Unit 4
Causes of Change

Mrs. Valentine

Physical Science

Section 1
The Nature of Energy

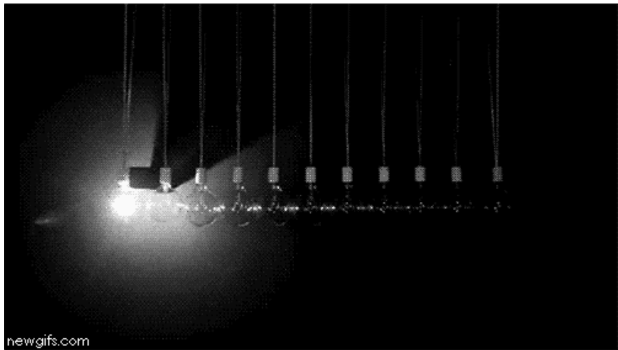
- How is it possible for wind to be so violent that it can rip apart houses?

- Wind has energy.

- **Definition:** <u>Energy</u> – the ability to do work or cause change.

- When an object or organism does work on an object, energy is transferred to that object.

- Work is the transfer of energy.



Discover Activity

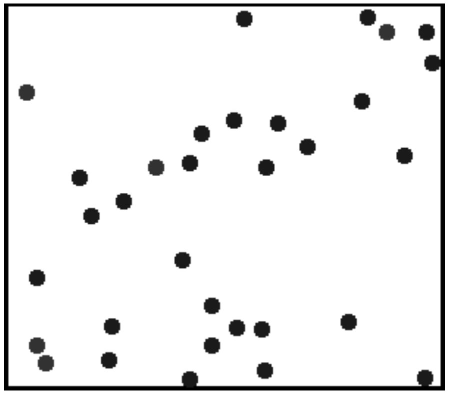
- How high does a ball bounce?
- Drop a tennis ball from 50cm and record the height of the bounce.
- Drop the tennis ball from 100cm and record the height of the bounce.
- How high will the ball bounce if dropped from 75cm?
- Test your prediction.

Kinetic Energy

- **The two kinds of energy are kinetic energy and potential energy.**

- The difference is whether the object possessing the energy is in motion or not.

- A moving object is capable of doing work.



- **Definition:** Kinetic Energy (E_K) – the energy of motion.

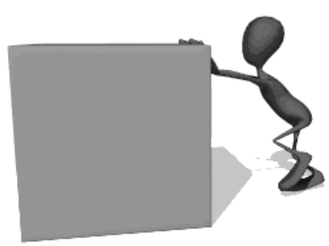
- The word kinetic comes from the Greek word *kinetos*, which means “moving.”

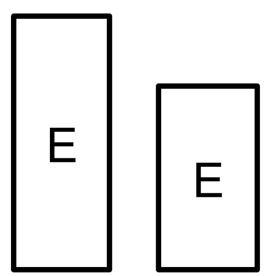
Mass and Velocity

- Kinetic energy depends upon both the mass and velocity of an object.

- Think about rolling a golf ball and a bowling ball so that they travel at the same velocity.

- The more work you do, the more energy the object the work is being done on receives.





Mass and Velocity

- The more mass the object has, the harder it will be to make it move faster.
- In order to make an object move faster, you would have to push it harder.
- Therefore, you would be doing more work on that object.
- Kinetic energy increases when velocity increases.
- Which has more kinetic energy, a tennis ball travelling at 23m/s or a baseball travelling at 23m/s?

Calculating Kinetic Energy

- Kinetic energy can be calculated using the following equation:

$$E_k = \frac{m * v^2}{2} = 0.5mv^2$$

- Changing the velocity will change the kinetic energy more than changing the mass.

Kinetic Energy Units

- When calculating the kinetic energy of an object, remember that what we do to our values, we also do to our units.

$$E_k = \frac{m * v^2}{2} = 0.5mv^2$$

- Assume that we have a 2kg object moving at 1m/s.

$$E_k = \frac{2kg * (1m/s)^2}{2}$$

- When we square our velocity, we also square the units of our velocity. Therefore, the units for our answer will be $kg*(m/s)^2$ or $kg*m^2/s^2$, and our answer will be $1kg*m^2/s^2$.

Kinetic Energy Practice Problems

$$E_K = \frac{m * v^2}{2}$$

- Find the kinetic energy for the following wagons:
  - A 10kg wagon moving at **10m/s**.

    m = 10kg

    v = 10m/s

    $$E_K = \frac{(10kg) * (10m/s)^2}{2}$$

    E_K = 500kg*m^2/s^2
  - A 10kg wagon moving at 5m/s.

    E_K = 125kg*m^2/s^2
  - A 20kg wagon moving at 5m/s.

    E_K = 250kg*m^2/s^2
- Which has the greatest kinetic energy?

Potential Energy

- Not all energy sets an object in motion. Sometimes, the object's shape or position is changed.

- **Definition:** Potential Energy (E_P)– energy that is stored and held in readiness.

