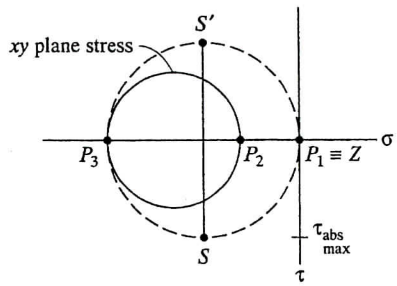
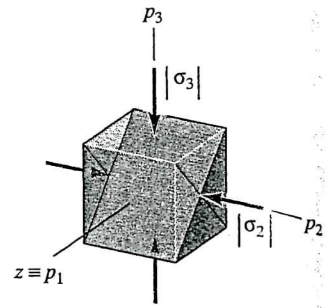
NAME:________________________________ SID #________________________

(a) Case I : Maximum **out-of-plane** shear stress (Rotation about x-axis)
(b) Case II : Maximum **in-plane** shear stress (Rotation about z-axis)
(c) Case III : Maximum **out-of-plane** shear stress (Rotation about y-axis)

(*a*) Case I, ($\sigma_3 \le \sigma_2 \le 0$)

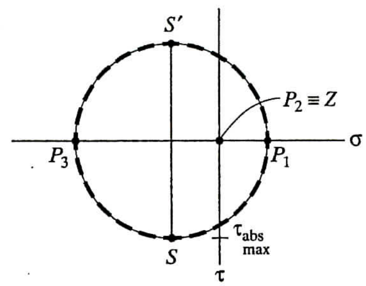


(*a*1) Mohr's circle.

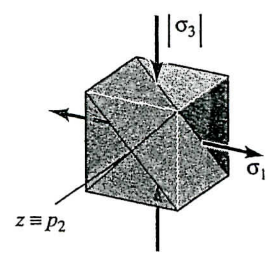


(*a*2) A maximum shear plane.

(*b*) Case II, ($\sigma_3 \le 0 \le \sigma_1$)

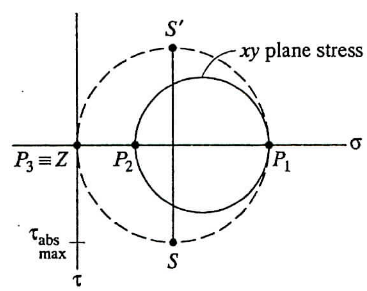


(*b*1) Mohr's circle.

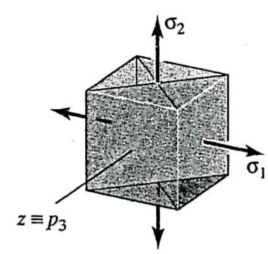


(*b*2) A maximum shear plane.

(*c*) Case III, ($0 \le \sigma_2 \le \sigma_1$)



(*c*1) Mohr's circle.

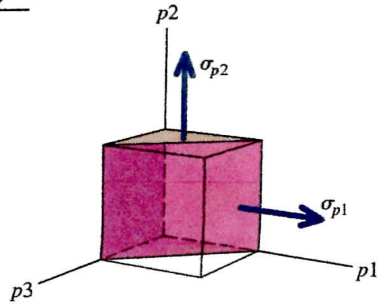


(*c*2) A maximum shear plane.

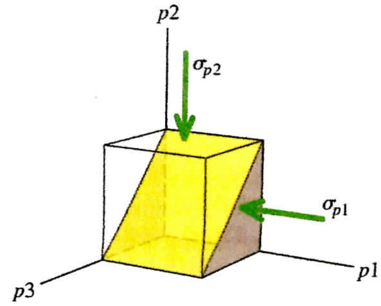
Case I ($\sigma_3 \le \sigma_2 \le 0$): $\tau_{\substack{abs\\max}} = \dfrac{-\sigma_3}{2}; \sigma_s = \dfrac{\sigma_3}{2}$

