ADELAIDE UNIVERSITY

DEPARTMENT OF MECHANICAL ENGINEERING

EXAMINATION FOR THE DEGREE OF B.E.

#2137 STRESS ANALYSIS AND DESIGN

NOVEMBER 2000

TIME ALLOWED: 3 HOURS

- In addition candidates are allowed ten minutes before the examination begins to read the paper.
- The use of notes, texbooks, and calculating devices is permitted in the examination room.
- Answer any **FIVE** questions **ONLY**.
- All questions carry equal marks.
- Appropriate engineering assumptions may be made for inadequate data.

QUESTION ONE

An oceangoing tanker has twin stream turbines that turn at 1800 rpm while delivering 8200 kW power each. The power of each turbine is transmitted by a shaft to a system of reduction gears, which, at an efficiency of 90%, reduces the rotational speed at which the power is transmitted to 107 rpm. A second shaft then transmits this power to a propeller.

a) If the yield stress in shear for the shafts is 6.9×10^8 Pa, what should the diameter be for the shafts if they are solid? Use a safety factor of 2 and assume that a thrust bearing absorbs the axial force from the propeller before it gets to the shafts in question.

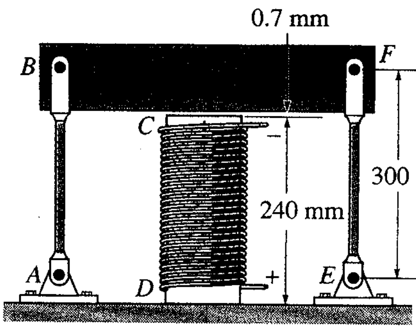
b) Design the shafts for a safety factor of 2 assuming they are hollow with the inside diameter one half of the outside diameter.

QUESTION TWO

The centre rod *CD* of the assembly is heated from $T_1 = 30°C$ to $T_2 = 180°C$ using electrical resistance heating. At the lower temperature T_1 the gap between *C* and the rigid bar is 0.7mm.

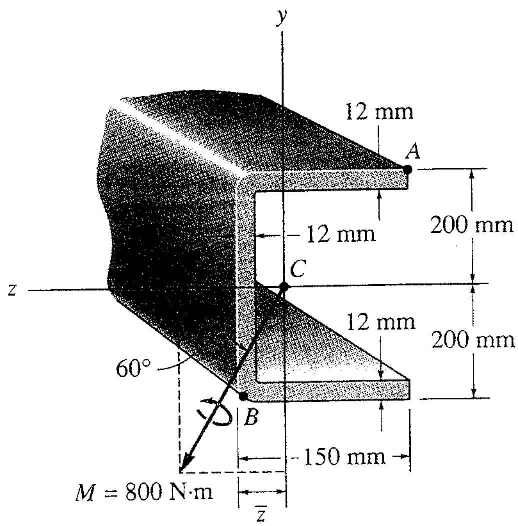
a) Determine the force in rods *AB* and *EF* caused by the increase in temperature. Rods *AB* and *EF* are made of steel, and each has a cross-sectional area of 125 mm^2. *CD* is made of aluminum and has a cross-sectional area of 375 mm^2. $E_{st} = 200$ GPa, $E_{al} = 70$ GPa, $\alpha_{al} = 23(10^{-6})/°C$, and $\alpha_{st} = 12 \times 10^{-6}/°C$.

b) Determine the force in end rods *AB* and *EF* caused by an increase in temperature from $T_1 = 30°C$ to $T_2 = 50°C$ while the centre rod assembly *CD* is heated simultaneously as described above, ie from $T_1 = 30°C$ to $T_2 = 180°C$.



