

## MECHANICS - SOME LAWS, DEFINITIONS AND FORMULAE

**Displacement :** distance in a specified direction.

**Velocity :** rate of change of displacement.

**Acceleration :** rate of change of velocity.

**Scalar :** a quantity with magnitude only.

**Vector :** a quantity with magnitude and direction.

**Equations of linear motion :**  $v = u + at$ .  $s = ut + \frac{1}{2}at^2$ .  $v^2 = u^2 + 2as$ .

**Newton 1 :** a body stay at rest or in uniform motion unless a resultant external force acts upon it.

**Newton 2 :** if a body is acted on by a resultant external force, then the rate of change (N.B.) of momentum of the body is proportional to the magnitude of the force acting.  
 $F = ma$  is a special case of this law.

**Newton 3 :** For every action there is an equal but opposite reaction.

**Newtons Universal law of gravitation :** Between any two point masses there exists a force which is directly proportional to the product of the masses and inversely proportional to the square of the distance between them.  $F = Gm_1m_2/d^2$ .

**Weight :** The force on a body pulling it towards the centre of the earth.  $W = mg$ .

**Momentum:** The mass of body multiplied by its velocity. Unit =  $kgms^{-1}$

**Principle of conservation of momentum :** In a closed system (i.e. in the absence of external forces) of colliding bodies the total amount of momentum is constant.

**Pressure :** force applied per unit area.  $P = F/A$ . unit is the Pascal.

**Pressure in a fluid :** density  $\times$  g  $\times$  depth.  $P = \rho gh$ .

**Archimedes' principle :** if a body is immersed in a fluid, the upthrust is equal to the weight of fluid displaced. (Law of flotation arises from Archimedes Principle - a floating body displaces its own weight of fluid).

**Boyle's law:** The pressure of a gas is inversely proportional to its volume provided the temperature remains constant.

**Moment :** the moment of a force about a point is the force  $\times$  perpendicular distance from the point to the line of action of the force.

**Couple:** Two equal and anti-parallel forces whose moment is one force  $\times$  distance between forces.

$$T = Fd$$

**Lever :** any rigid body free to rotate about a point.

**Equilibrium :** a body is in equilibrium if the sum of forces and the sum of the moments acting on it is zero (**The principle of moments**).

**Work :** work is done when a force moves a body. Unit the Joule - the amount of work done when a force of 1N moves its point of application a distance of 1m in the direction of the force.  $W = Fs$

**Energy :** the ability to do work. Unit, from above, is the Joule.

**Potential energy :** the energy a body possesses due to its position or mechanical condition.

Gravitational potential energy,  $E_p = mgh$

**Kinetic energy :** the energy a body has due to its motion.  $E_k = \frac{1}{2}mv^2$

**Principle of conservation of energy :** energy can neither be created nor destroyed but it may be changed into a different form of energy.

**Power :** Power is the rate at which work is done (or the rate at which energy is converted). **Power = work done/time taken**. Unit the watt - 1 watt is that amount of power which does a Joule of work in a second (or changes 1 Joule of energy into a different form in one second).

**Percentage efficiency:** % efficiency = Power output/Power input  $\times 100$

**Einsteins equation :** mass is a form of energy according to  $E = mc^2$

**Angular displacement :** length of arc/radius.  $\theta = s/r$  - measured in radians.

**Angular velocity :** rate of change of angular displacement.  $\omega = \theta/t$ . Units - rad/s. (Linear velocity  $v$  is related to angular velocity according to  $v = r\omega$ )

**Periodic time T :** time for one revolution (equals the reciprocal frequency  $T = 1/f$ )

**Centripetal force :** a force directed towards a point, which acting on a body of mass  $m$  moving with constant velocity of magnitude  $v$ , causes it to describe a circular path of radius  $r$ , centered on the point, and gives it an acceleration (the centripetal acceleration  $a = v^2/r$  or  $a = r\omega^2$ ) directed towards that point.  
 $F_c = mv^2/r$  or  $F_c = mr\omega^2$

**Period of a satellite :** the period  $T$  of a satellite describing an orbit of radius  $d$  about a celestial body of mass  $M$  is given by  $T^2 = 4\pi^2d^3/GM$ .

**Hooke's Law:** For a range of stresses, provided the elastic limit is not exceeded, the strain produced is proportional to the stress applied and independent of the time and disappears completely on removal of the stress. Or simply put, the restoring force is proportional to the displacement.  $F = -ks$ . Systems obeying Hooke's law execute SHM.

**Simple Harmonic Motion :** a bodys motion is said to be S.H.M. if its acceleration towards a particular point is directly proportional to its displacement from that point. In symbols this becomes ...  $a = -\omega^2s$ . The period of a body executing SHM is  $T = 2\pi/\omega$ .

**Period of a pendulum :**  $T = 2\pi\sqrt{l/g}$