Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2019/2020

COURSE NAME	:	SOLID MECHANICS
COURSE CODE	:	BNJ 20903
PROGRAMME CODE	:	BNM / BNL
EXAMINATION DATE	:	DECEMBER 2019 / JANUARY 2020
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FIVE (5)** QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF **SEVEN (7)** PAGES

Q1 (a) The **Figure Q1 (a)** shows the beam is subjected to a moment of 20 kN.m.

(i) Calculate the centroid and moment of inertia of cross-section of the beam. (6 marks)

(ii) Calculate the maximum tensile and compressive stress. (4 marks)

(b) The **Figure Q1 (b)** shows the compound beam is fixed at A, pin connected at B, and supported by a roller at C. The beam is rectangular cross-section 100 mm width x 200 mm length.

(i) Draw the support reaction. (2 marks)

(ii) Sketch the shear diagram. (3 marks)

(iii) Sketch the moment diagram. (3 marks)

(iv) Calculate the maximum normal stress. (2 marks)

Q2 Rod AB consists of two cylindrical portions AC and BC, each with a cross-sectional area of 1750 mm^2. Portion AC is made of a mild steel with E = 200 GPa and σ_y = 250 MPa, and portion BC is made of a high-strength steel with E = 200 GPa and σ_y = 345 MPa. A load P is applied at C as shown in **Figure Q2**. If P is gradually increased from zero until the deflection of point C reaches a maximum value δ_m = 0.3 mm and then decreased back to zero.

(a) Evaluate the maximum value of P. (8 marks)

(b) Evaluate the maximum stress in each portion of the rod. (6 marks)

(c) Calculate deflection of C after the load removed. (6 marks)

Q3 The **Figure Q3** shows the shaft is made of A992 steel (Modulus of Elasticity = 75 GPa) with the allowable shear stress, τ_{allow} = 75 MPa. If a gear B supplies 15 kW of power, while gears A, C and D withdraw 6 kW, 4 kW, and 5 kW, respectively. Determine:

(a) The angular velocity of the shaft, ω. (2 marks)

(b) The torque exerted on gears A (T_A), C(T_c) and D (T_D). (6 marks)

(c) The required minimum diameter d of the shaft in mm. (4 marks)

(d) The angle of twist. (8 marks)

Q4 (a) An element of material subjected to plane strain as shown in **Figure Q4 (a)** has strains as follows: $\epsilon_x = -150 \times 10^{-6}$, $\epsilon_y = 450 \times 10\text{-}6$ and $\gamma_{xy} = 200 \times 10^{-6}$.

(i) Identify the strains for an element oriented at angle $\theta = 50°$, $(\epsilon_{x'}, \epsilon_{y'}, \gamma_{x'y'})$
(3 marks)

(ii) Determine these strains on a sketch of properly oriented element.
(3 marks)

(b) Determine the equivalent state of stress in **Figure Q4 (b)** by using Mohr's Circle.

(i) Sketch of the Mohr's circle. Determine σ_{avg}, point A, point C and radius of the circle.
(6 marks)

(ii) Determine in-plane principle stress, σ_1, σ_2.
(2 marks)

(iii) Determine orientation of the principle plane, θ_{p1}.
(2 marks)

(iv) Determine maximum in-plane shear stress, $\tau_{max\ in\text{-}plane}$.
(2 marks)

(v) Determine of the plane of maximum in-plane shear stress, θ_s
(2 marks)

Q5 (a) The **Figure Q5 (a)** shows the steel channel is used to reinforce the wood beam.

(i) Determine the centroid, $\bar{y}$ and moment of inertia, I of the transformed section.
(4 marks)

(ii) Determine the maximum bending stress of the steel and the wood, σ_{steel}, σ_{wood}.
(4 marks)

(b) The **Figure Q5 (b)** shows the tube is made copper and has an outer diameter of 35 mm and a wall thickness of 7 mm. Determine the eccentric load P that it can support without failure using Euler's Formula and Secant Formula. The tube is pin supported at its ends. $E_{copper} = 120$ GPa, $\sigma_{max} = 750$ MPa.
(12 marks)

Q6 The **Figure Q6** shows the pipe assembly is fixed at A.

