UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION

SEMESTER I

SESSION 2013/2014

COURSE NAME	:	SOLID MECHANICS
COURSE CODE	:	BNJ 10403
PROGRAMME	:	2 BNL/2 BNH/2 BNK
EXAMINATION DATE	:	DECEMBER 2013/JANUARY 2014
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FIVE (5)** QUESTIONS ONLY

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

Q1 The rigid bar shown in Figure **Q1** is fixed to the top of the three post made of A-36 Steel and 2014-T6 aluminium. The post each have a length of 250 mm when no load is applied to the bar, and the temperature is $T_1 = 20^0$C. Determine the force supported by each post if the bar is subjected to a uniform distributed load of 150 kN/m and the temperature is raised to $T_2 = 80^o$ C. $\alpha_{steel} = 12 \times 10^{-6}/^0$C, $\alpha_{aluminum} = 23 \times 10^{-6}/^0$C, $E_{steel} = 200$ GPa , $E_{aluminium} = 73.1$ GPa

(20 marks)

Q2 A Solid steel shaft ABC of 50 mm diameter (Figure **Q2**) is driven at A by a motor that transmits 50 kW to the shaft at 10 Hz. The gears at B and C drive machinery requiring power equal to 35 kW and 15 kW, respectively. Compute:

(a) The maximum shear stress τ_{max} in the shaft

(10 marks)

(b) The angle of twist ϕ_{AC} between the motor A and the gear at C.
(Use G= 80 GPa)

(10 marks)

Q3 (a) A cylindrical pressure vessel is constructed from a long, narrow steel plate by wrapping the plate around a mandrel and welding along the edges of the plate to make a helical point. The helical weld makes an angle $\alpha = 55^0$ with the longitudinal axis (Figure **Q3 (a)**). The vessel has inner radius r = 1.8 m and the wall thickness t = 20 mm. The material is steel with modulus E= 200 GPa and Poisson' s ratio $\nu = 0.3$. The internal pressure p is 800 kPa.

Calculate the following quantities for the cylindrical part of the vessel:

(i) The maximum in plane and out-plane shear stress;

(5 marks)

(ii) Circumferential and longitudinal strains

(5 marks)

(b) Determine safety factors for the bracket rod shown in Figure **Q3 (b)** based on distortion and maximum shear theory. The material is 2024-T4 aluminum with a yield strength of 47 000 psi. The rod length l= 8 in and arm a= 10 in. The rod outside diameter d=1.5 in. Load F=1 000 lb.

(10 marks)

Q4 A beam is loaded shown in Figure **Q4 (a)**, *E I* constant. Apply Figure **Q4 (b)** if necessary.

(a) Determine the displacement at point 1 meter from support *A* and at *C*

(10 marks)

(b) Angle of rotation at the support *A* and *B* of the beam shown in Figure **Q4 (a)**

(10 marks)

Q5 Determine the shear and bending moment as function of x and draw the shear and moment diagram for the beam Figure **Q5.**

(20 marks)

Q6 (a) An aluminium column of length L= 30 in. Figure **Q6 (a)** and rectangular cross section has a fixed end at B and support a centric load at A. Two smooth and rounded fixed plates restrain end A from moving in one of the vertical planes of symmetry but allow it to move it in other plane. Design the dimension of a and b of the cross section . Factor Safety = 3, E = 10.1 x 10^6 psi, P = 10 kips , a= 0.35 b, Le/r_y= 138.6 /b.

(10 marks)

(b) A beam shown in Figure **Q6(b)** with P = 100 kips, L = 20 ft, a= 5 ft, b = 15 ft, $E = 29 \times 10^6$ psi, $I = 248$ in^4

(i) Develop a diagram of bending moment distribution

(2 marks)

(ii) Derive a equation for strain energy and determine the strain energy

(8 marks)

