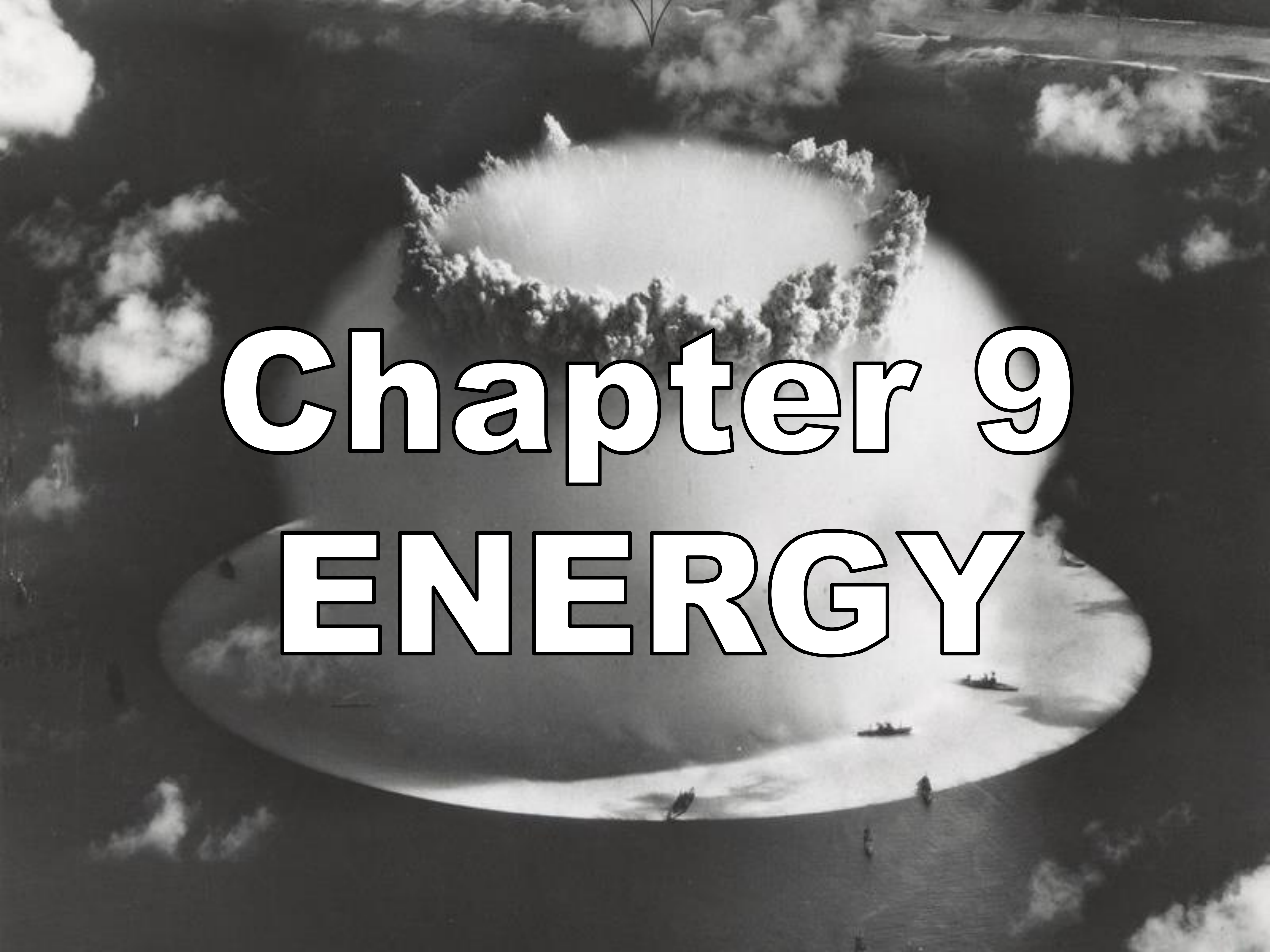
Chapter 9
ENERGY



THE BIG IDEA

Energy can change from one form to another without a net loss or gain.

Energy may be the most familiar concept in science, yet it is one of the most difficult to define.

We observe the effects of energy when something is happening—only when energy is being **transferred** from one place to another or **transformed** from one form to another.

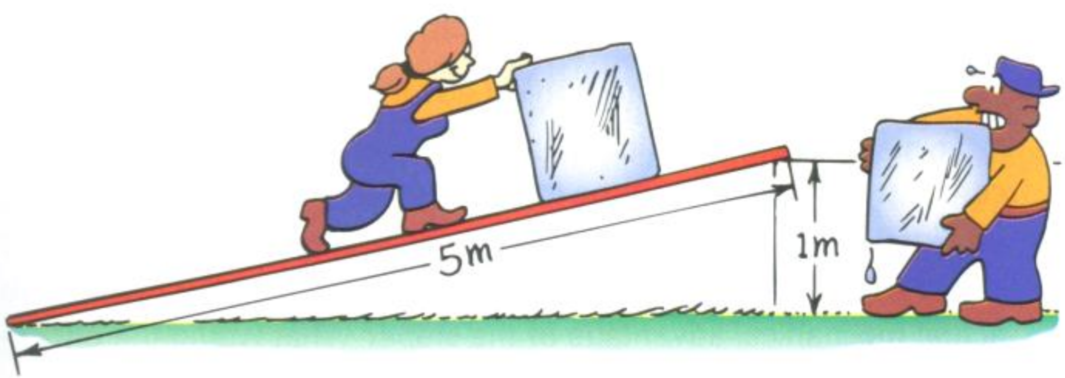
I. Work (9.1)

A. **Work– Force times distance**

1. Two things enter into every case when work is done.

a. The application of a **force**

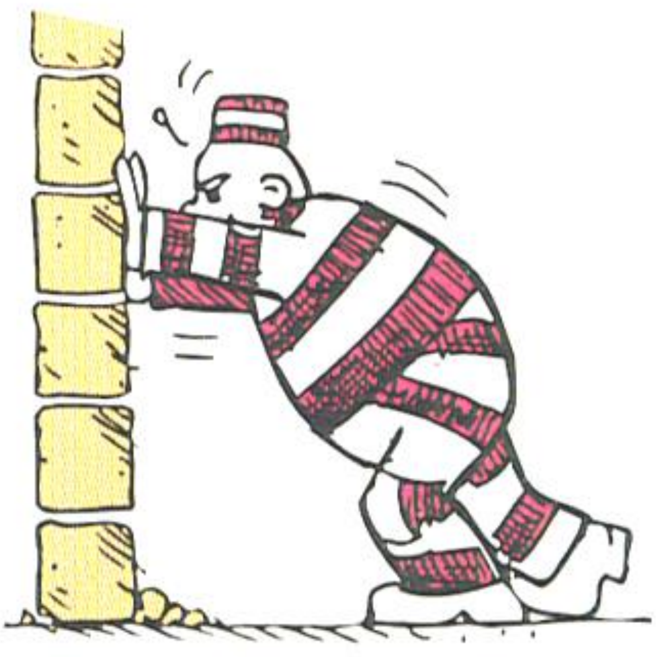
b. The **movement** of something by that force



2. Equation **work = force X distance**

$$W = Fd$$

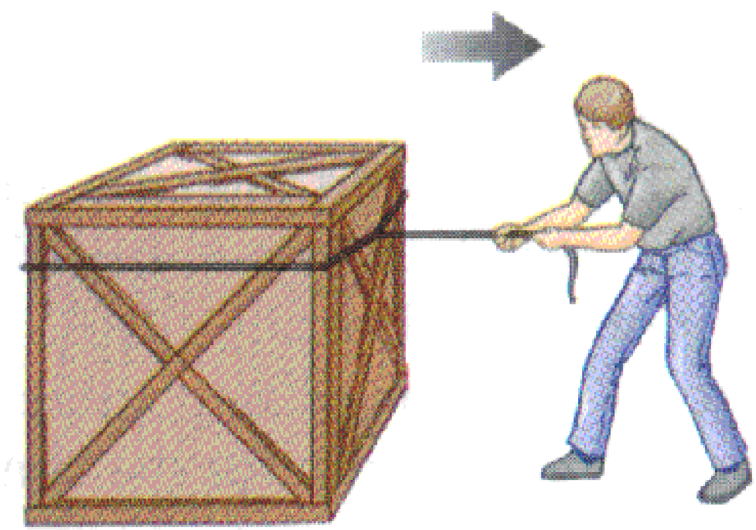
3. If object **does not move** then **no work** done on the object.



B. Work falls into **two** categories

1. **Work done against another force** (ie. Work against elastic force, against gravity-lifting object, against friction)

2. Work done to **change speed** of an object (ie. Speeding up or slowing down of a car)



C. Units of Work

1. Combine units of Force (**N**) with distance (**m**)

2. A **N-m** is called a **joule (J)**

a. A joule of work is done when force of 1 N is exerted over distance of 1 meter.

b. **kilojoules** (**KJ**) = 1000 joules

c. **megajoules** (**MJ**) = millions of joules

II. Power (9.2)

A. **Power** - the **rate** at which work is done

1. Equals the **amount of work done** divided by **time interval during which the work is done.**

2. $$\textbf{\textit{Power}} = \frac{\textbf{\textit{Work done}}}{\textbf{\textit{Time interval}}}$$

B. Unit of Power is the joule per second– also known as the **watt** (in honor of James Watt)

1. **One watt (W) of power is expended when one joule of work is done in one second**

2. **Kilowatt** = 1000 watts

3. **megawatt** = 1,000,000 watts

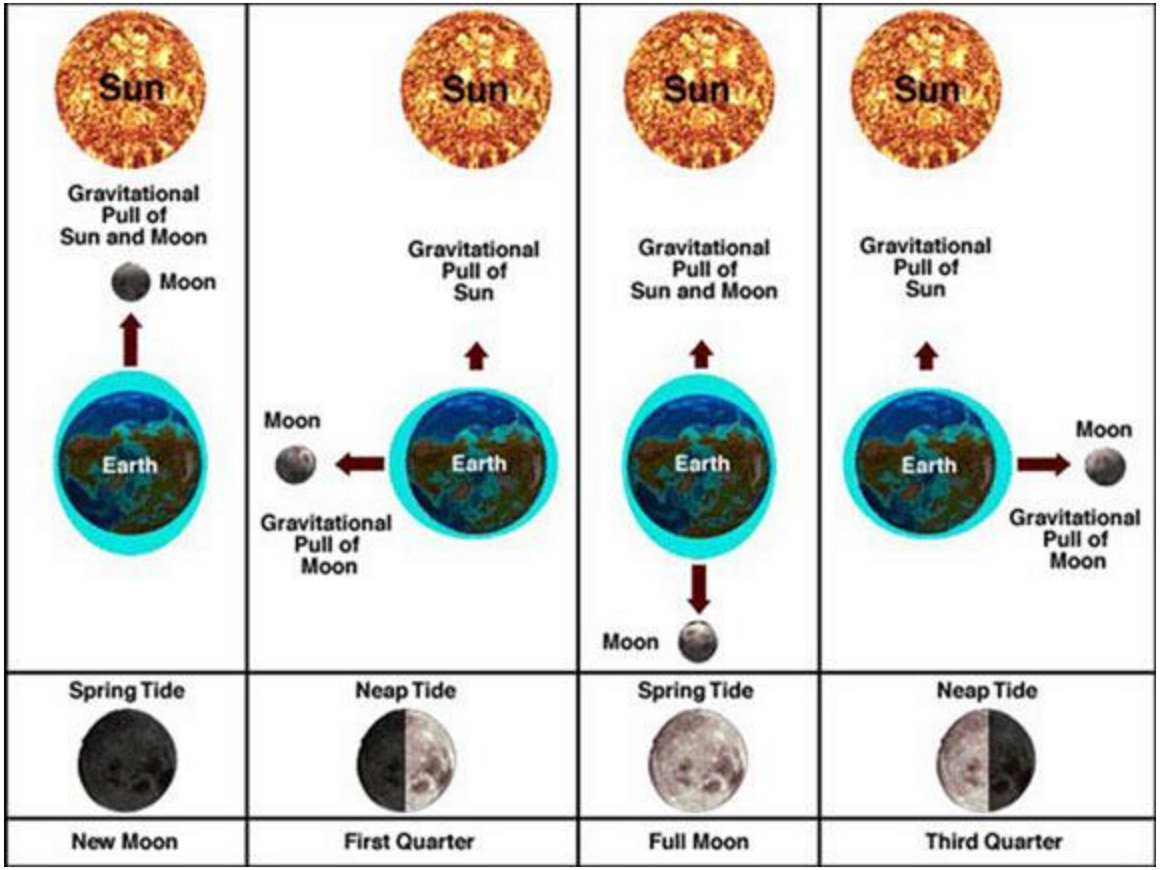
4. **One horse power (hp) = 0.75 kW**

III. Mechanical Energy (9.3)

A. Something has been acquired by object that enables the object to do work.

1. compression of atoms in material of object

2. physical separation of attracting bodies or rearrangement of electric charges in the molecules of a substance



