Work, Power, and Energy

1. **Work:** energy required to move an object from one place to another, is a measure of energy transfer. (It is zero work if object doesn't move.)
2. Work involves Force and Displacement (movement, change in position).
3. (F) required to lift a person = person's weight.
4. Formula: W = F x d (work = force(wt) x displacement)
5. Work units are Nm (Newton-meters) OR J (Joules).
6. **Simple Machines:** Tools that enable (F) & (d) to be varied while keeping work constant.
7. Can reduce (F) by increasing (d) through which force is exerted.
8. Examples:
9. Inclined plane 3. Pulley 5. Wedge 7. Block & tackle
10. Lever 4. Wheel & axle 6. Screw
11. **The Inclined Plane** (slanted surface / ramp)
12. The longer the ramp, the larger the (d), the less the F.
13. The shorter the ramp. The shorter the (d), the more the F.
14. Conservation of Energy (E): E without machine = E with machine. (W) without machine = (W) with machine.

IV. Effect of **Friction** on Machines:

1. Friction – force opposing motion, energy used to overcome friction changes to heat.
2. If friction is large, W with machine > W without machine.
3. If friction is small, W with machine = W without machine. < This is an **IDEAL** machine!>

V. **Output Force vs. Input Force**:

A. The force you put INto a machine is input force.

B. The force a machine produces (puts out) is the output force.

1. **Mechanical Advantage (MA)** also known as **Force Advantage**– how much easier a job is with a machine.
2. **Actual Mechanical Advantage: c**alculated by AMA=output F/input F (units: times easier to do the job with the machine)
3. Example: You use 50 N of force on a machine to lift a 250 N object. Calculate the AMA:

AMA = Fout/Fin

AMA = 250 N / 50 N

AMA = 5 times easier to do job with this machine

1. **Ideal Mechanical Advantage (IMA**) is mechanical advantage WITHOUT friction, calculated by IMA = Input distance/Output distance
2. Example: If a pulley has an output distance of 2.5m and your input distance using the pulley is 7.5m, find the IMA: IMA = din / dout

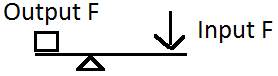
IMA = 7.5m/2.5m

IMA = 3 times easier to use this pulley system

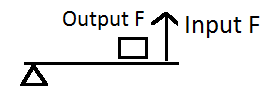
1. **Displacement Advantage:** when the advantage is with displacement, NOT force (you actually exert more force with the machine)! Ex: oars, broom

VIII. **Lever Classes**-based on positions of fulcrum and forces.

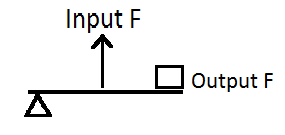
A. First class: ex: crowbar, seesaw



* 1. Second class: ex: wheelbarrow.



C. Third class: ex: fishing rod, human arm, baseball bat



1. **Efficiency:** percentage of work input that becomes work output
2. Calculated by: Efficiency = Wout / Win x 100%
3. Example: What is the efficiency of an ideal pulley that has a work output of 500 J and a work input of 750 J?

Efficiency = Wout / Win x 100

Efficiency = 500 J / 750 J x 100

Efficiency = .666 x 100 = 66.66%

1. **Power**: rate at which work is done, measure of the amount of work done in a certain amount of time.

A. Calculated by P = W/t

B. Units are in watts (W) {1W=1 Joule/second}

C. Example: Calculate the power of an athlete who can lift up 100N weight 1m in 0.8 seconds.

W = f x d P = W/t

W = 100N x 1m P = 100J/0.8s

W = 100J P = 125 Watts

1. **Energy**-ability to do work, measured in Joules.
   1. **TYPES** of Energy:

1. **Kinetic** (energy of motion)

a. K.E. = ½ mv2

b. Example: How much kinetic energy does a runner have if his mass is 65 kg and he is running uphill with a velocity of 2 m/s?

K.E. = ½ mv2

K.E. = ½ x 65 kg x 22

K.E. = 130 J

2. **Potential** (stored energy/energy of position)

a. **Gravitational** potential energy: Gained when raised to greater height: P.E. = m x g x h

b. Example: A 50 kg swimmer is standing on a diving board which is 2.5 m above the pool. How much potential energy does he have?

P.E. = m x g x h

P.E. = 50 kg x 9.8 m/s2 x 2.5 m

P.E. = 1225 J

c. **Elastic** potential energy: Gained when object like rubber band is stretched.

B. **FORMS** of energy:

* + 1. **Mechanical Energy:** The sum of an object’s potential and kinetic energy.

Example: A race car going around a track.

* + 1. **Thermal Energy:** The sum of the potential and kinetic energy of all particles in an object.

Example: The faster particles move, the higher the thermal energy (boiling water).

1. **Chemical Energy:** Stored energy that holds together chemical compounds.

Example: Fuels, like gasoline, is a rich store of chemical energy.

1. **Electrical Energy:** the transfer of electric charges.

Example: Lightning bolts are produced by electrical energy.

1. **Electromagnetic Energy:** Energy that travels through space as waves.

Example: Sunlight and x-rays.

1. **Nuclear Energy:** Stored energy that holds together the nucleus of an atom. This energy can be released by breaking apart heavy nuclei.

Example: Nuclear fission is process that splits the nucleus apart to release nuclear energy.

1. **Energy Conversion and Conservation:** Energy is transferred as it changes form; the total amount of energy stays the same. (Law of Conservation).
2. **Energy Resources**:
   1. **Renewable:** can be replaced in a relatively short period of time.
      * 1. **Hydroelectric energy**- from flowing water
        2. **Solar energy** -from sunlight
        3. **Geothermal energy**- from heat beneath the Earth’s surface
        4. **Biomass energy**-from chemical energy stored in living things.
        5. Can be changed into other usable forms of energy (electrical or thermal)
        6. Creates less pollution than fossil fuel types.
   2. **Nonrenewable:** limited in amount, take millions of years to replace.
      * 1. Include: oil, natural gas, coal, and uranium
        2. **Fossil fuel types** (oil & coal)
           1. Formed underground from dead organisms
           2. Most commonly used fuels
           3. Relatively cheap, widely available, but creates pollution