**FORMULÁRIO:**

$$\sigma = \frac{P}{A} \qquad \sigma = \lim_{\Delta A \to 0} \frac{\Delta F}{\Delta A} \qquad \tau = \lim_{\Delta A \to 0} \frac{\Delta V}{\Delta A} \qquad \tau_{xy} = \tau_{yx} \qquad \sigma = \frac{P}{A_0}\cos^2\theta$$

$$\tau = \frac{P}{A_0}\cos\theta\sin\theta \qquad \varepsilon = \frac{d\delta}{dx} \quad \sigma = E\varepsilon \qquad \varepsilon_T = \alpha\Delta T \qquad \delta = \frac{PL}{AE}$$

$$\delta = \sum_i \frac{P_i L_i}{A_i E_i} \qquad \delta = \int_0^L \frac{P}{AE} dx$$

$$\varepsilon_x = \frac{\sigma_x}{E} - \nu\frac{\sigma_y}{E} - \nu\frac{\sigma_z}{E} \qquad \varepsilon_y = -\nu\frac{\sigma_x}{E} + \frac{\sigma_y}{E} - \nu\frac{\sigma_z}{E} \qquad \varepsilon_z = -\nu\frac{\sigma_x}{E} - \nu\frac{\sigma_y}{E} + \frac{\sigma_z}{E}$$

$$\tau_{xy} = G\gamma_{xy} \qquad \tau_{yz} = G\gamma_{yz} \qquad \tau_{xz} = G\gamma_{xz} \qquad G = \frac{E}{2(1+\nu)}$$

$$\gamma = \frac{\rho\phi}{L} \quad \tau = \frac{T\rho}{J} \qquad \phi = \frac{TL}{JG} \qquad \phi = \sum_i \frac{T_i L_i}{J_i G_i} \qquad \phi = \int_0^L \frac{T}{JG} dx$$

$$\frac{1}{\rho} = \frac{M}{EI} \qquad \frac{1}{\rho'} = \frac{\nu}{\rho} \qquad \sigma_x = -\frac{My}{I} \qquad \sigma_x = \frac{P}{A} - \frac{My}{I}$$

$$\sigma_x = \frac{P}{A} - \frac{M_z y}{I_z} + \frac{M_y z}{I_y} \qquad \tan\phi = \frac{I_z}{I_y}\tan\theta \qquad \frac{dV}{dx} = -w \qquad V_D - V_c = -\int_{x_C}^{x_D} w\,dx$$

$$\frac{dM}{dx} = V \qquad M_D - M_c = \int_{x_C}^{x_D} V\,dx \qquad \frac{1}{\rho} = \frac{M(x)}{EI} \qquad \frac{d^2y}{dx^2} = \frac{M(x)}{EI}$$

$$K_{ij}^e = \int_0^{h^e} EA \frac{d\phi_i}{dx}\frac{d\phi_j}{dx} dx \qquad F_i^e = \int_0^{h^e} f\phi_i dx \qquad \left[K_{ij}^e\right] = \frac{E^e A^e}{L^e}\begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix} \qquad \left\{F_i^e\right\} = \frac{f^e L^e}{2}\begin{Bmatrix} 1 \\ 1 \end{Bmatrix}$$

$$\phi_1 = 1 - \frac{x}{h^e} \qquad \phi_2 = \frac{x}{h^e} \qquad K_{ij}^e = \int_0^{h^e} EI \frac{d^2\phi_i}{dx^2}\frac{d^2\phi_j}{dx^2} dx \qquad F_i^e = \int_0^{h^e} q\phi_i dx$$

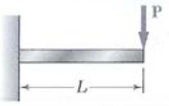
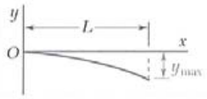
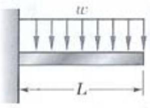
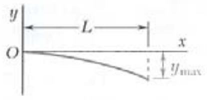
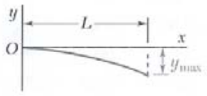
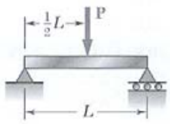
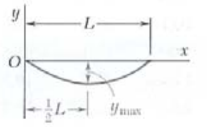
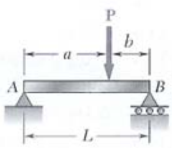
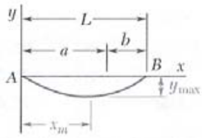
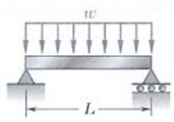
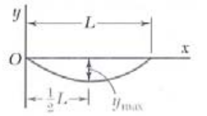
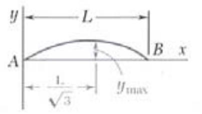
$$\phi_1 = 1 - 3\left(\frac{x}{h^e}\right)^2 + 2\left(\frac{x}{h^e}\right)^3 \qquad \phi_2 = x\left(1 - \frac{x}{h^e}\right)^2$$

