UNIVERSITY OF SASKATCHEWAN
College of Engineering
G.E. 213.3 Mechanics of Materials

Time: 3 hours **FINAL EXAMINATION** **December 19, 2003**

The exam is closed book. Calculator allowed.
Unless otherwise indicated, all dimensions shown in Figures are in mm. Assume linearly elastic action, unless otherwise indicated.
It is essential that you draw all necessary diagrams as part of solutions, list any assumptions, and provide equations that you use for full marks.

Marks

15 **1.** The bar *AB* is considered to be absolutely rigid and is horizontal before the load of 160 kN is applied, as shown in Fig. 1 . The connection at *A* is a pin, and *AB* is supported by the steel rod *EB* and the copper rod *CD*. The length of *CD* is 1 m, of *EB* is 1.5 m. The cross-sectional area of *CD* is 500 mm^2, and of *EB* is 300 mm^2. Determine the stress in each of the vertical rods and the deflection at the load point of bar *AB*. Neglect the weight of *AB*. For copper, *E*=120 GPa; for steel, *E*= 200 GPa.

15 **2.** Consider two solid circular shafts connected by 60 mm and 300 mm pitch diameter gears as in Fig. 2. The shafts are assumed to be supported by bearings in such a manner that they undergo no bending. Determine (a) the angular rotation of D, the right end of shaft CD, with respect to A, the left end of the shaft AB, caused by the torque of 250 N.m applied at D, and (b) shear stress in shaft AB. The shaft AB is steel for which *G*= 85 GPa and the shaft CD is brass for which *G*= 35 GPa.

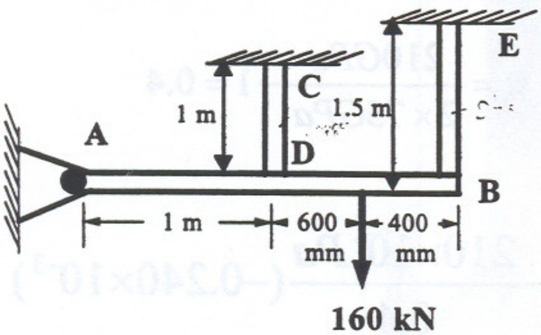


Fig.1

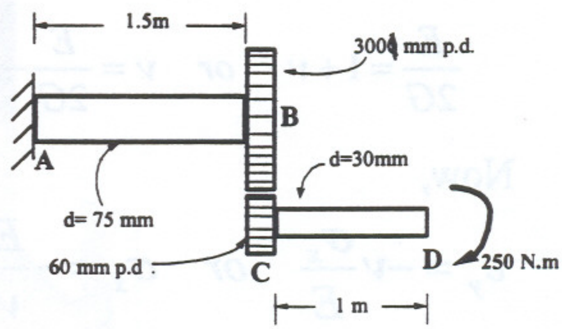


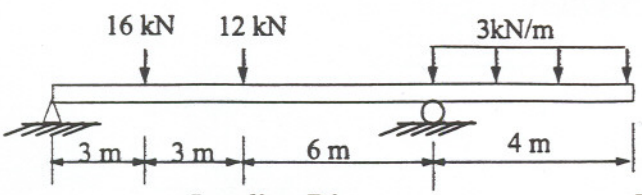
Fig. 2

3. For the loading shown on the beam in Fig. 3:

8 (a) Draw complete shear and moment diagrams.

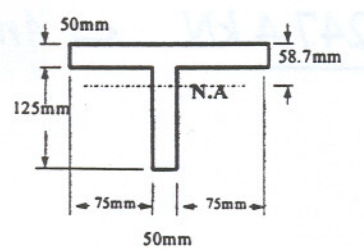
6 (b) Calculate the maximum tensile and compressive stresses for the tee-cross section of the beam is illustrated in Fig. 3.

6 (c) Calculate the maximum horizontal shear stress in the vertical arm of the beam (below the neutral axis) at the neutral axis.



Loading Diagram

Fig. 3



Cross-Section

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4. For the beam and the loading shown in Fig. 4:

7 (a) Using the singularity functions, express the shear and bending moment as a function of the distance x from the support A.

5 (b) Determine the numerical values of the shear and bending moment at point D.

