3 Dynamics

Newton's Laws of Motion

Newton's First Law

A body at rest remains at rest and an object in motion with remain in motion at a constant velocity unless acted upon by a resultant external force.

Mass versus Weight

Mass (kg) measures a body's inertia and is a scalar quantity.
Weight (Newtons, or N) of a body is defined as the force acting on the body due to gravity, and is a vector quantity as it is a force.

Linear Momentum and Conservation

Linear momentum of a body is defined as the product of its mass and velocity. Mathematically, $p = m \times v$ [unit: kg m s^{-1} or N s]. It is a vector acting in the same direction as that of velocity.

Newton's Second Law

The rate of change of momentum of a body is directly proportional to the resultant force acting on it and occurs in the direction of the force.

Mathematically, $F_{net} = \frac{dp}{dt}$ where force (N) is a vector. If mass is constant, $F_{net} = ma$, whereas $F_{net} = \frac{m\Delta v}{\Delta t}$ for fluids.

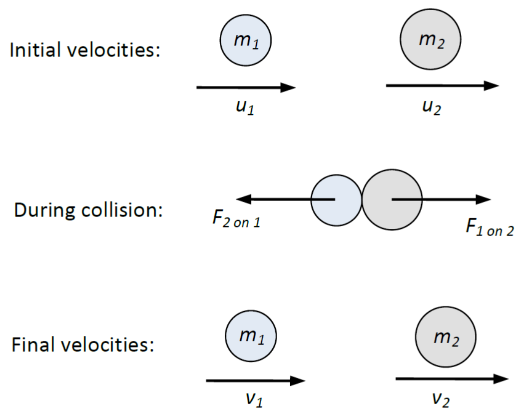
Effect of a force – Impulse

Impulse is defined as the product of the force F on an object and the time Δt that the force acts on it [unit: kg m s^{-1} or Ns]. Impulse = $\Delta p = F\Delta t$ (If force not constant, find area under F-t graph.)

Newton's Third Law

If object A exerts a force on object B, object B will also exert a force of the same type on object A with the same magnitude but opposite in direction.

Linear Momentum and Conservation



During collision between two bodies, the force and impulse acting on each body is **equal** and **opposite** in direction by N3L, i.e. $\Delta p_1 = -\Delta p_2$

$m_1v_1 - m_2u_2 = -(m_2v_2 - m_1u_1)$

$m_1v_1 + m_2v_2 = m_1u_1 + m_2u_2$ --- ❶

Principle of Conservation of Linear Momentum states that the total momentum of a system remains constant, provided no external force acts on it.

Types of Collisions

Elastic Collision	Inelastic Collision
Total momentum conserved during collision (Can use ❶)	
Total kinetic energy is conserved before and after collision, i.e. $\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$	Total kinetic energy not conserved (Final total KE < Initial total KE)
Relative speed of approach = relative speed of separation, i.e. $u_1 - u_2 = v_1 - v_2$ --- ❷ (only for head-on elastic collisions)	- For regular inelastic collision, bodies separate after collision - For totally inelastic collision, bodies coalesce after collision, i.e. $m_1u_1 - m_2u_2 = (m_1 + m_2)v$