B. **Energy** –the “something” that enables an object to do work.

1. Like work, measured in **joules**
2. Energy appears in many forms

3. Two most common forms of mechanical energy

a. Energy due to position of something (**Potential Energy**)

b. or the movement of something (**Kinetic Energy**)

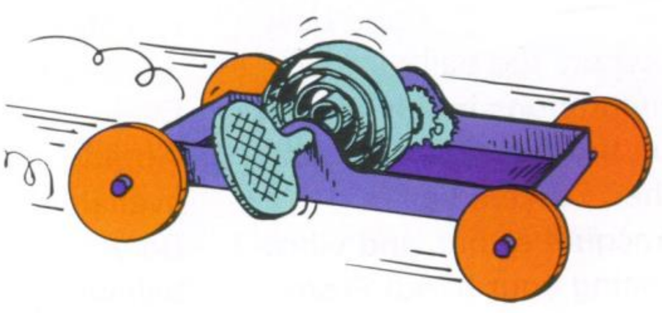
IV. Potential Energy (9.4)

A. Object may store energy by virtue of its **position**

1. **Potential Energy (PE)** - energy stored and held in readiness

a. Has **potential for doing work**

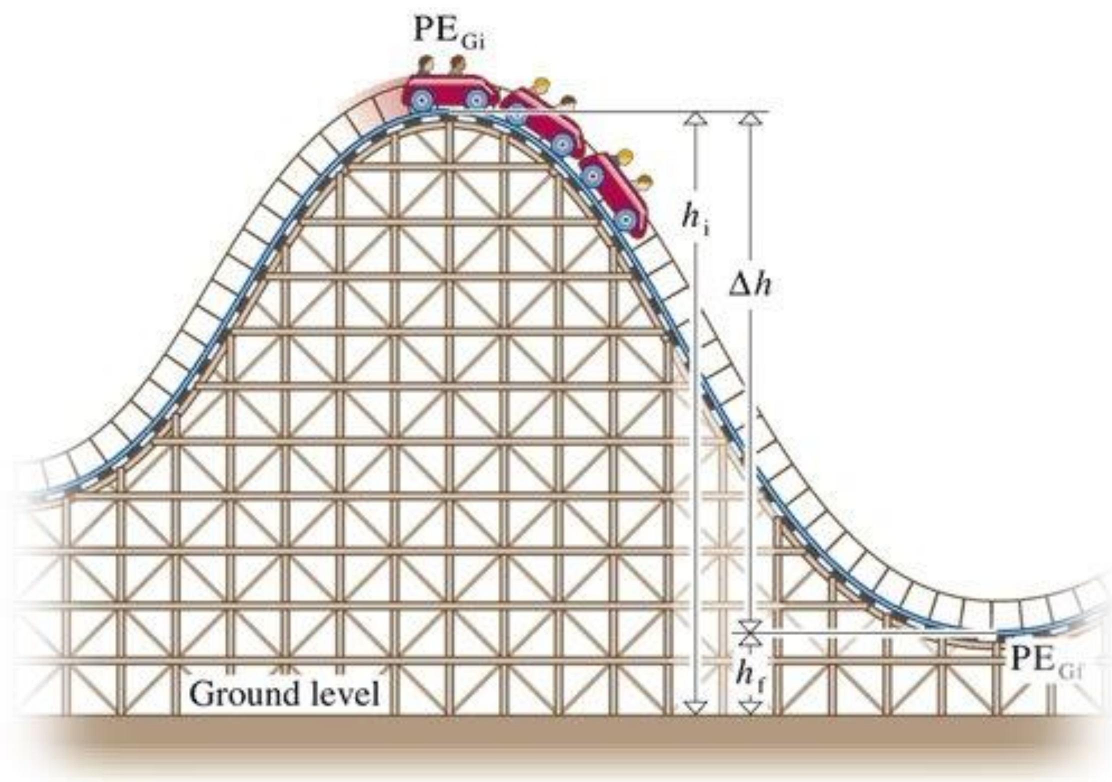
b. Many types of PE – compressed spring, stretched rubber band, chemical energy (fossil fuels, food, etc.)



B. **Gravitational Potential Energy** - PE due to elevated positions

1. **Gravitational PE = work done against gravity in lifting it.**

2. gravitational ***PE = weight x height***

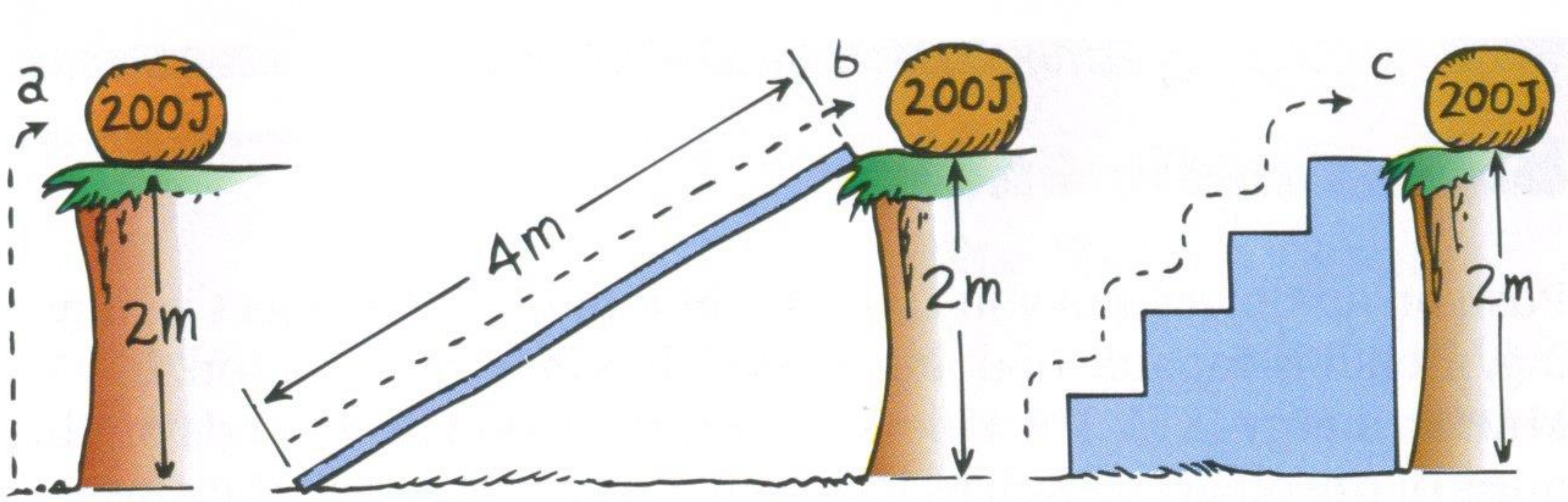


3. $$PE = mgh$$

a. **height** = distance above some chosen **reference level** (such as ground or floor of building)

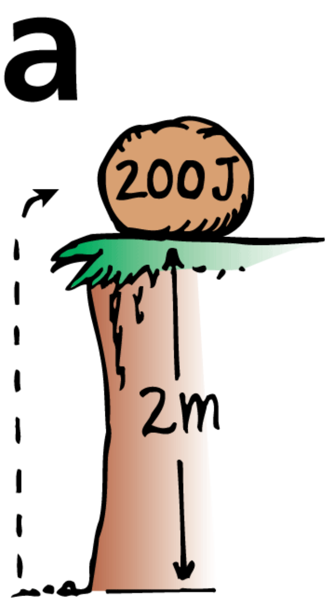
b. **gravitational PE** only depends on ***mgh***

c. Gravitational PE **does not depend** on the **path** taken to get it there



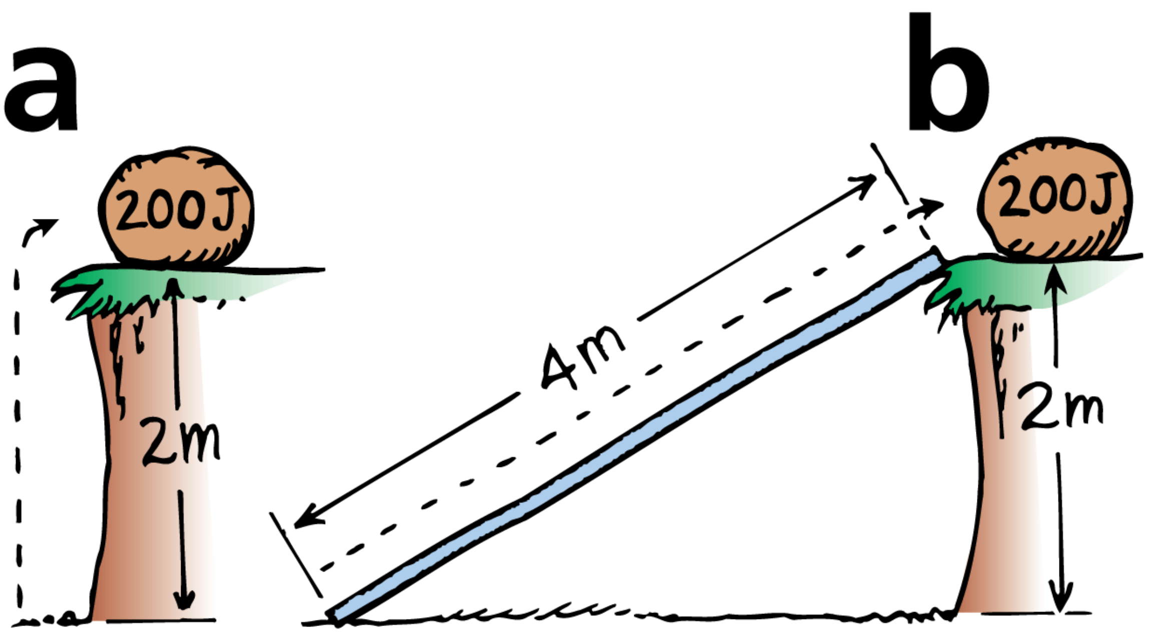
The potential energy of the 100-N boulder with respect to the ground below is 200 J in each case.

a. The boulder is lifted with 100 N of force.



