# NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

**FACULTY OF INDUSTRY TECHNOLOGY**

**DEPARTMENT OF CIVIL AND WATER ENGINEERING**

**MECHANICS OF SOLIDS**

**TCW 2103**

**Examination Paper**

**NOVEMBER 2015**

This examination paper consists of 4 pages

**Time Allowed: 3 hours**

**Total Marks: 100**

**Examiner's Name: Eng. K. Mushunje**

**INSTRUCTIONS**

1. Answer FOUR questions
2. Each question carries 25 marks
3. Use of calculators is permissible

**MARK ALLOCATION**

| QUESTION | MARKS |
|---|---|
| 1. | **25** |
| 2. | **25** |
| 3. | **25** |
| 4. | **25** |
| 5. | **25** |
| **TOTAL** | **100** |

**QUESTION 1**

a) Define what is meant by allowable stress. Explain how the concept of allowable stress is used during the design of structures. [5]

b) A steel bar serving as a vertical hanger to support heavy machinery in a factory is attached to a support by the bolted connection shown in Figure 1.1. The main part of the hanger has a rectangular cross section with width $b_1$ = 38 mm and thickness $t$ = 13 mm. At the connection the hanger is enlarged to a width $b_2$ = 75 mm. The bolt, which transfers the load from the hanger to the two gussets, has diameter $d$ = 25 mm. Determine the allowable value of the tensile load $P$ in the hanger based upon the following four considerations:

i. The allowable tensile stress in the main part of the hanger is 110 MPa.
ii. The allowable tensile stress in the hanger at its cross section through the bolt hole is 75 MPa. (The permissible stress at this section is lower because of the stress concentrations around the hole.)
iii. The allowable bearing stress between the hanger and the bolt is 180 MPa.
iv. The allowable shear stress in the bolt is 45 MPa. [20]

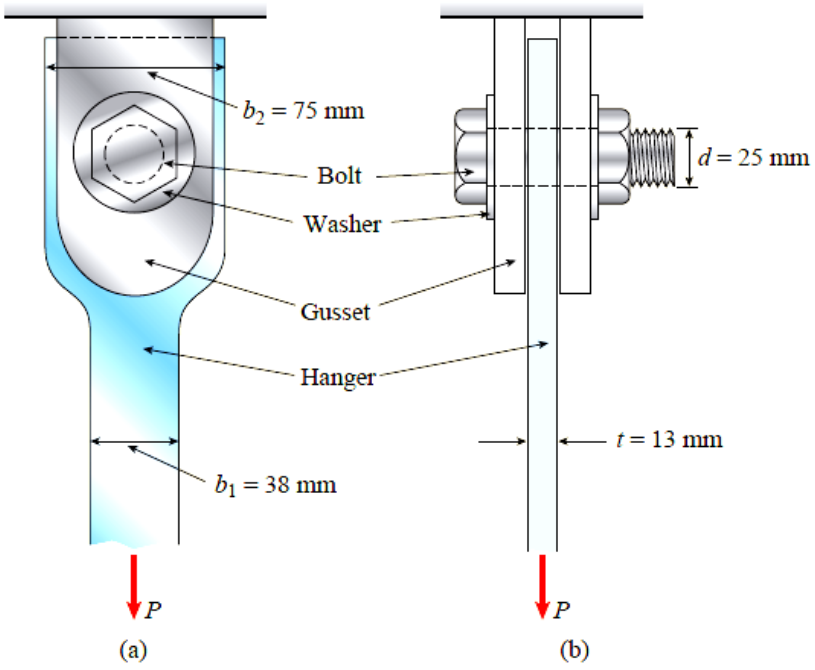


**Figure 1.1**

**QUESTION 2**

a) State the difference between a statically determinate structure and a statically indeterminate. Explain the difference in the analysis of the two structures. [5]

b) Members ABC and DEF are joined with steel links (E = 200 GPa). Each of the links is made of a pair of 25 x 35 mm plates. Determine the change in length of :

i. Member BE
ii. Member CF [10]

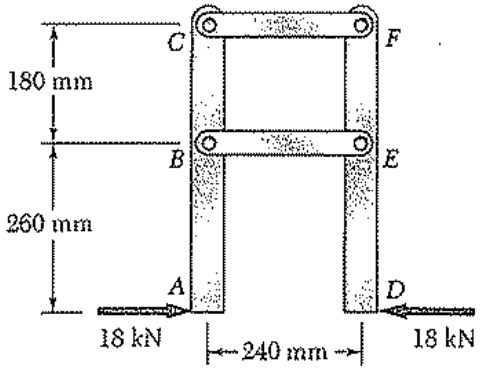


**Figure 2.1**

c) Two cylindrical rods, one of steel and the other of brass are joined at C and restrained by rigid supports at A and E. For the loading shown in Figure 2.2 and knowing that $E_{steel}$ = 200 GPa and $E_{brass}$ = 105 GPa, Determine:
   i. The reactions at A and E
   ii. The deflection of point C [15]