- It is called potential energy because it has the *potential* to do work.

- There are two kinds of potential energy that we will discuss: elastic potential energy and gravitational potential energy.

Elastic Potential Energy

- **Definition:** Elastic Potential Energy ($E_{Pelastic}$)– the potential energy associated with objects that can be stretched or compressed.

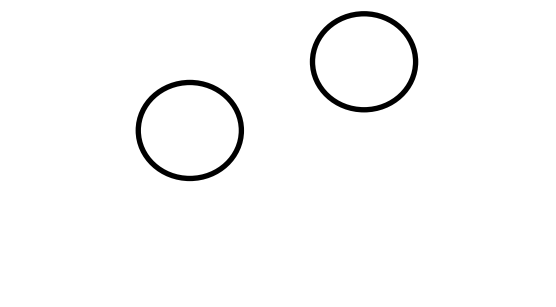
- When an archer pulls back the arrow with his bow, before he releases, the bow has elastic potential energy.

- Can anyone think of another example of a common object that might frequently have elastic potential energy?
  - Springs, bungee cords, rubber bands
  - Foam mattresses, trampolines

Elastic Potential Energy - Trampoline

Gravitational Potential Energy

- **Definition:** Gravitational Potential Energy ($E_{Pgravity}$) – potential energy dependent on height.



- The higher up an object is off the ground, the more gravitational potential energy that object has.

- The $E_{Pgravity}$ of an object is equal to the work done to lift the object.

- The unit of this energy is a Newton-meter when the weight is in Newtons and the height is in meters. This is also known as a Joule.

Gravitational Potential Energy

- To calculate the gravitational potential energy, multiply the weight and the height of the object.

$$E_{Pgrav} = wt * h$$

- Because we know that $wt = m * \alpha_{grav}$, we can substitute these in for weight in our equation.

$$E_{Pgrav} = m * \alpha_{grav} * h$$

Gravitational Potential Energy

- The heavier the object or the higher up the object is, the more gravitational potential energy it has.

- Which of the following boxes has the most gravitational potential energy?
  - A box with a weight of **45N** at a height of **23m**.

    wt = 45N

    h = 23m

    $E_{Pgrav} = (45N)*(23m)$

    $E_{Pgrav} = 1035J$

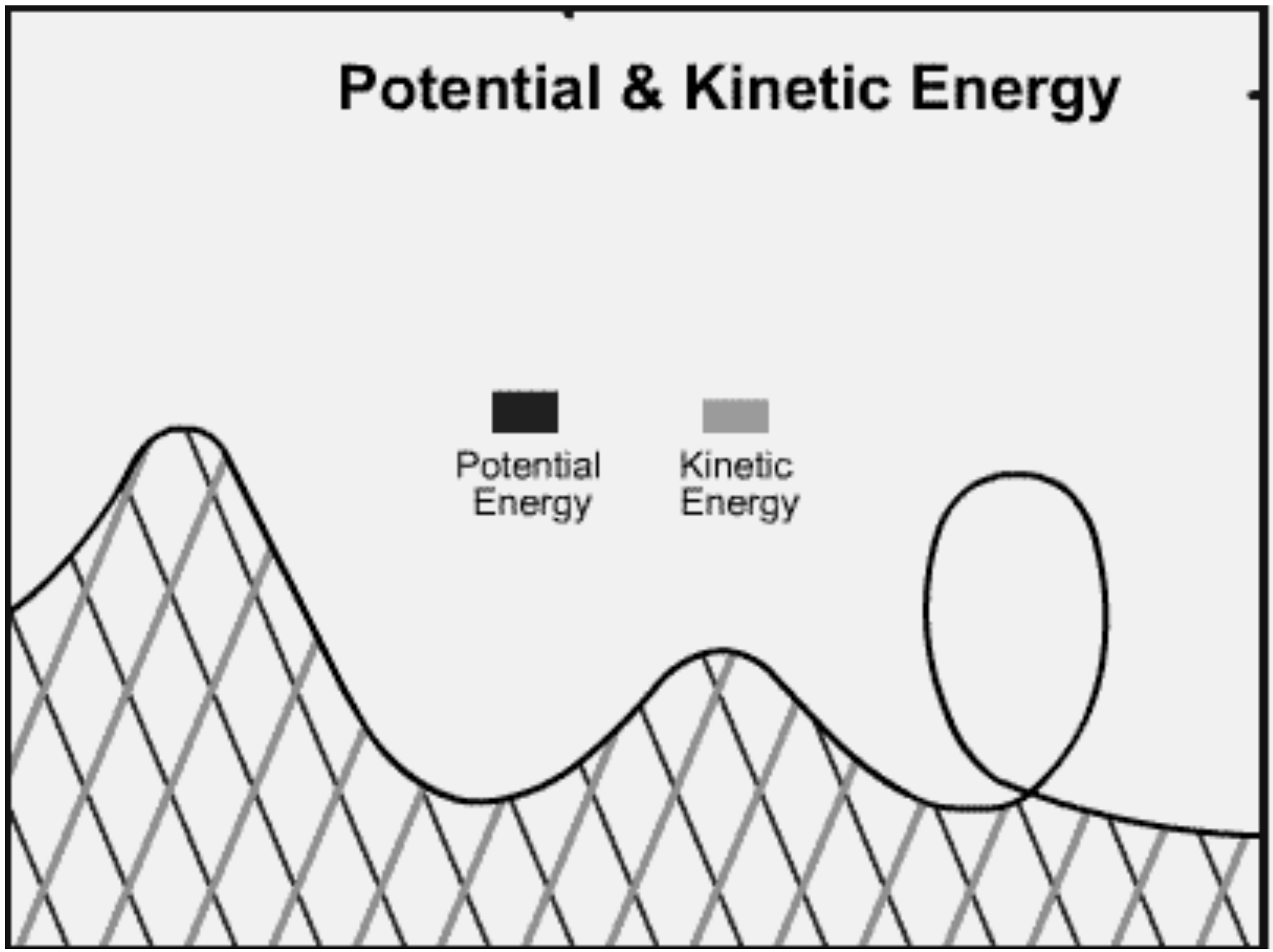
  - A box with a weight of 45N at a height of 34m.