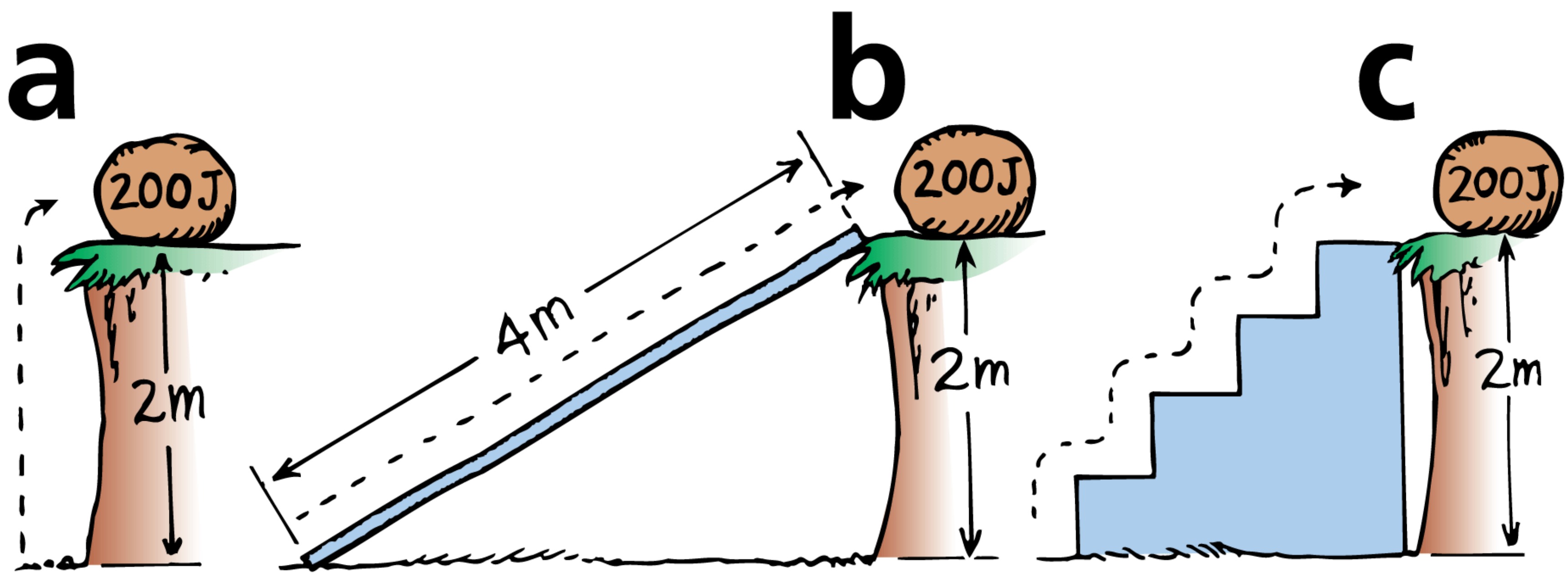
The potential energy of the 100-N boulder with respect to the ground below is 200 J in each case.

a. The boulder is lifted with 100 N of force.
b. The boulder is pushed up the 4-m incline with 50 N of force.



The potential energy of the 100-N boulder with respect to the ground below is 200 J in each case.

a. The boulder is lifted with 100 N of force.
b. The boulder is pushed up the 4-m incline with 50 N of force.
c. The boulder is lifted with 100 N of force up each 0.5-m stair.



V. Kinetic Energy (9.5)

A. **Kinetic energy = "energy in motion"**

1. Object that is **moving** has potential of doing **work**
2. **KE** depends on **mass** of object as well as **speed**

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

B. KE of moving object =

1. work required to bring it to that speed from rest

2. or the work the object can do while being brought to rest

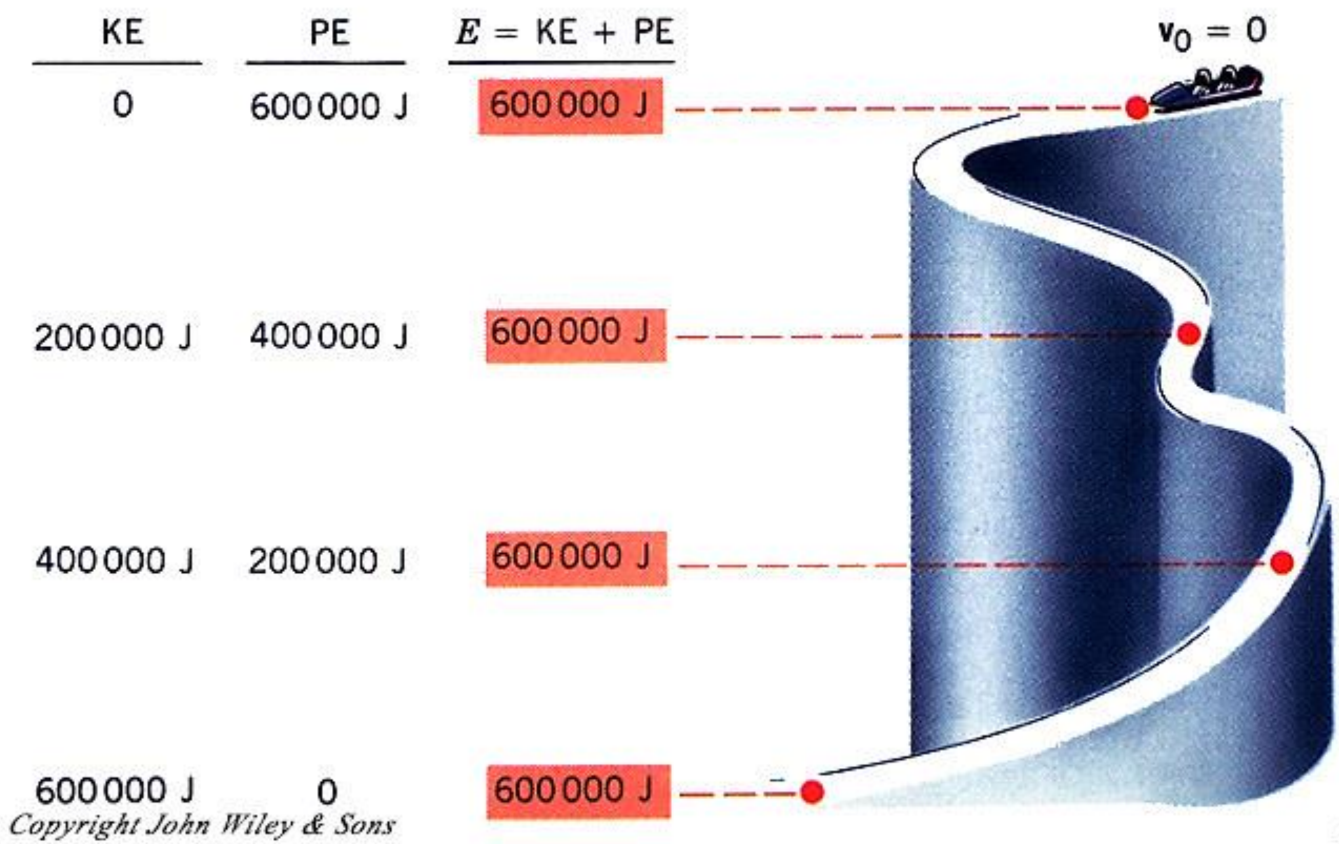
$$Fd = \frac{1}{2}mv^2$$

VI. Work-Energy Theorem (9.6)

A. Work changes amount of energy

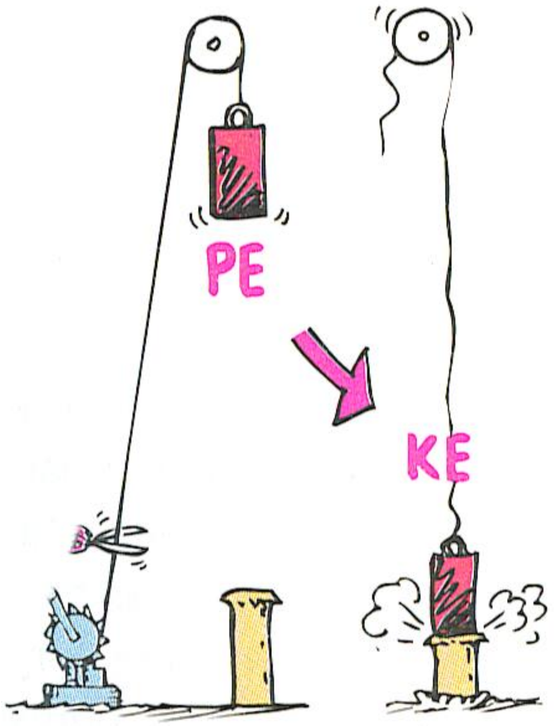
B. If no change in energy than no work done

