First Semester Examination
2023/2024 Academic Session

February 2024

EMM 213 – Strength of Materials
(Kekuatan Bahan)

Duration: 3 hours
(Masa: 3 Jam)

Please check that this examination paper consists of SIX (6) pages of printed material before you begin the examination.

[Sila pastikan bahawa kertas peperiksaan ini mengandungi ENAM (6) muka surat yang bercetak sebelum anda memulakan peperiksaan ini.]

Instructions: Answer ALL **FIVE (5)** questions.

*[**Arahan**: Jawab **LIMA (5)** soalan]*

1. (a) Figure 1 (a) shows a shaft subjected to torque at three different locations A, B and C with the distance between the points. Using steel with shear modulus of G = 80 GPa and allowable shear stress of 240 MPa,

   (i) sketch the torque diagram

   (ii) determine the safe diameter for the shaft and the largest angle of twist.

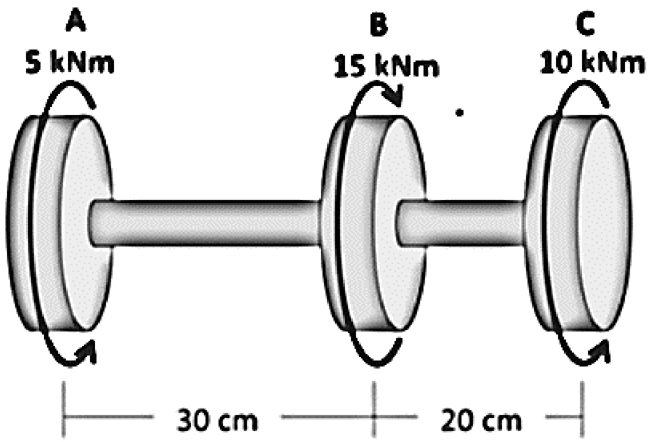


Figure 1 (a)

(50 marks)

(b) The pin-connected structure shown in Figure 1 (b) consists of a rigid bar *ABCD* and two axial members of bars (1) and (2). Bar (1) is a steel [E = 200 GPa, $\alpha = 11.7 \times 10^{-6}/°C$] with a cross-sectional area 400 mm^2. Bar (2) is an aluminum alloy [E = 70 GPa, $\alpha = 22.5 \times 10^{-6}/°C$] with a cross-sectional area 400 mm^2. The bars are unstressed when the structure is assembled. After a concentrated load of P = 36 kN is applied and the temperature is increased by 25°C, determine:

   (i) the normal stresses in bars (1) and (2).

   (ii) the deflection of point D on the rigid bar.

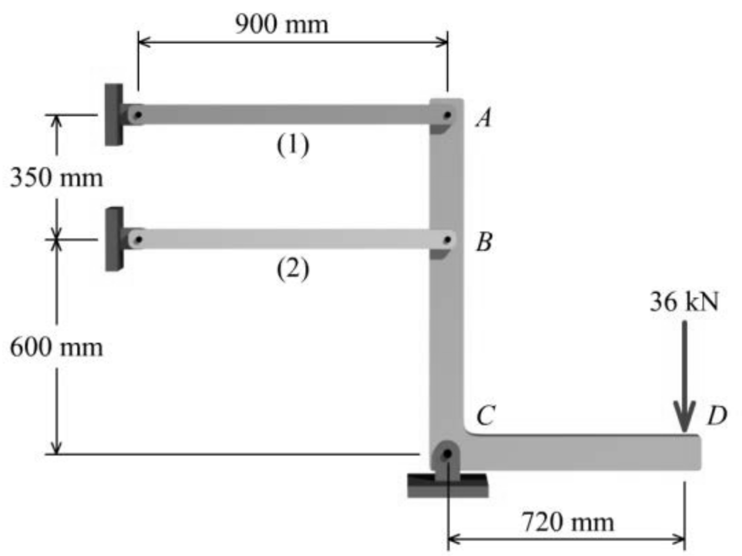


Figure 1 (b)

(50 marks)

2. Figure 2 shows a beam subjected to distributed load and a point load. Sketch the shear force and bending moment diagram for the beam. Given that the allowable stress is 200 MPa, determine the section modulus and recommend a suitable beam section from Table 1.

