

**B.E. DEGREE EXAMINATIONS: NOV/DEC 2010**

Fourth Semester

**ARONAUTICAL ENGINEERING**

U07AR403: Aircraft Structures – I

**Time: Three Hours**

**Maximum Marks: 100**

**Answer ALL Questions:-**

**PART A (10 x 1 = 10 Marks)**

1. The relationship between the number of joints ( $j$ ) and the number of members ( $m$ ) for a two-dimensional perfect truss is given by  
a)  $m=3j-2$       b)  $m=2j-3$       c)  $j=2m-3$       d)  $m=3j-6$
2. A prismatic bar is a bar of  
a) uniform Young's modulus throughout the length  
b) uniform cross-sectional area throughout the length  
c) uniform area moment of inertia throughout the length  
d) uniform width throughout the length
3. Which one of the following beam is statically indeterminate  
a) cantilever beam      b) overhanging beam  
c) simply supported beam      d) propped cantilever beam
4. Hardy Cross method is the other name of  
a) three moment method      b) conjugate beam method  
c) moment distribution method      d) moment area method
5. A bar of cross-sectional area  $A$ , Young's modulus  $E$ , and length  $L$  is fixed at one end and subjected to an axial compressive load  $P$  at the other end. If  $\sigma$  is the stress produced and  $\varepsilon$  is the strain developed, then the strain energy density of the bar is given by  
a)  $\frac{\sigma^2}{2E}$       b)  $\frac{\sigma\varepsilon}{3}$       c)  $\frac{\varepsilon^2}{2E}$       d)  $\frac{\sigma^2\varepsilon}{3E}$
6. The second theorem of Castigliano is given by  
a)  $P = \frac{\partial U}{\partial \Delta}$       b)  $U = \frac{\partial P}{\partial \Delta}$       c)  $\Delta = \frac{\partial U}{\partial P}$       d)  $P = \frac{\partial \Delta}{\partial U}$
7. Buckling is defined as  
a) Large lateral deflection due to axial compressive load  
b) Large bending deflection due to axial tensile load

- c) Large axial stretching due to axial tensile load  
d) Large bending deflection due to torsional load
8. The cross-section of a column is rectangular with dimensions 100 mm×200 mm. Which of the following value of the second moment of area (in mm<sup>4</sup>) must be used for the buckling load calculation?  
a)  $100 \times 200^3 / 12$       b)  $200 \times 100^3 / 12$       c)  $100 \times 200$       d)  $100 \times 200 \times 50$
9. Which of the following theory is widely regarded as the most reliable basis for design, when dealing with ductile materials?  
a) Maximum principal stress theory      b) Maximum shear stress theory  
c) Strain energy theory      d) Distortion energy theory
10. Materials that undergo large strains before failure are classified as  
a) brittle      b) ductile      c) rigid      d) composites

**PART B (10 × 2 = 20 Marks)**

11. Differentiate between a truss and a frame.
12. Define 'degree of indeterminacy'.
13. Define 'carry-over factor' used in the moment distribution method.
14. Write the expressions for fixed-end-moments for a fixed-fixed beam of length  $L$  carrying a concentrated load  $P$  applied at a distance ' $a$ ' ( $a < L$ ) from the left end.
15. Briefly explain the Castigliano's Second theorem as applied to the solution of indeterminate structures.
16. Write the expressions for strain energy in axial loading, bending and torsion.
17. What are the limitations of using Euler's theory for design of columns?
18. State the significance of the Southwell plot.
19. List at least six types of failures in structural components.
20. Sketch the failure envelope for maximum principal stress theory for two dimensional stress systems.

**PART C (5 × 14 = 70 Marks)**

- 21.a) A two dimensional truss of 12 m span is loaded as shown in Figure.1. Find the forces in the members of the truss by the method of sections only.

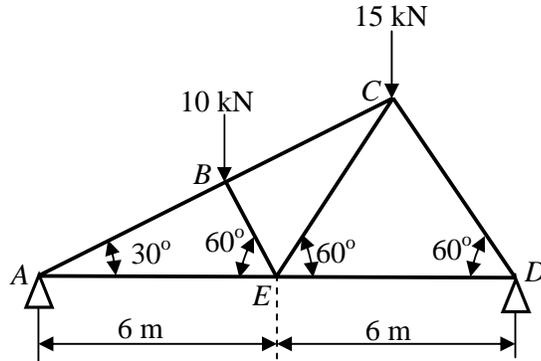


Figure.1.

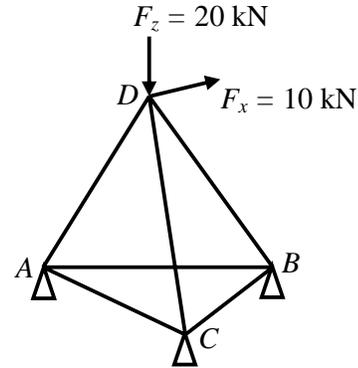


Figure.2.

