First Semester Examination
2022/2023 Academic Session

February 2023

EMM 213 – Strength of Materials
(Kekuatan Bahan)

Duration: 3 hours
(Masa: 3 jam)

Please check that this examination paper consists of SEVEN (7) pages of printed material before you begin the examination.

[Sila pastikan bahawa kertas peperiksaan ini mengandungi TUJUH (7) muka surat yang bercetak sebelum anda memulakan peperiksaan ini.]

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

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

...2/-

1. (a) The butt joint of Figure 1 (a) is fastened by four 15-mm diameter rivets. Determine the maximum load P if the stresses are not to exceed 100 MPa in shear, 140 MPa in tension, and 210 MPa in bearing. Assume that the load is equally divided among the rivets.

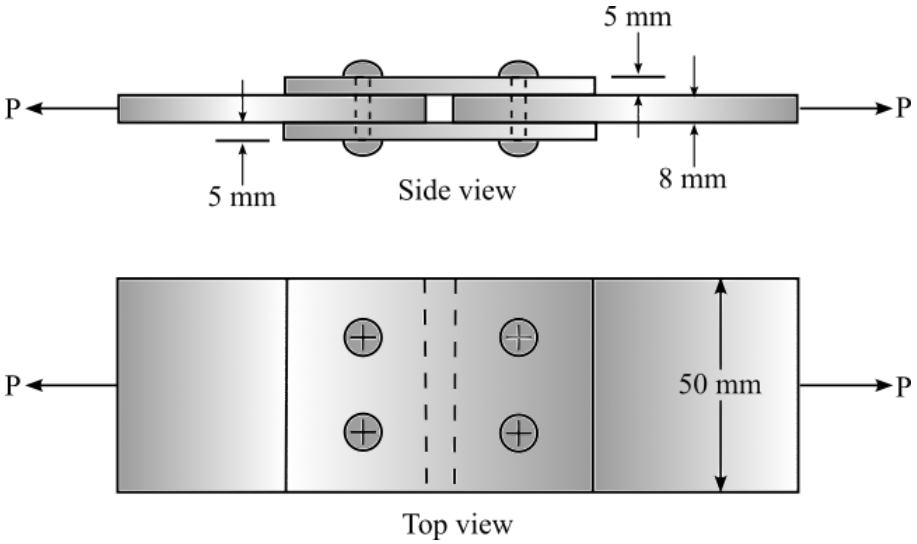

Figure 1 (a)

(40 marks)

(b) Double layered tubes are made with an inner tube and an outer tube, which need not be of the same material. Double-layered tubes are widely used for petrochemical plants, power generating facilities and machine parts as they provide greater reliability and resistance to explosion. Figure 1(b) shows the schematic drawing of the double-layered tube with AISI304 stainless steel is used for the inner tube and SS400 carbon steel is used for the outer tube. The tubes are fitted between two walls at ambient temperature 25 °C. The dimension and properties of the tube is given in Table 1(b).

(i) Determine the stresses in the tubes when the temperature of the tube is raised to 120 °C.

(ii) Determine the maximum temperature it can be raised to ensure the factor of safety 4. Given the ultimate tensile strength of the AISI304 stainless steel and SS400 carbon steel is 505 MPa and 685 MPa respectively.

...3/-

Table 1 (b)

	Inner Tube	Outer Tube
Material	AISI304 stainless steel	SS400 carbon steel
Radius (mm)	48.65	57.15
Thickness (mm)	3.00	8.50
Young's Modulus, E (GPa)	180	200
Coefficient of Thermal Expansion, α (/°C)	17. 3 x 10^{-6}	10.33 x 10^{-6}

