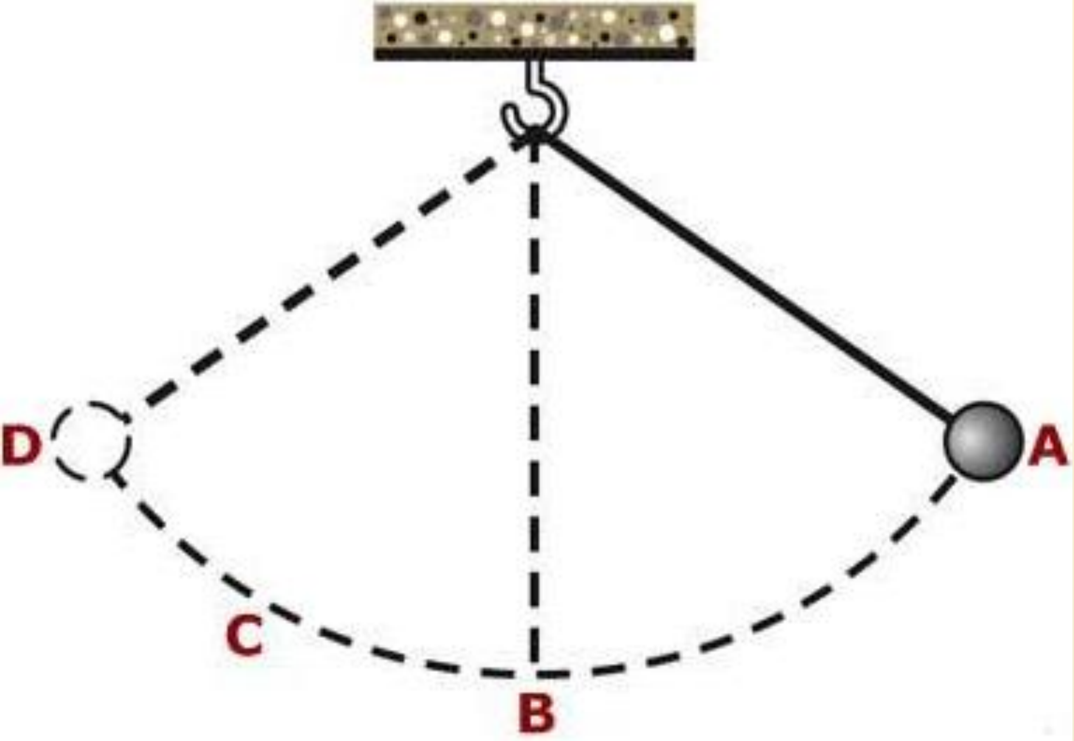
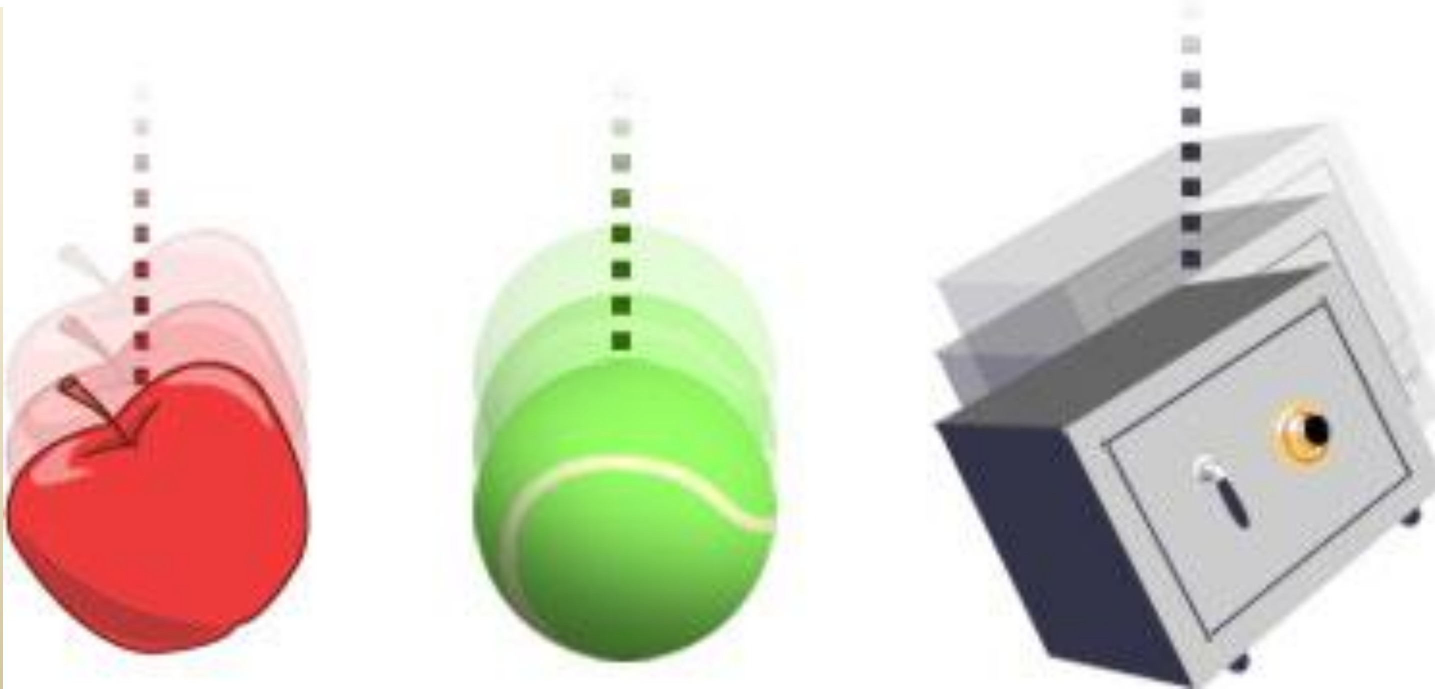


Energy

Chapter 15



WARM-UP

Name types of Energy.

Name types of Energy.

Kinetic & Potential

Light
Nuclear
Mechanical
Heat
Chemical
Electrical
Magnetic
Sound

LESSON QUESTION

Focus Questions

1. Define and calculate Potential Energy (PE) in terms of gravitational PE, and explain elastic PE.
2. Define and calculate Kinetic Energy (KE) related to the motion of object.
3. Recognize maximum PE, maximum KE, maximum velocity, rest position, and when PE = KE for moving objects.
4. Identify specific forms of energy and how they can be transformed into other forms.

Energy & Work

Energy → The ability to do work

There are two branches of Energy:

Potential (PE) → stored or inherent (built in)

Kinetic (KE) (energy of motion).

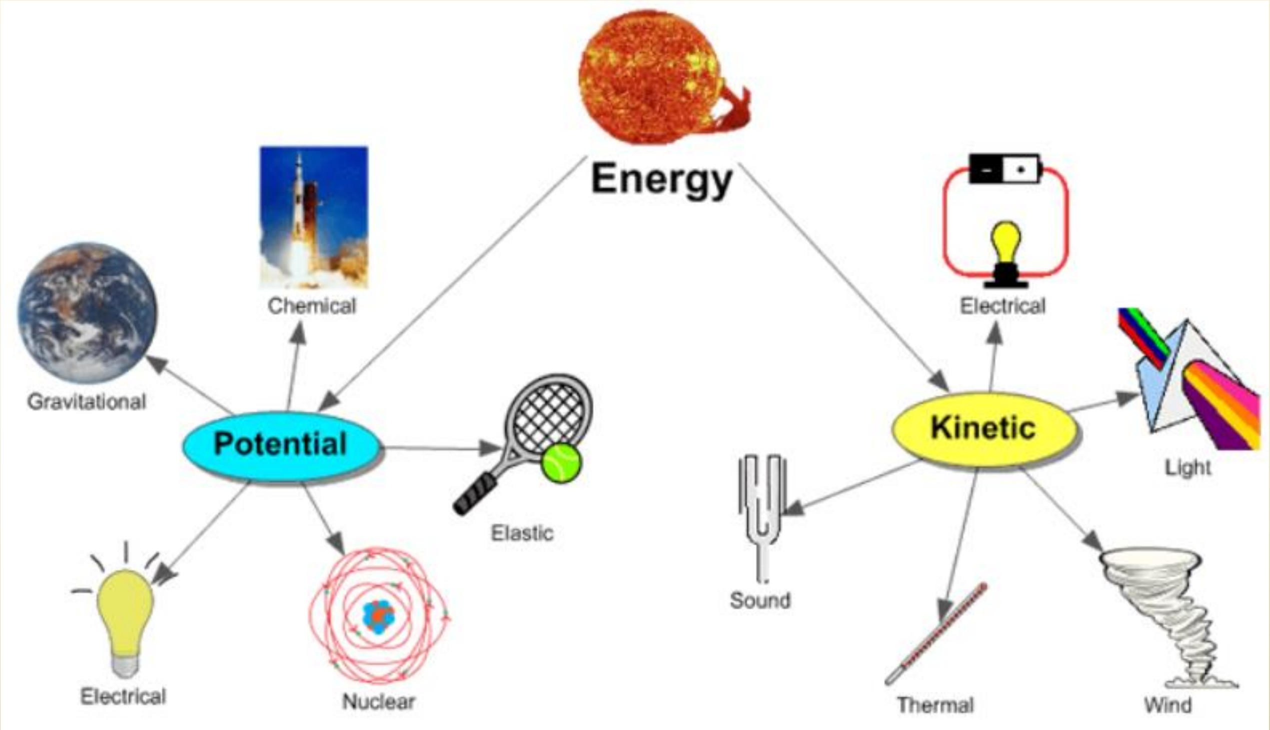
- Without motion, only PE exists.
- Moving objects usually have both PE & KE.
- Units of energy: joules (j).

Energy & Work

All the "forms" of energy … Light, Nuclear, Mechanical, Heat, Chemical, Electrical, Magnetic, and Sound involve the interaction of PE & KE.

Potential (PE) → stored or inherent (built in)

Kinetic (KE) (energy of motion).



Energy & Work

Whenever a net force is applied to an object, work is done.

Work = force x distance

W = f x d … measured in joules (j)

Without motion, no work is done.

An object with potential energy (PE) has the potential to do work.

