UNIVERSITEIT VAN JOHANNESBURG — UNIVERSITY OF JOHANNESBURG

11 NOVEMBER 2014
08h30

KURSUS :	INGENIEURSWESE	**TYD :**	3.0 URE
COURSE :	*ENGINEERING*	***TIME :***	*3.0 HRS*
VAK :	**Sterkteleer 3B**	**PUNTE :**	100
SUBJECT :	*STRENGTH OF MATERIALS 3B*	***MARKS :***	*100*

Hierdie vraestel bestaan uit **5** bladsye / This *paper consists of* **5** *pages*

Examiners / Eksaminators: Mr D.M. Madyira
Dr P.F.J. Henning

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1.1 Determine the actual hoop and longitudinal stresses present in the cylinder if E = 208 GPa and v = 0.29. [5]

1.2 Compare the hoop stresses so obtained with the theoretical values obtained using Lame's equations. [10]

1.3 Assuming that the above strain readings were obtained for a thick cylinder of 100 mm outside diameter and unknown inside diameter, calculate this internal diameter. [10]

QUESTION 2 [25]

A G-clamp is constructed from an I-section as shown in Figure Q2. It will experience a peak load of 2 kN.

2.1 Determine the maximum stresses at the central section AB [10]

2.2 What are the stresses if the section is changed to a circular section of the same area? [10]

2.3 Comment on your answer [2]

2.3 Compare these results with those obtained from simple bending theory [3]

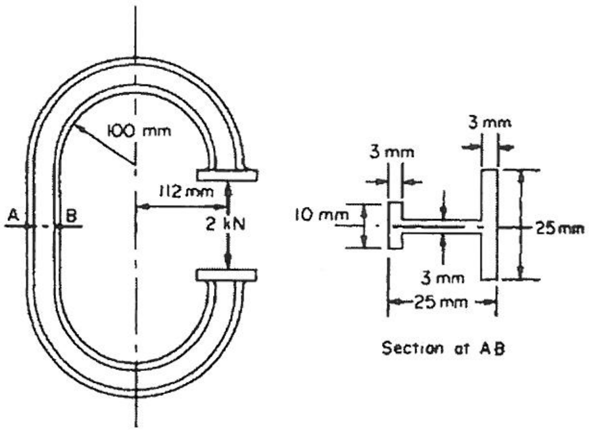

Figure Q2: G-clamp

QUESTION 3 [25]

In Figure Q3, member AC can be considered rigid and weightless. Columns BD and CE are pinned at both ends and have solid circular cross sections of diameter 15 mm. Column BD is made of structural steel with E = 207 GPa and column CE is made of aluminum alloy with E = 72 GPa. Determine the magnitude of P that will cause the column to buckle. [25]

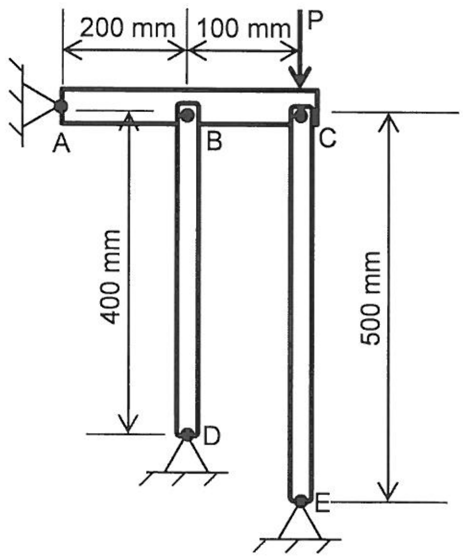

Figure Q3: Columns of unequal lengths

QUESTION 4 [25]

The gantry shown in Figure Q4 is 7 m high and has a 3 m overhang. The cross sections of the gantry members are I-shaped with dimensions shown. The orientation of the I-section on both members is such that bending occurs about the X-X axis as shown. The gantry carries a point load of 5kN load at the end of the overhang. The gantry is made of structural steel with E = 210 GPa and v = 0.33.