Case II ($\sigma_3 \le 0 \le \sigma_1$): $\tau_{\substack{abs\\max}} = \dfrac{\sigma_1 - \sigma_3}{2}; \sigma_s = \dfrac{\sigma_1 + \sigma_3}{2}$

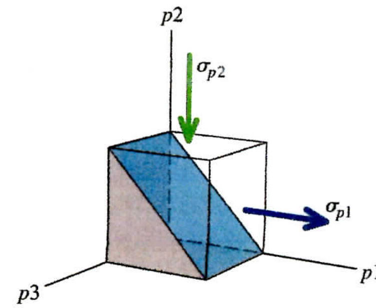
Case III ($0 \le \sigma_2 \le \sigma_1$): $\tau_{\substack{abs\\max}} = \dfrac{\sigma_1}{2}; \sigma_s = \dfrac{\sigma_1}{2}$



(a) If both σ_{p1} and σ_{p2} are positive



(b) If both σ_{p1} and σ_{p2} are negative



(c) If σ_{p1} is positive and σ_{p2} is negative

Planes of absolute maximum shear stress for plane stress.

$$\boxed{\tau_{\text{abs max}} = \frac{\sigma_{\max} - \sigma_{\min}}{2}}$$

(a) If both σ_{p1} and σ_{p2} are positive, then

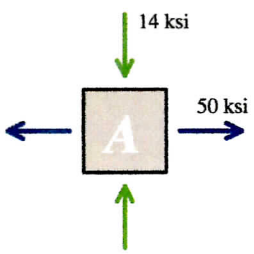
$$\tau_{\text{abs max}} = \frac{\sigma_{p1} - \sigma_{p3}}{2} = \frac{\sigma_{p1} - 0}{2} = \frac{\sigma_{p1}}{2}$$

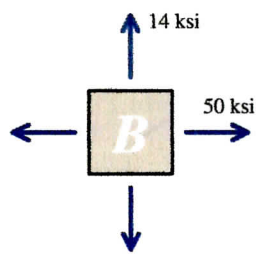
(b) If both σ_{p1} and σ_{p2} are negative, then

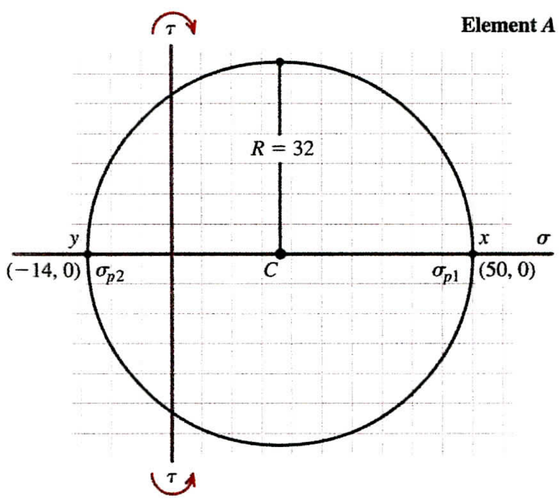
$$\tau_{\text{abs max}} = \frac{\sigma_{p3} - \sigma_{p2}}{2} = \frac{0 - \sigma_{p2}}{2} = -\frac{\sigma_{p2}}{2}$$

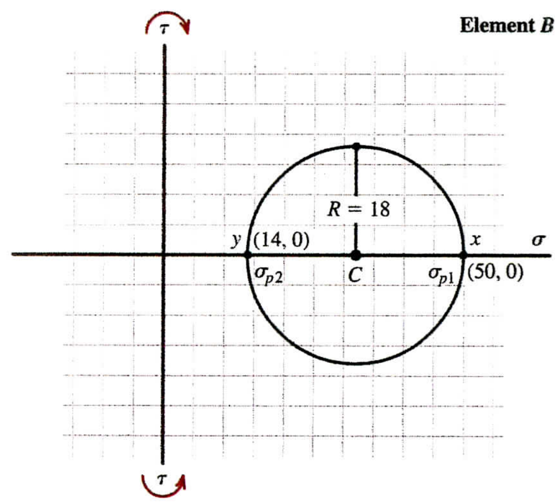
(c) If σ_{p1} is positive and σ_{p2} is negative, then

