Y/K/TX

Reg. No: [redacted]

VIT
Vellore Institute of Technology

Final Assessment Test – November 2024

Course: **BMEE301L - Design of Machine Elements**

Class NBR(s): **3772 / 3773 / 3774 / 3775 / 3776**

Slot: **A1+TA1+TAA1**

Time: **Three Hours**

Max. Marks: **100**

- **KEEPING MOBILE PHONE/ANY ELECTRONIC GADGETS, EVEN IN 'OFF' POSITION IS TREATED AS EXAM MALPRACTICE**
- **DON'T WRITE ANYTHING ON THE QUESTION PAPER**

General Instruction: PSG Design Data book is permitted inside the examination hall.

Answer ALL Questions

(10 X 10 = 100 Marks)

1. The stresses induced at a critical point in a machine component made of steel 45C8 (σ_{yt} = 380 N/mm^2) are as follows: **[10]**

   σ_x = 100 N/mm^2; σ_y = 40 N/mm^2; τ_{xy} = 80 N/mm^2. Calculate the factor of safety by (i) the maximum normal stress theory, (ii) the maximum shear stress theory, and (iii) the distortion energy theory.

2. A cantilever beam made of steel Fe 540 (σ_{ut} = 540 N/mm^2 and σ_{yt} = 320 N/mm^2) and subjected to a completely reversed load (P) of 5 kN is shown in Fig. 1. The beam is machined and the reliability is 50%. The factor of safety is 2 and the notch sensitivity factor is 0.9. Calculate (i) endurance limit at the fillet section; and (ii) diameter *d* of the beam for infinite life. **[10]**

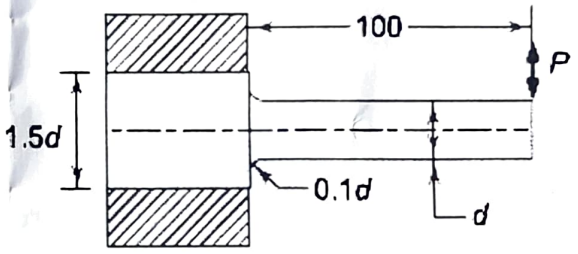

Fig. 1 Cantilever Beam (All dimensions are in mm)

3. A transmission shaft carries a pulley midway between the two bearings. The bending moment varies from 200 N-m to 600 N-m, as the torsional moment in the shaft varies from 70 N-m to 200 N-m. The frequencies of variation of bending and torsional moments are equal to the shaft speed. The shaft is made of steel FeE 400 (σ_{ut} = 540 N/mm^2). The corrected endurance limit of the shaft is 200 N/mm^2. Determine the diameter of the shaft using a factor of safety of 2. **[10]**

4. In an automotive plate clutch, six identical helical compression springs arranged in parallel provide the total axial thrust of 1500 N. The springs are compressed by 10 mm to provide this thrust force. The springs are identical and the spring index is 6. The springs are made of cold-drawn steel wires with ultimate tensile strength of 1200 N/mm^2. The permissible shear stress for the spring wire can be taken as 50% of the ultimate tensile strength. Take shear modulus 'G' = 81370 N/mm^2. The springs have squared and ground ends. There should be a gap of 1 mm between adjacent coils when the springs are subjected to the maximum force. Design the springs. **[10]**

5. Design a semi-elliptic leaf spring for the following specifications: Load (2P) = 20 kN, total number of leaves (n) = 10, span of spring (2L) = 0.6 m, permissible deflection (y) = 50 mm. Take modulus of elasticity E = 200 GPa and allowable stress for spring material is 600 MPa. The leaves are pre-stressed so as to equalize stresses in all leaves. **[10]**

6.a) The layout of a shaft carrying two pulleys 1 and 2, and supported on two bearings A and B is shown in Fig. 2. The shaft transmits 7.5 kW power at 360 rpm from the pulley 1 to the pulley 2. The diameters of pulleys 1 and 2 are 250 mm and 500 mm respectively. The masses of pulleys 1 and 2 are 10 kg and 30 kg respectively. The belt tensions act vertically downward and the ratio of belt tensions on the tight side to slack side for each pulley is 2.5. The shaft is made of plain carbon steel 40C8 (σ_{yt} = 380 N/mm^2) and the factor of safety is 3. Estimate suitable diameter of shaft. **[10]**