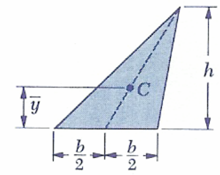
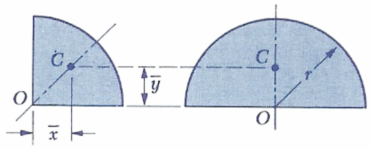
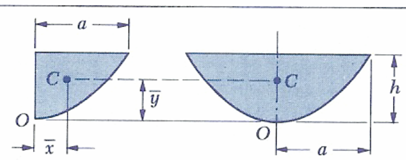
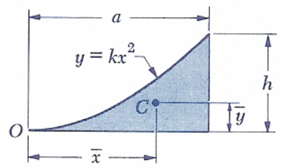
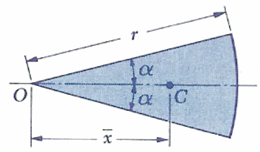
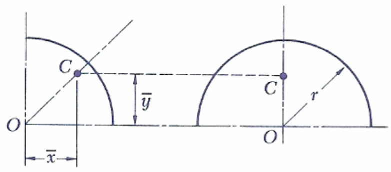
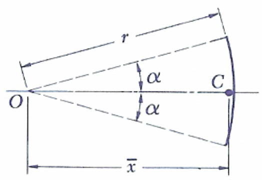
$$\phi_3 = 3\left(\frac{x}{h^e}\right)^2 - 2\left(\frac{x}{h^e}\right)^3 \qquad \phi_4 = x\left[\left(\frac{x}{h^e}\right)^2 - \frac{x}{h^e}\right]$$

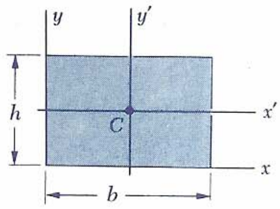
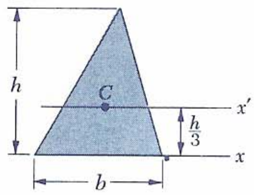
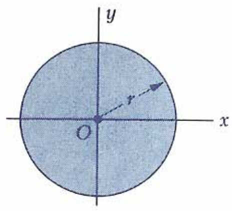
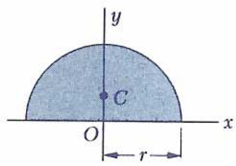
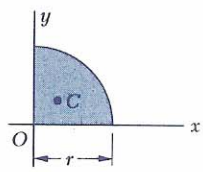
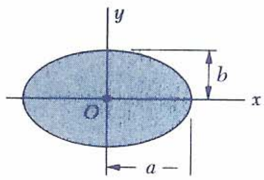
$$\left[K_{ij}^e\right] = \frac{2EI}{h_e^3}\begin{bmatrix} 6 & 3h_e & -6 & 3h_e \\ 3h_e & 2h_e^2 & -3h_e & h_e^2 \\ -6 & -3h_e & 6 & -3h_e \\ 3h_e & h_e^2 & -3h_e & 2h_e^2 \end{bmatrix} \qquad \left\{F_i^e\right\} = \frac{qh_e}{12}\begin{Bmatrix} 6 \\ h_e \\ 6 \\ -h_e \end{Bmatrix}$$

$$K_{\alpha\beta}^e = \int_{\Omega^e} k_{ij}\frac{\partial\phi_\alpha}{\partial x_i}\frac{\partial\phi_\beta}{\partial x_j} d\Omega \qquad F_\alpha^e = \int_{\Gamma_e} q\phi_\alpha d\Gamma$$

$$\phi_1 = \frac{1}{4}(1-\xi)(1-\eta) \qquad \phi_2 = \frac{1}{4}(1+\xi)(1-\eta) \qquad \phi_3 = \frac{1}{4}(1+\xi)(1+\eta) \qquad \phi_4 = \frac{1}{4}(1-\xi)(1+\eta)$$

