THE UNIVERSITY OF ADELAIDE
DEPARTMENT OF MECHANICAL ENGINEERING

EXAMINATION FOR THE DEGREE OF B.E.

2137: STRESS ANALYSIS & DESIGN

NOVEMBER 1999

TIME: 3 HOURS

[In addition, candidates are allowed ten minutes before the examination begins, to read the paper.]

[The use of notes, textbooks and calculating devices is permitted in the examination room]

[Answer all questions. All questions carry **unequal** marks.]

[Appropriate engineering assumptions may be made for inadequate data.]

Question #1. **(Marks: 18)**

A solid steel shaft has a 100 mm diameter for 2.0 m of its length and a 50 mm diameter for the remaining 1.0 m of its length, as shown in Figure 1 below. A 100 mm long pointer CD is attached to the end of the shaft. The shaft is attached to a rigid support at the end and is subjected to a 16 kN.m torque at the right end of the 100 mm section and a 4 kN.m torque at the right end of the 50 mm section. The modulus of rigidity G of the steel is 80 GPa. Determine:

(a) The maximum shearing stress in the 50 mm section of the shaft.
(b) The maximum shearing stress in the 100 mm section of the shaft.
(c) The rotation of a cross section at B with respect to its no - load position.
(d) The movement of point D with respect to its no-load position.

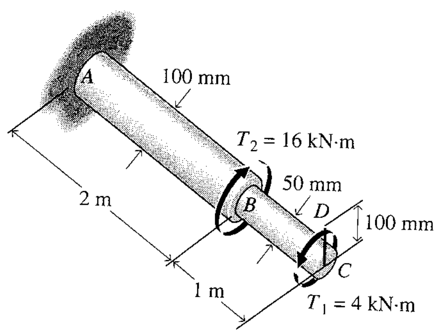

Figure 1.

Question #2 **(Marks: 8)**

A 1.5m long Brass [E=100 GPa , α= 17.6x10^{-6}/^{0}C] strap is intended to hold one side of a box together as shown in Figure 2. However, the box is slightly too large and the eyelets miss lining up by 1.0 mm.

(a) Determine how much the strap would have to be heated to lengthen the strap enough to insert the pin through the eyelets.

(b) Determine the stress that would exist in the strap after the strap (with the eyelets pinned) cooled back to room temperature.

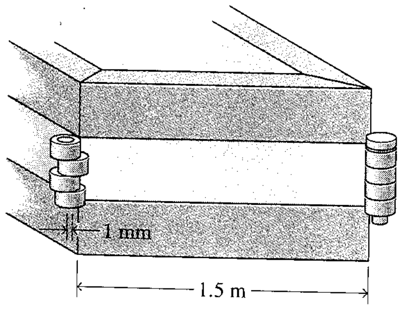

Figure 2.

Question #3. **(Marks: 15)**

At a point on the surface of an alloy steel [E=210GPa and ν= 0.30] machine part subjected to a biaxial state of stress, the measured strains were ε_x =+1394 μm, ε_y = - 660 μm and γ_{xy} = 2054 μrad. Determine:

(a) The stress components σ_x , σ_y , and τ_{xy} at that point.

(b) The principal stresses and the maximum shear stress at that point. Locate the planes on which these stresses act and show the stresses on a complete sketch.

Question #4 **(Marks: 17)**

A beam has a cross section shown in the figure below. On a section where the resisting moment is –75kN.m, determine:

(a) The maximum tensile flexural (bending) stress.
(b) The maximum compressive flexural stress.

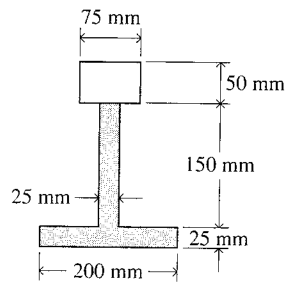

Figure Q# 4.

Question # 5. **(Marks: 17)**

At a point on the outside surface of a thin – walled pressure vessel there are normal and shearing stresses on horizontal and vertical planes through the point, as shown in Figure Q #5 below.

(a) Determine the principal stresses and the maximum shearing stresses at the point.
(b) Locate the planes on which these stresses act and show the stresses on a complete sketch.

Use **either** theoretical stress transformation equations **or** Mohr's stress circle approach.

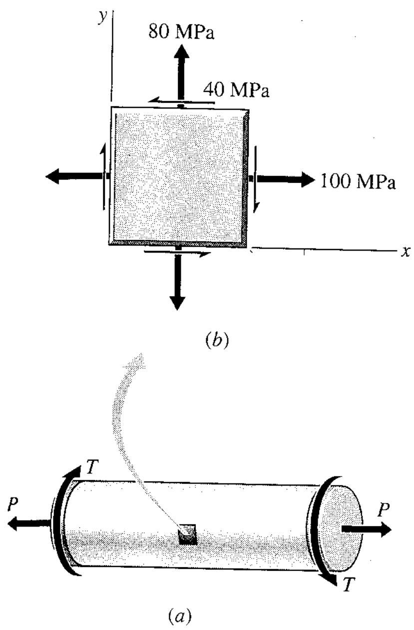

Figure Q #5.

Question#6. **(Marks: 10)**

A column of 6.0 m effective length, made of structural steel is used in an offshore platform installation. The cross section of the column is of hollow rectangular structural tube of uniform thickness as shown in the following figure. The modulus of Elasticity is 210 GPa and the yield strength of the material is 260 MPa. Determine the largest allowable compressive **centric** (load applied through the centre of gravity of the column) load ($P_{allowable}$) which may be applied to the column.

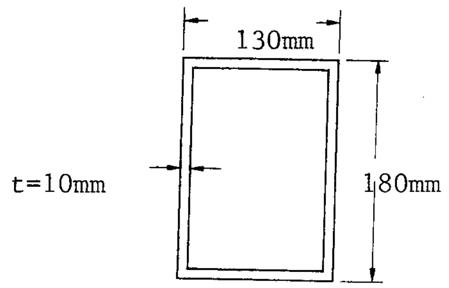

Figure Q #6.

Question#7. **(Marks: 15)**

A beam structure is composed of a circular member of diameter “d”. At a certain position along the member, the loading is found to consist of a shear force of 10 kN together with an axial tensile load of 20 kN. If the elastic limit in tension of the material of the member is 270 MN/m^2 and there is a factor of safety of 4.0, estimate the magnitude of diameter “d” required according to:

(a) the maximum principal stress theory and
(b) the maximum shear strain energy per unit volume theory.

The Poisson’s ratio $\nu = 0.283$.

END OF THE EXAMINATION