    $E_{Pgrav} = 1530J$

  - A box with a weight of 51N at a height of 34m.

    $E_{Pgrav} = 1734J$

Potential and Kinetic Energy on a Roller Coaster

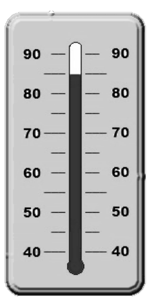


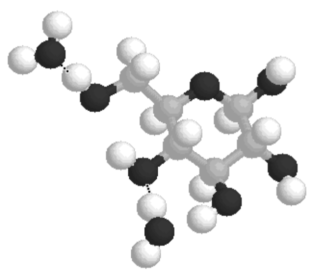
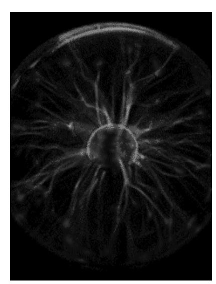
Different Forms of Energy

- The two kinds of energy we have talked about involve objects being moved or physically changed.

- Both kinetic and potential energy have multiple forms.

- **Some of the major forms of energy are mechanical energy, thermal energy, chemical energy, electrical energy, electromagnetic energy, and nuclear energy.**

Mechanical Energy

- **Definition:** Mechanical Energy – the energy associated with the motion or position of an object.

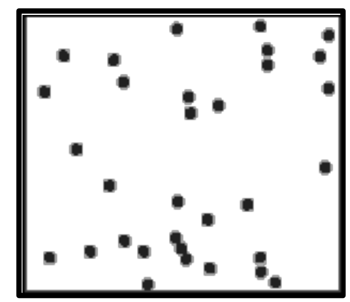
- Mechanical energy can occur as either kinetic or potential energy.

- Can anyone give an example of mechanical energy?

Thermal Energy

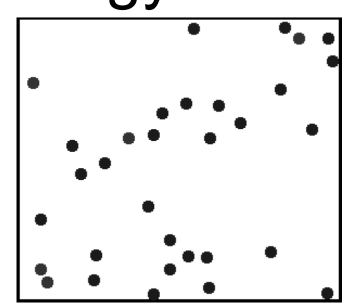
- **Definition:** Thermal Energy – the total energy of the particles of an object due to their movement or vibration.
- Temperature is a measure of thermal energy.
- As particles move faster, they have more thermal energy and feel warmer to the touch.

100°F



- As particles move slower, they have less thermal energy and feel cooler to the touch.

75°F



Chemical Energy

- **Definition:** <u>Chemical Energy</u> – potential energy stored in chemical bonds that hold chemical compounds together.

- Chemical energy is stored in the foods you eat.

- It can be found in a match that is ready to light.

- There is chemical energy in every cell in your body.

Electrical Energy

- **Definition:** Electrical Energy – the energy of moving electric charges.

- You experience electrical energy when you receive a shock from a metal door knob.

- Electrical energy is used whenever you put a battery into a machine, or turn on the television, radio or computer.

