

Statics Cheat Sheet

Forces · equilibrium · trusses · friction · centroids · moments of inertia

Forces and moments

Resultant of concurrent forces

$$R_x = \Sigma F_x; R_y = \Sigma F_y; R = \sqrt{R_x^2 + R_y^2}$$

F force components (N); R resultant (N)

Direction of a resultant

$$\theta = \tan^{-1}(R_y/R_x)$$

θ angle from the +x axis; check the quadrant

Moment of a force (scalar)

$$M_O = F \cdot d$$

F force (N); d perpendicular distance from O to the line of action (m); M (N·m)

Moment in 2D (components)

$$M_O = x \cdot F_y - y \cdot F_x$$

x, y position of any point on the line of action (m); counterclockwise positive

Couple

$$M = F \cdot d$$

Two equal, opposite forces d apart; the same moment about every point

Equilibrium and supports

2D equilibrium

$$\Sigma F_x = 0; \Sigma F_y = 0; \Sigma M_A = 0$$

Three equations, so at most three unknowns per free body

3D equilibrium

$$\Sigma F = 0; \Sigma M_O = 0$$

Six scalar equations: three forces, three moments

Two-force member

$$F_A = -F_B, \text{ along the line AB}$$

Pinned at both ends, no load between: pure tension or compression

Support reactions (2D)

$$\text{Roller: } 1 \cdot \text{Pin: } 2 \cdot \text{Fixed: } 2 + \text{moment}$$

Roller: normal force; pin: R_x, R_y ; fixed: R_x, R_y, M

Distributed loads

Uniform load

$$W = w \cdot L \text{ at } L/2$$

w load intensity (N/m); L loaded length (m); W resultant (N)

Triangular load

$$W = w_{\max} \cdot L/2 \text{ at } 2L/3 \text{ from the zero end}$$

$w_{\max}$ peak intensity (N/m)

General distributed load

$$W = \int w \, dx; x_W = \int x \cdot w \, dx / W$$

Resultant equals the area under the load curve, through its centroid

Trusses

Method of joints

$$\Sigma F_x = 0; \Sigma F_y = 0 \text{ at each joint}$$

Start at a joint with two unknowns; assume tension (pulling away from the joint)

Method of sections

$$\Sigma M = 0 \text{ about where two cut members meet}$$

Cut at most three members with unknown forces

Simple-truss determinacy

$$m + r = 2j$$

m members; r support reactions; j joints

Friction

Dry (Coulomb) friction

$$F \leq \mu_s \cdot N; \text{ sliding: } F = \mu_k \cdot N$$

N normal force (N); μ_s, μ_k static and kinetic coefficients

Angle of repose

$$\tan \phi_s = \mu_s$$

A block on an incline steeper than ϕ_s slides

Flat belt on a drum

$$T_2 = T_1 \cdot e^{\mu \beta}$$

$T_2 > T_1$ belt tensions (N); β wrap angle (rad)

Centroids and moments of inertia

Centroid of a composite area

$$x_c = \Sigma(x_i \cdot A_i) / \Sigma A_i$$

x_i centroid of part i (m); A_i area (m^2 , holes negative)

Rectangle about its centroid

$$I_x = b \cdot h^3 / 12$$

b width; h height, perpendicular to the axis (m); I (m^4)

Circle about its centroid

$$I = \pi \cdot r^4 / 4 = \pi \cdot d^4 / 64$$

r radius; d diameter (m)

Parallel-axis theorem

$$I = I_c + A \cdot d^2$$

I_c about the centroidal axis; d distance between the parallel axes (m)

Radius of gyration

$$r = \sqrt{I/A}$$

r (m); used in column slenderness