Topic 3A: Newton's Laws, Force Vectors and Equilibrium Equations

Skill 21: Force Vectors, Resultant and Equilibrant

The sum of 2 or more vectors is known as the **Resultant**. The force that balances the resultant [equal in magnitude but opposite in direction (180° away)] is known as the **equilibrant**.

- Parallel force Vectors (same axis) are combined by assigning positive or negative based on angle or direction. Ex: 3N north + 5 south = +3N + −5N = −2N = 2N south
- Perpendicular force Vectors (x & y axis) are combined by using equations. Pythagorean Theorem, sin, cos, tan

$F_{Net} = \sqrt{F_x^2 + F_y^2}$ $F_x = F\cos\theta$ $F_y = F\sin\theta$ $\theta = \tan^{-1}\left(\frac{F_y}{F_x}\right)$

[Combine any parallel vectors before using above equations]

- The maximum resultant occurs when adding vectors with the least difference in angle (0° or smallest angle; ie same or similar direction)
- The minimum resultant occurs when adding vectors with greatest difference in angle between
- To find the range (or possible) resultants (and equilibrants) find sum at 0° and sum at 180°. Possible values include max, min & #'s in between.
- As the angle decreases, resultant & equilibrant increase
- As the angle increases, resultant & equilibrant decrease

Skill 22: Part One – Identifying Forces

- **Weight (F_g)** "Force due to gravitational field" is a downward (y-axis) force $F_g = mg$
  - For a projectile (ie object in free fall) F_g is the only force therefore it is the net force.
  - For an object at rest on a surface $F_{Net} = 0$ so weight is balanced by force from surface
- **Normal Force (F_N)** Force due to surface, always perpendicular to surface

$F_N = F_g\cos\theta = mg\cos\theta$ when surface is level $\theta = 0$ so $F_N = F_g = mg$

as θ increases F_N decreases

- **Applied Force (F_A)** – A push or pull
- **Net Force (F_{Net})** – Sum of all forces (can only add same axis by addition/subtraction) (perpendicular forces use trig)
- **Frictional Force (F_f)** – Force that opposes motion due to surface
- **Tension Force (F_T)** – Force from rope or chain
- **Horizontal Component of Applied Force (F_{AX})** – $F_{AX} = F_A\cos\theta$ } For objects on level (horizontal surface)
- **Vertical Component of Applied Force (F_{AY})** – $F_{AY} = F_A\sin\theta$ }
- **Parallel Component of Weight ($F_{g\parallel}$)** – $F_{g\parallel} = F_g\sin\theta = mg\sin\theta$ } For objects on incline
- **Perpendicular Component of Weight ($F_{g\perp}$)** – $F_{g\perp} = F_N = F_g\cos\theta = mg\cos\theta$ }