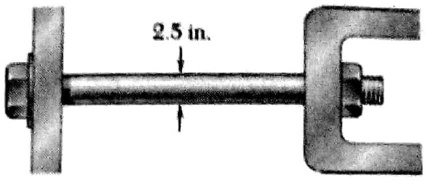
امتحان آخر العام وإجابته النموذجيه

Mansoura University
Faculty of Engineering
Prod. & Mech. Design Eng. Dept.
1st Term - 2018/2019

PME Dept. - Level 100
Strength of Materials [PDE181]
50 Marks – 2 Hours.
Final Exam

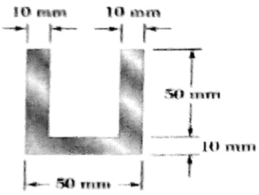
Question 1: [12 Marks]

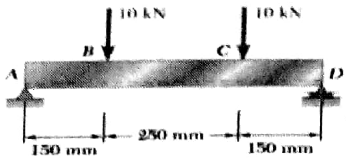
The change in diameter of a large steel bolt is carefully measured as the nut is tightened. Knowing that $E = 29\times10^6$ psi and $\nu = 0.30$, determine the internal force in the bolt, if the diameter is observed to decrease by 0.5×10^{-3} in.



Question 2: [13 Marks]

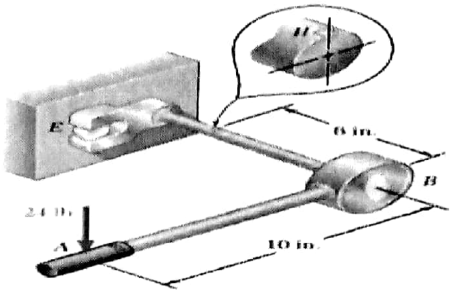
Two vertical forces are applied to a beam of the cross section shown. Determine the maximum tensile and compressive stresses in portion BC of the beam.





Question 3: [15 Marks]

A mechanic uses a crowfoot wrench to loosen a bolt at E. Knowing that the mechanic applies a vertical 24-lb force at A, determine the principal stresses and the maximum shearing stress at point H located as shown on top of the $3/4$-in. diameter shaft. Using analytical and graphical methods.



Question 4: [10 Marks]

1. Principle plan is a plan on which the shear stress is ....

(a) Zero (b) Maximum (c) Minimum

2. If the radius of a wire stretched by a load is doubled, it's Young's modulus will be ....

(a) Doubled (b) halved (c) Remain the same

3. Two shafts ***A*** and ***B*** are made of the same material. The shaft ***A*** is solid and has diameter ***D***. the shaft ***B*** is hollow with outer diameter ***D*** and inner diameter ***D/2***. The strength of the hollow shaft in torsion is .... as that of the solid shaft.

(a) 1/16 (b) 3/4 (c) 15/16

4. A steel bar of 5 mm diameter is heated from 15° C to 40° C and it is free to expand. The bar will induce .... stress.

(a) Tensile Thermal (b) Compressive Thermal (c) No

5. The ratio of lateral strain to axial strain is known as ....

(a) Elasticity Modulus (b) Material Strength (c) Poisson's Ratio

Best Wishes

Associate Prof. Dr. Noha Fouda

Question 1: **[12 Marks]**

$$\delta_y = -0.5 \times 10^{-3}\ in.\ ;\ y_0 = d = 2.5\ in.$$

$$\varepsilon_y = \frac{\delta_y}{y_0} = -\frac{0.5 \times 10^{-3}}{2.5} = -0.2 \times 10^{-3}$$

$$v = -\frac{\varepsilon_y}{\varepsilon_x} \qquad \therefore\ \varepsilon_x = -\frac{\varepsilon_y}{v} = \frac{0.2\times10^{-3}}{0.3} = 0.66667 \times 10^{-3}$$

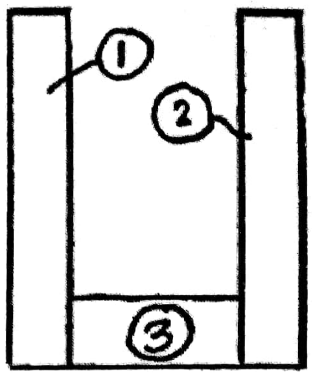
$$\sigma_x = E\varepsilon_x = (29 \times 10^6)(0.66667 \times 10^{-3}) = 19.334 \times 10^3\ psi$$

$$A = \frac{\pi}{4}d^2 = \frac{\pi}{4}(2.5)^2 = 4.9087\ in^2$$

$$F = \sigma_x A = (19.334 \times 10^3)(4.9087) = 94.902 \times 10^3\ lb$$

Question 2: **[13 Marks]**

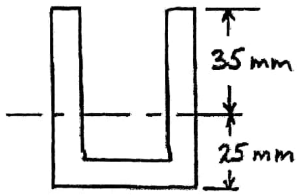
	A, mm	$\overline{y_0}, mm$	$A\overline{y_0}, mm^3$
(1)	600	30	18×10^3
(2)	600	30	18×10^3
(3)	300	5	1.5×10^3
	1500		37.5



