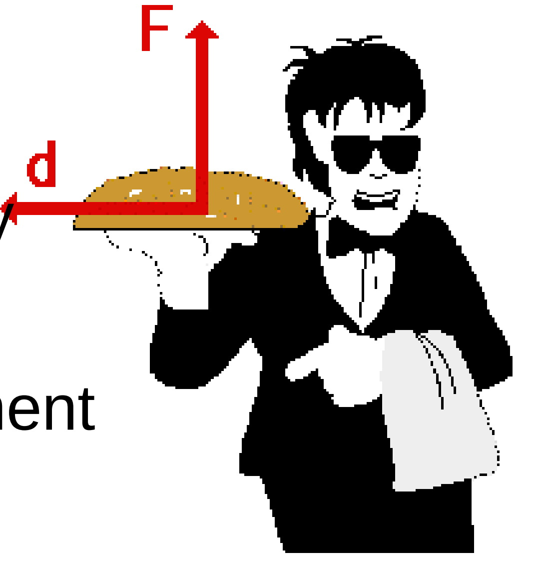
Example 7:

A locomotive exerts a constant forward force of 5.4×10^4 N while pulling a train at a constant velocity of 25 m/s for 1.0 hours. How much work does the locomotive do?

Question ?

- A waiter carries a tray full of meals above his head by one arm across the room. Is this an example of Work?

Waiter does not do work upon the tray as he carries it across the room.



The waiter provides an upward force on the tray but the displacement of the tray is a horizontal.

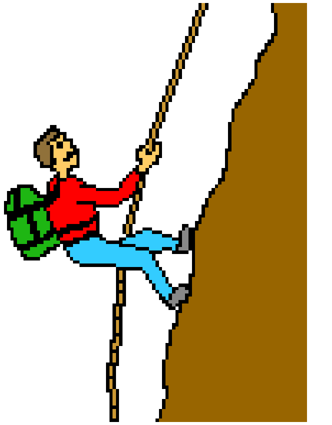
The angle between the force and the displacement is 90 degrees.

Work = F•d•cos 90 degrees is 0 (cosine of 90 degrees is 0)

Regardless of the magnitude of the force and displacement,. A vertical force can never cause a horizontal displacement.

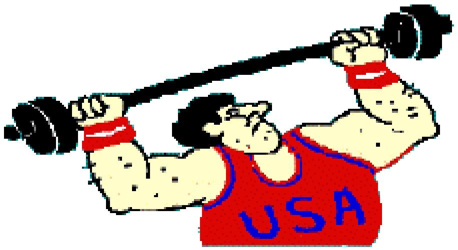
UNIT 3

Topic 2 :Power



Rock climbers do a lot of work at a slow rate; their power is small.

POWER



- Power refers to the rate at which work is done

$$P = \frac{Work}{\Delta\, time} = \frac{W}{\Delta t}$$

OR

$$Power = \frac{Energy}{\Delta Time} = \frac{E}{\Delta t}$$

Work done, *W* is measured in **joules (J)**

Time, *t* is measured in **seconds (s)**

power, *P* is measured in **J/s** or **Watts**

POWER OF LIFTING

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

- Since W = F● d, we can write power as

$$P = \frac{F \bullet d}{\Delta t}$$

- AND for lifting something, $F = F_g = mg$: therefore, for LIFTING ONLY

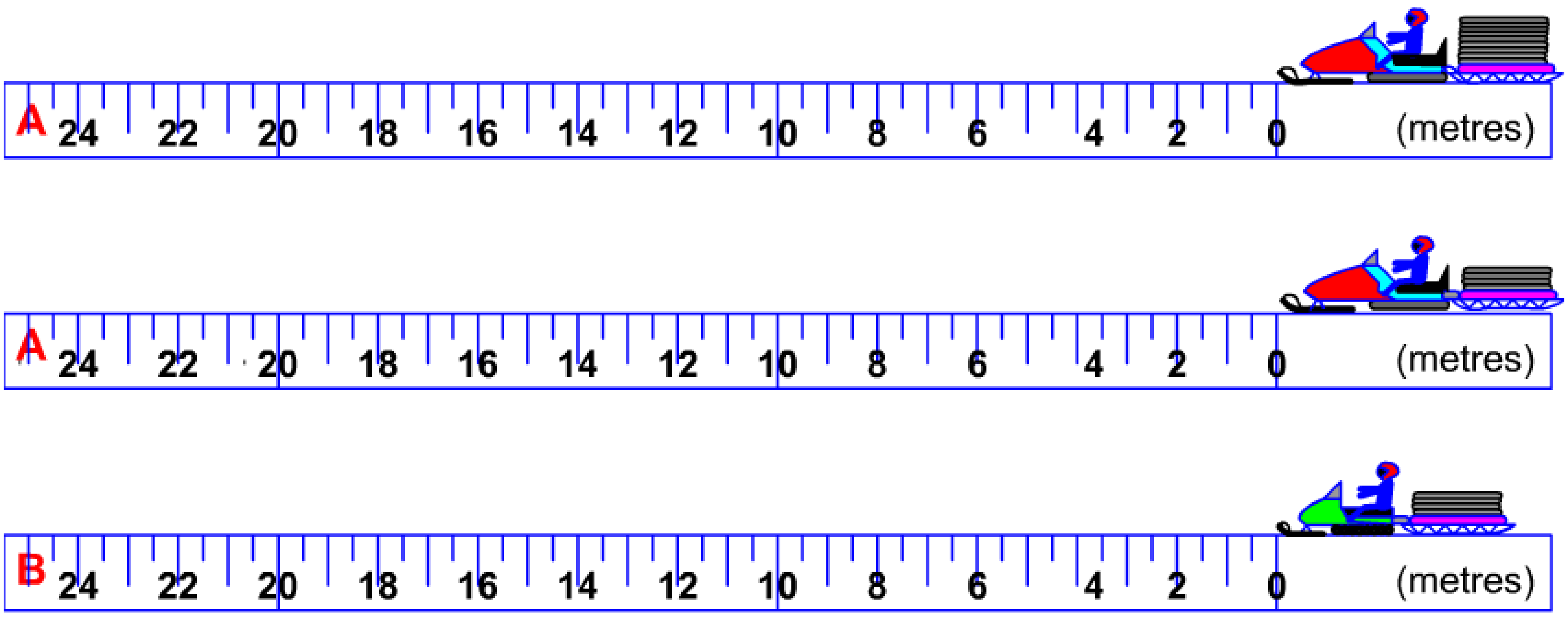
$$P = \frac{mgd}{\Delta t}$$

Equal Distances

1. load A = load B
2. load A = 2 x load B

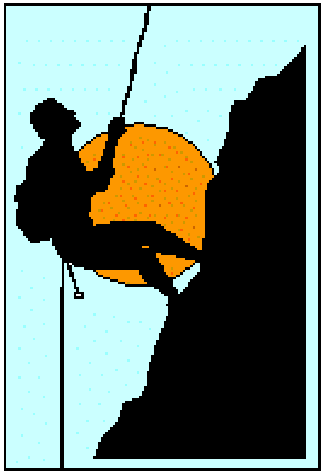
Equal Times

1. load A = load B
2. load A = 2 x load B



QUESTION!

Who has the greatest power:



Rock climbers do a lot of work at a slow rate; their power is small.

A rock climber or a trailer hiker who reach the same point on a cliff ?

Work has nothing to do with the amount of time that a force acts to cause the displacement.

The rock climber takes a long time to elevate her body up a few meters along the side of a cliff. However, a trail hiker might elevate her body a few meters in a short amount of time. The two people might do the same amount of work,

- **The hiker does the work in considerably less time than the rock climber. The hiker has a greater power rating than the rock climber.**

Example 1

Calculate the power developed by a runner able to do 7.0×10^2 J of work in 2.0 s.

Example 2

How much work is done by a crane in 1.7 s, if it has a power output of 3.9×10^4 W?

Example 3

How long would it take a 1.00 kW electric motor on a conveyor belt to do 750 J of work?

Example 4:

A woman lifts a 125 N child a distance of 1.5 m in 0.75 s. What is her power output in lifting the child?

Think about the following?

Why does a 250 cc two stroke engine produces the same power as a 500 cc four stroke engine for motorcycles and snowmobiles.

Two-Stroke Engine from a 2015 Husqvarna TE 250

Four-Stroke Engine from a 2013 KTM 450 SX-F

the two main functions of a two-stroke engine are compression and combustion. In a simple process, the engine will fire and ignite the spark plug for each revolution of the crankshaft.

The four-stroke engine has four main functions with intake, compression, combustion and exhaust. This engine will only fire every two revolutions of the crankshaft,

UNIT 3

Topic 3

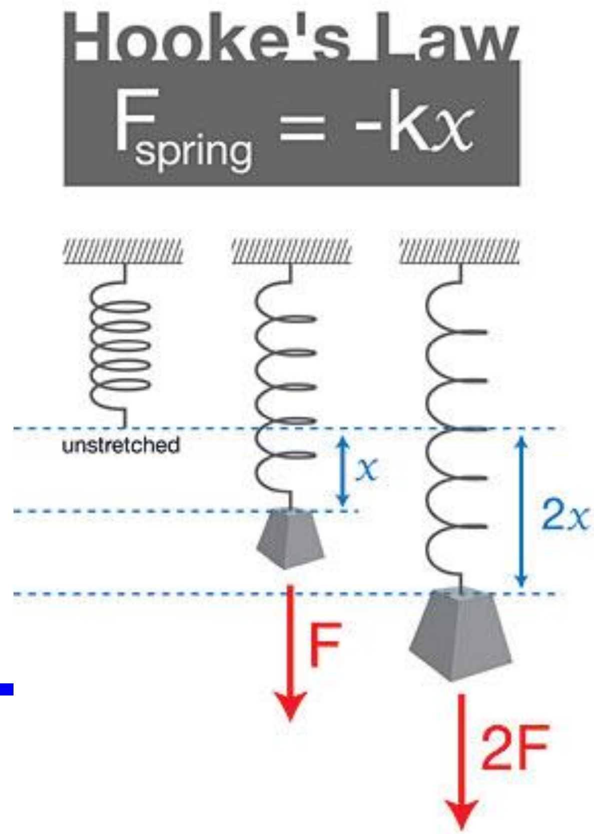
- **Hook’s Law**

Investigating my (Robert Hooke) law.

Hooke's Law

- Hooke's Law states that stretch is proportional to the applied force on a spring.

- The force needed to distort a spring is related to the displacement from the rest position according to:



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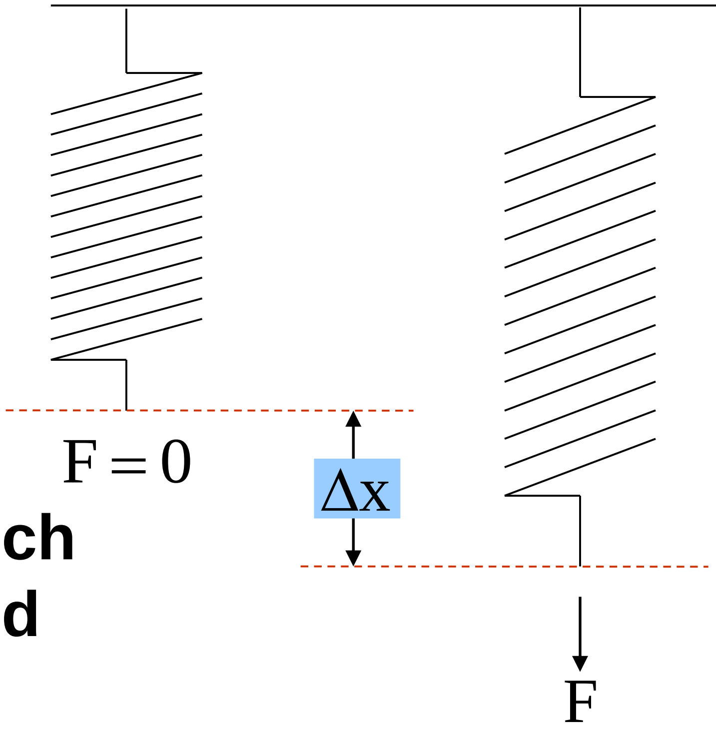
Hooke's Law

$F = -k\Delta x$ (Hooke's Law)



F = restoring force of spring **(N)**

.

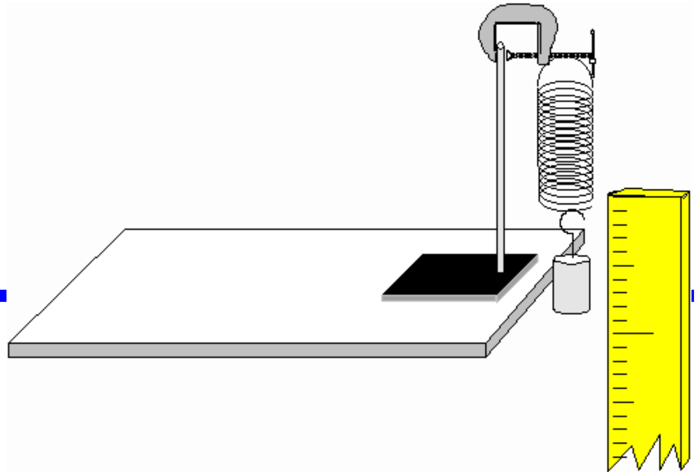
x = Displacement of the spring which has been stretch or compressed from equilibrium

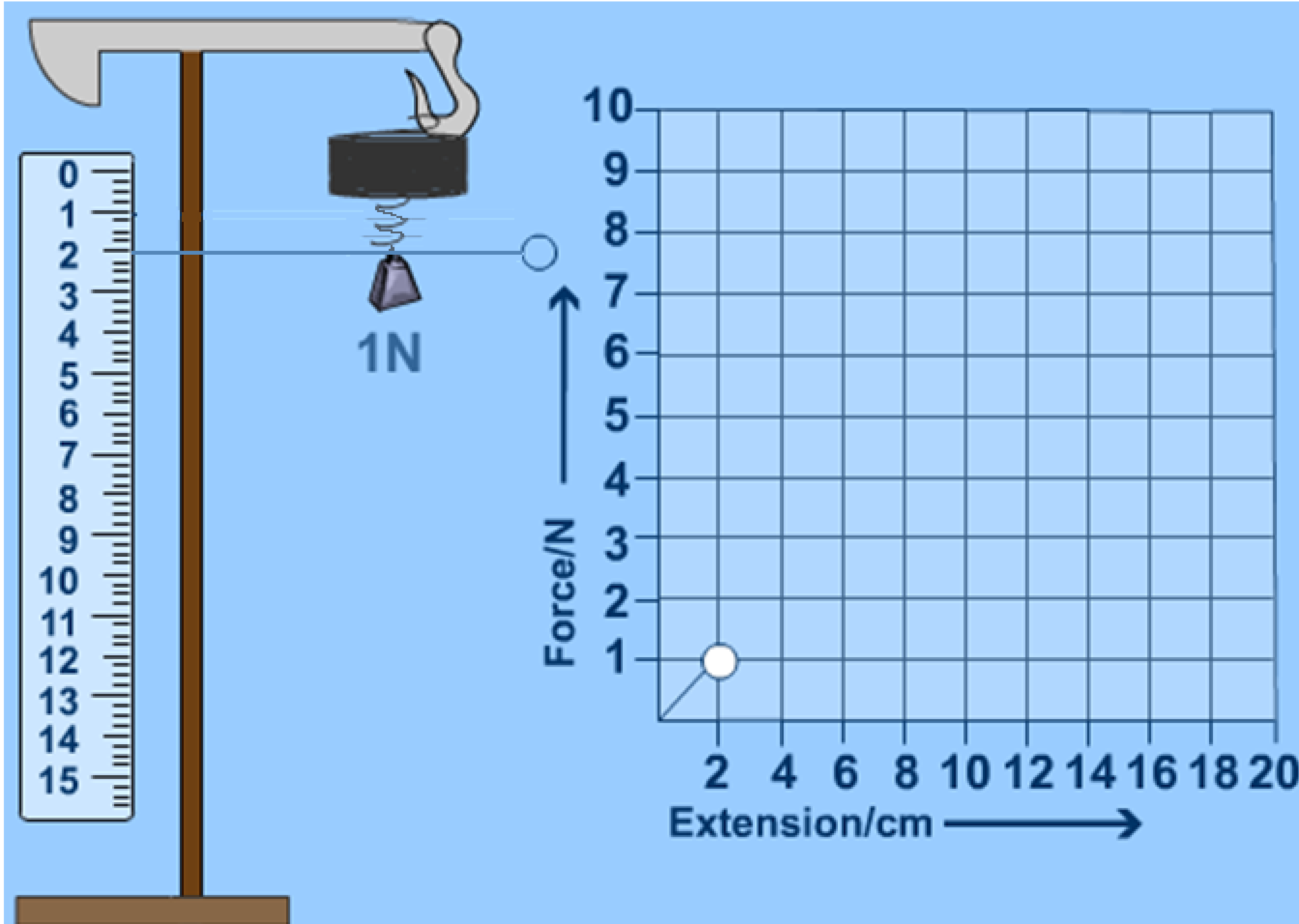
k = the spring constant **(N/m)**

Lab Activity

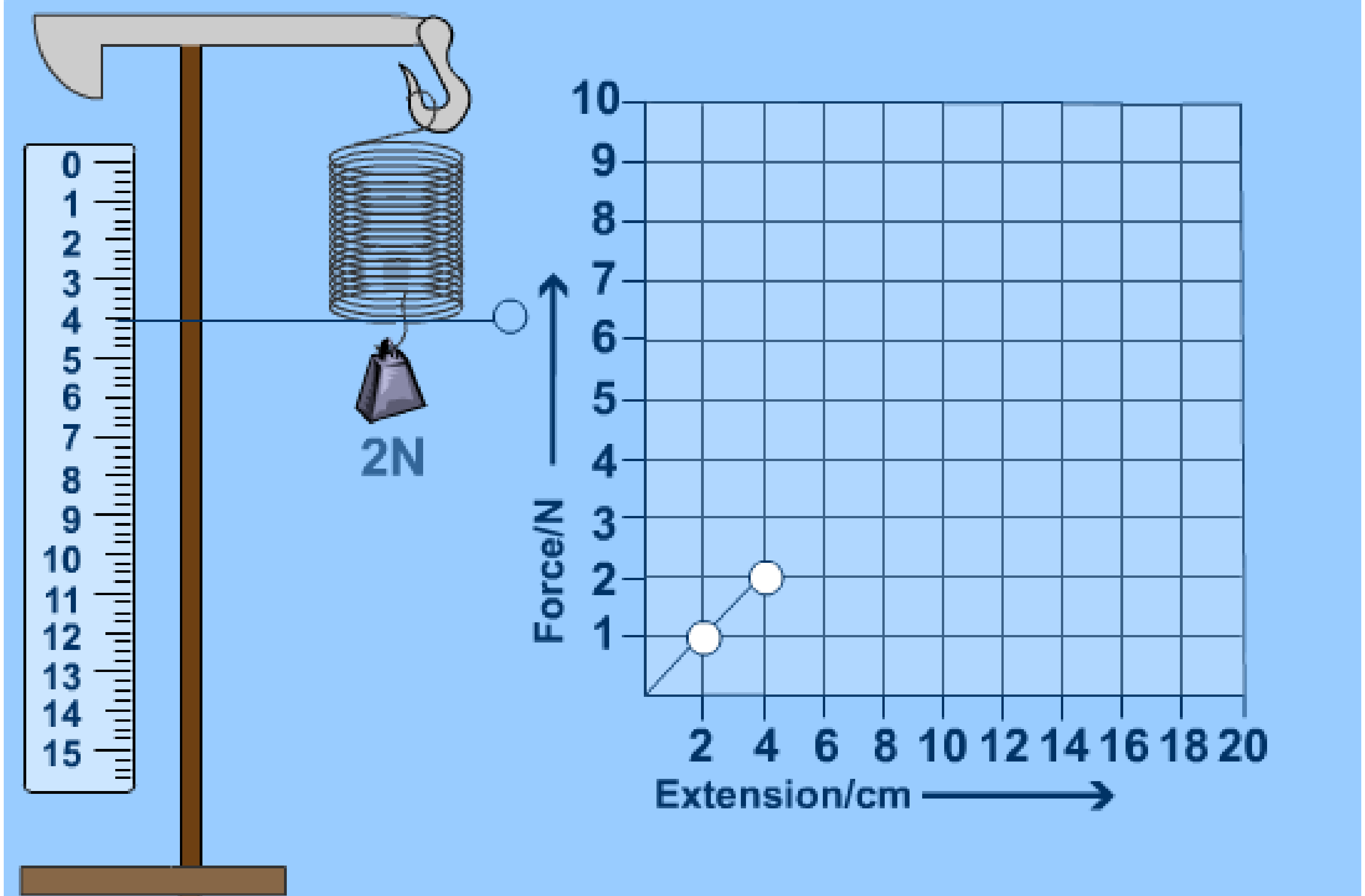
- **Prepare a data table:**

Mass (kg)	Applied Force (N) =F_g	Extension of Spring (m)
0.000	0 N	0m = equilibrium
0.200		
0.400		
0.600		
0.800		
1.000		