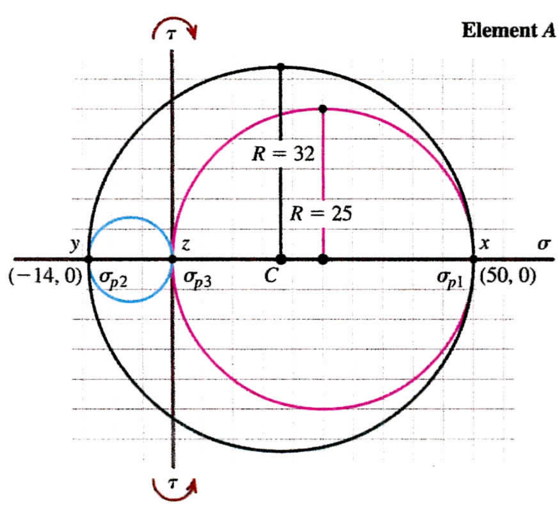
$$\tau_{\text{abs max}} = \frac{\sigma_{p1} - \sigma_{p2}}{2}$$

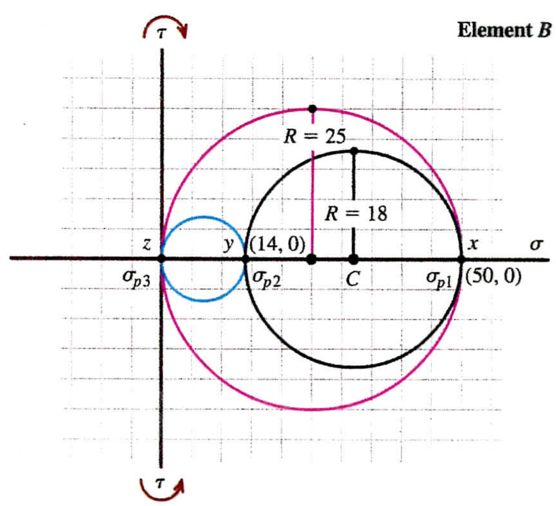


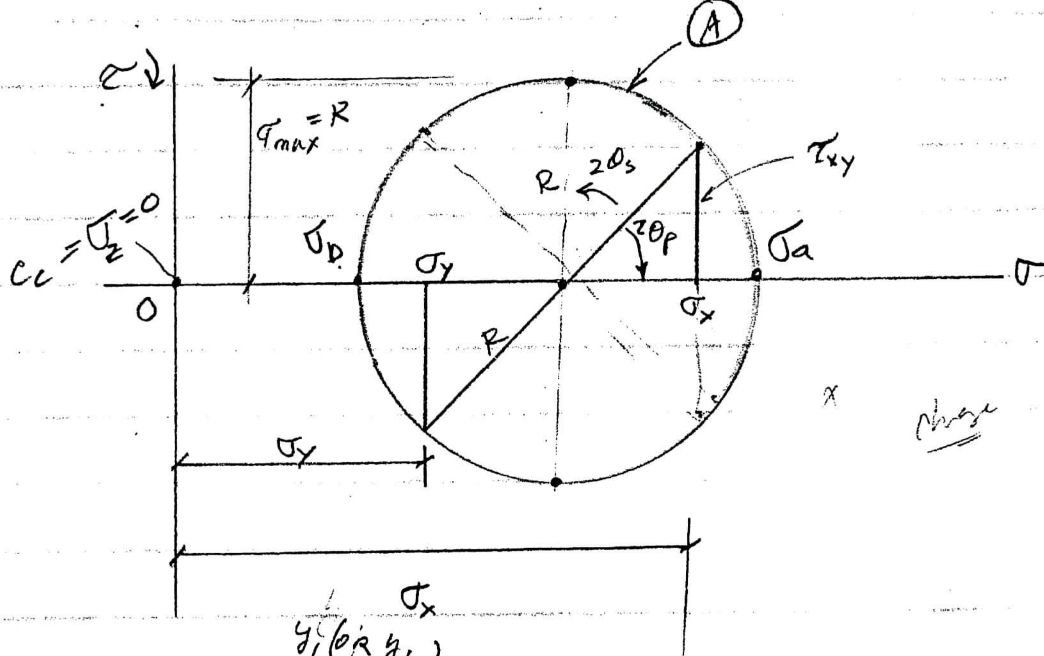


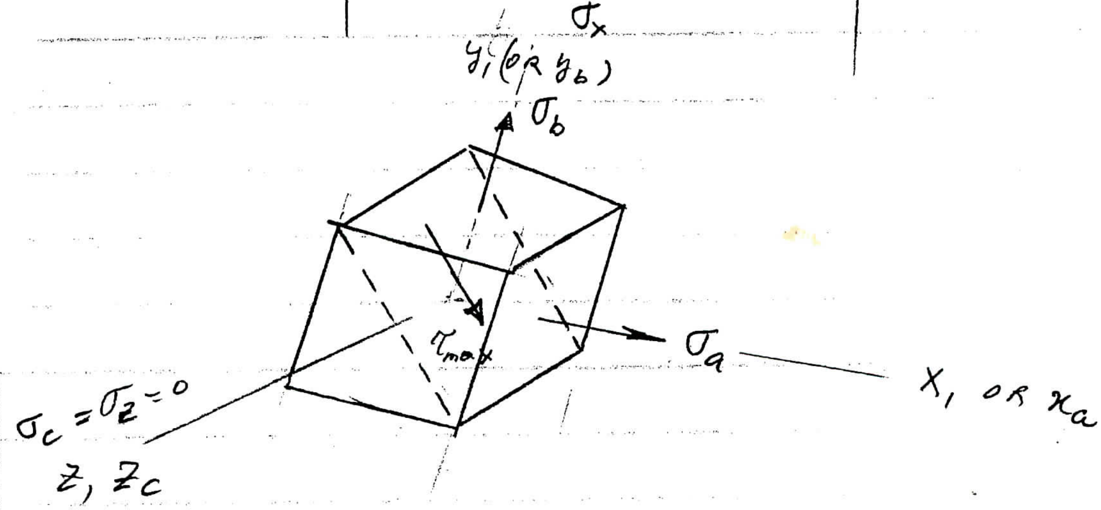








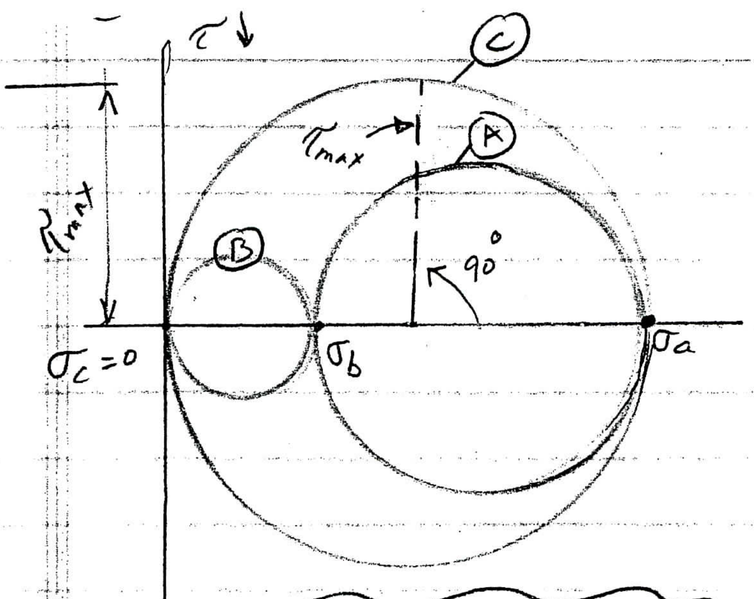


