一. Four gears are attached to a solid shaft and transmit the torques shown in the Figure 1. (20%)

(A) Determine the required diameter d_{ab}, d_{bc}, and d_{cd} for each part of the shaft if the allowable stress in shear is 10,000 psi.

(B) Determine the required diameter d_{ab}, d_{bc}, and d_{cd} for each part of the shaft if the shaft is hollow with an inside diameter of 1 in., and the allowable stress in shear is 10,000 psi.

Note: $\tau_{max} = \frac{Tr}{I_p}$　$I_p = \frac{\pi d^4}{32}$

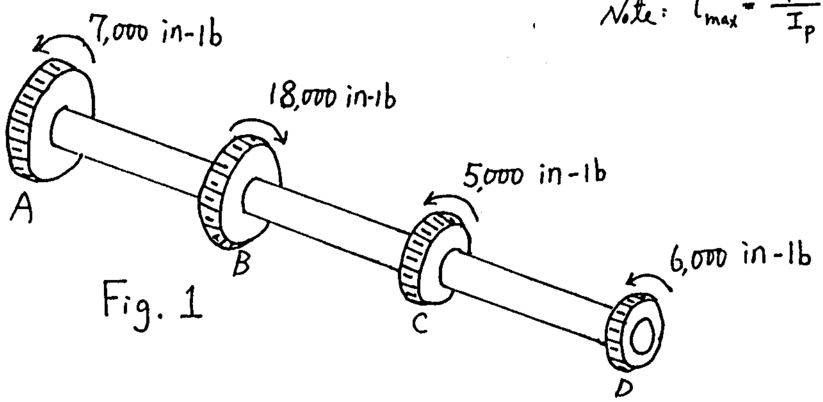

Fig. 1

二. Construct shear and moment diagrams for the beam loaded as shown in Figure 2.. You are asked to show the free-body diagrams of hypothetical segments cut at change-of-load points, equations of V and M (shear force and bending moment) for each segments (For instance, segment AB), and finally the shear and moment diagrams. (20%)

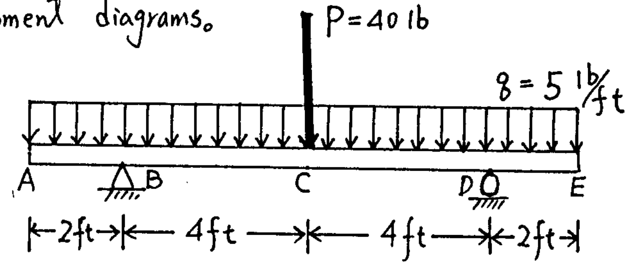

Fig. 2

三. The column shown in the Figure 3. is fixed at the base and free at the upper end. A compressive load P acts at the top of the column. Beginning with the differential equation, derive formulas for: (A) the maximum deflection δ of the column, (B) the maximum (15%)

bending moment M_{max} in the column. Note: $EIV'' = -M$.

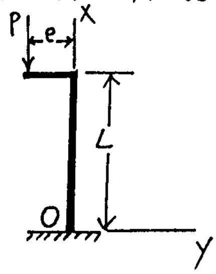

Fig. 3

四 (A) Determine the deflection δ_c at the end of the overhang for the
(30%) beam ABC shown in Figure 4.1.

(B) If an another load Q is applied at the midpoint of the beam AB as shown in Figure 4.2. Determine the ratio Q/P that will make the deflection at C equal to zero. (Assume EI is constant).

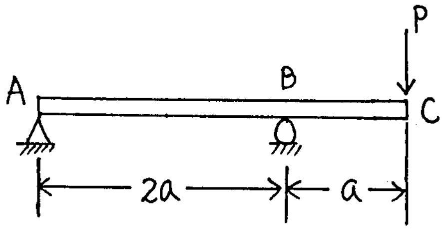

Fig. 4.1

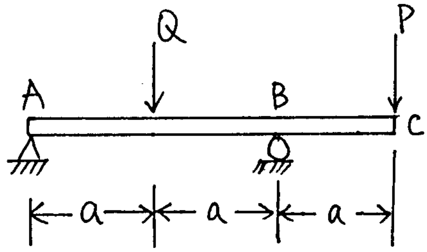

Fig. 4.2

五. A tapered cantilever beam AB of Length L has square cross section and supports a concentrated load P at the free end
(15%) shown in Figure 5. The width and height of the beam vary linearly from h_a at the free end to h_b at the fixed end. Considering only the effects of bending due to load P, determine the distance X from the free end to the cross section of maximum normal stress if $h_a = \frac{1}{2} h_b$. What is the magnitude of the maximum normal stress σ_{max}? What is the ratio of this stress to the largest stress σ_b at the support? Note: $\sigma = M/S$ $S = \frac{bh^2}{6}$ for rectangular cross section

Fig. 5