Energy

We will start the Energy section with definitions and formulae which you can write up in your PHYSICS notebooks.

Energy is the capacity (ability) for doing work.

Symbol: E Unit: Joules, J

Kinetic Energy: energy an object possesses as a result of its motion

$$\boxed{E_k = \tfrac{1}{2} mv^2}$$

Where: E_k = kinetic energy (J)

m = mass (kg)

v = velocity ($m.s^{-1}$)

Velocity and speed have the same units and can be regarded as the same thing at this stage…more on velocity later in the year ☺

Potential Energy: stored energy

A body possesses potential energy, E_p, when it has the ability to do work due to:

- its **position** (e.g. gravity)
- or its **form** (e.g. coiled spring)

Gravitational Potential Energy:

energy an object has because of its position in the gravitational field relative to the surface of the Earth

$$\boxed{E_p = mgh}$$

Where: E_p = gravitational potential energy (J)

m = mass (kg)

g = gravitational acceleration (constant) = 9,8 $m.s^{-2}$

h = height above Earth's surface (m)

Law of Conservation of Energy:

The total energy of an isolated system remains constant.

Isolated system: a system that does not interact with its surroundings; i.e. no transfer of energy or mass between system and surroundings

This means that Energy cannot be created or destroyed, but is merely transformed from one form to another.

Mechanical Energy: the sum of the gravitational potential energy and kinetic energy

$$\boxed{E_{mech} = E_p + E_k}$$

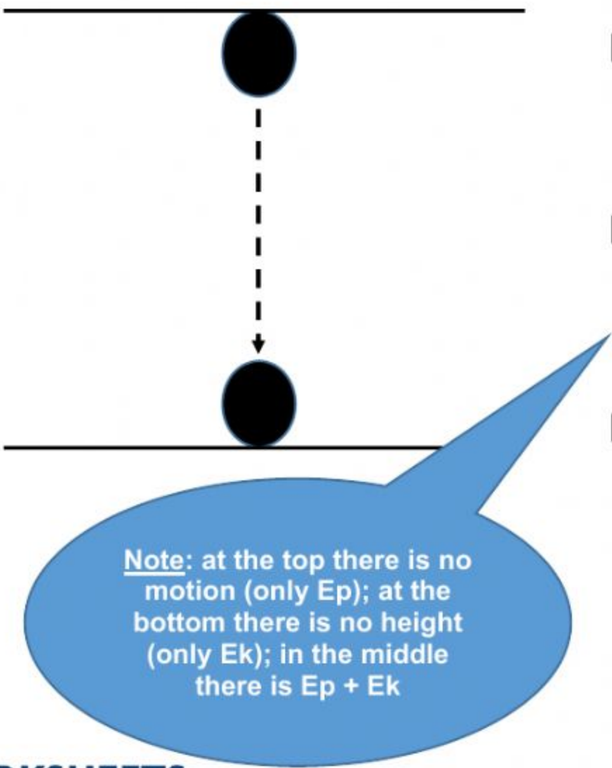
Conservation of Mechanical Energy:

The total mechanical energy in an isolated system remains constant.

e.g. as an object falls, decrease in E_p = increase in E_k
(as long as there are no outside forces like friction)

The principle of conservation of mechanical energy allows us to do calculations in the following scenarios:

1. **An object that falls freely** (dropped from zero velocity)
   If E_{mech} stays constant at all times, then $\mathbf{E_{mech\ (top)} = E_{mech\ (bottom)}}$



$$E_{mech\ (top)} = E_k + E_p$$
$$= 0 + mgh$$

$$E_{mech(middle)} = E_k + E_p$$
$$= ½mv^2 + mgh$$

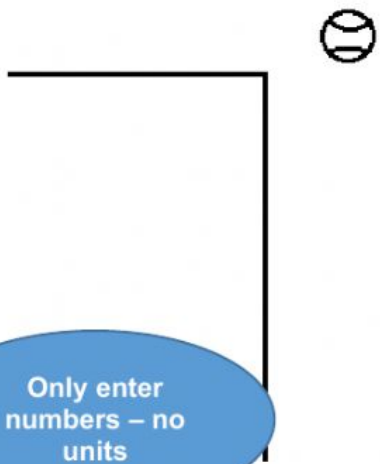
$$E_{mech\ (bottom)} = E_k + E_p$$
$$= ½mv^2 + 0$$

NB!

