B.E. MECHANICAL ENGINEERING SECOND YEAR SECOND SEMESTER EXAM 2024

DESIGN OF MACHINE ELEMENTS - 1

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

Missing data, if any, are to be reasonably chosen.
Different parts of a question must be answered together.
Give sketches wherever applicable.

Section – A (10 × 4 = 40)

1. (*a*) Explain what do you understand by fundamental design considerations.
(*b*) What are the different factors that need to be considered while choosing a material for a component/product?
(*c*) Define factor of safety and discuss its importance in machine design. [04+03+03]

2. (*a*) Write down the advantages of standardization in the context of machine design.
(*b*) Explain the terms Tolerance and Fit. Describe different types of fits with appropriate schematic diagrams.
(*c*) In relation to design of cast members, discuss the importance of reducing shrinkage stress with an appropriate example and diagrams. [03+04+03]

3. A solid shaft transmits 12 kW power at 360 rpm and it is simultaneously subjected to a bending moment of 500 N-m. The shaft is made of plain carbon steel (S_{ut} = 650 N/mm^2, S_{yt} = 380 N/mm^2). The shaft has a keyway for mounting of pulley. Estimate suitable diameter of shaft following ASME Code for design of shaft. Consider, k_b = 1.5 and k_t = 1.0. [10]

4. Define theoretical and fatigue stress concentration factors. [03]
A flat plate, used for a critical machine component, is subjected to a tensile force of 7.50 kN (Figure Q4). The plate consists of a filleted section and a circular hole as shown in the figure. The plate material is grey cast iron with S_{ut} = 250 N/mm^2 and the factor of safety is 2.5. Determine the thickness of the plate. [07]

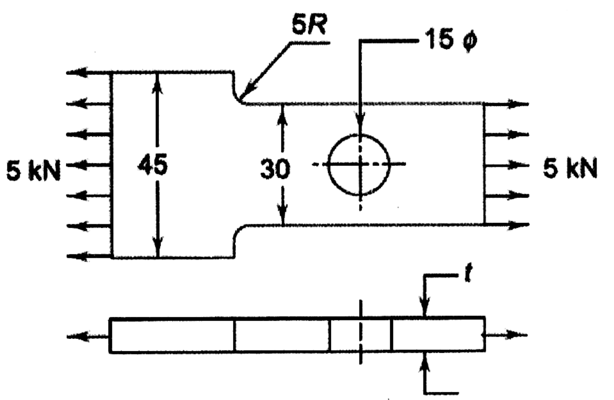

Figure Q4

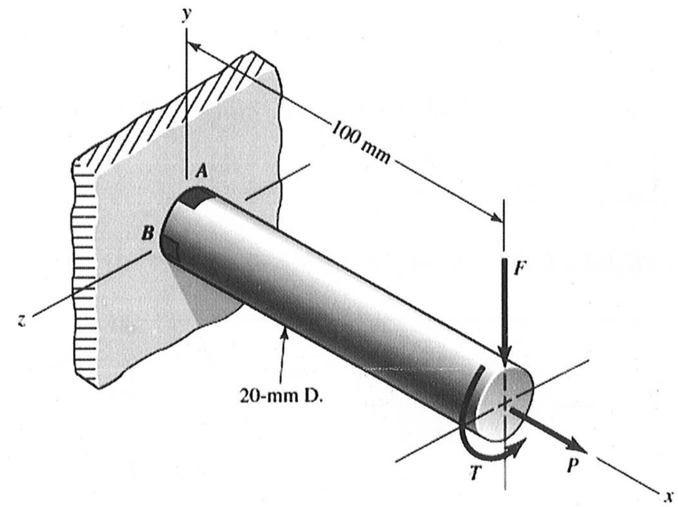

Figure Q5

Section – B (Answer Any 3: 16 × 3 = 48)

5. (*a*) Discuss the design principles for low cycle fatigue regime. [04]
(*b*) Compute the factors of safety at the critical location of the circular beam (20 mm in diameter and 100 mm in length) shown in Figure Q5, based upon the distortion energy theory. The beam is made of cold-drawn steel with S_{yt} = 450 N/mm^2 and is loaded simultaneously by axial tensile load, transverse bending load and twisting moment. The magnitudes of the forces are as follows: F = 0.75 kN, P = 5.0 kN, and T = 40 N-m. [12]

