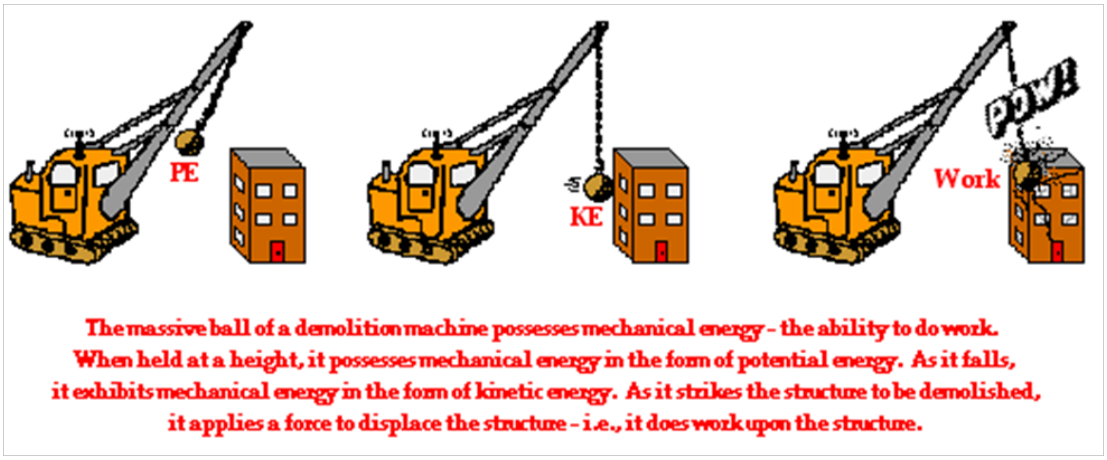
Outcome 2b:

Mechanical Energy
http://www.physicsclassroom.com/class/energy/u5l1d.cfm

Mechanical energy is the sum of potential energy and kinetic energy present in the components of a system



The massive ball of a demolition machine possesses mechanical energy - the ability to do work. When held at a height, it possesses mechanical energy in the form of potential energy. As it falls, it exhibits mechanical energy in the form of kinetic energy. As it strikes the structure to be demolished, it applies a force to displace the structure - i.e., it does work upon the structure.

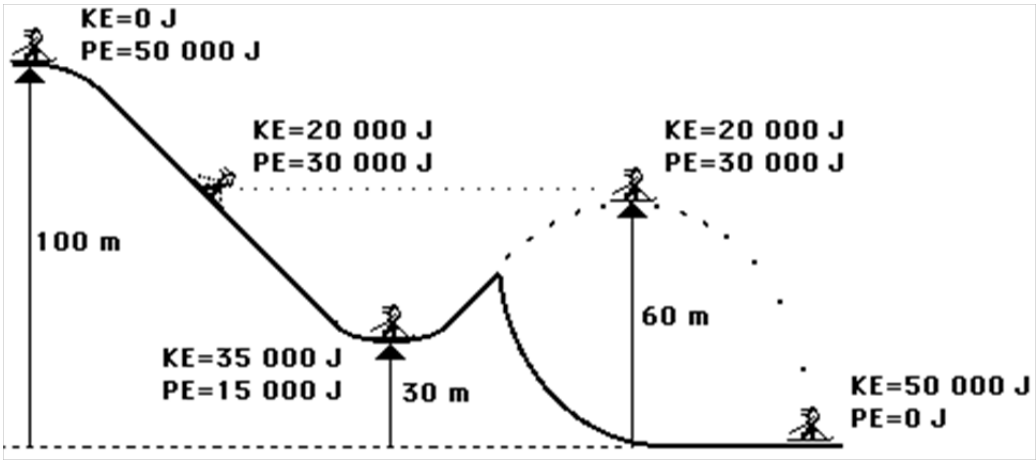
- When energy is transferred to an object, it can cause a change in **BOTH** its total kinetic and potential energy.

- One example is throwing a baseball. It has **gravitational potential energy** (because it is above the ground) and it has **kinetic energy** (because it is now in motion)

$$E_{p(grav)} = mgh \qquad E_K = {}^1/_2\, mv^2$$

- Since an object can have both kinetic and potential energy **at the same time** and the amount of both can be constantly changing, there needs to be a way to simplify things.

- Fortunately, the **Law of Conservation of Energy** states that the **total amount of energy** of any system remains the same, it just changes form from one type to another.



