

A5: Bracket Design

Safety Factor = 4

$200 \text{ lbf} < F < 300 \text{ lbf}$

Assume no failure due to direct shear stress

HDPE, Torlon[®] PAI, or Nylon

not enough info

higher E
higher strength
lower elongation %

lower E
lower strength
higher elongation %

winner

Torlon[®] PAI

$E = 600,000 \text{ psi}$

Tensile strength = $20,000 \text{ psi}$

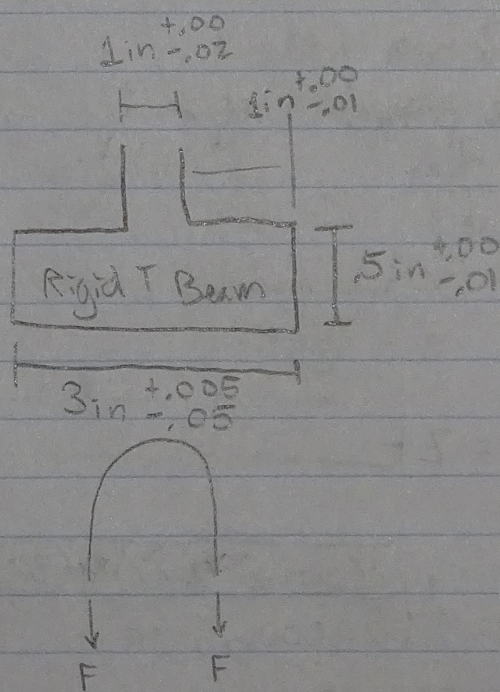


Figure 1)

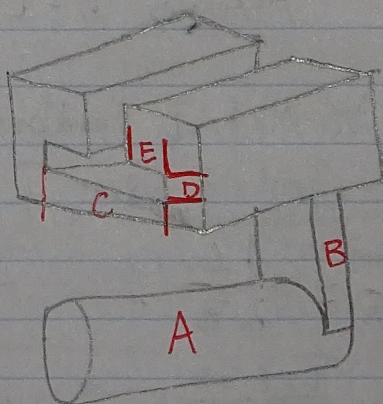
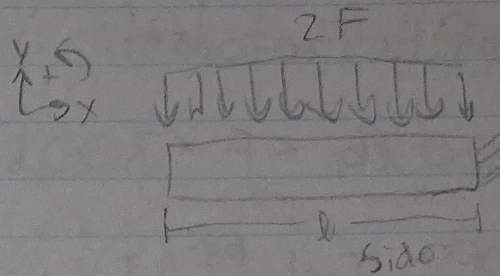
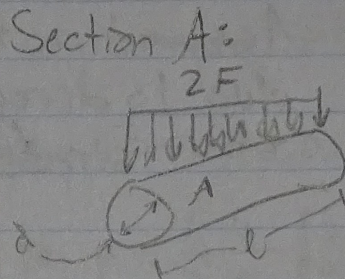


Figure 2)
from Appendix C

Stress Analyses



Model as cantilever beam

Known

$$F = 250 \text{ lbf}$$

$$E = 600 \text{ ksi}$$

$$\sigma_{\text{yield}} = 20 \text{ ksi}$$

$$SF = 4$$

Unknown

d

Area

Assume no shear failure

$l > \text{width of uline polyester strip} > 3/4 \text{ in}$

Assume $l = 1 \text{ in}$

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Section modulus circle ϕ

$$Z = \frac{\pi d^3}{32}$$

$$\frac{\sigma}{SF} = \frac{W l}{Z}$$

$$W = 2F$$

$$Z = \frac{W l SF}{\sigma}$$

$$d = \sqrt[3]{\frac{2(250 \text{ lbf})(1 \text{ in})(4)(32)}{(20,000 \text{ psi}) \pi}}$$

