Reg. No. :

Question Paper Code : 20072

B.E./B.Tech. DEGREE EXAMINATIONS, APRIL/MAY 2022.

Fourth Semester

Aeronautical Engineering

AE 8403 – AIRCRAFT STRUCTURES – I

(Regulations 2017)

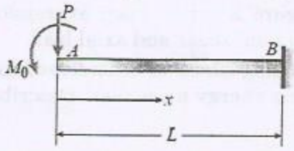
Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

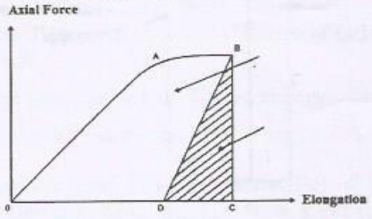
1. A beam of length L is pinned at its left end ($x = 0$) and supported by 2 rollers at $x = L/2$ and $x = L$. If the given beam is subject to a uniformly distributed load throughout its length, how would the bending moment diagram look like?

2. List 4 assumptions used in plane truss analysis.

3. 

Explain the superposition principle with reference to the beam given above.

4. A uniform bar is being subject to tension. Identify the region of elastic strain energy in the diagram given below.



5. Explain the effect of eccentricity on column behaviour.

6. Which of the statement(s) given below is incorrect?
   (a) Long columns in compression fail by fracture.
   (b) Columns in compression always fail by crippling.

7. Which parts of an aircraft are subject to thermal loads?

8. $\sigma \geq \tau_y$

Summarize the failure theory based on the expression given above.

9. Why does material creep occur?

10. Give an example of stress relaxation

PART B — (5 × 13 = 65 marks)

11. (a) A planar truss is given in Figure 1. Find the axial force in members CB and CE. Identify the four zero-force members. (13)

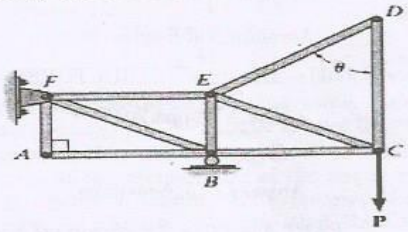


Figure 1

Or

(b) Derive necessary equations and explain the analysis procedure of continuous beams using Clapeyron's 3-moment equation. (13)

12. (a) (i) For the structure shown in Figure 2, write down expressions for strain energy due to bending, torsion, shear and axial load.

(ii) If the strain energy due to bending alone is considered, find the vertical deflection at end A using energy principles. Describe your procedure. (13)

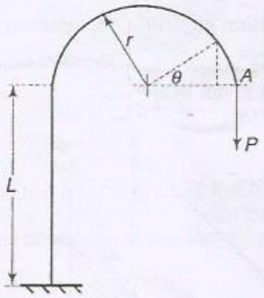


Figure 2

Or

(b) The tip deflection and tip rotation of a cantilever beam subject to a single vertical force F, applied at $x = L/2$, are to be calculated. Determine these quantities using energy theorems and principles. (13)

13. (a) (i) Differentiate between ideal column behavior and practical column behavior. What is an Euler column? (5)

(ii) Derive and obtain the buckling load of a hinged-hinged column of length L and flexural rigidity EI where the column mid-point is prevented from undergoing any lateral displacement. Sketch the buckled mode shape of this column. (8)

Or

(b) Derive and obtain an expression for the bent configuration of a beam-column of length L and flexural rigidity EI, when the beam-column is subject to axial compression P and a uniformly distributed transverse load q_o. State the assumptions used. Next, obtain an expression for the maximum stress in the given beam-column. (13)

14. (a) A force $F = 45{,}000$ N is necessary to rotate the shaft shown in Figure 3 at uniform speed. The crank shaft is made of ductile steel whose elastic limit is 207,000 kPa both in tension and compression. With $E = 207 \times 10^6$ kPa and Poisson ratio $\nu = 0.25$, determine the diameter of the shaft using (i) the octahedral shear stress failure theory and (ii) the maximum shear stress failure theory. Use a factor of safety $n = 2$. Consider a point on the periphery at section A for analysis. (13)

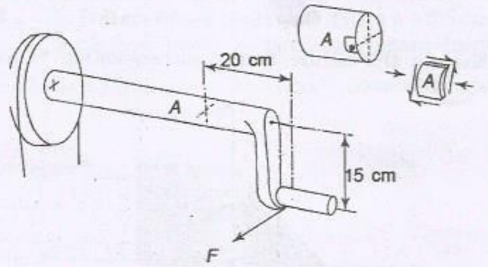


Figure 3

Or

(b) Determine the diameter d of a circular shaft subject to a bending moment M and a torque T, according to the theories of failure listed below. Use a factor of safety N. (13)

- maximum principal strain failure theory
- octahedral shear stress failure theory

15. (a) A round, prismatic steel bar (E = 210 GPa) of length L = 2.0 m and diameter d = 15mm hangs vertically from a support at its upper end as shown in Figure 4. A sliding collar of mass M = 20 kg drops from a height h = 150 mm onto the flange at the lower end of the bar without rebounding. (i) Calculate the maximum elongation of the bar due to the impact and determine the corresponding impact factor. (ii) Calculate the maximum tensile stress in the bar. (13)

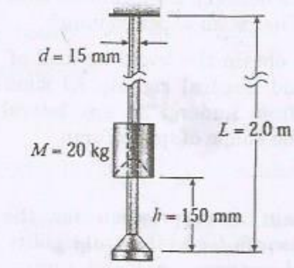


Figure 4

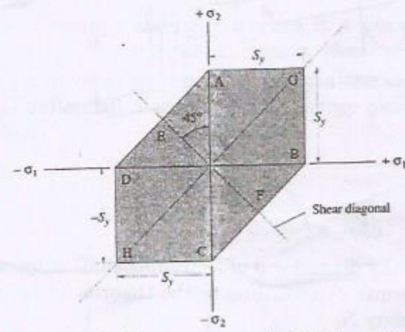
Or

(b) (i) Differentiate between fatigue and fracture. Explain the Palmgren-Miner rule for fatigue life prediction. (7)

(ii) A prismatic bar AB of length L is held between immovable supports. If the temperature of the bar is raised uniformly by an amount delta T, obtain an expression for the thermal stress developed in the bar. (Assume that the bar is made of linearly elastic material) (6)

PART C — (1 × 15 = 15 marks)

16\. (a) (i) Explain the failure theory corresponding to the failure envelope shown below. (6)



(ii) A shaft is loaded by a torque of 5 KN-m. The material has a yield point of 350 MPa. Find the required shaft diameter using the maximum shear stress failure theory with a factor of safety of 2.5. (9)

Or

(b) A fixed-fixed beam of length L and flexural rigidity EI is subject to a uniformly distributed load q_o N/m throughout its length. Determine the support reactions using energy principles. Draw the shear force and bending moment diagrams.