Ref. No.: Ex/ME/5/T/222/2023

BACHELOR OF ENGINEERING (MECHANICAL ENGINEERING)
SECOND YEAR SECOND SEMESTER - 2023
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) Describe the experimental process of obtaining the stress vs strain curve for a ductile material? Give suitable diagrams/sketches. [8]
(b) How can you differentiate between a brittle material and a ductile material from the stress-strain curve? Which is the actual parameter defining ductility of a material? [3+1]
(c) How can you get the yield point of a material which doesn't show a well-defined yield point in the stress-strain curve? [4]
(d) What is adaptive design? Give an example. [4]

2. (a) A 30 × 60 mm bar of rectangular cross-section is made of plain carbon steel 40C8 (Syt = 380 N/mm^2 and E = 207 000 N/mm^2). The length of the bar is 550 mm. The two ends of the bar are hinged and the factor of safety is 2.5. The bar is subjected to axial compressive force. (i) Determine the slenderness ratio; (ii) Which of the two equations—Euler's or Johnson's—will you apply to the bar? (iii) What is the safe compressive force for the bar? [10]
(b) Briefly state the following theories of failure and compare their regions of safety for ductile materials: Maximum normal stress theory, Maximum shear stress theory and Distortion energy theory. [10]

3. (a) What is factor of safety? How it is different from margin of safety? [1+2]
(b) List the factors affecting the factor of safety of a component? [5]
(c) The shaft of an overhang crank subjected to a force P of 1 kN as shown in Fig. 3(c). The shaft is made of plain carbon steel 45C8 and the tensile yield strength is 380 N/mm^2. The factor of safety is 2.0. Determine the diameter of the shaft using the maximum shear stress theory. [12]

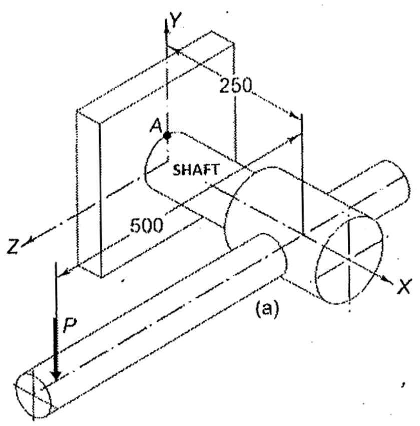

Fig. 3(c)

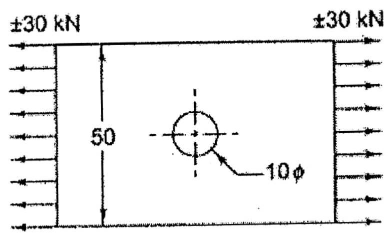

Fig. 4(b)

4. a) A bar of steel has an ultimate tensile strength of 700 MPa and yield strength of 400 MPa. The corrected endurance limit is 220 MPa. The bar is subjected to a mean bending stress of 60 MPa and a stress amplitude of 80 MPa. Superimposed on it is a mean torsional stress and torsional stress amplitude of 70 MPa and 35 MPa respectively. Find the factor of safety following: (i). Soderberg line (ii) Goodman line and (iii) Gerber line. [12]

b) A steel plate (Sut = 440 N/mm^2) in hot rolled condition is subjected to completely reversed axial load of 30 kN, as shown in Figure Q4b. The notch sensitivity factor can be taken as 0.8 and the expected reliability is 90%. Suitable load factor for axial loading is given as 0.85. The size factor is 0.85. The factor of safety is 2.0. Determine the thickness of the plate. [8]

5. a) What is Marin's equation and what is its significance? Also name the different factors modifying the endurance limit. [2+3]

b) A shaft is subjected to the following loads:

$$(M_t)_{max} = 250 \text{ N-m}; (M_t)_{min} = 70 \text{ N-m}; (M_b)_{max} = 650 \text{ N-m}; (M_b)_{min} = 200 \text{ N-m}$$

Determine the diameter of the shaft using Modified Goodman theory for a factor of safety of 2.0 if the yield and ultimate tensile stress of the shaft material are 400N/mm^2 and 540N/mm^2 respectively. [12]

c) Theoretical stress concentration factor may not be required at all for design with ductile material under static loading, but it must be used for design with brittle materials subjected to static loads – Explain. [03]

6. Discuss briefly/Write short notes on the following topics (any 4) [4 × 5]

i) Preferred numbers
ii) Modes of failure in mechanical components
iii) Fatigue stress concentration factor
iv) Equivalent bending moment in shaft design
v) Heat treatment in steel