7 (c) Using the moment equation obtained in (a) above, determine the equation of elastic curve. Calculate deflection at point D (modulus of elasticity E = 200 GPA for the material of the beam)

7 (d) Calculate the average shear stress in the 15 mm diameter rivets that attach the two channel sections to make the beam cross section, at the location of maximum shear. Each row of rivets is spaced at 100 mm along the beam length. Note that *each* horizontal leg of the channel sections is 20 mm thick. (The moment of inertia of the combined section (two channels) about the neutral axis is 3.65×10^{-6} m^4).

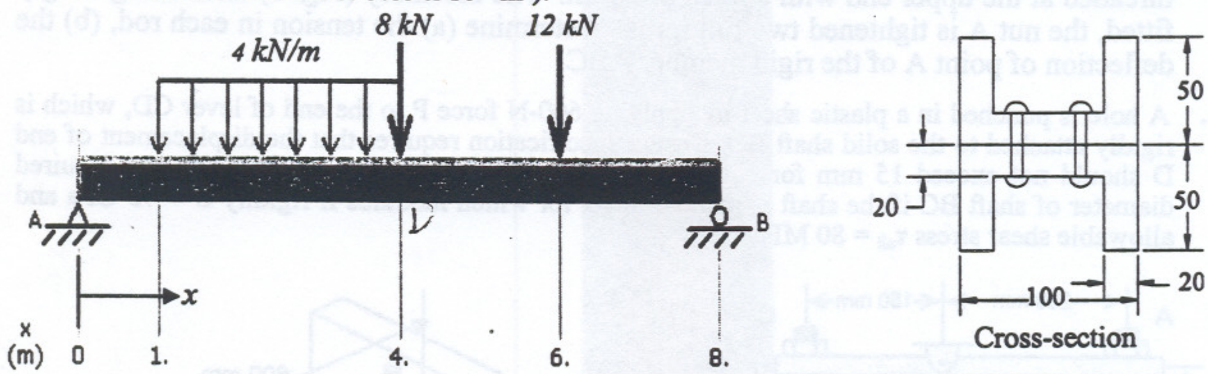

Fig.4

12 **5.** A single horizontal force **P** = 900 N is applied to the end D of lever ABD (Fig. 5). The diameter of the lever bar is 35 mm. Determine (a) the normal and shearing stresses on the element located at point **H** and having sides parallel to x and y axes; (b) the principal stresses at point **H**. You may use the equation:

$$\sigma_{max\ or\ min} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{[(\frac{\sigma_x - \sigma_y}{2})^2 + \tau_{xy}^2]}$$

12 **6.** A horizontal bar AB is supported by a column CD as shown with end conditions in Fig. 6. The column is a steel bar (E = 200 GPa) of 50x30mm ~~square~~ cross section. Calculate the allowable load P if the factor of safety of 3 is required with respect to buckling of the column. [*Buckling load* = $(\pi^2 EI)/(KL)^2$]

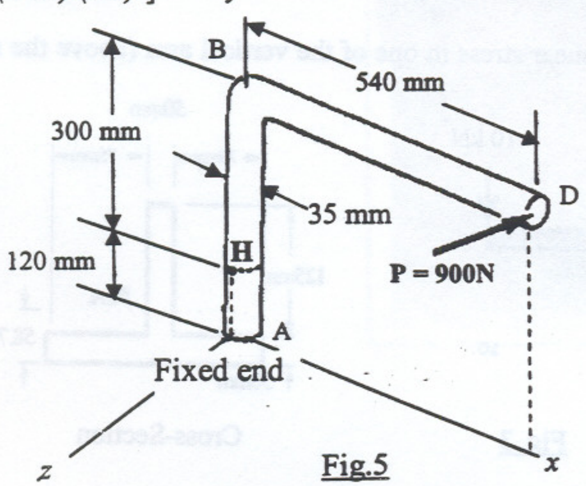

Fig.5

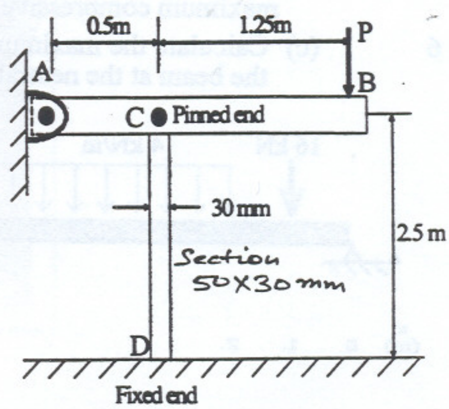

Fig. 6

*** *The End* ***

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