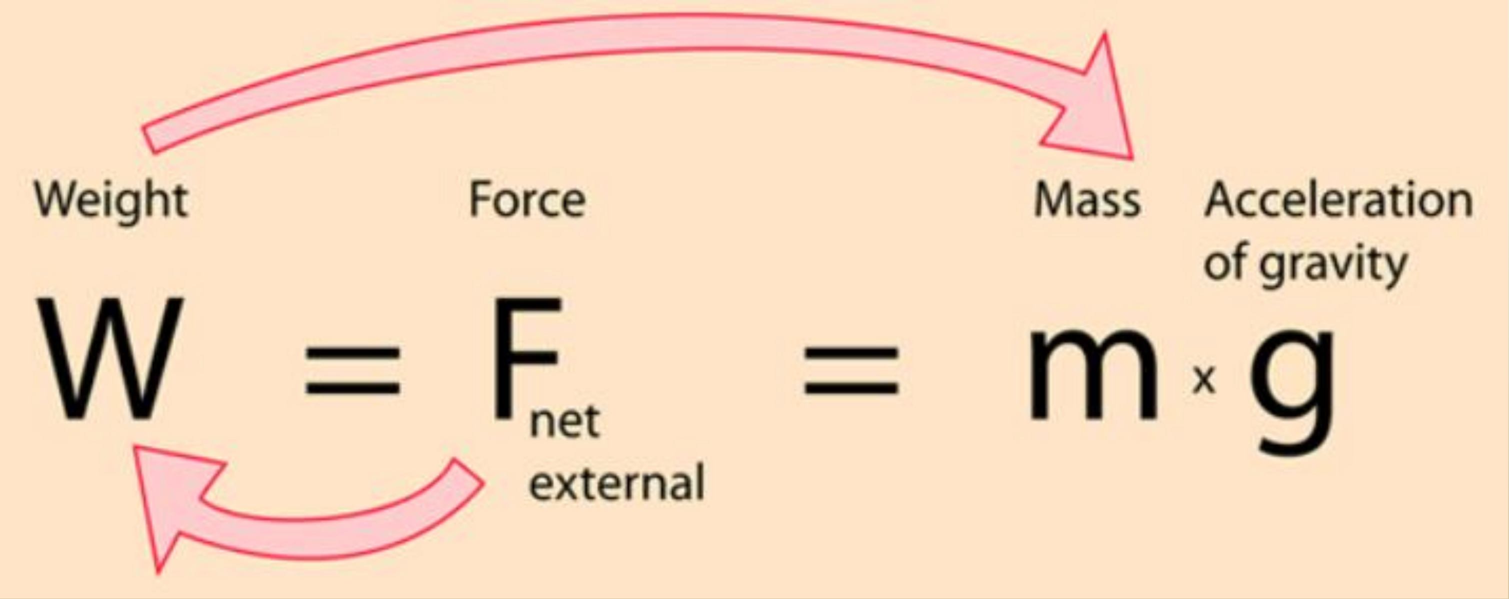
Energy is always conserved but can be changed from one form to another.

Potential Energy (PE)

PE = Work (W = f x d) in the downward direction and represents "potential" to fall. Therefore, replace

W with PE → **PE = f x d**

Force (f) in the downward direction is "weight"



Potential Energy (PE)

PE = Work (W = f d) in the <u>downward</u> direction and represents "potential" to fall. Therefore, replace

W with PE → **PE = f x d**

Force (f) in the downward direction is "weight"

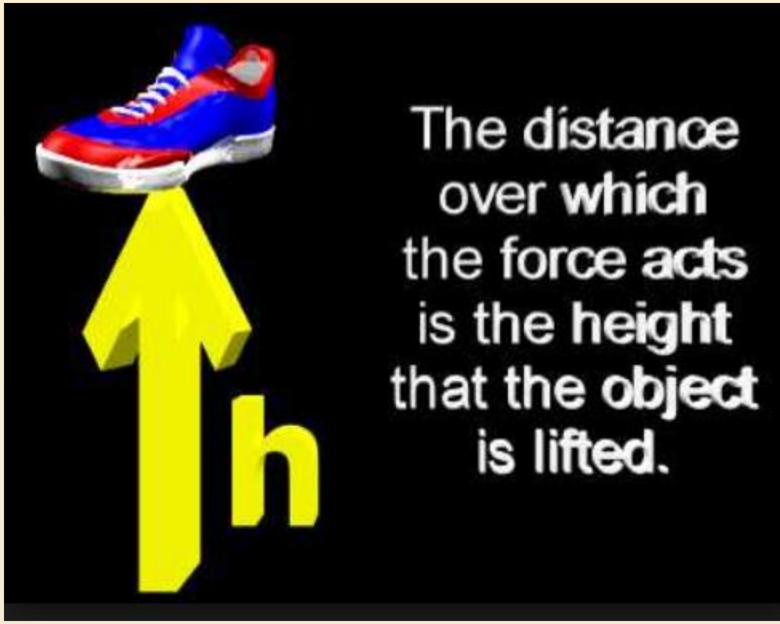
Weight is a force based on an object's mass and the acceleration due to gravity (*i.e. based on Newton's second law: $f = ma$*).

f = W = mass x gravity

$$f = W = mg$$

Potential Energy (PE)

PE = f x d → Since distance (d) is in the downward direction, we can replace "d" with "h" (height) based on the height an object will fall …



$$PE = f \times h$$

Since force (f) is also in the downward direction and equals "weight" (W = mg), replace "f" with "mg":

$$PE = mgh$$

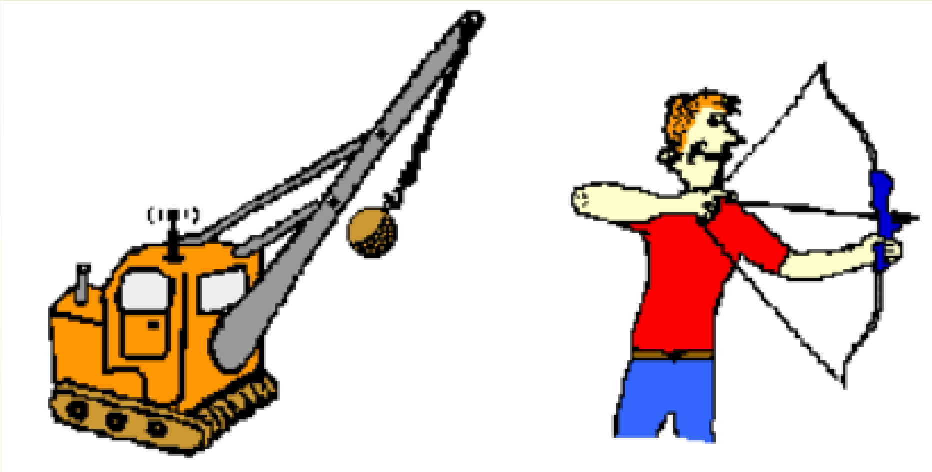
Potential Energy (PE)

THINK ABOUT IT

$$PE = mgh$$

Does a car hoisted for lubrication in a service station have PE? How can you tell?

(*Would you want the car to fall on you?*)



QUICK CHECK

Potential Energy (PE)

$$PE = mgh$$

How does the PE change if the car is hoisted twice as high?

How does the PE change if the car is hoisted three times as high?

How does the PE change if the car is twice as massive?

The energy stored in the bonds between atoms of a compound is called ___ energy.

electromagnetic ... chemical energy ... atomic energy ... thermal

QUICK CHECK

Potential Energy (PE)

$$PE = mgh$$

How does the PE change if the car is hoisted twice as high?

PE = mg(2H) … twice the PE

How does the PE change if the car is hoisted three times as high?

PE = mg(3H) … three times the PE

How does the PE change if the car is twice as massive?

PE = (2m)gH … twice the PE

The energy stored in the bonds between atoms of a compound is called ___ energy.

electromagnetic ... **chemical energy** … atomic energy … thermal

Potential Energy (PE)

QUICK CHECK

A 0.25 kg (mass) ball drops 2 meters (height) to the floor. How much PE does it have?

A

G

E

S

A small airplane and a helicopter have identical masses. If the airplane's altitude compared to the ground is three times that of the helicopter, how much more gravitational potential energy does the airplane have than the helicopter?

QUICK CHECK

Potential Energy (PE)

A 0.25 kg (mass) ball drops 2 meters (height) to the floor. How much PE does it have?

A PE

G m = 0.25 kg; h = 2 m; g = 10 m/s/s

E PE = mgh

S PE = (0.25 kg)(10 m/s/s)(2 m) = **~5 joules**

A small airplane and a helicopter have identical masses. If the airplane's altitude compared to the ground is three times that of the helicopter, how much more gravitational potential energy does the airplane have than the helicopter? PE = mg(3h) = 3 times as much

Potential Energy (PE)

All major forms of energy have potential energy but we will focus on:

Gravitational PE

PE = mgh … "g" is acceleration due to gravity and applies to any object experiencing gravity.

Elastic PE

Related to any object that is compressed or stretched and recoils back to its original position.

(Give some examples of Elastic PE)

Potential Energy (PE)

Elastic PE

All major forms of energy have potential energy: chemical, electrical, magnetic, mechanical, nuclear, light, sound, and heat.

Kinetic Energy (KE)

KE = Work (W = f x d) in motion or work is the change in kinetic energy (KE) applied to an object.

Replace W with KE → **KE = f x d**

Kinetic Energy (KE)

$$KE = f \times d$$

Force is the unbalanced force that produces motion *and can be defined by Newton's second law:* $f = ma$. Therefore, replace "f" with "ma"

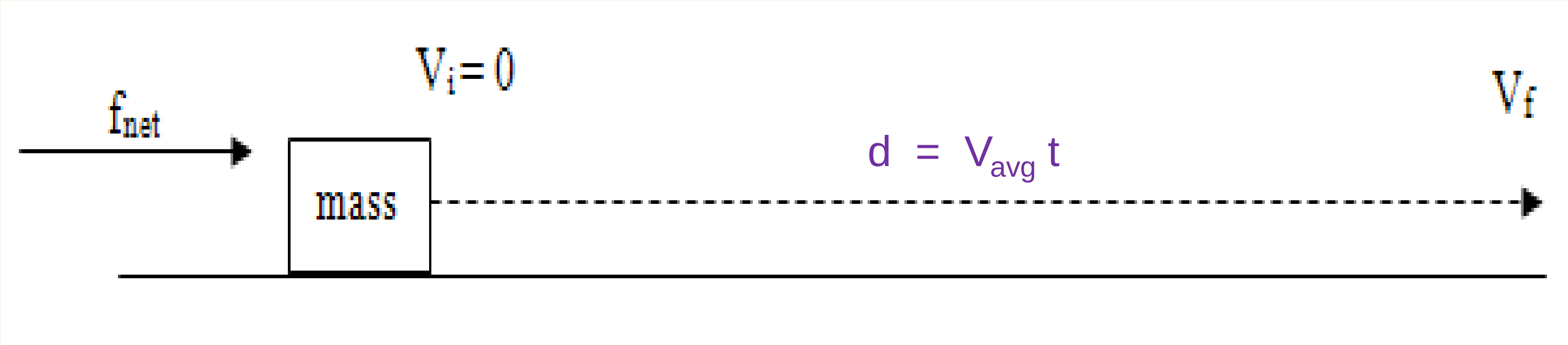
$$KE = mad$$

"d" is the displacement based on the net force acting on an object (doing work on that object in motion).

