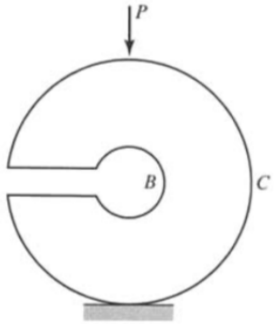
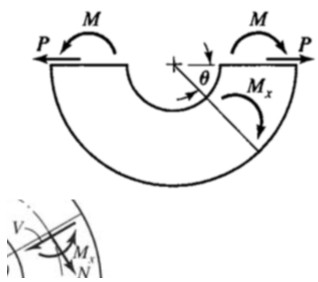
1) 9.7

9.7. The curved beam in Figure P9.7 has a circular cross section 50 mm in diameter. The inside diameter of the curved beam is 40 mm. Determine the stress at B for $P = 20$ kN.



Section cut



$$\text{sigma}[\text{theta, theta}] := \frac{N}{A} + \frac{M(A - r \cdot A[m])}{A \cdot r(R \cdot A[m] - A)}$$

$$\sigma_{\theta,\theta} := \frac{N}{A} + \frac{M(-r A_m + A)}{A r(R A_m - A)} \quad \textbf{(1)}$$

$P := 20 \cdot 1000$ #N

$$P := 20000 \quad \textbf{(2)}$$

$A[m] := evalf(2 \cdot \text{Pi} \cdot (45 - \text{sqrt}(45^2 - 25^2)))$

$$A_m := 47.64807164 \quad \textbf{(3)}$$

$A := evalf\left(\text{Pi}\left(\frac{10}{2}\right)^2\right)$ #mm^2

$$A := 78.53981635 \quad \textbf{(4)}$$

$Rm := 40 + \frac{(50 - 40)}{2}$

$$Rm := 45 \quad \textbf{(5)}$$

$r := 20$

$$r := 20 \quad \textbf{(6)}$$

#*Sum force*

$F[x] := 0$

$$F_x := 0 \quad \textbf{(7)}$$

$N := -P$ #*Sum F*

$$N := -20000 \quad \textbf{(8)}$$

$M := -P \cdot (24)$

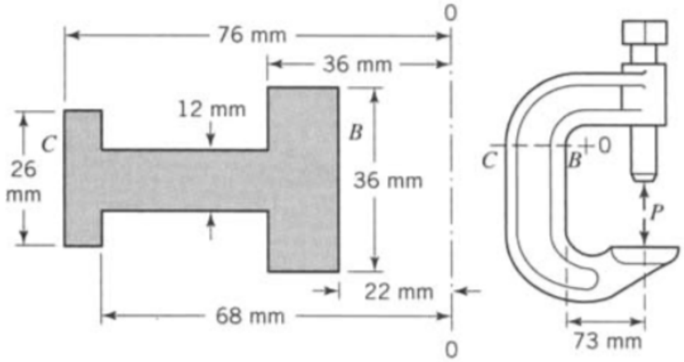
$$M := -480000 \quad \textbf{(9)}$$

$$\text{sigma}[\text{theta, theta}] := \frac{N}{A} + \frac{M(A - r \cdot A[m])}{A \cdot r(R \cdot A[m] - A)}$$

$$\sigma_{\theta,\theta} := -560.2253996 \quad \textbf{(10)}$$

2) 9.20-9.21. Ignore Bleich factors (section 9.4 is not covered in this course)

9.20. A load $P = 12.0$ kN is applied to the clamp shown in Figure P9.20. Determine the circumferential stresses at points B and C, assuming that the curved beam formula is valid at that section.



