4 Forces

Types of Forces

Elastic Forces

Hooke's Law states that the change in length *x* of a material is directly proportional to the resultant force *F* applied to it, i.e. $F = kx$ where *k* is proportionality/spring constant.

Field of Force

A **field** is a region in space in which a body experiences a force due to the presence of other body(s).

Contact Forces & Viscous Force

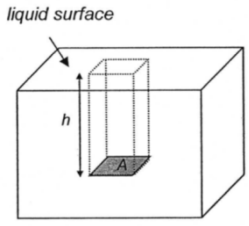
Frictional force (F_f) is the tangential force that occurs between two surfaces, opposing *relative motion* of the surfaces. F_f is **proportional** to normal contact force.

Viscous or drag force acts whenever an object moves through a fluid (Chapter 2).

Centre of Gravity

The centre of mass of a body is the mean location of all the mass in the body, while the **centre of gravity** (C.G) of a body is an imaginary point at which the entire weight of the body seems to act.

Derivation of hydrostatic pressure

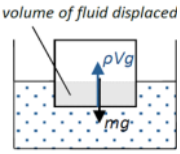


Density $\rho = \frac{m}{V}$, and

pressure $P = \frac{\text{Force}}{\text{Area}}$

Thus, P due to a column of fluid = $\frac{W_{fluid}}{\text{Area}} = h\rho_f g$.

Upthrust



Upthrust (U) is the vertical upward force exerted by surrounding fluid on a fully partially submerged object,

U = weight of vol. of fluid displaced = $\rho_f V_{disp} g$

The **principle of flotation** states that when a body is floating in eq^{m} in a fluid, U acting on the body = magnitude of its weight, i.e $\rho_f V_{disp}\, g = m_{obj}\, g$

Turning Effects of Forces

The **moment of a force** about a pivot is the product of the force and the perpendicular distance from the pivot to the force's line of action, i.e *moment* = $F \times d_{\perp}$, or $Fd\sin\theta$.

A **couple** is a pair of forces, of equal magnitude and opposite direction, acting on a body. *Torque of a couple* = $F \times d$ (unit: N m), where d is the perpendicular distance between the forces.

Equilibrium of Forces

Conditions for Static Equilibrium

1. **Translational eq^{m}** – no net force
2. **Rotational eq^{m}** – no net torque

Translational Equilibrium

To achieve translational eq^{m}, either:

1. Resolve all forces into their components in two chosen perpendicular distances, e.g. $\sum F_x$ and $\sum F_y = 0$, or
2. Form a closed polygon as vector sum of these forces must be zero in order for the resultant forces to be zero.

Rotational Equilibrium

Principle of moments states that if a body is in eq^{m}, the sum of clockwise moments about any axis must equal the sum of anticlockwise moments about the same axis.