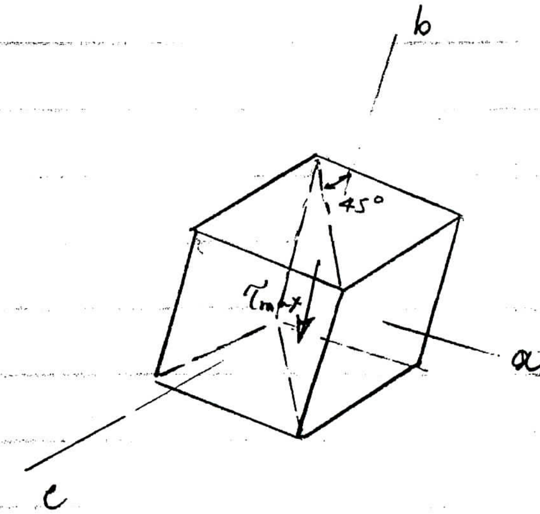


→ (τ_{max} at 45° to the principal plane) ←

Rotation is xy plane or

About z-axis



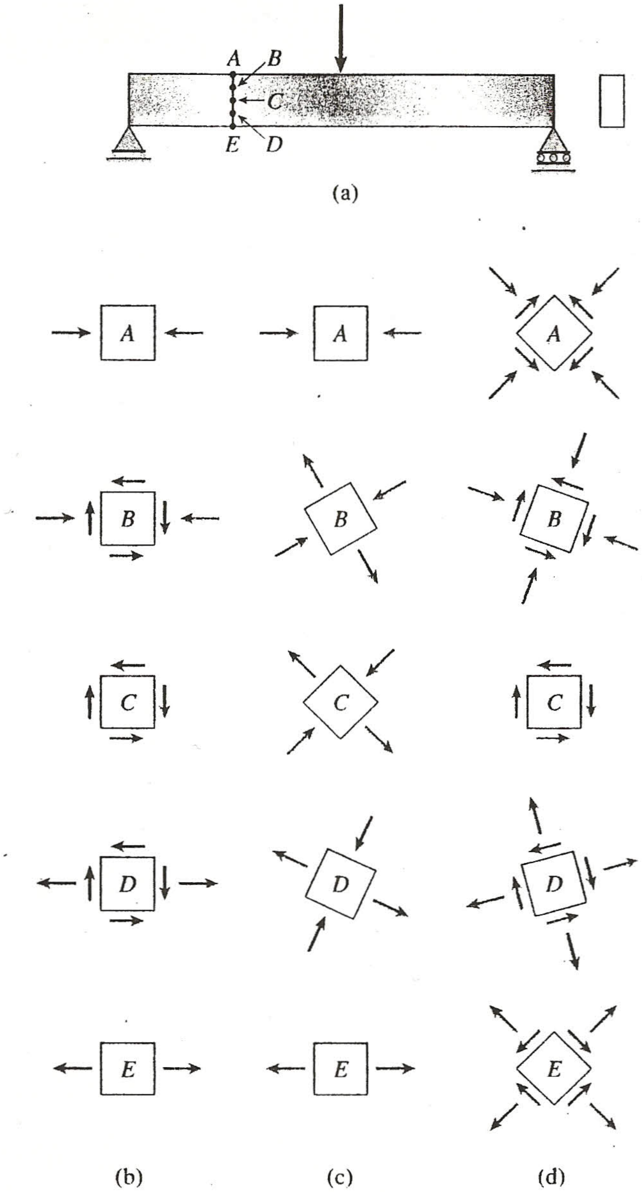


$$\boxed{\tau_{max} = R_c = \frac{1}{2}|\sigma_a|}$$

a, b & c principal axes

out-of-plane

max-shear-stress

