Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2022/2023

COURSE NAME	:	AIRCRAFT STRUCTURE
COURSE CODE	:	BDU 20103
PROGRAMME CODE	:	BDC
EXAMINATION DATE	:	JULY/AUGUST 2023
DURATION	:	3 HOURS
INSTRUCTION	:	1. ANSWER ONLY **FIVE (5)** QUESTIONS FROM **SIX (6)** QUESTIONS PROVIDED. 2. THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK.** 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK.

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

Q1 (a) Define plane strain and plane stress.

(4 marks)

(b) The 60° strain rosette bracket is mounted on the aircraft Boeing-787 Dreamliner wing as shown in **Figure Q1(a)**. The bracket is made of steel with the Modulus of Elasticity, $Est = 200$ GPa and the Poisson's ratio, $\nu = 0.3$. Due to the loadings during flight test, the readings from the gauges give $\varepsilon_a = 85(10^{-6})$, $\varepsilon_b = 150(10^{-6})$ and $\varepsilon_c = 283(10^{-6})$. Determine:

(i) The in-plane principal strains and the directions in which they act. Sketch the deformed element for principal strains.

(10 marks)

(ii) The maximum and minimum in-plane shear strains.

(2 marks)

(iii) The principal stresses at that point.

(4 marks)

Q2 (a) Define the elastic curve.

(2 marks)

(b) Sketch the boundary condition for roller, pin, and fixed end supports.

(3 marks)

(c) A wing spar of Beechcraft King 260 is subjected to a triangular distributed loading as shown in **Figure Q2(c)**. W_o and L are given as 15 kN/m and 10 m, respectively and EI is constant. Determine:

(i) Reactions at support A and B. Sketch the Free Body Diagram of the spar.

(5 marks)

(ii) The equations of the elastic curve for $0 < x < L/2$ (in terms of EI).

(8 marks)

(iii) The maximum displacement of the spar (in terms of EI).

(2 marks)

Q3 (a) Define column and explain buckling of a column.

(2 marks)

(b) Explain the assumption made in Secant formula for buckling, which is derived from the Euler buckling equation.

(4 marks)

(c) Truss members are assumed to be pin connected as shown in **Figure Q3(c)**. If the rod member AB is 40 mm diameter and is made of a A-36 steel with Modulus of Elasticity, $E = 200$ GPa and Yield Strength, $\sigma_Y = 250$ MPa, determine:

(i) Internal axial forces F_{AB}, F_{AC} and F_{AE}. by sketching the Free Body Diagram at point A.

(4 marks)

(ii) The maximum force P that can be supported by the truss without causing the member to buckle. Check the validity of Euler's formula.

(14 marks)

Q4 (a) Define strain energy and provide **one (1)** example of a storage device that use the concept of strain energy.

(4 marks)

(b) Explain the principle used in Castigliano's Theorem which is related to the strain energy.

(2 marks)

(c) **Figure Q4(c)** shows rod assembly ABCD subjected to tension-compression axial loadings. The material for portion AB is steel, BC is brass, and CD is aluminum. Modulus of Elasticity, E for each steel, brass, and aluiminum are; $E_{st} = 200$ GPa, $E_{br} = 101$ GPa, and $E_{al} = 73.1$ GPa, respectively. Sketch the Free Body Diagram for each portion and determine the strain energy in the rod assembly.

(7 marks)

(d) The A-36 steel shaft as shown in **Figure Q4(d)** has a radius of 30 mm and Modulus of Rigidity, $G = 75$ GPa is subjected to torsional loadings. Sketch the Free Body Diagram for each portion and determine the torsional strain energy in the shaft.

(7 marks)

Q5 (a) Describe **three (3)** characteristics of a thick cylinder.

(3 marks)

(b) Explain **two (2)** assumptions made in Lame's Theory.

(2 marks)

(c) A compound tube used in Cessna Skyhawk landing gear is formed by shrinking a tube of 250 mm internal diameter and 25 mm wall thickness onto another tube of 250 mm external diameter and 25 mm wall thickness. The cross section of the tube is shown in **Figure Q5(c)**. Both tubes are made of high-strength-low-alloy (HSLA) material. The stress set up at the junction owing to shrinkage is 10 MPa. The compound tube is then subjected to an internal pressure of 80 MPa. Determine the final stress setup across the section.

(15 marks)

Q6 (a) List **two (2)** examples of elastic failure theories.

(2 marks)

(b) Explain about the following failure modes:

(i) Fracture

(ii) Buckling

(iii) Yielding

(6 marks)

(c) The state of plane stress shown occurs at a critical point of Cessna 172 landing gear is shown in **Figure Q6(c)** where $\sigma_x = 85$ MPa, $\sigma_y = -45$ MPa, and $\tau_{xy} = 25$ MPa. As a result of several tensile tests, it has been found that the tensile yield strength is $\sigma_Y = 250$ MPa for the grade of steel used. Determine:

(i) Principle stresses and maximum shear stress.

(4 marks)

(ii) The factor of safety with respect to yield, using the maximum shearing stress theory and the maximum distortion energy theory.

