Mansoura University
Faculty of Engineering
Prod. Eng. & Mech. Design Dept.

Level 100 -Biomedical Eng. Dept.
PDE181 - Strength of Materials
50 Marks - 2 Hours

Question One ***(10 Marks)***

1. ***The ability of a material to absorb energy in the elastic range of stress is …***

(a) Stiffness	(b) Strength	(c) Toughness	(d) Resilience

2. ***The maximum shear stress occurs on a plane making an angle of … with part axis.***

(a) 0°	(b) 45°	(c) 90°	(d) otherwise

3. ***If a part is subjected to double shear stress, there is (are) … shear plane(s).***

(a) 1	(b) 2	(c) 3	(d) otherwise

4. ***For a bar restrained by fixed supports from both sides, if the temperature is decreased by a certain amount, the bar is subjected to … stress.***

(a) Tensile Thermal	(b) Compressive Thermal	(c) Shear	(d) Combined

5. ***The factor of safety is defined as the ratio between ultimate strength to ……***

(a) Tensile strength	(b) Yield Strength	(c) Allowable stress	(d) otherwise

Question Two ***(15 Marks)***

A uniform concrete slab of total weight W is to be attached, as shown in Fig. 1, to two rods whose lower ends are on the same level. Determine the ratio of the areas of the rods so that the slab will remain level.

Figure P-215

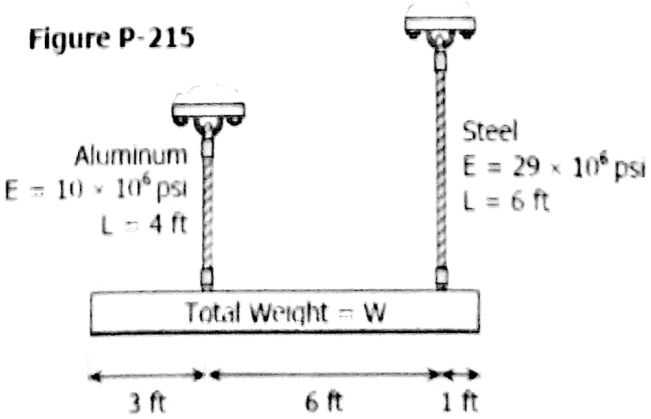


Fig. 1

Question Three ***(10 Marks)***

Determine the maximum torque that can be applied to a hollow circular steel shaft of 100-mm outside diameter and an 80-mm inside diameter without exceeding a shearing stress of 60 MPa or a twist of 0.5 deg/m. Use G = 83 GPa.

Question Four ***(15 Marks)***

A single horizontal force P of 150 lb magnitude is applied to end D of lever ABD as shown in Fig. 2. Determine (a) the normal and shearing stresses on an element at point H having sides parallel to the x and y axes, (b) the principal planes and principal stresses at the point H.

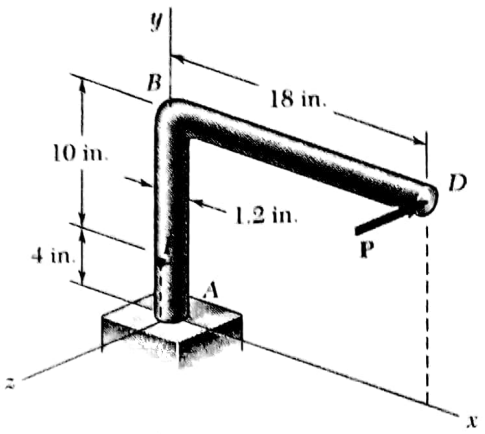


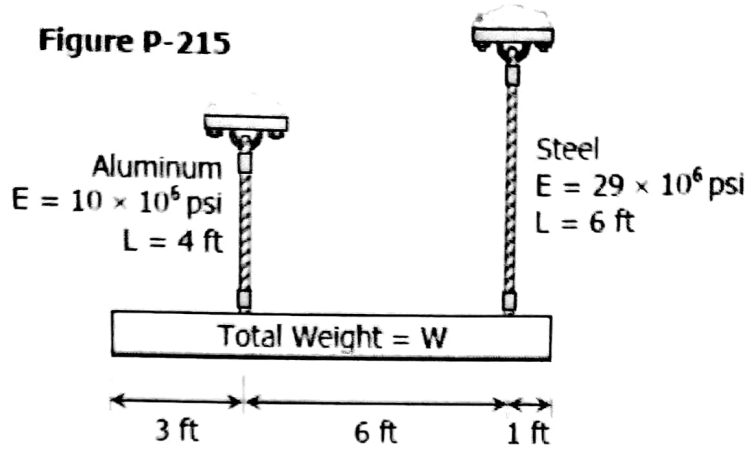
Fig. 2

Good Luck
Dr. Noha Fouda

Question Two 15 Marks

A uniform concrete slab of total weight W is to be attached, as shown in Fig. P-215, to two rods whose lower ends are on the same level. Determine the ratio of the areas of the rods so that the slab will remain level.