- END OF QUESTION –

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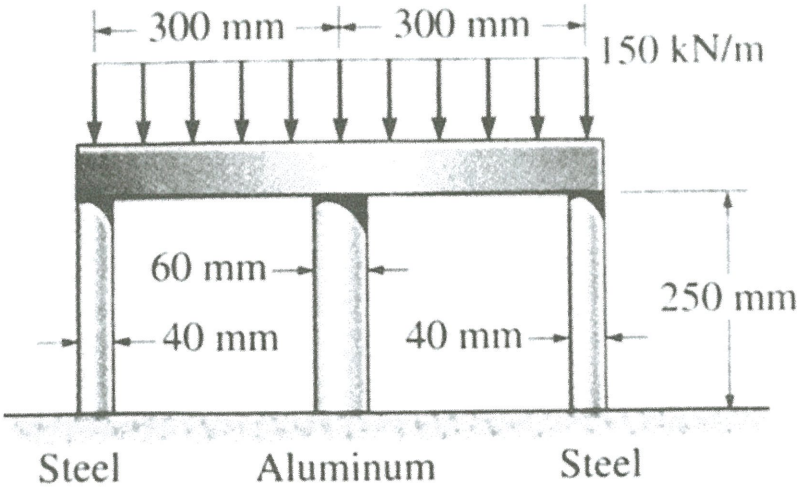

FIGURE Q1

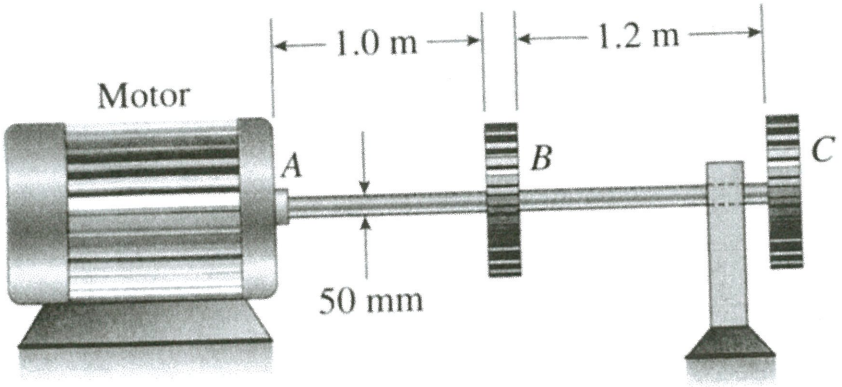

FIGURE Q2

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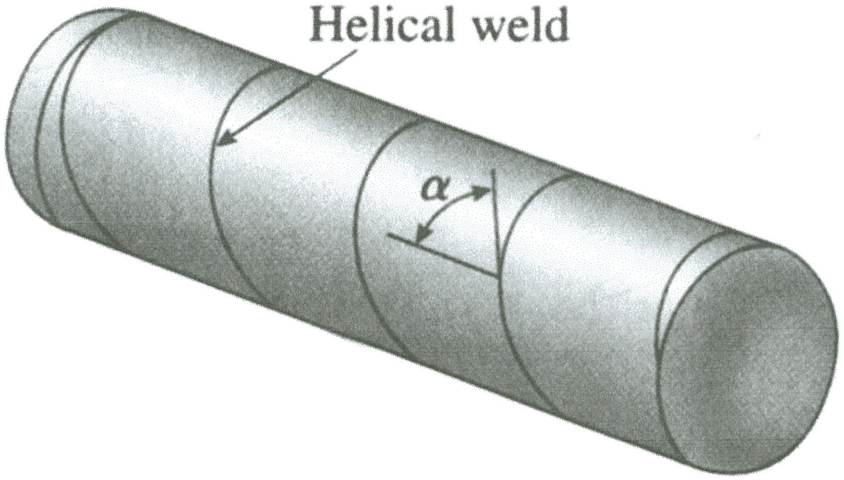

FIGURE Q3 (a)

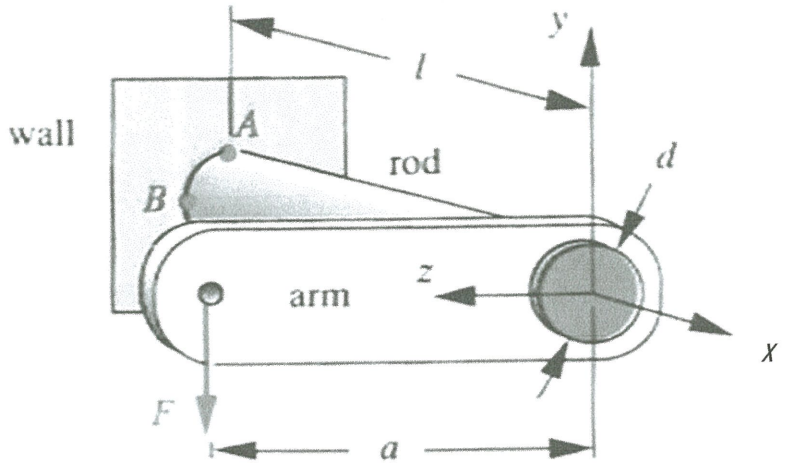

FIGURE Q3(b)