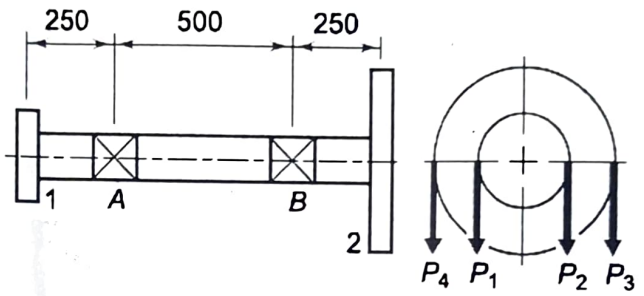

Fig.2. Shaft carrying two pulleys (All dimensions are in mm)

OR

6.b) Design a protective type of cast iron flange coupling for a steel shaft transmitting 15 kW at 200 r.p.m. and having an allowable shear stress of 40 MPa. The working stress in the bolts should not exceed 30 MPa. Assume that the same material is used for shaft and key and that the crushing stress is twice the value of its shear stress. There are 4 numbers of bolts connecting the flanges. The maximum torque is 25% greater than the full load torque. The shear stress for cast iron is 14 MPa. Perform the design calculations only for hub and bolts. Assume that the bolts are fitted in reamed and ground holes. **[10]**

7. A bracket is welded to the vertical column by means of two fillet welds at the top and bottom as shown in Fig. 3. Determine the size of the welds, if the permissible shear stress in the weld is limited to 70 N/mm^2. **[10]**

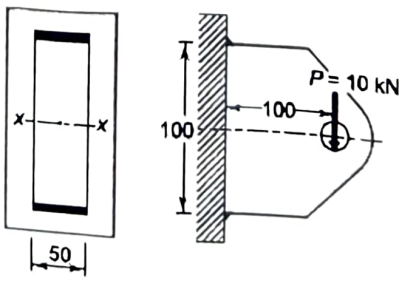

Fig. 3. Welded Bracket (All dimensions are in mm)

8. A riveted joint, consisting of four identical rivets, is subjected to an eccentric force of 5 kN as shown in Fig. 4. Determine the diameter of rivets, if the permissible shear stress is 60 N/mm^2. **[10]**

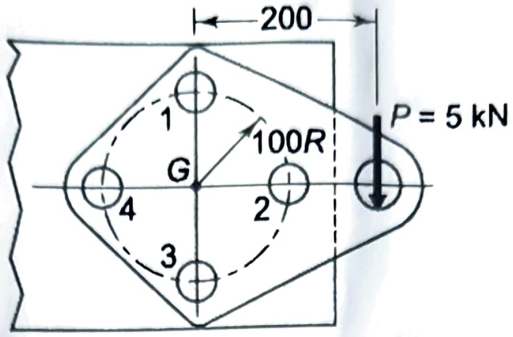

Fig. 4. Riveted Joint (All dimensions are in mm)

9. Design a sleeve and cotter joint to resist a tensile load of 60 kN. All parts of the joint are made of the same material with the following allowable stresses : **[10]**

σ_t = 60 MPa ; τ = 70 MPa ; and σ_c = 125 MPa.

Determine the following:

i) Diameter of the rods
ii) Diameter of enlarged end of rod and thickness of cotter
iii) Outside diameter of the sleeve

10.a) The following data is given for the cap and bolts of the big end of connecting rod: Engine speed = 1800 rpm; Length of connecting rod = 350 mm; Length of stroke = 175 mm; Mass of reciprocating parts = 2.5 kg; Length of crank pin = 76 mm; Diameter of crank pin = 58 mm; Thickness of bearing bush = 3 mm; Permissible tensile stress for bolts = 60 N/mm^2; Permissible bending stress for cap = 80 N/mm^2; Calculate the nominal diameter of bolts and thickness of cap for the big end. **[10]**

OR

10.b) A single cylinder double acting steam engine develops 150 kW at a mean speed of 80 r.p.m. The coefficient of fluctuation of energy is 0.1 and the fluctuation of speed is ± 2% of mean speed. If the mean diameter of the flywheel rim is 2 metres and the hub and spokes provide 5 percent of the rotational inertia of the wheel, find the mass of the flywheel and cross-sectional area of the rim. Assume the density of the flywheel material as 7200 kg / m^3. **[10]**

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