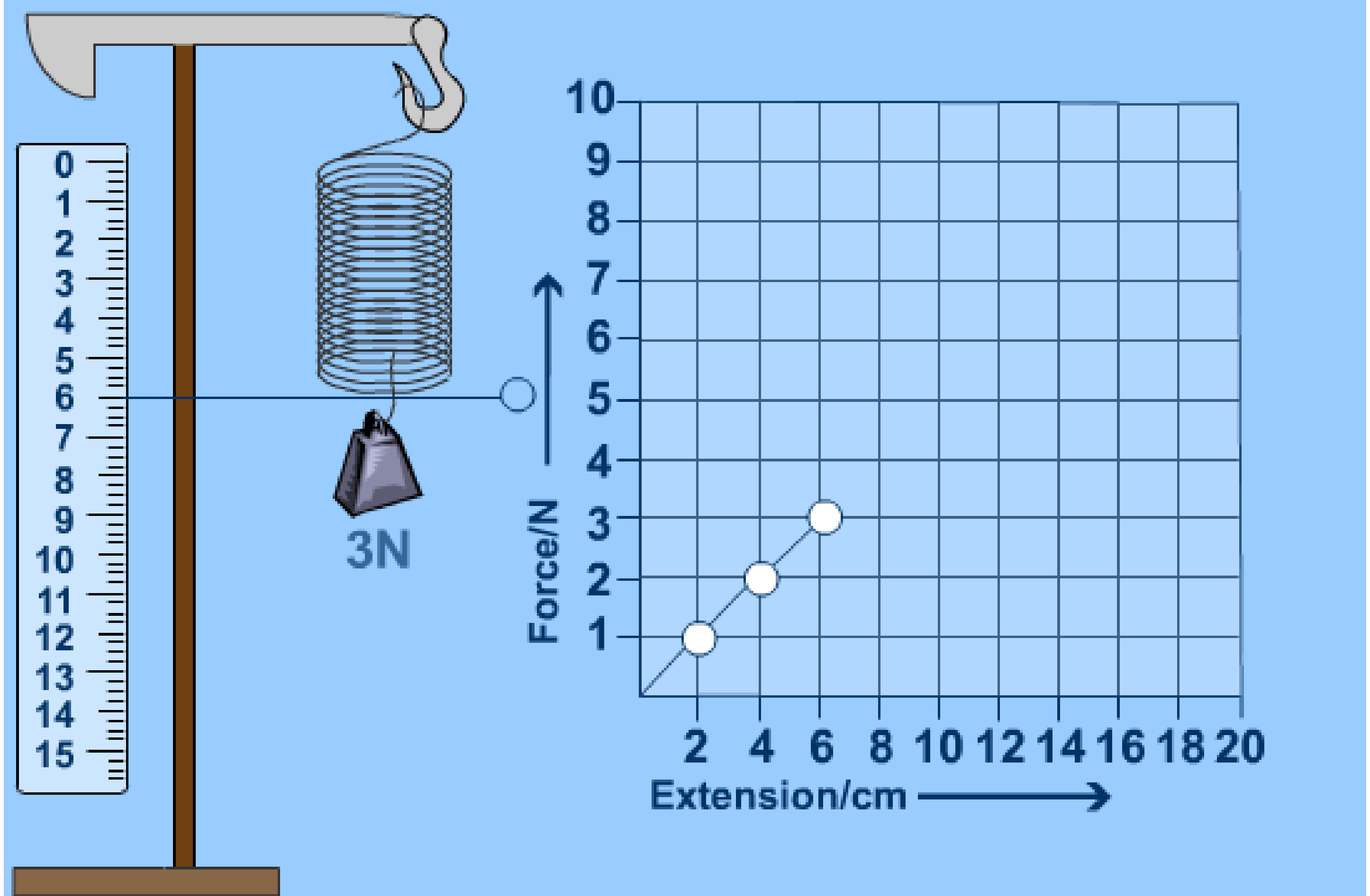




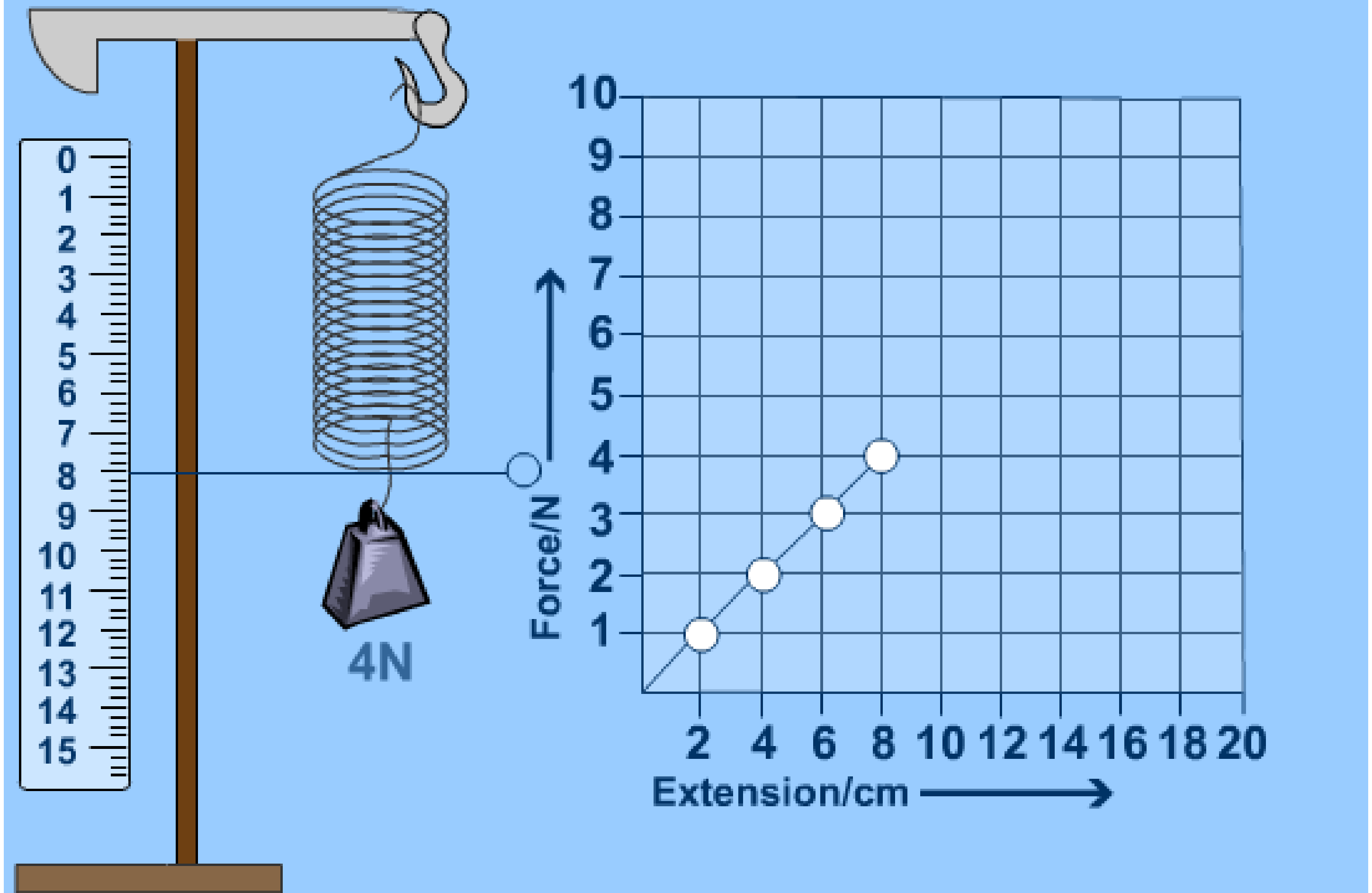
Weight in Newtons	1N	2N	3N	4N	5N	6N
Extension cm	2					



Weight in Newtons	1N	2N	3N	4N	5N	6N
Extension cm	2	4				

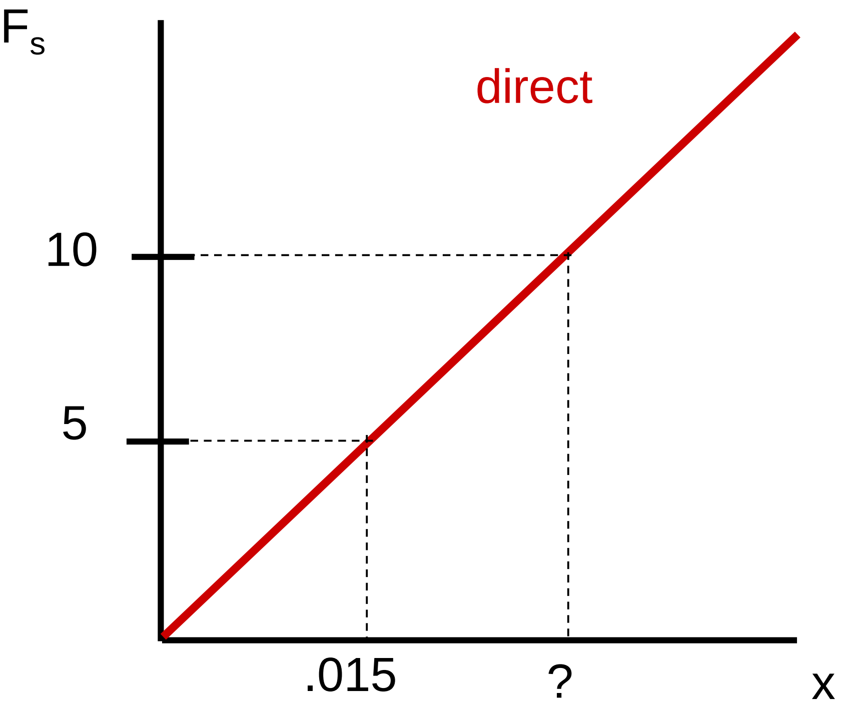


Weight in Newtons	1N	2N	3N	4N	5N	6N
Extension cm	2	4	6			



Weight in Newtons	1N	2N	3N	4N	5N	6N
Extension cm	2	4	6	8		

$F_s = kx$



Ex: A force of 5.0 N causes the spring to stretch 0.015 m. How far will it stretch if the force is 10 N?

2 (0.015 m)
= 0.030 m

What quantity does the slope represent?

slope = $\Delta y/\Delta x$

= F_s/x

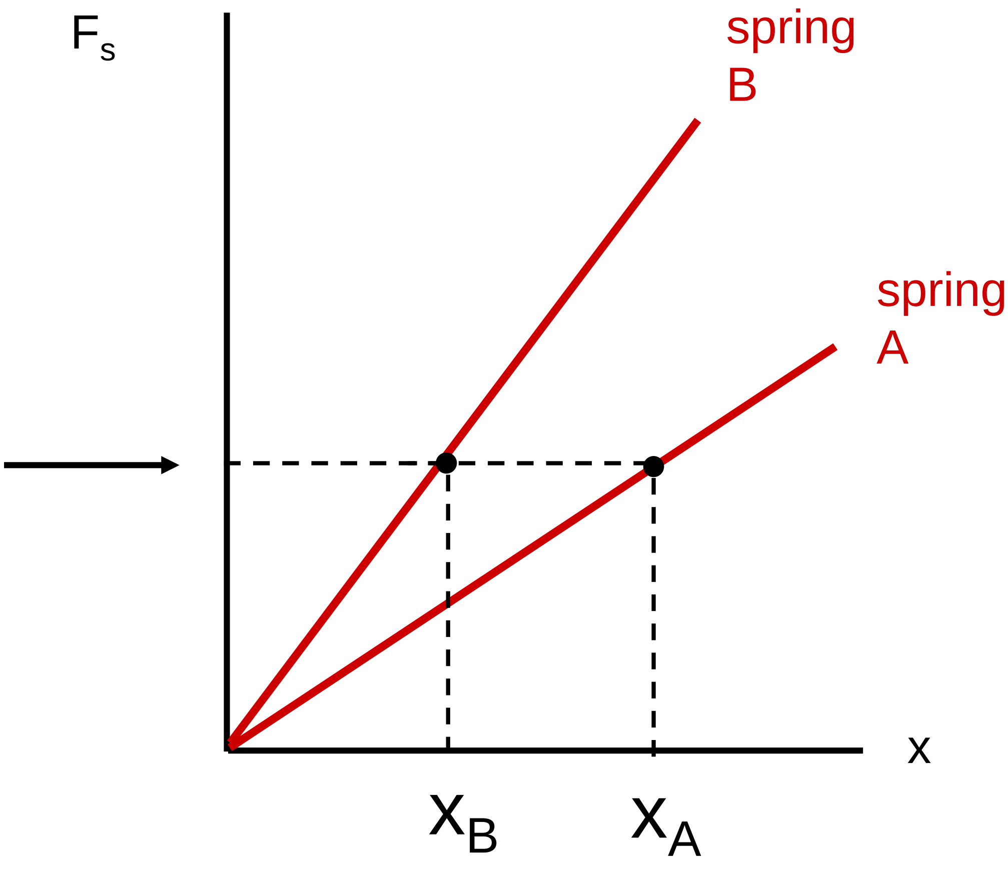
Compare to $F_s = kx$

Solve for F_s/x = k

The slope represents the spring constant, *k*.

Ex. Comparing two springs that stretch different amounts.

Applying the same force F to both springs



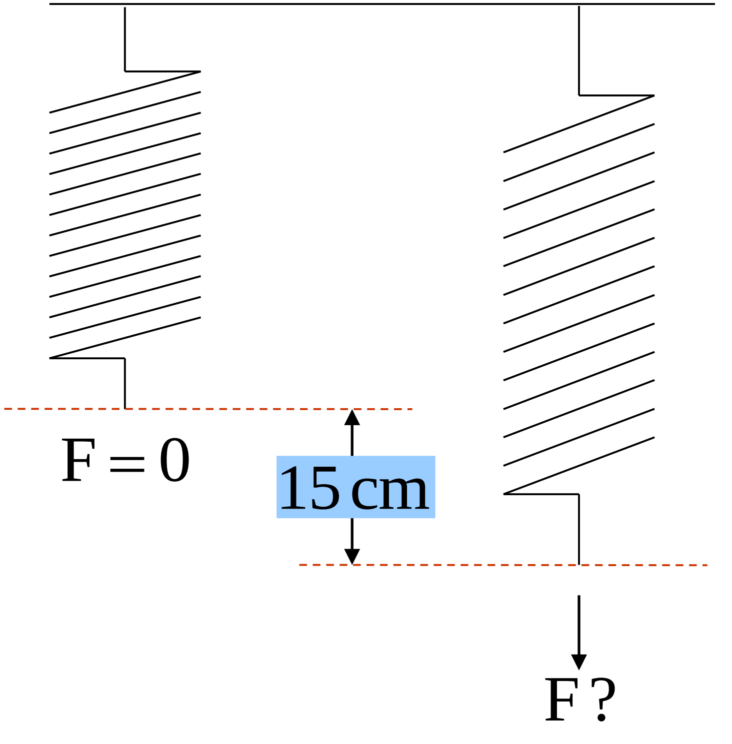
Which spring stretches more? A

Which is stiffer? B

☆ stiffer spring → greater slope → larger k

Example 1

A spring has a spring constant, k, of 5.0 N/m. What load will cause it to stretch by 15 cm?

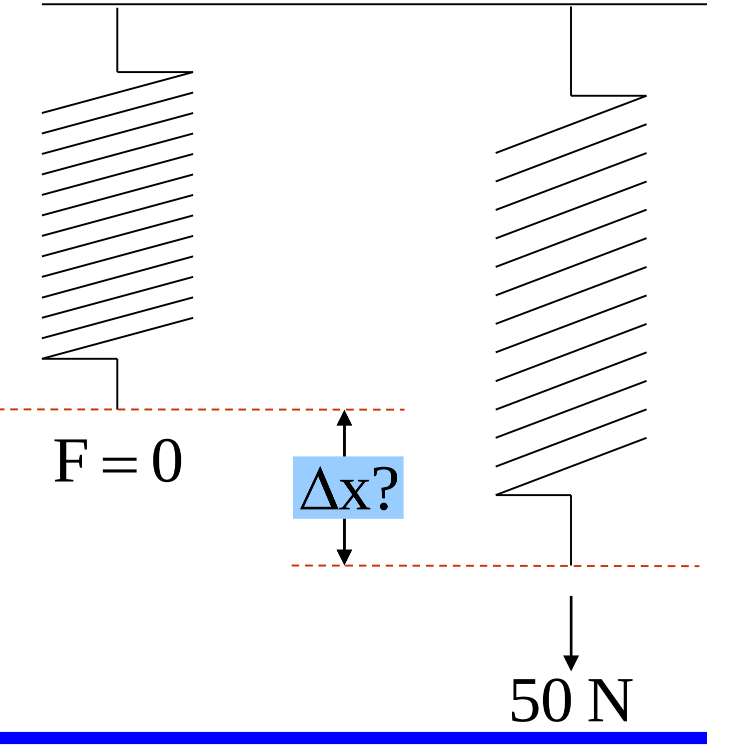


Example 2

- A spring is 0.38m long. When it is pulled by a force of 2.0 N, it stretches to 0.42 m. What is the spring constant? Assume the spring behaves elastically.