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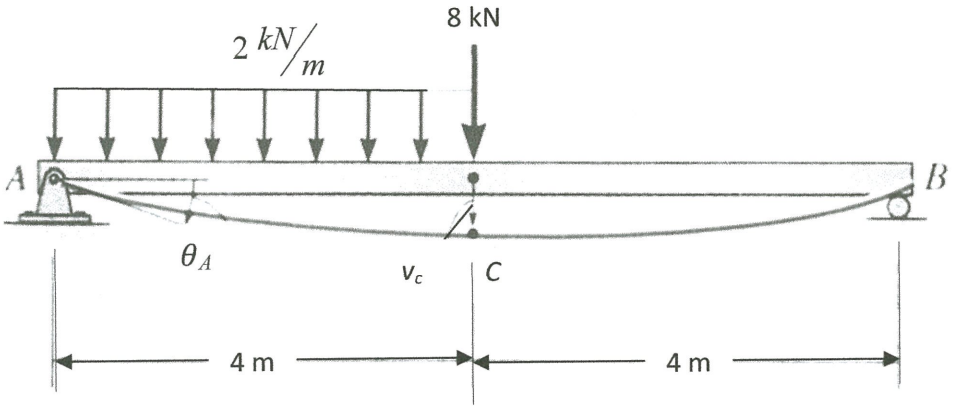

FIGURE Q4 (a)

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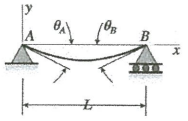
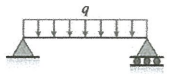


EI = constant

v = deflection in the y direction (positive upward)
$v' = dw/dx$ = slope of the deflection curve
$\delta_C = -v(L/2)$ = deflection at midpoint C of the beam (positive downward)
x_1 = distance from support A to point of maximum deflection
$\delta_{max} = -v_{max}$ = maximum deflection (positive downward)
$\theta_A = -v'(0)$ = angle of rotation at left-hand end of the beam (positive clockwise)
$\theta_B = v'(L)$ = angle of rotation at right-hand end of the beam (positive counterclockwise)

1

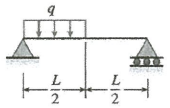


$$v = -\frac{qx}{24EI}(L^3 - 2Lx^2 + x^3)$$

$$v' = -\frac{q}{24EI}(L^3 - 6Lx^2 + 4x^3)$$

$$\delta_C = \delta_{max} = \frac{5qL^4}{384EI} \qquad \theta_A = \theta_B = \frac{qL^3}{24EI}$$

2



$$v = -\frac{qx}{384EI}(9L^3 - 24Lx^2 + 16x^3) \qquad \left(0 \le x \le \frac{L}{2}\right)$$

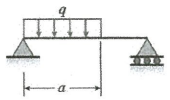
$$v' = -\frac{q}{384EI}(9L^3 - 72Lx^2 + 64x^3) \qquad \left(0 \le x \le \frac{L}{2}\right)$$

$$v = -\frac{qL}{384EI}(8x^3 - 24Lx^2 + 17L^2x - L^3) \qquad \left(\frac{L}{2} \le x \le L\right)$$

$$v' = -\frac{qL}{384EI}(24x^2 - 48Lx + 17L^2) \qquad \left(\frac{L}{2} \le x \le L\right)$$

$$\delta_C = \frac{5qL^4}{768EI} \qquad \theta_A = \frac{3qL^3}{128EI} \qquad \theta_B = \frac{7qL^3}{384EI}$$

3



$$v = -\frac{qx}{24LEI}(a^4 - 4a^3L + 4a^2L^2 + 2a^2x^2 - 4aLx^2 + Lx^3) \qquad (0 \le x \le a)$$