| Viga e carregamento | Linha elástica | Flecha máxima | Rotação na extremidade | Equação da linha elástica |
|---|---|---|---|---|
| 1  |  | $-\dfrac{PL^3}{3EI}$ | $-\dfrac{PL^2}{2EI}$ | $y=\dfrac{P}{6EI}(x^3-3Lx^2)$ |
| 2  |  | $-\dfrac{pL^4}{8EI}$ | $-\dfrac{pL^3}{6EI}$ | $y=-\dfrac{p}{24EI}(x^4-4Lx^3+6L^2x^2)$ |
| 3  |  | $-\dfrac{ML^2}{2EI}$ | $-\dfrac{ML}{EI}$ | $y=-\dfrac{M}{2EI}x^2$ |
| 4  |  | $-\dfrac{PL^3}{48EI}$ | $\pm\dfrac{PL^2}{16EI}$ | Para $x \le \frac{1}{2}L$: $y=\dfrac{P}{48EI}(4x^3-3L^2x)$ |
| 5  |  | Para $a > b$: $-\dfrac{Pb(L^2-b^2)^{3/2}}{9\sqrt{3}EIL}$ em $x_m=\sqrt{\dfrac{L^2-b^2}{3}}$ | $\theta_A=-\dfrac{Pb(L^2-b^2)}{6EIL}$ $\theta_B=+\dfrac{Pa(L^2-a^2)}{6EIL}$ | Para $x < a$: $y=\dfrac{Pb}{6EIL}[x^3-(L^2-b^2)x]$ Para $x = a$: $y=-\dfrac{Pa^2b^2}{3EIL}$ |
| 6  |  | $-\dfrac{5pL^4}{384EI}$ | $\pm\dfrac{pL^3}{24EI}$ | $y=-\dfrac{p}{24EI}(x^4-2Lx^3+L^3x)$ |
| 7  |  | $\dfrac{ML^2}{9\sqrt{3}EI}$ | $\theta_A=+\dfrac{ML}{6EI}$ $\theta_B=-\dfrac{ML}{3EI}$ | $y=-\dfrac{M}{6EIL}(x^3-L^2x)$ |

| Shape | | $\bar{x}$ | $\bar{y}$ | Area |
| --- | --- | --- | --- | --- |
| Triangular area |  | | $\frac{h}{3}$ | $\frac{bh}{2}$ |
| Quarter-circular area |  | $\frac{4r}{3\pi}$ | $\frac{4r}{3\pi}$ | $\frac{\pi r^2}{4}$ |
| Semicircular area | | 0 | $\frac{4r}{3\pi}$ | $\frac{\pi r^2}{2}$ |
| Semiparabolic area |  | $\frac{3a}{8}$ | $\frac{3h}{5}$ | $\frac{2ah}{3}$ |
| Parabolic area | | 0 | $\frac{3h}{5}$ | $\frac{4ah}{3}$ |
| Parabolic spandrel |  | $\frac{3a}{4}$ | $\frac{3h}{10}$ | $\frac{ah}{3}$ |
| Circular sector |  | $\frac{2r \sin \alpha}{3\alpha}$ | 0 | $\alpha r^2$ |
| Quarter-circular arc |  | $\frac{2r}{\pi}$ | $\frac{2r}{\pi}$ | $\frac{\pi r}{2}$ |
| Semicircular arc | | 0 | $\frac{2r}{\pi}$ | $\pi r$ |
| Arc of circle |  | $\frac{r \sin \alpha}{\alpha}$ | 0 | $2\alpha r$ |

| | | |
|---|---|---|
| Rectangle |  | $\bar{I}_{x'} = \frac{1}{12}bh^3$<br>$\bar{I}_{y'} = \frac{1}{12}b^3h$<br>$I_x = \frac{1}{3}bh^3$<br>$I_y = \frac{1}{3}b^3h$<br>$J_C = \frac{1}{12}bh(b^2 + h^2)$ |
| Triangle |  | $\bar{I}_{x'} = \frac{1}{36}bh^3$<br>$I_x = \frac{1}{12}bh^3$ |
| Circle |  | $\bar{I}_x = \bar{I}_y = \frac{1}{4}\pi r^4$<br>$J_O = \frac{1}{2}\pi r^4$ |
| Semicircle |  | $I_x = I_y = \frac{1}{8}\pi r^4$<br>$J_O = \frac{1}{4}\pi r^4$ |
| Quarter circle |  | $I_x = I_y = \frac{1}{16}\pi r^4$<br>$J_O = \frac{1}{8}\pi r^4$ |
| Ellipse |  | $\bar{I}_x = \frac{1}{4}\pi ab^3$<br>$\bar{I}_y = \frac{1}{4}\pi a^3b$<br>$J_O = \frac{1}{4}\pi ab(a^2 + b^2)$ |