Chapter Seven: Work and Energy

- 7.1 Force, Work, and Machines
- 7.2 Energy and the Conservation of Energy
- 7.3 Efficiency and Power

7.2 Learning Goals

- Describe how energy changes as systems change.
- Discuss examples of energy transformations.
- Explore the energy involved in carrying out daily activities.

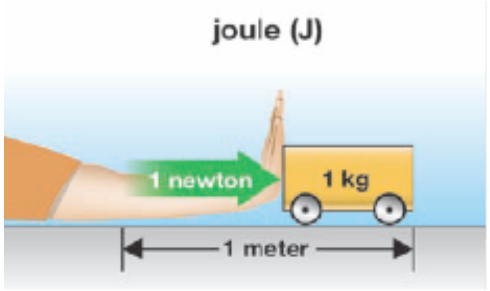
7.2 What is energy?

- **Energy** measures the ability for things to change themselves or to cause change in other things.
- Some examples are changes in temperature, speed, position, pressure, or any other physical variable.

7.2 Units of energy

- Pushing a 1-kilogram object with a force of one newton for a distance of one meter uses one joule of energy.

- A joule (J) is the S.I. unit of measurement for energy.



7.2 Joules

- **One joule is a pretty small amount of energy.**

Units Related to the Joule

1 joule = 1 newton-meter

1 newton = 1 kg-m/s^2

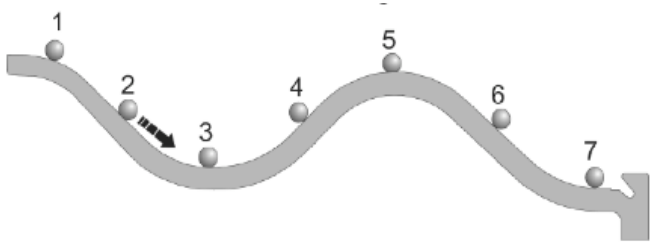
therefore...

1 joule = 1 kg-m^2/s^2

- **An ordinary 100 watt electric light bulb uses 100 joules of energy every second!**

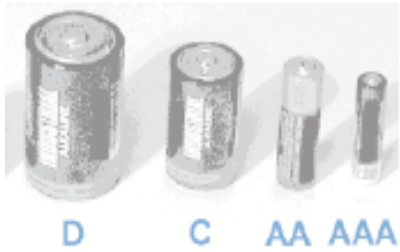
7.2 Some forms of energy

- **Mechanical energy** is the energy possessed by an object due to its motion or its position.
- Potential energy and kinetic energy are both forms of mechanical energy.



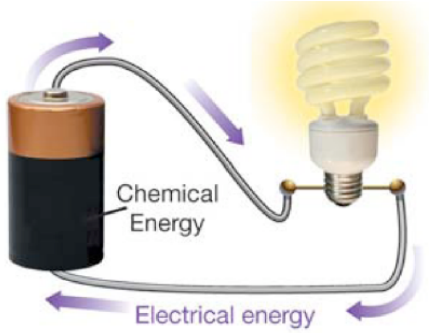
7.2 Some forms of energy

- **Chemical energy is a form of energy stored in molecules.**
- **Batteries are storage devices for chemical energy.**



7.2 Some forms of energy

- **Electrical energy comes from electric charge, which is one of the fundamental properties of all matter.**



7.2 Some forms of energy

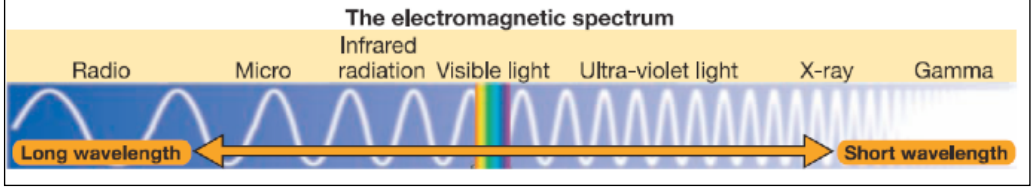
- Elastic energy is energy that is stored or released when an object changes shape (or deforms).
- Objects commonly used to store and release elastic energy include rubber bands, springs, and archery bows.

