Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(ONLINE)
SEMESTER II
SESSION 2019 / 2020

COURSE NAME	:	SOLID MECHANICS 2
COURCE CODE	:	BDA 20903
PROGRAMME	:	2 BDD
EXAMINATION DATE	:	JULY 2020
DURATION	:	3 HOURS
INSTRUCTION :	:	ANSWER **ALL** QUESTIONS IN **PART A** AND **ONE (1)** QUESTION IN **PART B**

TERBUKA

THIS QUESTION PAPER CONSISTS OF **TEN (10)** PAGES

PART A

Q1 The beam is subjected to the loads shown in **Figure Q1**.

(a) Determine the support reactions at point A and B,

(4 marks)

(b) Using Macaulay Functions as shown in **Table Q1** and also method of superposition, examine the deflection of the beam by determine the equation of the elastic curve,

(10 marks)

(c) Identify the slope at point A and B. Given $E = 200\,GPa$ and $I = 84.9(10^{-6})\,m^4$.

(6 marks)

Q2 A pin-jointed aluminium alloy has a modulus of elasticity, $E = 72\,GPa$ as shown in **Figure Q2**, carries a concentrated load, F. Both members have a section of $50\,x\,50\,mm^2$. Assuming that buckling can only occur in the plane of structure and by using Euler's formula,

(a) Determine the critical load, P_{cr} of member AB and BC.

(10 marks)

(b) Examine the minimum value of load, F that will cause buckle to occur.

(10 marks)

Q3 (a) Prove that the elastic strain energy due to the bending as shown in **Figure Q3(a)** is

$$U = \frac{(W^2 L^5)}{40\,EI}$$

(8 marks)

(b) A steel rod forms a cantilever ABC in a vertical plane as shown in **Figure Q3 (b)**. An angle load of 20 kN acts at C. Using the Castigliano's Theorem (strain energy method), determine the vertical displacement at free end at point C. Given EI = 80 kNm^2.

(12 marks)

Q4 (a) Based on **Figure Q4**, derive and prove that the Hoop Stress, σ_H and the Radial Stress, σ_R can be expressed as follow:

$$\sigma_R = \frac{a^2 P_a - b^2 P_b}{(b^2 - a^2)} - \frac{a^2 b^2 (P_a - P_b)}{r^2 (b^2 - a^2)}$$

$$\sigma_H = \frac{a^2 P_a - b^2 P_b}{(b^2 - a^2)} + \frac{a^2 b^2 (P_a - P_b)}{r^2 (b^2 - a^2)}$$

where

a = internal radius

b = external radius

P_a = internal pressure

P_b = external pressure

r = arbitrary radius

(17 marks)

(b) A thick cylindrical shell with inner radius 150 mm and outer radius 210 mm is subjected to an internal pressure of 90 MPa. Find the maximum and minimum hoop stresses.

(8 marks)

PART B

Q5 The steel with properties $E = 200\,GPa$ and $v = 0.32$ position in vertical post is loaded to the forces as shown in **Figure Q5**. If the strain gauges a and b are firmly attached at point A give readings of $\varepsilon_a = 300(10^{-6})$ and $\varepsilon_b = 175(10^{-6})$. Determine the magnitudes of $P1$ assuming that $P1 = P2$. There is no transverse force occurs at point A. Solve the following problems:

(a) Sketch the free body diagram at point A,

(5 marks)

(b) Find the moment of inertia of the cross section,

(5 marks)

(c) Analyze the normal strains at point A, and

(8 marks)

(d) Find force P1.

(2 marks)

Q6 On your first assignment as a mechanical engineer, you need to define the loading capacity of the company cantilever beam. As shown in **Figure Q6**, the yield stress, σ_Y of the beam is 300 MPa.

