IB Physics Topics A1 A2 A3; SL & HL

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1 Newton's Laws of Motion

1. N^{1st}: An object will remain at rest or in uniform motion unless acted upon by a net external force.

2. N^{2nd}: The acceleration of an object is directly proportional to the net force acting on it

3. N^{3rd}: For every action, there is an equal and opposite reaction.

2 Special Forces

2.1 Drag Force

The drag force in a fluid is given by:

$$F_d = 6\pi\eta r v$$

where:

- F_d is the drag force
- η is the viscosity of the fluid
- r is the radius of the object
- v is the velocity of the object

It is in the opposite direction of the velocity vector.

2.2 Buoyancy Force

The buoyancy force exerted by a fluid on an object is given by:

$$F_b = \rho g V$$

where:

- F_b is the buoyancy force
- ρ is the density of the fluid
- g is the acceleration due to gravity
- V is the volume of the fluid displaced

This force is always directed upwards, against the force of gravity. It is worth noting that, when the object is fully submerged, the volume of the fluid displaced is equal to the volume of the object.

This allows us to find the terminal velocity v_0 of an object of volume V and density ρ_{obj} falling through a fluid of density ρ_{fluid}:

$$F_b + F_d = F_g$$

$$\rho_{\text{fluid}} g V + 6\pi\eta r v_0 = \rho_{\text{obj}} g V$$

$$v_0 = \frac{(\rho_{\text{obj}} - \rho_{\text{fluid}})\, gV}{6\pi\eta r}$$

2.3 Frictional Force

The frictional force is given by:

$$F_f = \mu F_n$$

where:

- F_f is the frictional force
- μ is the coefficient of friction
  - The static coefficient $\mu = \mu_s$ is used when the object is at rest relative to the surface.
  - The kinetic coefficient $\mu = \mu_d$ is used when the object is in motion relative to the surface.

It then follows that the maximum force along the surface before the object starts moving is given by:

$$F_{f,\max} = \mu_s F_n$$

Exerting a force greater than this limit will cause the object to start moving, in which case, the frictional force now must use the kinetic coefficient.

2.4 Spring Force

The spring force is given by:

$$F_s = -kx$$

where:

- F_s is the spring force
- k is the spring constant
- x is the displacement from the equilibrium position

The negative sign indicates that the force is always directed opposite to the displacement.

3 Circular Motion

The equations are

- Linear acceleration: $a = v\omega = \dfrac{v^2}{r}$
- Linear speed: $v = \dfrac{2\pi r}{T} = r\omega = 2\pi r f$
- Angular speed: $\omega = \dfrac{2\pi}{T}$
- Frequency: $f = \dfrac{1}{T}$