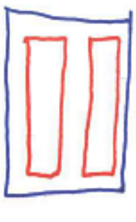
# STRENGTH OF MATERIALS I
## 2nd Midterm Exam
## 06/12/2013
## Solutions

1) $I_{global} = I_{outer} - I_{inner}$ (Caution: centroid remains same)

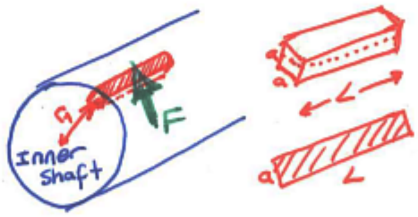
20pt



$$I_g = \frac{1}{12} \cdot 140 \cdot 200^3 - 2 \cdot \left( \frac{1}{12} 40 \cdot 160^3 \right)$$
$$= 6{,}603 \times 10^7$$

2)

20pt




$$F = \frac{Moment}{Moment\ arm} = \frac{5 \cdot 10^3}{0{,}1} = 5 \cdot 10^4 N$$

$$\tau_{max} = \frac{F}{A_{min}} \qquad a = \frac{5 \cdot 10^4}{200 \cdot 10^6 \cdot 0{,}1} = 2{,}5 mm$$

$$200 MPa = \frac{F}{a \cdot L}$$

3) Maximum load the steel rod can withstand

$$P_{max-steel} = \sigma_{max} \cdot A = 200 \cdot 10^6 \cdot \left( \frac{1}{4} \pi\, 0{,}01^2 \right) = 1{,}571 \cdot 10^4 N$$

Remaining load to be supported by aluminum rod $= 20 \cdot 10^3 - 15{,}71 \cdot 10^3 = 4{,}292 \times 10^3 N$

Because both rods will elongate same amount:

$$\frac{Force_{st} \cdot L_{st}}{A_{st} \cdot E_{st}} = \frac{Force_{al}\, L_{al}}{A_{al}\, E_{al}} \qquad L_{al} = L_{st} \Rightarrow A_{al} = \frac{F_{al} \cdot A_{st} \cdot E_{st}}{F_{st}\, E_{al}}$$

30pt

$$\frac{1}{4} \pi d_{al}^2 = \frac{4{,}292 \cdot 10^3 \cdot \frac{1}{4} \pi \cdot 0{,}01^2 \cdot 209 \cdot 10^9}{1{,}571 \cdot 10^4 \cdot 69 \cdot 10^9}$$

$$d_{al} = 9{,}097 mm$$

$$\sigma_{al} = \frac{4{,}292 \cdot 10^3}{\frac{1}{4} \pi (0{,}009097)^2} = 66{,}03 MPa$$ which is greater than $\sigma_{yield-aluminum}$

So the reference should be aluminum rod.

$$\frac{F_{st}}{A_{st}E_{st}} = \frac{F_{al}}{A_{al}E_{al}}$$ → should be $\sigma_{max\text{-}aluminum}$

$$\frac{F_{st}}{\frac{1}{4}\pi 0{,}01^2\, 209 \times 10^9} = \frac{55.10^6}{69 \times 10^9}$$

$F_{st} = 13{,}08\ kN \rightarrow \sigma_{st} = 166{,}54\ MPa$ (safe)

$F_{al} = 6{,}92\ kN$

$$\frac{1}{4}\pi d_{al}^2 = \frac{6{,}92.\,10^3.\left(\frac{1}{4}\pi\, 0{,}01^2\right).\,209.10^9}{(13{,}08.10^3)\,(69.10^9)}$$

$d_{al} = 12{,}66\ mm$

4) $I_g = I_{outer} - I_{inner}$

$$I_g = \frac{1}{12}20.10^3 - \frac{1}{12}.(20-2t).(10-2t)^3$$

$$I_g = 1166{,}67t - 300.\,t^2 + 33.3333t^3 - 1{,}33333t^4$$

$M_{ws} = 1{,}96697.10^6$
$M_{wh} = 1{,}63583.10^6$

30 pt

Because the midship section is symmetric with respect to neutral axis, we consider the max of the 2 moments.

$M_{max} = 1{,}96697.10^6$

$$M_{max} = \frac{\sigma_{max}.\,I}{y} \qquad 1{,}96697.10^6 = \frac{200.10^6.\,I_g}{5}$$

$\Rightarrow t = 4{,}26\ mm$