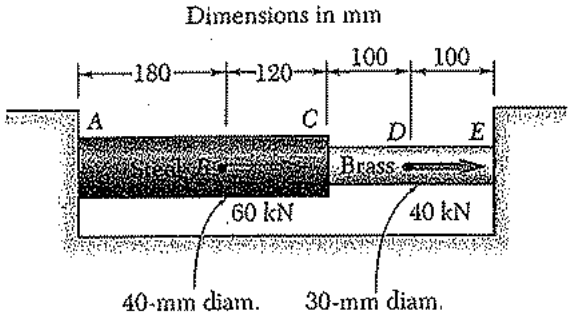


**Figure 2.2**

**QUESTION 3**

A beam is loaded as shown in Figure 3.1. Find:

a) The reactions at the supports
b) The maximum bending moment and shear force
c) Point(s) of contra-flexure (if any)
d) Draw the shear force and bending moment diagrams [25]

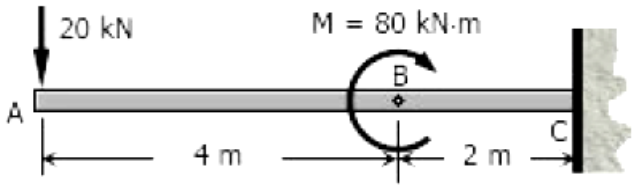


**Figure 3.1**

**QUESTION 4**

a) State and explain the assumptions made in pure bending theory. Also state the limitations associated with some of these assumptions in actual practice. [10]

b) A cast iron machine part shown in Figure 4.1 is acted upon by the 3 kNm couple shown. Knowing that E = 165 GPa and neglecting the effect of fillets. Determine:

i. the maximum tensile and compressive stresses in the casting

ii. the radius of curvature of the casting

[15]

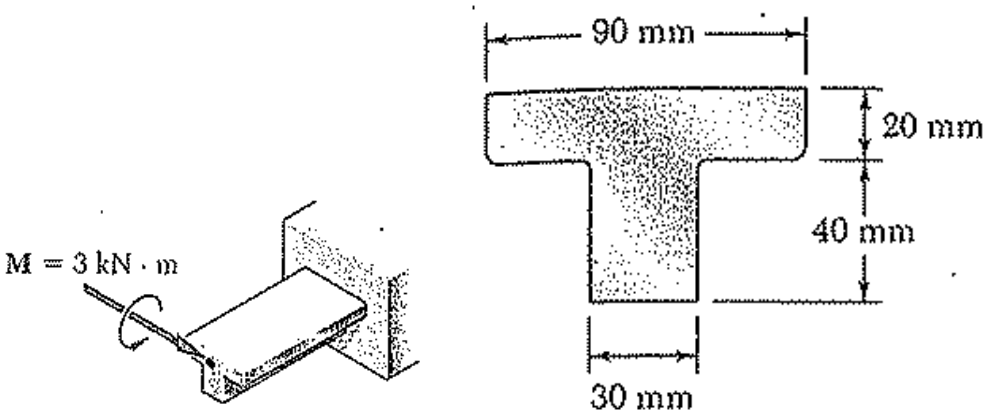


**Figure 4.1**

**QUESTION 5**

a) Shaft BC shown in Figure 5.1 is hollow with inner and outer diameters of 90 mm and 120 mm respectively. Shafts AB and CD are solid and diameter *d*. For the loading shown, determine:

i. The maximum and minimum shearing stress in shaft BC.

ii. The required diameter d for shafts AB and CD if the allowable in these shafts is 65 MPa. [15]

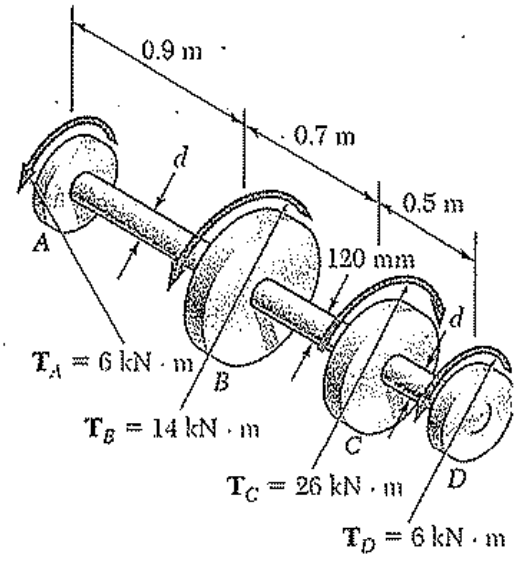


**Figure 5.1**

**b)** A shaft consisting of steel tube of 50 mm outer diameter is to transmit 100 kW of power while rotation at a frequency of 20 Hz. Determine the tube thickness which should be used if the shearing stress is not to exceed 60 MPa. [10]