Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2022 / 2023

COURSE NAME	:	SOLID MECHANICS
COURCE CODE	:	BDX 20303
PROGRAMME CODE	:	BDX
EXAMINATION DATE	:	FEBRUARY 2023
DURATION	:	3 HOURS
INSTRUCTION	:	1. **PART A** : ANSWER **THREE (3)** QUESTIONS **ONLY** AND **PART B** : ANSWER **ALL** QUESTIONS 2. THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSE BOOK** 3. STUDENTS ARE **PROHIBITED** O CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK.

THIS QUESTION PAPER CONSISTS OF **NINE (9)** PAGES

PART A (OPTIONAL) :
Answer **THREE (3)** questions **ONLY.**

Q1 (a) Steel cable with diameter of 32 mm is used in a construction yard to lift a structure section weighing 40 kN as sown in **Figure Q1(a)**. The cable has an effective modulus of elasticity, E = 140 GPa.

i) If the cable is 14 m long, how much will it stretch when the load is picked up?

(2 marks)

ii) If the cable is rated for a maximum load of 100 kN, what is the factor of safety with respect to failure of the cable? (Given that ULT of steel 641 kN)

(3 marks)

(b) A plastic rod AB of length L = 0.5 m has a diameter d_1 = 30 mm as shown in **Figure Q1(b)**. A plastic sleeve CD of length c = 0.3 m and the outer diameter d_2 = 45 mm is securely bonded to the rod so that no slippage can occur between the rod and the sleeve. The rod is made of an acrylic with modulus of elasticity E_1 = 3.1 GPa and the sleeve is made of a polyamide with E_2 = 2.5 GPa. If the rod is pulled by axial forces P = 15 kN.

(i) Draw the free body diagram of bonded rod.

(5 marks)

(ii) Evaluate the elongation, δ of the rod.

(10 marks)

Q2 (a) The railroad track are welded together at their ends when the temperature is 16 °C. what is the compressive stress, σ produced when the rails are heated by the sunlight to 49 °C. Given that the α = 11.7 x 10-6 and E = 206.8 GPa

(5 marks)

(b) A beam ACB as illustrated in **Figure Q2(b)** has an overhang at one end supports a uniform load of intensity 600 kg/m and another uniform load intensity 450 kg/m at the other end

(i) Draw the free body diagram (FBD) of the beam.

(2 marks)

(ii) Calculate the vertical support forces.

(2 marks)

(iii) Draw the Shearing Force Diagram (SFD) and the Bending Moment Diagram (BMD) of the beam up to 8 m from point A.

(10 marks)

(iv) Determine the maximum absolute value of the bending moment from point A.

(1 mark)

Q3 (a) A circular aluminium tube subjected to pure torsion by torques T, has an outer radius r_2 equal to 1.5 times the inner radius r_1 as shown in **Figure Q3(a)**

i) If the maximum shear strain in the tube is measured as 400 x 10^{-6} rad, what is the shear strain $\gamma 1$ at the inner surface?

(2 marks)

ii) If the maximum allowable rate of twist is 0.125 degrees per foot and the maximum shear strain is to be kept at 400 x 10-6 rad by adjusting the torque T, what is the minimum required outer radius r2 min?

(3 marks)

(b) A steel beam AB as shown in **Figure Q3(b)** is supported by fix support at A and moveable support at B. The steel beam then being push downwards by a concentrated force of P = 7 kN. Length of the steel beam is given as 3.2 m, d = 1.25 m, b = 85 mm, t = 30 mm, h = 120 mm and h1 = 90 m.

i) Determine the cross section centroid of the beam

(5 marks)

ii) Determine the moment of inertia of the cross sectional beam

(5 marks)

iii) Find the maximum bending moment of the beam and its maximum compressive and tensile stress.

(5 marks)

Q4 (a) Define what is angle of twist.

(2 marks)

(b) The aluminium shaft shown in **Figure Q4(b)** with fixed supports at end A and D is acted upon by two equal and oppositely directed torques T0 as shown. The torques are applied at points B and C each of which is located at distance x from one end of the bar. (the distance x may vary from zero to L/2)

(i) At what distance x will the angle of twist at points B and C be a maximum?

(9 marks)

(ii) Calculate the correcsponding angle of twist $\emptyset_{max}$. (Give your answer in term of T, L, G and I)

(9 marks)

PART B (COMPULSORY) :
Answer **ALL** questions.

Q5 The steel pressure tank shown in **Figure Q5** has a 750 mm inner diameter and a 9 mm wall thickness. Knowing that the butt-welded seams form an angle $\beta = 50°$ with the longitudinal axis of the tank and that the gage pressure in the tank is 1.4 MPa,

(a) determine the normal stress perpendicular to the weld

(10 marks)

(b) determine the shearing stress parallel to the weld

(10 marks)

Q6 (a) The stresses acting on element A on the web of a train rail (**Figure Q6(a)**) are found to be 45 MPa tension in the horizontal direction and 120 MPa compression in the vertical direction (see figure part b). Also, shear stresses with a magnitude of 25 MPa act in the directions shown. Determine the stresses acting on an element oriented at a counterclockwise angle of 40° from the horizontal. Show these stresses on a sketch of an element oriented at this angle.