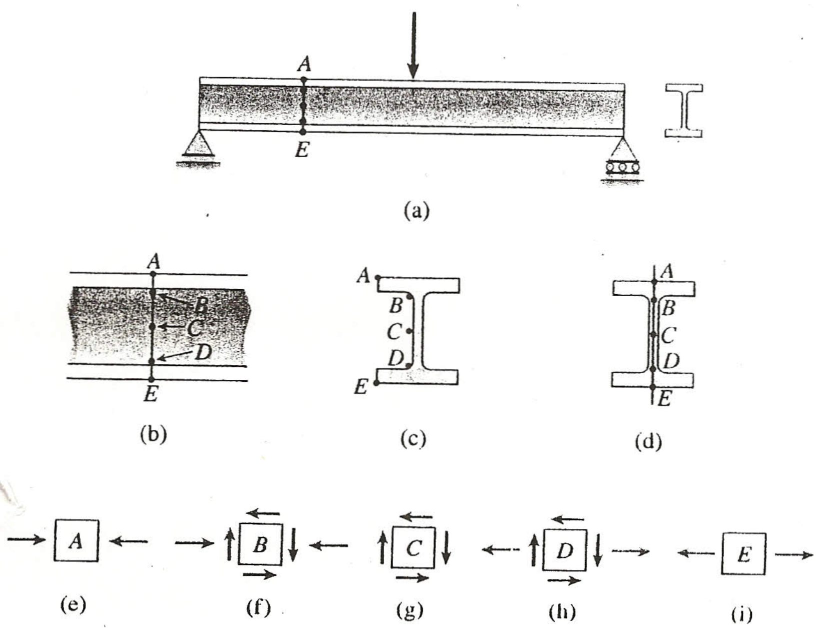


(a)- Stresses in a beam of rectangular cross section.

(b)- Normal & Shear stresses acting on stress elements at points A, B, C, D and E.

(c)- Principal Stresses.

(d)- Maximum Shear Stresses.



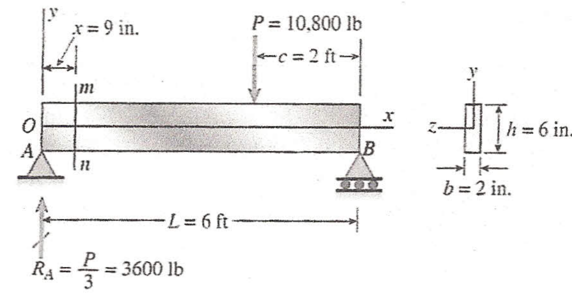
(a)- Stresses in a wide-flange beam.

(b&c)-Points to be considered.

(d)- Points can be considered along axis of symmetry.

(e to i)- Normal & Shear Stresses acting on stress elements at points A to E.

Find Principal Stresses and Absolute Maximum Shear in the cross section m-n of the beam at points A,B,C,D,E,F and G.