(a) Calculate the stresses acting at the critical location

(8 marks)

(b) Use Mohr's circle to define the principal stresses, σ_1 and σ_2

(4 marks)

(c) Define the maximum force **P** that can be applied before the beam fails by considering the Tresca and Von Mises criteria

(8 marks)

-END OF QUESTIONS-

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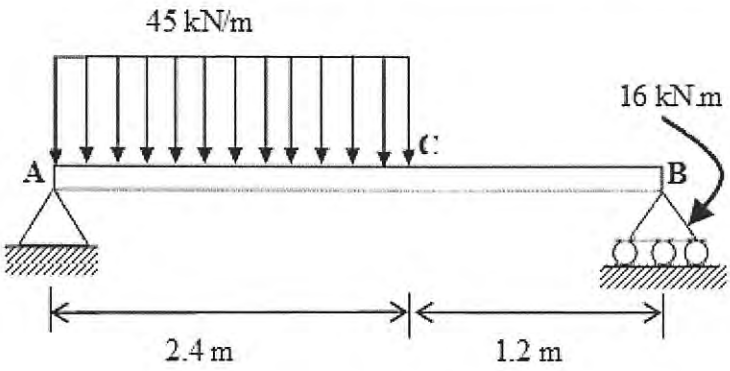
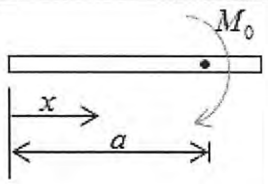
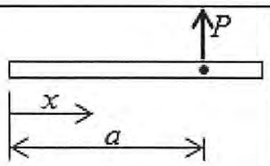
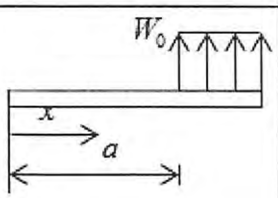


Figure Q1

Table Q1

Loading	Loading Function $w = w(x)$	Shear $V = \int w(x)dx$	Moment $M = \int V dx$
	$w = M_0 < x-a >^{-2}$	$V = M_0 < x-a >^{-1}$	$M = M_0 < x-a >^{0}$
	$w = P < x-a >^{-1}$	$V = P < x-a >^{0}$	$M = P < x-a >^{1}$
	$w = W_0 < x-a >^{0}$	$V = W_0 < x-a >^{1}$	$M = \frac{W_0}{2} < x-a >^{2}$

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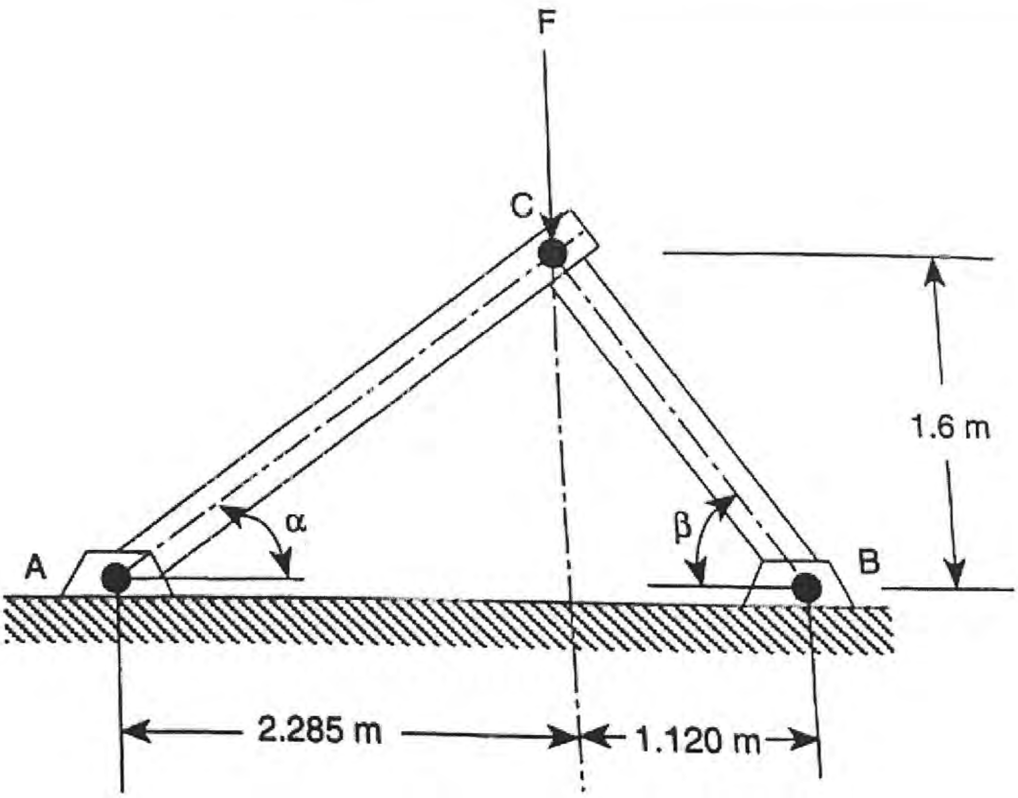