[Turn over

6. A joint that connects two circular rods is required to transmit 125 kN of axial tensile force. As per requirement, there should not be any relative rotation between the rods about an axis perpendicular to the rod axes. Any plastic deformation of the rods/joint results in loss of component functionality and hence to be avoided. What type of joint would you recommend for the above-mentioned situation? Write down the names of different parts of the joint. Design any two of the above-mentioned parts. Consider the material to be plain C-steel having tensile yield strength (S_{yt}) of 400 N/mm^2 and ultimate tensile strength (S_{ut}) of 620 N/mm^2. [16]

7. (*a*) Write down the Marin equation for determination of corrected endurance limit and discuss about the different factors involved in the equation. [04]

(*b*) A solid circular shaft, 15 mm in diameter, is subjected to torsional shear stress, which varies from 0 to 40 N/mm^2 and at the same time, is subjected to an axial stress that varies from –25 to +35 N/mm^2. The frequency of variation of these stresses is equal to the shaft speed. The shaft is made of steel FeE 400 (S_{ut} = 540 N/mm^2 and S_{yt} = 400 N/mm^2) and the corrected endurance limit of the shaft is 200 N/mm^2. Determine the factor of safety using Soderberg, Goodman and Gerber diagram. Comment on the variation of the values of factor of safety obtained from these three diagrams. [12]

8. (*a*) Write down the statement and schematically show the regions of safety (for bi-axial state of stresses) corresponding to the following failure theories: Maximum shear stress theory and Maximum principal strain theory. [05]

(*b*) Derive the ratio between yield strength in shear and yield strength in tension for the following theories of failure: (*i*). Maximum shear stress theory and (*ii*). Maximum principal strain theory. [05]

(*c*) Find the critical slenderness ratio by which long and short columns can be differentiated. Also derive an expression for determination of critical buckling load for short column. [06]

Section – C

9. At a critical location of a component, the following stress cycles are repetitively applied and it includes completely reversed bending stresses, as well as, general fluctuating stresses. The details of the stress cycles are as follows –

(*i*) σ_{max} = 140 N/mm^2, σ_{min} = - 140 N/mm^2 (for 15% of time)

(*ii*) σ_{max} = 410 N/mm^2, σ_{min} = - 410 N/mm^2 (for 45% of time)

(*iii*) σ_{max} = 285 N/mm^2, σ_{min} = - 130 N/mm^2 (for 40% of time)

The material (S_{ut} = 725 N/mm^2) has a corrected endurance limit of 150 N/mm^2. Determine the life of the component. [12]

Relevant Data, Charts and Tables for Design:

Standard Shaft Diameters: 5, 6, 8, 10, 12, 14, 16, 18, 20, 22, 25, 28, 30, 32, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85 ...

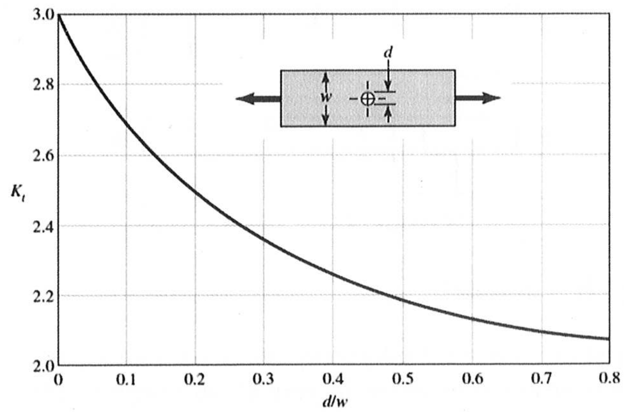

Chart 1: Flat plate in simple tension with a transverse circular hole.

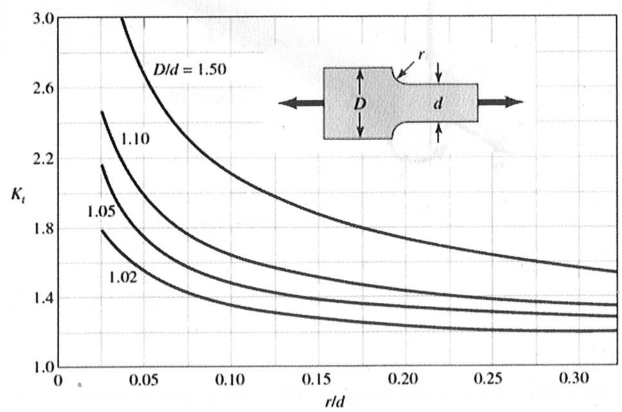

Chart 2: Rectangular filleted bar in tension or simple compression.