C. **When work is done energy changes**

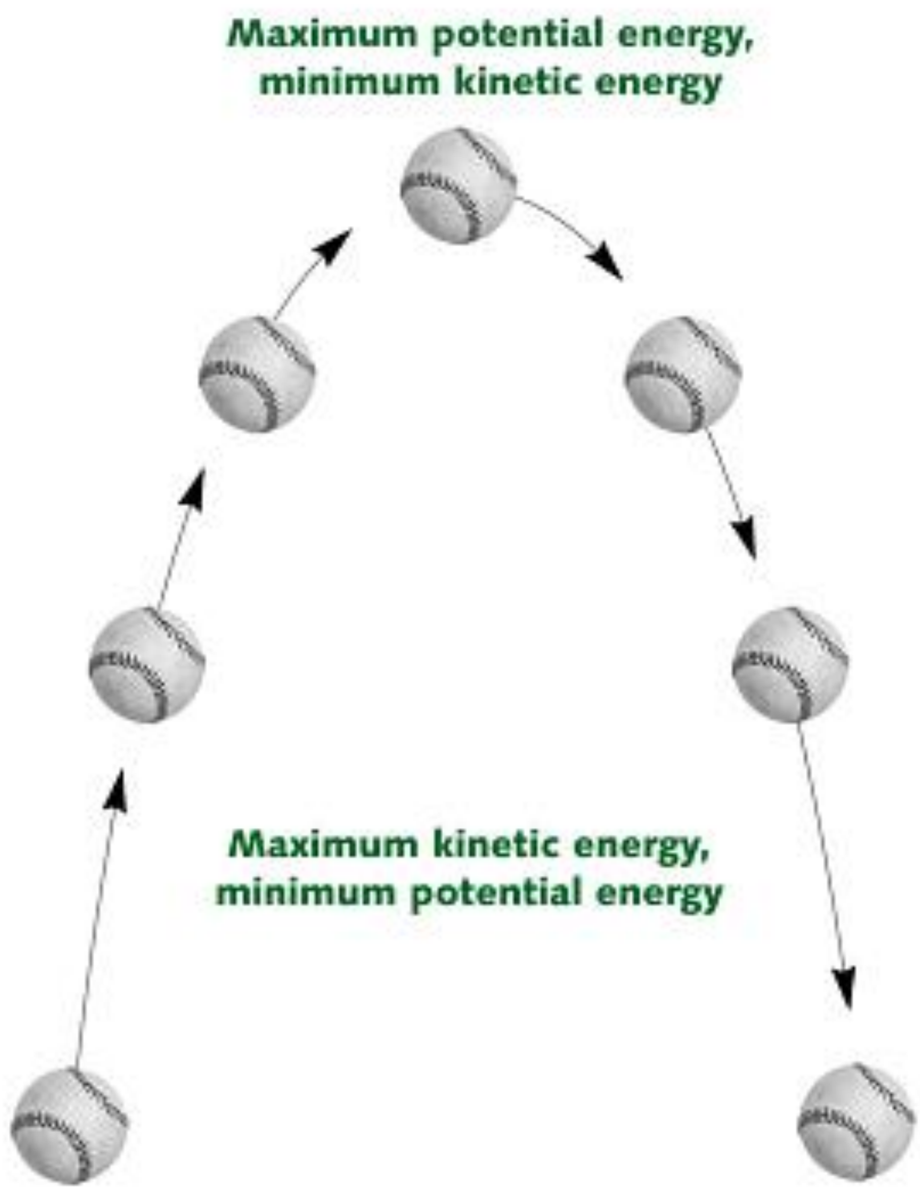


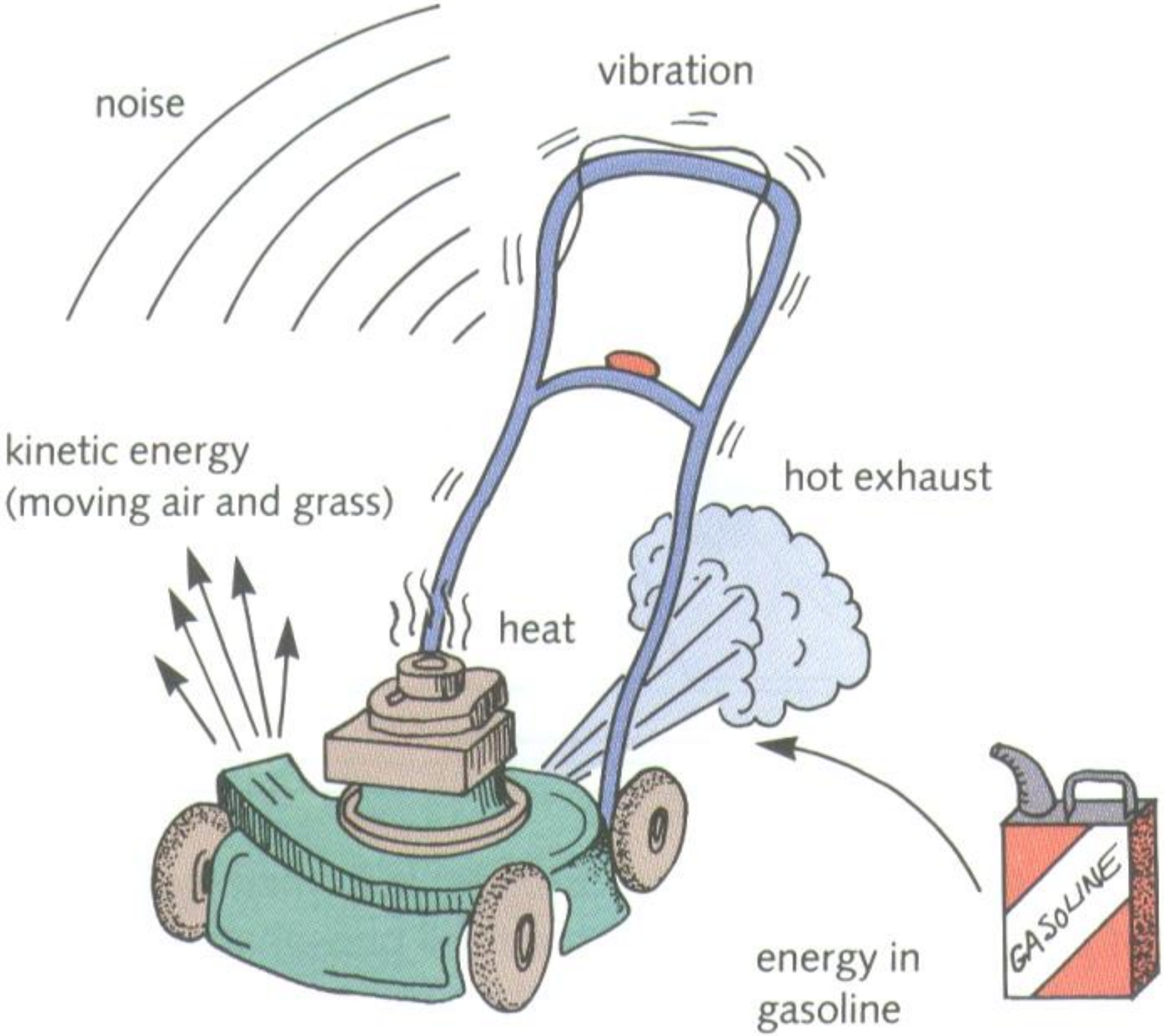
VII. Conservation of Energy (9.7)

A. **Law of conservation of Energy**



1. Energy <u>cannot</u> be **created** or **destroyed**.
2. It can be **transformed** from **one form to another**
3. **Total amount of energy never changes**

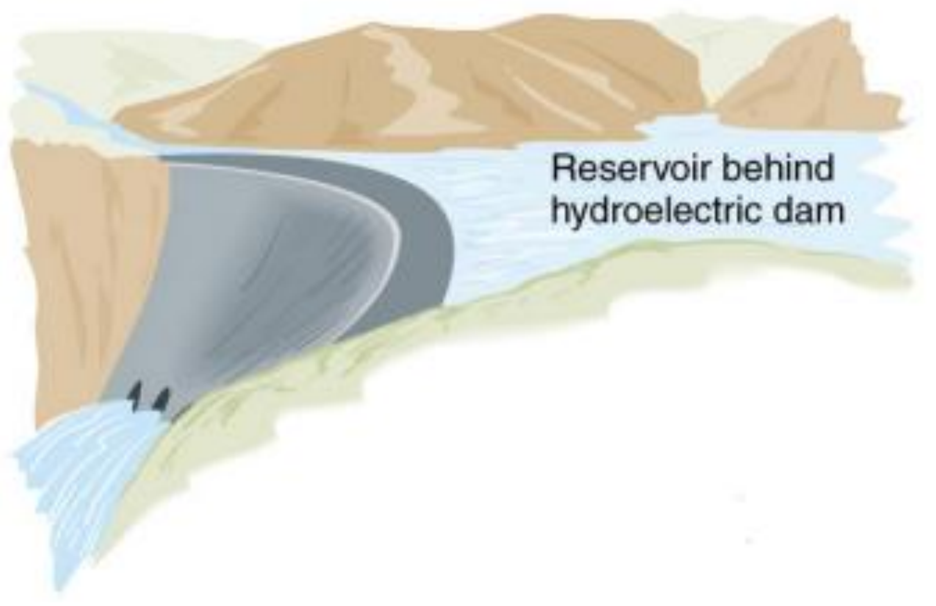

Maximum potential energy,
minimum kinetic energy
Maximum kinetic energy,
minimum potential energy

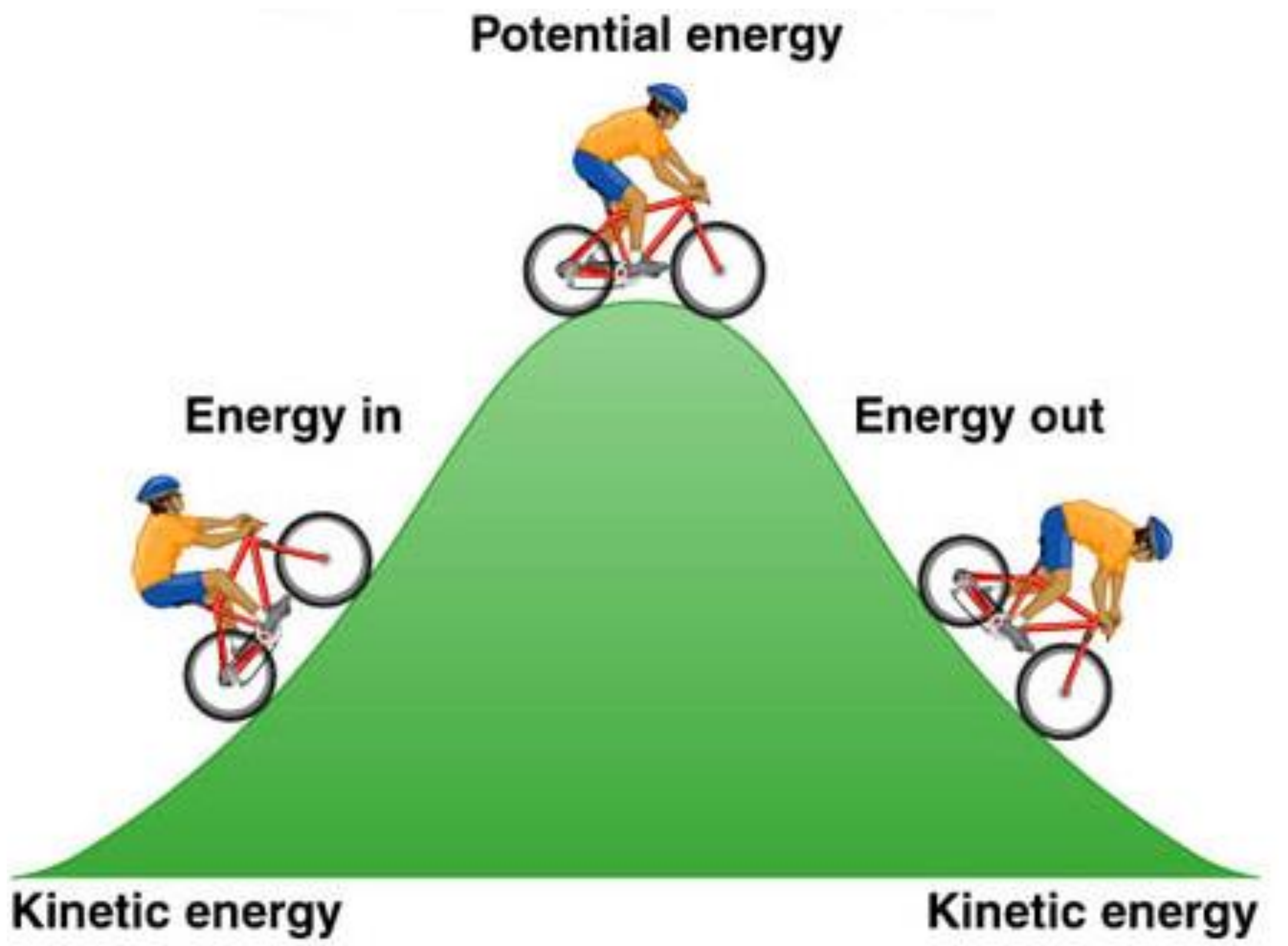

noise
vibration
kinetic energy
(moving air and grass)
hot exhaust
heat
GASOLINE
energy in
gasoline