7.2 More forms of energy

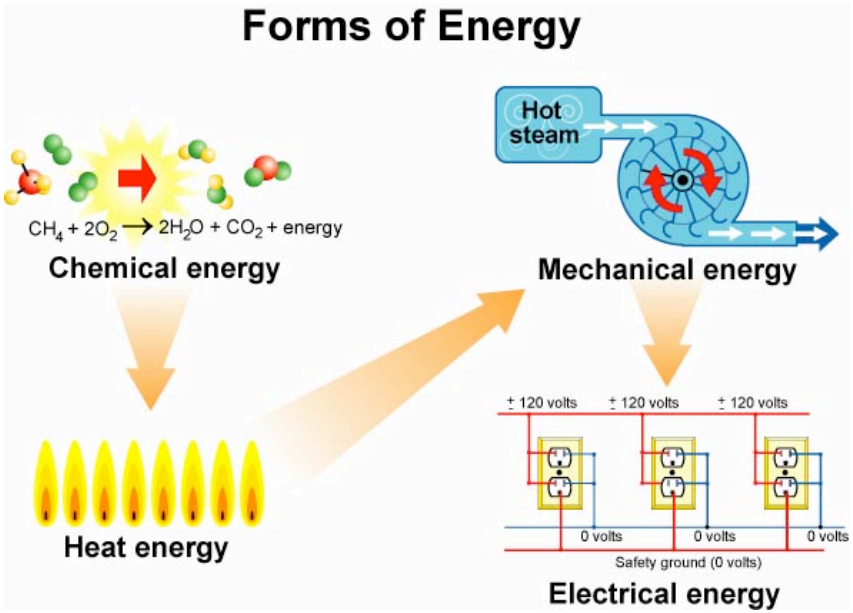
- Nuclear energy is a form of energy stored in the nuclei of atoms.
- In the Sun, nuclear energy is transformed to heat that eventually escapes the sun as radiant energy.

7.1 More forms of energy

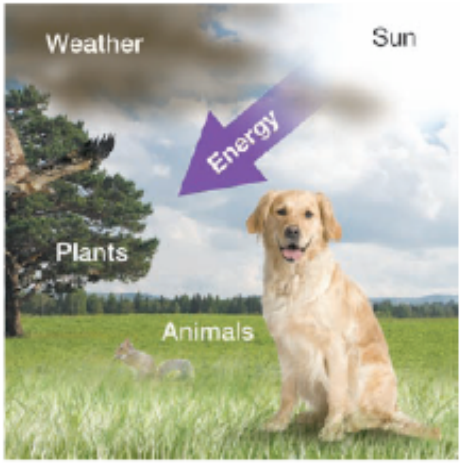
- The electromagnetic spectrum includes visible light infrared radiation (heat), and ultraviolet light.
- Light energy and heat energy are included in the electromagnetic spectrum.



Forms of Energy



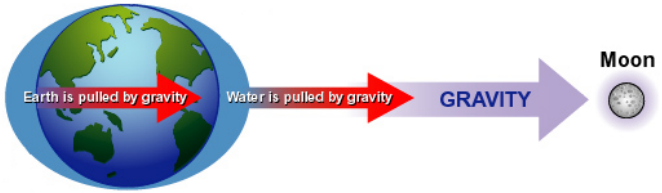
7.2 Sources of energy



- Without the Sun's energy, Earth would be a cold icy place with a temperature of −273 °C.
- As well as warming the planet, the Sun's energy drives the entire food chain.

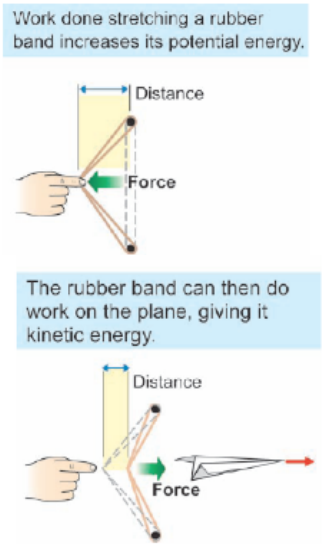
7.2 Sources of energy

- All objects with mass feel forces in the presence of Earth's gravity.
- These forces are a source of energy for objects or moving matter such as falling rocks and falling water.



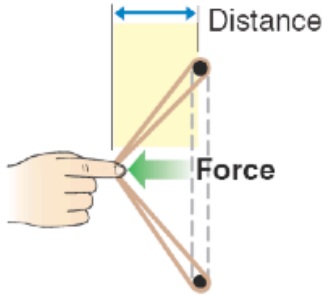
7.2 Energy and work

- In physics, the word work has a very specific meaning.
- Work is the transfer of energy that results from applying a force over a distance.

