1. 20%

(a) Describe the basic requirements for $\delta = \frac{PL}{EA}$ to be valid.

(b) (i) Describe the difference between $\tau = \frac{Tr}{I_p}$ and $\tau = \frac{T}{2A_m t}$.

(ii) Under what conditions both of the torsion formulas can be applied?

(c) How to modify the flexure formula $\sigma = \frac{My}{I}$ for composite beam and unsymmetric bending problems?

(d) Briefly explain the Maxwell's reciprocal theorem. Also state the basic requirements for this theorem to be valid.

(e) Which of the followings are valid for nonlinear inelastic materials. Write down your answer and explain briefly.

(i) $\epsilon_x = -\kappa y$, (ii) $\sigma_{x_1} = \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x - \sigma_y}{2}\cos 2\theta + \tau_{xy}\sin 2\theta$

(iii) $\tau = \frac{Tr}{I_p}$, (iv) The principle of virtual work

2. 20% For the two cantilever beams AB and CD, determine the deflection at end B caused by the load P. (see Figure 1)

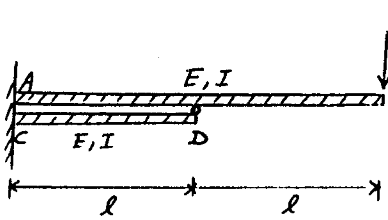


Figure 1

3. A linearly elastic simply supported beam with varying cross section as shown:
15%

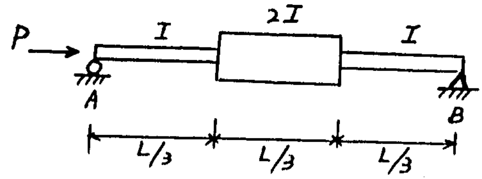


Figure 2

Assuming the beam is homogeneous with Young's modulus E, use the Rayleigh-Ritz method to determine the critical value of P that produces buckling of the pinned-end column.

Note: Rayleigh-Ritz method.

(i) assume an appropriate mode shape, for example, $\delta \sin\frac{\pi x}{L}$, satisfying geometric boundary condition, i.e., deflection is zero at A and B.

(ii) calculate the total potential energy PE, i.e.

PE = (strain energy of the structure) + (potential energy of P)

(iii) minimize total potential energy and obtain P_{cr}.

4. A thin walled z-section is shown in Figure 3. Determine the shear flow distribution due to a shear load S_y applied through the shear center of the section.
20%

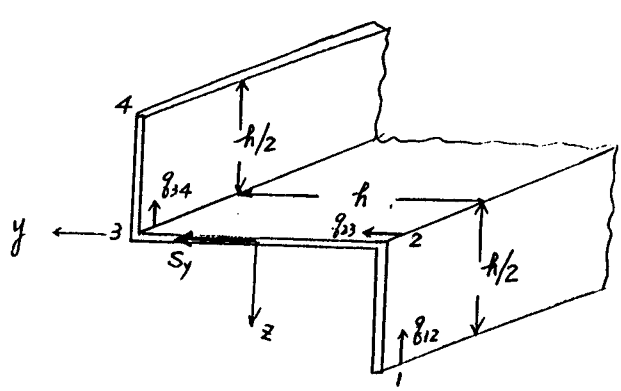


Figure 3

Thickness = t for all webs

$I_{zz} = \frac{h^3 t}{3}$, $I_{yy} = \frac{h^3 t}{12}$, $I_{yz} = \frac{h^3 t}{8}$

Note that the details of derivation for I_{zz}, I_{yy}, I_{yz} have to be shown. Shear flow notations are q_{12}, q_{23}, q_{34}.

5. A cantilever beam is loaded by its own weight q (assumed uniformly
25% distributed along the beam) and an inclined force P as shown in Figure 4.

(a) Determine the stresses at points A and B in the figure.

(b) If the allowable tensile stress and shear stress are limited to σ_0 and τ_0, respectively. Also, $L \gg d \tan\alpha$, $P\cos\alpha \gg qL$, $30^\circ < \alpha < 60^\circ$. What is the largest permissible value of the load P?

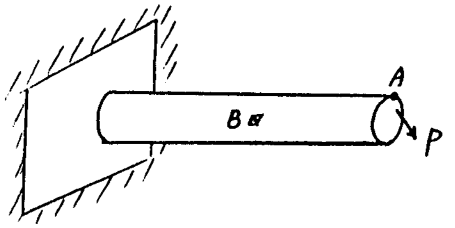
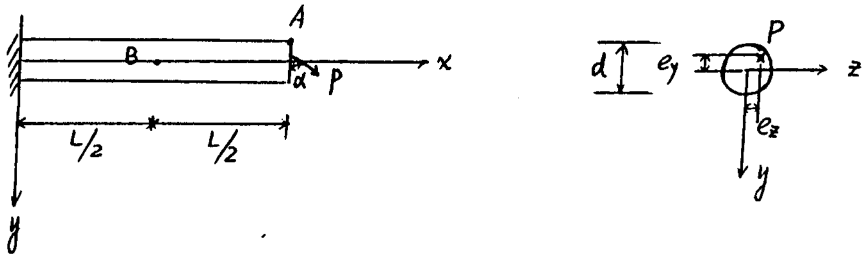


Figure 4

Side-view:



Note: * P is an eccentric inclined force parallel to x-y plane.

* Both A and B are located on the outer surface of the circular cross section.

* Express your solutions in terms of P, q, L, e_y, e_z, d, α, σ_0, τ_0.