Figure P-215



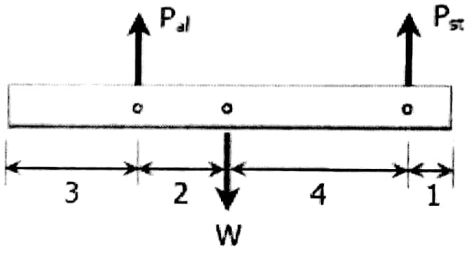
Solution

$\Sigma M_{al} = 0$

$6P_{st} - 2W = 0$

$P_{st} = \frac{1}{3}W$

(5)



$\Sigma M_{st} = 0$

$6P_{al} = 4W$

$P_{al} = \frac{2}{3}W$

$\delta_{st} = \delta_{al}$

$$\left[\frac{PL}{AE}\right]_{st} = \left[\frac{PL}{AE}\right]_{al}$$

(5)

$$\frac{\frac{1}{3}W(6 \times 12)}{A_{st}(29 \times 10^6)} = \frac{\frac{2}{3}W(4 \times 12)}{A_{al}(10 \times 10^6)}$$

(5)

$$\frac{A_{al}}{A_{st}} = \frac{\frac{2}{3}W(4 \times 12)(29 \times 10^6)}{\frac{1}{3}W(6 \times 12)(10 \times 10^6)}$$

$$\frac{A_{al}}{A_{st}} = 3.867$$

answer

Question Three

Determine the maximum torque that can be applied to a hollow circular steel shaft of 100-mm outside diameter and an 80-mm inside diameter without exceeding a shearing stress of 60 MPa or a twist of 0.5 deg/m. Use G = 83 GPa.

Solution

Based on maximum allowable shearing stress:

$$\tau_{max} = \frac{16TD}{\pi(D^4 - d^4)}$$

$$60 = \frac{16T(100)}{\pi(100^4 - 80^4)}$$

5

$$T = 6\,955486.14\ \text{N} \cdot \text{mm}$$

$$T = 6\,955.5\ \text{N} \cdot \text{m}$$

Based on maximum allowable angle of twist:

$$\theta = \frac{TL}{JG}$$

$$0.5^\circ \left(\frac{\pi}{180^\circ}\right) = \frac{T(1000)}{\frac{1}{32}\pi(100^4 - 80^4)(83\,000)}$$

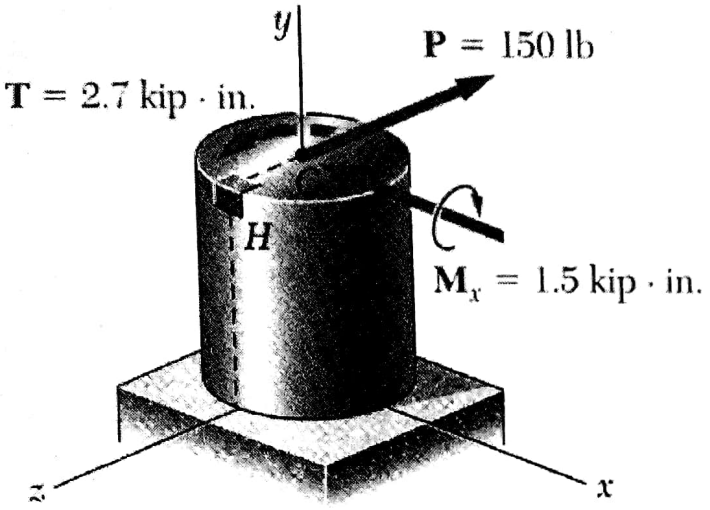
5

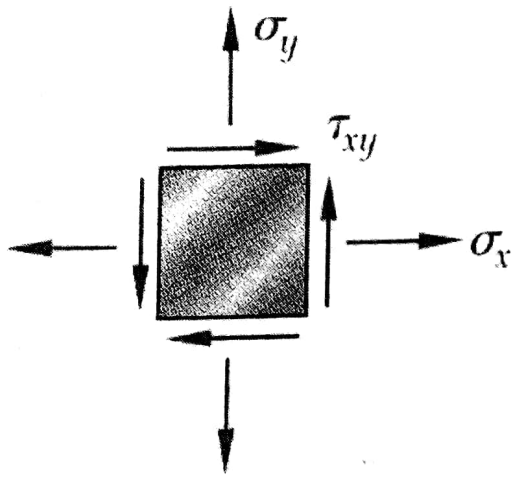
$$T = 4\,198\,282.97\ \text{N} \cdot \text{mm}$$