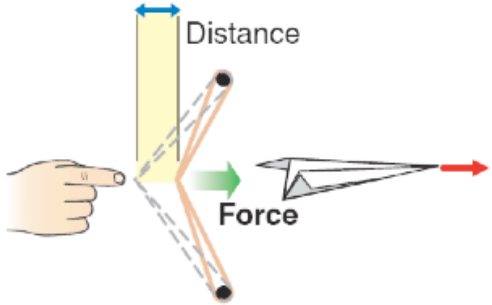


Energy and Work

Work done stretching a rubber band increases its potential energy.

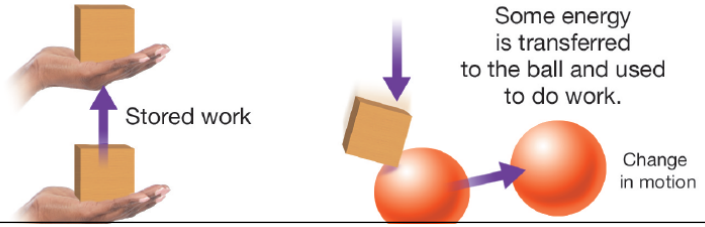


The rubber band can then do work on the plane, giving it kinetic energy.

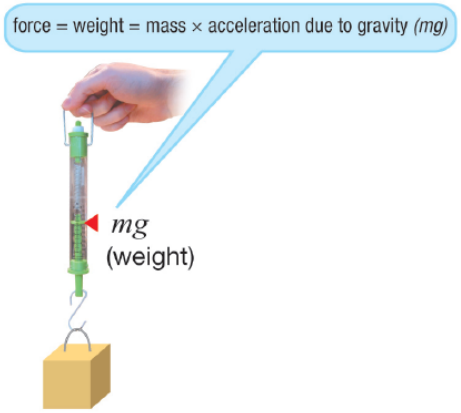


7.2 Potential energy

- Systems or objects with potential energy are able to exert forces (exchange energy) as they change.
- Potential energy is energy due to position.



7.2 Potential energy



- A block suspended above a table has potential energy.
- If released, the force of gravity moves the block down to a position of lower energy.
- The term gravitational potential energy describes the

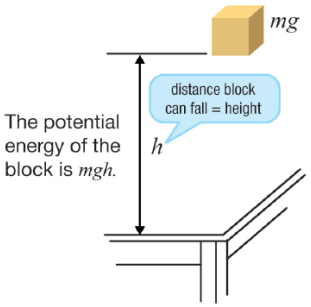
7.2 Potential Energy

mass of object (g)

height object raised (m)

PE (joules) → $E_P = mgh$

gravity (9.8 m/sec^2)



The potential energy of the block is mgh.

7.2 Kinetic energy

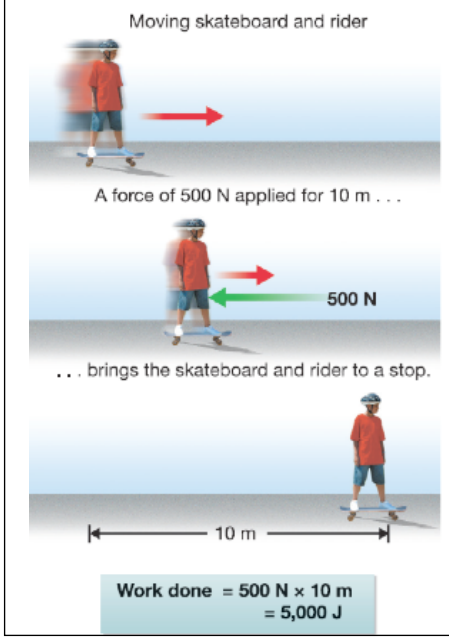
- Energy of motion is called kinetic energy.
- Kinetic energy can easily be converted

KINETIC ENERGY

Kinetic energy (J) $E_k = \frac{1}{2}mv^2$

Mass (kg)

Speed (m/s)



Work done = 500 N × 10 m
= 5,000 J

7.2 Kinetic energy

- The amount of kinetic energy an object has equals the amount of work the object can do by exerting force as it stops.