Example 3

A spring has a spring constant, k, of 10 N/m. What will the extension be for a load of 50 N?



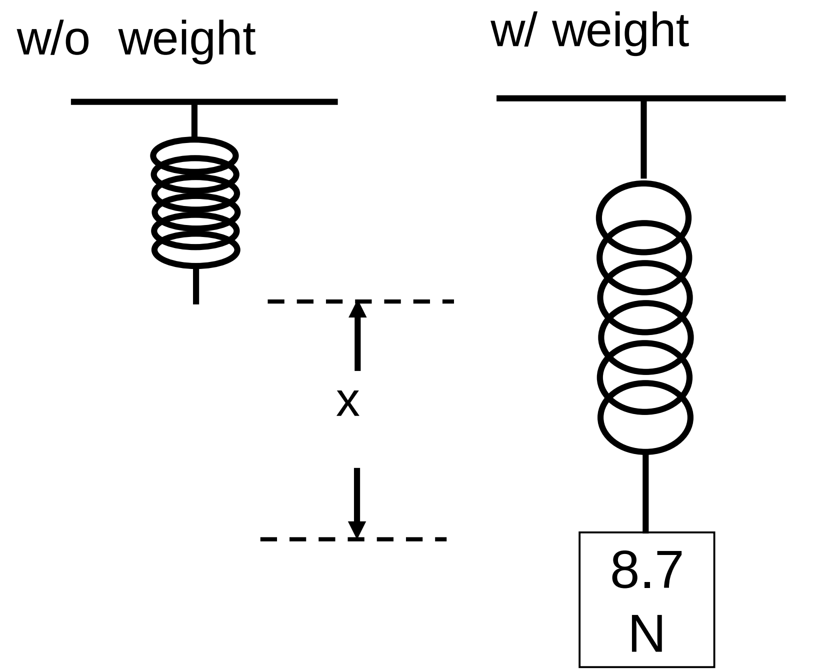
Example 4

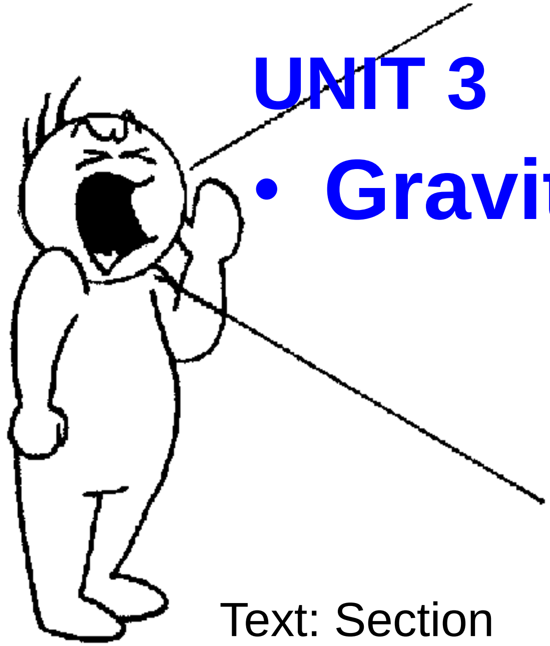
Ex. A weight of 8.7 N is attached to a spring that has a spring constant of 190 N/m. How much will the spring stretch?

Given:

F_s = 8.7 N

k = 190 N/m





UNIT 3 Topic 4

- **Gravitational Potential Energy**

Text: Section

Potential Energy

Potential Energy is stored energy.

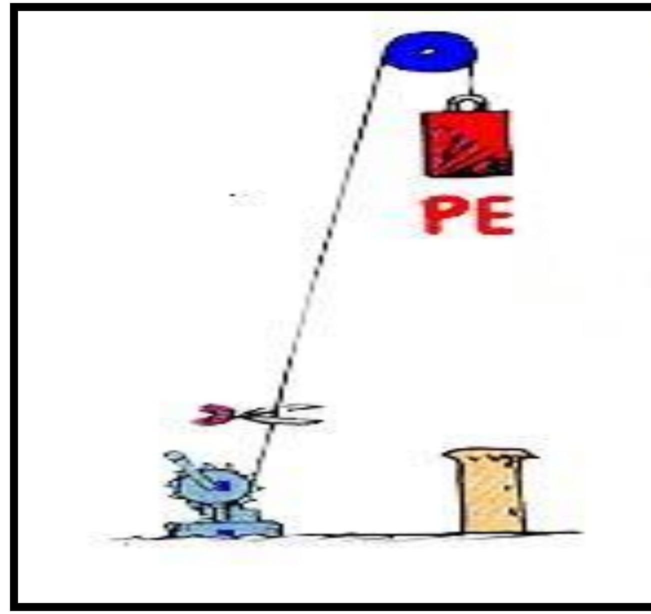
To gain potential energy (PE) WORK MUST BE DONE ON THE SYSTEM.

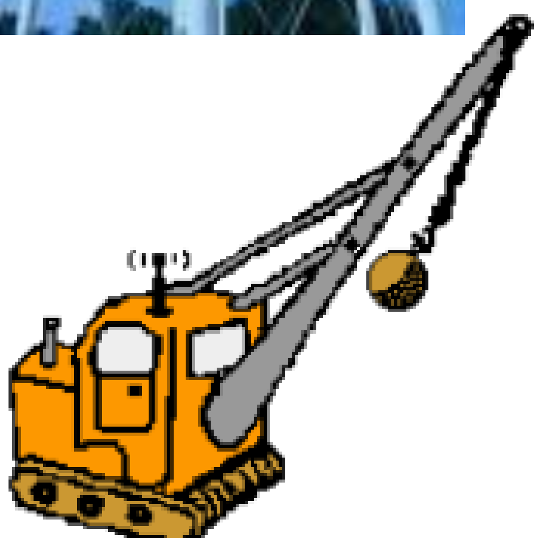
- "There are many ways to store energy, each resulting in a different name for potential energy. Two of the most common types are

1) Gravitational Potential Energy

2) Elastic Potential Energy

Examples of Gravitational Potential Energy?





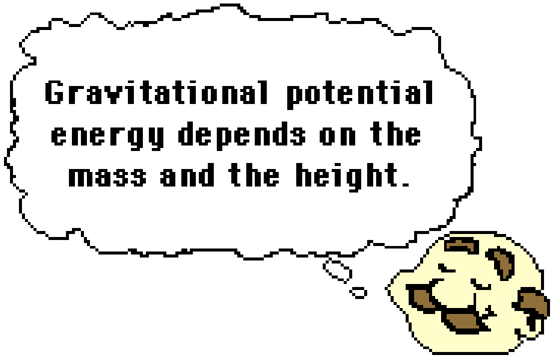
Gravitational Potential Energy?

Gravitational potential energy refers to potential energy that is stored every time something is lifted against gravity

Gravitational potential energy = Force of Gravity x Height

$$PE = F_g \Delta h$$

$$PE = mg \Delta h$$



m is mass measure in kg

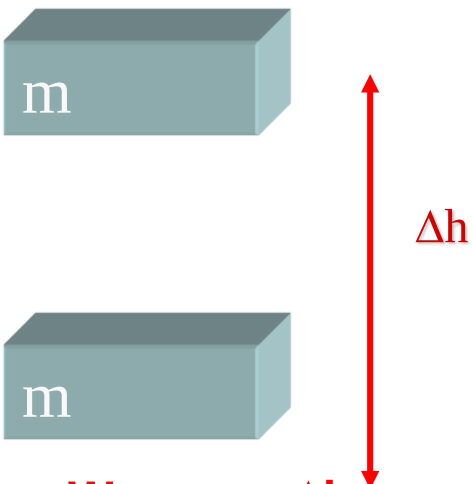
g is freefall acceleration measured in m/s/s

h is height measured in m

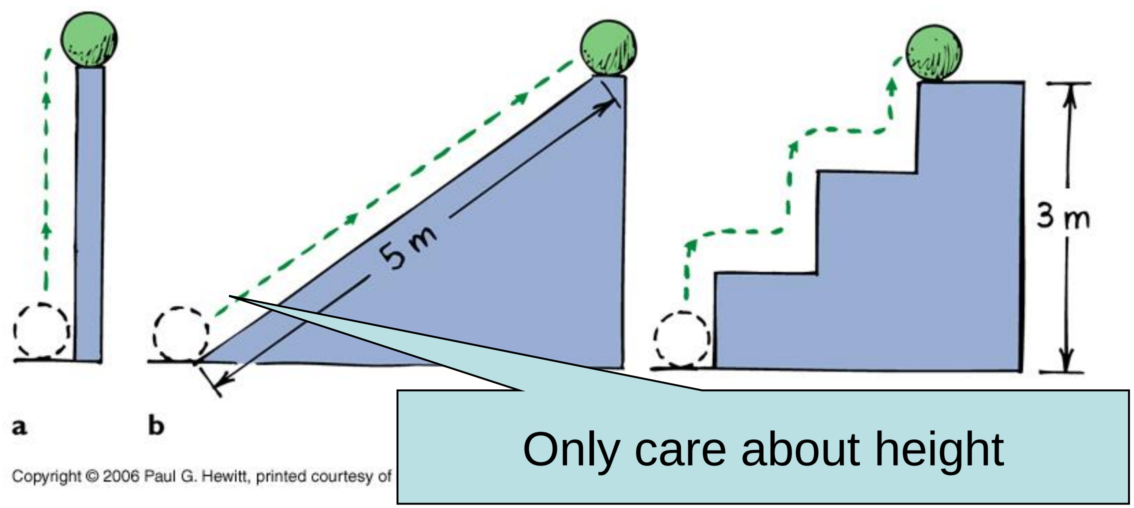
The unit of measure for energy is joules (J)

Gravitational Potential Energy

- Gravitational Potential Energy near the surface of the Earth:

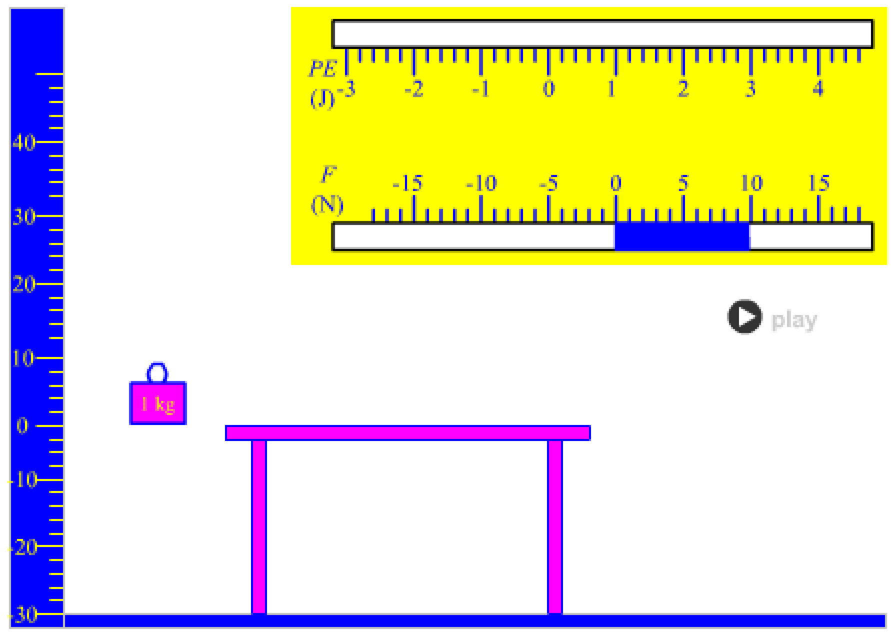


$W = mg \times \Delta h$



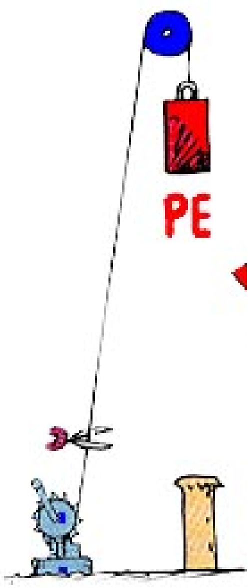
UNIT 3 WORK POWER AND ENERGY

Studying Potential Energy



HANDOUT ON ACTIVITY

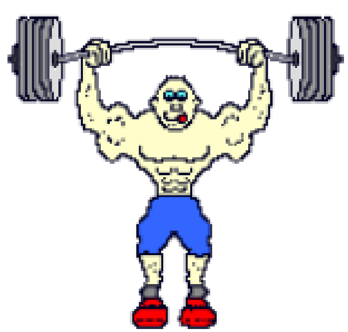
- Gravitational potential energy of an object depend on two factors:



1) **Mass of the object**

2) **Distance it is raised.**

Note: The more work that is done on an object In lifting it, the more gravitational potential energy it will have.



A weightlifter applies a force to cause a barbell to be displaced. The barbell then possesses mechanical energy - all in the form of potential energy.

Example 1

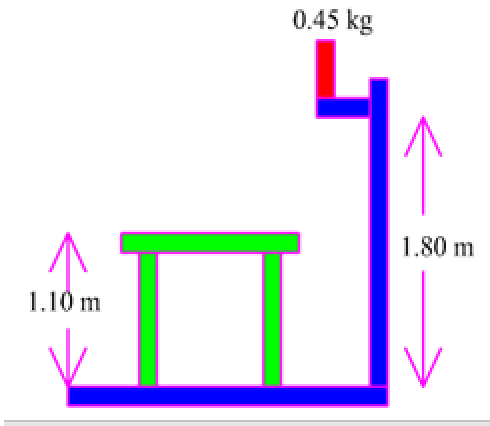
A climber drops a 1.2 kg pack from a cliff that is 28 m high. Calculate the gravitational potential energy of the pack relative to the ground just before the climber drops it.

Example 2

An object that has 446 J of gravitational potential energy is 136 m above the ground. What is the object's mass?

Example 3:

The diagram shows a 0.45 kg book on a shelf 1.80 m above the floor. The table top is 1.10m above the floor. What is the gravitational potential energy of the book relative to the table top?



Example 4:

The gravitational potential energy of an 65.0 kg person changes by 13.4 kJ as she climbs the stairs. If she is initially on the tenth floor and each floor of the building has a height of 3.50 m, what floor has she reached?

Summary of Gravitational Potential Energy

- The formula for Calculating Gravitational Potential energy is:

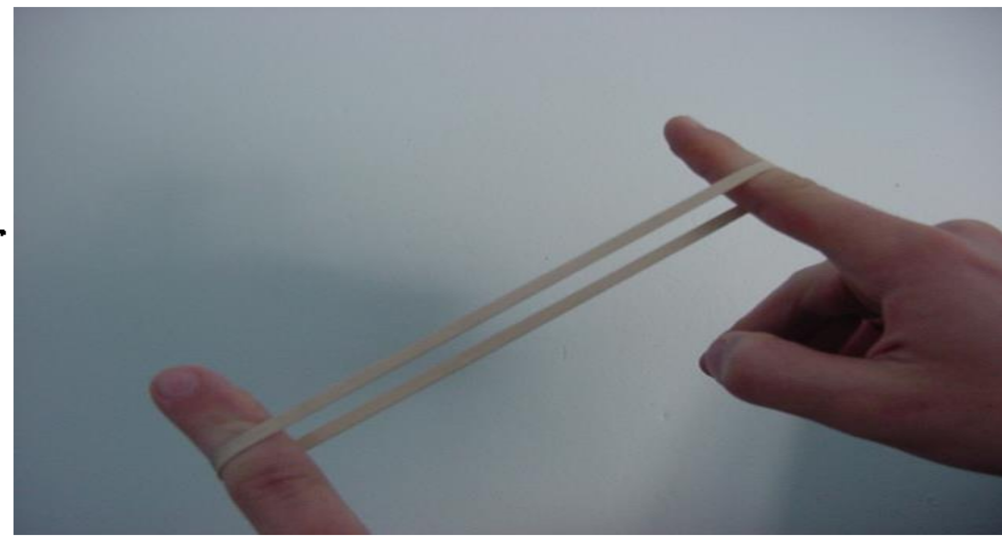
- $PE_{grav} = W = F_g \Delta h = mg \Delta h$

- W= Work
- F_g= Force of Gravity
- Δh= is change in height
- m=mass
- G= gravity

- Note: The more work that is done on an object in lifting it, the more gravitational potential energy it will have.

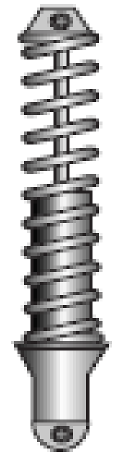
UNIT 3 Topic 5

- **Elastic Potential Energy**

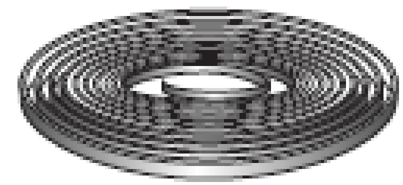


Text: Section

Examples of Elastic Potential Energy?



