1. What is the definition of shear strain(5%)? According to the definition of shear strain, please use cylindrical coordinate r, θ, z to describe the shear strain in the torsion of a circular shaft (5%). The shaft is made of an elastic perfectly plastic material as shown in the Fig. 1. Plot the shear stress distribution acting along a radial line if it is subjected to a torque of T = 2 kN · m.(7%) What is the residual stress distribution in the shaft when the torque is removed? (8%).

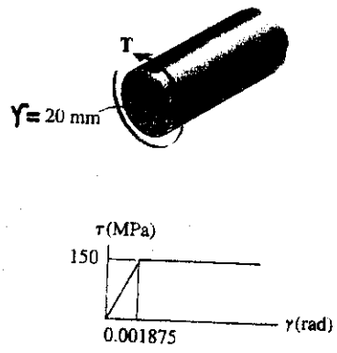

Fig. 1

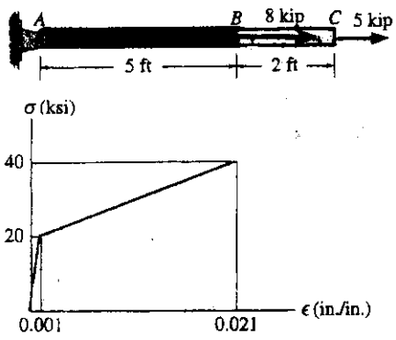

Fig. 2

2. The bar has a cross-sectional area of 0.4 in^2 and is made of a material that has a stress-strain diagram that can be approximated by the two segments shown in the Fig. 2. Determine the elongation of the bar due to the applied loading.(10%).

3. The aluminum 2014-T6 pipe CD is placed within the clamp and the screws on the clamp are tightened snug such that the axial force in the pipe in negligible. If the assembly experiences a temperature increase of $\Delta T = 50°C$, determine the average normal stress developed within the pipe and screws. Assume the heads on the clamp are rigid and the screws are made of A-36 steel. The screws have a diameter of 14 mm, and the pipe has an outer diameter of 35 mm and a wall thickness of 2 mm. $E_{st} = 200GPa$, $E_{al} = 70GPa$, $\alpha_{st} = 12(10^{-6})/°C$, $\alpha_{al} = 23(10^{-6})/°C$.(15%)

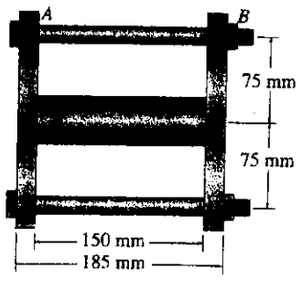

Fig. 3

(背面仍有題目,請繼續作答)

4. (a) The three-dimensional stress state of a volume element is shown in Fig. 4(a). Please derive the strain energy density, which is expressed as follow:

$$\frac{dU}{dV} = \frac{1}{2}\sigma\varepsilon + \frac{1}{2}\tau\gamma$$

where ε and γ are normal strain and shear strain, respectively. (10%)

(b) What assumptions have you made in Part (a)? (5%)

(c) Usually, we apply the following total strain energy to solve the deflection of beam problems:

$$U = \int \frac{M^2}{2EI} dx$$

where EI is the bending rigidity and M is the bending moment. Please derive the expression of U. (5%)

(d) Have we ignored some energy in Part (c)? Why? (5%)

(e) Please use Castigliano second theory to compute the maximum bending moment in the beam problem shown in Fig. 4(b). (10%)

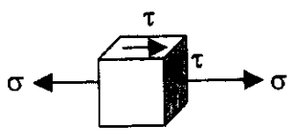

Fig. 4(a)

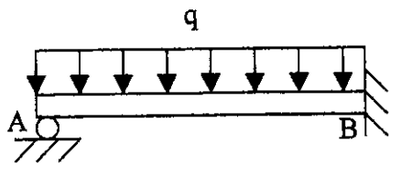

Fig. 4(b)

5. (a) Please use the maximum shearing stress theory and maximum distortional energy theory to compute the stress σ_0 of a three-dimensional stress state shown in Fig. 5 if yielding occurs. Assume that σ_Y is the yield strength. (10%)

(b) Are the values of σ_0 predicted by these two theories equal or not? Why? (5%)

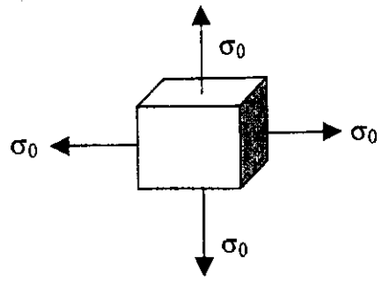

Fig. 5