Ref. No.: Ex/ME/5/T/222/2025

BACHELOR OF ENGINEERING (MECHANICAL ENGINEERING)
SECOND YEAR SECOND SEMESTER - 2025
MACHINE DESIGN - I

Time: **Three hours** Full Marks: **100**

Missing data, if any, are to be reasonably assumed.
Different parts of a question must be answered together.
Give sketches wherever applicable.
Answer any **Five (5)** questions

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1. (a) Discuss the role of safety, reliability, and manufacturability in machine design philosophy. [06]

   (b) Why a relatively lower factor of safety is employed for design of aerospace components? Does it imply that air travel is risky? Explain [02 + 03]

   (c) What are standards in machine design and what are the advantages of employing them. Name the organization responsible for setting and maintaining standards in India. [05 + 01]

   (d) Name some machine elements which follow standards. [03]

2. (a) Draw a schematic representation of the stress-strain diagram as obtained from the standard tensile test for ductile material and show the important points on it. Discuss the procedure for determining the yield strength of a material which does not exhibit a well-defined yield point on the stress-strain diagram. [03 + 02]

   (b) A steel rod of 500 mm length is clamped to a wall and supports a vertical point load of 3 kN at the free end. The diameter of the rod is 60mm. In addition to the vertical load, the rod is also subjected to a torsional moment of 200 Nm at the free end. Assume the rod material is ductile (S_{yt} = 250 N/mm^2) and a FOS of 2.0 is considered.
   i. Identify the critical cross-section for stress analysis.
   ii. Calculate the bending stress and shear stress at the critical section due to the vertical load and the torsion respectively
   iii. Determine the principal stresses and maximum shear stress at the critical section. [10]

   (c) Define Hardness and Toughness in a material and name the tests for determining them [05]

3. (a) Name one suitable theory of failure for ductile materials and one for brittle materials. Write the statement of each theory and draw the regions of safety. [08]

   (b) Which theory of failure you would prefer to use in case of ductile material and why? [02]

   (c) The load on a bolt consists of an axial pull of 12kN together with a transverse shear force of 6kN. Find the diameter of the bolt required according to i) Maximum principal stress theory, ii) Maximum shear stress theory and iii) Maximum Distortion energy theory. Take permissible tensile stress = 120 N/mm^2.and Poisson's Ratio = 0.3 [10]

4. (a) How does the design philosophy differ for static vs. dynamic loading conditions? [04]

   (b) Define fatigue stress concentration factor? What is its significance? [03]

   (c) Draw a typical S-N diagram for ferrous material and indicate various key points/regions. [06]

   (d) Define endurance limit. What are the factors on which the endurance limit is dependent. [07]

5. A cantilever beam (circular cross section) made of steel (S_{ut} = 540 N/mm^2 and S_{yt} = 320 N/mm^2) is subjected to force P at its free end as shown in Fig 5a. Magnitude of the force varies from -100N to +200N. The beam is machined (Surface finish factor, K_{surf} = 0.85) and the reliability is 50% (Reliability factor K_r =1). The factor of safety is 2.0, theoretical stress concentration factor is 1.7 and the notch sensitivity factor is 0.9. Calculate (*i*). Endurance limit at the fillet section, (*ii*). Diameter of the beam using Soderberg, Goodman and Gerber equations. [20]

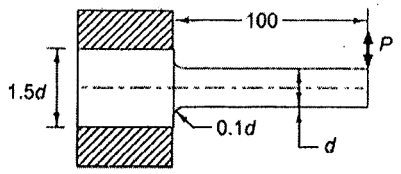

Fig. 5a

6. (a) Design a solid circular shaft made of C45 steel (S_{ut} = 580 MPa, S_{yt} = 350 MPa) to transmit 20 kW of power at 1440 rpm. The shaft is supported by two bearings placed 1.2 meters apart and carries a pulley of 400 mm diameter located at the center of the shaft. The pulley weighs 200 N. Assume a factor of safety of 2.0, and use the maximum shear stress theory for design. Neglect keyway effects. [10]

   (b) Compare the torsional rigidity and weight of solid vs. hollow shafts for the same material and torque capacity. [10]

7. Write description/short notes on the following topics: [4 × 05]

   (a) Methods of reducing stress concentration.

   (b) Factors affecting Factor of Safety.

   (c) Material selection criteria in machine design.

   (d) Stress concentration is not a point of concern for ductile materials subjected to static loads.