Exam problem E06-1. ES2502, Furlong

$\phi AC := 0.75$ in $LAC := 4$ $LCD := 8$

$\phi CB := 1.5$ in $LDB := 10$

$JAC := \frac{\pi}{2}\cdot\left(\frac{\phi AC}{2}\right)^4 = 0.031$ in^4

$JCB := \frac{\pi}{2}\cdot\left(\frac{\phi CB}{2}\right)^4 = 0.497$ in^4

$Gbr := 5.4\cdot 10^6$ psi

$Gst := 11\cdot 10^6$ psi

$Tapplied := 600\cdot 12 = 7.2\times 10^3$ lb-in

Solve system of equations for reaction torques: equilibrium + compatibility

Guess: $TA := 100$ $TB := 100$

Given

$TA + TB = Tapplied$ Equilibrium

$\frac{TA\cdot LAC}{JAC\cdot Gbr} + \frac{TA\cdot LCD}{JCB\cdot Gst} = \frac{TB\cdot LDB}{JCB\cdot Gst}$ Compatibility

$a := \text{Find}(TA, TB) = \begin{pmatrix} 485.272 \\ 6.715\times 10^3 \end{pmatrix}$

$TA := a_0$ $TA = 485.272$ lb-in

$TB := a_1$ $TB = 6.715\times 10^3$ lb-in

Check: $\frac{TA + TB}{12} = 600$ (Correct computation of torques)

$TA + TB - Tapplied = 9.095 \times 10^{-13}$ (zero, which means that TA and TB have same direction and are opposit to applied torque)

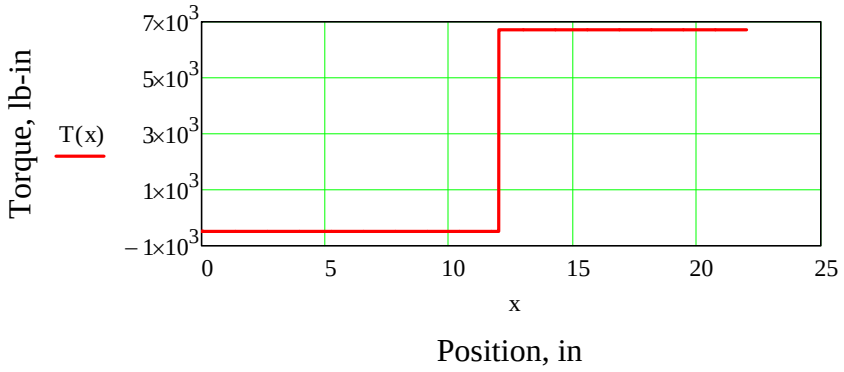
$-TA + Tapplied = 6.715 \times 10^{3}$

Plot torque-diagram:

Define step function: $S(x,z) := \text{if}(x \geq z, 1, 0)$

$x := 0, 0.001 .. (LAC + LCD + LDB)$

Torque function: $T(x) := -TA + S(x, LAC + LCD) \cdot Tapplied$



Part (a): $\tau CB := \dfrac{TB \cdot \left(\dfrac{\phi CB}{2}\right)}{JCB} = 1.013 \times 10^{4}$ psi

Part (b): $\tau AC := \dfrac{TA \cdot \left(\dfrac{\phi AC}{2}\right)}{JAC} = 5.858 \times 10^{3}$ psi

Part (c): $\alpha := \dfrac{TA \cdot LAC}{JAC \cdot Gbr} \cdot \dfrac{180}{\pi} = 0.663$ degrees

Exam problem E06-2. ES2502, Furlong

$P := 20 \cdot 550 \cdot 12$ $\quad P = 1.32 \times 10^5$ lb in/sec

$\omega A := 1750 \cdot \frac{2 \cdot \pi}{60}$ $\quad \omega A = 183.26$ rad/sec

$rA := 2$ in

$rBC := 5$ in

$\omega BC := \frac{\omega A \cdot rA}{rBC}$ $\quad \omega BC = 73.304$

Torques:

$TA := \frac{P}{\omega A}$ $\quad TA = 720.29$ lb in

$TBC := \frac{P}{\omega BC}$ $\quad TBC = 1.801 \times 10^3$ lb in

Allowed stress: $\tau allow := 10000$ psi

Diameters:

$sdA := \sqrt[3]{\frac{2 \cdot TA}{\pi \cdot \tau allow}} \cdot 2$ $\quad sdA = 0.716$ Round to: 3/4" (at A)

$sdBC := \sqrt[3]{\frac{2 \cdot TBC}{\pi \cdot \tau allow}} \cdot 2$ $\quad sdBC = 0.972$ Round to: 1" (at BC)

Check: compute stresses with new diameters

$$\tau Acheck := \frac{2 \cdot TA}{\pi \cdot \left(\frac{0.75}{2}\right)^3} = 8.695 \times 10^3$$

$$\tau BCcheck := \frac{2 \cdot TBC}{\pi \cdot \left(\frac{1}{2}\right)^3} = 9.171 \times 10^3$$

Both of the stresses are within allowed limit.