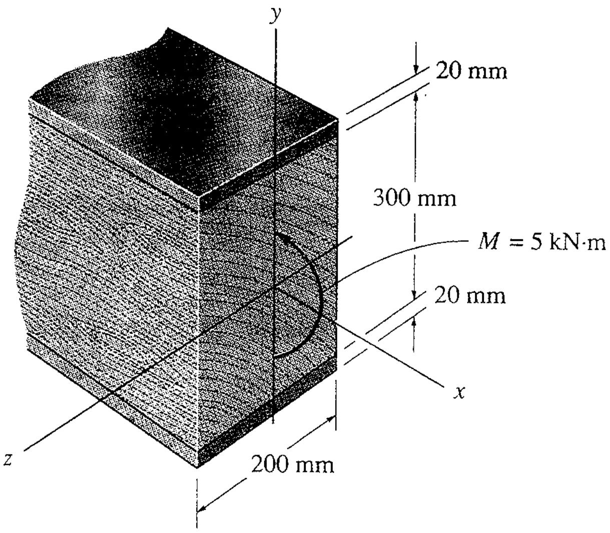
QUESTION THREE (i)

If the internal moment acting on the cross section of the strut has a magnitude of M = 800 N·m and is directed as shown, determine the bending stress at points *A* and *B*. The location $\bar{z}$ of the centroid C of the strut's cross-sectional area must be determined. Also, specify the orientation of the neutral axis.



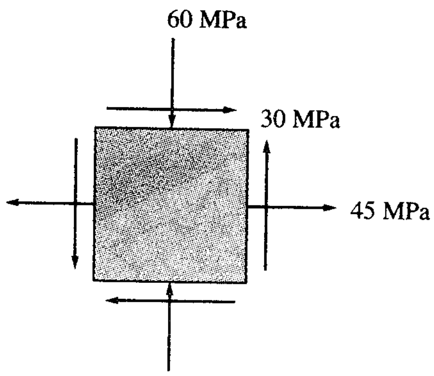
QUESTION THREE (ii)

A wooden beam is reinforced with steel straps at its top and bottom as shown. Determine the maximum stress developed in the wood and steel if the beam is subjected to a bending moment of M = 5 kN.m. Sketch the stress distribution acting over the cross section. Take E_w = 11 GPa, E_{st} = 200 GPa.



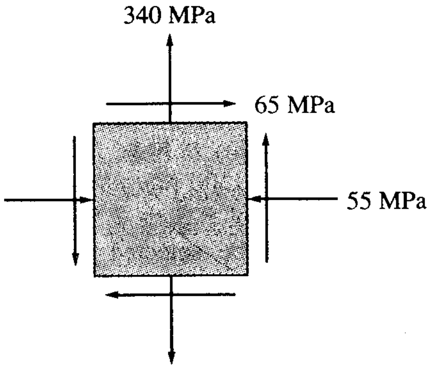
QUESTION FOUR

The state of stress at a point is shown on the element. Determine *(a)* the principal stresses and *(b)* the maximum in-plane shear stress and average normal stress on the element. Specify the orientation of the element in each case. Use the stress transformation equations and Mohr's stress circle concepts.



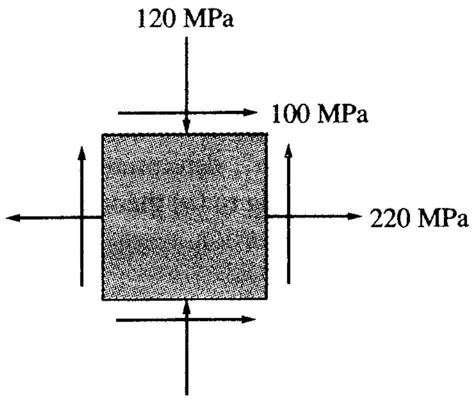
QUESTION FIVE (i)

The components of plane stress at a critical point on a thin steel shell are shown. Determine if failure (yielding) has occurred on the basis of *(a)* the maximum-shear-stress theory and *(b)* the distortion-energy theory. The yield stress for the steel is $\sigma_Y = 650$ MPa.