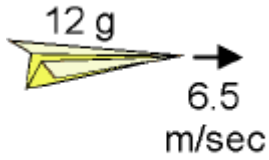
7.2 Kinetic Energy

KE (joules)

mass of object (kg)

$$E_K = \tfrac{1}{2} mv^2$$

velocity (m/sec)



Solving Problems: Potential and Kinetic Energy

POTENTIAL ENERGY

Potential energy (J) $E_p = mgh$

Mass (kg)

Height (m)

Acceleration due to gravity (9.8 m/s²)

KINETIC ENERGY

Kinetic energy (J) $E_k = \frac{1}{2}mv^2$

Mass (kg)

Speed (m/s)

Solving Problems

A 2 kg rock is at the edge of a cliff 20 meters above a lake.

It becomes loose and falls toward the water below.

Calculate its potential and kinetic energy when it is at the top and when it is halfway down.

Its speed is 14 m/s at the halfway point.

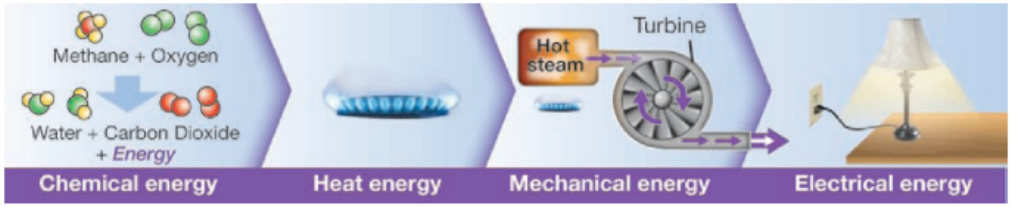
Solving Problems

1. **Looking for:**
   - …initial E_K, E_P and E_K, E_P half way down.
2. **Given:**
   - mass = 2.0 kg; h = 20 m
   - v = 14 m/s (half way)

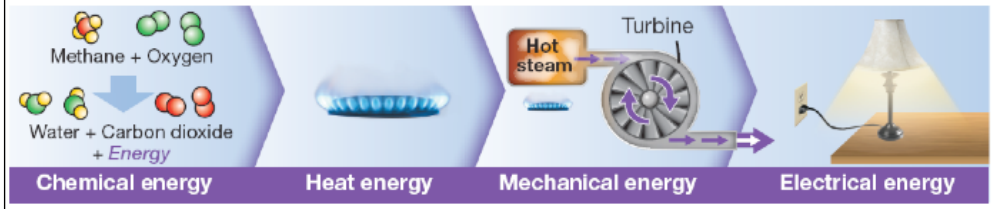
3. **Relationships:**
   - $E_P = mgh$
   - $E_K = \frac{1}{2} mv^2$
   - Assume rock starts from rest.

7.2 Transforming Energy

- Systems change as energy flows and changes from one part of the system to another.
- Each change transfers energy or transforms energy from one form to another.

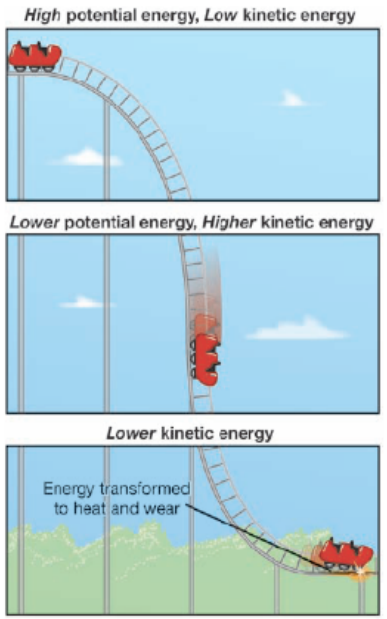


Energy Flow Example



7.2 Energy flow

- How can we predict how energy will flow?
- One thing we can always be sure of is that systems tend to move from higher to lower energy.