The key point in these calculations is that E_{mech} at ANY POINT in the motion is the same value. So in the above example,

$$E_{mech}(top) = E_{mech}(middle) = E_{mech}(bottom)$$

Example 1:



A tennis ball, with a mass of 0,2 kg is dropped from a 50 m high building. (If there is no air friction)

Calculate:

1.1 **the E_k of the ball at the top of the building**

(Hint: BEFORE it is dropped)

Ek (top) = ½ mv² = ½ x x 0 m.s⁻¹

= J

Only enter numbers – no units

1.2 the E_p at at the top of the building

Ep (top) = mgh = x 9,8 x

= J

1.3 the E_{mech} at the top of the building

Emech (top) = Ep + Ek

= +

= J

Already calculated above

1.4 the E_{mech} at the bottom of the building

Emech (bottom) = Emech (top) = J

1.5 the E_p at the bottom of the building

Ep(bottom) = mgh = x x

= J

1.6 **the E_k at the bottom of the building** (the split second before it hits the ground)

Ek (bottom) = ½ mv^2

BUT WE DON'T KNOW "v" ……So we do this:

Emech(bottom) = J ………………..from 1.4

Emech(bottom) = Ep + Ek (bottom)

Therefore:

Ek(bottom) = Emech(bottom) - Ep ……………..remember Ep (bottom) = 0

Ek(bottom) = J

1.7 the speed of the ball just before it hits the ground

Ek (bottom) = ½ mv^2

= ½ x x v^2

x 2 = v^2

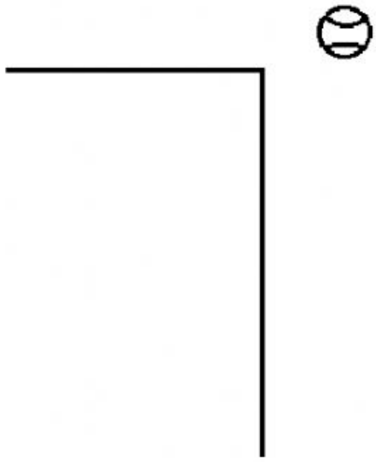
v^2 = …………………………now square root!

v = $m.s^{-1}$

Example 2

A tennis ball, with a mass of 0,2 kg is dropped from a 40 m high bridge. (If there is no air friction)

Calculate:



2.1 the E_k of the ball at the top of the building

Ek (top) = J

2.2 the E_p at the top of the building

Ep (top) = mgh

= x x

= J

2.3 the E_{mech} at the top of the building

Emech (top) = Ep + Ek

= +

= J

2.4 the E_{mech} of the ball at a height of 20 m

Emech (20m) = J

2.5 the E_p of the ball at a height of 20 m

Ep (20m) = mgh

= x x

= J

2.6 the E_k of the ball at a height of 20 m

Emech (20m) = J

Emech (20m) = Ep + Ek

J = + Ek

Ek = J

2.7 the speed of the ball at a height of 20 m

Ek (20m) = $\frac{1}{2} mv^2$

= $\frac{1}{2}$ x x v^2

v^2 =

v = $m.s^{-1}$

2.8 the speed of the ball just before it hits the ground

Emech (bottom) = J = Ek(bottom) …remember Ep(bottom) is 0

Ek (bottom) = $\frac{1}{2} mv^2$

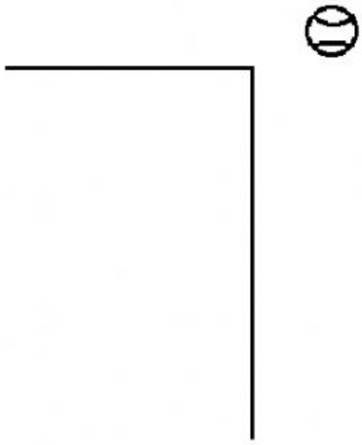
= $\frac{1}{2}$ x x v^2

v^2 =

v = $m.s^{-1}$

Example 3

Assuming there is no air friction, if a 100 g ball is dropped from a 60 m high building, calculate:



3.1 **the E_p of the ball at the top of the building**

Ep(top) = mgh

= x x

= J

3.2 **the E_{mech} at the top of the building**

Emech (top) = Ep + Ek (top)

= +

= J

3.3 **the E_p of the ball <u>after it has fallen</u> 15 m**

Ep = mgh

= x x

= J

<u>Hint</u>: Emech is constant the whole way down!

3.4 **the E_k of the ball after it has fallen 15 m**

Emech (after 15m) = J

Ek (after 15m) = J

<u>Hint</u>: Emech = Ep + Ek

(We know Emech & Ep)

3.5 **the speed of the ball after it has fallen 15 m**

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

$= \frac{1}{2} \times \qquad \times \; v^2$

$v^2 =$

$v = \qquad m.s^{-1}$

3.6 **the E_p of the ball at a height of 10 m**

Ep (10m) $= mgh$

$= \qquad \times \qquad \times$

$= \qquad J$

3.7 the velocity of the ball at a height of 10 m

Emech (10m) = J

Ek (10m) = J

Remember Emech is constant the whole way down!