UNIVERSITY OF JOHANNESBURG

PROGRAM	:	BACCALAUREUS INGENERIAE *CIVIL ENGINEERING SCIENCE*
SUBJECT	:	**STRENGTH OF MATERIALS 2B**
CODE	:	**SMC2B21**
DATE	:	SSA EXAMINATION DECEMBER/JANUARY 2019
DURATION	:	3 Hours
WEIGHT	:	50 : 50
TOTAL MARKS	:	100

ASSESSOR	:	MR P VAN TONDER
MODERATOR	:	PROF EKOLU
NUMBER OF PAGES	:	4 PAGES

INSTRUCTIONS	:	ONLY ONE POCKET CALCULATOR PER CANDIDATE MAY BE USED
REQUIREMENTS	:	NONE

INSTRUCTIONS TO STUDENTS

HAND IN THE QUESTION PAPER AND ANSWER BOOKS.

QUESTION 1 [13]

Prove that for any stress block as shown in figure 1, rotated anti-clockwise through an angle θ, the maximum stresses and angles for these maximum stresses are:

$$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2} \qquad \tan 2\theta_p = \frac{\tau_{xy}}{(\sigma_x - \sigma_y)/2}$$

$$\tau_{\max\ in-plane} = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2} \qquad \tan 2\theta_s = -\frac{(\sigma_x - \sigma_y)/2}{\tau_{xy}}$$

Further prove that the radius and center point for a Mohr circle of stress for figure 1 are:

$$\sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2} \qquad \left(\frac{\sigma_x + \sigma_y}{2};0\right)$$

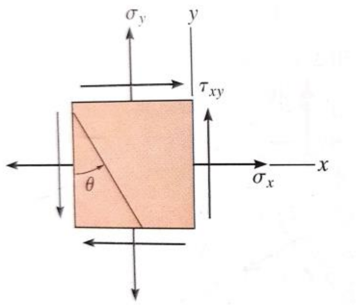


Figure 1

QUESTION 2 [10]

The specimen in figure 2 represents a filament reinforced matrix system made from plactic(matrix) and glass(fiber). If there are *n* fibers, each having a cross-sectional area of A_f and modulus of elasticity of E_f, embedded in a matrix having a cross-sectional area of A_m and modulus of elasticity of E_m, determine the stress in the matrix and the fiber when the force P is applied to the specimen.

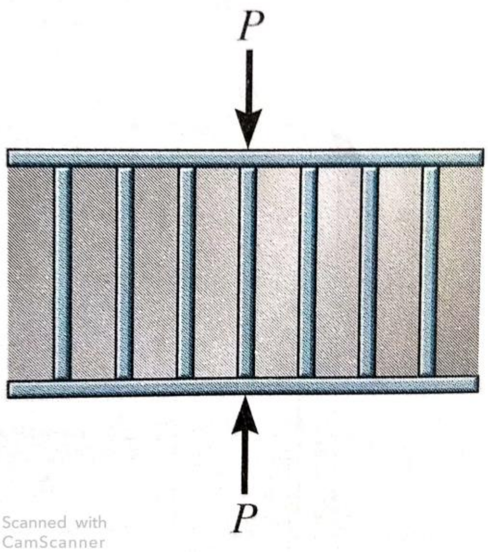


Figure 2

QUESTION 3 [31]

A point on a thin plate is subjected to the strains as shown in figure 3. Determine (a) the strains if the x-axis is rotated 25° clockwise (use the method of Mohr) and (b) the strains if the y-axis is rotated 50° counter-clockwise (use the stress transformation equations). (ε_x = -780x10^{-6}, ε_y = 400x10^{-6} and γ_{xy} = 500 x10^{-6}) Which block elongates the most? Which block is squashed the most?

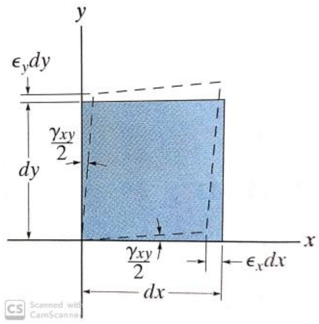


Figure 3

QUESTION 4 [34]

Figure 4 shows a stress block experiences by a structural element. . Determine the principle stresses and in-plane maximum shear stresses. Hence determine the orientation and stresses of the stress block where the shear stress is half of the in-plane maximum shear stress. Use the method of Mohr Circles.

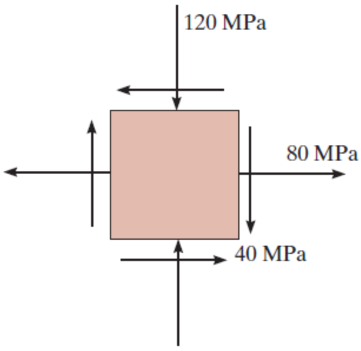


Figure 4

QUESTION 5 [12]

The bolt in figure 5 is made of aluminum alloy(E=73.1GPa) and is tightened so it compresses a cylindrical tube made of magnesium alloy(E=44.7GPa). The tube has an outer radius of 10mm and it is assumed that both the inner radius of the tube and the radius of the bolt are 5mm. The washers at the top and bottom of the tube are considered to be rigid and have a negligible thickness. Initially the nut is hand tightened snuggle; then, using a wrench, the nut is further tightened one-half turn. If the bolt has 1 thread per mm, determine the stress in the bolt.