(a) Determine the internal loadings.
(4 marks)

(b) Determine the torsional strain energy, J and bending strain energy, I.
(8 marks)

(c) Determine the strain energy stored in pipe.
(2 marks)

(d) Determine the external work or external force.
(2 marks)

(e) Determine the conservation of energy and vertical displacement of end C, Δc.
(4 marks)

-END OF QUESTION-

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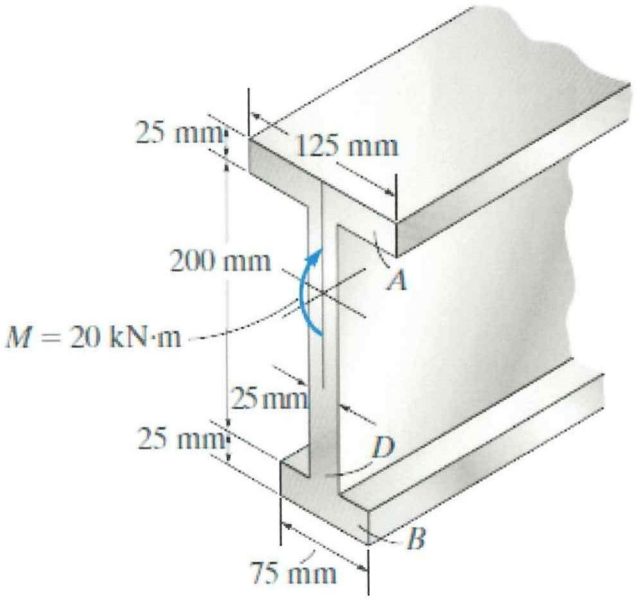

Figure Q1 (a)

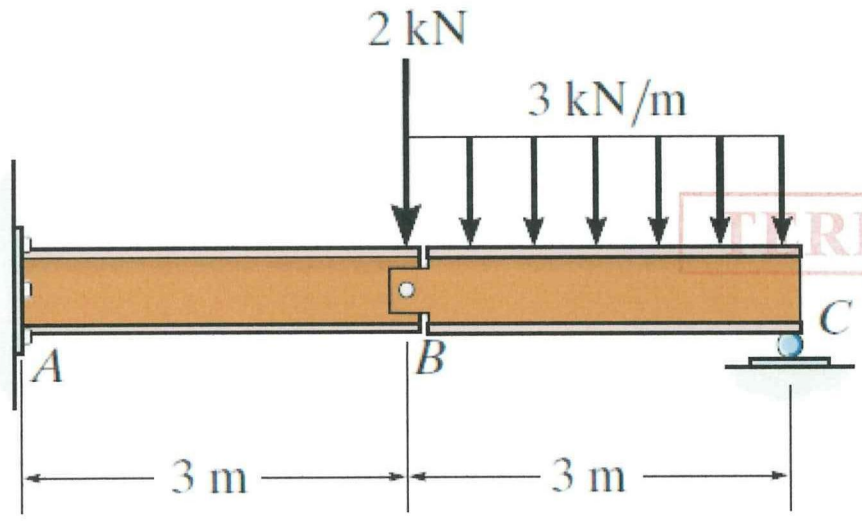

Figure Q1 (b)

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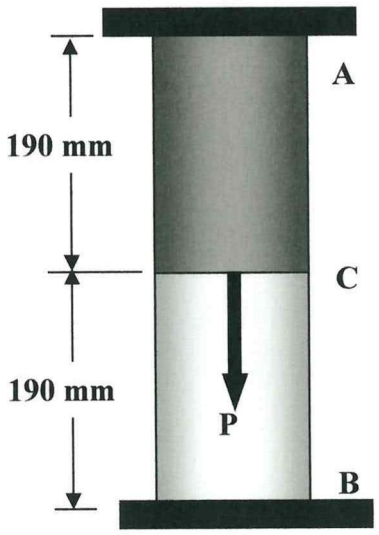