4.1 Determine the total strain energy induced in the gantry. [10]

4.2 Use Castigliano's Second Principle to calculate the vertical displacement at point C. [15]

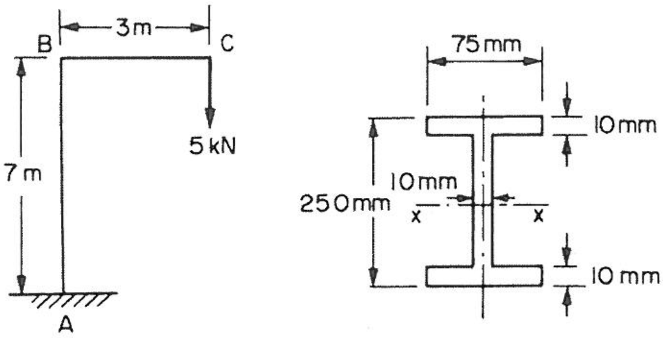

Figure Q4: Gantry with I-cross section

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Formula Sheet

Buckling Equations

$$P_{cr} = \frac{\pi^2 EI}{4L^2} \qquad P_{cr} = \frac{\pi^2 EI}{L^2} \qquad P_{cr} \approx \frac{2\pi^2 EI}{L^2} \qquad P_{cr} = \frac{4\pi^2 EI}{L^2}$$

$$\sigma_{\max} = \frac{P}{A}\left[1 + \frac{ec}{r^2}\sec\left(\frac{L}{2r}\sqrt{\frac{P}{EA}}\right)\right]$$

Initially Curved Sections

$$R = A \Big/ \int_A \frac{dA}{r} \qquad \sigma = \frac{M(R-r)}{rA(\bar{r}-R)}$$

Bending Stress Equations:

$$\frac{M}{I} = \frac{\sigma}{y} = \frac{E}{R} \qquad \tau_{xy} = \tau_{yx} = \frac{Q}{b \cdot I} \cdot \int_A y \cdot dA = \frac{Q \cdot A \cdot \bar{y}_A}{b \cdot I}$$

Springs

$$\tau_{\max} = \frac{8 \cdot F \cdot D}{\pi \cdot d^3} + \frac{4F}{\pi \cdot d^2} \qquad y = \alpha \cdot \frac{D}{2} = \frac{8 \cdot F \cdot D^3 \cdot N}{d^4 \cdot G} \qquad k = \frac{d^4 \cdot G}{8 \cdot D^3 \cdot N}$$

$$\sigma = \frac{M}{I/c} + \frac{F}{A} = K \cdot \frac{32 \cdot F \cdot r_m}{\pi \cdot d^3} + \frac{4 \cdot F}{\pi \cdot d^2} \qquad K \approx \frac{r_m}{r_i} \qquad N = N_T - N_D$$

Thick Cylinders

$$\sigma_r = \frac{1}{k^2-1} \cdot \left[p_i \cdot \left(1 - \frac{r_o^2}{r^2}\right) - p_o \cdot k^2 \cdot \left(1 - \frac{r_i^2}{r^2}\right)\right] \qquad \sigma_r = \frac{p_i}{k^2-1} \cdot \left(1 - \frac{r_o^2}{r^2}\right)$$

$$\sigma_\theta = \frac{1}{k^2-1} \cdot \left[p_i \cdot \left(1 + \frac{r_o^2}{r^2}\right) - p_o \cdot k^2 \cdot \left(1 + \frac{r_i^2}{r^2}\right)\right] \qquad \sigma_\theta = \frac{p_i}{k^2-1} \cdot \left(1 + \frac{r_o^2}{r^2}\right)$$

$$k = \frac{r_o}{r_i} \qquad \sigma_r = A - \frac{B}{r^2} \qquad \sigma_\theta = A + \frac{B}{r^2}$$

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

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

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Rotating Components

$$\frac{d\sigma_r}{dr} + \frac{\sigma_r - \sigma_\theta}{r} + \rho \cdot \omega^2 \cdot r = 0 \qquad \sigma_r = A - \frac{B}{r^2} - \left(\frac{3+\nu}{8}\right) \cdot \rho \cdot \omega^2 \cdot r^2$$

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

$$\omega_Y = \sqrt{\frac{4 \cdot \sigma_Y}{\rho \cdot \left[(3+\nu) \cdot r_e^{\,2} + (1-\nu) \cdot r_i^{\,2}\right]}} \qquad \sigma_{r1} \cdot z_1 = \sigma_{r2} \cdot z_2 \qquad F_c = m \cdot \omega^2 \cdot r$$