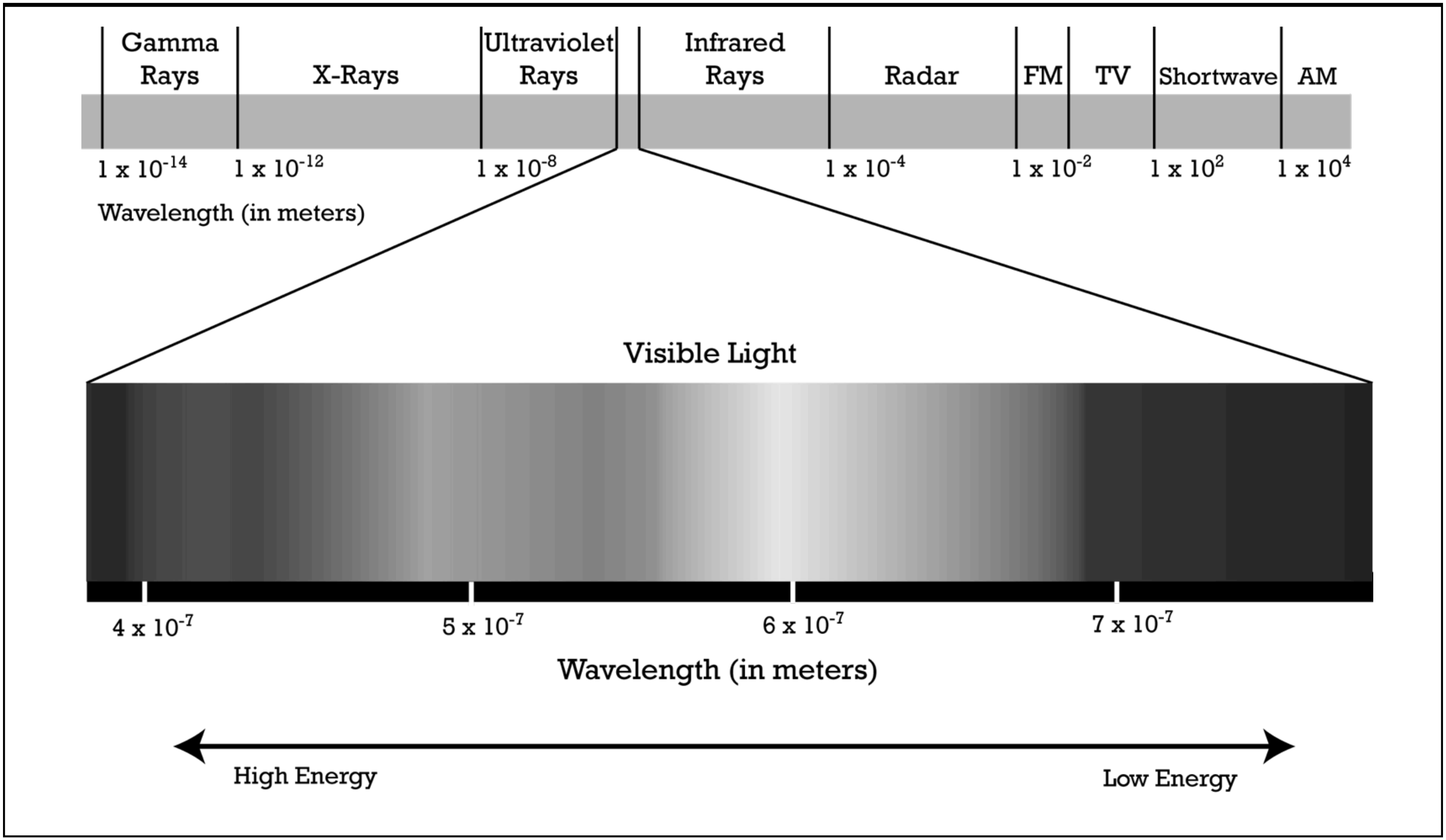
Electromagnetic Energy

- **Definition:** Electromagnetic Energy – the energy of light and other forms of radiation.

- Electromagnetic radiation travels in waves, which have some electrical properties and some magnetic properties.

- Examples include x-rays, microwaves, and radio waves.

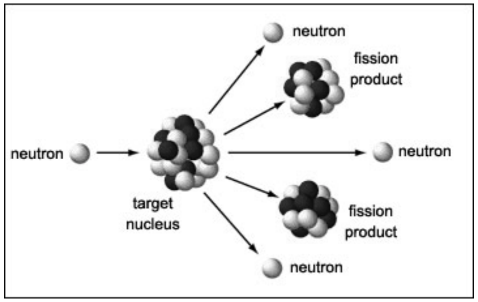
Electromagnetic Spectrum

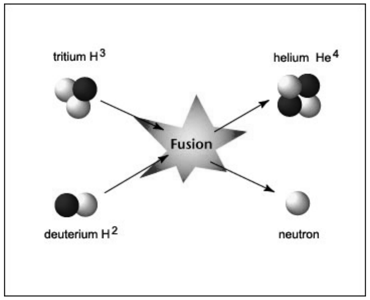


Nuclear Energy

- **Definition:** Nuclear Energy – the energy stored in the nucleus of an atom that is released during nuclear reactions.

- Nuclear fission releases nuclear energy when a nucleus splits.



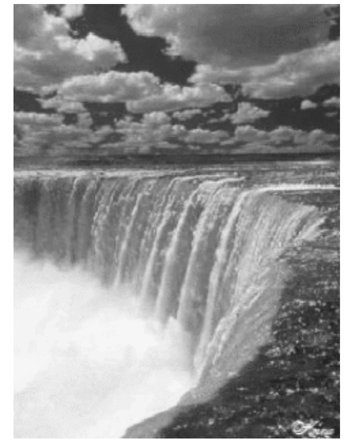


- Nuclear fusion releases nuclear energy to join two nuclei together.