(8 marks)

- END OF QUESTIONS -

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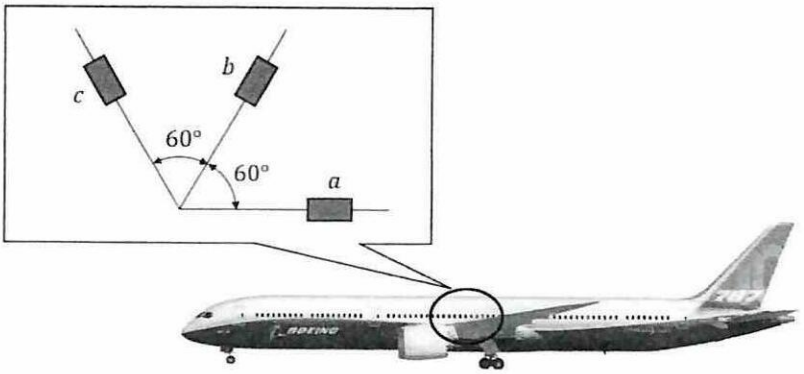

Figure Q1(a)

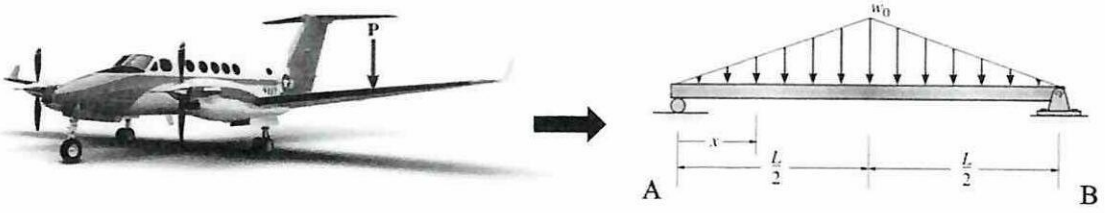

Figure Q2(c)

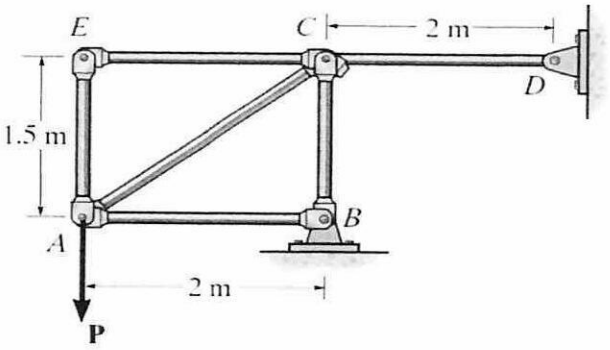

Figure Q3(c)

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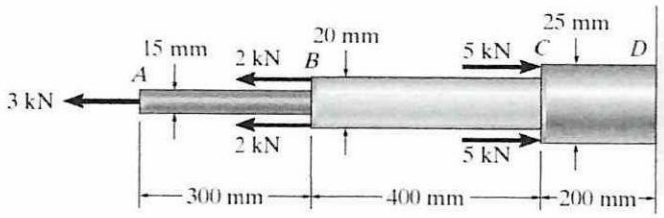

Figure Q4(c)

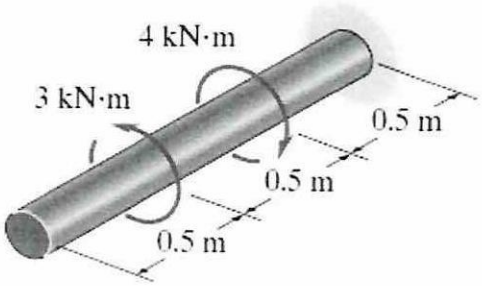

Figure Q4(d)

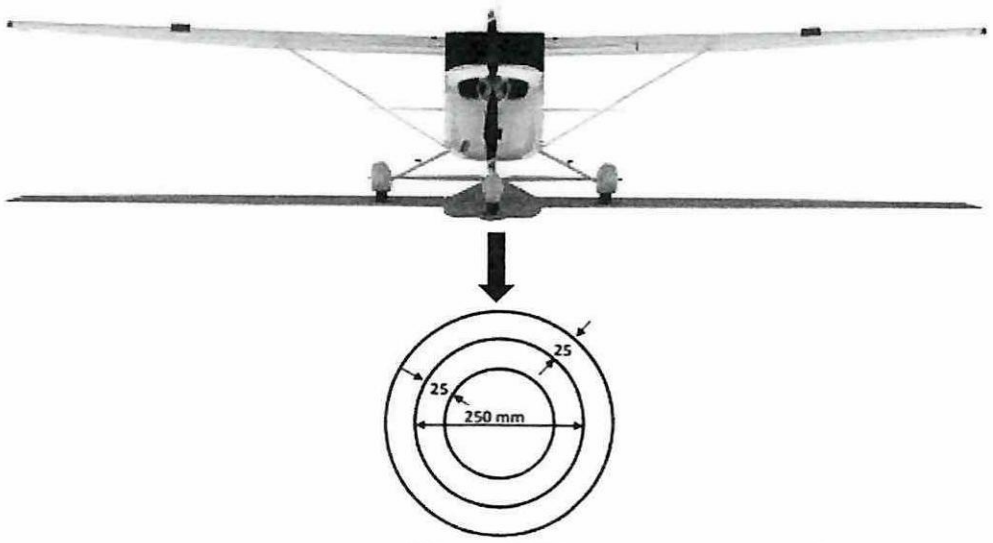

Figure Q5(c)

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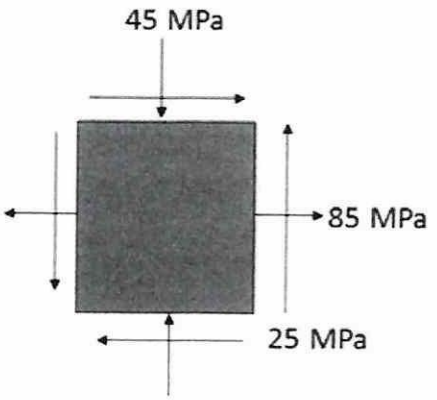

Figure Q6(c)