UNIVERSITY OF JOHANNESBURG

PROGRAM	:	BACCALAUREUS INGENERIAE *MECHANICAL ENGINEERING*
SUBJECT	:	**STRENGTH OF MATERIALS 3B**
CODE	:	**SLR 3B21 / SLRBCB3**
DATE	:	SUMMER EXAMINATION NOVEMBER 2019
DURATION	:	3 HOURS
WEIGHT	:	50:50
TOTAL MARKS	:	100

EXAMINER	:	DR D. M. MADYIRA
MODERATOR	:	PROF R. F. LAUBSCHER
NUMBER OF PAGES	:	6 PAGES

INSTRUCTIONS	:	QUESTION PAPERS MUST **NOT** BE HANDED IN.
REQUIREMENTS	:	ANSWER SHEETS

INSTRUCTIONS TO CANDIDATES:

1. Answer all questions.
2. Explain answers and give all the necessary steps to arrive at the answer – simply giving the answer is not sufficient.
3. The examination is not an open book exam. All required formulae are given in the formulae sheet.
4. Do all the questions in the answer scripts.

QUESTION 1 [25]

The crane frame shown in Figure Q1 is made of two A36 steel W460 × 68 wide flange sections (overall height 459 mm, web thickness 9.14 mm, flange width 154 mm and flange thickness 15.4 mm). Use Castigliano's second principle to determine the vertical displacement of point C. For A36 steel, E = 200 GPa, G = 75 GPa, $\nu = 0.26$ and $\sigma_Y = 250$ MPa.

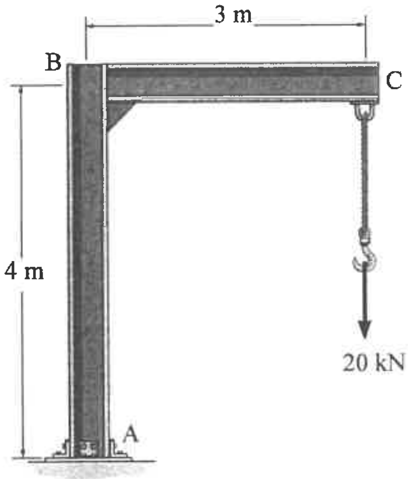


Figure Q1: Crane frame

QUESTION 2 [25]

The open ring illustrated in Figure Q2 supports an 80 kN force as shown. Determine and schematically indicate the position of the neutral axis. Henceforth, find the stresses at points P and Q.

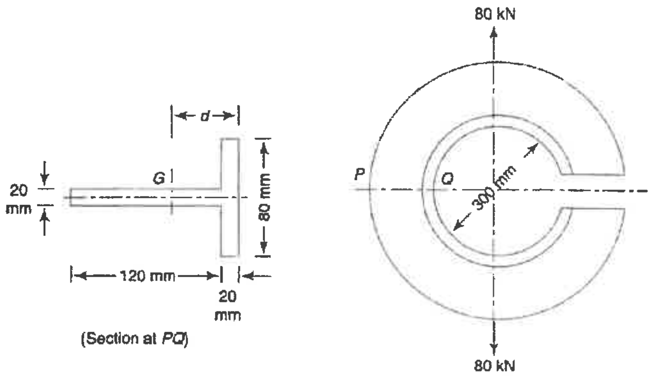
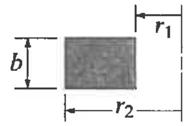
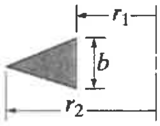
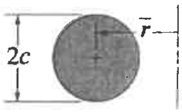
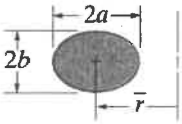


Figure Q2: Curved beam

QUESTION 3 [25]

A steel disc of 250-mm external diameter and 50 mm internal diameter is shrunk on to a steel shaft so that the pressure between the shaft and the disc at standstill is 50 MPa. Neglecting the change in diameter of the shaft, determine the speed at which the disc will loosen from the shaft. The density of steel is 7500 kg/m^3, the Young's Modulus is 200 GPa and the Poisson's ratio is 0.3.

Shape	$\int_A \frac{dA}{r}$
	$b \ln \frac{r_2}{r_1}$
	$\frac{b\, r_2}{(r_2 - r_1)}\left(\ln \frac{r_2}{r_1}\right) - b$
	$2\pi\left(\bar{r} - \sqrt{\bar{r}^2 - c^2}\right)$
	$\frac{2\pi b}{a}\left(\bar{r} - \sqrt{\bar{r}^2 - a^2}\right)$

$$\delta = -u' + u'' = r_m \cdot (\varepsilon_\theta'' - \varepsilon_\theta')$$

$$\varepsilon_\theta'' = \frac{1}{E}\left(\sigma_\theta'' - \nu\sigma_r''\right) \quad outer\ cylinder$$

$$\varepsilon_\theta' = \frac{1}{E}\left(\sigma_\theta' - \nu\sigma_r'\right) \quad inner\ cylinder$$

Rotating Components

$$\frac{d\sigma_r}{dr} + \frac{\sigma_r - \sigma_\theta}{r} + \rho \cdot \omega^2 \cdot r = 0$$

$$\omega_Y = \frac{1}{r_e} \cdot \sqrt{\frac{8 \cdot \sigma_Y}{(3+\nu) \cdot \rho}}$$

$$\omega_Y = \sqrt{\frac{4 \cdot \sigma_Y}{\rho \cdot \left[(3+\nu) \cdot r_e^2 + (1-\nu) \cdot r_i^2\right]}}$$

$$\sigma_r = A - \frac{B}{r^2} - \left(\frac{3+\nu}{8}\right) \cdot \rho \cdot \omega^2 \cdot r^2$$

$$\sigma_\theta = A + \frac{B}{r^2} - \left(\frac{1+3\cdot\nu}{8}\right) \cdot \rho \cdot \omega^2 \cdot r^2$$

$$\sigma_{r1} \cdot z_1 = \sigma_{r2} \cdot z_2 \qquad F_c = m \cdot \omega^2 \cdot r$$

Torsion of Non-circular sections

$$T = \alpha b t^2 \frac{G\theta}{L} = \beta b t^3 \frac{G\theta}{L} \qquad \tau_{\max} = \frac{G\theta t}{L} \qquad T = \frac{1}{3} b t^2 \frac{G\theta}{L}$$

b/t	**1**	**1.5**	**2**	**2.5**	**3**	**4**	**6**	**10**	**∞**
α	0.208	0.231	0.246	0.256	0.267	0.282	0.299	0.312	0.333
β	0.141	0.196	0.229	0.249	0.263	0.281	0.299	0.312	0.333