Kinetic Energy (KE)

Enrichment

A **net force** acting on a mass at rest will produce **acceleration** (**f** = m**a** … therefore, **a** = **f**/m).



acceleration = $(V_f - V_i)/t$

Since $V_i = 0$, $$a = V_f / t$$ (*assume no friction*)

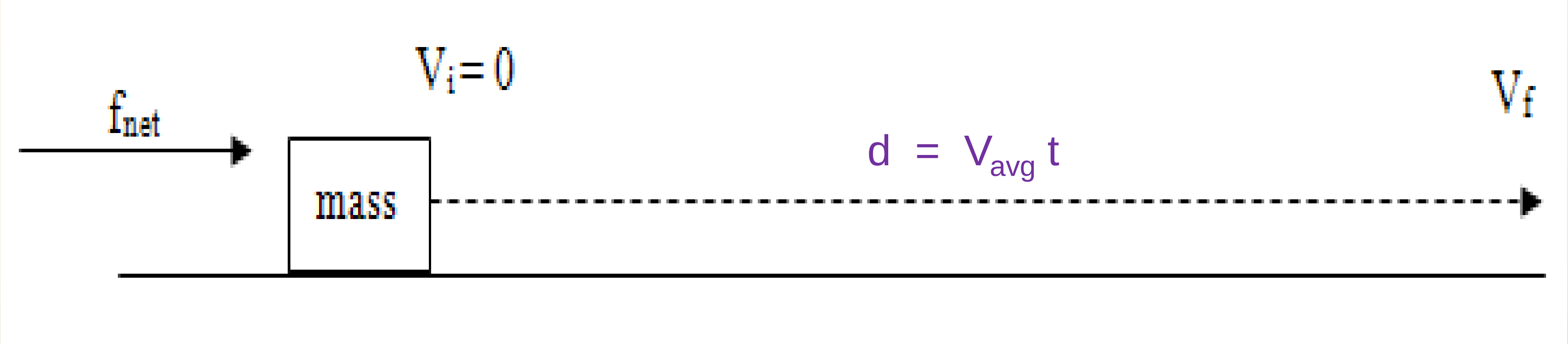
Kinetic Energy (KE)

Enrichment

$$a = V_f / t$$

KE = mad … substitute V_f / t for a:

$$KE = m (V_f / t) d$$



Kinetic Energy (KE)

Enrichment

Displacement (d) is based on the average velocity in a given time, derived from $V_{avg} = d / t$

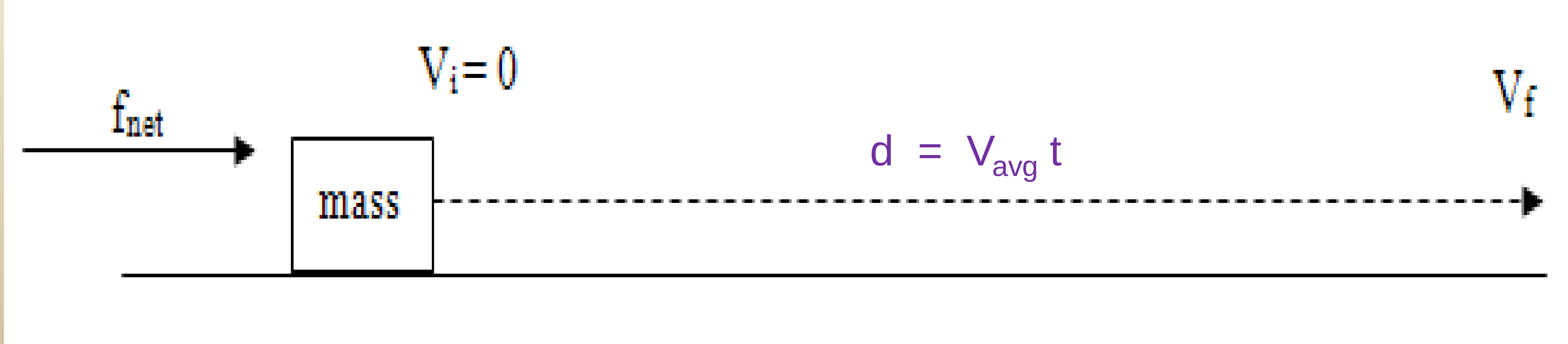
Rearranging: $d = V_{avg}\, t$

Determine $V_{avg} = (V_f + V_i) / 2$

Substituting: $d = V_{avg}\, t = \frac{1}{2} (V_f + V_i)\, t$

In this case, $V_i = 0$ because the mass begins at rest.

Therefore, $d = \frac{1}{2} V_f\, t$



Kinetic Energy (KE)

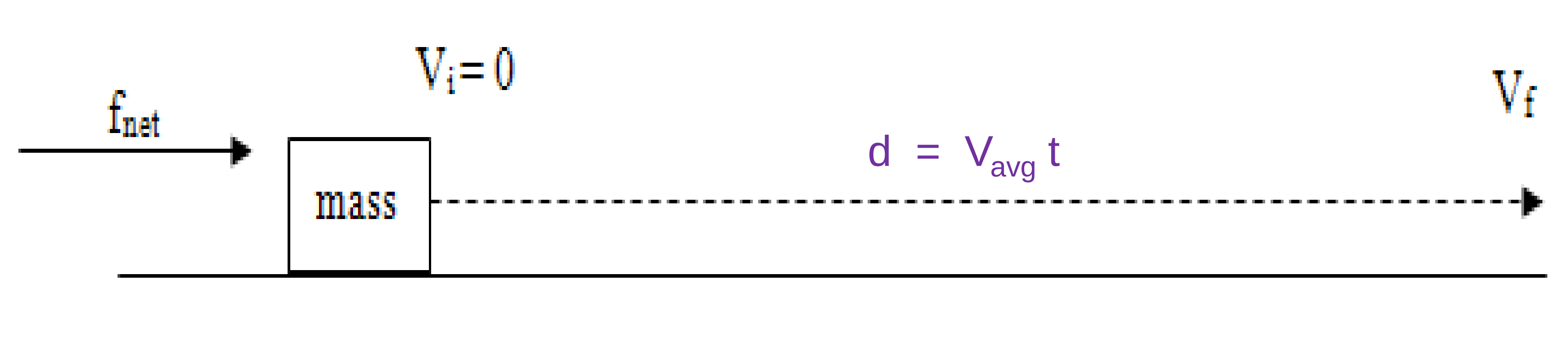
Enrichment

$$KE = m\,(V_f / t)\,d$$

$$d = \frac{1}{2} V_f\, t$$

Substituting: $KE = m\,(V_f / t)\,(\frac{1}{2} V_f\, t)$

$$KE = \frac{1}{2} m V_f^2$$



TRY IT

Kinetic Energy (KE)

$$KE = \frac{1}{2} m V_f^2$$

KE = ½ (mass)(final velocity)^2

When a car slows down due to air drag, what happens to its KE?

How much KE does a 2 kg motion cart have when moving 3 m/s?

TRY IT

Kinetic Energy (KE)

$$KE = \frac{1}{2} m V_f^2$$

KE = ½ (mass)(final velocity)²

When a car slows down due to air drag, what happens to its KE?

decreases

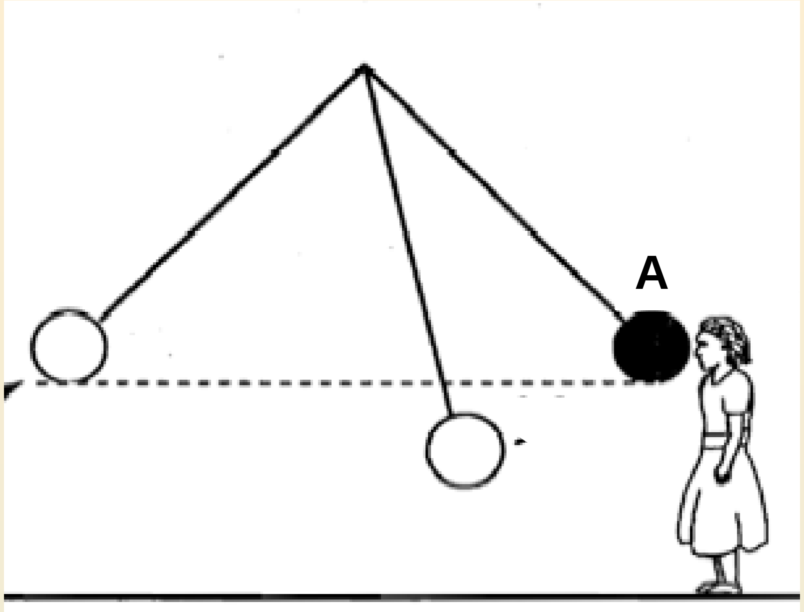
How much KE does a 2 kg (mass) motion cart have when moving 3 m/s (velocity) ?

$KE = 1/2\, mV_f^2 \rightarrow \frac{1}{2}(2\text{ kg})(3\text{ m/s})^2 = 9$ joules

Bravery with a Pendulum

PREDICT:

The girl and point A are at the same height. If the Ball is released from Point A (touching her nose) and allowed to swing back and forth, will it hit the girl?