(10 Marks)

(b) An element in uniaxial stress is subjected to tensile stresses $\sigma_x = 98MPa$, as shown in the figure. Using Mohr's circle, determine the following.

(i) The stresses acting on an element oriented at a counterclockwise angle $\theta = 29°$ from the x axis.

(5 marks)

(ii) The maximum shear stresses and associated normal stresses. Show all results on sketches of properly oriented elements

(5 marks)

- END OF QUESTION -

FINAL EXAMINATION

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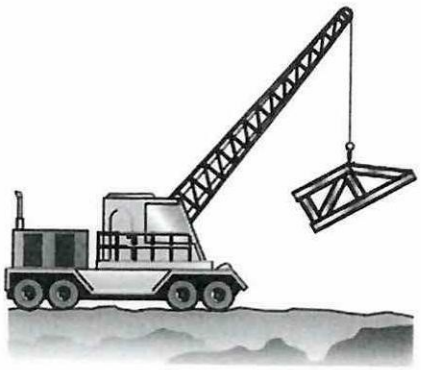

Figure Q1(a)

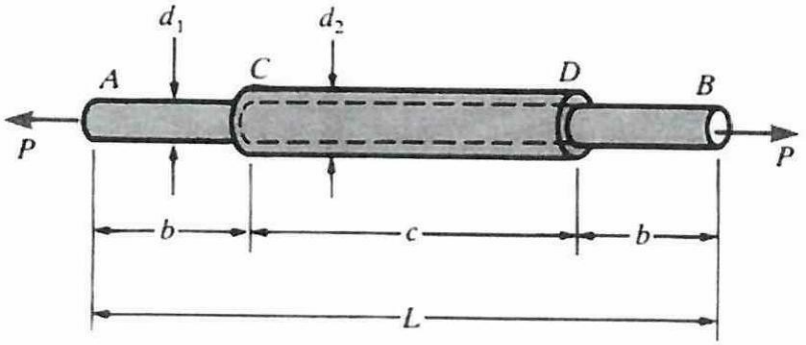

Figure Q1(b)

FINAL EXAMINATION

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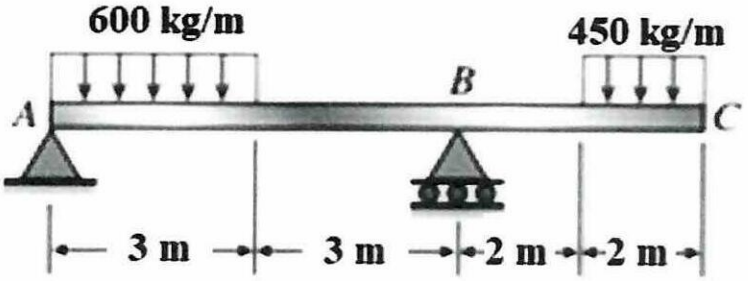

Figure Q2(b)

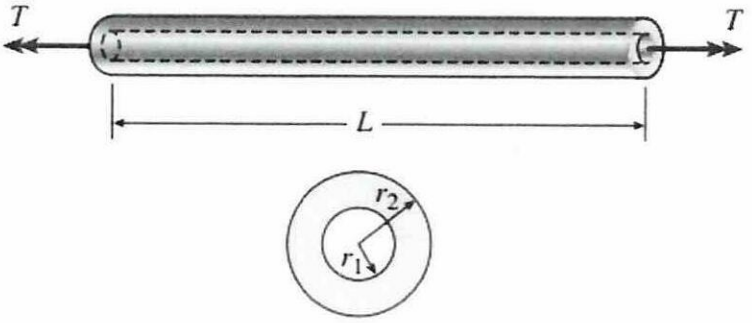

Figure Q3(a)

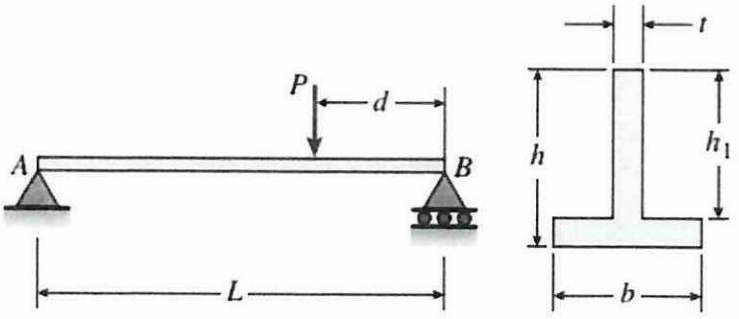

Figure Q3(b)