- The total amount of **both kinetic and gravitational potential energy** in a system is called its **mechanical energy**, or E_m.

mechanical energy = potential energy + kinetic energy

$$E_m = E_{p(grav)} + E_K$$

or

$$E_m = mgh + \frac{1}{2}mv^2$$

You will just need to be able to use **both formulas** now at the same time to solve the problems you are given.

Here are a few hints to remember to make solving the work easier:

- For an object at rest: $E_K = 0$ (since it is not in motion)
- For an object at "ground level": $E_{P(grav)} = 0$ (since it has no height)
- We assume that the total amount of mechanical energy, E_M, in a problem remains constant.
- We will not be accounting for energy lost due to friction

Example

1) An airplane with a mass of 8500 kg traveling at a horizontal speed of 250 m/s is 4.5 km above the surface of the earth. What is the total mechanical energy of the plane?

$m = 8500\,kg$
$v = 250\,m/s$
$h = 4.5\,km = 4500\,m$
$g = 9.81\,m/s^2$

$E_m = E_p + E_k$
$E_m = mgh + 0.5mv^2$
$E_m = (8500\,kg)(9.81\,m/s^2)(4500\,m) + (0.5)(8500\,kg)(250\,m/s)^2$
$E_m = 6408575000\,J$
$= 6.4 \times 10^8\,J$ $0.64\,GJ$

A peregrine falcon has a mass of 2.2 kg and is hovering 120 m above the ground. It dives and strikes a pigeon that is 20 m above the ground. How fast was the falcon going when it struck the pigeon?

Practice Sheet 3

1. A baseball with a mass of 145 g is hit out of a baseball park. If it's total mechanical energy is 100.0 J and it was moving at 32m/s when it cleared the fence:

a) What is the total gravitational potential energy of the ball when it cleared the fence?

$E_m = E_p + E_k$

$E_m = E_p + 0.5mv^2$

$100.0\,J = E_p + 0.5(0.145kg)(32\frac{m}{s})^2$

$100.0\,J = E_p + 74.24\,J$

$E_p = 25.76\,J \approx 26\,J$

b) How high was the baseball when it cleared the fence?

$h = ?$

$g = 9.81 m/s^2$

$m = 0.145kg$

$E_p = 25.76J$

$E_p = mgh$

$25.76\,J = (0.145kg)(9.81 m/s^2)\,h$

$25.76\,J = 1.42245\,(h)$

$h = 18.109\ldots m \approx 18m$

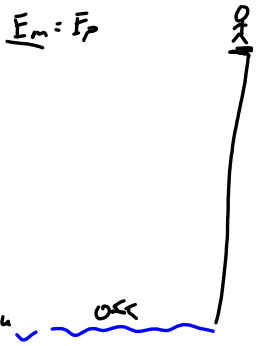
2. Scott decides to take up cliff diving and (strangely) decides to turn his exercise in death-defiance into a physics problem. If Scott has a mass of 73 kg and is jumping off of a 20 m, what will his speed be in m/s AND km/hr at the moment he hits the water?

$E_m = E_p = mgh$

$= (73kg)(9.81 m/s^2)(20m)$

$= 14322.6\,J$

$E_m = E_p$



$E_m = E_k = 0.5mv^2$

$14322.6\,J = 0.5(73kg)v^2$

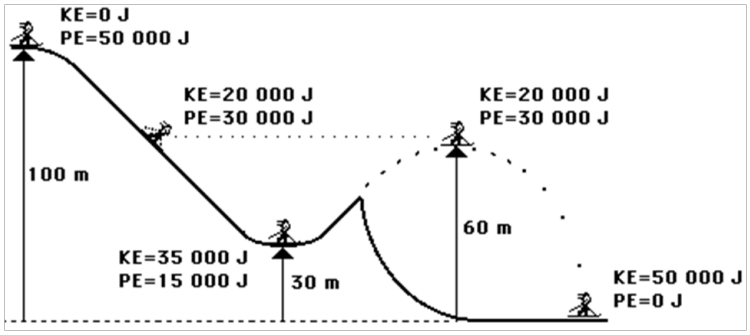
$v^2 = 392.4$

$v = 19.80\ldots m/s \approx 20m/s$

$\approx 71 km/h$

$E_m = E_k$ ✓ ok

Use the diagram below to answer the questions that follow



3. Calculate the mass of the ski jumper.

4. Calculate the speed of the ski jumper when she is 30 m above the ground.

5. Calculate the speed of the ski jumper the moment before she lands.