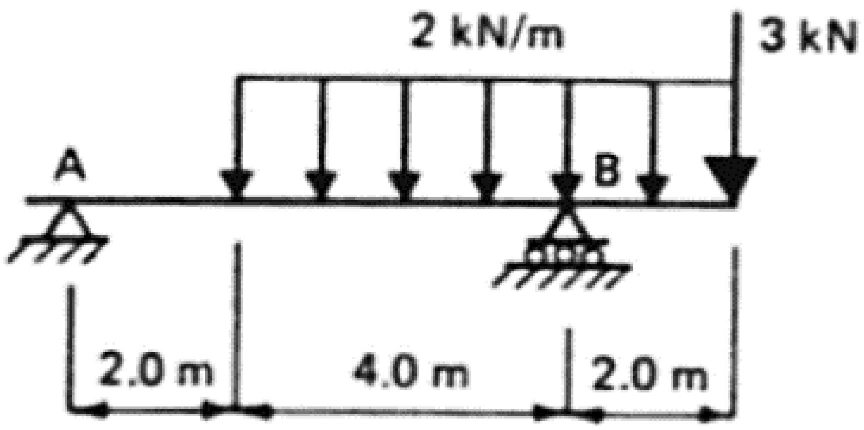


Figure 2

Table 1

American Wide Flange Beams - Static Parameters											
Designation		Dimensions						Static Parameters			
								Moment of Inertia		Elastic Section Modulus	
Imperal (in x in x lb/ft)	Metric (mm x mm x kg/m)	Depth - h - (mm)	Width - w - (mm)	Web Thickness - s - (mm)	Flange Thickness - f - (mm)	Sectional Area (cm^2)	Weight (kg/m)	I_x (cm^4)	I_y (cm^4)	S_x (cm^3)	S_y (cm^3)
W 4 x 4 x 13	W 100 x 100 x 19.3	106	103	7.1	8.8	24.7	19.3	475.9	160.6	89.9	31.2
W 5 x 5 x 16	W 130 x 130 x 23.8	127	127	6.1	9.1	30.4	23.8	885.5	311	139.5	49
W 5 x 5 x 19	W 130 x 130 x 28.1	131	128	6.9	10.9	35.9	28.1	1099	381.4	167.7	59.6
W 8 x 8 x 31	W 200 x 200 x 46.1	203	203	7.2	11.0	58.9	46.1	4545	1535	448	151.2
W 8 x 8 x 35	W 200 x 200 x 52	206	204	7.9	12.6	66.5	52	5268	1784	512	174.9
W 8 x 8 x 40	W 200 x 200 x 59	210	205	9.1	14.2	75.5	59	6113	2040	582	199.1
W 8 x 8 x 48	W 200 x 200 x 71	216	206	10.2	17.4	91	71	7658	2537	709	246.3

(100 marks)

3. Figure 3 shows a pipe with external diameter of 80 mm and internal diameter of 60 mm which is subjected to combined loading.

   (a) Determine the bending stress, axial stress and shear stress due to torque at points H and K respectively. For this problem, ignore the shear stress due to the shear force.

   (b) For each point, draw the stress element

      (i) determine the principal stresses and assess the suitability of cast iron with allowable shear stress of 50 MPa and tensile stress of 100 MPa for this pipe.

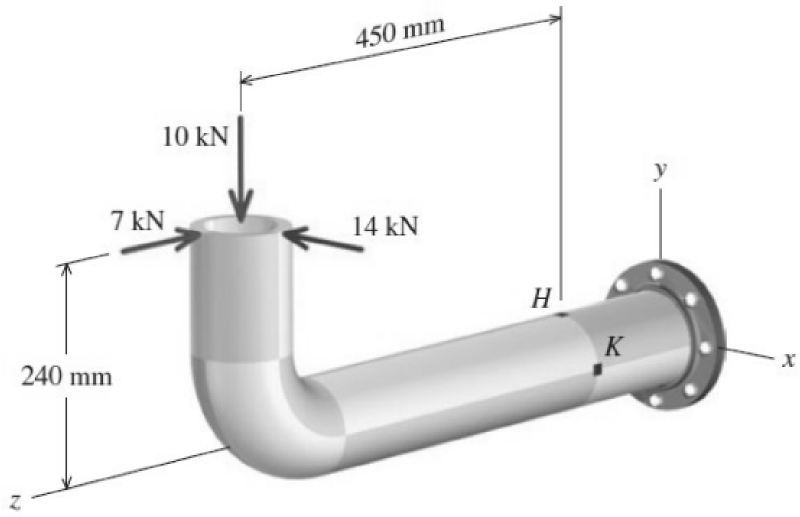


Figure 3

(100 marks)

4. A point on a structure is represented by the stress element shown in Figure 4 and another stress condition is superposed. Draw the Mohr's circle for the combined stress condition and determine the maximum shear stress and the principal stresses.

