Mechanical Engineering Science

QB

Unit: 2 – Engineering Materials, Stress Analysis, and Power Transmission   Dr. MBK

1. Explain the mechanical properties of engineering materials in brief.
2. Classify the engineering materials and explain the application and constituents of some of the important ferrous and non-ferrous materials.
3. What are engineering materials and why are they important in design and manufacturing?
4. What is stainless steel, and what makes it corrosion-resistant?
5. What are composites, and how do fiber-reinforced composites work?
6. Explain the classification, properties, and applications of composite materials. Discuss in detail the structure and advantages of fiber-reinforced composites and metal matrix composites with suitable examples.
7. Define smart materials and explain their types with examples. Discuss the working principle, types, and engineering applications of rheological materials.
8. Define stress and strain.
9. What do you mean by normal stress and shear stress?
10. Define longitudinal and lateral strains.
11. Define linear, superficial, and volumetric strain.
12. Define: Young's modulus, elastic limit, proportional limit, yield point, ultimate point, breaking point, modulus of rigidity, bulk modulus, and Poisson's ratio.
13. Differentiate engineering strain and true strain.
14. State Hooke's law.
15. A mild steel specimen with an original diameter of 10 mm and gauge length of 50 mm was found to have an ultimate load of 60 kN and breaking load of 40 kN. The gauge length at rupture was 55 mm and diameter at rupture cross-section was 8 mm. Determine (i) the ultimate stress, (ii) breaking stress, (iii) true breaking stress, (iv) percentage elongation, and (v) percentage reduction in area.
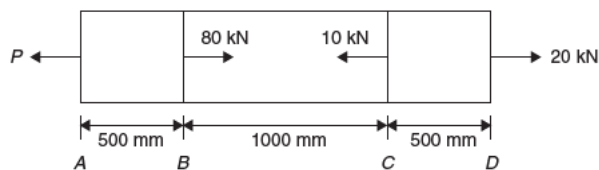16. A brass rod in static equilibrium is subjected to axial load as shown in Figure a

Figure a: A Bar Under Static Equilibrium

Find the load P and change in length of the rod if its diameter is 100 mm. Take $E = 80$ GN/m^2.
17. A concrete column of 37.5 cm2 cross-section, reinforced with steel rods having a total cross-sectional area 7.5 cm2 carries a load of 800 kN as shown in Figure a. If E for steel is 15 times greater than that of concrete, calculate the stresses produced in steel, and concrete.
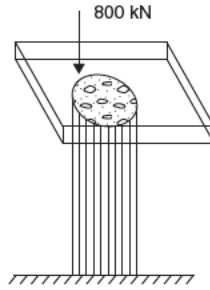
Figure a: Concrete Column

18. A bar of 50 mm diameter is subjected to a load of 100 kN. The measured extension on the gauge length of 250 mm is 0.12 mm and the change in diameter is 0.0040 mm. Calculate Poisson's ratio, and value of E and G.

19. For a given material, Young's modulus is 110 GN/m2 and shear modulus is 42 GN/m2. Find the lateral contraction of a round bar of 37.5 mm diameter and 2.4 m long when stretched by 2.5 mm.

20. A bar 2 cm × 4 cm in cross-section and 40 cm long is subjected to an axial tensile load of 70 kN as shown in Figure a. It is found that the length increases by 0.175 mm and lateral dimension of 4 cm decreases by 0.0044 mm. Find (i) Young's modulus, (ii) Poisson's ratio.
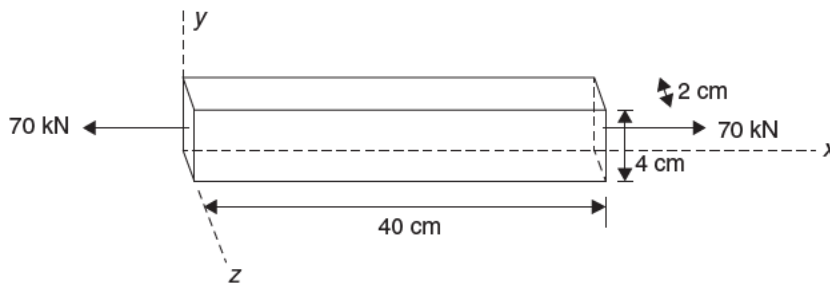

Figure a: A Rod Under Tensile Load

21. An 80-m-long wire of 5-mm diameter is made of a steel with $E = 200$ GPa and an ultimate tensile strength of 400 MPa. If a factor of safety of 3.2 is desired, determine (a) the largest allowable tension in the wire, (b) the corresponding elongation of the wire.

22. Two gage marks are placed exactly 250 mm apart on a 12-mm-diameter aluminum rod with $E = 73$ GPa and an ultimate strength of 140 MPa. Knowing that the distance between the gage marks is 250.28 mm after a load is applied, determine (a) the stress in the rod, (b) the factor of safety.

23. An 18-m-long steel wire of 5-mm diameter is to be used in the manufacture of a prestressed concrete beam. It is observed that the wire stretches 45 mm when a tensile force P is applied. Knowing that $E = 200$ GPa, determine (a) the magnitude of the force P, (b) the corresponding normal stress in the wire.

24. A polystyrene rod of length 300 mm and diameter 12 mm is subjected to a 3-kN tensile load. Knowing that $E = 3.1$GPa, determine (a) the elongation of the rod, (b) the normal stress in the rod.

25. Two gage marks are placed exactly 250 mm apart on a 12-mm-diameter aluminum rod. Knowing that, with an axial load of 6000 N acting on the rod, the distance between the gage marks is 250.18 mm, determine the modulus of elasticity of the aluminum used in the rod.

26. The speed of a driving shaft is 80 rpm and the speed of driven shaft is 120 rpm. Diameter of the driving pulley is given as 600 mm. Find the diameter of driven pulley in the following cases:
    (a) If belt thickness is negligible
    (b) If belt thickness is 5 mm
    (c) If total slip is 10% (considering thickness of belt)
    (d) If a slip of 2% on each pulley (considering thickness of belt)

27. Two shafts are arranged parallel to each other at a distance of 8 m. If the pulleys' diameters mounted on the shafts are of 600 and 1,000 mm, find the ratio of length of belts for open and cross-belt drives.

28. An open-belt drive transmits a power of 5 kW. The linear velocity of the belt is 8 m/s. Angle of lap on smaller pulley is 165°. The coefficient of friction between belt and pulley is 0.25. Determine the effect of the following on power transmission:
    (a) Initial tension in belt is increased by 5%.
    (b) Angle of lap is increased by 5% using idler pulley for same speed and tension in tight side.
    (c) Coefficient of friction is increased by 5%.

29. The gear 1, mounted on motor shaft, rotates at 600 rpm. Find the speed of gear 6 mounted on output shaft.
    The number of teeth on each gear is given below:

Gear	1	2	3	4	5	6
Teeth	20	30	60	40	80	100