$$T = 4\,198.28\ \text{N} \cdot \text{m}$$

Use the smaller torque, T = 4 198.28 N·m. *answer*

Question Four





SOLUTION:

- Determine an equivalent force-couple system at the center of the transverse section passing through *H*.

$$P = 150\,\text{lb}$$

$$T = (150\,\text{lb})(18\,\text{in}) = 2.7\,\text{kip}\cdot\text{in}$$

$$M_x = (150\,\text{lb})(10\,\text{in}) = 1.5\,\text{kip}\cdot\text{in}$$

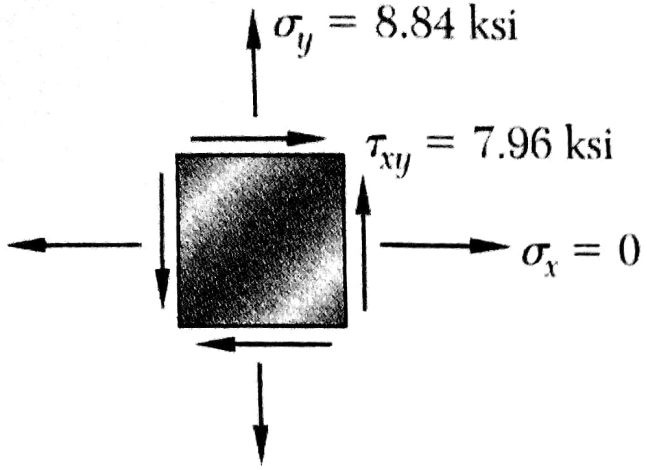
- Evaluate the normal and shearing stresses at *H*.

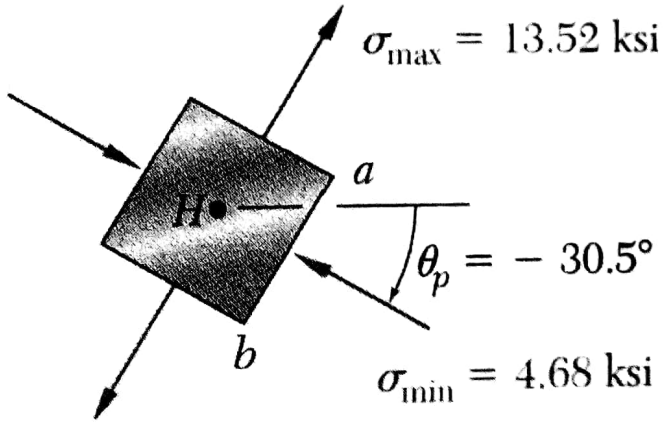
$$\sigma_y = +\frac{Mc}{I} = +\frac{(1.5\,\text{kip}\cdot\text{in})(0.6\,\text{in})}{\frac{1}{4}\pi(0.6\,\text{in})^4}$$

$$\tau_{xy} = +\frac{Tc}{J} = +\frac{(2.7\,\text{kip}\cdot\text{in})(0.6\,\text{in})}{\frac{1}{2}\pi(0.6\,\text{in})^4}$$

(5)

$$\boxed{\sigma_x = 0 \quad \sigma_y = +8.84\,\text{ksi} \quad \tau_y = +7.96\,\text{ksi}}$$





- Determine the principal planes and calculate the principal stresses.

$$\tan 2\theta_p = \frac{2\tau_{xy}}{\sigma_x - \sigma_y} = \frac{2(7.96)}{0 - 8.84} = -1.8$$

(5)

$$2\theta_p = -61.0°, 119°$$

$$\boxed{\theta_p = -30.5°,\ 59.5°}$$

$$\sigma_{max,min} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$= \frac{0 + 8.84}{2} \pm \sqrt{\left(\frac{0 - 8.84}{2}\right)^2 + (7.96)^2}$$

$$\boxed{\begin{aligned}\sigma_{max} &= +13.52\,\text{ksi} \\ \sigma_{min} &= -4.68\,\text{ksi}\end{aligned}}$$

(5)