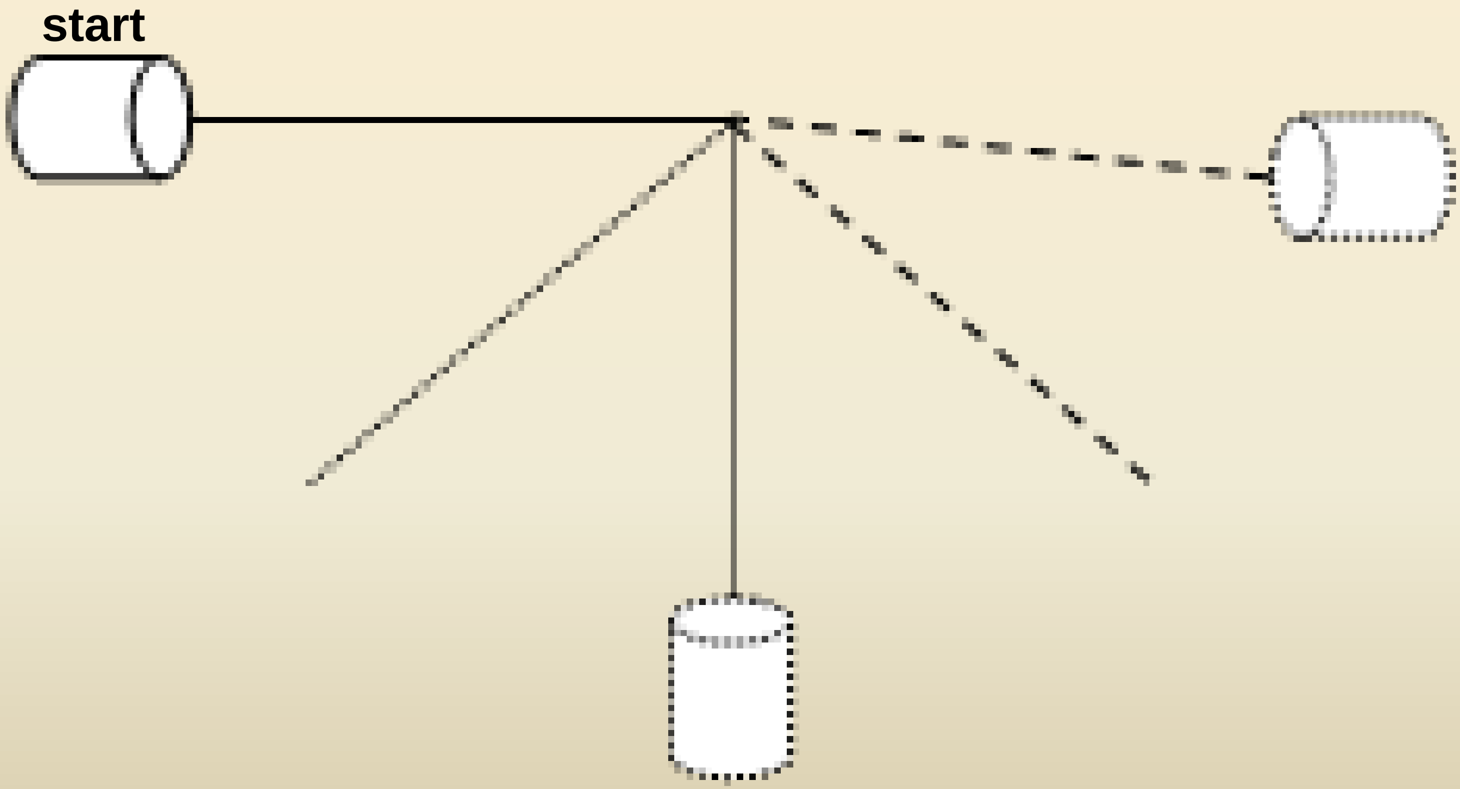


http://somup.com/cFX2bVniRL

(1:17)

Energy of a Pendulum

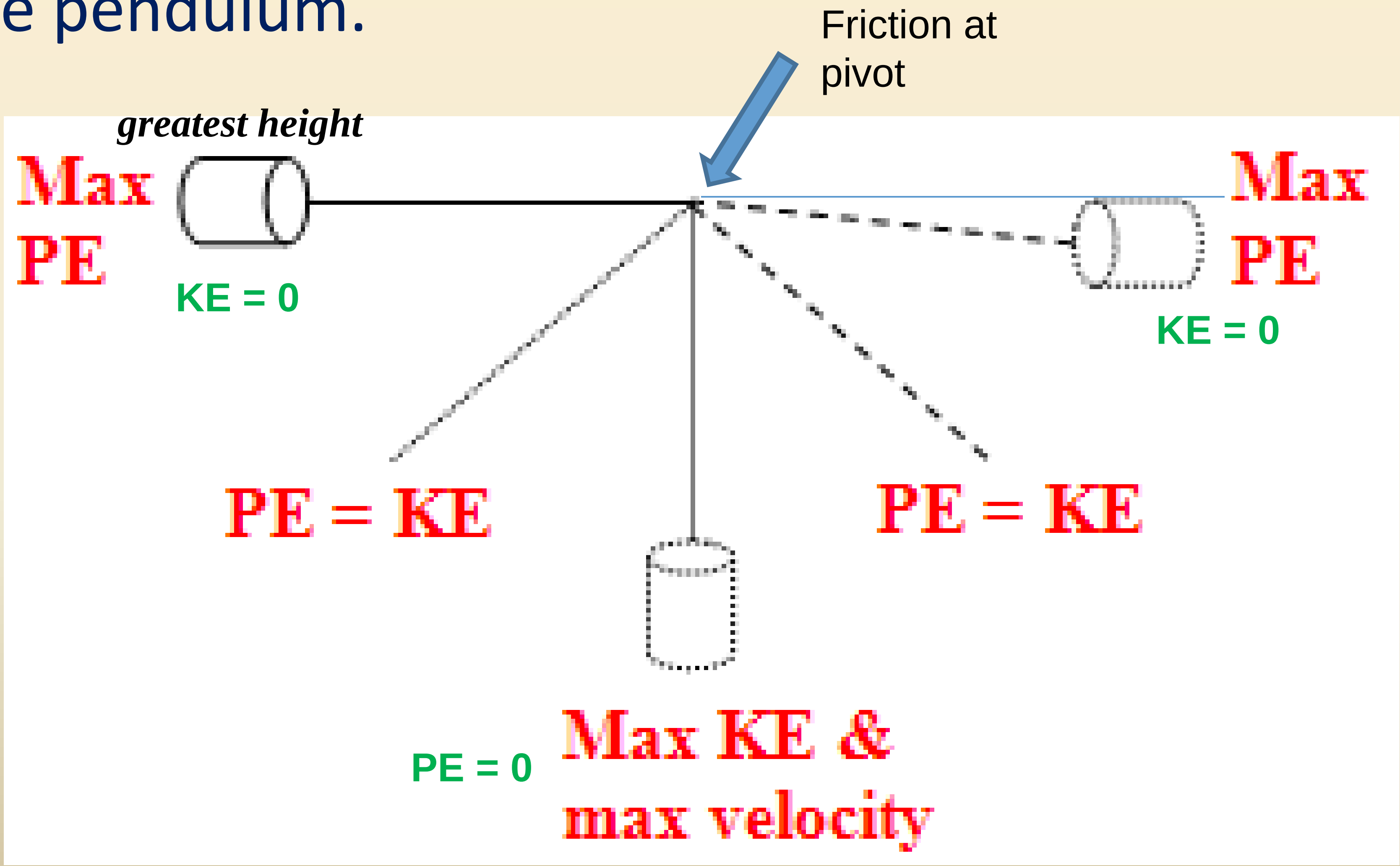
Describe the energy (PE & KE) at each position of the pendulum.



Why doesn't the mass swing to the same height on the right side?

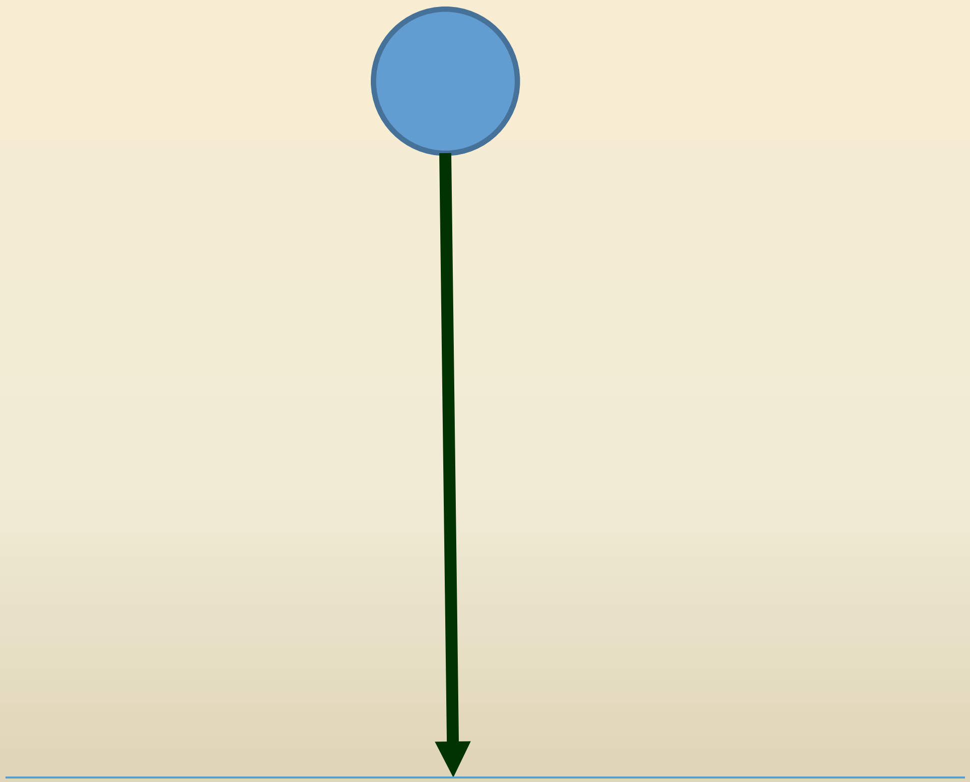
Energy of a Pendulum

Describe the energy (PE & KE) at each position of the pendulum.