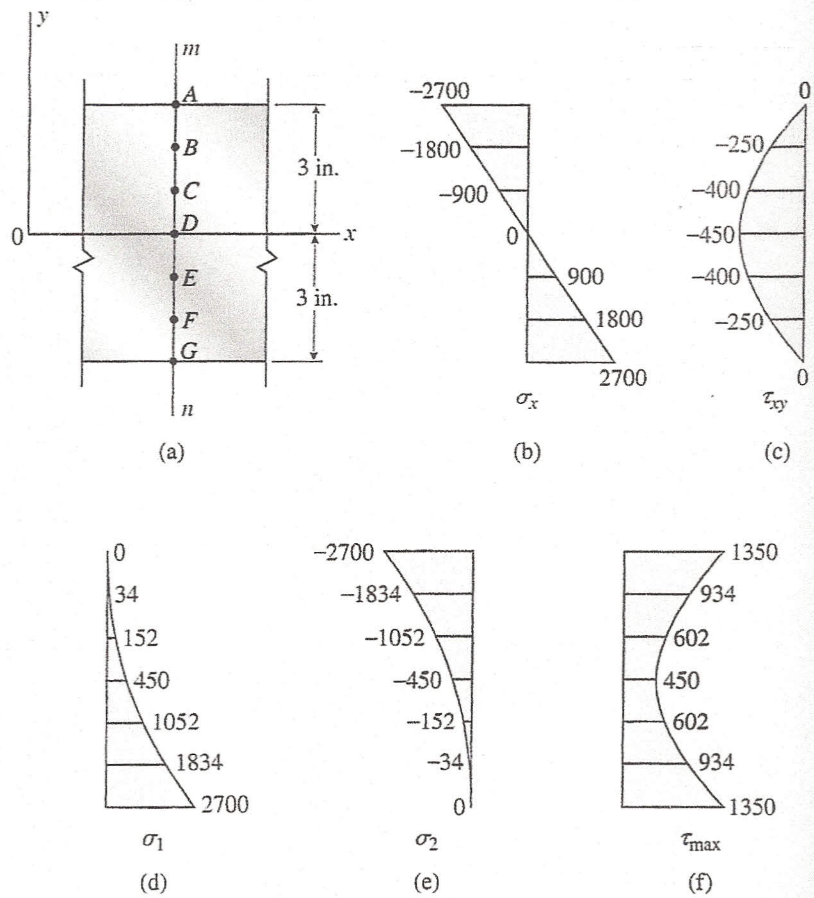


Fig. 8-19

Example 8-3: Stresses in the beam of Fig. 8-17 (a) Points *A, B, C, D, E, F,* and *G* at cross section *mn*; (b) normal stresses σ_x acting on cross section *mn*; (c) shear stresses τ_{xy} acting on cross section *mn*; (d) principal tensile stresses σ_1; (e) principal compressive stresses σ_2; and (f) maximum shear stresses τ_{max}. (*Note:* All stresses have units of psi.)

Table 8-1

Stresses at Cross Section *mn* in the Beam of Fig. 8-17

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Point	y (in.)	σ_x (psi)	τ_{xy} (psi)	σ_1 (psi)	σ_2 (psi)	τ_{max} (psi)
A	3	−2700	0	0	−2700	1350
B	2	−1800	−250	34	−1834	934
C	1	−900	−400	152	−1052	602
D	0	0	−450	450	−450	450
E	−1	900	−400	1052	−152	602
F	−2	1800	−250	1834	−34	934
G	−3	2700	0	2700	0	1350