B. Many forms of energy transformation

1. **PE to KE or KE to PE**

2. Thermonuclear, light, heat, chemical, electrical, etc.

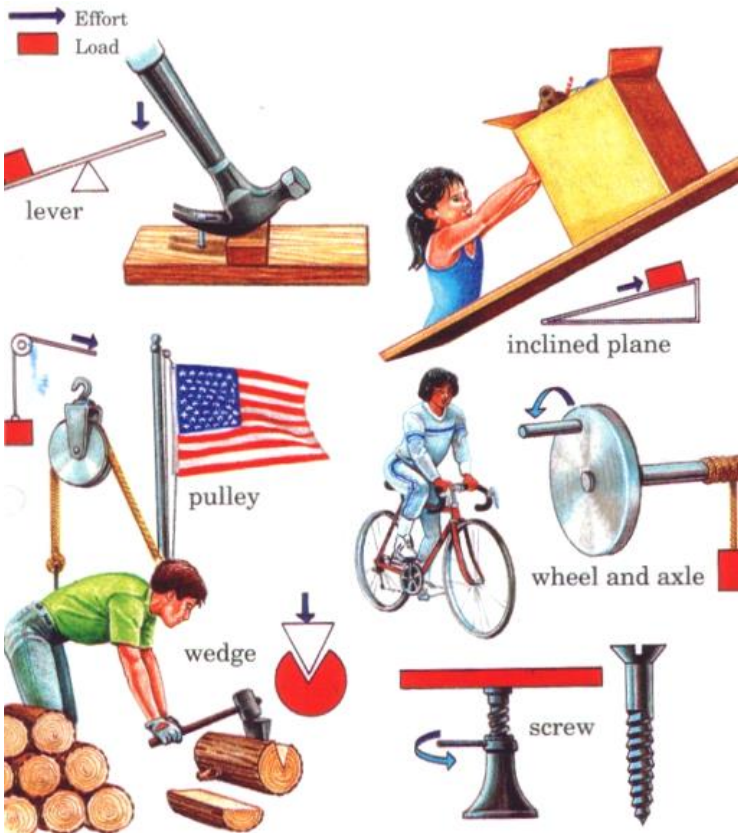


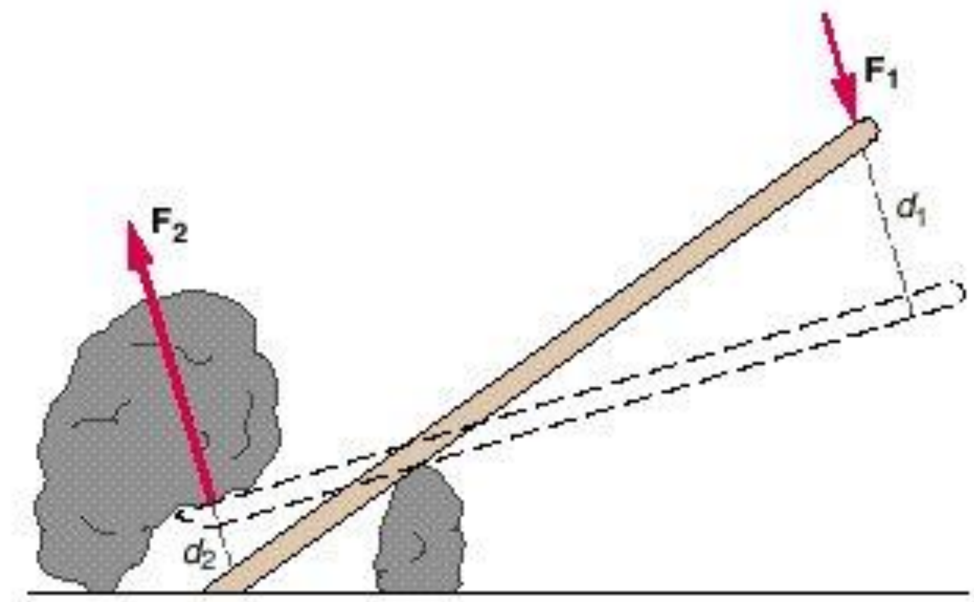

Potential energy
Energy in
Energy out
Kinetic energy
Kinetic energy

VIII. Machines (9.8)

A. **machine** - device used to **multiply forces** or **change direction of force**

1. **Lever**– direction of force is changed.

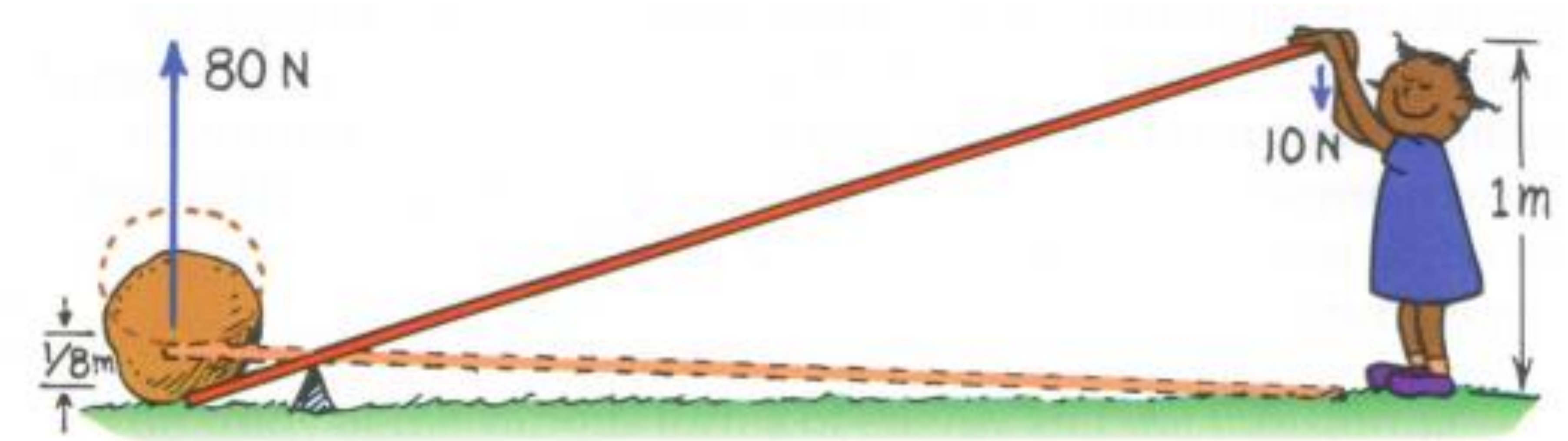




2. **work input equals work output**

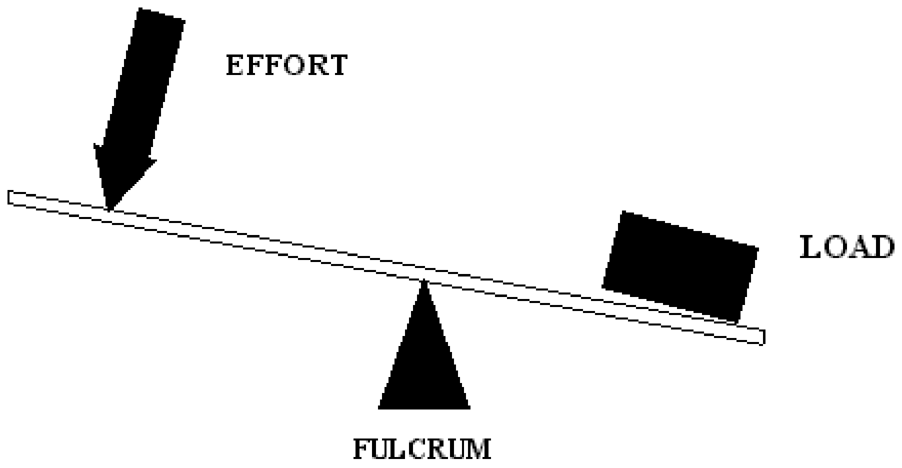
a. Since work equals force times time, we get:

(force x distance)input = (force x distance)output

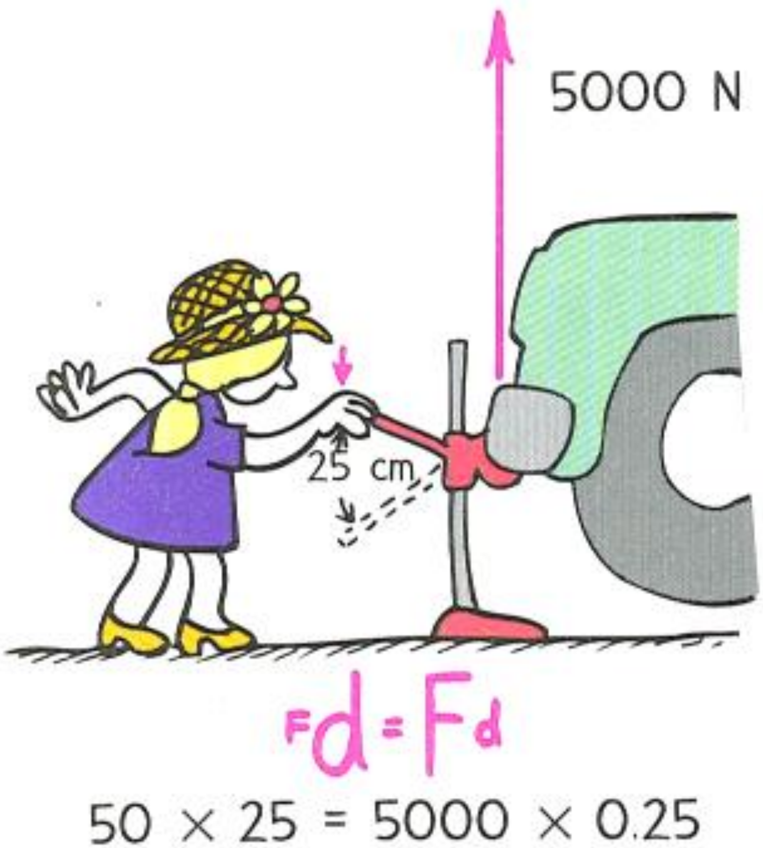


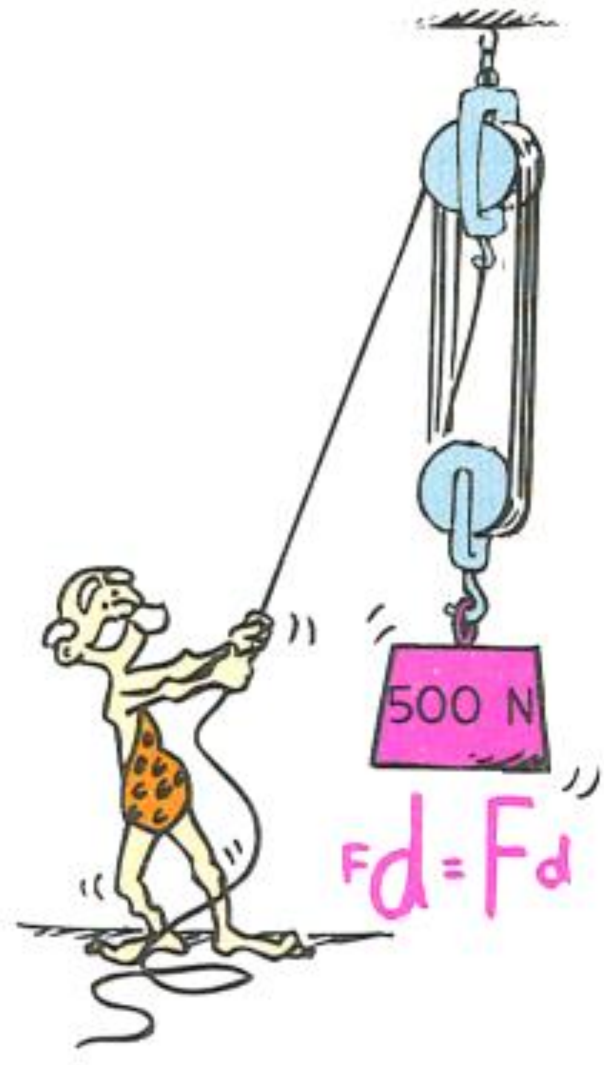
The output force (80 N) is eight times the input force (10 N), while the output distance (1/8 m) is one-eighth of the input distance (1 m).