Spring
(shock absorber)



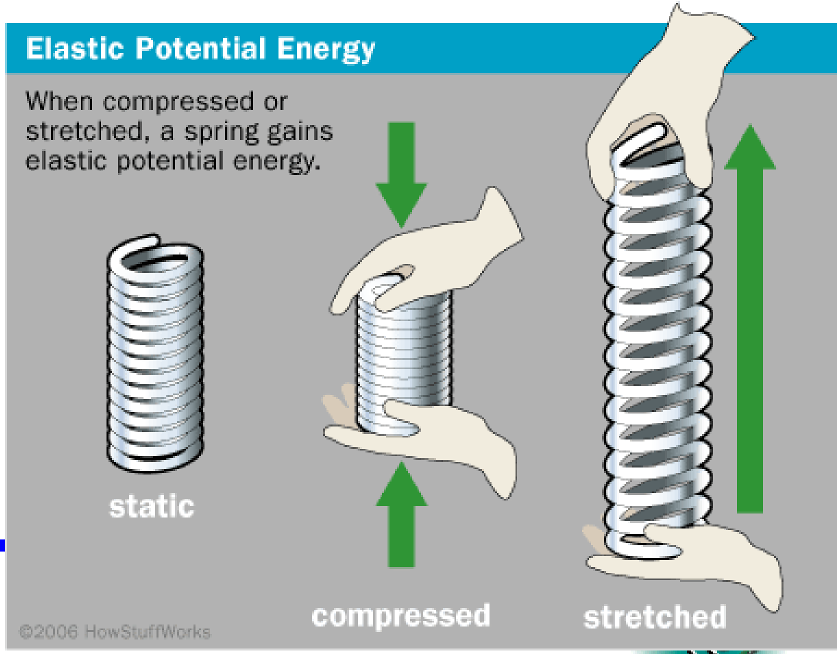
Windup spring
(toys, watches)

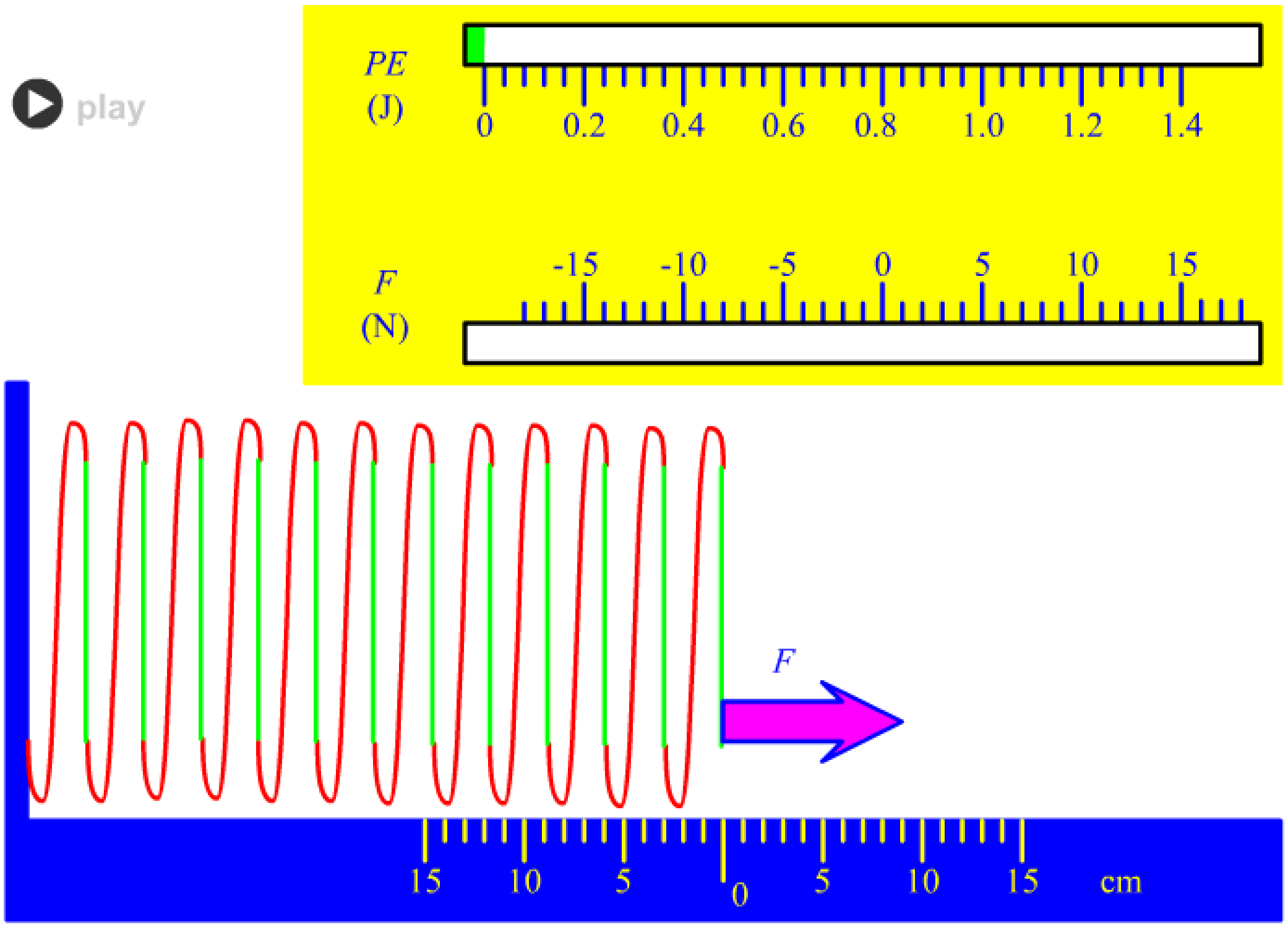
The compressed springs of a dart gun store elastic potential energy. When the trigger is pulled, the springs apply a force to do work on the dart.

Elastic Potential Energy?

- **Type 2: Elastic Potential Energy: is the energy stored in elastic materials as the result of their stretching or compressing**

For example, when you stretch a rubber band, or pull back the arrow in a bow, the energy is of this type. If you use spring exercisers to develop your muscles, every time you extend the springs, energy is being stored in the spring as you do work to extend the exerciser.




play
PE
(J)
0 0.2 0.4 0.6 0.8 1.0 1.2 1.4
F
(N)
-15 -10 -5 0 5 10 15
F
15 10 5 0 5 10 15 cm

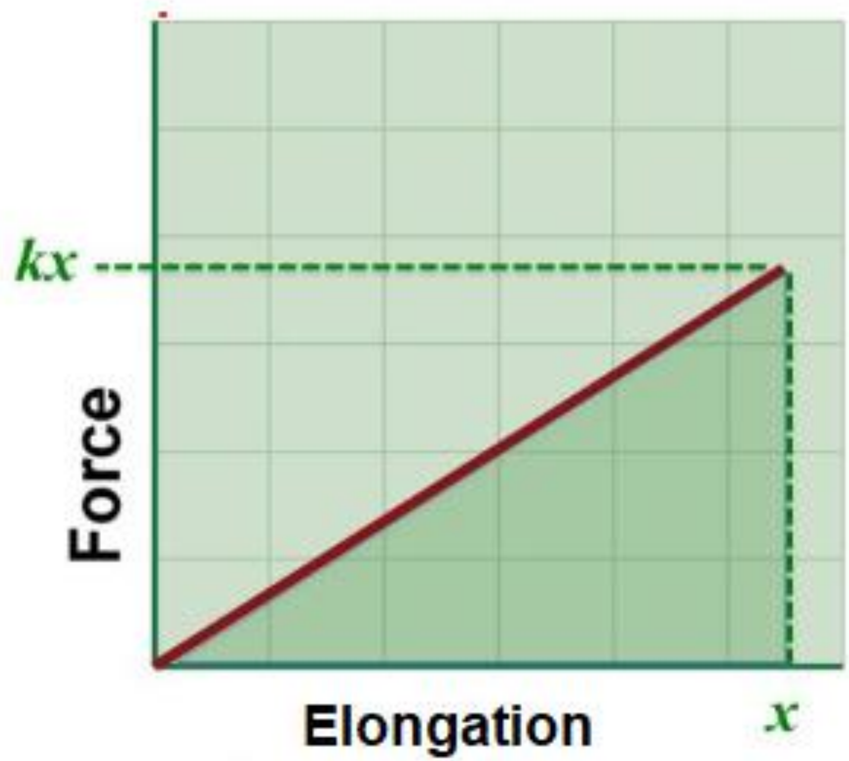
Remember From The Lab

Elastic Poential Energy is equal to the area under a Force Versus Elongation Graph

$$A = \frac{1}{2} base \times height$$

$$W = \frac{1}{2} x \times kx$$

$$W = \frac{1}{2} kx^2$$



Deriving Elastic Potential Energy Formula

$$PE_{elastic} = W = F_{av}\,\Delta x$$

The average force is the force that occurs halfway through the displacement. This means that it occurs at one-half Δx.

In other words, while in general, F = kΔx,, for this special average force we write F_{av} = k½Δx.

$$
\begin{aligned}
PE_{Elastic} &= W \\
&= F_{av}\Delta x \\
&= k\left(\frac{1}{2}\Delta x\right)\Delta x \\
&= \frac{1}{2}k(\Delta x)^2
\end{aligned}
$$

Elastic Potential Energy Formula

$$PE_{elastic} = \frac{1}{2} k x^2$$

k is spring constant = N/m

x is the amount of compression/stretch relative to equilibrium position = m

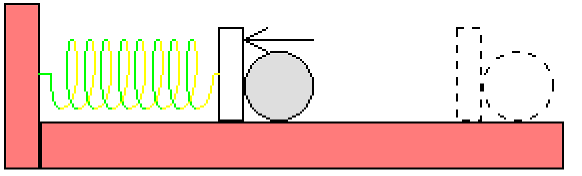
The unit of measure for energy is joules (J)

Example 1:

- What is the Elastic potential energy of a car spring that has been stretched 0.5 meters? The spring constant for the car spring is 90 N/m.

Example 2:

A ball is pushed into a spring-loaded launcher with a force of 20 N, which compresses the spring 0.08 m.



a) What is the spring constant of the spring

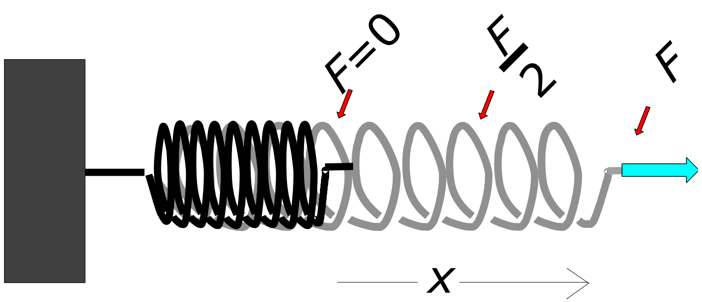
b) Find the elastic potential energy (PEs) stored in the spring (or the work done on the spring)

Example 3:

A spring with a force constant of 5.20 N/m has a relaxed length of 2.45 m. When a mass is attached to the end of the spring and allowed to come to rest, the vertical length of the spring is 3.57 m. Calculate the elastic potential energy stored in the spring.

Summary:

"When work is done on a system, potential energy is stored in the system—and the potential energy = the work"



$PE = W = F_{ave}$ x distance $= ½\,Fx$

Or, using **Hooke's Law**-- $F = \mathbf{kx}$:

$PE = ½\,\mathbf{kx}(x) = ½\,kx^2$

UNIT 3 Topic 6

- **Kinetic Energy**

Text: Section

Examples of Kinetic Energy:

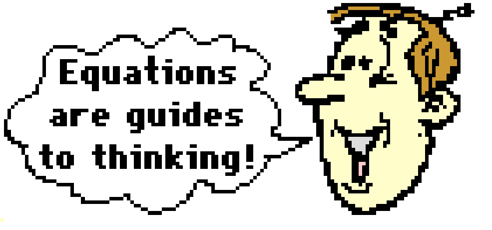
KINETIC ENERGY

- **Kinetic energy (K.E. OR $E_{k)}$** is the energy of motion. An object which has motion - whether it be vertical or horizontal motion - has kinetic energy.

$$KE = \frac{1}{2} * m * v^2$$

where **m** = mass of object

v = speed of object

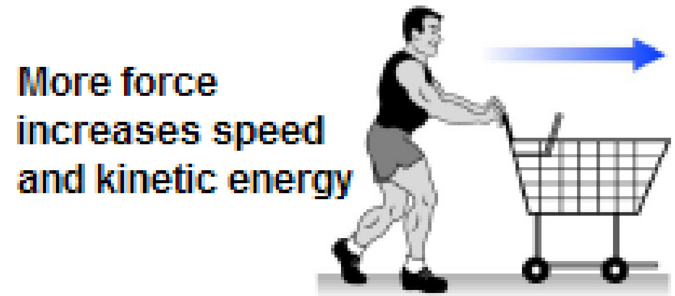


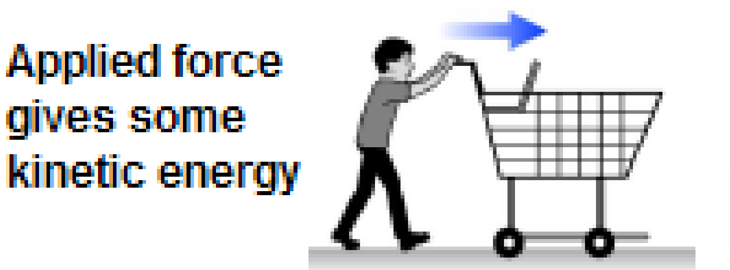
- Kinetic Energy ıs a scalar quantıty measured in Joules (J)

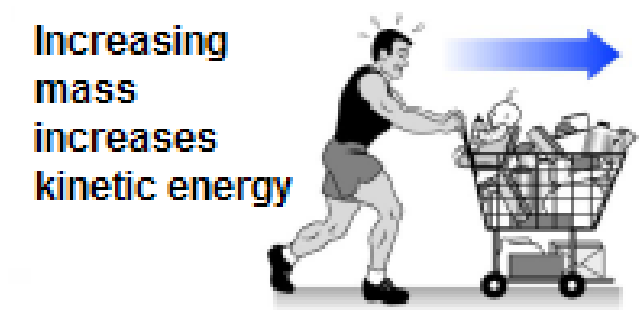
Kinetic energy is affected by two variables:

1) **Mass of the object**

2) **Speed of the object**

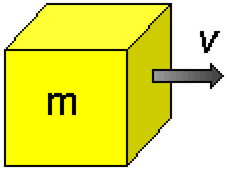




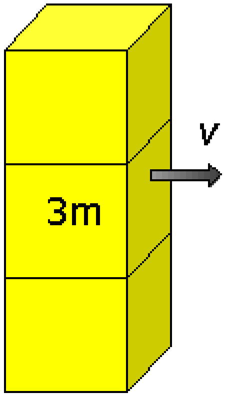


Question

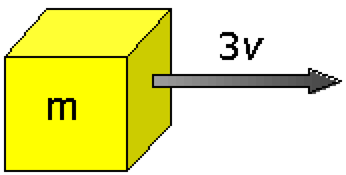
When these objects move at the same speed, which will have more kinetic energy?

a) 

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

b) 

$$KE_b = \frac{1}{2}3mv^2 = 3\left[\frac{1}{2}mv^2\right] = 3\,KE_a$$

c) 

$$KE_c = \frac{1}{2}m(3v)^2 = \left[\frac{1}{2}m9v^2\right] = 9\left[\frac{1}{2}mv^2\right] = 9\,[KE_a]$$

"Kinetic energy is energy in motion—it depends on the mass of the moving object, but even more on its speed"

This equation reveals that the kinetic energy of an object is directly proportional to the square of its speed. That means that for a threefold increase in speed, the kinetic energy will increase by a factor of nine

Example 1:

- What is the kinetic energy of a 965 kg moose is running at 2.0 m/s?

Example 2:

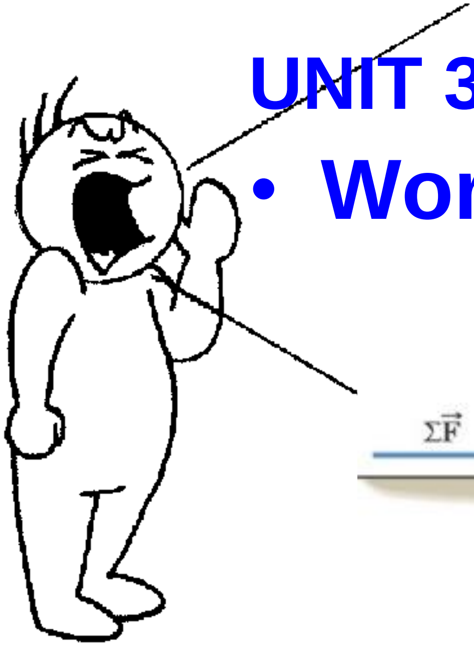
- While a 23 gram bullet is in the barrel of a rifle, it accelerates at 2.25×10^5 m/s2 for 2.00×10^{-2} s. What is the KE of the bullet as it leaves the rifle?

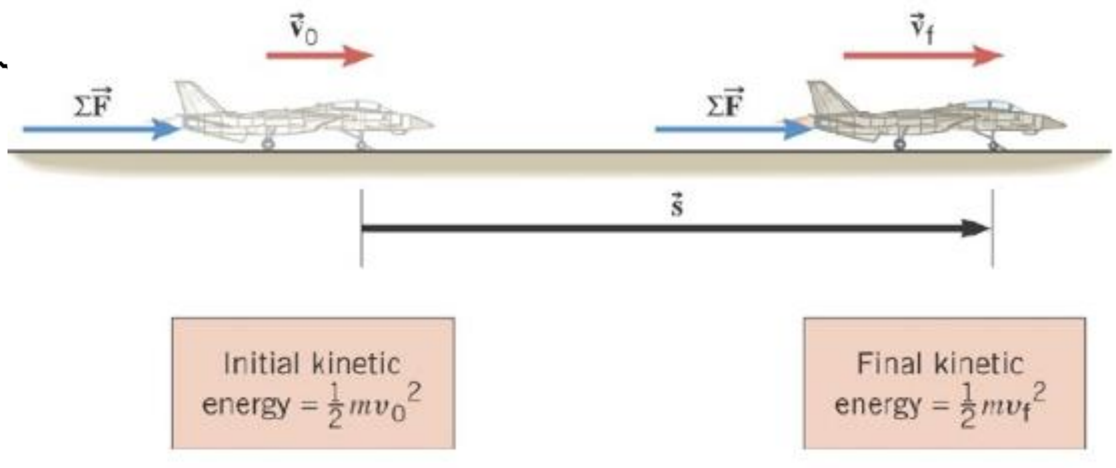
Example 3:

A 2.4 kg can of paint falls 2.7 m from the top rung of a ladder to the ground. By the time it hits the ground, all of its 64 J of PE_{grav} have been changed into *KE*. With what speed does it hit the ground?

UNIT 3 Topic 7

- **Work Energy Theorem**

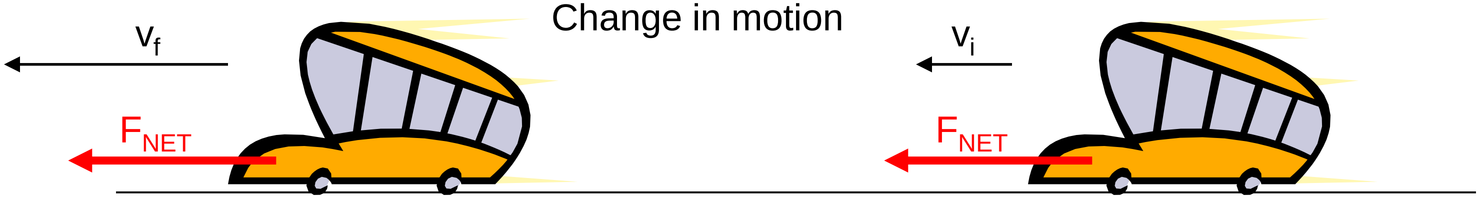




Text: Section

THE WORK–ENERGY THEOREM

When work is done on a perfectly frictionless horizontal surface, all the work is transformed into kinetic energy of the object.