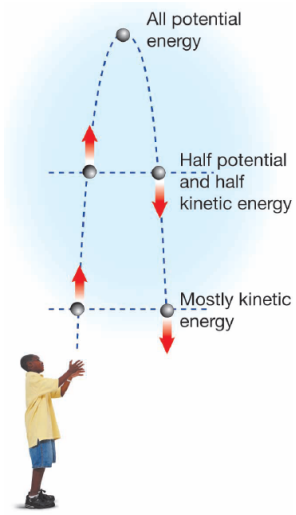


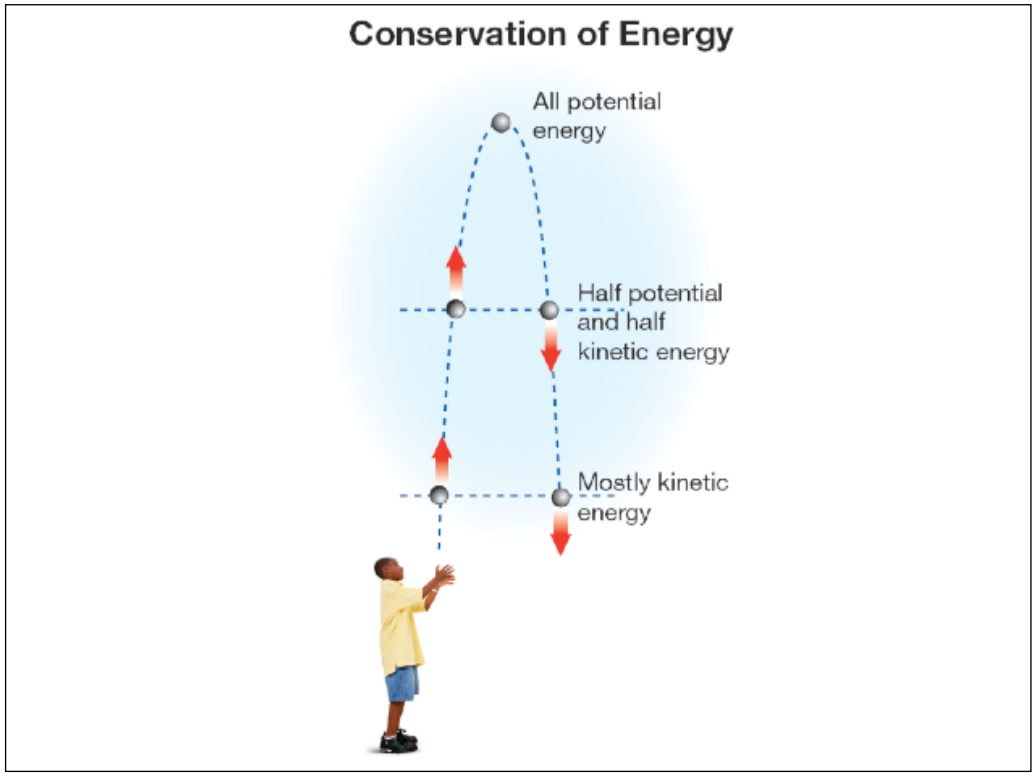
7.2 Conservation of Energy

- The idea that energy tranforms from one form into another without a change in the total amount is called the law of conservation of energy.
- The law of energy conservation says the total energy before the change equals the total energy after it.

7.2 Conservation of Energy

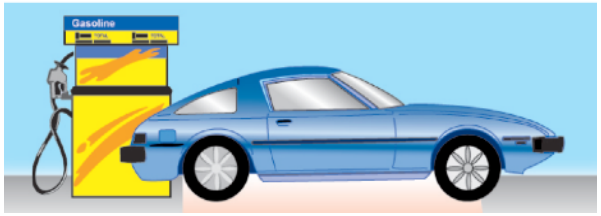
- When you throw a ball in the air, the energy transforms from kinetic to potential and then back to kinetic.




Conservation of Energy
All potential energy
Half potential and half kinetic energy
Mostly kinetic energy

7.2 Conservation of Energy

- People concerned about "running out" of energy really mean "running out of certain types of energy" that are easy to transform.
- Fossil fuels and natural gas are cheaply converted to mechanical and electrical energy.



7.2 Conservation of Energy

- It took millions of years to accumulate these fuels because they are derived from decaying, ancient plants that obtained their energy originally from the Sun when they were alive.
- Because it took a long time for these plants to grow, decay, and become oil and gas, fossil fuels are a limited resource.

7.2 Conservation of Energy

- Regular (incandescent) light bulbs convert only 10% of electrical energy to light.
- That means 90% of the energy is released as wasted heat.
- When someone asks you to turn out the lights to conserve energy, they are asking you to use less electrical energy, which uses less fossil fuel.