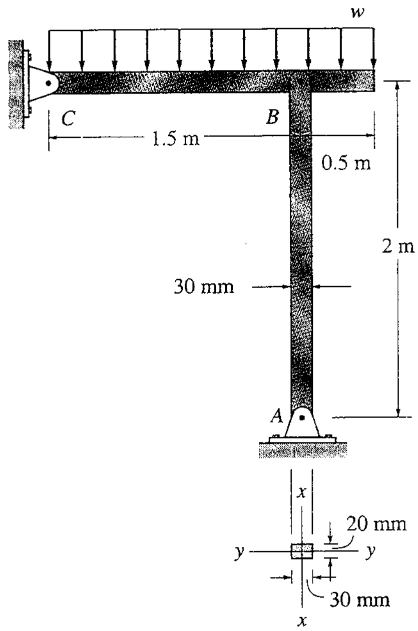
QUESTION FIVE (ii)

Cast iron when tested in tension and compression has an ultimate strength of $(\sigma_{ult})_t = 280$ MPa and $(\sigma_{ult})_c = 420$ MPa, respectively. Also, when subjected to pure torsion it can sustain an ultimate shear stress of $\tau_{ult} = 168$ MPa. Plot the Mohr's circles for each case and establish the failure envelope. If a part made of this material is subjected to the state of plane stress shown, determine if it fails according to Mohr's failure criterion.



QUESTION SIX

Determine the maximum allowable intensity w of the distributed load that can be applied to member BC without causing member AB to buckle. Assume that AB is made of steel and is pinned at its ends for $x - x$ axis buckling and fixed at its ends for y - y axis buckling. Use a factor of safety with respect to buckling of F.S. = 3. E_{st} = 200 GPa, σ_Y = 360 MPa.



QUESTION SEVEN

Answer the following question briefly.

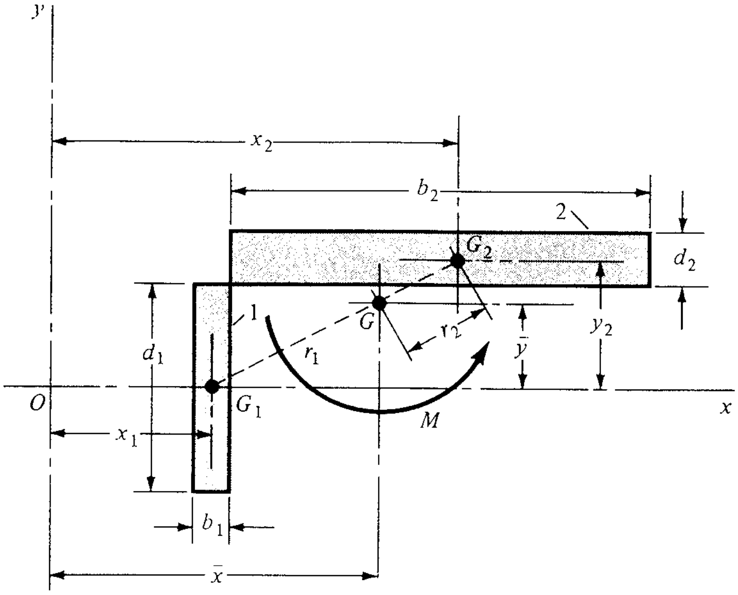
(i) Define Stress Concentration Factor and its importance in Design.

(ii) Define fatigue notch factor. Why is the fatigue notch factor lower than the theoretical stress concentration factor for a ductile material?

(iii) Define the endurance limit for stress life (S-N) curve. What are the major differences between S-N curves for a mild steel and aluminum alloy? What are the major factors that modify endurance strength? Draw the Soderberg line and modified Goodman line taking mean stress as the X axis and alternating stress amplitude as the Y axis in the 1st and 2nd quadrants only.

Question Seven Continued…

(iv) Show the normal and shear stress distribution in a fillet weld. Considering two adjacent welds from an arbitrary weld group, calculate the second polar moment of area of the weld group as shown in the figure.



END OF EXAMINATION PAPER.