3. **fulcrum**– pivot point of lever

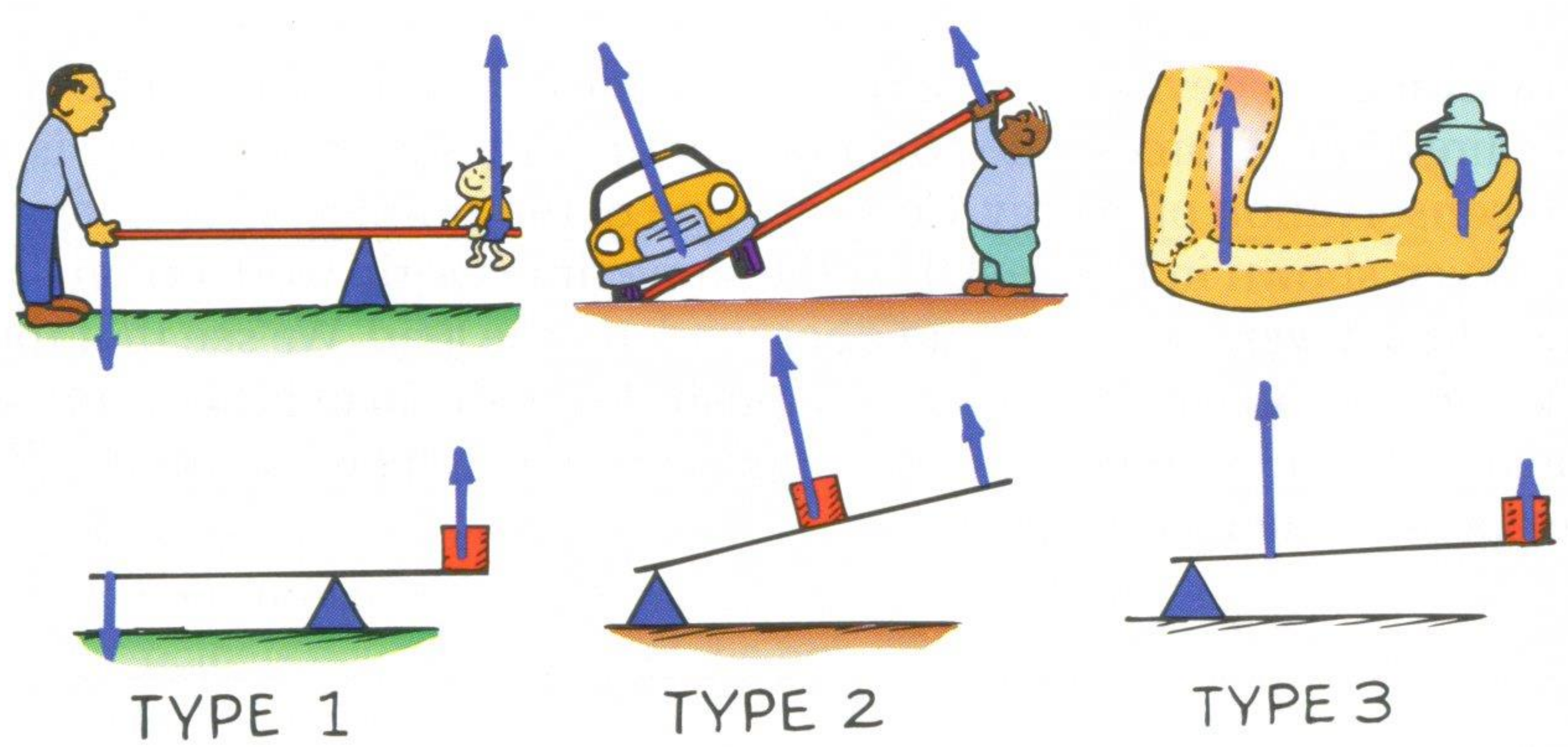


B. **Mechanical advantage**– ratio of output force to input force

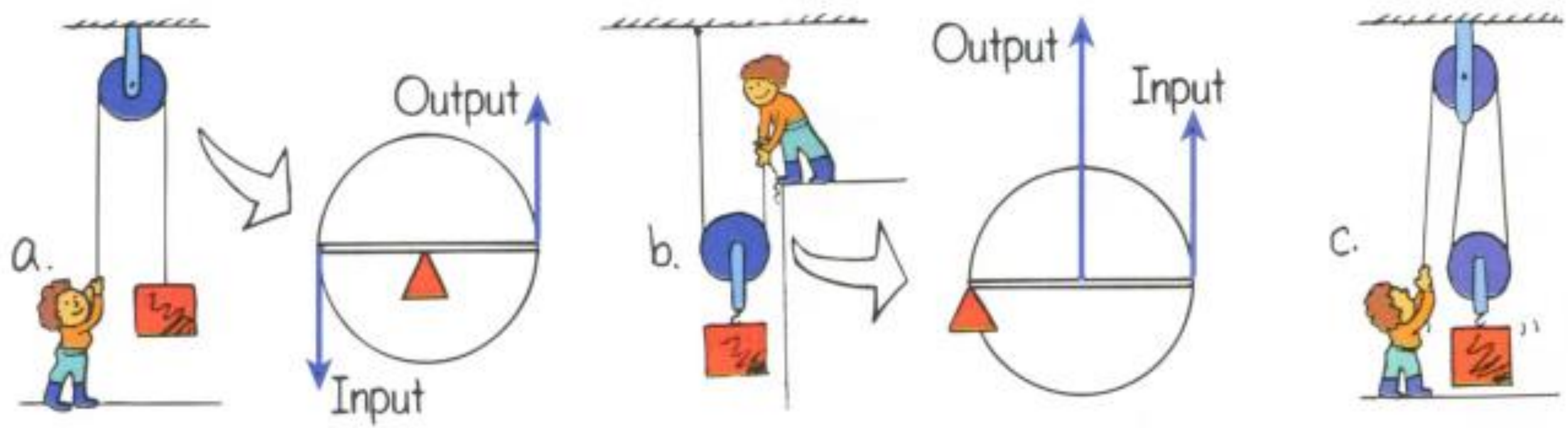




1. **Three kinds of levers**



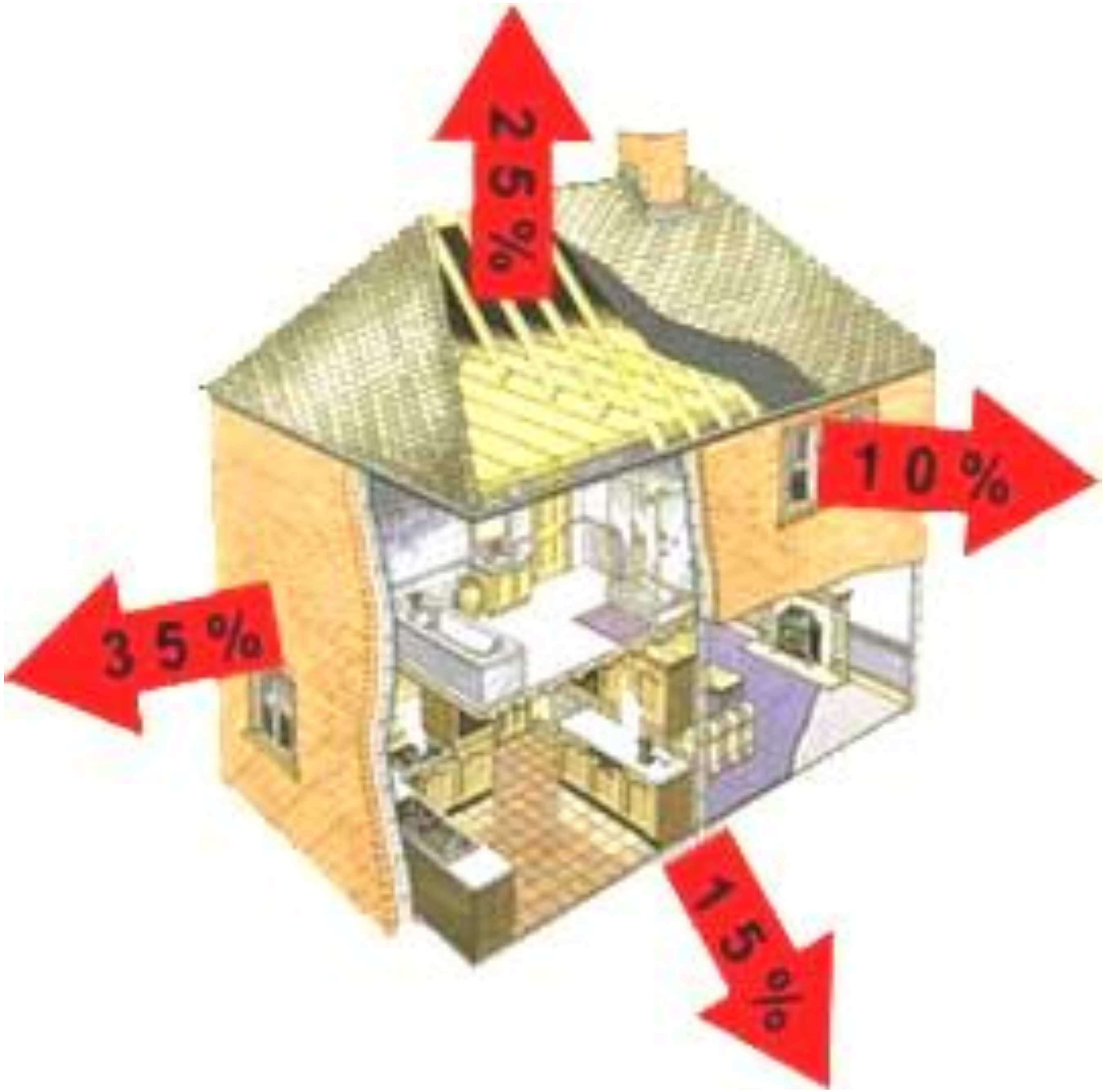
2. **Pulley**– basically kind of lever can be used to change the direction of force and to multiply forces



IX. Efficiency (9.9)

A. **efficiency** = ratio of useful work output to total work input

$$\textbf{\textit{efficiency}} = \frac{\textbf{\textit{Useful work output}}}{\textbf{\textit{Total work input}}}$$


25%
10%
35%
15%

1. **Efficiency will always be a fraction less than 1**

2. Transforming 100% of thermal energy into mechanical energy is **not possible**

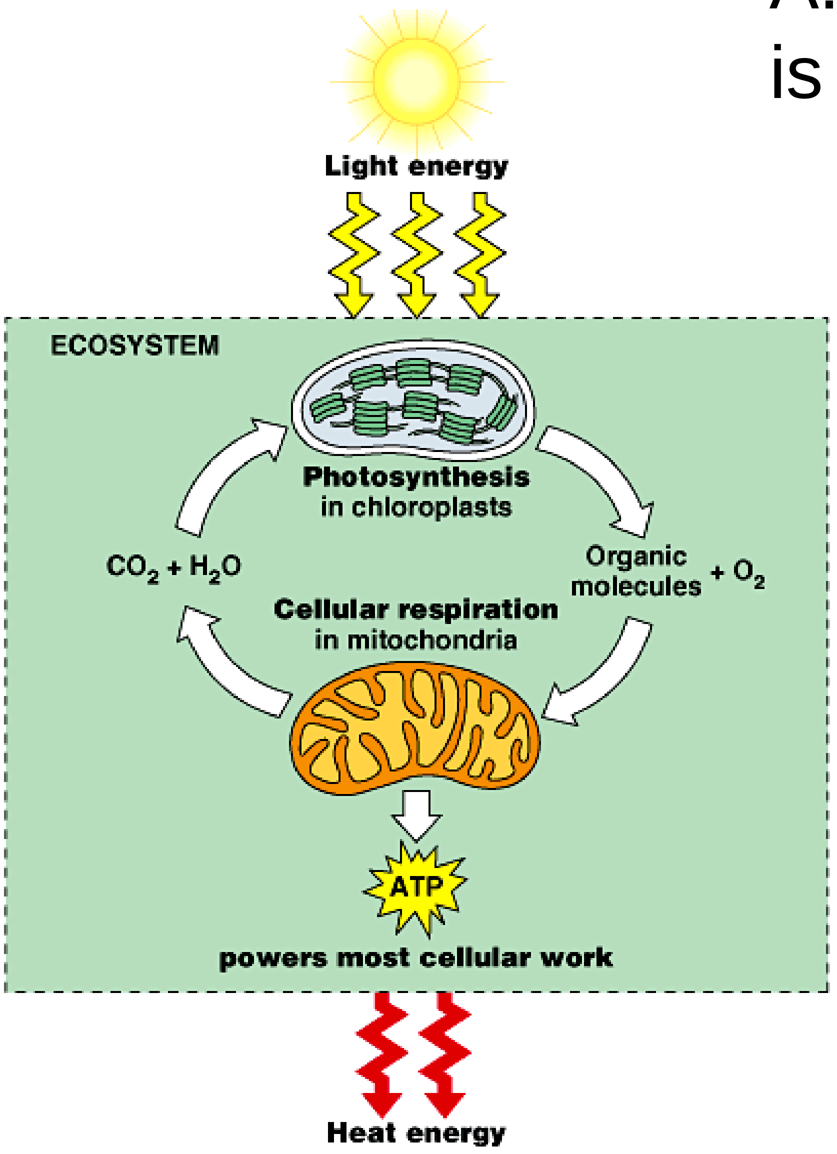
   a. Engines lose energy in form of **heat** (thermal energy)

   b. Lose energy by **friction**

   c. Best designed engines not more than **35%** efficient.