Work done = the change in KE of the object.

$$Work = \Delta E_k$$

$$W = E_{k2} - E_{k1}$$

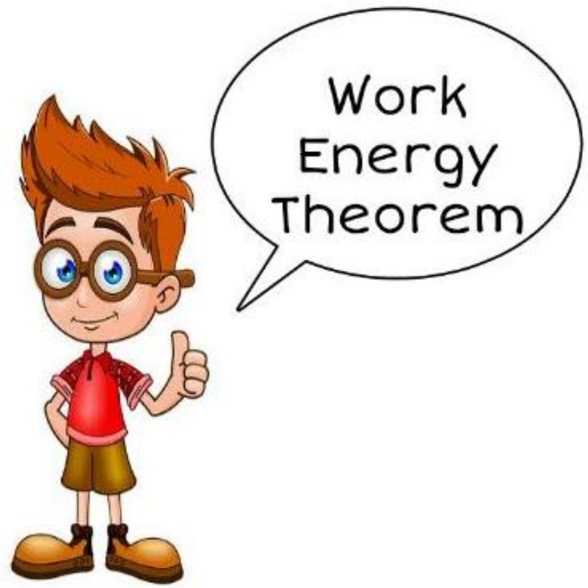
Rewrite the equation as follows:

$$Fd = \frac{1}{2}mv_2^{\,2} - \frac{1}{2}mv_1^{\,2}$$

TWO conditions of the Work-Energy Theorem.

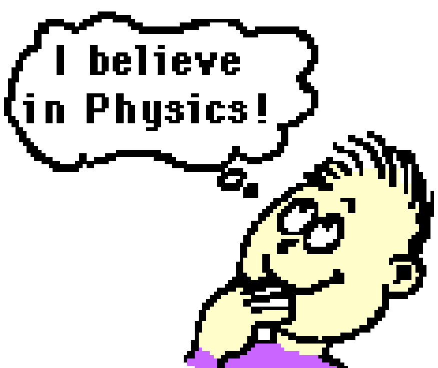
(1) **There is assumed to be <u>no friction</u>.** If there were friction, not all of the applied force would be translated into motion and thus KE, some would be wasted overcoming friction

(2) **The motion is assumed to be <u>horizontal</u>.** That is, the object was not raised or lowered.



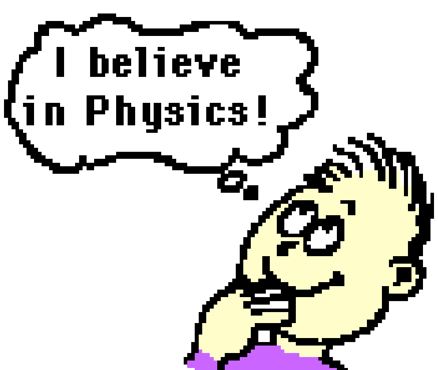
Example 1:

Student wearing frictionless roller skates on a horizontal surface is pushed by a friend with a constant force of 45 N. How far must the student be pushed, starting from rest, so that her final kinetic energy is 352 J?



Example 2:

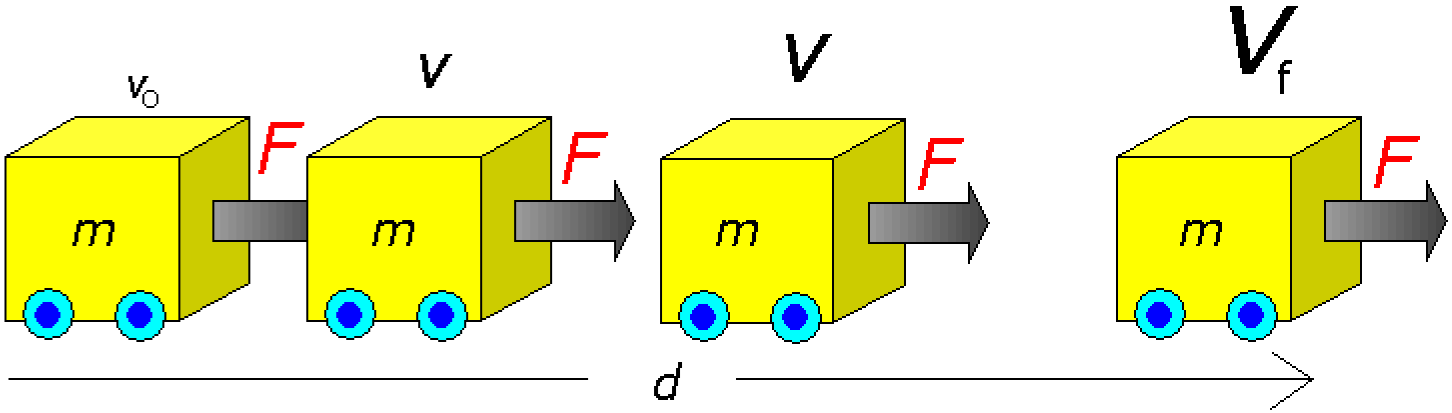
A plane is taxiing at 22 m/s when the pilot opens the throttle. The effective force on the plane is 5.2×10^3 N, which is applied for a distance of 1.1 km. What will be the final speed of the plane if its mass is 1.2×10^4 kg?



Example 3:

During a braking sequence, the wheels of 1200 kg car lock and the car slows from 98 km/hr to 43 km/hr. The skid mark is 17 m long. What is the effective braking force on the car?

Review Work – Energy Theorem



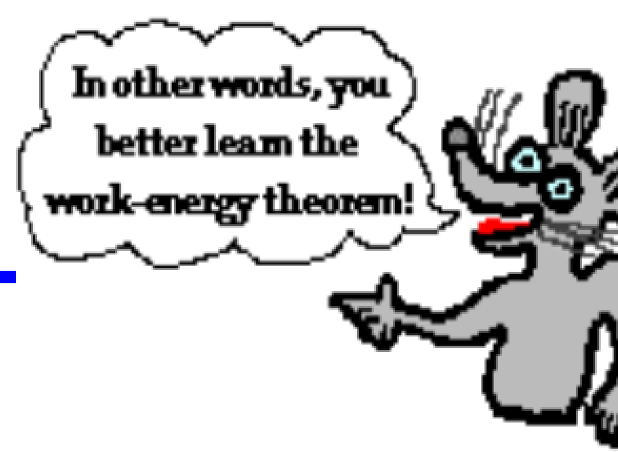
Absolutely no friction in the wheels

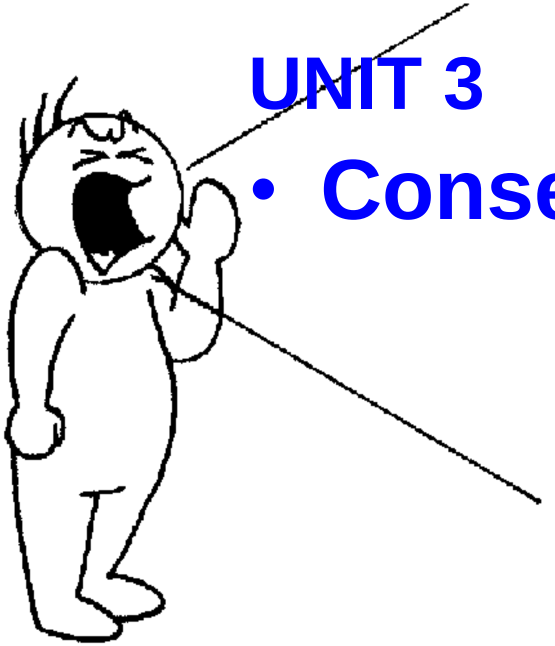
Original kinetic energy = $\frac{1}{2} m v_o^2$

Work done = $W = Fd$

Final kinetic energy = $\frac{1}{2} m v_f^2$

$$Fd = \Delta KE = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_o^2$$





UNIT 3 Topic 8

- **Conservation of Energy**

Text: Section

Energy

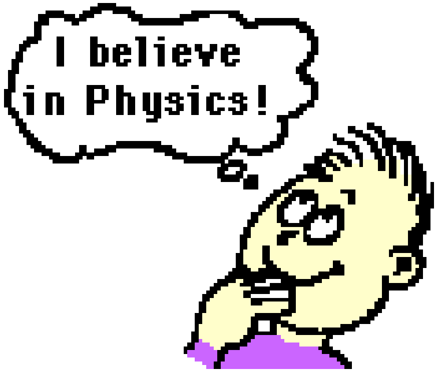
- **Energy** (E) is defined as *the capacity to do work (scalar)*

Mechanical energy- the energy due to the position of something or the movement of something.

Mechanical Energy can be divided into to categories;:

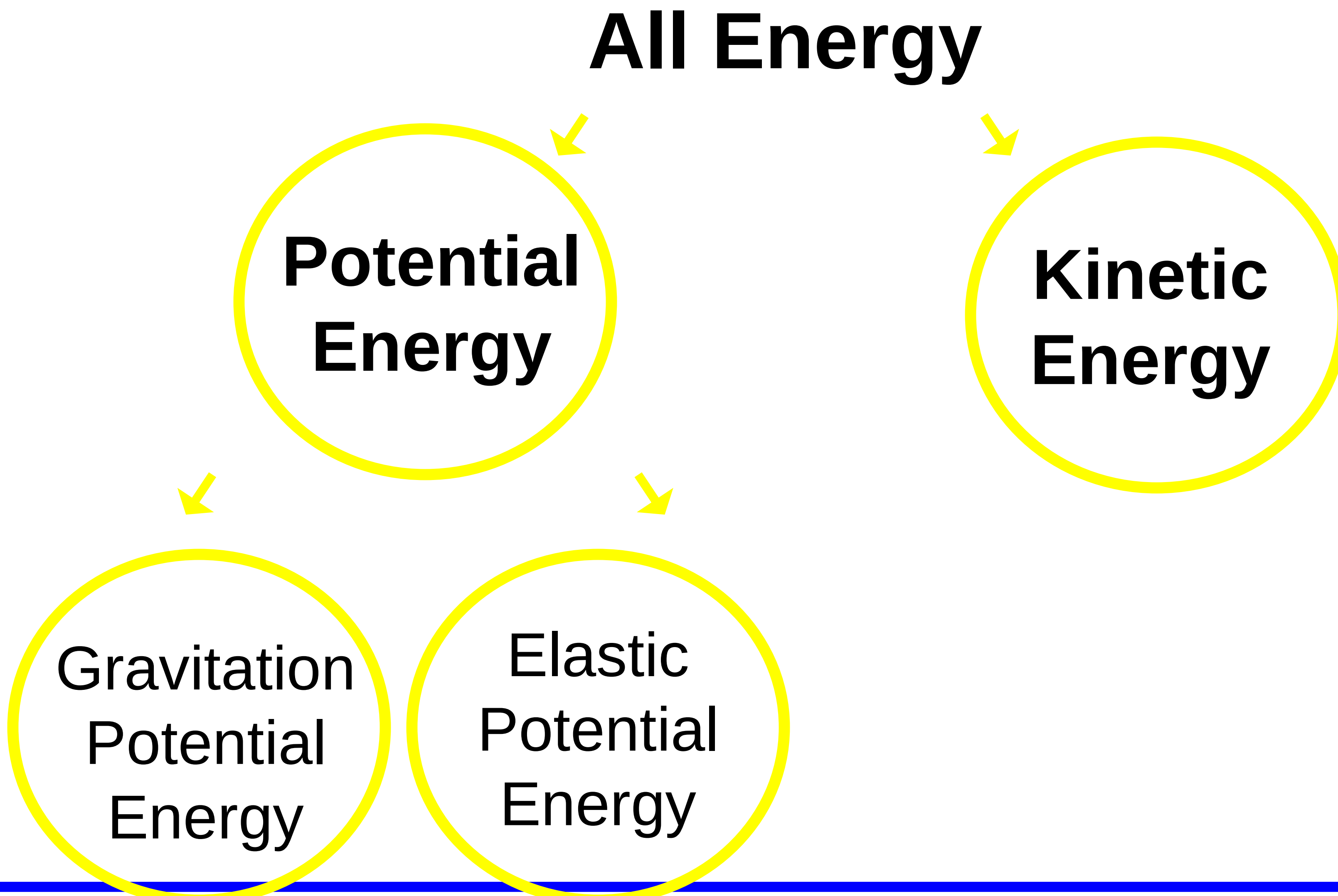
1) **Potential Energy (PE):**

2) **Kinetic Energy (KE)**

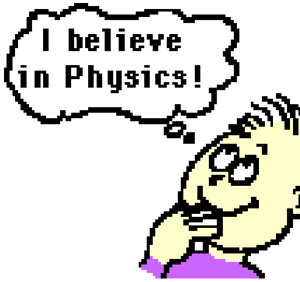


- The unit for all energy and work is the **Joule**

How is all energy divided?

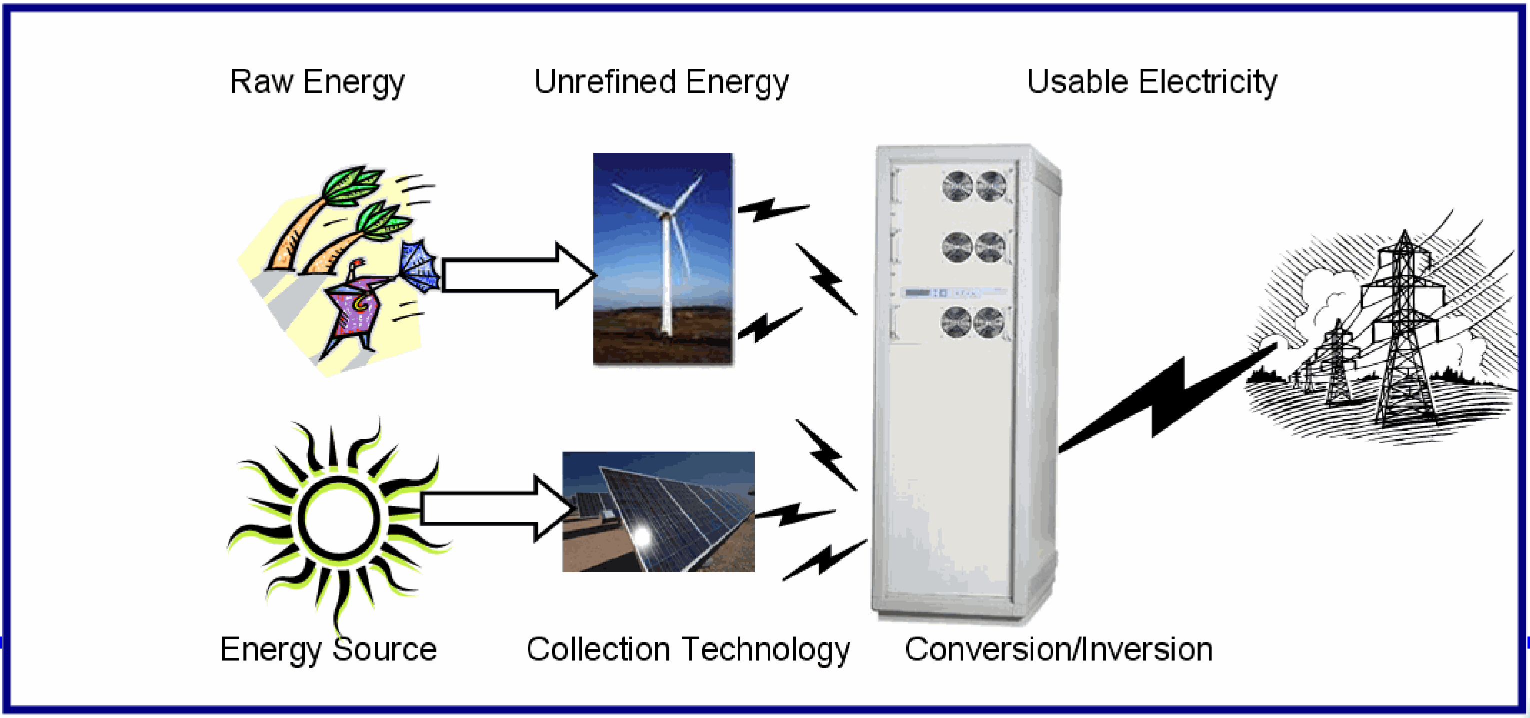


CONSERVATION OF MECHANICAL ENERGY



- The Conservation of Energy States that :

Energy can't be created or destroyed. It can only be transformed into other types of energy. the TOTAL amount of energy is CONSTANT



In Fact:

IF NO ENERGY IS LOST DUE TO FRICTION,

MECHANICAL ENERGY IS CONSERVED

AT ALL POINTS IN THE MOTION.

Or

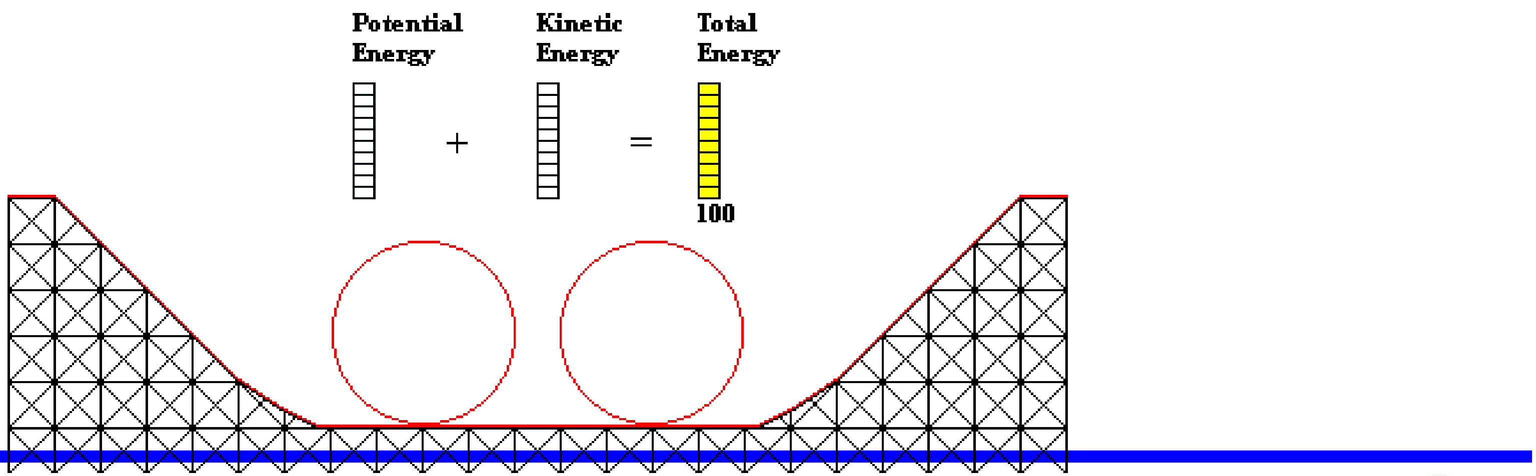
Total Energy is equal at all points as object rises or falls.