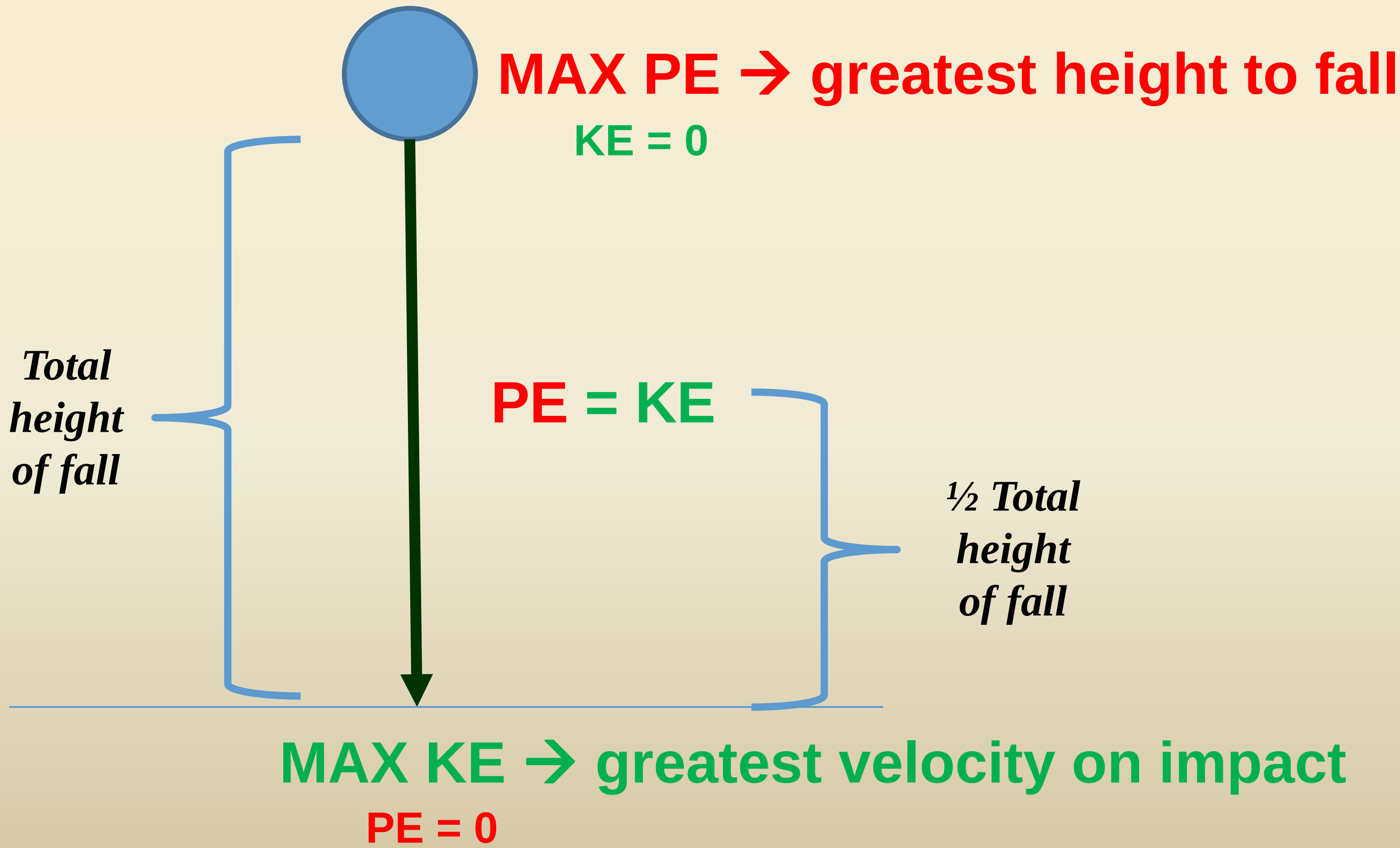
Energy of a Falling Object

Describe the energy (PE & KE) at each position of the object at rest that falls to the ground.



Energy of a Falling Object

Describe the energy (PE & KE) at each position of the object at rest that falls to the ground.



Energy of a Pendulum

What do we call the energy that is stored, ready for motion? What equation is used to calculate this energy?

What do we call the energy of motion? What equation is used to calculate this type of energy?

Based on your observations of a pendulum and a dropped ball, what is the overall ideal relationship between the maximum potential energy and the maximum kinetic energy for either the pendulum or the dropped ball?

Energy of a Pendulum

What do we call the energy that is stored, ready for motion? What equation is used to calculate this energy?

Potential energy $PE = mgh$

What do we call the energy of motion? What equation is used to calculate this type of energy?

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

Based on your observations of a pendulum and a dropped ball, what is the overall ideal relationship between the maximum potential energy and the maximum kinetic energy for either the pendulum or the dropped ball?

Total Energy = PE + KE*, So when PE is Maximum, KE = 0 and when KE is maximum, PE = 0. Therefore max PE = max KE*

Energy Conversions

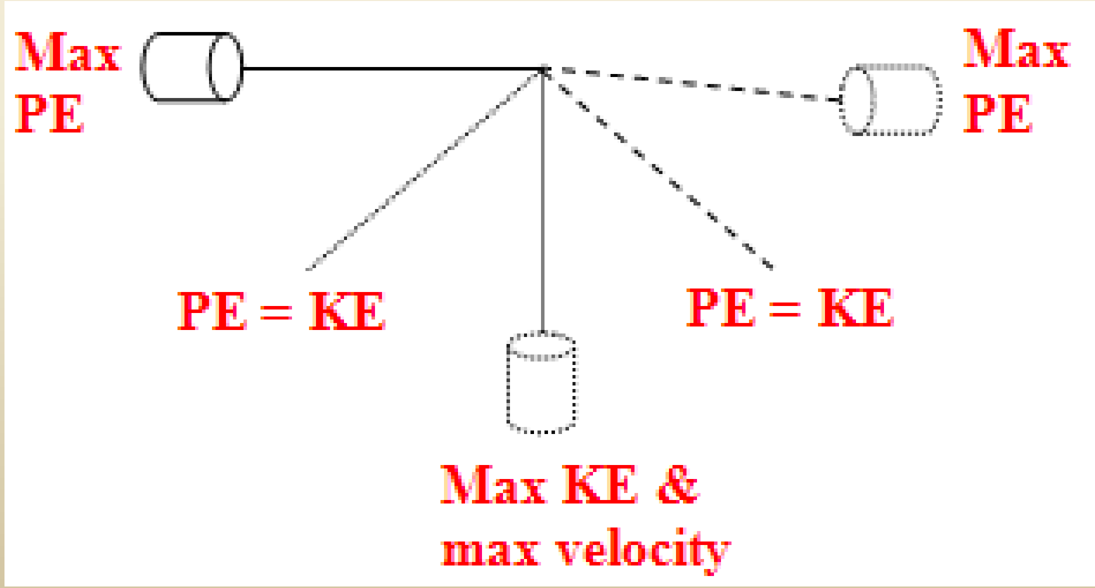
The law of conservation of energy applies to any mechanical process. If friction can be neglected, the total mechanical energy remains constant.

Conservation of Mechanical Energy

$$(KE + PE)_{beginning} = (KE + PE)_{end}$$

Energy of a Pendulum

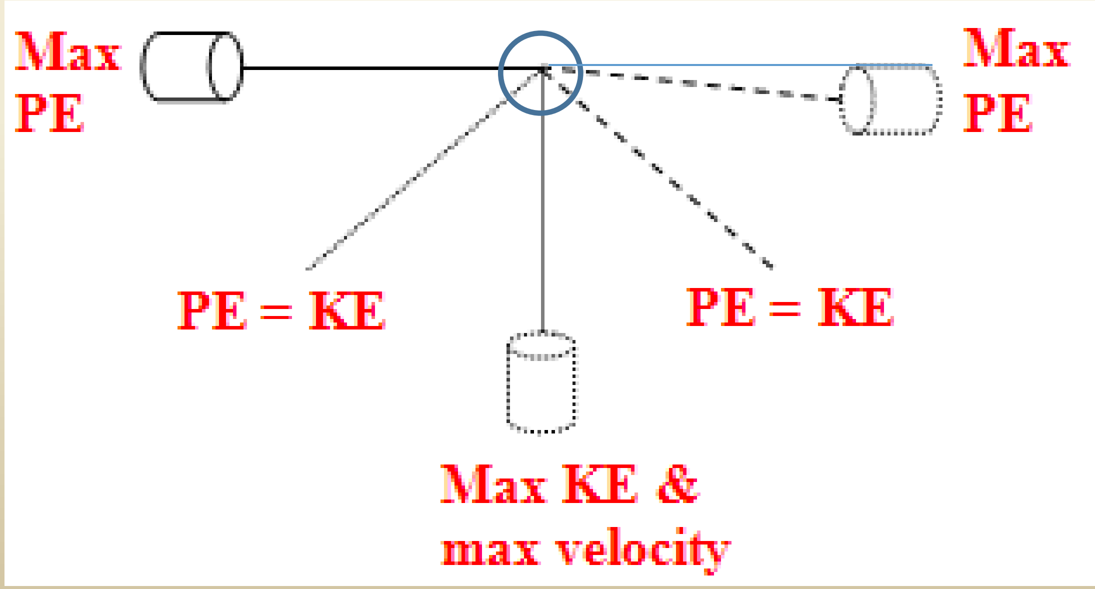
What accounts for the seeming “loss” of energy observed especially in the pendulum swing?



Energy of a Pendulum

What accounts for the seeming "loss" of energy observed especially in the pendulum swing?

***Energy is transformed** (converted into, transferred) into **heat** because of **friction**. The pendulum pivot point was the main source of friction.* *There is minimal air drag.*



Notice the pendulum swing on the RIGHT does not reach the same height as on the LEFT.

Energy Transformation

Specific Forms of Energy (*Each has both PE & KE*)

Chemical energy → The energy associated with chemical changes due to bonds (*energy is also involved with physical changes*) … food, fuel, ammunition.

Mechanical energy → sum total of PE + KE to accomplish a task using force and involving motion (i.e. associated with machines)

*For elastic collisions, mechanical energy is conserved, meaning that no energy is lost (ideal) … e.g. you bounce a ball and it rebounds back to the same height you dropped it from. In **real life** inelastic collisions occur in which some mechanical energy is converted into heat.*

Electrical energy → Stored energy (batteries, clouds before lightning strike, etc.) & the flow of electrons.