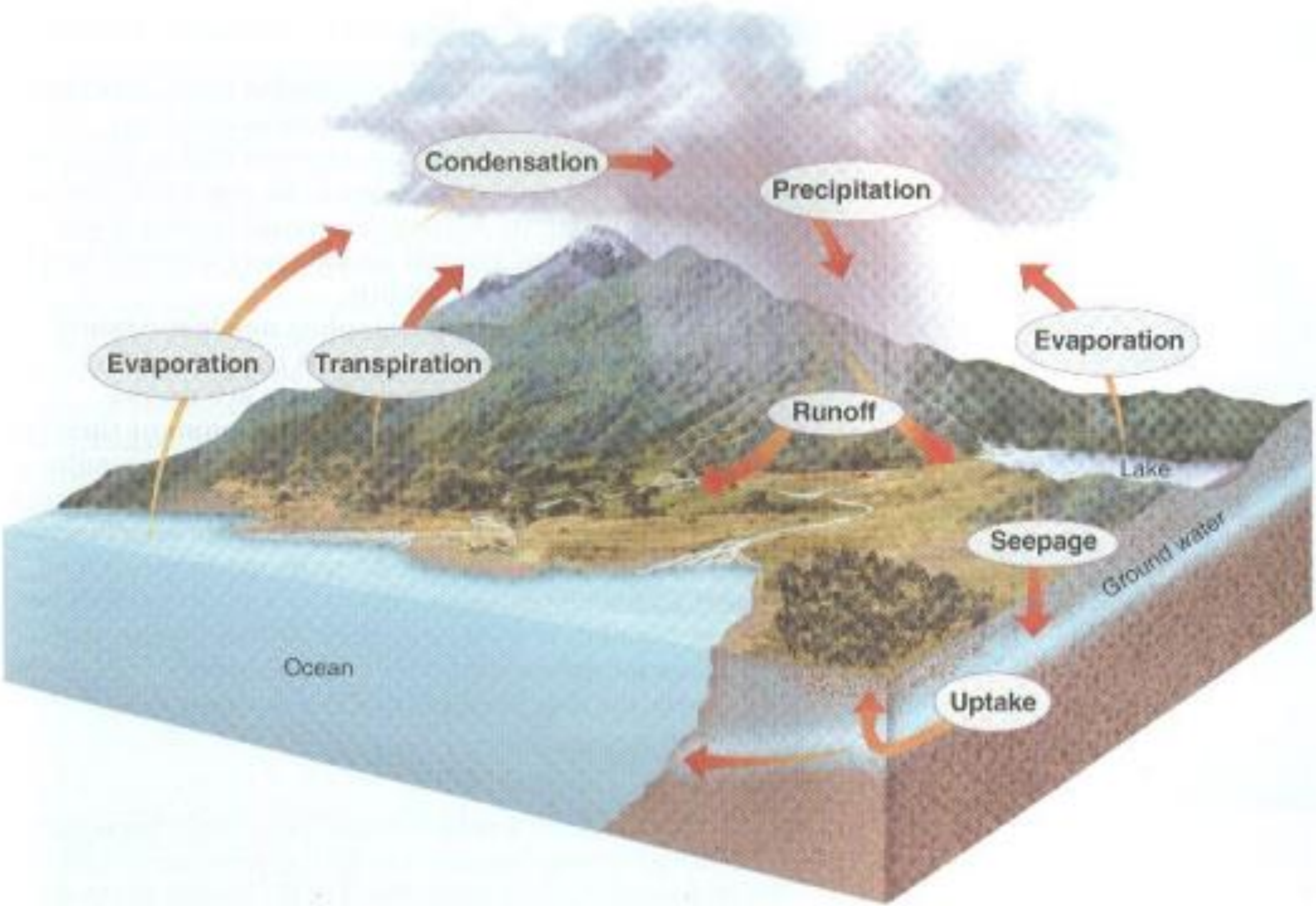
X. Energy of Life (9.10)

A. Every cell in every organism is a machine



B. **Cellular respiration**- organisms gain energy from food

C. **Photosynthesis**– sunlight converted into chemical energy.

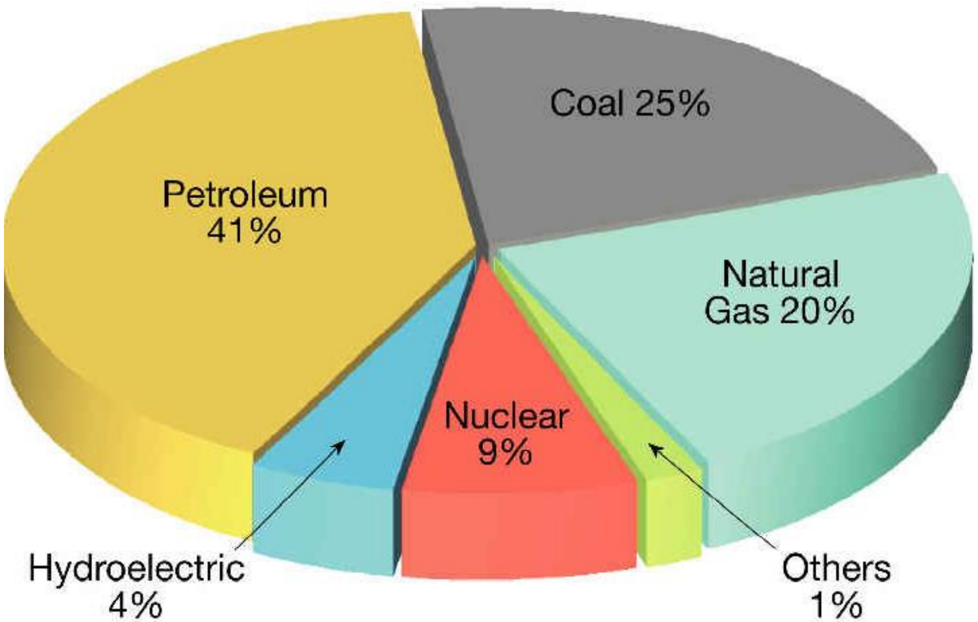


Condensation
Precipitation
Evaporation
Transpiration
Evaporation
Runoff
Lake
Seepage
Ground water
Ocean
Uptake

XI. Sources of Energy (9.11)

A. The sun is the source of practically all our energy on Earth

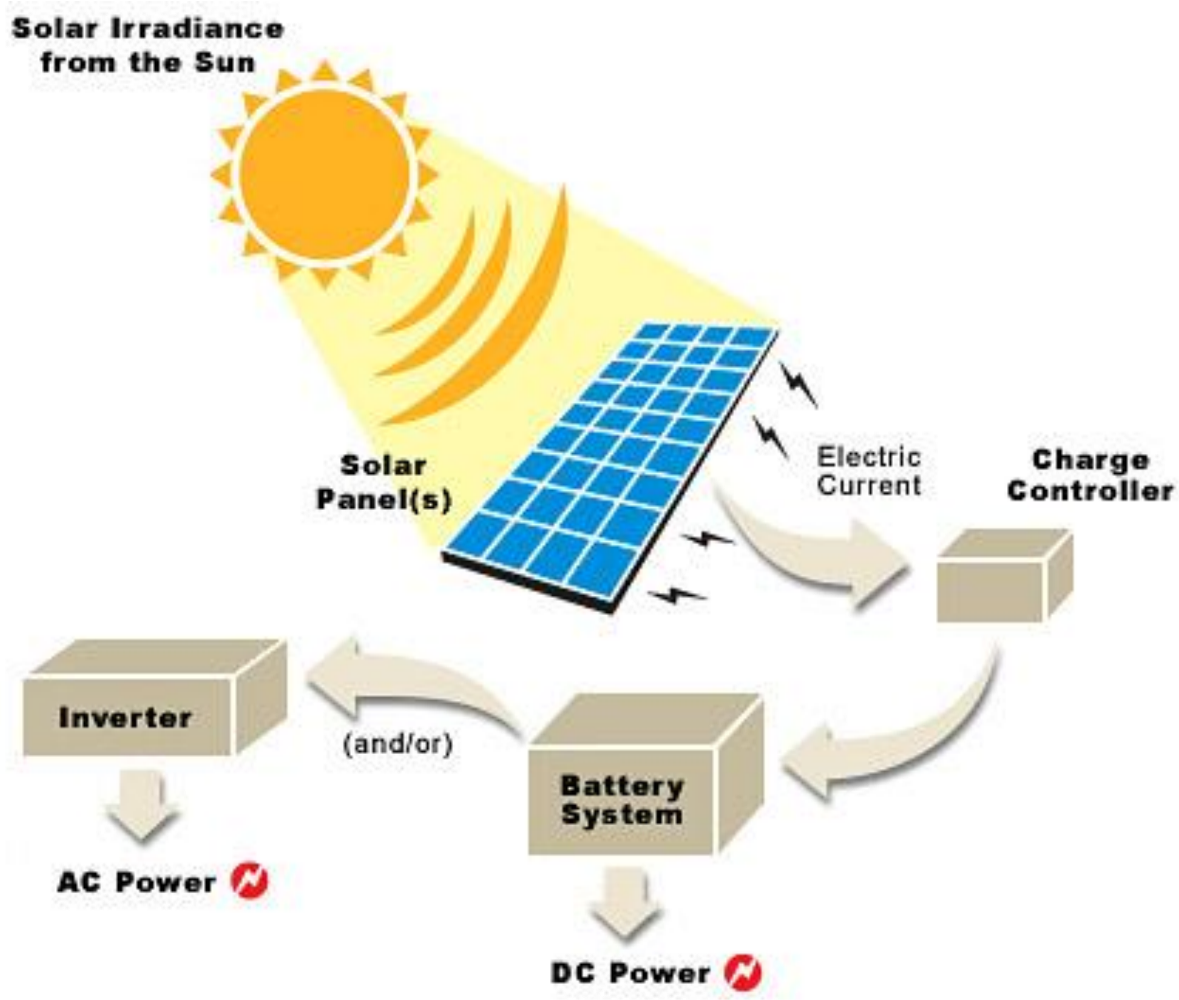
1. Exceptions are nuclear and geothermal energy