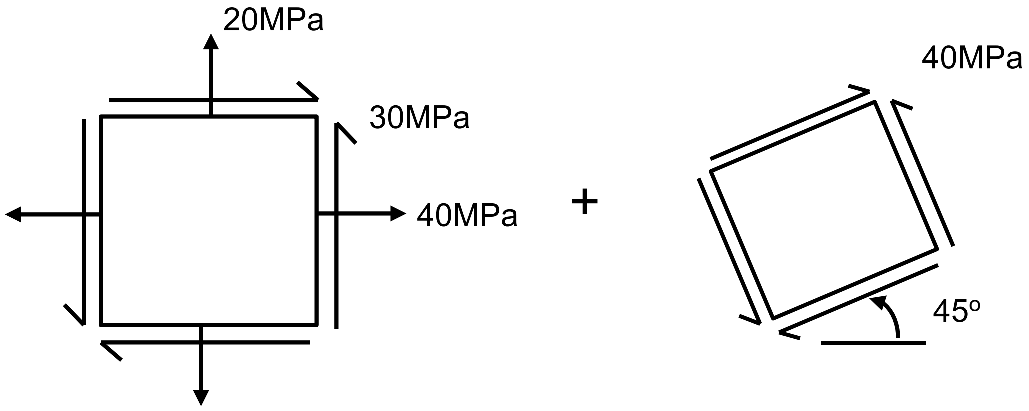


Figure 4

(100 marks)

5. A 45-degree strain rosette is installed on a surface of a steel (Poisson ratio = 0.30, E = 200 GPa) structure as shown in Figure 5. The reading obtained from each strain gauge is as follows: $\varepsilon_a = 750 \times 10^{-6}$; $\varepsilon_b = -125 \times 10^{-6}$; $\varepsilon_c = -250 \times 10^{-6}$. The general equation for the strain gauge is given in the Table 2.

   (a) Determine the strain components

   (b) Sketch the strain Mohr's circle and determine the maximum shear strain and principal strains of the point.

   (c) Determine the principal stresses

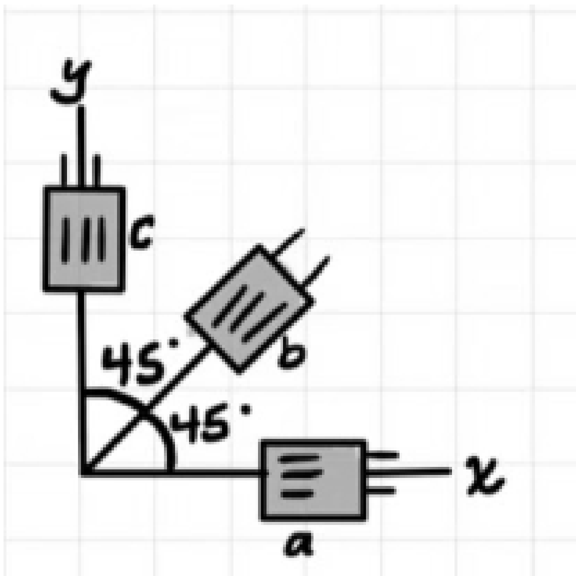
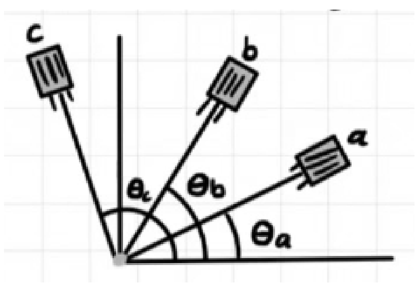


Figure 5

Table 2

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

(100 marks)

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