Energy Transformation

Light energy (electromagnetic **radiation**)

gamma … *highest energy, highest frequency, shortest wavelength*

X-ray - UV - visible (VIBGYOR) … *400 nm to 700 nm*

infrared - microwave

Radio … *lowest energy, lowest frequency, longest wavelength (> 1 m)*

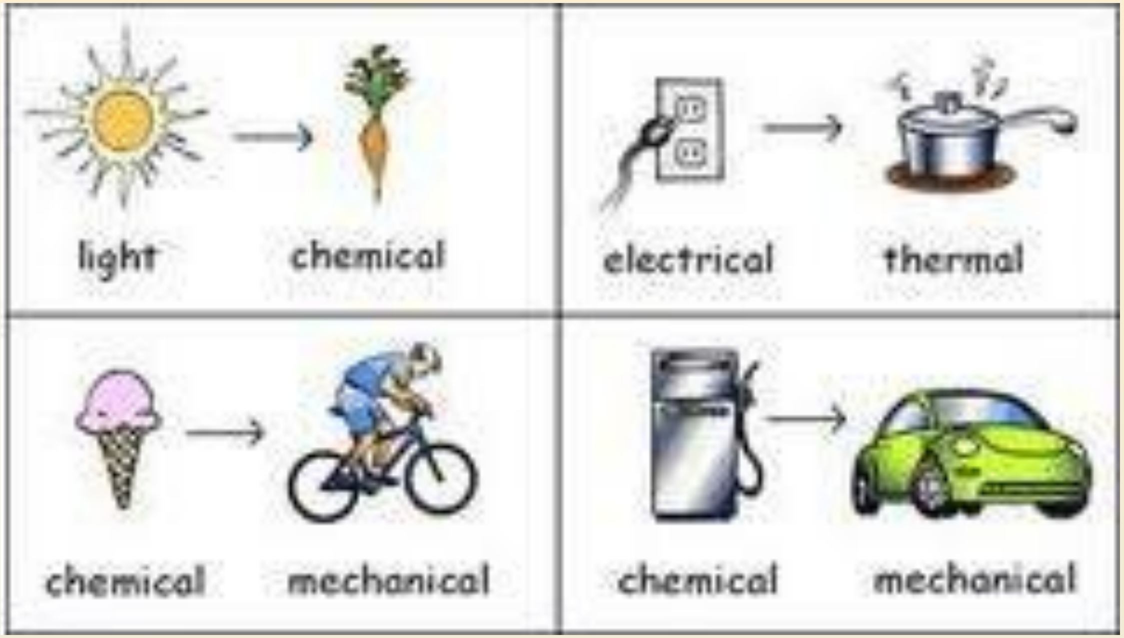
Sound energy → sonar, ultrasound

Magnetic energy → magnetic field (NMR diagnostic techniques) MRI

Heat (thermal) energy → form of energy that takes into account the quantity of matter

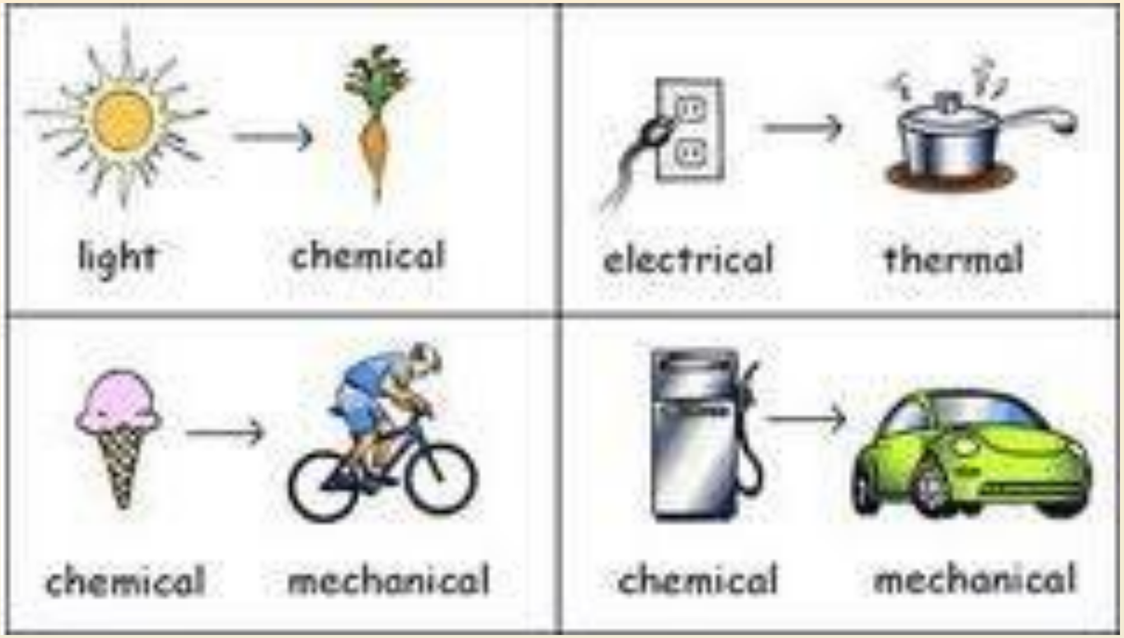
Nuclear Energy → fission (splitting atoms), fusion (combining atoms) … fuel rods versus explosions.

Energy Transformation



What energy transformations are involved with lighting a bulb?

Energy Transformation

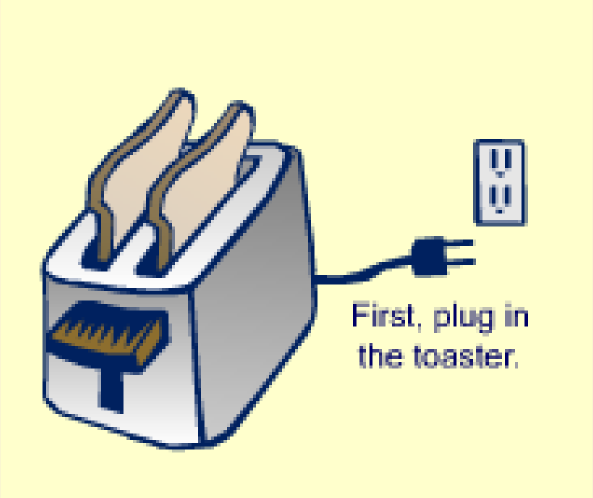


What energy transformations are involved with lighting a bulb?

electrical (outlet) → mechanical (turn switch on) → chemical (filament) → heat (of filament) → light (filament glows)

Energy Transformation

THINK ABOUT IT



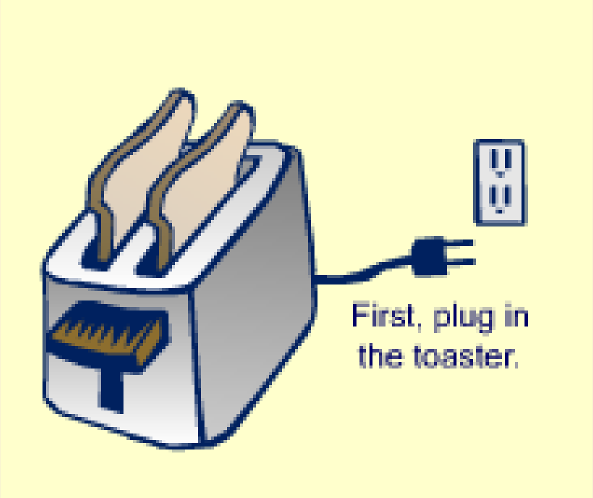
What energy transformations are involved with a toaster?

1. The type of energy given to a car when you speed it up is
   a) potential b) kinetic c) chemical d) electromagnetic

2. When a piece of paper catches on fire it is converting _____ energy to _____ energy. a) KE to heat b) light to heat c) chemical to heat d) chemical to PE

3. The energy stored in the water behind a tall dam is in the form of
   a) gravitational potential c) kinetic
   b) electromagnetic d) elastic energy

Energy Transformation



What energy transformations are involved with a toaster?

mechanical (push handle) → electrical → heat / light → chemical (toast)

1. The type of energy given to a car when you speed it up is
   a) potential **b) kinetic** c) chemical d) electromagnetic

2. When a piece of paper catches on fire it is converting _____ energy to _____ energy. a) KE to heat b) light to heat **c) chemical to heat** d) chemical to PE

3. The energy stored in the water behind a tall dam is in the form of
   a) gravitational potential c) kinetic
   b) electromagnetic d) elastic energy

Energy Transformation

4. A basketball rolls down a hallway, gradually slowing down. During this time, its kinetic energy is transformed into what type of energy?
   a) elastic b) heat c) electromagnetic d) potential

5. A bungee jumper (1) falls freely, (2) accelerates while falling, (3) gets suspended by the bungee cord which stretches 5 meters beyond its normal length. What energy transformations took place?
   a. gravitational PE → KE → elastic PE
   b. elastic PE → gravitational KE → chemical
   c. chemical → heat → KE
   d. mechanical → KE → elastic PE

6. A boy blows up a balloon, and then sticks a pin in it to make it pop. When it pops, it con-verts _______ energy into _______ energy.
   a) elastic → sound c) kinetic → heat
   b) thermal → sound d) kinetic → elastic

Energy Transformation

4. A basketball rolls down a hallway, gradually slowing down. During this time, its kinetic energy is transformed into what type of energy?
   a) elastic **b) heat** c) electromagnetic d) potential

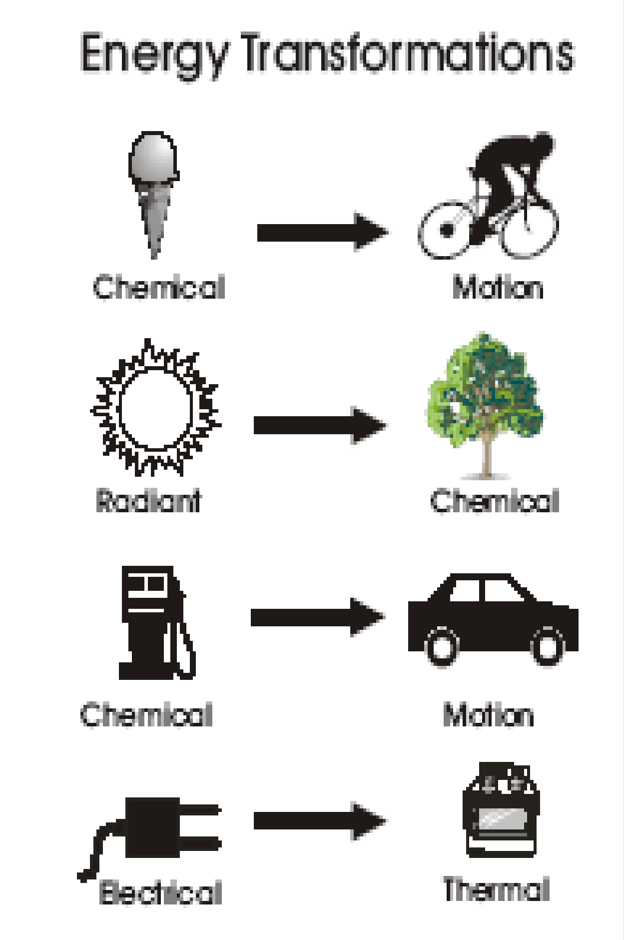
5. A bungee jumper (1) falls freely, (2) accelerates while falling, (3) gets suspended by the bungee cord which stretches 5 meters beyond its normal length. What energy transformations took place?
   a. gravitational PE → KE → elastic PE
   b. elastic PE → gravitational KE → chemical
   c. chemical → heat → KE
   d. mechanical → KE → elastic PE

6. A boy blows up a balloon, and then sticks a pin in it to make it pop. When it pops, it con-verts _______ energy into _______ energy.
   a) elastic → sound
   b) thermal → sound
   c) kinetic → heat
   d) kinetic → elastic
   The elasticity causes the PE to build up, the "pop" is a sound

Energy Transformation

- The law of conservation of energy states that energy can’t be created, or destroyed, but can change forms.

- Some may say that energy is “lost” if it’s not usable, but it just changes form to a different type of energy.