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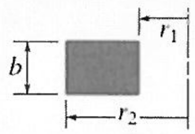
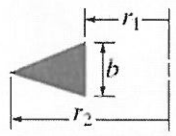
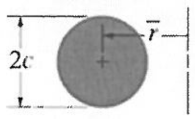
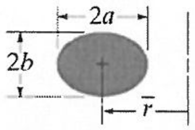
Shape	$\int_A \frac{dA}{r}$
	$b \ln \frac{r_2}{r_1}$
	$\frac{b\, r_2}{(r_2 - r_1)}\left(\ln \frac{r_2}{r_1}\right) - b$
	$2\pi\left(\bar{r} - \sqrt{\bar{r}^2 - c^2}\right)$
	$\frac{2\pi b}{a}\left(\bar{r} - \sqrt{\bar{r}^2 - a^2}\right)$

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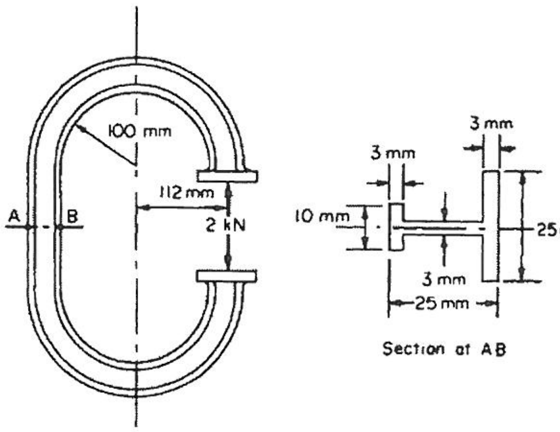

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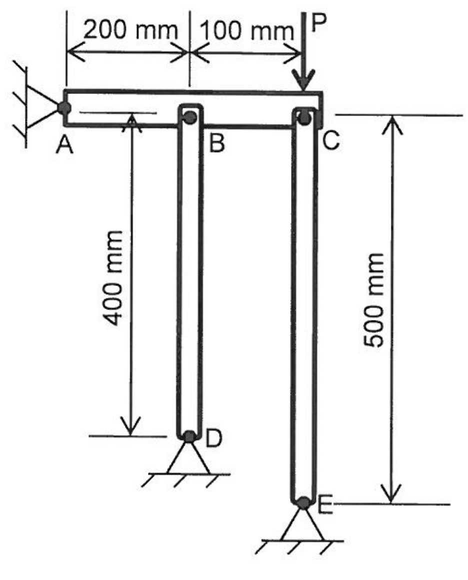

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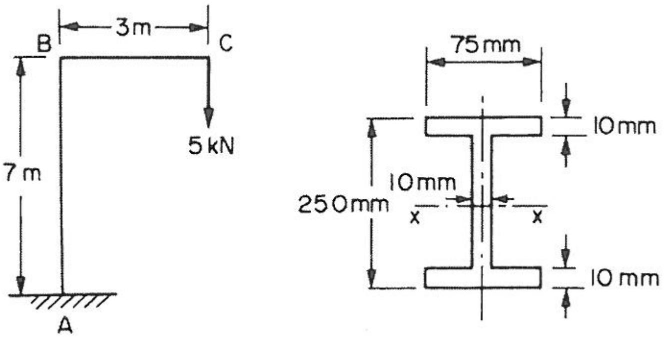

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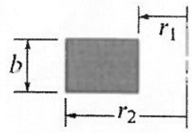
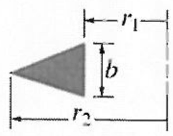
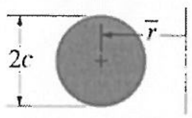
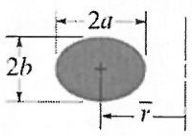
	$b \ln \frac{r_2}{r_1}$
	$\frac{b\, r_2}{(r_2 - r_1)} \left(\ln \frac{r_2}{r_1}\right) - b$
	$2\pi \left(\bar{r} - \sqrt{\bar{r}^2 - c^2}\right)$
	$\frac{2\pi b}{a} \left(\bar{r} - \sqrt{\bar{r}^2 - a^2}\right)$