$$\overline{Y_0} = \frac{37.5 \times 10^3}{1500} = 25\ mm$$

neutral axis lies 25 *mm above the base.*

$$I_1 = I_2 = \frac{1}{12}(10)(60)^3 + (600)(5)^2 = 195 \times 10^3\ mm^4$$



$$I_3 = \frac{1}{12}(300)(10)^3 + (300)(20)^2 = 145 \times 10^3\ mm^4$$

$$I = I_1 + I_2 + I^3 = 535\ mm^4$$

$y_{top} = 35\ mm = 0.035\ m;$ $\qquad y_{bottom} = -25\ mm = -0.025\ m$

$a = 150\ mm = 0.150\ m$ $\qquad P = 10 \times 10^3\ N$

$$M = Pa = (10 \times 10^3)(0.150) = 1.5 \times 10^3\ N.m$$

$$\sigma_{top} = -\frac{My_{top}}{I} = -\frac{(1.5 \times 10^3)(0.035)}{535 \times 10^{-9}} = -98.13 \times 10^6\ Pa\ (Comp.)$$

$$\sigma_{bottom} = -\frac{My_{bottom}}{I} = -\frac{(1.5 \times 10^3)(0.025)}{535 \times 10^{-9}} = 70.09 \times 10^6\ Pa\ (Ten.)$$

Question 3: **[15 Marks]**

$V = 24\ lb;\quad M = (24)(6) = 144\ lb.in.;\quad T = (24)(10) = 240\ lb.in.$

$d = 0.75\ in.;\qquad c = \frac{1}{2}d = 0.375\ in.$

$J = \frac{\pi}{2}c^4 = 0.031063\ in^4;\qquad I = \frac{1}{2}J = 0.015532\ in^4$

$$Torsion: \tau = \frac{Tc}{J} = \frac{(24)(0.375)}{0.031063} = 2.897 \times 10^3\ psi = 2.897\ Ksi.$$

$$Bending: \sigma = \frac{Mc}{I} = \frac{(144)(0.375)}{0.015532} = 3.477 \times 10^3\ psi = 3.477\ Ksi$$

$Transverse\ shear: At\ point\ H\ stress\ due\ to\ transverse\ shear\ is\ zero.$

$Resultant\ stresses: \sigma_x = 3.477\ Ksi;\quad \sigma_y = 0;\quad \tau_{xy} = 2.897\ Ksi$

$$\sigma_{avg.} = \frac{1}{2}(\sigma_x + \sigma_y) = 1.738$$

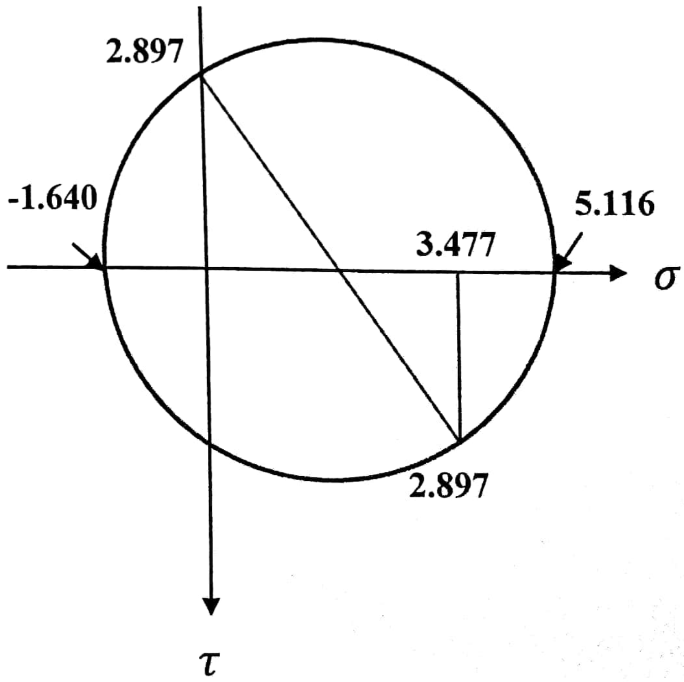
$$R = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2} =$$

$$\sqrt{1.738^2 + 2.897^2} = 3.378\ Ksi$$

$$\sigma_a = \sigma_{Avg.} + R = 5.116\ Ksi$$

$$\sigma_b = \sigma_{Avg.} - R = -1.640\ Ksi$$

$$\tau_{max,min} = R = 3.378\ Ksi$$



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