Figure Q2

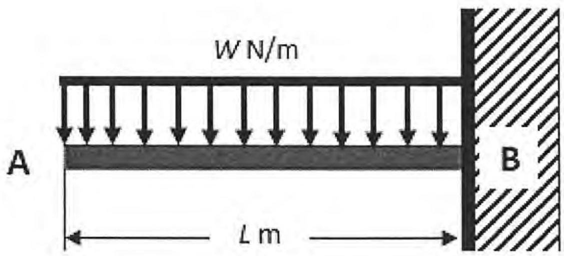

Figure Q3(a)

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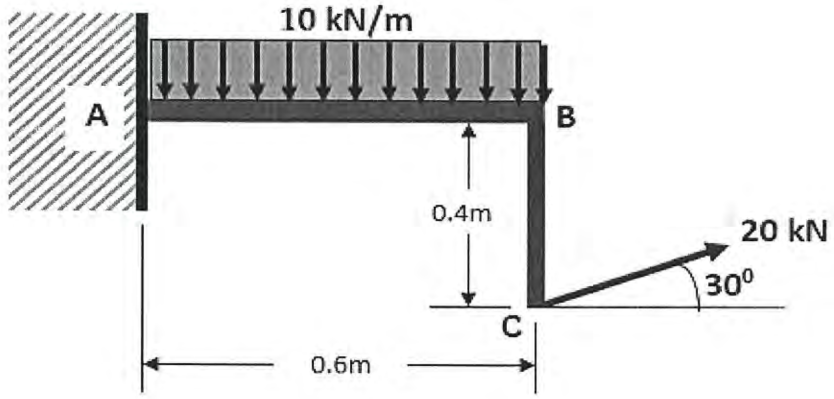

Figure Q3(b)