Energy Transformation

electrical → **chemical**

chemical → **heat**

heat → **light**

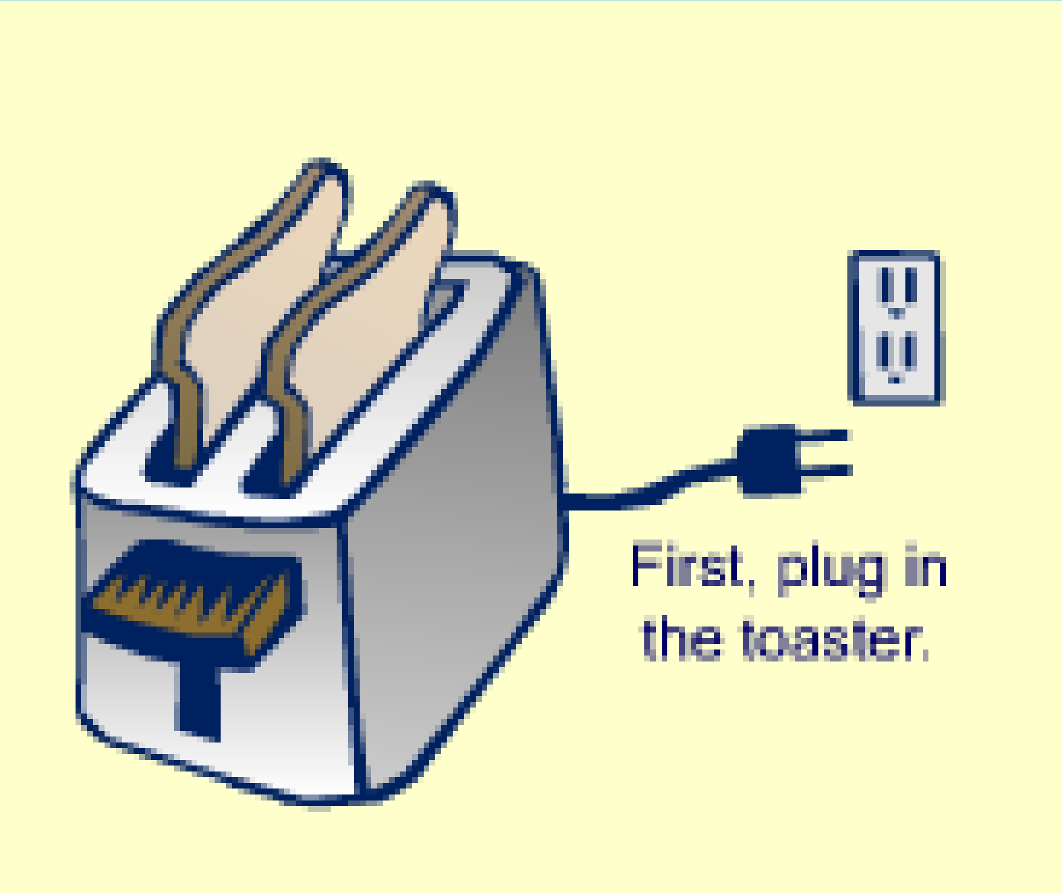
Energy Transformation

mechanical
(push handle) →

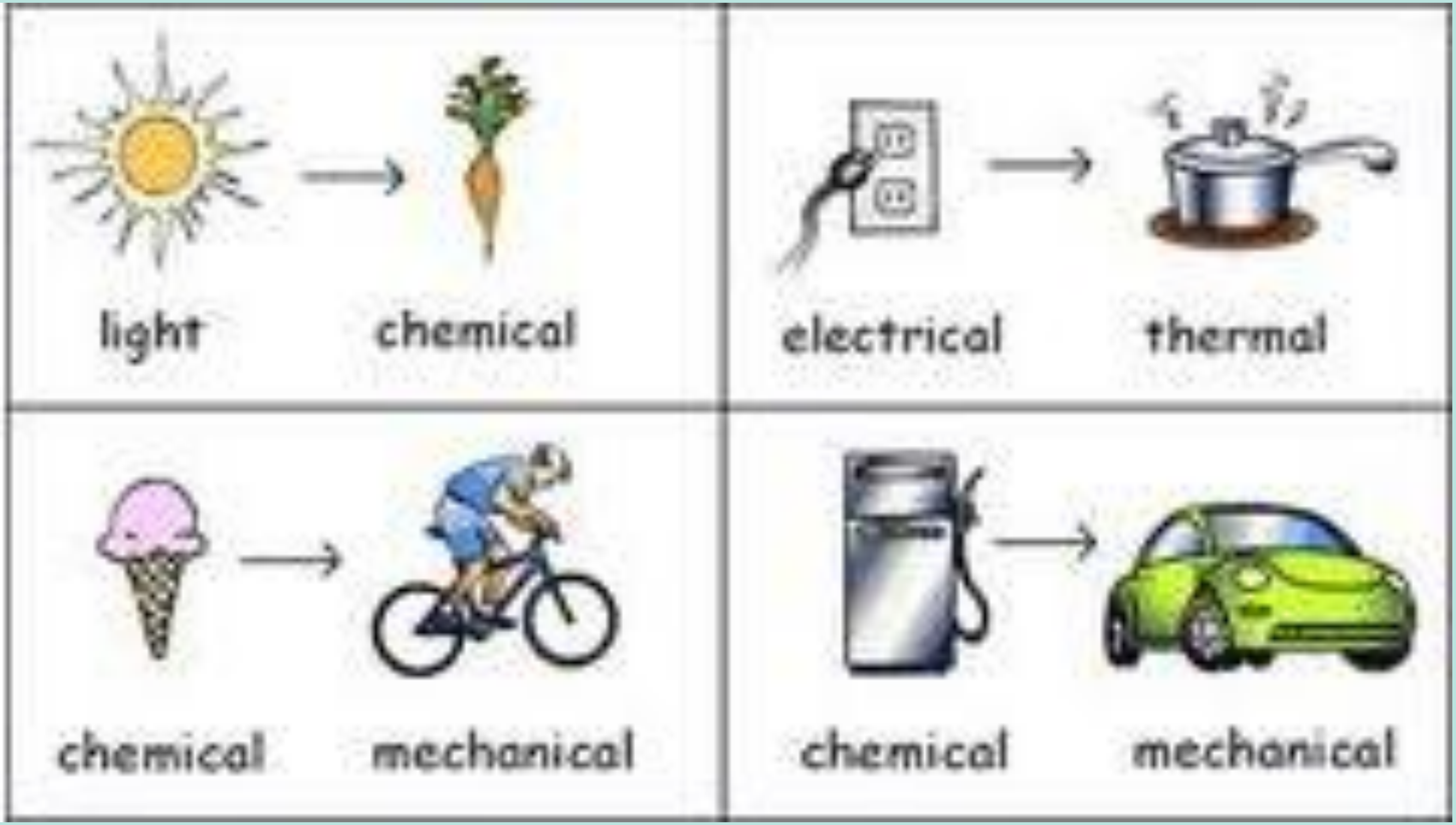
electrical →

heat / light →

chemical (toast)



Chose a device or reaction and list the energy transformations involved



Energy Transformations and Energy Efficiency

- **Ideally, we may think that machines, devices, or reactions are 100% efficiency … meaning that it does all of the useful work intended.**

- **This is never true in reality because energy is converted / transformed and therefore, lost as heat.**

Energy Transformations and Energy Efficiency

In regards to energy used for transportation, electricity and heating, the conversion from one energy type to another (e.g. car fuel → car motion) is not 100% efficient.

That is, if we put in three units of fuel into a system, we don't get three energy units out of the system.

Some of this energy is "lost" to non-usable forms of energy.

(some fuel energy may be "lost" (transformed) due to heat and sound).

Why a Loss in Efficiency?

- A car burns gasoline converting chemical energy into kinetic energy and **heat** energy.
- Pressing on the brakes decreases the kinetic energy and increases the **thermal** energy.
- Solar cells turn radiant energy into electrical energy, but "**heat**" is produced in transmission.

We use machines to help transform energy. Some machines are simple while some machines are more complex (NO machine is 100% efficient; There will ALWAYS be some energy that is unusable).

Nonrenewable energy resources exist in limited quantities and, once used, cannot be replaced except over the course of millions of years.

Crude oil is pumped out of the ground, refined, and turned into gasoline, fuel oil, and other oil products.

Nonrenewable Energy Resources

Oil, natural gas, and coal are known as **fossil fuels**.

- They were formed underground from the remains of once-living organisms.
- Fossil fuels account for the great majority of the world’s energy use.
- These fuels are not distributed evenly throughout the world.

Renewable Energy Resources

Renewable energy resources are resources that can be replaced in a relatively short period of time.

Hydroelectric, solar, geothermal, wind, biomass, and, possibly in the future, nuclear fusion.

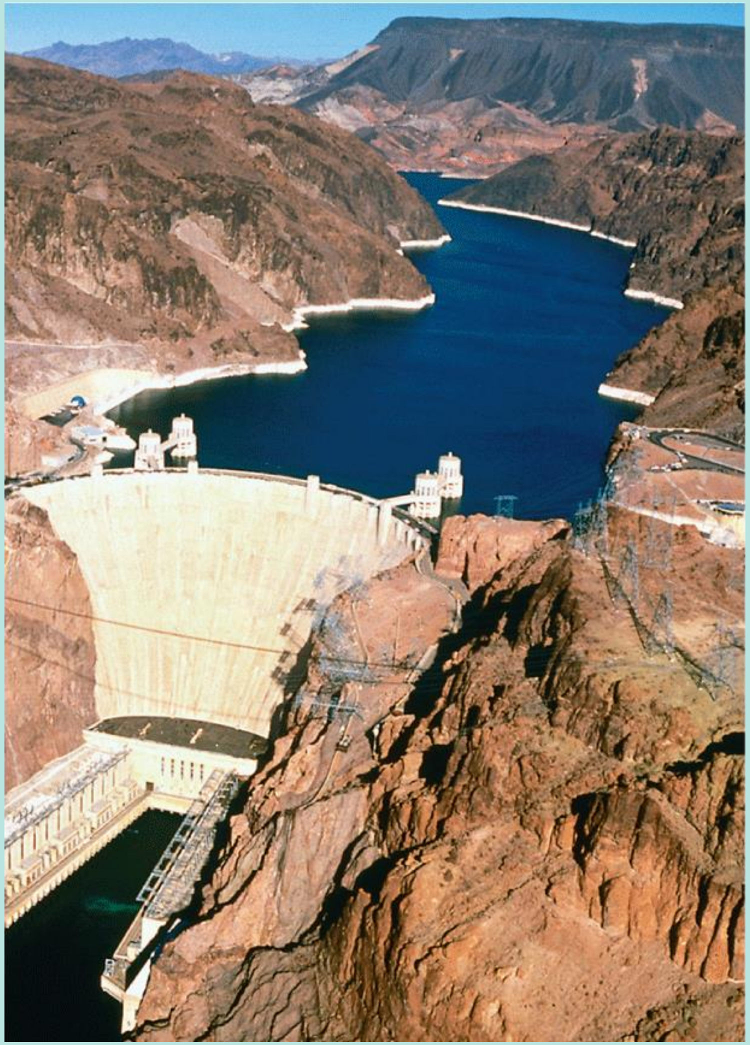
Most renewable energy resources originate either directly or indirectly from the sun.