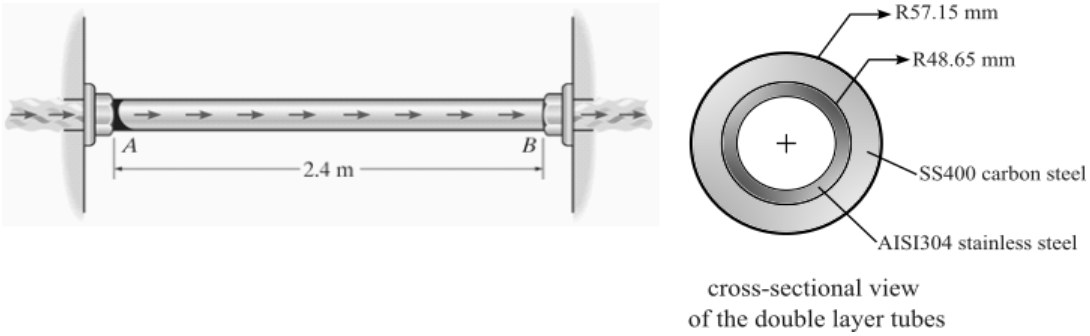

Figure 1 (b)

(60 marks)

2. (a) Two rigid bars AB and CD are supported by a pin joint at A and B, and two vertical rods, as shown in Figure 2 (a). The vertical rod EF is made of aluminum (E = 70 GPa) with the cross-sectional area of 300 mm^2. The vertical rod BD is made of steel (E = 200 GPa) with the cross-sectional area of 500 mm^2. All connections used in this structure are pin joints. Determine the maximum force P that can be applied to the structure if the vertical displacement at point D is limited to 10 mm. Neglect the weights of the members.

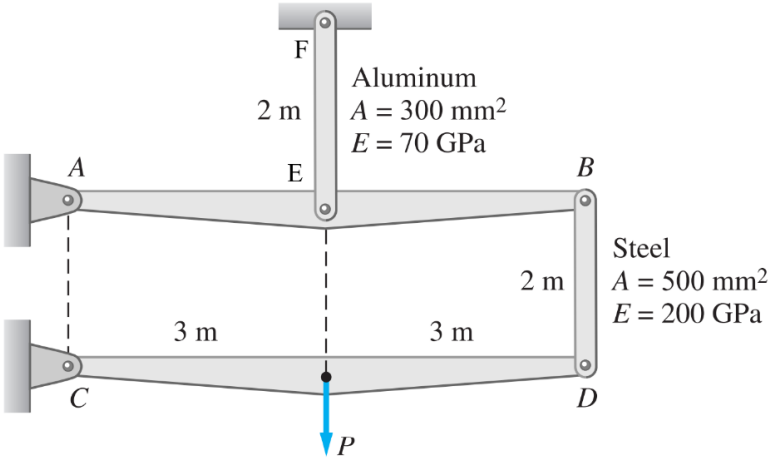

Figure 2 (a)

(50 marks)

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(b) Two solid 30-mm-diameter steel shafts are connected by the gears shown in Figure 2 (b). The shaft lengths are L_1 = 500 mm and L_2 = 300 mm. Assume that the shear modulus of both shafts is G = 80 GPa and that the bearings shown allow free rotation of the shafts. If the torque applied at gear D is T_D = 160 Nm, determine:

(i) the internal torques T_1 and T_2 in the two shafts.
(ii) the angles of twist ϕ_1 and ϕ_2.
(iii) the rotation angles ϕ_B and ϕ_C of gears B and C.
(iv) the rotation angle of gear D.

