Mechanics Definitions

A **vector** quantity has both magnitude (size) and direction. A **scalar** quantity has magnitude only.

Displacement is the shortest distance in a particular direction of an object from a fixed starting point.

Average speed is the total distance travelled divided by the time taken.

Velocity is rate of change of displacement.

Instantaneous speed is the speed of an object at a given moment in time.

Acceleration is rate of change of velocity.

Newton's first law of motion: An object will remain at rest or keep moving at constant velocity unless there is a net force acting on the object.

Newton's second law of motion: The resultant force acting on a body is directly proportional to the rate of change of momentum and occurs in the same direction. $F = \Delta p/\Delta t$ If the mass is constant this can be simplified to:
Resultant force = mass x acceleration $\mathbf{F_{net} = ma}$

Newton's third law of motion: When two bodies A and B interact, the force exerted by A on B is equal in magnitude and opposite in direction to the force exerted on B by A.

One newton is defined as the force that is required to accelerate a mass of 1 kg through an acceleration of 1 ms^{-2} in the direction of the force.

Weight is the gravitational force acting on a body. $\boldsymbol{W = mg}$ where W = weight in newtons, m = mass in kg and g is the gravitational field strength (9.81 Nkg^{-1} on the earth's surface.

Drag is the resistive force which acts against motion when an object passes through a fluid (a liquid or gas)

Terminal velocity is the velocity at which an objects drag is equal to its accelerating force so there is no net force acting and the velocity remains constant.

The **Centre of Gravity** is the point where the weight of an object appears to act.

The **Centre of Mass** is the point through which any externally applied force produces straight-line motion but no rotation.

The **moment** of a force is equal to the magnitude of the force x the **perpendicular** distance of the pivot from the line of action of the force.

The Principle of Moments: For an object to be in **rotational equilibrium** the sum of the clockwise moments about any point equals the sum of the anticlockwise moments about the same point.

For an object to be at **equilibrium** there must be **no net force** and **no net moment.**

A **couple** is a pair of equal and opposite forces separated by a distance.

Torque = one of the forces of a couple x the perpendicular distance between them.

Density is mass per unit volume.

Pressure is the normal force per unit cross-sectional area.

Archimedes' Principle: When an object is submerged in a fluid it experiences an **upthrust** equal to the weight of the fluid it has displaced.

Thinking distance is distance travelled by a vehicle from when the driver sees a hazard until the brakes are applied.

Braking distance is distance travelled by a vehicle from the moment the brakes are applied until the vehicle comes to a stop.

Stopping distance equals the sum of the thinking distance and the braking distance.

Work done = force x the distance moved in the direction of the force. Work done is equal to the energy transferred from one form into another.

One joule is defined as the amount of work done when a force of 1 newton moves through a distance of 1 metre in the direction of the force.

The Principle of Conservation of Energy: In a closed system, energy cannot be created or destroyed. It can only be converted from one form to another. ie The total energy remains constant.

Kinetic Energy: $E_k = \frac{1}{2}mv^2$ where m = mass in kg and v = velocity in ms^{-1}

Change in Gravitational Potential Energy: $E_p = mgh$ where m = mass in kg, h = height in metres and g is the gravitational field strength (9.81N/kg on the surface of the Earth)

Power is rate of work done. It can be found from $P = W/t$ where W is work done or energy transferred. Where a constant force is applied to an object moving at constant velocity $P = Fv$

1 watt is 1 joule per second. ($1\ W = 1\ Js^{-1}$)

Efficiency = $\frac{\text{useful output energy}}{\text{total input energy}} \times 100$

Hooke's Law: Extension is proportional to the applied force as long as the elastic limit is not exceeded. $F = kx$

The **force constant *k*** is defined as the force per unit extension

Tensile Stress (σ) is the force applied per unit cross-sectional area. ie $\sigma = F/A$
Tensile Strain (ε) is the extension per unit (original) length. ie $\varepsilon = x/L$

Young modulus is the ratio of stress to strain for a given material, providing Hooke's law is obeyed. ie **Young modulus (E) = stress/strain** as long as the elastic limit is not exceeded

Elastic deformation means the object will return to its original shape when the force is removed.
Plastic deformation means the object will be permanently deformed when the force is removed.

Ultimate tensile strength (UTS) is the breaking stress of a material. It is given by: UTS = $\frac{\text{breaking force}}{\text{Cross-sectional area}}$

Linear momentum = mass x velocity

Impulse = force x time for which it acts. Impulse is equal to the change in momentum

The principle of conservation of momentum: In a closed system total momentum in any direction remains constant

In a **perfectly elastic collision** no kinetic energy is lost. In an **inelastic collision** some kinetic energy is lost.