Ref. No.: Ex/ME/5/T/222/2024

BACHELOR OF ENGINEERING (MECHANICAL ENGINEERING)
SECOND YEAR SECOND SEMESTER - 2024
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) What are the primary modes of failure in mechanical components? [3]
(b) Explain the following theories of failure: Maximum Principal Stress Theory, Maximum Shear Stress Theory, Maximum Distortion energy Theory. Also compare their regions of safety. [12+5]

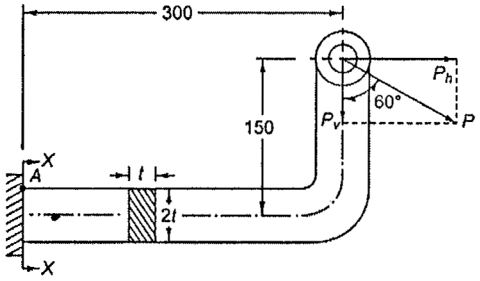

Fig. Q2a

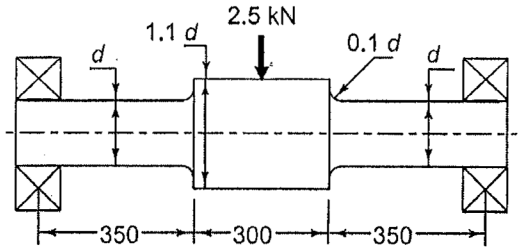

Fig. Q2b

2. (a) A wall bracket with a rectangular cross-section is shown in Fig. Q2a. The depth of the cross-section is twice of the width. The force P acting on the bracket at 60° to the vertical is 5kN. The material of the bracket is grey cast iron FG 200. If the width of the bracket is selected to be 35mm, what is the factor of safety of the system. You may assume maximum principal stress theory of failure. [10]
(b) A beam supporting a load of 2.5kN is shown in Fig. Q2b. The beam is made of brittle material, with an ultimate tensile strength of 300 N/mm^2. The factor of safety is 3.0. Determine the dimensions of the shaft. [10]

3. (a) Explain the S-N curve (stress-life curve) and its significance in fatigue design. Provide examples of components or structures that are susceptible to fatigue failure. [6+2]
(b) A solid circular shaft, 15 mm in diameter, is subjected to torsional shear stress, which varies from 0 to 35 N/mm^2 and at the same time, is subjected to an axial stress that varies from –15 to +30 N/mm^2. The frequency of variation of these stresses is equal to the shaft speed. The shaft is made of steel FeE 400 IS (S_{ut}= 540 N/mm^2 and S_{yt} = 400 N/mm^2) and the corrected endurance limit of the shaft is 200N/mm^2. Determine the factor of safety using Soderberg line, Goodman line and Gerber line. [12]

4. (a) What is slenderness ratio? [2]
(b) What do you understand by long and short column? Write the governing equations for determining the critical buckling load for both types of columns. [8]
(c) It is required to design the screw of a screw-jack by buckling consideration. One end of the screw is fixed in the nut and the other end supports a load of 20 kN. The length of the screw between the fixed and free ends is 500 mm, when the load is completely raised. The screw is made

of steel 40C8 (S_{yt} = 380 N/mm^2 and E = 207 000 N/mm^2). Assuming a factor of safety of 2.5, determine the diameter of the screw (assume the screw to be a solid circular rod). [10]

5. (a) Explain the concept of material selection in machine design. What factors should engineers consider when selecting materials for specific machine components? [5]
(b) Describe briefly the testing method used to evaluate tensile strength of a material. [6]
(c) What is clearance fit, transition fit and interference fit? Give examples [6]
(d) What are preferred numbers? [3]

6. (a) A solid circular shaft diameter d is subjected to a bending moment of M_b and a torsional moment of M_t. Prove that according to the maximum principal stress theory, [10]

$$\frac{S_{yt}}{(fs)} = \frac{16}{\pi d^3}\left[M_b + \sqrt{(M_b)^2 + (M_t)^2}\right]$$

the terms bear their usual meaning
(b) Discuss the ASME code for shaft design. [7]
(c) What types of stresses are normally encountered in shafts? [3]

7. (a) Define stress concentration and explain why it is a critical factor in machine design. Provide examples of machine components where stress concentration is a concern. [3+2]
(b) Discuss the methods to reduce stress concentration. [5]
(c) Write short notes on the following (any 2) [2×5]
i) Heat treatment in steel
ii) Percentage elongation and its significance.
iii) Use of standards in the design process

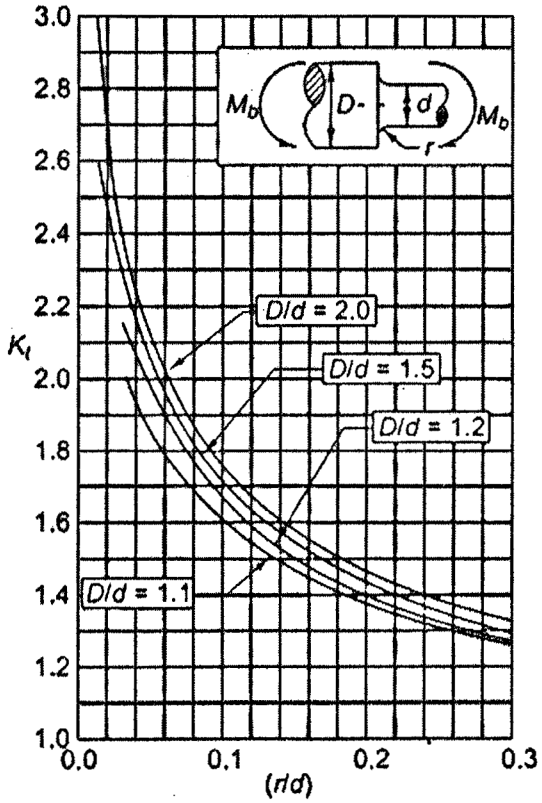

Fig. Stress Concentration Factor (Round Shaft with Shoulder Fillet in Bending)