Assumption: that the Neutral Axis and the centroid are the same distance form the axis of curvature.

$$yBar := \frac{\text{Sigma } A \cdot y}{\text{Sigma}[0] \cdot A[i]}$$

$$yBar := \frac{\Sigma\, A\, y}{\Sigma_0\, A_i} \qquad (1)$$

$$A[1] := (36 - 22) \cdot 36$$

$$A_1 := 504 \qquad (2)$$

$$A[2] := 12 \cdot (68 - 36)$$

$$A_2 := 384 \qquad (3)$$

$$A[3] := (76 - 68) \cdot 26$$

$$A_3 := 208 \qquad (4)$$

$$yBar := evalf\left(\frac{A[1] \cdot (29) + A[2] \cdot (52) + A[3] \cdot (72)}{A[1] + A[2] + A[3]}\right)$$

$$yBar := 45.21897810 \qquad (5)$$

$$R := yBar$$

$$R := 45.21897810 \qquad (6)$$

$$r[B] := 22$$

$$r_B := 22 \qquad (7)$$

$$r[C] := 76$$

$$r_C := 76 \qquad (8)$$

$$Am[1] := evalf\left(36 \cdot \ln\left(\frac{36}{22}\right)\right)$$

$$Am_1 := 17.72915346 \qquad (9)$$

$$Am[2] := evalf\left(12 \cdot \ln\left(\frac{68}{36}\right)\right)$$

$$Am_2 := 7.631865202 \qquad (10)$$

$$Am[3] := evalf\left(26 \cdot \ln\left(\frac{76}{68}\right)\right)$$

$$Am_3 := 2.891866518 \qquad (11)$$

$$Am := Am[1] + Am[2] + Am[3]$$

$$Am := 28.25288518 \qquad (12)$$

$$A[tot] := A[1] + A[2] + A[3]$$

$$A_{tot} := 1096 \qquad (13)$$

#Sum of Forcs

$$P := 12 \cdot 1000$$

$$P := 12000 \qquad (14)$$

$$N := P$$

$$N := 12000 \qquad (15)$$

$$M := P \cdot (73 + 22)$$

$$M := 1140000 \qquad (16)$$

$$\text{sigma}[\text{theta, theta } B] := \frac{N}{A[tot]} + \frac{M(A[tot] - r[B] \cdot Am)}{A[tot] \cdot r[B] \cdot (R \cdot Am - A[tot])}$$

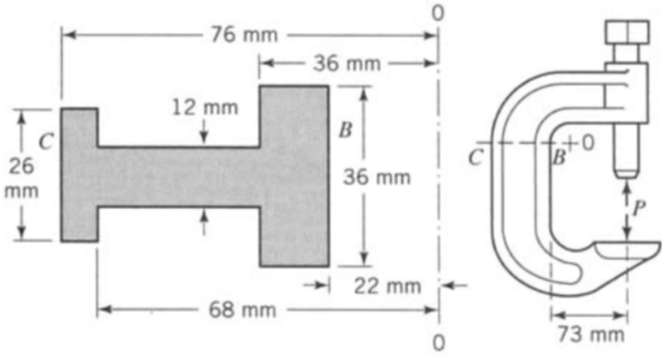
$$\sigma_{\theta,\,\theta B} := 11.20930192 \qquad (17)$$

$$\text{sigma}[\text{theta, theta } C] := \frac{N}{A[tot]} + \frac{M(A[tot] - r[C] \cdot Am)}{A[tot] \cdot r[C] \cdot (R \cdot Am - A[tot])}$$

$$\sigma_{\theta,\,\theta C} := 11.02428313 \qquad (18)$$

3) 9.21

9.21. Determine the radial stress at the junction of the web and inner flange of the curved beam portion of the clamp in Problem 9.20. Neglect stress concentrations.