(OR)

- b) A space truss shown in Figure.2 is subjected to a load  $F_x = 10$  kN along positive  $x$ -direction and a load  $F_z = 20$  kN along negative  $z$ -direction acting simultaneously at joint  $D$ . The co-ordinates of the joints  $A, B, C$  and  $D$  are  $(0,6,0)$  m,  $(5,-6,0)$  m,  $(-6,-6,0)$  m,  $(0,0,10)$  m. Find the forces in all the members of the space truss. All the joints are ball and socket joints and frictionless. Take  $E = 200$  GPa and cross-sectional areas of all members as  $30$  mm<sup>2</sup>.
- 22.a) A three-span continuous beam  $ABCD$  is simply supported at all supports  $A, B, C$  and  $D$ .  $AB = 4$  m,  $BC = 4$  m,  $CD = 4$  m. A uniformly distributed load of  $2$  kN/m acts over the full span of  $AB$ . A concentrated load  $4$  kN acts at the mid-span of  $BC$ . Another concentrated load  $5$  kN acts at a distance  $1$  m to the left of support  $D$ . Moment of inertia of span  $AB = I$  mm<sup>4</sup>, Moment of inertia of span  $BC = 1.5I$  mm<sup>4</sup>, Moment of inertia of span  $CD = I$  mm<sup>4</sup>. Draw the bending moment diagram and find the support reactions for this continuous beam. Use Clayperon's three moment equation or moment distribution method.
- (OR)
- b) A two-span continuous beam  $ABC$  is fixed at the ends  $A$  and  $C$  and simply supported at  $B$ .  $AB = 6$  m and  $BC = 4$  m. A clock-wise moment of  $180$  kN-m is applied at a point a distance  $4$  m from the left end  $A$  and a uniformly distributed load of  $30$  kN/m acts for the full span  $BC$ . Find the support reactions and the support moments using moment distribution method only. Also draw the shear force and bending moment diagrams.

- 23.a) The cross-sectional area of each member of the truss shown in Figure.3 is  $A = 400 \text{ mm}^2$  and  $E = 200 \text{ GPa}$ . Determine the vertical displacement of joint  $C$  if a  $4 \text{ kN}$  force is applied to the truss at  $C$ . Use unit load method or Castigliano's theorem.

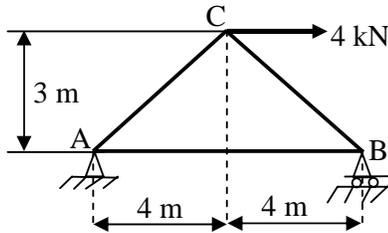


Figure 3.

(OR)

- b) A simply supported beam of length  $8 \text{ m}$  is subjected to a UDL of  $8 \text{ kN/m}$  for  $4 \text{ m}$  starting from the left support and a concentrated load of  $20 \text{ kN}$  at a distance  $4 \text{ m}$  from the left support. Determine the vertical displacement at a point  $4 \text{ m}$  from the left support. Take  $E = 200 \text{ GPa}$  and  $I = 150 \times 10^6 \text{ mm}^4$ . Use unit load method or Castigliano's theorem.

- 24.a) Compare the crippling loads given by Rankine's and Euler's formulae for a tubular strut  $3 \text{ m}$  long having outer and inner diameters of  $40 \text{ mm}$  and  $35 \text{ mm}$  loaded through pin-joint at both ends. Take compressive yield stress of the material as  $320 \text{ MPa}$  and the Rankine's constant ' $a$ ' =  $1/7500$  and  $E = 200 \text{ GPa}$ . If the elastic limit of the material is taken as  $200 \text{ MPa}$ , then for what length of the strut does the Euler's formula cease to apply?

(OR)

- b) Derive the governing equations for buckling of a column with initial curvature and explain how you will obtain the Southwell plot.

- 25.a) A shaft  $AB$  of  $38 \text{ mm}$  diameter is made of grade steel for which the yield strength is  $250 \text{ MPa}$ . End  $A$  of the shaft is fixed and at the other end  $B$ , an axial tensile load  $P$  and a torque  $T$  act simultaneously. Determine the magnitude of torque  $T$  for which yield occurs when  $P = 240 \text{ kN}$ , (a) using the maximum shearing stress criterion and (b) using the maximum distortion energy criterion.

(OR)

- b) A circular shaft of tensile strength  $350 \text{ MPa}$  is subjected to a combined state of loading defined by bending moment  $M = 8 \text{ kN-m}$  and torque  $T = 24 \text{ kN-m}$ . Calculate the required shaft diameter ' $d$ ' in order to achieve a factor of safety  $n = 2$ . Apply (a) maximum shearing stress theory and (b) maximum distortion energy theory.

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