Now to apply this to solve some problems:

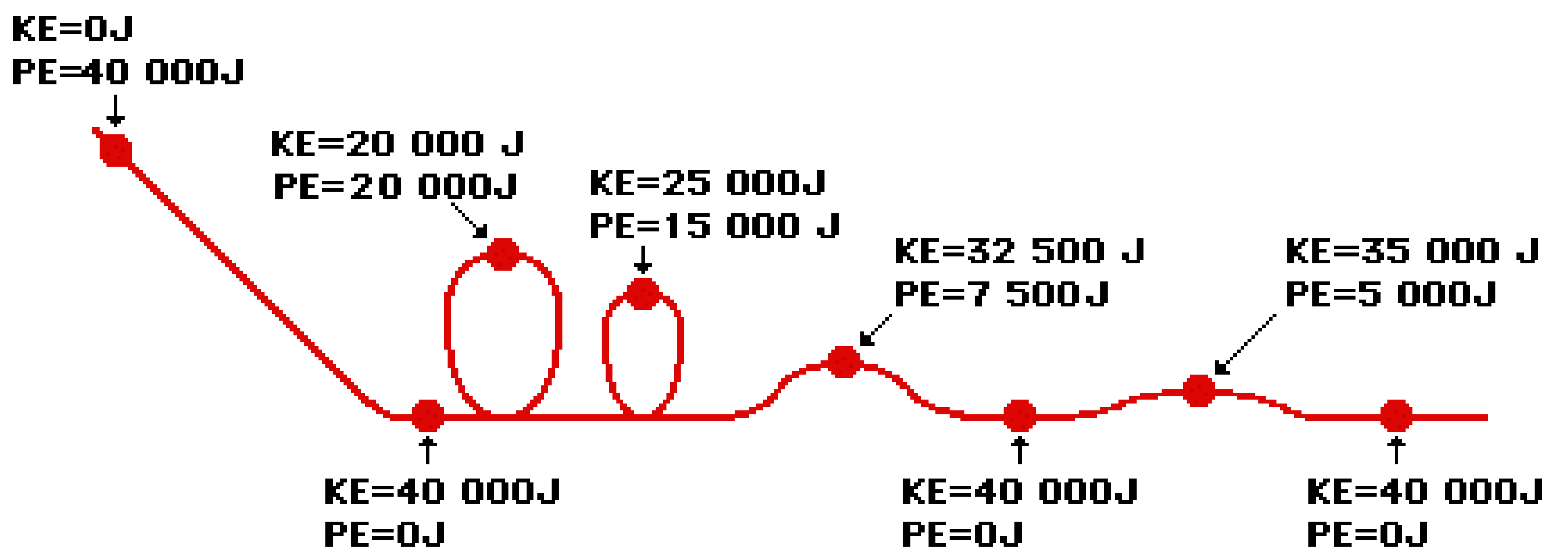
We will look at the Law of Conservation of Energy as it applies to mechanical energy only. For a particular object the sum of the potential energy and the Kinetic energy is a constant term. That is the initial Mechanical energy is equal to the final mechanical energy. This can be summarized in the following:

$$ME_i = ME_f$$

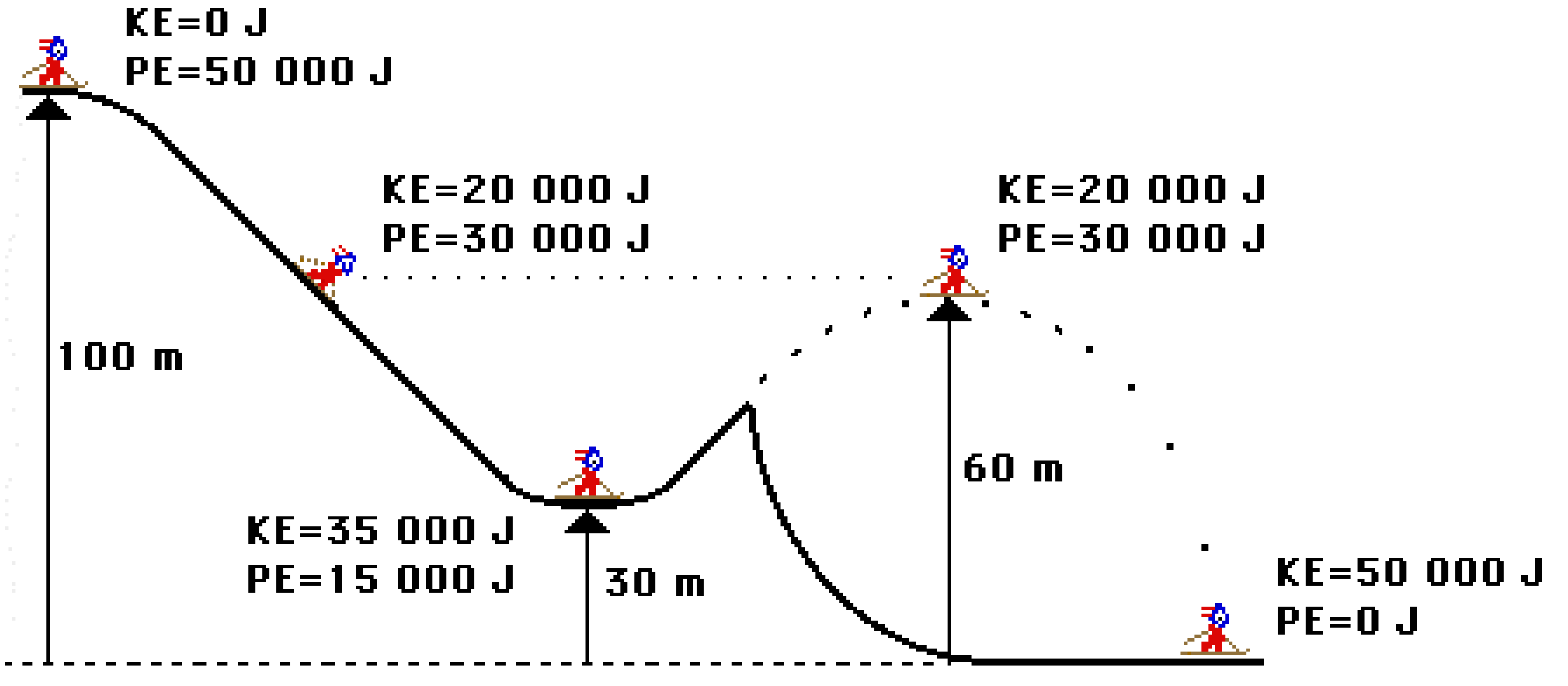
$$PE_i + KE_i = PE_f + KE_f$$



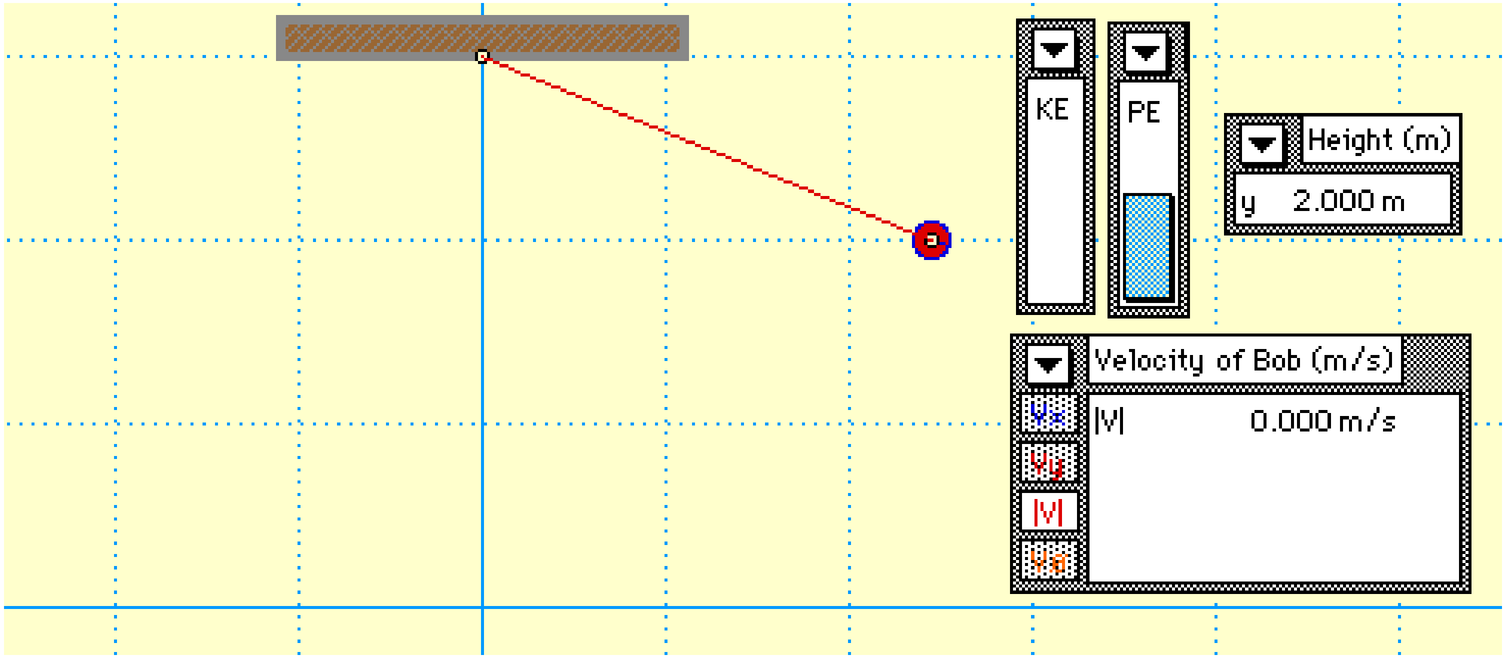
Roller Coaster



Skiing


KE=0 J
PE=50 000 J
KE=20 000 J
PE=30 000 J
KE=20 000 J
PE=30 000 J
100 m
60 m
KE=35 000 J
PE=15 000 J
30 m
KE=50 000 J
PE=0 J

Pendulum



In Fact:

IF NO ENERGY IS LOST DUE TO FRICTION,

MECHANICAL ENERGY IS CONSERVED

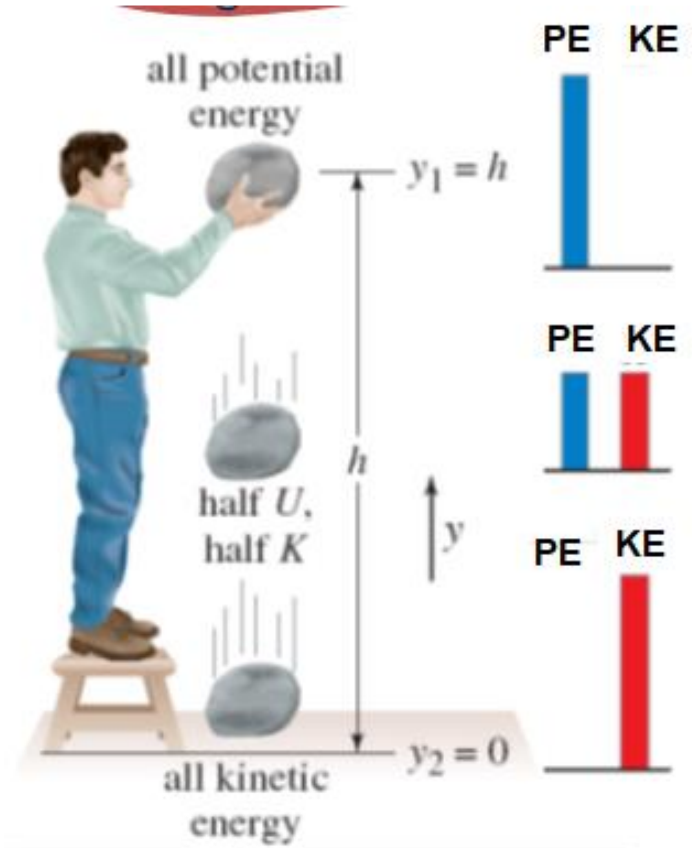
AT ALL POINTS IN THE MOTION.

Or

Total Energy is equal at all points as object rises or falls.

Now to apply this to solve some problems:

For A Falling Object



$KE_{top} + PE_{top} = KE_{bottom} + PE_{bottom}$

0 (not moving) + $PE_{top} = KE_{bottom}$ + 0 (no height)

$PE_{top} = KE_{bottom}$

$$mgh = \frac{1}{2} m \vec{v}_f^{\,2}$$

Example 1:

Mr. Car Pentar’s 2.1 kg lunch-pail slips off the roof of a 4 storey building (height 12.2 m) and falls to the ground. With what speed does it strike the ground?

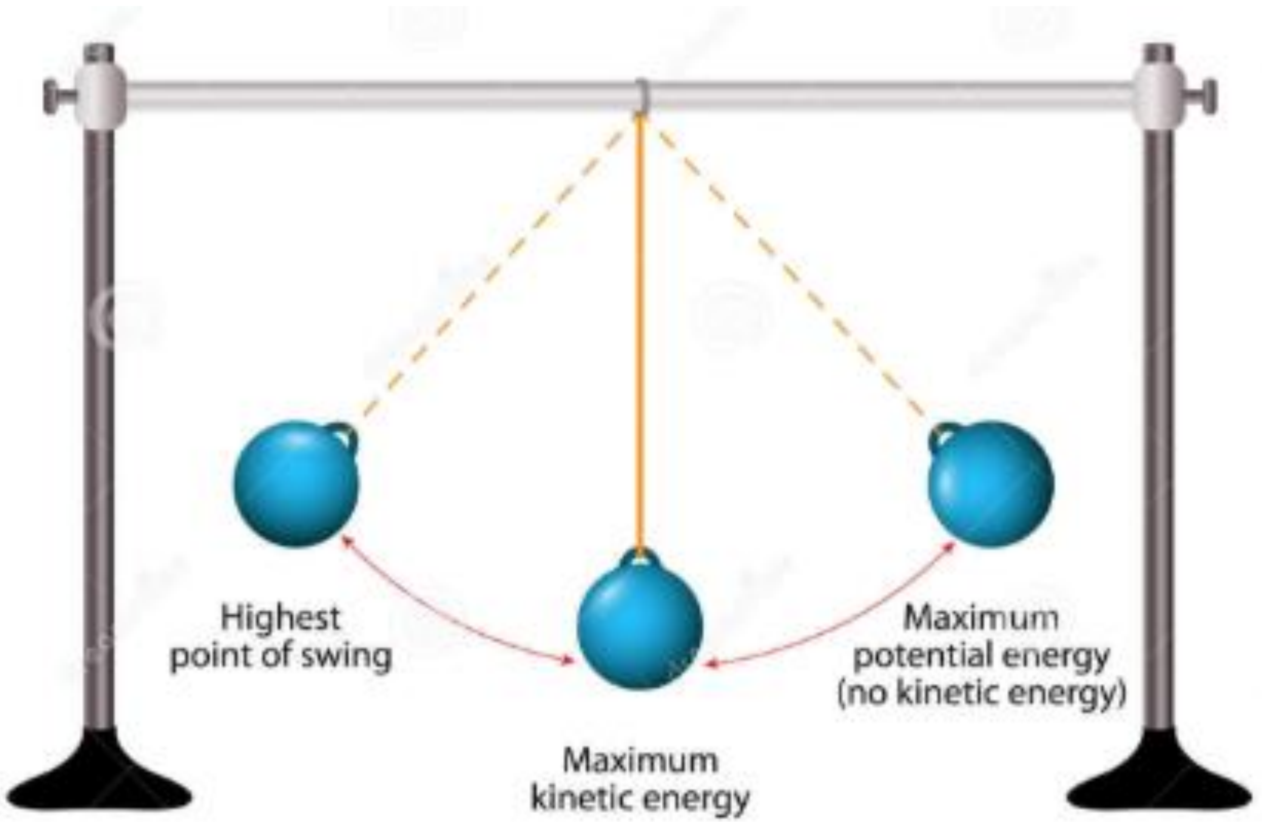
Example 2:

A ball with a mass of 0.95 kg is launched vertically upwards from ground level with an initial speed of 35.0 m/s. What will be the maximum height reached by this ball?

Example 3:

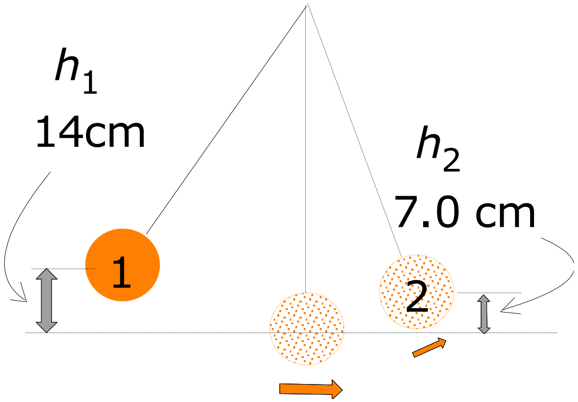
A rock is thrown straight down from the top of a cliff 9.0 m above the water. The initial speed of the rock is 8.0 m/s. With what speed will the rock strike the water?

For A Pendulum

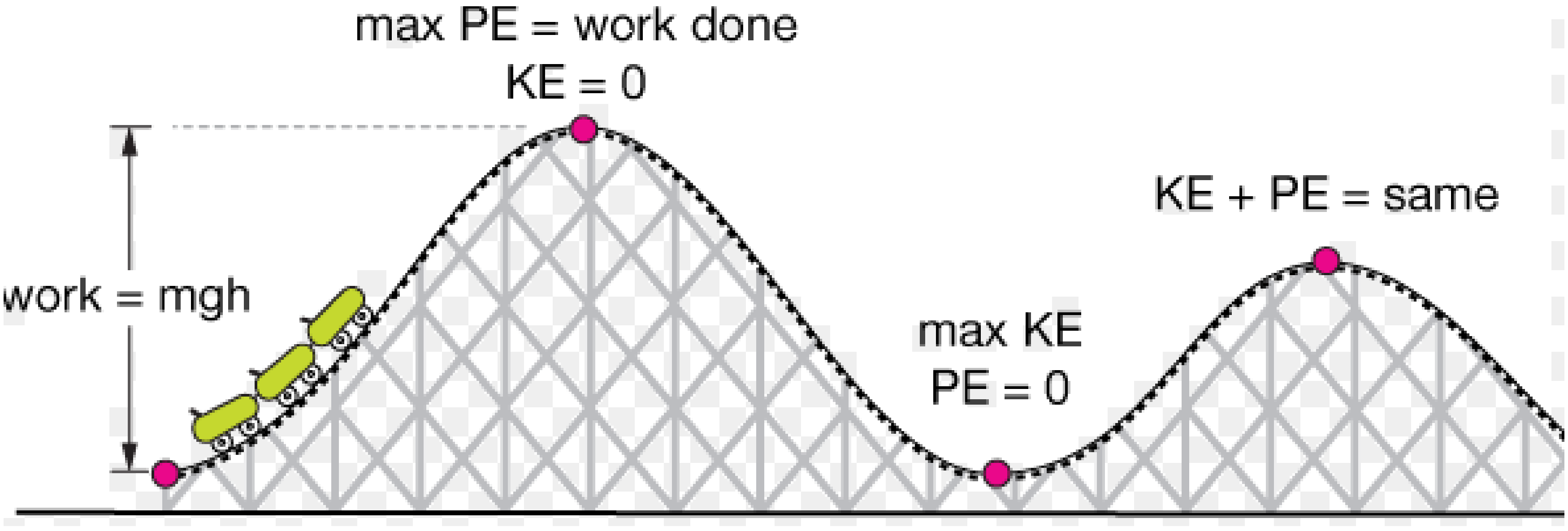


Example 4

The picture shows a pendulum bob that is displaced to a height of 14 cm (position “1”). How fast will it be moving at position “2” which is 7.0 cm above its lowest position?