2. Fossil fuels (oil, natural gas, coal) comes from sun-created by photosynthesis

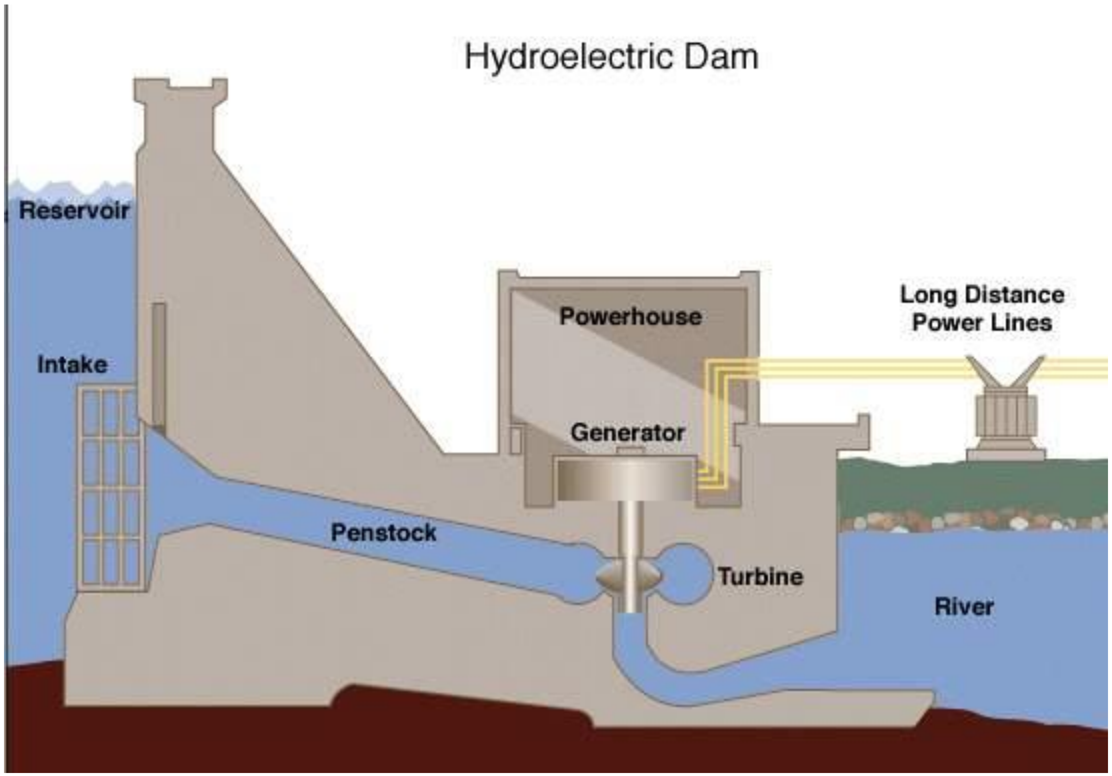
B. Solar Power-

1. Sunlight transformed into electricity by photovoltaic cells

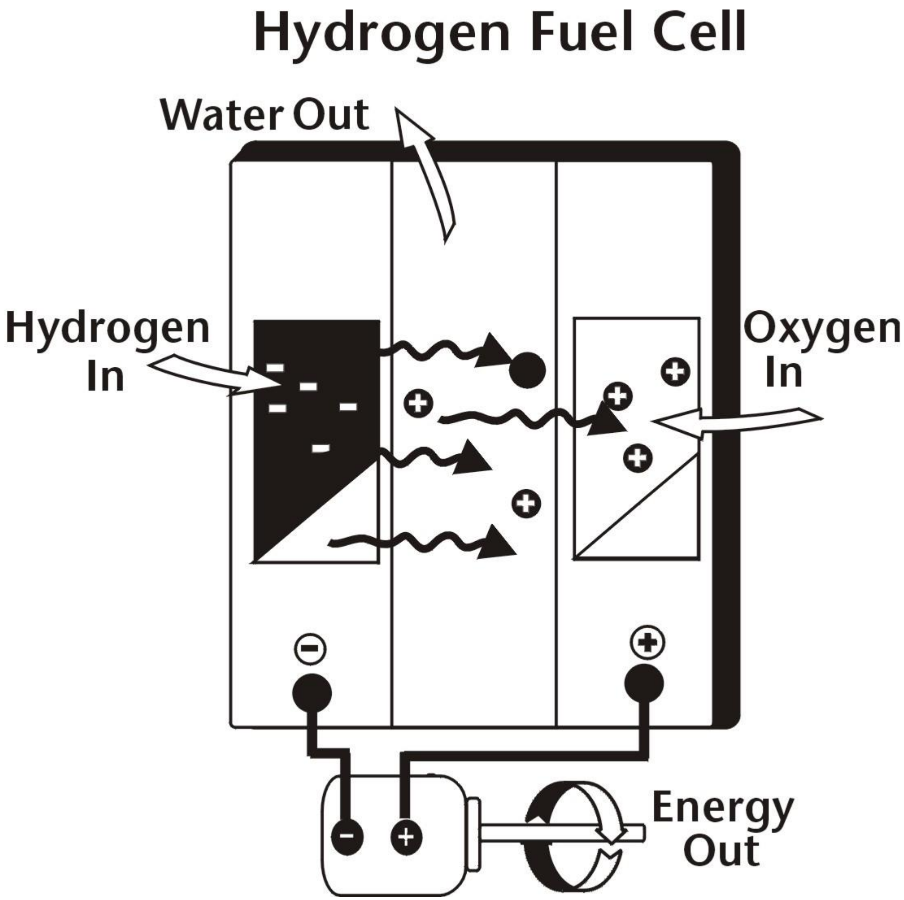


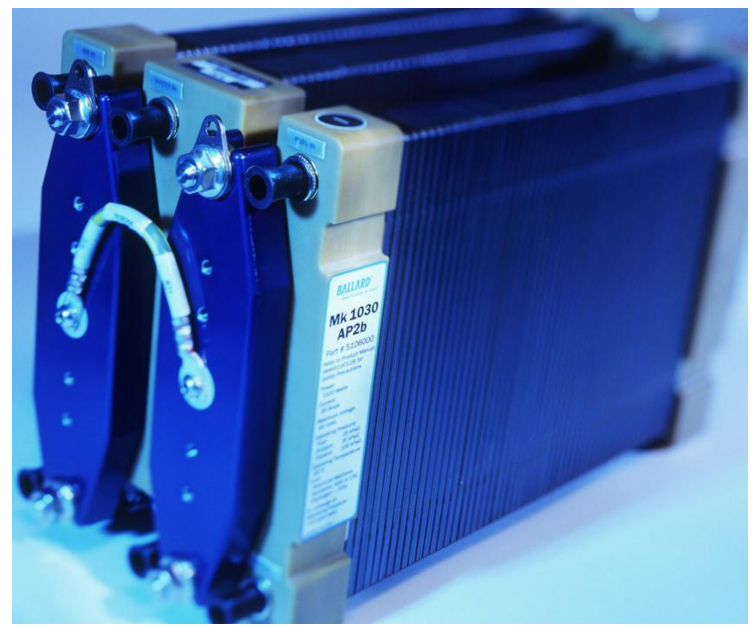
2. Use suns energy indirectly with hydroelectric power

3. Energy of wind created by suns warming of air



C. Fuel Cells- hydrogen and oxygen combine to form water and electricity





D. Nuclear and Geothermal Energy

1. Most concentrated form of useable energy stored in uranium and plutonium (nuclear fuels)
2. Byproduct of radioactivity in Earth’s interior is geothermal

Assessment Questions

1. Raising an auto in a service station requires work. Raising it twice as high requires
   a. half as much work.
   b. the same work.
   c. twice the work.
   d. four times the work.

Assessment Questions

1. Raising an auto in a service station requires work. Raising it twice as high requires
   a. half as much work.
   b. the same work.
   c. twice the work.
   d. four times the work.

Answer: C

Assessment Questions

2. Raising an auto in a service station requires work. Raising it in half the time requires
   a. half the power.
   b. the same power.
   c. twice the power.
   d. four times the power.

Assessment Questions

2. Raising an auto in a service station requires work. Raising it in half the time requires
   a. half the power.
   b. the same power.
   c. twice the power.
   d. four times the power.

Answer: C

Assessment Questions

3. The energy due to the position of something or the energy due to motion is called

   a. potential energy.

   b. kinetic energy.

   c. mechanical energy.

   d. conservation of energy.

Assessment Questions

3. The energy due to the position of something or the energy due to motion is called
   a. potential energy.
   b. kinetic energy.
   c. mechanical energy.
   d. conservation of energy.

Answer: C

Assessment Questions

4. After you place a book on a high shelf, we say the book has increased
   a. elastic potential energy.
   b. chemical energy.
   c. kinetic energy.
   d. gravitational potential energy.

Assessment Questions

4. After you place a book on a high shelf, we say the book has increased
   a. elastic potential energy.
   b. chemical energy.
   c. kinetic energy.
   d. gravitational potential energy.

Answer: D

Assessment Questions

5. An empty truck traveling at 10 km/h has kinetic energy. How much kinetic energy does it have when it is loaded so its mass is twice, and its speed is increased to twice?
   a. the same KE
   b. twice the KE
   c. four times the KE
   d. more than four times the KE

Assessment Questions

5. An empty truck traveling at 10 km/h has kinetic energy. How much kinetic energy does it have when it is loaded so its mass is twice, and its speed is increased to twice?
   a. the same KE
   b. twice the KE
   c. four times the KE
   d. more than four times the KE

Answer: D

Assessment Questions

6. Which of the following equations is most useful for solving a problem that asks for the distance a fast-moving crate slides across a factory floor in coming to a stop?

   a. $F = ma$

   b. $Ft = \Delta mv$

   c. $\mathrm{KE} = 1/2mv^2$

   d. $Fd = \Delta 1/2mv^2$

Assessment Questions

6. Which of the following equations is most useful for solving a problem that asks for the distance a fast-moving crate slides across a factory floor in coming to a stop?

   a. $F = ma$

   b. $Ft = \Delta mv$

   c. $\text{KE} = 1/2mv^2$

   d. $Fd = \Delta 1/2mv^2$

Answer: D

Assessment Questions

7. A boulder at the top of a vertical cliff has a potential energy of 100 MJ relative to the ground below. It rolls off the cliff. When it is halfway to the ground its kinetic energy is
    a. the same as its potential energy at that point.
    b. negligible.
    c. about 60 MJ.
    d. more than 60 MJ.

Assessment Questions

7. A boulder at the top of a vertical cliff has a potential energy of 100 MJ relative to the ground below. It rolls off the cliff. When it is halfway to the ground its kinetic energy is

   a. the same as its potential energy at that point.

   b. negligible.

   c. about 60 MJ.

   d. more than 60 MJ.

Answer: A

Assessment Questions

8. In an ideal pulley system, a woman lifts a 100-N crate by pulling a rope downward with a force of 25 N. For every 1-meter length of rope she pulls downward, the crate rises
   a. 25 centimeters.
   b. 45 centimeters.
   c. 50 centimeters.
   d. 100 centimeters.

Assessment Questions

8. In an ideal pulley system, a woman lifts a 100-N crate by pulling a rope downward with a force of 25 N. For every 1-meter length of rope she pulls downward, the crate rises

   a. 25 centimeters.

   b. 45 centimeters.

   c. 50 centimeters.

   d. 100 centimeters.

Answer: A

Assessment Questions

9. When 100 J are put into a device that puts out 40 J, the efficiency of the device is

   a. 40%.

   b. 50%.

   c. 60%.

   d. 140%.

Assessment Questions

9. When 100 J are put into a device that puts out 40 J, the efficiency of the device is
   a. 40%.
   b. 50%.
   c. 60%.
   d. 140%.

Answer: A

Assessment Questions

10. An energy supply is needed for the operation of a(n)
    a. automobile.
    b. living cell.
    c. machine.
    d. all of these

Assessment Questions

10. An energy supply is needed for the operation of a(n)
    a. automobile.
    b. living cell.
    c. machine.
    d. all of these

Answer: D

Assessment Questions

11. The main sources of energy on Earth are
    a. solar and nuclear.
    b. gasoline and fuel cells.
    c. wind and tidal.
    d. potential energy and kinetic energy.

Assessment Questions

11. The main sources of energy on Earth are
    a. solar and nuclear.
    b. gasoline and fuel cells.
    c. wind and tidal.
    d. potential energy and kinetic energy.

Answer: A