3.11 Tension mbr., square with side h.
Required X and maximum ΔL.
First, look at mass and cost for given X.

$$\sigma = \frac{\sigma_c}{X} = \frac{P}{h^2}, \quad h^2 = \frac{PX}{\sigma_c} \quad \left(\begin{array}{l} h \text{ is geom.} \\ \text{that varies} \end{array}\right)$$

$$m = h^2 L \rho = \frac{PXL\rho}{\sigma_c} = \left[PXL\right]\left[\rho/\sigma_c\right] = f_1 f_2$$

Compare materials: $f_2 = \frac{\rho}{\sigma_c}, \frac{C_m \rho}{\sigma_c}$

Material	Modulus E, GPa	Strength σ_c, MPa	Density ρ, g/cm^3	Rel Cost C_m
1020 steel	203	260	7.9	1
4340 steel	207	1103	7.9	3
7075 Al	71	469	2.7	6
Ti-6-4	117	1185	4.5	45
PC	2.4	62	1.2	5
Pine	12.3	88	0.51	1.5
GFRP	21	380	2	10
CFRP	76	930	1.6	200

Material	Mass f_2 ρ/σ_c	Mass Rank	Cost f_2 $C_m\rho/\sigma_c$	Cost Rank
1020 steel	0.03038	8	0.0304	3
4340 steel	0.00716	6	0.0215	2
7075 Al	0.00576	4	0.0345	4
Ti-6-4	0.00380	2	0.1709	7
PC	0.01935	7	0.0968	6
Pine	0.00580	5	0.0087	1
GFRP	0.00526	3	0.0526	5
CFRP	0.00172	1	0.3441	8

(3.11, p.2)

Second, look at mass and cost for given maximum ΔL. From Fig. A.1(a):

$$\Delta L = \frac{PL}{AE} = \frac{PL}{h^2 E}, \quad h^2 = \frac{PL}{\Delta L E} .$$

h is again the geometry that varies,

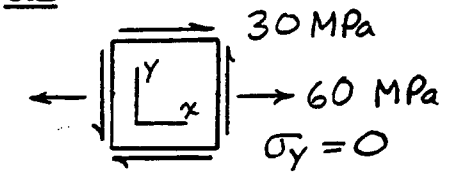
$$m = h^2 L \rho = \frac{PL^2 \rho}{\Delta L E} = \left[\frac{PL^2}{\Delta L}\right]\left[\frac{\rho}{E}\right] = f_1 f_2$$

Compare materials: $f_2 = \frac{\rho}{E}, \frac{C_m \rho}{E}$

Material	Mass f_2 ρ/E	Mass Rank	Cost f_2 $C_m\rho/E$	Cost Rank
1020 steel	0.0389	5	0.0389	1
4340 steel	0.0382	3	0.1145	3
7075 Al	0.0380	2	0.2282	4
Ti-6-4	0.0385	4	1.7308	6
PC	0.5000	8	2.5000	7
Pine	0.0415	6	0.0622	2
GFRP	0.0952	7	0.9524	5
CFRP	0.0211	1	4.2105	8

If cost is unimportant, CFRP is the clear choice. 7075 Al is a good compromise considering cost, and is resistant to corrosion and rot. ◀

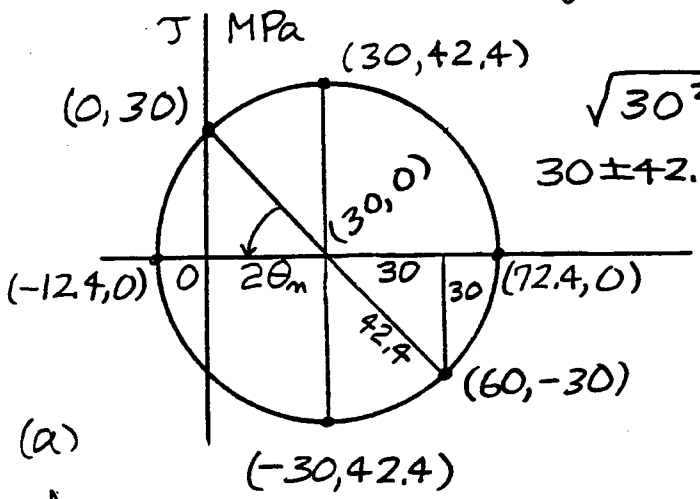
6.2



$\tan 2\theta_m = \frac{30}{30}$

$\theta_m = 22.5°$ ↺

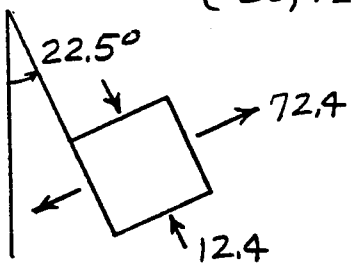
$\theta_s = 45 - \theta_m = 22.5°$ ↻

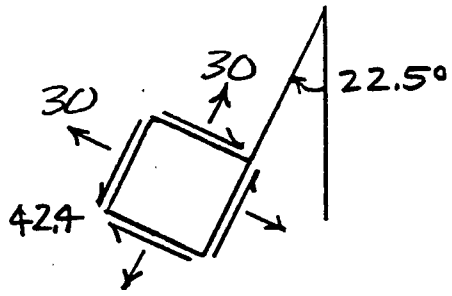


$\sqrt{30^2+30^2} = 42.4$

$30 \pm 42.4 = 72.4, -12.4$

(a)





$\sigma_1, \sigma_2 = 72.4, -12.4$ MPa, $T_3 = 42.4$ MPa ◀

(b) $\sigma_3 = 0$

$$T_{max} = MAX\left(\frac{|\sigma_1 - \sigma_2|}{2}, \frac{|\sigma_2 - \sigma_3|}{2}, \frac{|\sigma_3 - \sigma_1|}{2}\right)$$

$T_{max} = MAX\,(42.4, 6.2, 36.2) = 42.4$ MPa ◀