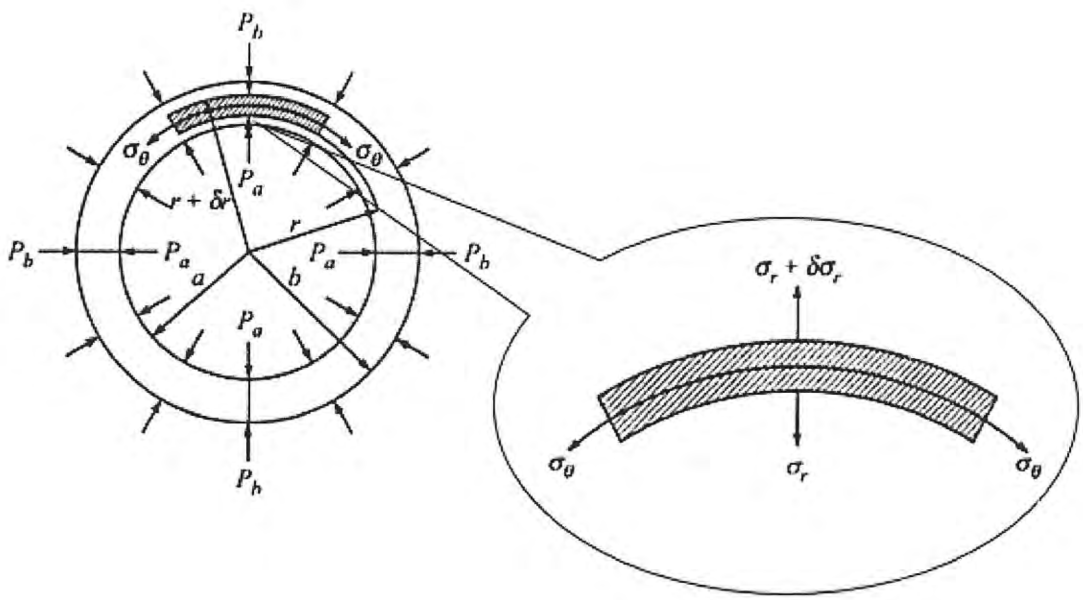

Figure Q4

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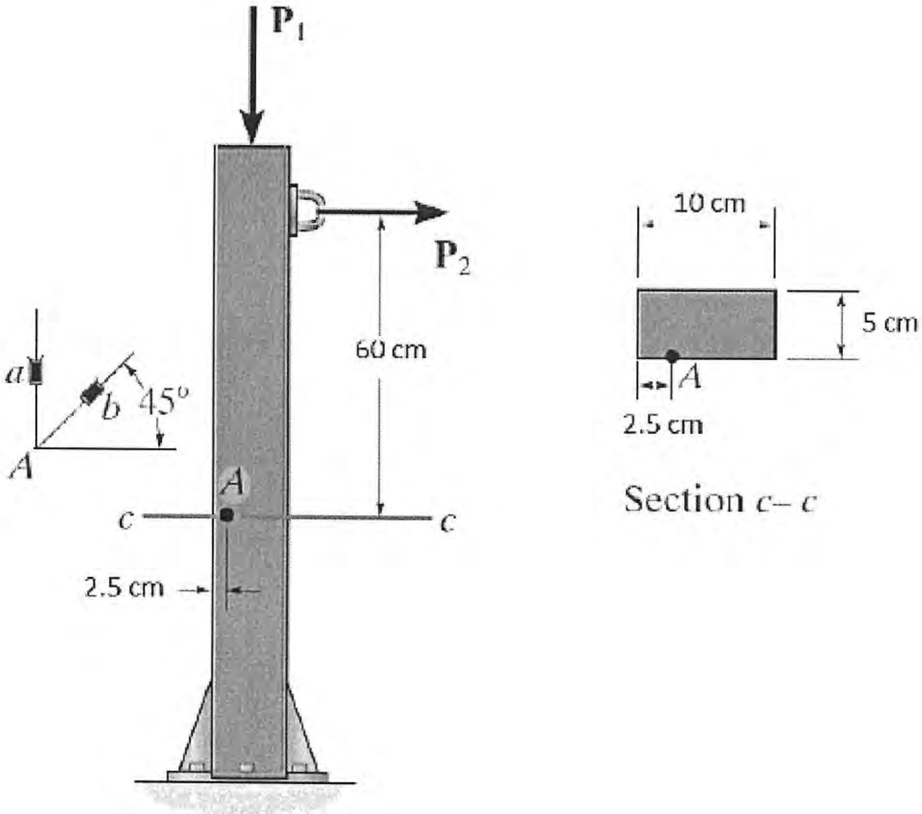