- This is the kind of energy that nuclear power plants use to produce electricity.

Section 2
Energy Conversion and Conservation

- What does water have to do with electricity?



- The mechanical energy of moving water can be converted into electrical energy

- **Definition:** Energy Conversion – a change from one form of energy to another.

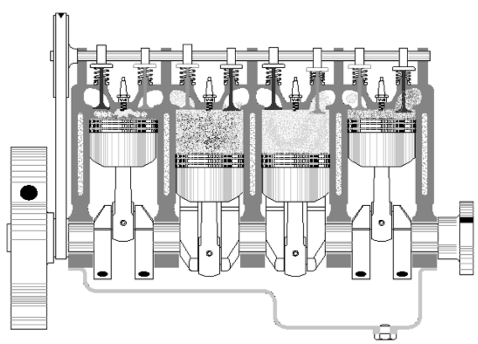
- **Most forms of energy can be converted into any other form.**

Conversions Between Forms of Energy

- Toasters convert electrical energy to thermal energy.
- Your body converts chemical energy into both thermal and mechanical energy.
- Many times, a series of conversions may need to be done in order to do a task.
- Example: lighting a match.

Energy Conversions in a Car

- In a car engine, electrical energy produces a hot spark.
- The thermal energy of the spark releases chemical energy in the fuel.
- When the fuel burns, thermal energy is produced.



- This thermal energy is converted to mechanical energy that is used to move the car.

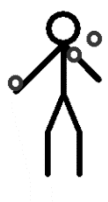
Kinetic and Potential Energy

- A very common conversion is from potential to kinetic and vice versa.

- Stretching a rubber band gives it elastic potential energy.
- Releasing the rubber band shoots it across the room, meaning that it’s potential energy was converted to kinetic energy.
- Once shot, the rubber band has mechanical kinetic energy.

Energy Conversion in Juggling

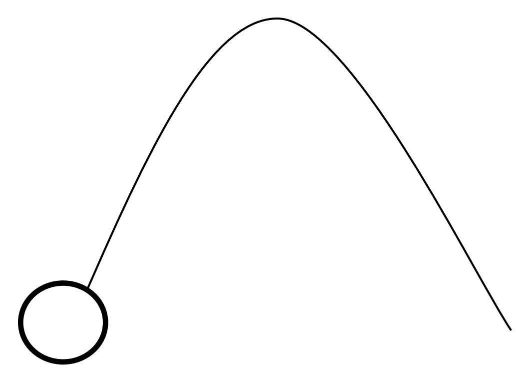
- Any object that rises or falls experiences a change in its kinetic and gravitational potential energy.



- When someone juggles, the ball has its maximum kinetic energy when it has just left the juggler's hand.

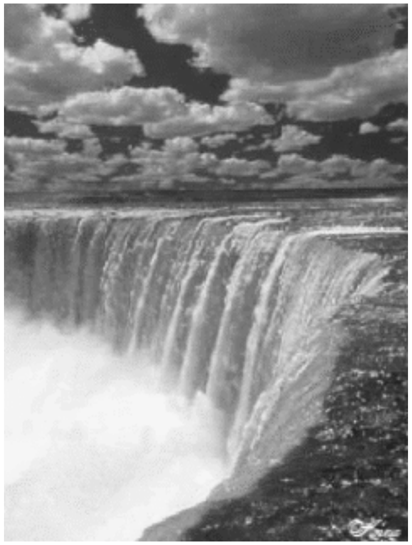
- Half way to the top of it's trajectory, it will have 50% of its energy as kinetic and 50% as potential.

- When it reaches its maximum height, it has its maximum potential energy.



Energy Conversion in a Waterfall

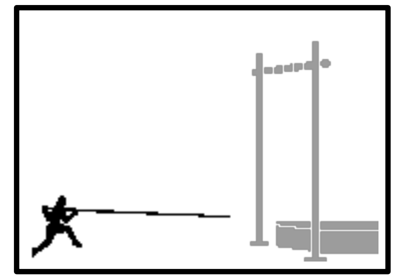
- There is a conversion between potential and kinetic energy on a large scale at Niagara Falls.



- The water at the top has gravitational potential energy.
- As the water falls, the potential energy decreases and the kinetic energy increases.
- Thus potential energy is converted to kinetic energy.