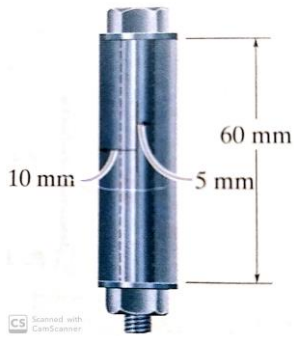


Figure 5

Information Sheet

$$\delta = \frac{PL}{AE} \qquad \delta_T = \alpha \Delta T L \qquad \tau = \frac{T\rho}{J} \qquad \phi = \frac{TL}{JG}$$

$$J = \frac{\pi}{2} r^4 \qquad J = \frac{\pi}{2}\left(r_o^4 - r_i^4\right) \qquad \tau = \frac{VQ}{It} \qquad \sigma = \frac{P}{A}$$

$$\sigma = \frac{My}{I} \qquad \sigma_1 = \frac{pr}{t} \qquad \sigma_2 = \frac{pr}{2t}$$

$$\sigma_{x'} = \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x - \sigma_y}{2}\cos 2\theta + \tau_{xy}\sin 2\theta \qquad \sigma_{y'} = \frac{\sigma_x + \sigma_y}{2} - \frac{\sigma_x - \sigma_y}{2}\cos 2\theta - \tau_{xy}\sin 2\theta$$

$$\tau_{x'y'} = -\frac{\sigma_x - \sigma_y}{2}\sin 2\theta + \tau_{xy}\cos 2\theta \qquad \sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$\tan 2\theta_p = \frac{\tau_{xy}}{\left(\sigma_x - \sigma_y\right)/2} \qquad \tau_{\max\, in-plane} = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$\tan 2\theta_s = -\frac{\left(\sigma_x - \sigma_y\right)/2}{\tau_{xy}} \qquad \tau_{average} = \frac{\sigma_x + \sigma_y}{2}$$

$$\tau_{abs\max} = \frac{\sigma_1}{2} \qquad \tau_{abs\max} = \frac{\sigma_1 - \sigma_2}{2}$$

$$\varepsilon_{x'} = \varepsilon_x \cos^2\theta + \varepsilon_y \sin^2\theta + \gamma_{xy}\sin\theta\cos\theta \qquad \varepsilon_{x'} = \frac{\varepsilon_x + \varepsilon_y}{2} + \frac{\varepsilon_x - \varepsilon_y}{2}\cos 2\theta + \frac{\gamma_{xy}}{2}\sin 2\theta$$

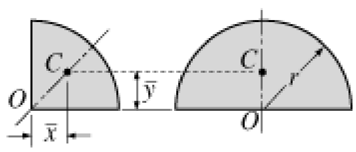
$$\frac{\tau_{x'y'}}{2} = -\frac{\varepsilon_x - \varepsilon_y}{2}\sin 2\theta + \frac{\gamma_{xy}}{2}\cos 2\theta \qquad \varepsilon_{y'} = \frac{\varepsilon_x + \varepsilon_y}{2} - \frac{\varepsilon_x - \varepsilon_y}{2}\cos 2\theta - \frac{\gamma_{xy}}{2}\sin 2\theta$$

$$\tan 2\theta_p = \frac{\gamma_{xy}}{\left(\varepsilon_x - \varepsilon_y\right)} \qquad \varepsilon_{1,2} = \frac{\varepsilon_x + \varepsilon_y}{2} \pm \sqrt{\left(\frac{\varepsilon_x - \varepsilon_y}{2}\right)^2 + \left(\frac{\gamma_{xy}}{2}\right)^2}$$

$$\tan 2\theta_s = -\frac{\left(\varepsilon_x - \varepsilon_y\right)}{\gamma_{xy}} \qquad \frac{\gamma_{\max\, in-plane}}{2} = \sqrt{\left(\frac{\varepsilon_x - \varepsilon_y}{2}\right)^2 + \left(\frac{\gamma_{xy}}{2}\right)^2}$$

$$\varepsilon_{avg} = \frac{\varepsilon_x + \varepsilon_y}{2} \qquad \gamma_{abs\max} = \varepsilon_1$$

$$\varepsilon_{abs\max} = \varepsilon_1 - \varepsilon_2$$

Shapes	Images	$\bar{x}$	$\bar{y}$	Area
Quarter–circular area		$\frac{4r}{3\pi}$	$\frac{4r}{3\pi}$	$\frac{\pi r^2}{3\pi}$
Semicircular area		0	$\frac{4r}{3\pi}$	$\frac{\pi r^2}{2}$