Figure Q2

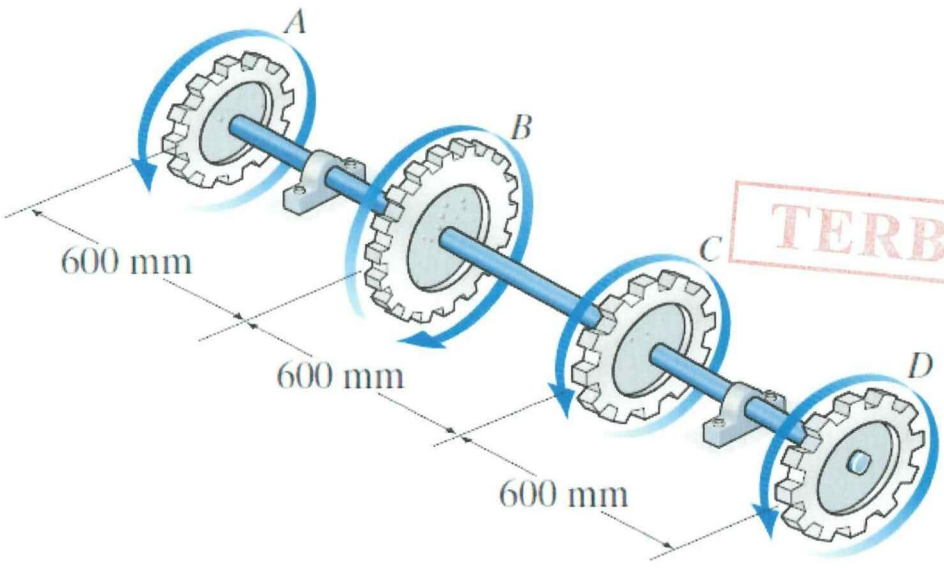

Figure Q3

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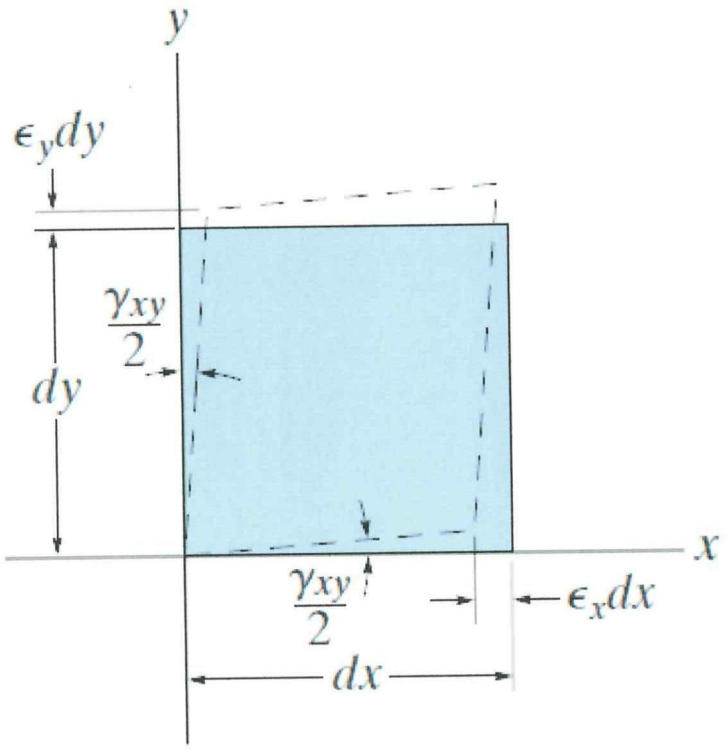