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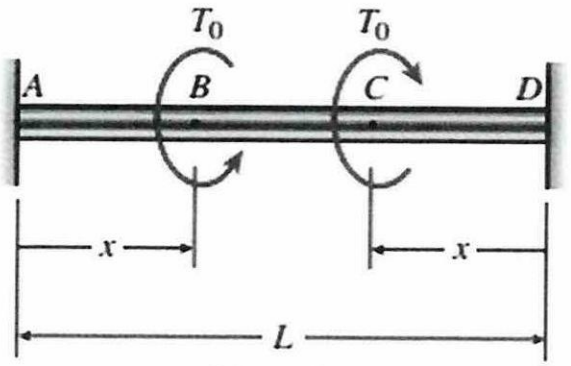

Figure Q4(b)

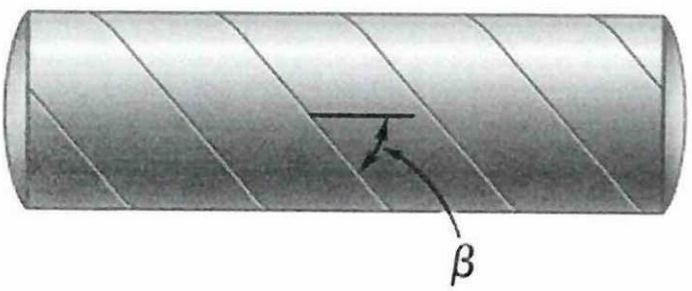

Figure Q5

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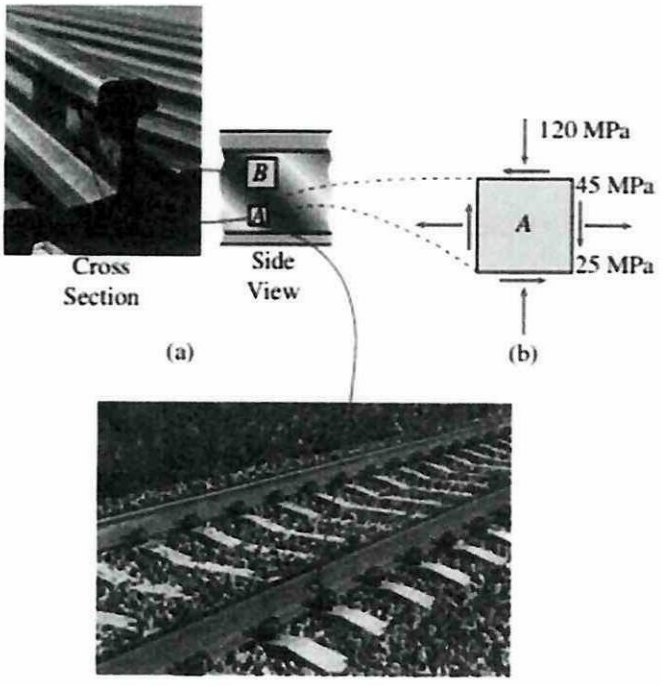

Figure Q6(a)

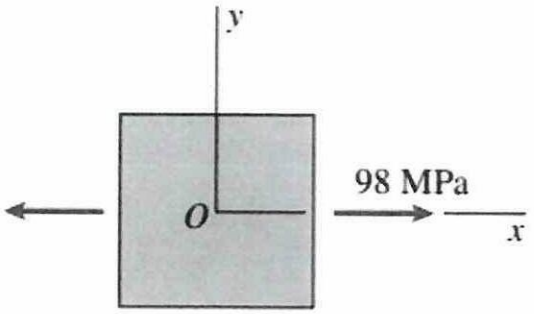

Figure Q6(b)

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EQUATIONS

$$\sigma_{ave} = \frac{P}{A} \qquad \delta = \sum_i \frac{P_i L_i}{A_i E_i}$$

$$\delta_T = \alpha(\Delta T)L \qquad n = \frac{E_2}{E_1}$$

$$\sigma_{ave} = \frac{\sigma_x + \sigma_y}{2} \qquad R = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$\sigma_{\max,\min} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$\tan 2\theta_p = \frac{2\tau_{xy}}{\sigma_x - \sigma_y}$$

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

$$\tau_{\max} = \frac{Tc}{J} \text{ and } \tau = \frac{T\rho}{J}$$

$$J = \tfrac{1}{2}\pi c^4 \qquad J = \tfrac{1}{2}\pi\left(c_2^4 - c_1^4\right)$$

$$\gamma_{\max} = \frac{\tau_{\max}}{G} = \frac{Tc}{JG} \qquad \phi = \sum_i \frac{T_i L_i}{J_i G_i}$$

$$T = \frac{P}{\omega} = \frac{P}{2\pi f} \qquad \tau_{\max} = \frac{T}{c_1 ab^2} \qquad \phi = \frac{TL}{c_2 ab^3 G}$$

$$\sigma_x = -\frac{My}{I} \qquad \frac{1}{\rho} = \frac{M}{EI}$$

$$\bar{Y} = \frac{\sum \bar{y}A}{\sum A} \qquad I_{x'} = \sum\left(\bar{I} + Ad^2\right)$$