WORK, ENERGY, POWER

Law of conservation of energy: The total energy of an isolated system cannot change—it is conserved over time. Energy can be neither created nor destroyed, but can change form e.g. from g.p.e to k.e

Work Done

Work done by a force: The product of the force and displacement in the direction of the force. i.e ($W = F \times S$)

Work done by an expanding gas: The product of the force and the change in volume of gas. i.e ($W = P \times \delta V$)

Condition for formula:

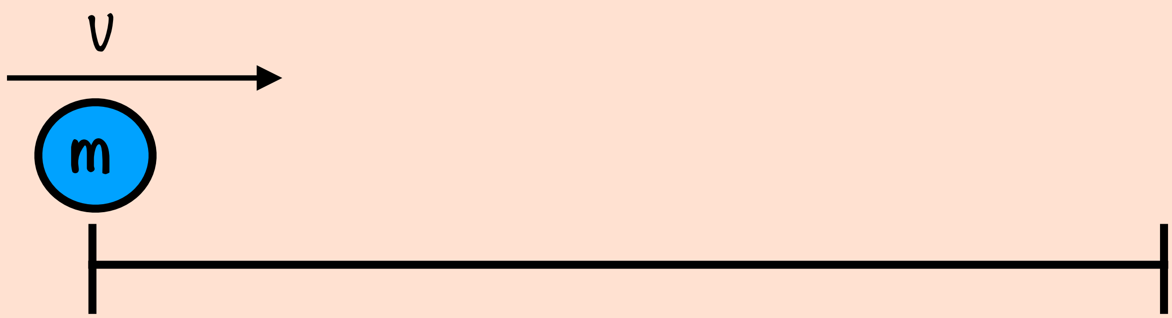
- Temperature of gas is constant
- The change in distance of the piston, δx, is very small therefore it is assumed that p remains constant

Kinetic Energy

- Kinetic energy is energy an object has due to its **motion** (or velocity)
- A force can make an object accelerate; work is done by the force and energy is transferred to the object
- Using this concept of work done and an equation of motion, the extra work done due to an object's speed can be derived

- The derivation for this equation is shown below:

Consider a mass M at rest which accelerates to a speed V over a distance d



Work done in accelerating the mass, $W = F \times d$

We, have $F = ma$

so, $W = ma \times d$

Recall the equation $v^2 = u^2 + 2as$

If $u = 0 \quad and \quad s = d$

$$a = \frac{v^2}{2d}$$

Replacing the value of a we got, $w = m \,.\, \frac{v^2}{2\cancel{d}} \times \cancel{d}$

$$\therefore W = \frac{1}{2}mv^2$$

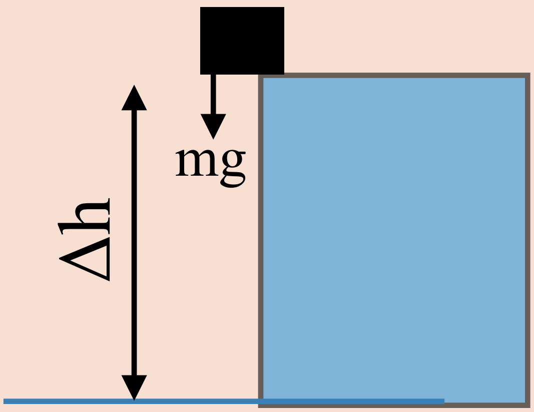
G.P.E and E.P

Gravitational Potential Energy: Arises in a system of masses where there are attractive gravitational forces between them. The g.p.e of an object is the energy it possesses by virtue of its position in a gravitational field.

Deriving Gravitational Potential Energy;

Consider a mass **m** lifted through height **h**

The weight of the mass is **mg** where **g** is the gravitational field strength.



Work done (W) = $F \times s = mg \times \Delta h$

$\therefore W = mg\Delta h$.

Due to its new position, the body is now able to do extra work equal to **mgΔh**.

$\therefore$ **Change in potential energy = mhΔh**

Elastic potential energy: This arises in a system of atoms where there are either attractive or repulsive short-range inter-atomic forces between them.

Electric potential energy: Arises in a system of charges where there are either attractive or repulsive electric forces between them.

Internal Energy

Internal energy: Sum of the K.E. of molecules due to its random motion & the P.E. of the molecules due to the intermolecular forces.

Gases: $k.e. > p.e.$

- Molecules far apart and in continuous motion = $k.e$
- Weak intermolecular forces so very little $p.e.$

Liquids: $k.e. \approx p.e.$

o Molecules able to slide to past each other = $k.e.$

o Intermolecular force present and keep shape = $p.e.$

Solids: $k.e. < p.e.$

o Molecules can only vibrate $\therefore$ $k.e.$ very little

o Strong intermolecular forces $\therefore$ high $p.e.$

Power and Efficiency

Power: Work done per unit of time

$$Power = \frac{Work\ Done}{Time\ Taken} = \frac{W}{T}$$

Deriving it to form P = FV

$$P = \frac{W}{T} = \frac{F \times S}{T}$$

$$= \left(\frac{S}{T}\right) \times F = F \times V$$

$$\therefore P = FV$$

Efficiency: Ratio of (useful) output energy of a machine to the input energy. Multiplying this ratio by 100 gives the efficiency as a percentage

$$Efficiency = \frac{Useful\ Energy\ Output}{Total\ Energy\ Input} \times 100\,\%$$

Efficiency can also be written in terms of power (the energy per second):

$$Efficiency = \frac{Useful\ Power\ Output}{Total\ Power\ Input} \times 100\,\%$$