$$A'_m = \int_a^r \frac{dA}{r} \quad \text{and} \quad A' = \int_a^r dA \qquad (9.20)$$

$$\sigma_{rr} = \frac{AA'_m - A'A_m}{trA(RA_m - A)} M_x \qquad (9.21)$$

Inner flange disst from O is 68mm

$r := 68 \# mm$

$$r := 68 \qquad \textbf{(2)}$$

$A\_prime[1] := 36 \cdot (14)$

$$A\_prime_1 := 504 \qquad \textbf{(3)}$$

$A\_prime[m] := evalf\left(\int_{22}^{36} \frac{361}{r} \, dr\right) \#(9.20)$

$$A\_prime_m := 177.7840113 \qquad \textbf{(4)}$$

$Area := 14 \cdot 36 + 12 \cdot 32 + 8 \cdot 26$

$$Area := 1096 \qquad \textbf{(5)}$$

$t := 12$

$$t := 12 \qquad \textbf{(6)}$$

$yBar := 45.21897810$

$$yBar := 45.21897810 \qquad \textbf{(7)}$$

$R := yBar$

$$R := 45.21897810 \qquad \textbf{(8)}$$

$M := 1140000 \#prob2\ N \cdot m$

$$M := 1140000 \qquad \textbf{(9)}$$

$A[m] := 1096 \# prob2$

$$A_m := 1096 \qquad \textbf{(10)}$$

$\text{sigma}[rr] := evalf\left(\frac{(Area \cdot A\_prime[m] - A\_prime[1] \cdot A[m])}{t \cdot r \cdot Area \cdot (R \cdot A[m] - Area)} \cdot M\right)$

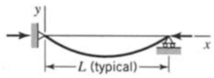
$$\sigma_{rr} := -9.403741443 \qquad \textbf{(11)}$$

3) 12.6

12.6. Three pinned-end columns each have a cross-sectional area of 2000 mm^2 and length of 750 mm. They are made of 7075-T5 aluminum alloy (E = 72.0 GPa and σ_{PL} = 448 MPa).

One of the columns has a solid square cross section. A second column has a solid circular cross section. The third has a hollow circular cross section with an inside diameter of 30.0 mm. Determine the critical buckling load for each of the columns.

Pined is kind of like a ball and socket

Simple support–simple support $\frac{\pi^2 EI}{L^2}$  L

Square Cross Section

$$I_C = \frac{bh}{12}(b^2 + h^2)$$

Circular Cross Section

$$I_C = \frac{\pi d^4}{32}$$

Hollow Circular Cross Section

$$I_C = \frac{\pi}{32}(d^4 - d_i^4)$$

$solve(2000 = b^2, \{b\})$

$$\{b = -20\sqrt{5}\}, \{b = 20\sqrt{5}\} \quad (1)$$

$solve(2000 = \mathrm{Pi}\cdot r^2, \{r\})$

$$\left\{r = -\frac{20\sqrt{5}}{\sqrt{\pi}}\right\}, \left\{r = \frac{20\sqrt{5}}{\sqrt{\pi}}\right\} \quad (2)$$

$r[inner] := \frac{30}{2}$ #mm

$$r_{inner} := 15 \quad (3)$$

$solve(2000 = \mathrm{Pi}\cdot r[out]^2 - \mathrm{Pi}\cdot r[inner]^2, \{r[out]\})$

$$\left\{r_{out} = -\frac{5\sqrt{\pi\,(9\,\pi + 80)}}{\pi}\right\}, \left\{r_{out} = \frac{5\sqrt{\pi\,(9\,\pi + 80)}}{\pi}\right\} \quad (4)$$

$b := 20\sqrt{5}$

$$b := 20\sqrt{5} \quad (5)$$

$\mathrm{Iota}[Sqr] := evalf\left(\frac{1}{12} b^4\right)\left(\frac{1}{1000^4}\right)$ # m^4

$$\mathrm{I}_{Sqr} := 3.333333333\ 10^5 \quad (6)$$

$d := 2\cdot\left(\frac{20\sqrt{5}}{\sqrt{\pi}}\right)$

$$d := \frac{40\sqrt{5}}{\sqrt{\pi}} \quad (7)$$

$\mathrm{Iota}[cir] := evalf\left(\frac{\mathrm{Pi}\cdot d^4}{32}\right)\left(\frac{1}{1000^4}\right)$ # m^4

$$\mathrm{I}_{cir} := 6.366197722\ 10^5 \quad (8)$$

$d[out] := evalf\left(2\left(\frac{5\sqrt{\mathrm{Pi}\ (9\ \mathrm{Pi} + 80)}}{\mathrm{Pi}}\right)\right)$