For Roller Coaster



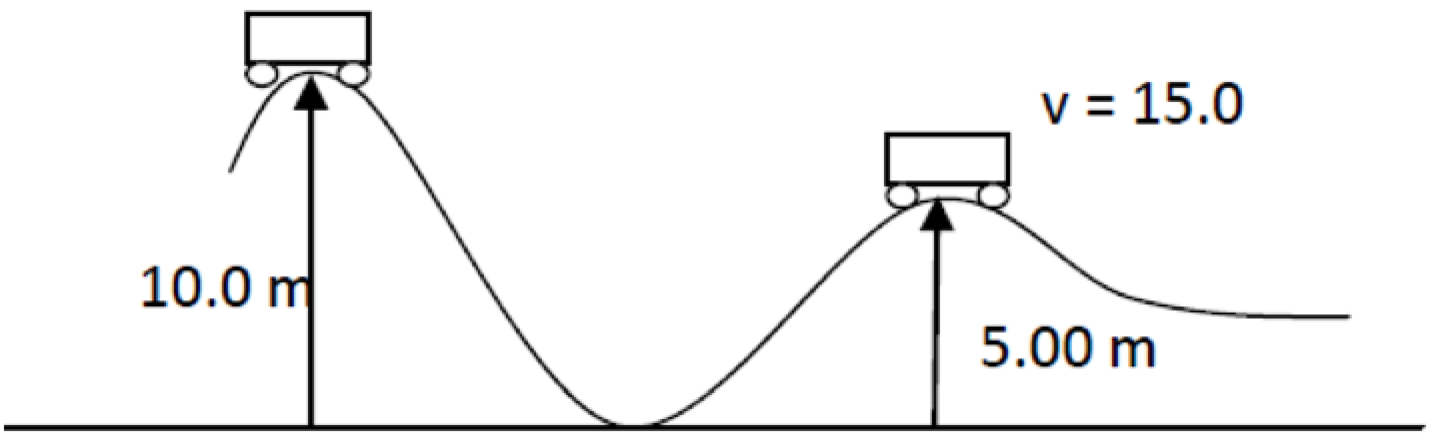
Example 5

A 5.00×10^2 kg roller coaster travels at a speed of 15.0 m/s when at a height of 5.00 m above the ground (assume mechanical energy is conserved).

A) Calculate the kinetic energy at 5.00 m.

B) Calculate the gravitational potential energy at 5.00 m.

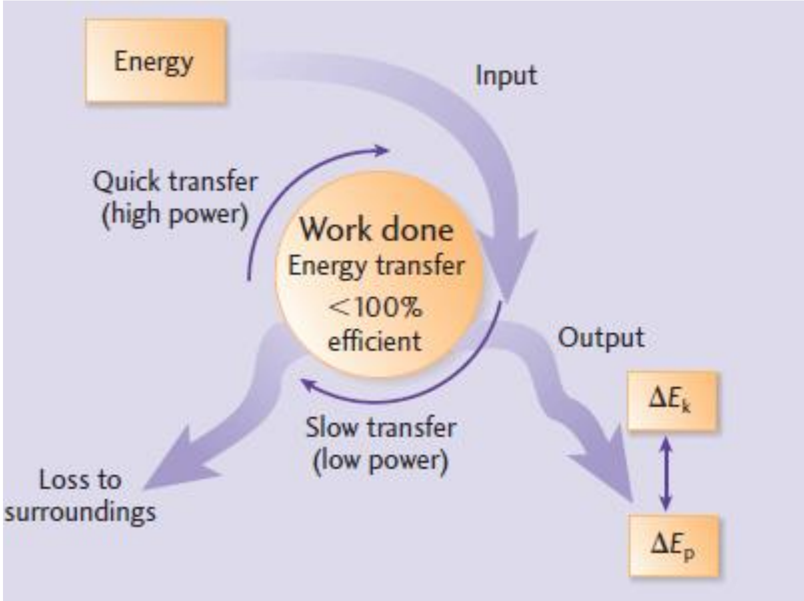
C) Calculate the speed of the roller coaster when it is at a height of 10.0 m.



UNIT 3 Topic 9

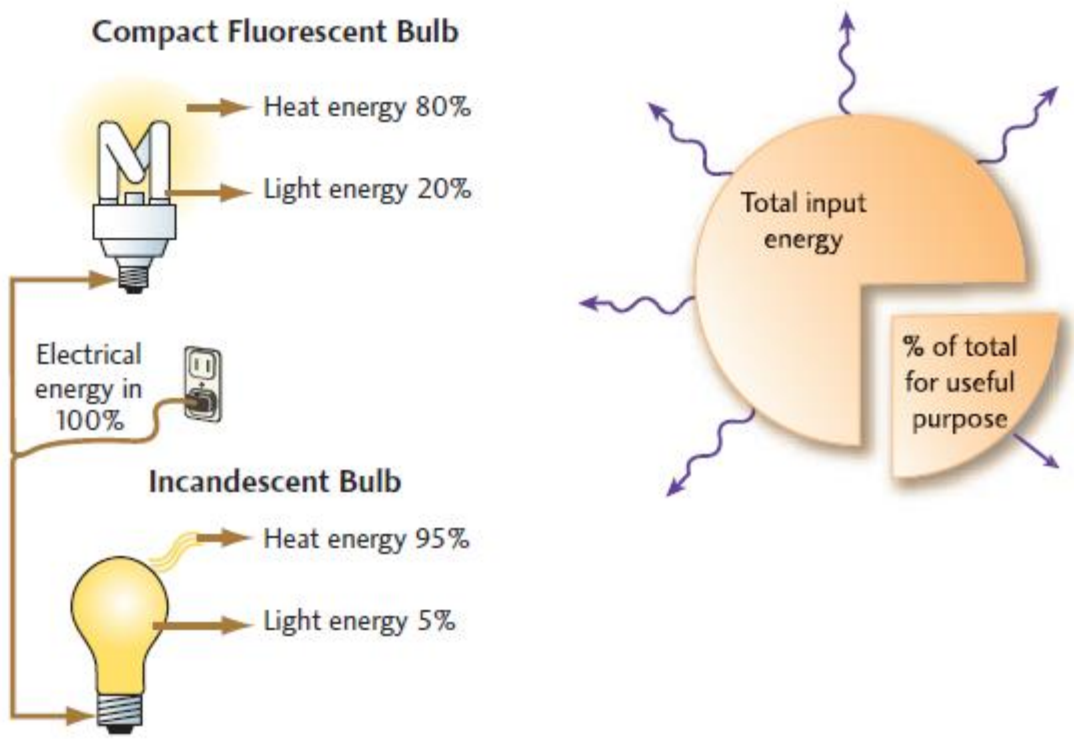
- **Efficiency**

Text: Section



Remember: Conservation Of Energy

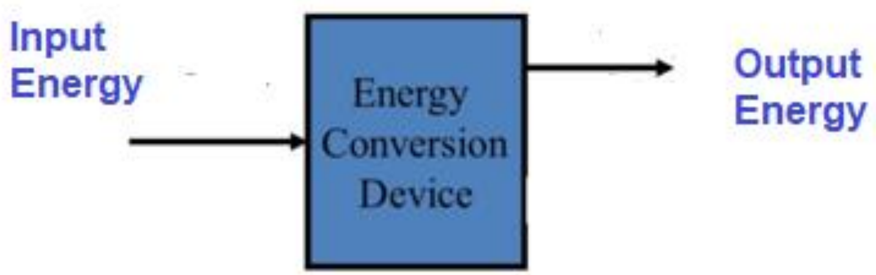
According to the law of conservation of energy, none of the energy is destroyed but energy is transferred from one form to another, However, some of it is transferred to a form that is not useful for its intended purpose.



Input Energy Versus Output Energy

Input Energy (Work In) is the amount of energy going into a system.

Output Energy (Workout) is the amount of energy going out of a system.



Ideal Machine

Ideal machines have 100% efficiency. This means that all of the energy put into the machine exits as useful energy

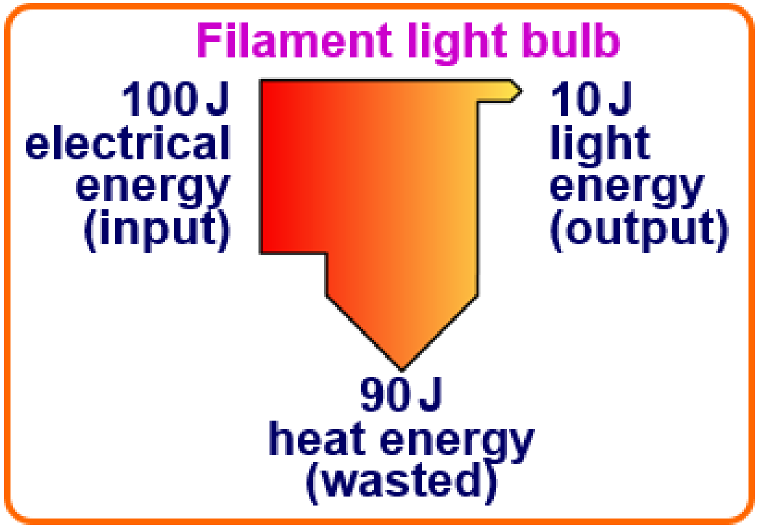
All other machines will ALWAYS have an efficiency of less than 100%

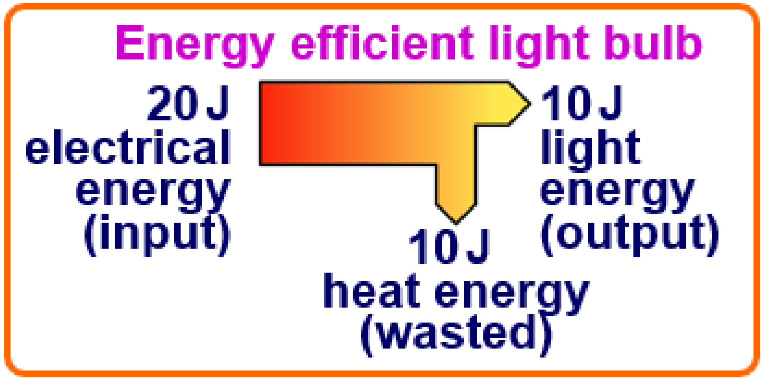
A machine cannot output more work than is put into it

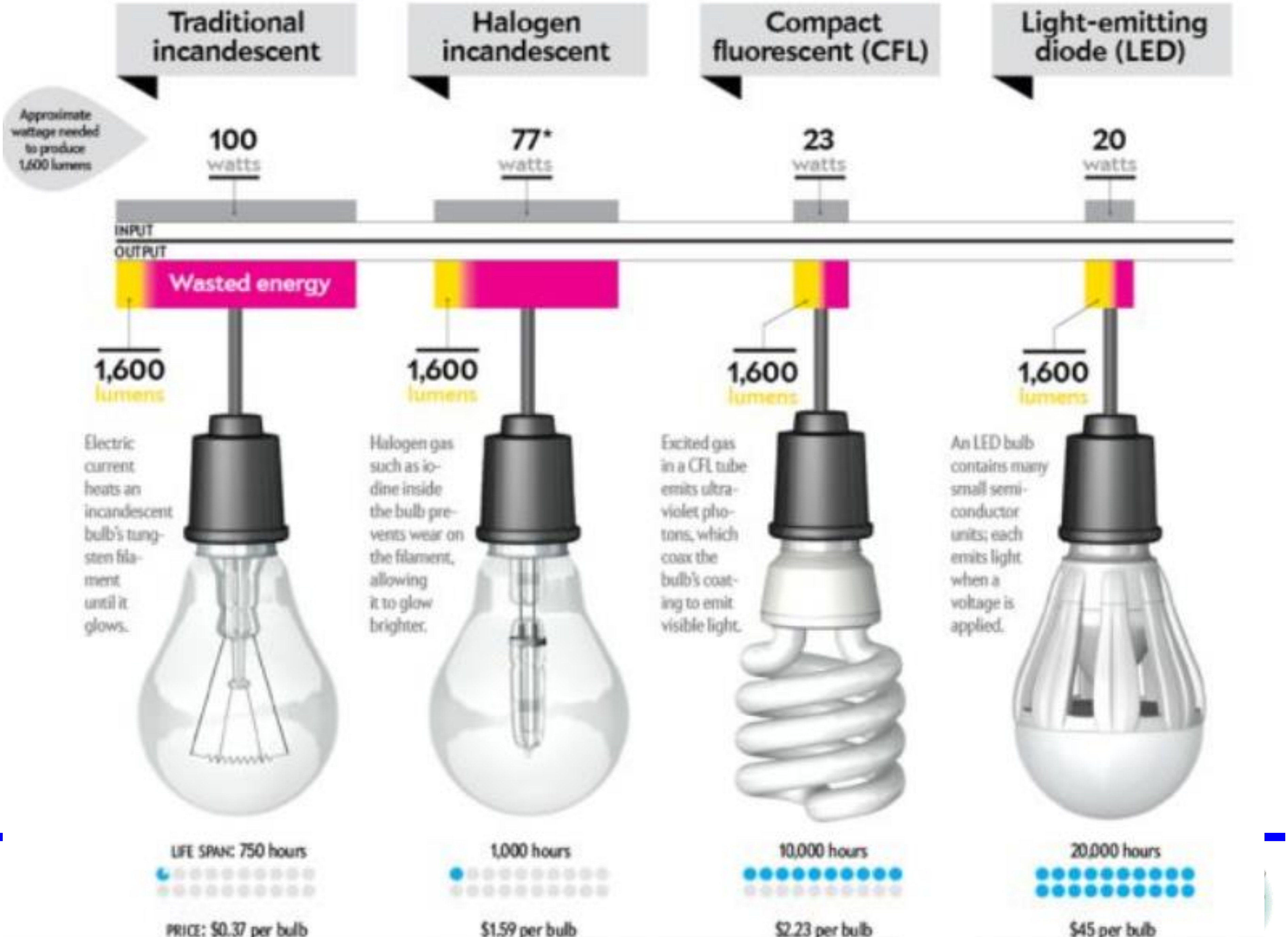
How Is Energy Wasted?

Energy that does not do useful work is called wasted energy

In a mechanical system where the loss is use to friction, the lost energy goes into heat?







Traditional incandescent
Halogen incandescent
Compact fluorescent (CFL)
Light-emitting diode (LED)
Approximate wattage needed to produce 1,600 lumens
100 watts
77* watts
23 watts
20 watts
INPUT
OUTPUT
Wasted energy
1,600 lumens
1,600 lumens
1,600 lumens
1,600 lumens
Electric current heats an incandescent bulb's tungsten filament until it glows.
Halogen gas such as iodine inside the bulb prevents wear on the filament, allowing it to glow brighter.
Excited gas in a CFL tube emits ultraviolet photons, which coax the bulb's coating to emit visible light.
An LED bulb contains many small semiconductor units; each emits light when a voltage is applied.
LIFE SPAN: 750 hours
1,000 hours
10,000 hours
20,000 hours
PRICE: $0.37 per bulb
$1.59 per bulb
$2.23 per bulb
$45 per bulb

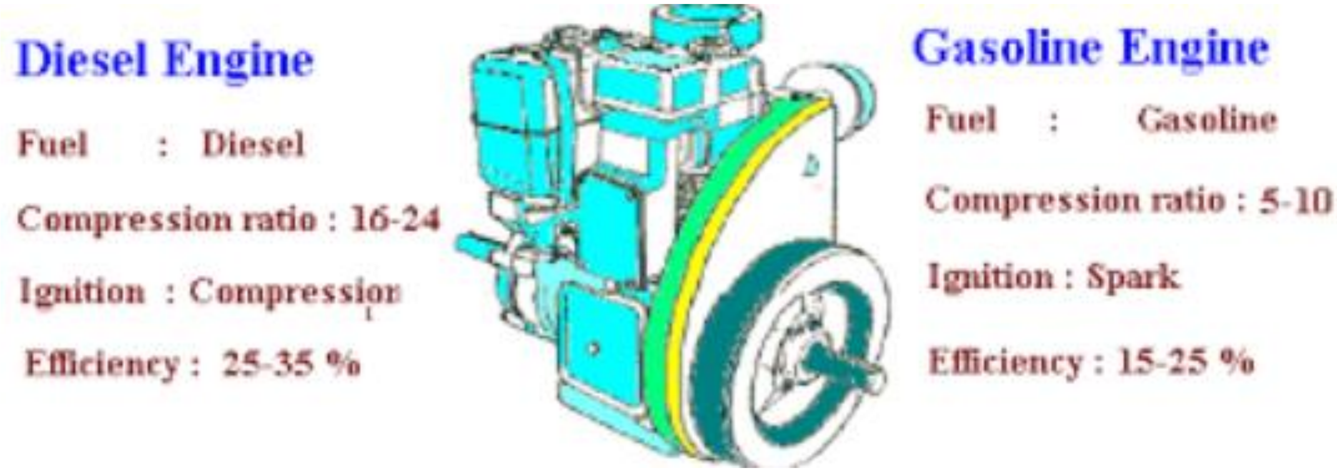
Energy Transfer In A Car Engine

What are the main energy transfers in a **car engine**?

(Don't forget the wasted energy.)

chemical → **kinetic**, **sound**, **heat**

Gas Versus Diesel



Diesel engines are more fuel efficient and have more low-end torque than similar-sized gasoline engines, and diesel fuel contains roughly 10% to 15% more energy than gasoline. So, diesel vehicles can often go about 20% to 35% farther on a gallon of fuel than their gasoline counterparts

EFFICIENCY

- **Efficiency:** a measure (usually expressed as a percent) of the amount of useful output energy from a machine, compared with the input energy needed to run a machine.

$$\text{Efficiency} = \frac{\text{Output Energy}}{\text{Input Energy}} \times 100\%$$

- Nothing is perfectly efficient, therefore, Work in is usually greater than work out.

