EngG 130 Formula Sheet
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Determinants:

Second order:

$$\begin{vmatrix} a_1 & a_2 \\ b_1 & b_2 \end{vmatrix} = a_1 b_2 - a_2 b_1$$

Third order:

$$\begin{vmatrix} a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \\ c_1 & c_2 & c_3 \end{vmatrix} = a_1 \begin{vmatrix} b_2 & b_3 \\ c_2 & c_3 \end{vmatrix} - a_2 \begin{vmatrix} b_1 & b_3 \\ c_1 & c_3 \end{vmatrix} + a_3 \begin{vmatrix} b_1 & b_2 \\ c_1 & c_2 \end{vmatrix}$$

Trigonometry:

Sine law: $\frac{\sin A}{\sin B} = \frac{a}{b}$ Cosine law: $c^2 = a^2 + b^2 - 2ab\cos C$

Vector Expressions:

$\mathbf{F} = \mathbf{F_x} + \mathbf{F_y} + \mathbf{F_z} = F_x\,\mathbf{i} + F_y\,\mathbf{j} + F_z\,\mathbf{k} = F(\cos\alpha\,\mathbf{i} + \cos\beta\,\mathbf{j} + \cos\gamma\,\mathbf{k})$ $(\cos\alpha)^2 + (\cos\beta)^2 + (\cos\gamma)^2 = 1$

$\mathbf{F} = F\mathbf{u}$ where $\mathbf{u}$ is a unit vector in the direction of $\mathbf{F}$, and $\mathbf{u} = \frac{\mathbf{r}}{r}$

Position vector:

$\mathbf{r}_{AB} = (x_B - x_A)\,\mathbf{i} + (y_B - y_A)\,\mathbf{j} + (z_B - z_A)\,\mathbf{k}$

Equilibrium Conditions:

particle: $\sum \mathbf{F} = \mathbf{0} = \sum F_x\,\mathbf{i} + \sum F_y\,\mathbf{j} + \sum F_z\,\mathbf{k}$

rigid body: $\sum \mathbf{F} = \mathbf{0}$ and $\sum \mathbf{M} = \mathbf{0}$

Dot product:

$\mathbf{A} \cdot \mathbf{B} = AB\cos\theta = A_x B_x + A_y B_y + A_z B_z$ $\cos\theta = \frac{\mathbf{A} \cdot \mathbf{B}}{AB}$

Component of a vector parallel to a line in the direction of u:

$A_{\parallel} = A\cos\theta = \mathbf{A} \cdot \mathbf{u}$ (which is a scalar)

Vector Cross Product:

magnitude of the vector cross product: $C = AB\sin\theta$

as a vector: $\mathbf{C} = \mathbf{A} \times \mathbf{B} = (AB\sin\theta)\mathbf{u}_c$; $\mathbf{u}_c =$ a unit vector $\perp$ to $\mathbf{A}$ and $\mathbf{B}$, sense given by the right hand rule.

Cartesian vector formulation: $\mathbf{A} \times \mathbf{B} = \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix}$

Moment of a Force:

$M = F\,d$ (scalar form); $\mathbf{M} = \mathbf{r} \times \mathbf{F}$ (vector form)

Moment about a specified axis;

scalar form: $M_a = \mathbf{u_a} \cdot (\mathbf{r} \times \mathbf{F}) = \begin{vmatrix} u_{a_x} & u_{a_y} & u_{a_z} \\ r_x & r_y & r_z \\ F_x & F_y & F_z \end{vmatrix}$; vector form: $\mathbf{M_a} = [\mathbf{u_a} \cdot (\mathbf{r} \times \mathbf{F})]\mathbf{u_a}$

Distributed Load, Shear Force, and Bending Moment:

$\frac{dV}{dx} = -w(x)$ $\frac{dM}{dx} = V(x)$ $\Delta V_{AB} = -\int_A^B w(x)\,dx$ $\Delta M_{AB} = \int_A^B V(x)\,dx$

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Friction:

maximum static friction force: $F_{max} = \mu_s N$

kinetic friction force: $F = \mu_k N$

angles of friction; $\phi_s = \tan^{-1}\left(\frac{F_s}{N}\right) = \tan^{-1}\mu_s$ $\qquad \phi_k = \tan^{-1}\left(\frac{F_k}{N}\right) = \tan^{-1}\mu_k$