Figure Q4 (a)

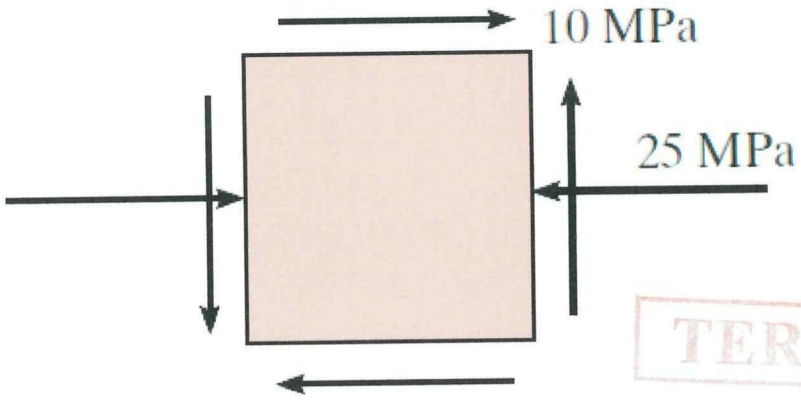

Figure Q4 (b)

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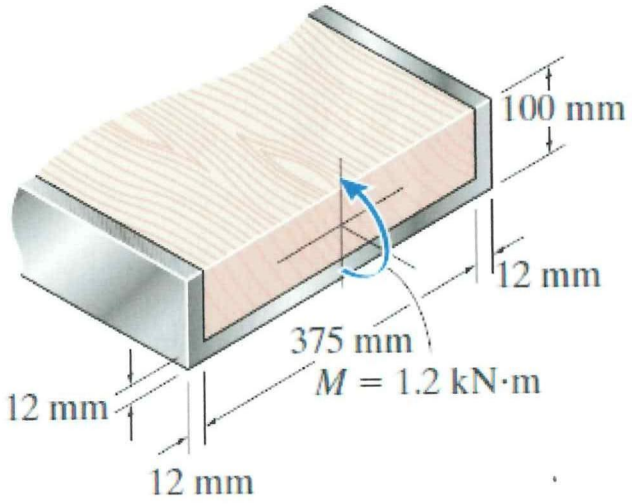

Figure Q5 (a)

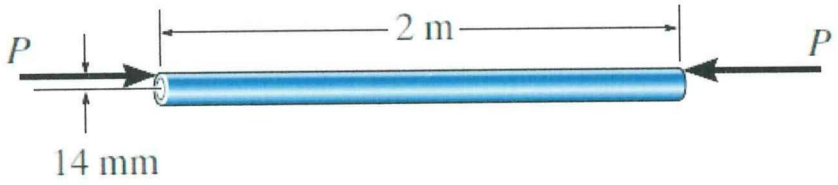

Figure Q5 (b)

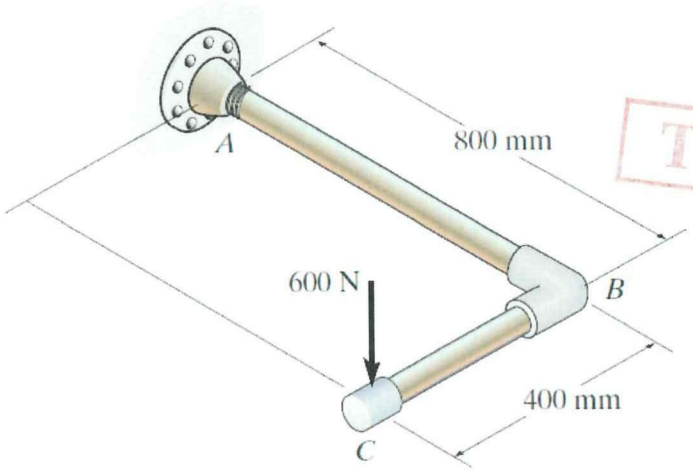

Figure Q6