Energy Conversion in a Pole Vault

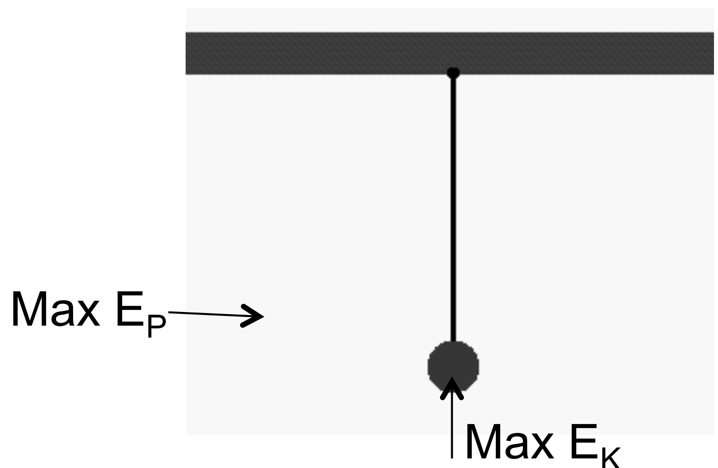
- As a pole vaulter runs, he has kinetic energy.



- When he plants the pole, it bends.
- In this case, some of his kinetic energy is converted to elastic potential energy.
- As the pole straightens, he is lifted into the air, converting the elastic potential energy into gravitational potential energy.
- Once over the bar, the gravitational potential energy is converted back to kinetic energy.

Energy Conversion in a Pendulum

- A pendulum experiences a continuous conversion of energy from kinetic to potential and back as it swings from side to side.



- It has its maximum potential energy when it has swung out as far as it can.

- Its maximum kinetic energy is when it has dropped as far as it can, right before it swings to the other side.

Conservation of Energy

- A pendulum will not remain in motion forever.
- However, the energy is not destroyed over time.
- **Definition:** The Law of Conservation of Energy – when one form of energy is converted to another, no energy is destroyed in the process.
- **According to the law of conservation of energy, energy cannot be created or destroyed.**

Energy and Friction

- As the pendulum moves, it has friction with the air.
- What type of friction?
- With friction, thermal energy increases.
- This means that the mechanical energy must decrease to compensate.
- This principle is why no machine is 100% efficient.
- Has anyone ever taken advantage of this principle to stay warm?

Energy Practice Problem (p.3 in packet)

$E_{Pgrav} = wt * h$

$E_K = \frac{m * v^2}{2}$

- The empire state building is **381m** tall. If Percy dropped a CD with a **0.090kg** mass and a weight of **0.88N** from the top of the building, and it used **132J** of energy to overcome friction, what is the velocity of the disc just before it hits the ground?

wt = 0.88N

h = 381m

$E_{friction}$ = 132J

m = 0.090kg

$E_{Pgrav} = (0.88N) * (381m)$

$E_{Pgrav} = 335.28J$

$E_K = E_{Pgrav} – E_{friction} = 335.28J - 132J$

$E_K = 203.28J$

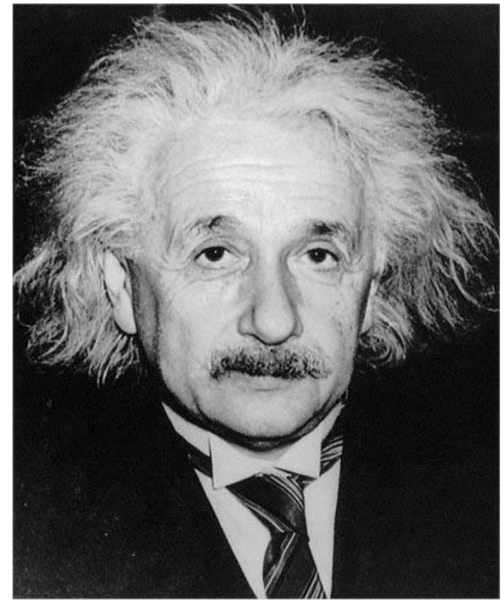
$$v = \sqrt{\frac{2E_K}{m}}$$

$$v = \sqrt{\frac{2*(203.28J)}{(0.090kg)}}$$

$$v = \sqrt{(2258.67m^2/s^2)}$$

v =47.53m/s

Energy and Matter



- Albert Einstein theorized that energy can be created by destroying matter, and energy can be destroyed by creating matter.
- This process is important in nuclear reactions, where huge amounts of energy are produced by destroying tiny amounts of matter.
- This means that in some cases, energy alone is not conserved.

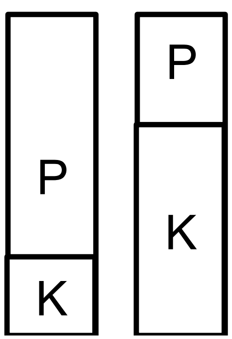
Conserving Energy

- However, matter and energy together are always conserved.

- Just as different forms of energy are converted, so can matter and energy be converted back and forth.

- NOTE: Conserving energy and the law of conservation of energy are not the same thing!

- Conserving energy refers to not wasting energy and fossil fuels.