Example1:

What is the efficiency of a crane that uses 5.10×10^5 J of energy to lift 1000 kg a vertical height of 32.0 m?

Example 2:

A quad with a weight of 2450 N needs to be raised to a height of 0.60 m so it can be placed in the pan of a pickup truck.

A) Use the given information to calculate Wout.

B) Several planks are used to make a ramp that is 2.5 m long. With the ramp, an applied force of 625 N can be used to move the quad into the truck. Use this information to calculate Win.

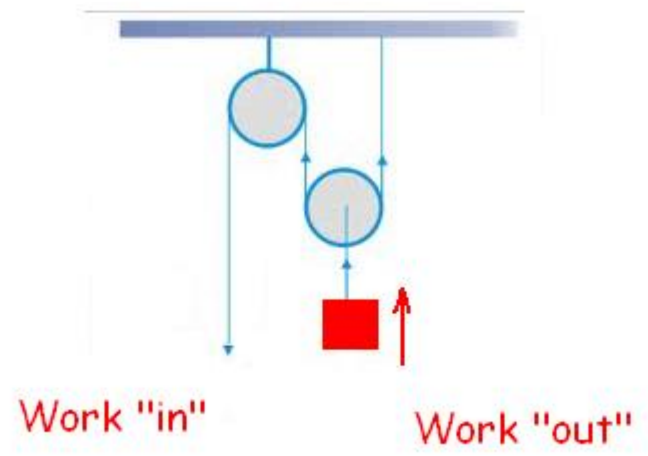
C) What is the efficiency of the ramp?

Example 3:

The handle of a screw jack is 0.30 m long. An applied force of 50.0 N allows it to make one complete revolution. This raises a load of 800 kg by 1.0 cm. Use the given information to calculate the efficiency of the jack.

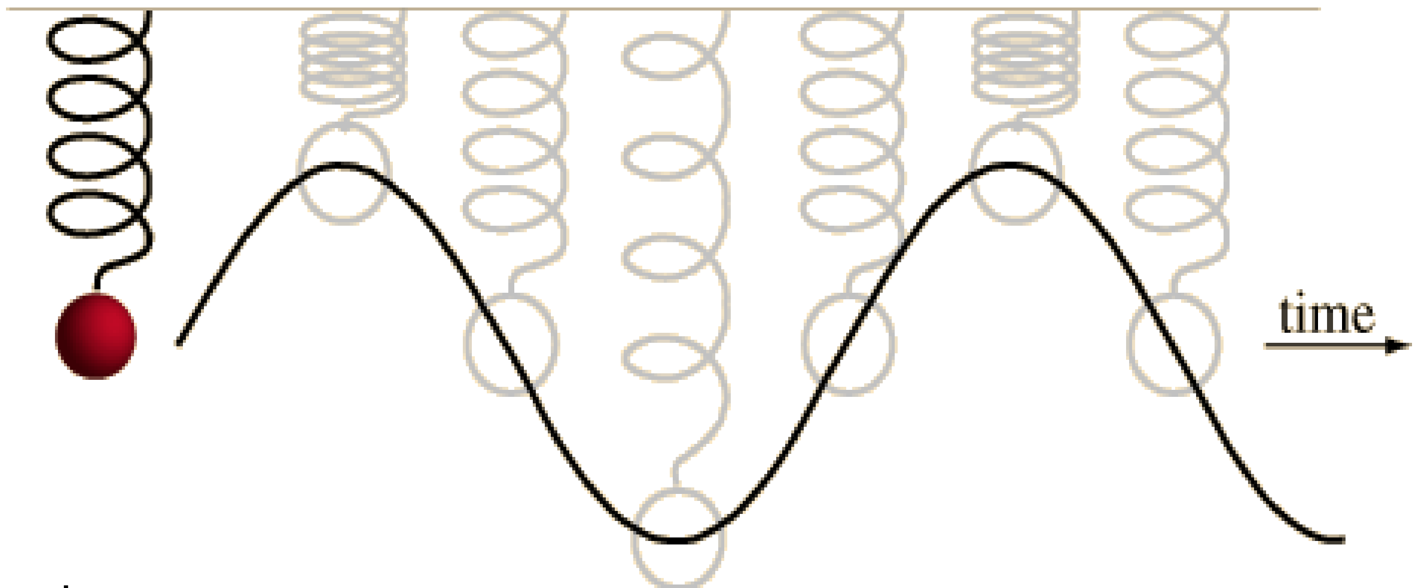
Example 4:

Suppose that it is estimated that a pulley arrangement is 95% efficient. It is to be used to raise a 3900 N engine block to a height of 1.3 m. What W_{in} is required?



UNIT 3 Topic 10

- **Simple Harmonic Motion (SHM)**

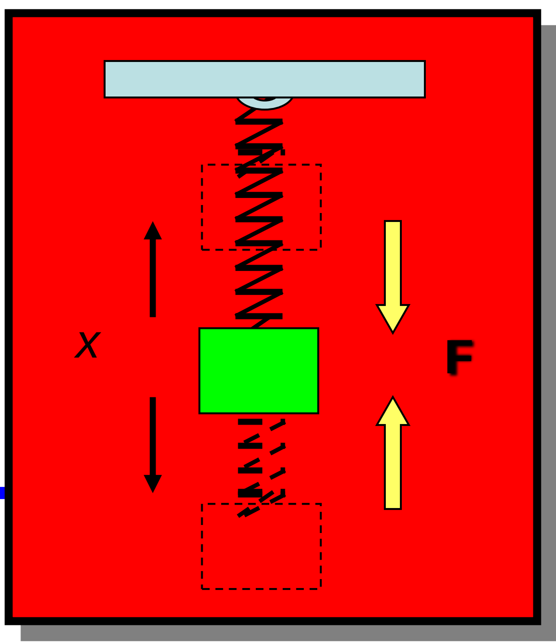


Text: Section

Simple Harmonic Motion, SHM

Simple harmonic motion is periodic motion in the absence of friction and produced by a restoring force that is directly proportional to the displacement and oppositely directed.

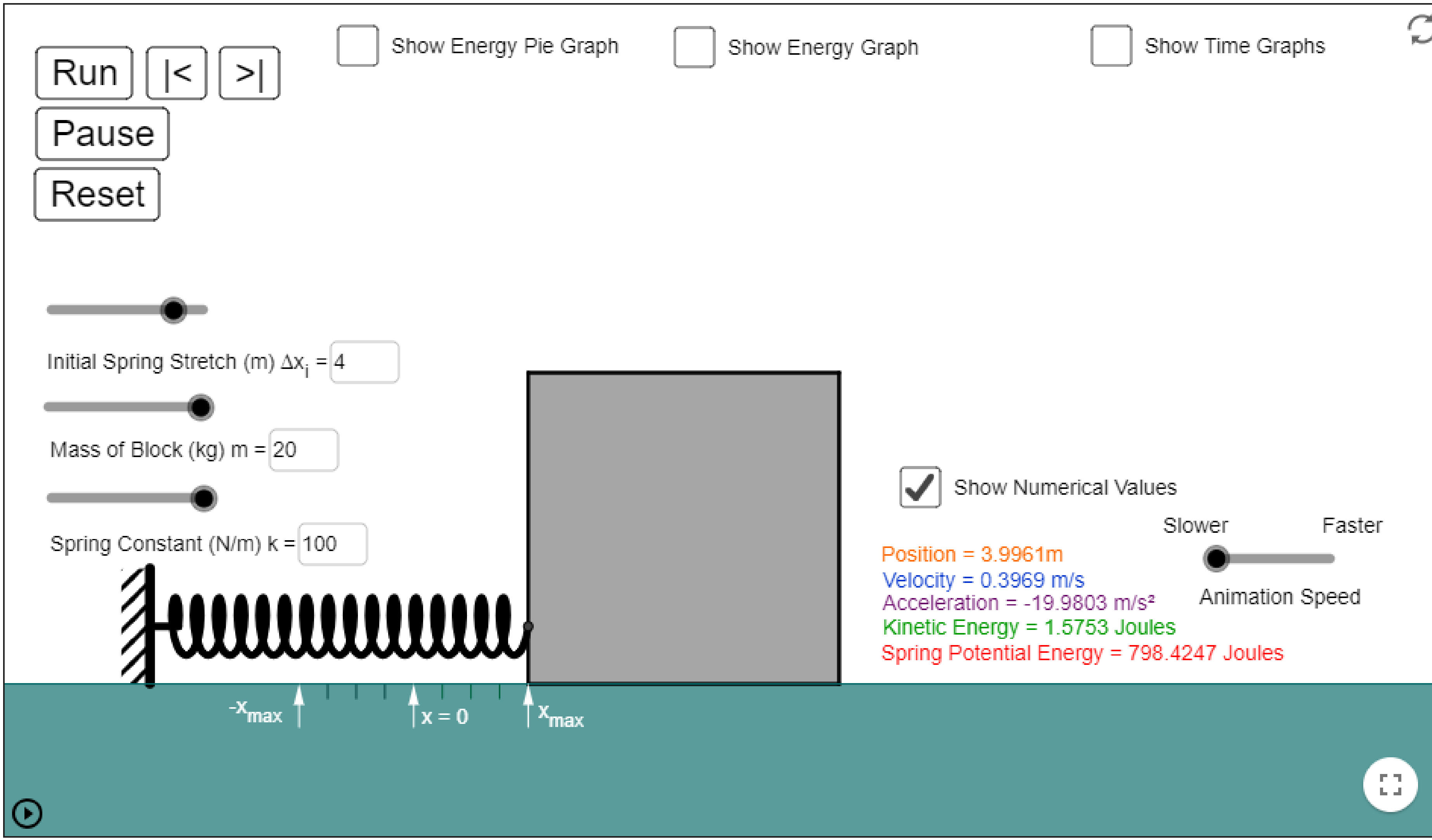
An example of simple harmonic motion would be a mass attached to a spring moving back and forth Objects.



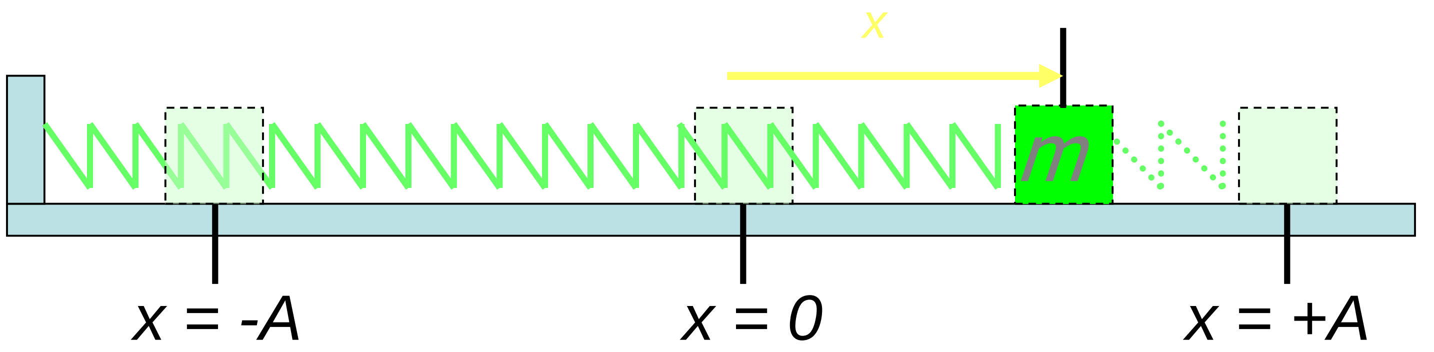
A restoring force, F, acts in the direction opposite the displacement of the oscillating body.

$F = -kx$

SIMPLE HARMONIC MOTION (SHM) SIMULATION LAB



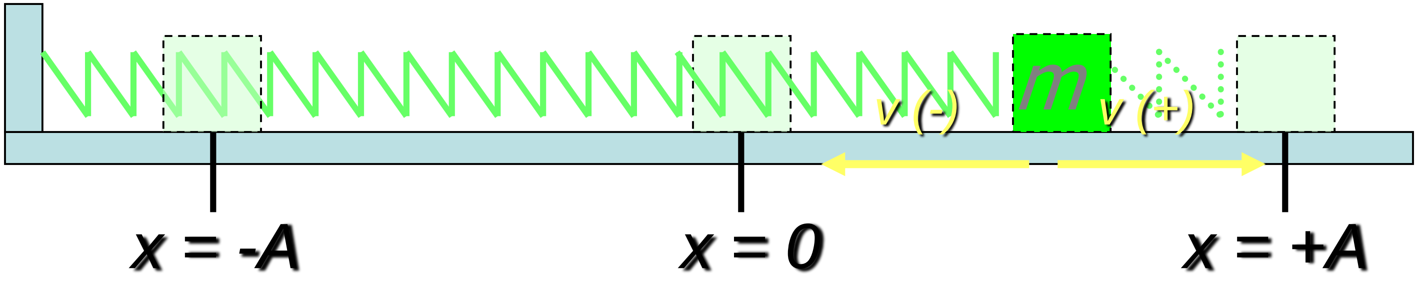
Displacement in SHM



- Displacement is positive when the position is to the right of the equilibrium position (x = 0) and negative when located to the left.

- The maximum displacement is called the amplitude A.

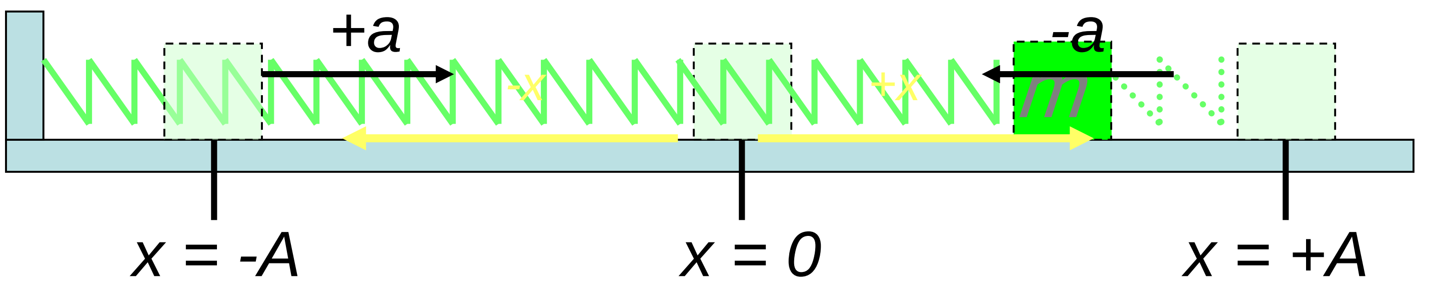
Velocity in SHM



- Velocity is positive when moving to the right and negative when moving to the left.

- It is zero at the end points and a maximum at the midpoint in either direction (+ or -).

Acceleration in SHM

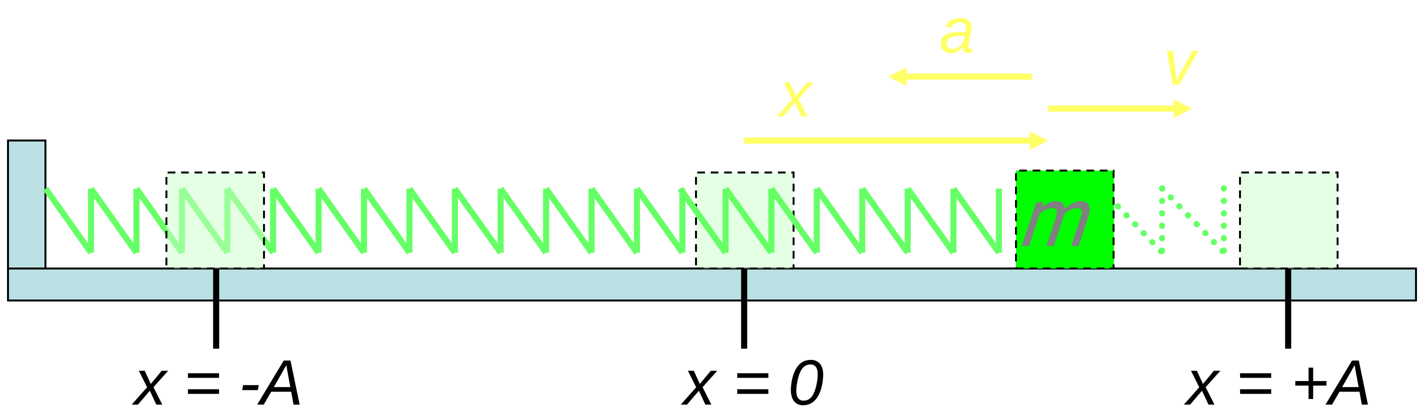


- **Acceleration is in the direction of the restoring force. (*a* is positive when x is negative, and negative when x is positive.)**

$$F = ma = -kx$$

- Acceleration is a maximum at the end points and it is zero at the center of oscillation.

Acceleration vs. Displacement



Given the spring constant, the displacement, and the mass, the acceleration can be found from:

$$F = ma = -kx$$

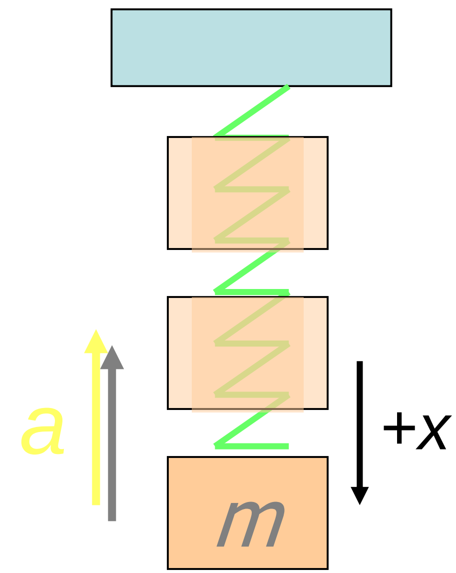
or

$$a = \frac{-kx}{m}$$

Note: Acceleration is always opposite to displacement.

Example 1:

A 2-kg mass hangs at the end of a spring whose constant is k = 400 N/m. The mass is displaced a distance of 12 cm and released. What is the acceleration at the instant the displacement is x = +7 cm?



Example 2:

A 150 g mass is attached to a spring and pulled 7.5 cm to the right with a force of 12.0 N. The system oscillates horizontally.

(A) Draw a rough sketch of the set-up. Calculate
(B) the maximum acceleration of the mass
(C) the acceleration when the mass is in the mid-point of the oscillation
(D) the acceleration 5.0 cm to the right of the equilibrium position
(E) the acceleration 6.0 cm to the left of the equilibrium position

Example 3

A spring with a 0.250 kg mass attached is stretched 12.0 cm from equilibrium by a force of 7.5 N. Determine

(a) the amplitude of the oscillation
(b) the maximum velocity
(c) the magnitude of the velocity when the mass is at half-amplitude