$$d_{out} := 58.70672098 \quad (9)$$

$d[inner] := (r[inner]\cdot 2)$

$$d_{inner} := 30 \quad (10)$$

$\mathrm{Iota}[HollC] := evalf\left(\frac{\mathrm{Pi}\cdot\left(d[out]^4 - d[inner]^4\right)}{32}\right)\left(\frac{1}{1000^4}\right)$ # m^4

$$\mathrm{I}_{HollC} := 0.000001086619772 \quad (11)$$

$E := 72\cdot 10^9$ #Pa

$$E := 72000000000 \quad (12)$$

$P[crit\_sq] := \frac{\pi^2 E\cdot \mathrm{Iota}[Sqr]}{(.75)^2}$ # N

$$P_{crit\_sq} := 4.211031214\ 10^{17} \quad (13)$$

$P[crit\_ci] := \frac{\pi^2 E\cdot \mathrm{Iota}[cir]}{(.75)^2}$ # N

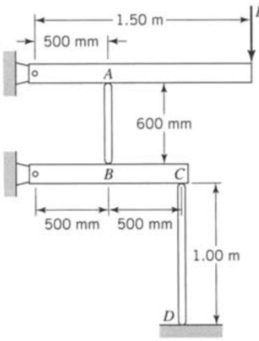
$$P_{crit\_ci} := 8.042477196\ 10^{17} \quad (14)$$

$P[crit\_Hci] := \frac{\pi^2 E\cdot \mathrm{Iota}[HollC]}{(.75)^2}$ # N

$$P_{crit\_Hci} := 1.372736933\ 10^6 \quad (15)$$

4) 12.8. Assume that the horizontal members are rigid and weightless.

12.8. In Figure P12.8, columns *AB* and *CD* have pinned ends, are made of an aluminum alloy (E = 72.0 GPa), and have equal rectangular cross sections of 20 mm by 30 mm. Determine the magnitude of P that will first cause one of the columns to buckle. Assume elastic conditions.



$b := .03$

$b := 0.03$ **(1)**

$h := .02$

$h := 0.02$ **(2)**

$\text{Iota}[x] := \frac{1}{12} b \cdot h^3 \; \#m^4$

$I_x := 2.000000000\ 10^{-8}$ **(3)**

$b := .02$

$b := 0.02$ **(4)**

$h := .03$

$h := 0.03$ **(5)**

$\text{Iota}[y] := \frac{1}{12} b \cdot h^3$

$I_y := 4.500000000\ 10^{-8}$ **(6)**

$L[AB] := .6 \; \#m$

$L_{AB} := 0.6$ **(7)**

$L[CD] := 1 \; \#m$

$L_{CD} := 1$ **(8)**

$E := 72 \cdot 10^9$

$E := 72000000000$ **(9)**

$F[C, Ix] := \frac{\pi^2 E \cdot \text{Iota}[x]}{L[CD]^2}$

$F_{C,\,Ix} := 14212.23034$ **(10)**

$F[C, Iy] := \frac{\pi^2 E \cdot \text{Iota}[y]}{L[CD]^2}$

$F_{C,\,Iy} := 31977.51827$ **(11)**

$F[A, Ix] := \frac{\pi^2 E \cdot \text{Iota}[x]}{L[AB]^2}$

$F_{A,\,Ix} := 39478.41762$ **(12)**

$F[A, Iy] := \frac{\pi^2 E \cdot \text{Iota}[y]}{L[AB]^2}$

$F_{A,\,Iy} := 88826.43964$ **(13)**

$\#F_{C,\,Ix}$ *is the Lowest*

$F[A\_new] := \frac{F_{C,\,Ix}}{.5}$

$F_{A\_new} := 28424.46068$ **(14)**

$P := \frac{F_{A\_new} \cdot (.5)}{1.5} \#N$

$P := 9474.820226$ **(15)**