Centres of gravity:

particles or discrete parts:

$$\bar{x} = \frac{\Sigma \tilde{x} W}{\Sigma W}, \quad \bar{y} = \frac{\Sigma \tilde{y} W}{\Sigma W}, \quad \bar{z} = \frac{\Sigma \tilde{z} W}{\Sigma W}.$$

continuous body:

$$\bar{x} = \frac{\int \tilde{x} dW}{\int dW}, \quad \bar{y} = \frac{\int \tilde{y} dW}{\int dW}, \quad \bar{z} = \frac{\int \tilde{z} dW}{\int dW}.$$

Area Moments of Inertia:

$$I_x = \int y^2 dA \qquad I_y = \int x^2 dA$$

$$I_{xy} = \int xy dA \qquad J_o = \int r^2 dA = I_x + I_y$$

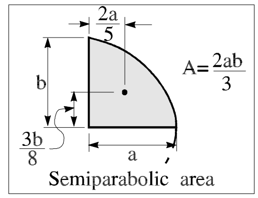
radii of gyration:

$$k_x = \sqrt{\frac{I_x}{A}} \qquad k_y = \sqrt{\frac{I_y}{A}} \qquad k_o = \sqrt{\frac{J_o}{A}}$$

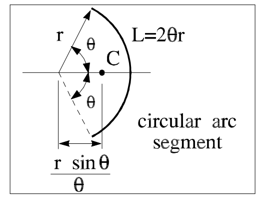
parallel axis theorem:

$$I_x = \bar{I}_{x'} + Ad_y^2 \qquad I_y = \bar{I}_{y'} + Ad_x^2$$

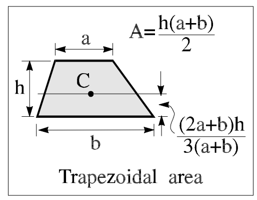
$$I_{xy} = \bar{I}_{x'y'} + Ad_x d_y \qquad J_o = \bar{J}_c + Ad^2$$



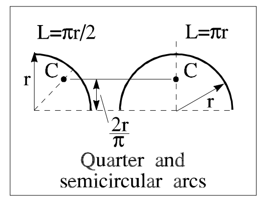
Semiparabolic area



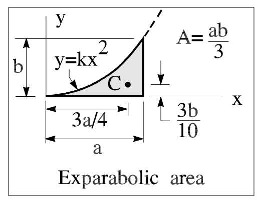
circular arc segment



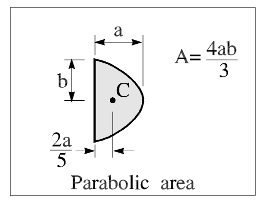
Trapezoidal area



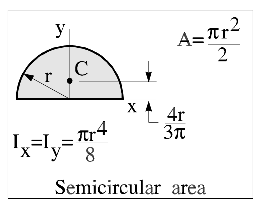
Quarter and semicircular arcs



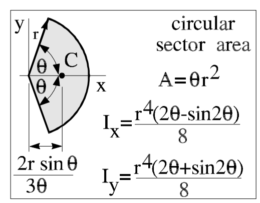
Exparabolic area

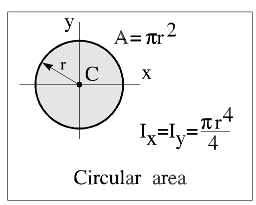


Parabolic area

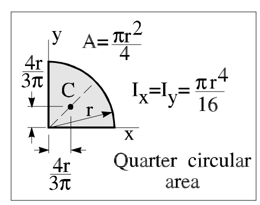


Semicircular area

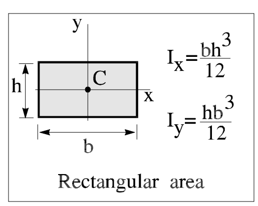




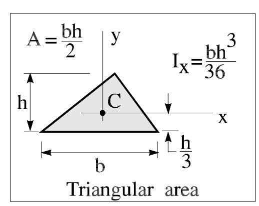
Circular area



Quarter circular area



Rectangular area



Triangular area