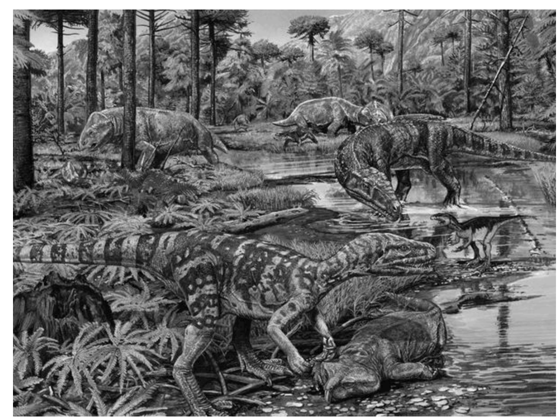


  - The law of conservation of energy refers to a quantity of energy remaining the same.

Section 3
Energy Conversions and Fossil Fuels

- Ancient forests and creatures are very important to us today. Perhaps even more so than we usually think.

- **Definition:** <u>Fossil Fuels</u> – materials such as coal and gasoline that are burned to release their chemical energy.

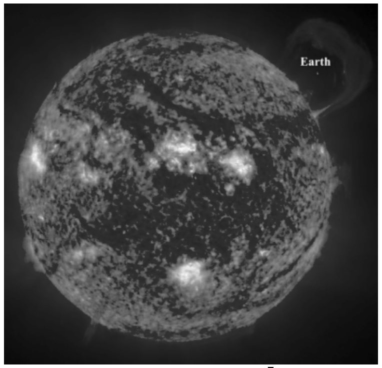


- We call them "fossil" fuels because they are made from ancient forests and creatures.

- Some of our fossil fuels were formed hundreds of millions of years ago by geological processes.

Formation of Fossil Fuels

- **Fossil fuels contain energy that came from the sun.**
- Inside the sun, the hydrogen nuclei are being fused together to form helium atoms.



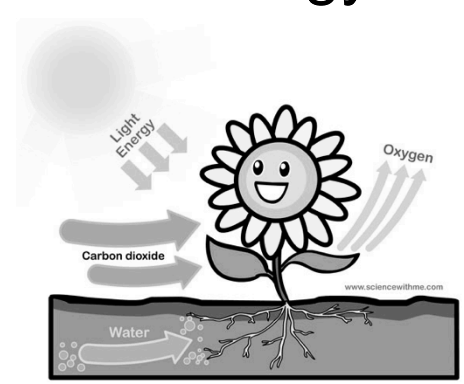
- This converts their nuclear energy into electromagnetic and thermal energy.

- Some of this energy reaches Earth as visible light.

Formation of Fossil Fuels

- Coal was formed from ancient forests.
- The sun converts nuclear energy into electromagnetic energy.

- This energy travels through space, and reaches Earth.
- The plants absorb it, and convert it into chemical energy for their food.
- This process is known as photosynthesis.



Formation of Fossil Fuels

- Sometimes, animals eat these plants and absorb the energy.

- Eventually, the plants and animals die. Over time, they are covered with dirt, mud, and other layers of earth.

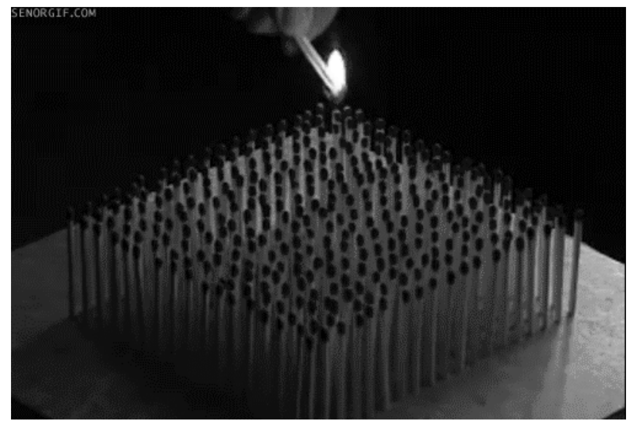
- This creates high pressure which, when combined with high temperatures for millions of years, turns the dead plants into coal.

- The coal has the energy that the plant had still stored inside of it.

Use of Fossil Fuels

- **Fossil fuels can be burned to release the potential chemical energy stored millions of years ago.**

- This is known as combustion.

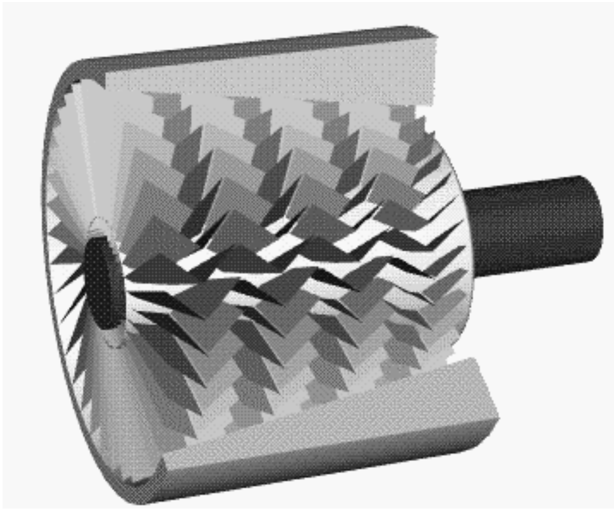


- During combustion, the fuel’s chemical energy is converted to thermal energy.