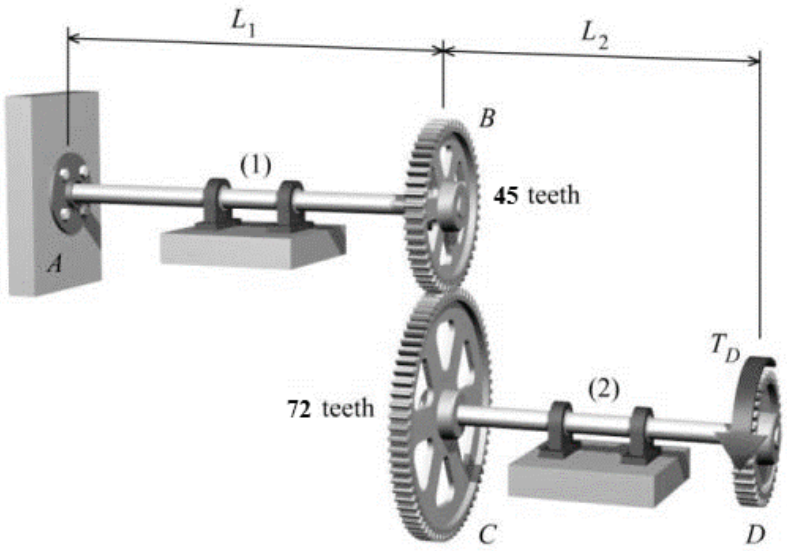

Figure 2 (b)

(50 marks)

3. A simply supported beam is used to support the loads shown on the beam in Figure 3 (a). The cross-sectional dimensions of the beam are shown in Figure 3 (b).

a) Draw the shear-force and bending-moment diagrams for the beam and determine the maximum shear force and bending moment that occur in the beam.

b) At the section of maximum shear force, determine the shear stress in the cross section at point H, which is located 100 mm above the bottom surface of the tee shape.

c) Determine the maximum bending stress produced in the cross section. State whether the stress in tension or compression.

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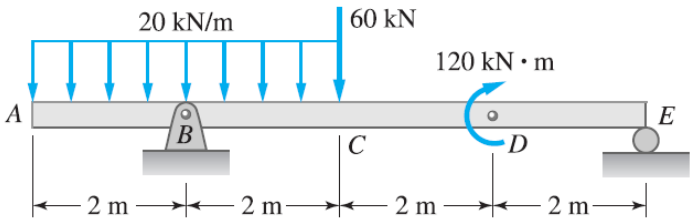
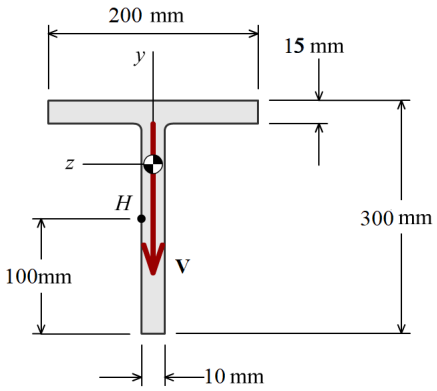


(a)



(b)

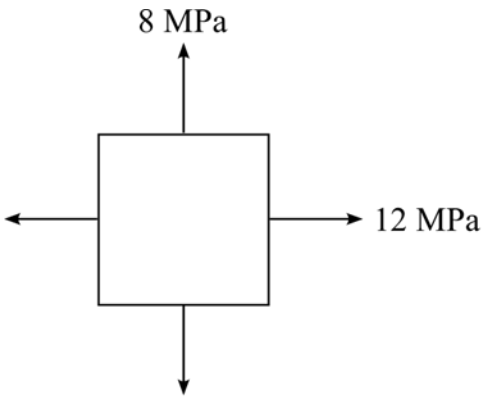
Figure 3

(100 marks)

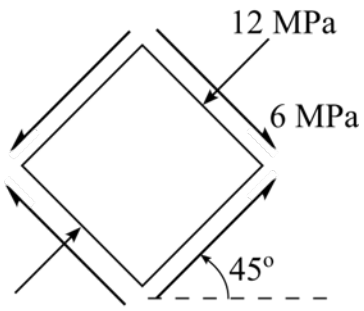
4. (a) Figure 4 shows two stress elements of (a) and (b).

(i) Sketch the Mohr's circle for each element and evaluate the principal stresses and the principal angle.

(ii) Sketch the resultant element when the two stress states of (a) and (b) are combined and evaluate the principal stresses for this combined stress.



(a)



(b)

Figure 4

(40 marks)

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(b) A steel shaft, shown in Figure 4 (b), is subjected to a torque of 20 Nm and bending moment of 10 Nm and also axial load of 2.5 kN. If the allowable stress is 250 MPa in the normal direction and 120 MPa in the shear direction

(i) Sketch the stress element combining all the loadings above and the associated stress values.

