UNIVERSITY OF JOHANNESBURG

PROGRAM	:	BACCALAUREUS INGENERIAE *CIVIL ENGINEERING SCIENCE*
SUBJECT	:	**STRENGTH OF MATERIALS 2B**
CODE	:	**SMC2B21**
DATE	:	SUMMER EXAMINATION NOVEMBER 2019
DURATION	:	(SESSION 1) 8:30 - 11:30
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 new stresses are:

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

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

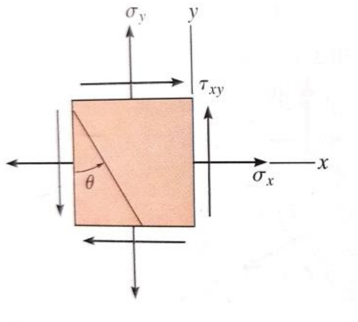


Figure 1

QUESTION 2 [10]

The shaft shown in figure 2 has a radius c and is subjected to a distributed torque t, measured as torque/length of the shaft. Determine the angle of twist of the shaft at the end A. Draw the torque diagram for the shaft. The shear modulus of the shaft is G.

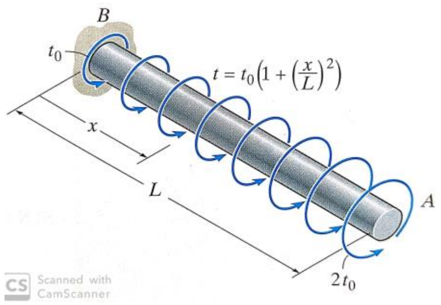
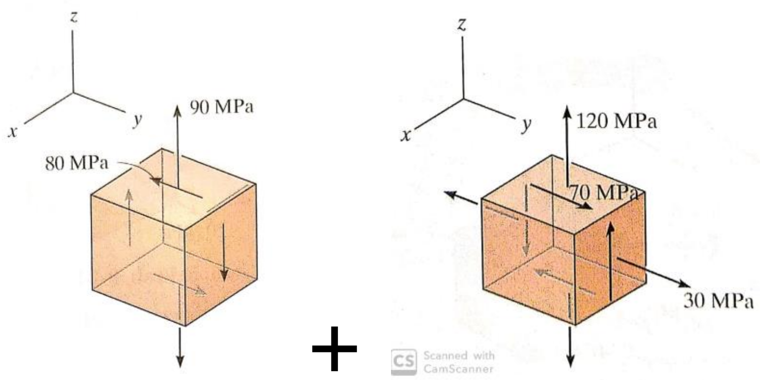


Figure 2

QUESTION 3 [31]

A point on a thin plate is subjected to the two successive states of stress as shown in figure 3. Determine the resultant state of stress represented on the element orientated as described. Use the method indicated below the stress block.



(Mohr circle) **(stress transformation equations)**

= Resultant rotated stress Block 30° clockwise from the positive z-axis

Figure 3

QUESTION 4 [34]

The 60° strain rosette is mounted on the surface of the bracket as shown in figure 4. The following readings are obtained for each gage: $\varepsilon_a = -780 \times 10^{-6}$, $\varepsilon_b = 400 \times 10^{-6}$ and $\varepsilon_c = 500 \times 10^{-6}$. Use the method of Mohr's circle to determine (a) the in-plane principle strains (b) the maximum in-plane shear strain (c) the absolute maximum shear strain. Specify and draw the orientation of the element in each case.

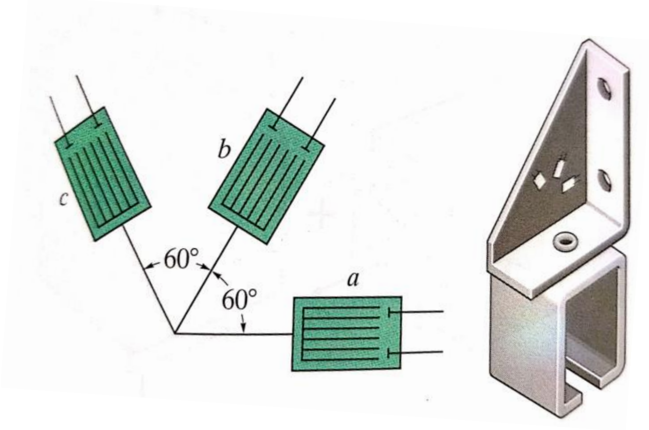
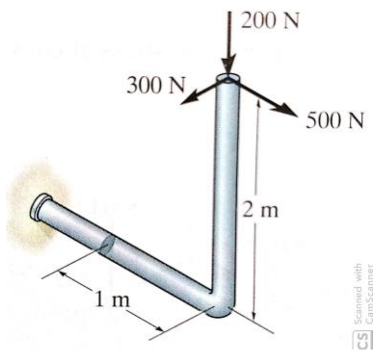


Figure 4

QUESTION 5 [12]

The loadings on a bent shaft are shown in figure 5. Determine ONLY the internal loadings on the shaded section of the shaft. The positive x-axis is opposite to the 300N force, the positive y-axis is vertical up and the positive z-axis is in the same direction as the 500N force. Draw the loadings on a cross section of a shaft at the shaded area.



Information Sheet

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

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

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

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

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

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

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

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

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

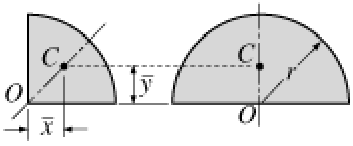
$$\frac{\tau_{x'y'}}{2} = -\frac{\varepsilon_x - \varepsilon_y}{2}\sin 2\theta + \frac{\gamma_{xy}}{2}\cos 2\theta \qquad \varepsilon_{y'} = \frac{\varepsilon_x + \varepsilon_y}{2} - \frac{\varepsilon_x - \varepsilon_y}{2}\cos 2\theta - \frac{\gamma_{xy}}{2}\sin 2\theta$$

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

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

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

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

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	$\frac{4r}{3\pi}$	$\frac{\pi r^2}{2}$