Figure Q5

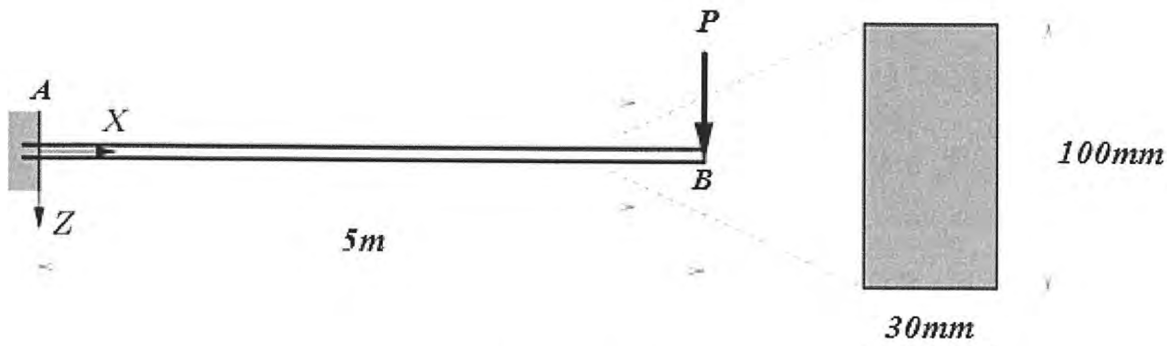

Figure Q6

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FORMULA

$$\varepsilon(\theta) = \varepsilon_x \cos^2\theta + \varepsilon_y \sin^2\theta + \gamma_{xy} \sin\theta\cos\theta$$

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

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

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

$$\tan 2\theta_p = \frac{\gamma_{xy}}{\varepsilon_x - \varepsilon_y}$$

$$\varepsilon_a = \varepsilon_x \cos^2\theta_a + \varepsilon_y \sin^2\theta_a + \gamma_{xy} \sin\theta_a \cos\theta_a$$

$$\varepsilon_b = \varepsilon_x \cos^2\theta_b + \varepsilon_y \sin^2\theta_b + \gamma_{xy} \sin\theta_b \cos\theta_b$$

$$\varepsilon_c = \varepsilon_x \cos^2\theta_c + \varepsilon_y \sin^2\theta_c + \gamma_{xy} \sin\theta_c \cos\theta_c$$

$$\frac{d^2y}{dx^2} = \frac{M(x)}{EI}$$

$$\frac{dV}{dx} = -w$$

$$\frac{dM}{dx} = V$$

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FORMULA

$$U = \frac{1}{2} P x$$

$$U = \sum \frac{F_i^2 L_i}{2 A_i E_i}$$

$$U = \int \frac{M^2}{EI} dx$$

$$y_j = \frac{\partial U}{\partial P_j} = \int \frac{M}{EI} \frac{\partial M}{\partial P_j} dx$$

$$|\sigma_a| < \sigma_Y ; |\sigma_b| < \sigma_Y$$

$$|\sigma_a - \sigma_b| < \sigma_y$$

$$|\sigma_a| < \sigma_U ; |\sigma_b| < \sigma_U$$

$$|\varepsilon_a| < \varepsilon_U ; |\varepsilon_b| < \varepsilon_U$$

$$\tau_{\max} = \frac{1}{2} \sigma_Y$$

$$\tau_{\max} = \frac{1}{2} (\sigma_a - \sigma_b)$$

$$\sigma_a^2 - \sigma_a \sigma_b + \sigma_b^2 \le \sigma_Y^2$$

$$U = \int \frac{M^2}{EI} dx$$

$$y_j = \frac{\partial U}{\partial P_j} = \int \frac{M}{EI} \frac{\partial M}{\partial P_j} dx$$

$$\varepsilon_1 = \frac{\sigma_1}{E} - \frac{\nu}{E} \sigma_2$$

$$\varepsilon_2 = \frac{\sigma_2}{E} - \frac{\nu}{E} \sigma_1$$

$$\varepsilon_x = \frac{\sigma_x}{E} - \frac{\nu}{E} \sigma_y$$

$$\varepsilon_y = \frac{\sigma_y}{E} - \frac{\nu}{E} \sigma_x$$