(ii) Sketch the Mohr's circle for the element and clearly mark the lines of 250 MPa normal stress and 120 MPa.

(iii) Evaluate the minimum diameter that can sustain the above loadings. Limit your iteration to only three.

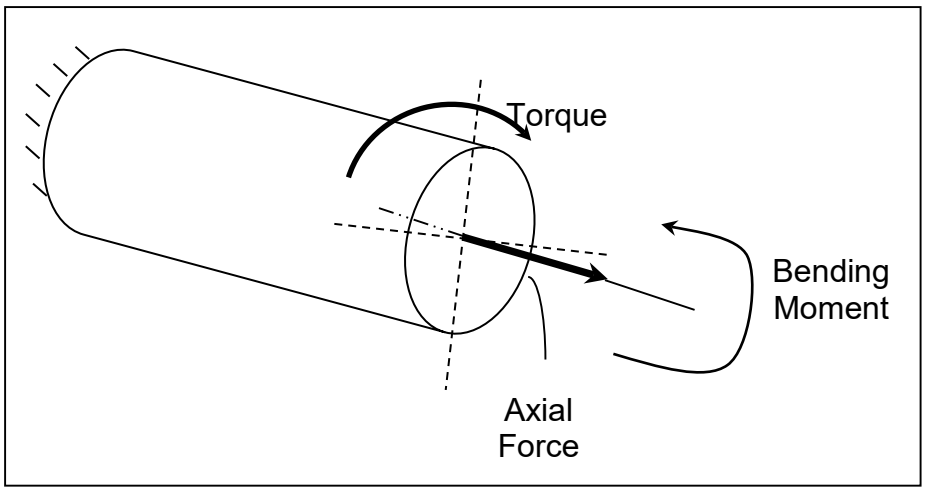

Figure 4 (b)

(60 marks)

5. (a) Define plane stress and plane strain with help of sketches and give **ONE (1)** example of each in the engineering application.

(10 marks)

(b) Explain with the help of sketch the basic components of strain measurement system in the case of quarter-bridge strain circuit.

(20 marks)

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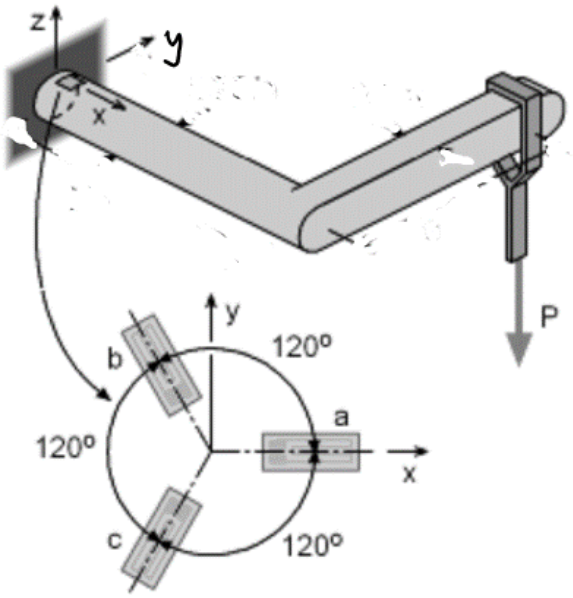
(c) Figure 5 below shows a 60-degree strain rosette attached to a machine component. The following reading is recorded in the measurement and the associated formulae for the calculation of strain component is also listed below. Calculate the principal strain and the maximum shear strain. Using stress-strain transformation, determine the principal stress given the Young's modulus, E = 200 GPa and the Poisson ratio is 0.3.

The listed strain readings are,

$$\varepsilon_a = 224.8\mu$$
$$\varepsilon_b = 118.3\mu$$
$$\varepsilon_c = 132.9\mu$$

and the equation for the basic strain rotation equation is,

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



Strain Gage Rosette on Bracket

Figure 5

(70 marks)

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