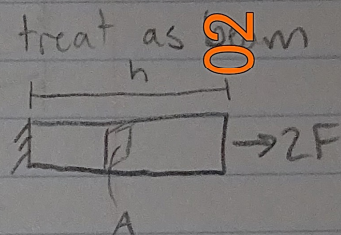
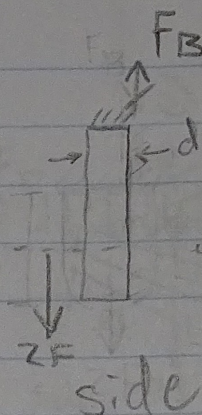
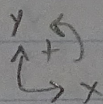
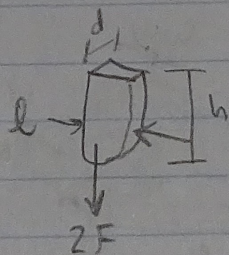
$$\frac{\pi d^3}{32} = \frac{2F l SF}{\sigma}$$

$$d = 1.006 \text{ in}$$

$$d = \sqrt[3]{\frac{2F l SF 32}{\sigma \pi}}$$

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Section B:

known

$F = 250 \text{ lbf}$

$F_B = 2F$

$\sigma = 20 \text{ ksi}$

unknown d d h

Assume no shear failure

Model as cantilever beam

Assume $l = \phi_A = 1.006 \text{ in}$ Assume $A = d \cdot l$

Assume

 $h = \phi_A + \text{clearance}$ $\therefore h \approx 1.25 \text{ in}$

Model as a rod in tension

Assume $h > \phi_A$ Set arbitrary h at $1.25''$

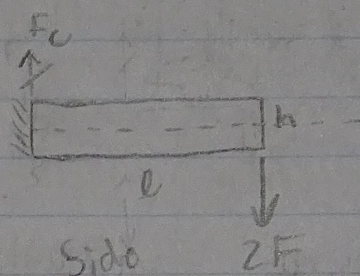
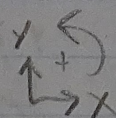
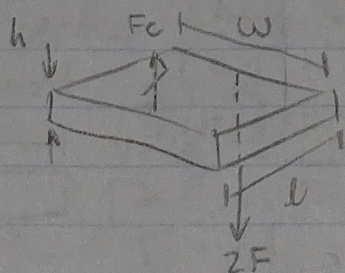
$$\frac{\sigma}{SF} = \frac{F}{A} = \frac{2F}{d \cdot l}$$

$$d = \frac{2F \cdot SF}{l \cdot \sigma}$$

$$d = \frac{2(250 \text{ lbf}) \cdot 4}{(1.006)(20,000 \text{ psi})}$$

$$d = 0.0994 \text{ in}$$

Section C:

known

$F = 250 \text{ lbf}$

$\sigma = 20 \text{ ksi}$

$SF = 4$

unknown

h

w

l

Model as cantilever beam

Assume no shear failure

Assume $l \geq \text{Section A} = 1 \text{ in}$ Assume $w \geq \text{width of T-beam} = 3 \text{ in} + .005$ Assume $w = 3.50 \text{ in}$ (fit .25 on each side
4.00 in for 1/2 in on each side)

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$$\frac{\sigma}{SF} = \frac{Wl}{Z}$$

$$Z = \frac{bd^2}{6}$$

$$\begin{aligned} d &= h \\ b &= w \end{aligned}$$

$$Z = \frac{Wl}{\sigma SF}$$

$$\frac{wh^2}{6} = \frac{2FlSF}{\sigma}$$

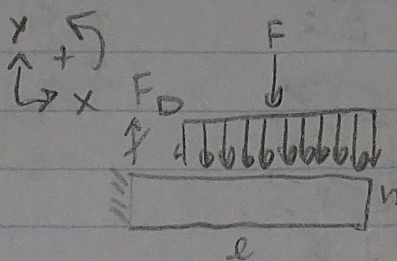
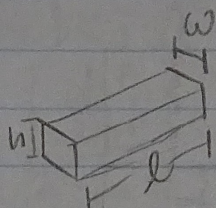
$$h = \sqrt{\frac{2(250 \text{ lbf})(1.00 \text{ in})(4)6}{(20,000 \text{ psi})(4.00 \text{ in})}}$$

$$h = \sqrt{\frac{2FlSF}{\sigma w}}$$

$$h = 0.387 \text{ in}$$

$$h = 0.387 \text{ in}$$

Section D:



side view

known

$F = 250 \text{ lbf}$

$SF = 4$

$\sigma = 20 \text{ ksi}$

unknown

l

h

w

Assume no shear failure

Model as cantilever beam

Assume $l = 1 \text{ in}$ Assume $h = 0.60$ - flange height + clearanceTarget $w < 0.5 \text{ in}$

$$\frac{\sigma}{SF} = \frac{Wl}{Iz}$$

$$I = \frac{bd^3}{12} \quad \begin{matrix} d=h \\ b=w \end{matrix}$$

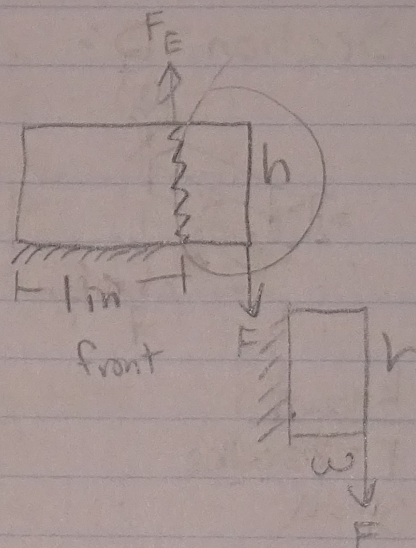
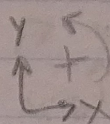
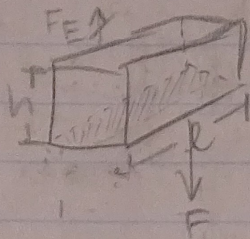
$$I = \frac{F l SF}{\sigma} = \frac{w h^3}{12}$$

$$w = \frac{F l SF}{\sigma h^3}$$

$$w = \frac{(250 \text{ lbf})(1.00 \text{ in})(4)}{(20,000 \text{ psi})(0.60)^3}$$

$$w = 0.417 \text{ in}$$

Section E:

known

$F = 250 \text{ lbf}$

$SF = 4$

$\sigma = 20 \text{ ksi}$

unknown

h

w

l

Assume no shear failure

Assume $l = 1.00 \text{ in}$ Assume $w = 0.417 \text{ in}$ same as width of D
model as cantilever

$$\frac{\sigma}{SF} = \frac{Wl}{Z} \quad l = w$$

$$Z = \frac{bd^2}{6} \quad d = h \quad b = l$$

$W = F$

$$\frac{\sigma}{SF} = \frac{Fw}{Z} \quad Z = \frac{lh^2}{6}$$

$$h = \sqrt{\frac{Fw SF 6}{\sigma l}}$$

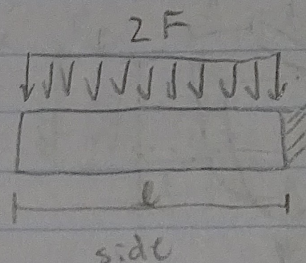
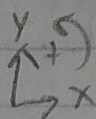
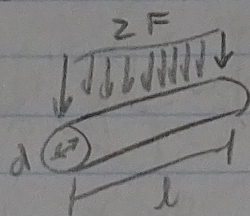
$$h = \sqrt{\frac{(250 \text{ lbf})(0.417 \text{ in})(4)6}{(20,000 \text{ psi})(1.00 \text{ in})}}$$