- The sun and Earth are constantly releasing large amounts of energy.
- This energy could be used for generating electric power, heating buildings, or other purposes.

Hydroelectric Energy

Energy obtained from flowing water.

- As water flows downhill, its gravitational potential energy is converted into kinetic energy.
- This kinetic energy turns turbines connected to electric generators.
- The major advantages of hydroelectric energy include its low cost to produce and lack of pollution.



Solar Energy

- Sunlight converted into usable energy is called **solar energy.**
- In passive solar designs, sunlight heats a building without using machinery.
- In active solar energy systems, sunlight heats flat collection plates through which water flows.

Geothermal Energy

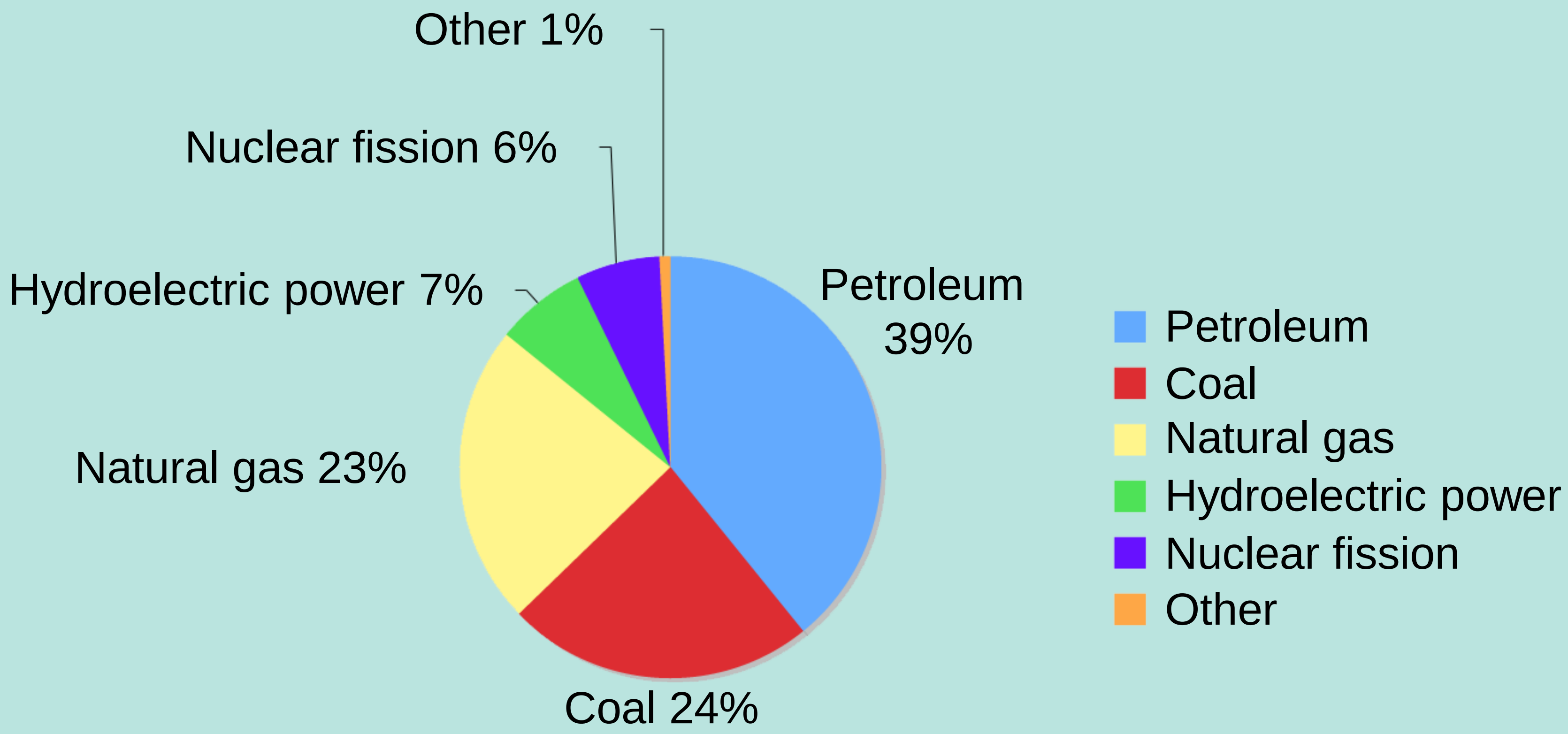
- **Geothermal energy** is thermal energy beneath Earth's surface.
- In some regions, especially near volcanoes, geothermal energy is used to generate electricity.
- Geothermal energy is nonpolluting but is not widely available.

Other Renewable Resources

The chemical energy stored in living things is called **biomass energy**. Biomass can be converted directly into thermal energy or converted into a high-energy alcohol fuel.

A **hydrogen fuel cell** generates electricity by reacting hydrogen with oxygen. Hydrogen fuel cells can be used to convert energy from renewable resources.

World Energy Use



Conserving Energy Resources

Energy resources can be conserved by reducing energy needs and by increasing the efficiency of energy use.

Finding ways to use less energy or to use energy more efficiently is known as energy conservation.

- Making appliances, cars, and even light bulbs more energy efficient is a way of reducing energy use.
- Energy-efficient purchases often cost more initially, but can save money in fuel costs over time.
- Mass Transportation (park n ride; car pool)

Which of the following is a nonrenewable energy resource?

a. geothermal energy
b. hydroelectric energy
c. hydrogen fuel cells
d. natural gas

QUICK CHECK

What is one of the advantages of hydroelectric power?

a. can be used everywhere
b. does not cause any environmental problems
c. uses energy produced by Earth
d. inexpensive compared to other energy sources

QUICK CHECK

Which of the following is a nonrenewable energy resource?

a. geothermal energy
b. hydroelectric energy
c. hydrogen fuel cells
d. **natural gas**

What is one of the advantages of hydroelectric power?

a. can be used everywhere
b. does not cause any environmental problems
c. uses energy produced by Earth
d. **inexpensive compared to other energy sources (also low pollution)**

Kinetic Energy

Math Practice

1. A 70.0-kilogram man is walking at a speed of 2.0 m/s. What is his kinetic energy?

Answer:

Kinetic Energy

Math Practice

1. A 70.0-kilogram man is walking at a speed of 2.0 m/s. What is his kinetic energy?

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

$KE = (0.50)(70.0\ kg)(2.0\ m/s)^2 = 140\ J$

Kinetic Energy

Math Practice

2. A 1400-kilogram car is moving at a speed of 25 m/s. How much kinetic energy does the car have?

Answer:

Kinetic Energy

Math Practice

2. A 1400-kilogram car is moving at a speed of 25 m/s. How much kinetic energy does the car have?

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

$= (0.50)(1400\ \text{kg})(25\ \text{m/s})^2$

$= 440{,}000\ \text{J}$

Potential Energy

What is the potential energy relative to the water surface of a diver at the top of a 10.0-meter-high diving platform. Suppose she has a mass of 50.0 kilograms.

Potential Energy

What is the potential energy relative to the water surface of a diver at the top of a 10.0-meter-high diving platform. Suppose she has a mass of 50.0 kilograms.

PE = *mgh*

$= (50.0\ \text{kg})(9.8\ \text{m/s}^2)(10.0\ \text{m})$

$= 4900\ \text{kg}\bullet\text{m}^2/\text{s}^2 = 4900\ \text{J}$

Assessment Questions

3. Which of these is an example of elastic potential energy?
   a. a bow prepared to release an arrow
   b. a rubber ball thrown into the air
   c. a book about to fall from a table
   d. a truck pulling a trailer

Assessment Questions

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   ANS: A

Assessment Questions

4. A small airplane and a helicopter have identical masses. If the airplane's altitude compared to the ground is three times that of the helicopter, how much more gravitational potential energy does the airplane have than the helicopter?
   a. 0.333 times as much
   b. 3 times as much
   c. 6 times as much
   d. 9 times as much

Assessment Questions

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ANS: B

Assessment Questions

5. The energy stored in the bonds between atoms of a compound is called
   a. electromagnetic energy.
   b. chemical energy.
   c. atomic energy.
   d. thermal energy.

Assessment Questions

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   a. electromagnetic energy.
   b. chemical energy.
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   ANS: B

Assessment Questions

1. What energy conversion occurs as a result of friction?
   a. chemical energy to thermal energy
   b. kinetic energy to potential energy
   c. kinetic energy to thermal energy
   d. potential energy to thermal energy

Assessment Questions

1. What energy conversion occurs as a result of friction?
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   c. kinetic energy to thermal energy
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   ANS: C

Assessment Questions

2. At what point in a pendulum's swing does it have maximum kinetic energy?
   a. the highest point of the swing
   b. the lowest point of the swing
   c. halfway between the lowest and highest point
   d. same at all positions of the swing

Assessment Questions

2. At what point in a pendulum's swing does it have maximum kinetic energy?
   a. the highest point of the swing
   b. the lowest point of the swing
   c. halfway between the lowest and highest point
   d. same at all positions of the swing

   ANS: C

Assessment Questions

1. According to the law of conservation of mass, energy can be converted from one from to another but not created or destroyed.

   True
   False

Assessment Questions

1. According to the law of conservation of mass, energy can be converted from one from to another but not created or destroyed.

   True
   False

   ANS: F, law of conservation of energy

Assessment Questions

1. Which of the following is a nonrenewable energy resource?
   a. geothermal energy
   b. hydroelectric energy
   c. hydrogen fuel cells
   d. natural gas

Assessment Questions

1. Which of the following is a nonrenewable energy resource?
   a. geothermal energy
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   c. hydrogen fuel cells
   d. natural gas

   ANS: D

Assessment Questions

2. What is one of the advantages of hydroelectric power?
   a. can be used everywhere
   b. does not cause any environmental problems
   c. uses energy produced by Earth
   d. inexpensive compared to other energy sources

Assessment Questions

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   ANS: D