- This thermal energy has a variety of uses, including heating water.

Use of Fossil Fuels

- In coal-fired power plants, the steam produced by this thermal energy is raised to a very high temperature in order to produce a high pressure.



- This is used to turn a turbine.
- **Definition:** Turbine – a fan with blades attached to a shaft.
- The high pressure turns the turbine very fast.

Use of Fossil Fuels

- This converts the thermal energy to mechanical energy.

- The turbines are attached to generators which convert the mechanical energy to electrical energy.

- This is the electrical energy that is used to turn on the lights, power a projector, cook meals, etc.

Section 4
Power

- Some machines work faster than others.

- For example, some cars accelerate faster than others do. A Ferrari will accelerate faster than a Honda Odyssey.

- **Definition:** <u>Power</u> – the rate at which work is done or the amount of work done in a unit of time.

- When you carry an object up stairs, you do the same amount of work on the object whether you walk or run. However, you have more power when you run.

Calculating Power

- **Power is calculated by dividing the amount of work done by the amount of time taken to do the work.**

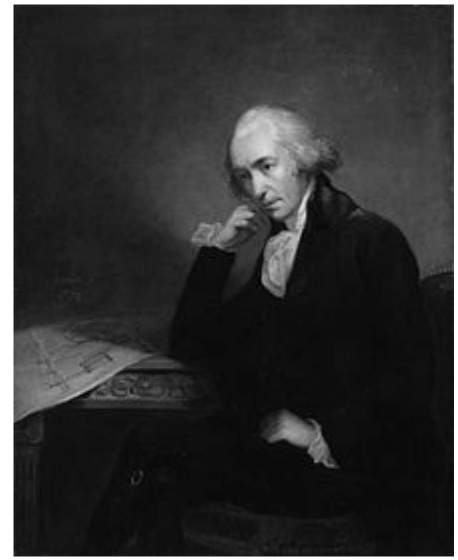
$$P = \frac{w}{t}$$

- Since work is equal to force times distance, the equation can be rewritten as follows:

$$P = \frac{F*d}{t}$$

- The unit of power is joules per second when work is measured in joules and time is measured in seconds.

Calculating Power



- This unit (J/s) is also known as the watt (W).
- This was named for James Watt, who made great improvements to the steam engine.
- One watt = 1 joule per second 1W=1J/s.
- 1 watt is a small unit of power.
- Power is often measured in kilowatts (kW).

Power and Energy

- **Power is the rate at which energy is transferred from one object to another or converted from one form to another.**

- Power can be found whenever energy is being transferred or converted.

- It is not limited to objects being moved.

- For example, we see power in light bulbs.

- Which is brighter, a 40-watt bulb or a 100-watt bulb?

Power, Energy, and Horsepower

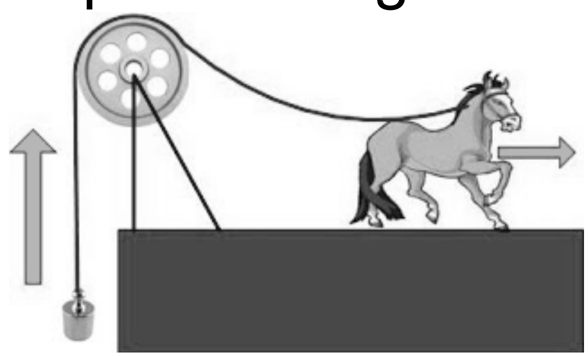
- A 40-watt bulb converts energy at 40 joules per second. A 100-watt bulb converts energy at 100 joules per second.
- Therefore, a 100-watt bulb is brighter because it gives off more energy per second.
- When people discuss the power of car engines, they speak about horsepower.
- 1 horsepower is equal to 746 watts.
- Horsepower is not an SI unit.

Horsepower

- The term horsepower was coined by James Watt to describe the power of his steam engine.

- The idea was to compare the amount of work his steam engine could do to the amount of work a horse could do hauling coal.

- Watt defined one horsepower as the amount of work a horse does to lift a 33 000-pound weight a distance of 1ft/min.



Power Practice Problems

$$P = \frac{F*d}{t}$$

1hp = 746W

- A motor exerts a force of **10000N** to lift an elevator **6m** in **5s**. What is the power produced by the motor?

  F = 10000N

  d = 6m

  t = 5s

  $$P = \frac{(10000N)*(6m)}{5s}$$

  P = 12000W

- What is the horsepower of the motor?

  P = 12000W

  $$12000W * \frac{1hp}{746W}$$

  = 16.1hp

- A tow truck exerts a force of 9000N to pull a car out of a ditch. It moves the car a distance of 6m in 25s. What is the power of the tow truck?

  P = 2160W or 2.90hp