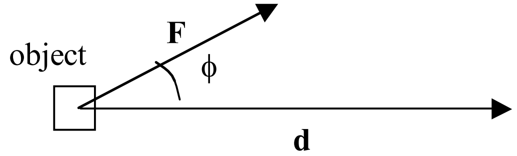
Work, Energy & Power

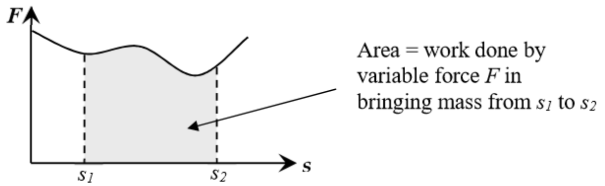
<u>Work and energy</u> are scalar quantities and therefore have no direction.

<u>Work done by a constant force</u> is defined as the product of the *force* and the *displacement* in the direction of the force.



$W = F\,d\cos\phi$

<u>Work done by a variable force</u> is determined by the area under the force displacement graph.



<u>Positive and Negative W.D</u>
Negative W.D. by a force means that energy is taken out of the system while positive W.D. means that energy is put into the system.

<u>Joule</u>
The **joule** (**J**) is defined as the amount of work done when a force of one Newton moves its point of application through a distance of one metre in the direction of the force.

<u>Net work done</u>
The net work done on an object is always equal to the change in K.E of the object.

<u>Work done by gas</u>
$W = P\,(V_f - V_i)$
Where P is a constant external pressure and $(V_f - V_i)$ is the change in volume of the gas.

<u>Conservation of energy</u>
Energy cannot be created or destroyed but converted from one form to another.

Therefore, By Conservation of Energy,
<u>Total initial energy = Total final energy</u>
Provided no external force acts on system (or no change in total energy for isolated system).

For ease of calculations, mechanical energy (See **) is commonly being used instead of total energy.

<u>For Isolated system under conservative forces, free from the influence of a net external force.</u>

Total initial Mechanical Energy
= Total final Mechanical Energy
OR
Total Change in Mechanical Energy = 0

<u>For Non-isolated system, because of the presence of non-conservative forces, we have to account for $W_{n.c}$</u>

Total initial Mechanical Energy + $W_{n.c}$
= Total final Mechanical Energy
OR
Total Change in Mechanical Energy = $W_{n.c}$

<u>**Types of energy included in Mechanical energy</u>
(Mechanical Energy is the Sum of P.E and K.E)
G.P.E = mgh, where h is the vertical height h, and only applicable when near the Earth's surface
K.E = $1/2\ mv^2$
E.P.E = strain/compression energy
= $1/2\ k\,x^2$ (k spring constant and x is the extension of the spring.)
Electrical potential energy is not discussed here but in the topic of Electric field.

<u>Power</u> – rate at which work is being done.
$P = W / t$
which can be derived to get
$P = F\,v$
where F and v are in the same direction.

<u>Efficiency</u>
= useful output power/input power x 100%

<u>Additional notes for students.</u>

Conservative forces are forces where the work done is dependent on position and independent of the path taken, examples are spring force and gravitational force.

For ease of calculations, the lowest position attained by the object is normally taken as zero G.P.E.

For calculations involving connected bodies, the system taken should be that of the bodies that are connected.

The benefits of work energy theorem is that it deals with only magnitude but not direction. Consider ball projected down and projected horizontally at 5 ms^{-1}. K.E is the same although their directions are different.

The derivation of K.E and G.P.E is a requirement in the A level syllabus and can be derived from equations of motion and work done by a force respectively.

In the use of P = Fv, it is important to know to take note of the relevance of quantities. power delivered by **A** is the force exerted by **A** and the velocity of **A** in the direction of the force exerted by A.