1. Dowling 1.6

Failures could be due to corrosion from salt water or fatigue from cyclic loading.
Redesign steps:

- Select new material that is more corrosion/fatigue resistant
- Perform analysis for stresses and fatigue
- Make and test prototype components (reduces costs over testing full assembly)
    - Durability testing for corrosion as well as look for stress concentrations
- Incorporate safety factors and/or life factor into analysis

3.11 Cantilever beam, circular cross sec.

$$v_{max} = \frac{PL^3}{3EI}, \quad I = \frac{\pi r^4}{4} \quad \text{(Figs. A.4, A.2)}$$

Requirements: L, P, v_{max}

Geometry: r Material: ρ, E

Minimize: (a) $m = \pi r^2 L \rho$

(b) cost, $C_m m$

$$v_{max} = \frac{PL^3}{3E}\frac{4}{\pi r^4}, \quad r^2 = \left(\frac{4PL^3}{3\pi E v_{max}}\right)^{0.5}$$

$$m = \pi L \rho \left(\frac{4PL^3}{3\pi E v_{max}}\right)^{0.5} = f_1(\text{Req.})\, f_2(\text{Mat'l.})$$

$$m = \left[2L^{2.5}\left(\frac{\pi P}{3 v_{max}}\right)^{0.5}\right]\left[\frac{\rho}{\sqrt{E}}\right] = f_1 f_2$$

For the Table 3.13 materials, use the properties given to calculate:

(a) $f_2 = \rho/\sqrt{E}$, (b) $f_2 = C_m \rho/\sqrt{E}$

(a)

Material	Modulus E, GPa	Density ρ, g/cm^3	Mass f_2 $\rho/E^{0.5}$	Mass Rank
1020 steel	203	7.9	0.554	7
4340 steel	207	7.9	0.549	6
7075 Al	71	2.7	0.320	3
Ti-6-4	117	4.5	0.416	4
PC	2.4	1.2	0.775	8
Pine	12.3	0.51	0.145	1
GFRP	21	2.0	0.436	5
CFRP	76	1.6	0.184	2

(3.11, p.2)

Pine has the lowest mass, and CFRP the second lowest. ◀

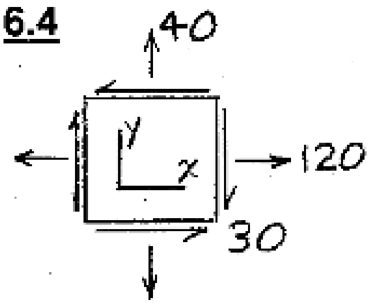
(b)

Material	Rel Cost C_m	Cost f_2 $C_m \rho / E^{0.5}$	Cost Rank
1020 steel	1	0.554	2
4340 steel	3	1.647	3
7075 Al	6	1.923	4
Ti-6-4	45	18.721	7
PC	5	3.873	5
Pine	1.5	0.218	1
GFRP	10	4.364	6
CFRP	200	36.707	8

Pine also has the lowest cost, but now 1020 steel is second. ◀

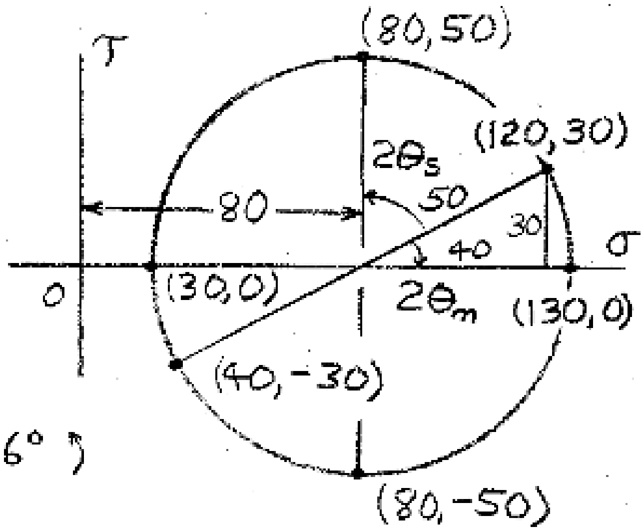
(c) If pine is suitable, it is the clear choice. If not, then 7075 Al or 4340 steel might be reasonable. ◀

6.4



$\sigma_x = 120,\ \sigma_y = 40$ MPa

$\tau_{xy} = -30$ MPa

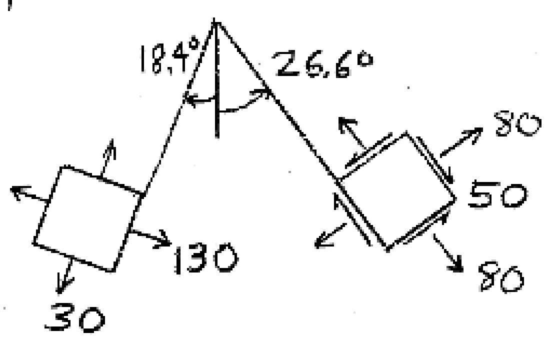


$\tan 2\theta_n = \frac{30}{40}$

$\theta_n = 18.4°$ ↻

$\theta_s = 45 - 18.4 = 26.6°$ ↺

(a)



$\sigma_1, \sigma_2 = 130, 30$ MPa ◀

$\tau_3 = 50$ MPa

(τ_3 is not τ_{max})

$\sigma_3 = 0$

(b) $\sigma_3 = 0$

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

$\tau_{max} = MAX(15, 65, 50) = 65$ MPa ◀

$\sigma_{max} = 130$ MPa ◀