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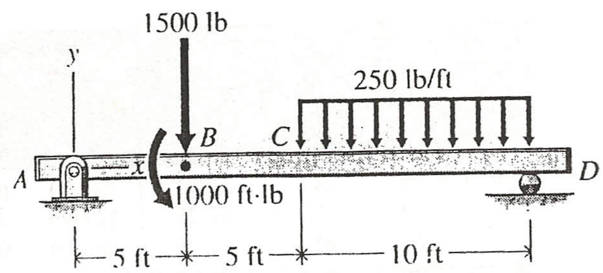
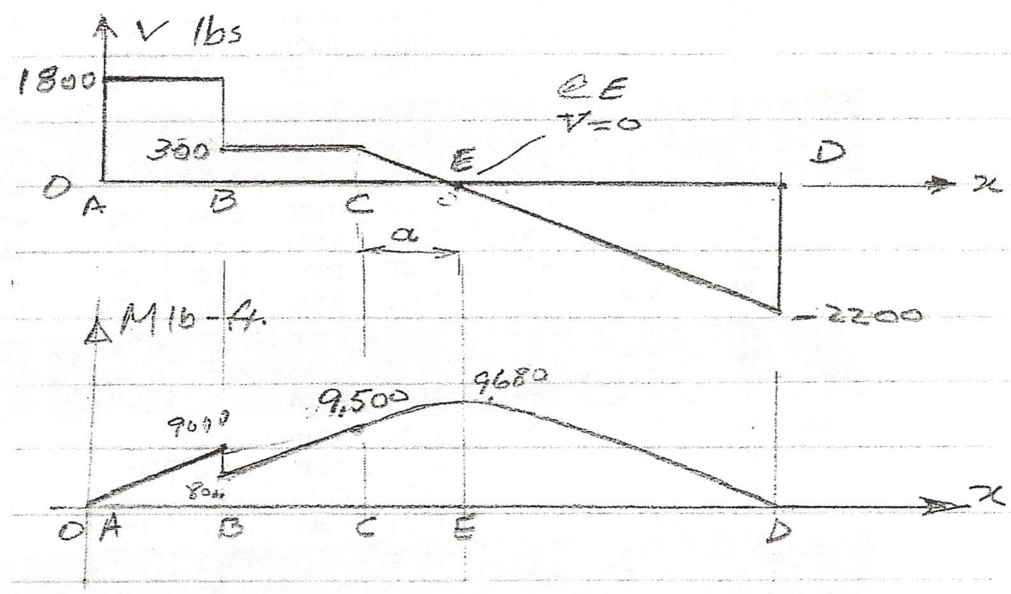
For the beam and loading shown:
a- Draw shear and moment diagram
b- Design the beam and choose a steel WF section if $\sigma_{allow} = 12\text{-ksi}$ and $\tau_{allow} = 6\text{-ksi}$
c- Check all relevant points



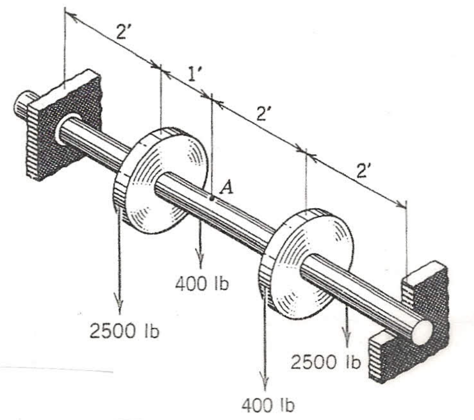


Question:

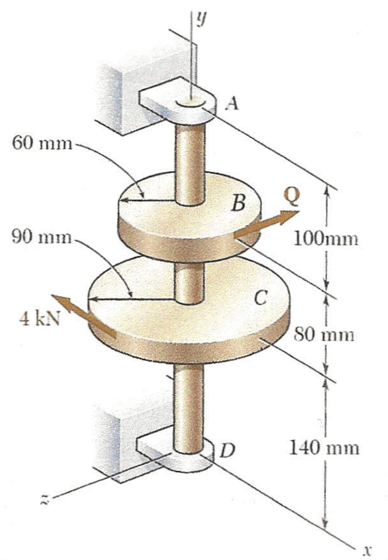
A steel solid shaft with diameter d is supported with frictionless bearings at it's ends and loaded as shown. Pulleys have 12-in radius. Knowing that $\tau_{allow} = 6\text{-ksi}$ and $\sigma_{allow} = 12\text{-ksi}$, determine:

a- the smallest permissible diameter of the shaft.

b- the state of stress at point A.



Question 1:
The 4-kN force is parallel to the x-axis and the force Q is parallel to the z-axis. The shaft AD is hollow. Knowing that the inner diameter is half the outer diameter and that $\tau_{allow} = 60$-MPa, determine the smallest permissible outer diameter of the shaft.



Question 2:
The solid shaft AB rotates at 450-rpm and transmits 20-kW from the motor M to machine tools connected to gears F and G. Knowing that $\tau_{allow} = 55$-MPa and assuming that 8-kW is taken off at gear F and 12-kW is taken off at gear G, determine the smallest permissible diameter of shaft AB.