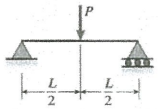
$$v' = -\frac{q}{24LEI}(a^4 - 4a^3L + 4a^2L^2 + 6a^2x^2 - 12aLx^2 + 4Lx^3) \qquad (0 \le x \le a)$$

$$v = -\frac{qa^2}{24LEI}(-a^2L + 4L^2x + a^2x - 6Lx^2 + 2x^3) \qquad (a \le x \le L)$$

$$v' = -\frac{qa^2}{24LEI}(4L^2 + a^2 - 12Lx + 6x^2) \qquad (a \le x \le L)$$

$$\theta_A = \frac{qa^2}{24LEI}(2L - a)^2 \qquad \theta_B = \frac{qa^2}{24LEI}(2L^2 - a^2)$$

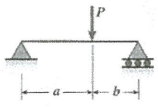
4



$$v = -\frac{Px}{48EI}(3L^2 - 4x^2) \qquad v' = -\frac{P}{16EI}(L^2 - 4x^2) \qquad \left(0 \le x \le \frac{L}{2}\right)$$

$$\delta_C = \delta_{max} = \frac{PL^3}{48EI} \qquad \theta_A = \theta_B = \frac{PL^2}{16EI}$$

5



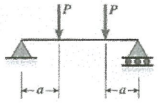
$$v = -\frac{Pbx}{6LEI}(L^2 - b^2 - x^2) \qquad v' = -\frac{Pb}{6LEI}(L^2 - b^2 - 3x^2) \qquad (0 \le x \le a)$$

$$\theta_A = \frac{Pab(L + b)}{6LEI} \qquad \theta_B = \frac{Pab(L + a)}{6LEI}$$

If $a \ge b$, $\delta_C = \dfrac{Pb(3L^2 - 4b^2)}{48EI}$ If $a \le b$, $\delta_C = \dfrac{Pa(3L^2 - 4a^2)}{48EI}$

If $a \ge b$, $x_1 = \sqrt{\dfrac{L^2 - b^2}{3}}$ and $\delta_{max} = \dfrac{Pb(L^2 - b^2)^{3/2}}{9\sqrt{3}\,LEI}$

6



$$v = -\frac{Px}{6EI}(3aL - 3a^2 - x^2) \qquad v' = -\frac{P}{2EI}(aL - a^2 - x^2) \qquad (0 \le x \le a)$$

$$v = -\frac{Pa}{6EI}(3Lx - 3x^2 - a^2) \qquad v' = -\frac{Pa}{2EI}(L - 2x) \qquad (a \le x \le L - a)$$

$$\delta_C = \delta_{max} = \frac{Pa}{24EI}(3L^2 - 4a^2) \qquad \theta_A = \theta_B = \frac{Pa(L - a)}{2EI}$$

7

$$v = -\frac{M_0x}{6LEI}(2L^2 - 3Lx + x^2) \qquad v' = -\frac{M_0}{6LEI}(2L^2 - 6Lx + 3x^2)$$

$$\delta_C = \frac{M_0L^2}{16EI} \qquad \theta_A = \frac{M_0L}{3EI} \qquad \theta_B = \frac{M_0L}{6EI}$$

$$x_1 = L\left(1 - \frac{\sqrt{3}}{3}\right) \text{ and } \delta_{max} = \frac{M_0L^2}{9\sqrt{3}\,EI}$$

FIGURE Q4 (b) BEAM DEFLECTION FORMULA

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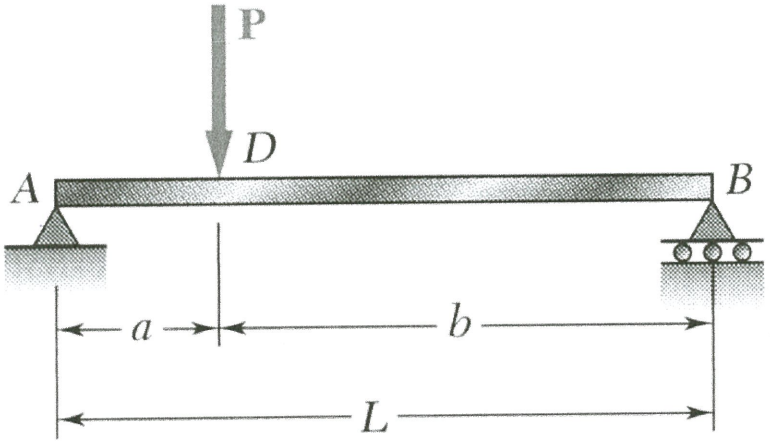

FIGURE Q6 (b)