$$h = 0.354 \text{ in}$$

Stiffness Analyses

$$\delta_{max} = 0.005 \text{ in}$$

Section A



Known

$$\delta_{max} = 0.005''$$

$$E = 600 \text{ ksi}$$

$$F = 250 \text{ lbf}$$

$$SF = 4$$

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Unknown

$$l$$

$$d$$

Assume shear deflection negligible

Assume $l = 1 \text{ in}$

$$\delta = \frac{W l^3}{8 E I}$$

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$$I = \frac{\pi d^4}{64}$$

$$I = \frac{W l^3 SF}{8 E \delta} = \frac{\pi d^4}{64}$$

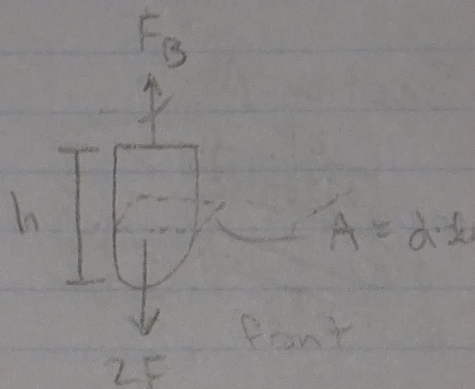
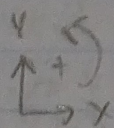
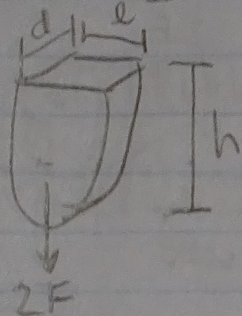
$$d = \sqrt[4]{\frac{(2F) l^3 SF}{8 E \delta_{max} \pi}}$$

$$d = \sqrt[4]{\frac{2(250 \text{ lbf})(1)^3(4)(64)}{8(600,000 \text{ psi})(0.005)\pi}}$$

$$d = 1.52 \text{ in}$$

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Section B:

known

$F = 250 \text{ lbf}$

$SF = 4$

$E = 600 \text{ ksi}$

unknown

d

l

h

Assume negligible shear

Model as rod in tension

Assume $l = \phi_A = 1.52 \text{ in}$ Assume $h > 1.52 \text{ in}$ add $\sim 1/4''$ for clearance say $h = 1.75''$

$$\sigma_{\max} = \frac{Pl}{AE}$$

$P = 2F$

$l = h$

$A = d \cdot l$

$$\frac{\sigma}{SF} = \frac{2Fh}{d l E}$$

$$d = \frac{2(250 \text{ lbf})(1.75 \text{ in})(4)}{(0.005 \text{ in})(1.52 \text{ in})(600,000 \text{ psi})}$$

$$d = \frac{2Fh SF}{\sigma l E}$$

$$d = 0.768 \text{ in}$$

ideally $d \leq 1/4''$

but cannot be done

easily w/ this mode

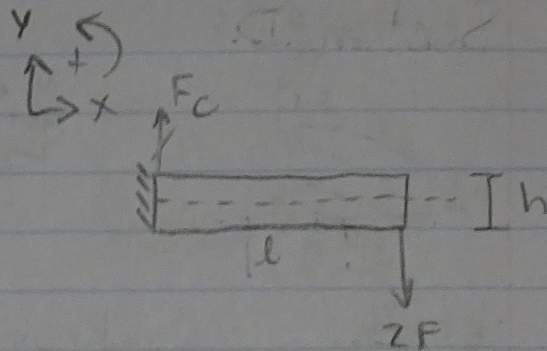
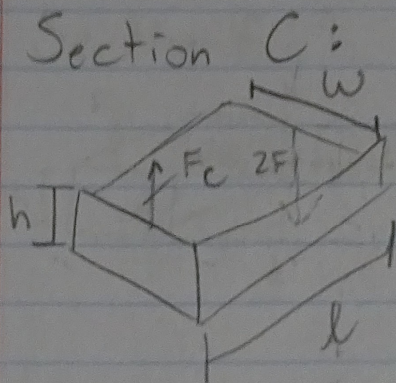
 h is limited by ϕ_A l should be limited by ϕ_A but mostly by CW

$$\sigma = \frac{F}{A}$$

$$\sigma = \frac{F l}{A l}$$

$$\sigma = \frac{F l}{A l}$$

$$\sigma = \frac{F l}{A l}$$



known

$$F = 250 \text{ lbf}$$

$$E = 600 \text{ ksi}$$

$$SF = 4$$

unknown

h

w

l

Assume negligible shear

Model as cantilever beam

Assume $l \approx \text{Section } A_e = 1 \text{ in}$

Assume $w > \text{width of T beam} + 1/2 \text{ for each D section}$

Assume $w = 4.00 \text{ in}$

$$\frac{\delta}{SF} = \frac{Wl^3}{3EI}$$

$$W = 2F$$

$$I = \frac{bh^3}{12}$$

$$b = w$$

$$I = \frac{(2F)l^3 SF}{3E\delta} = \frac{wh^3}{12}$$

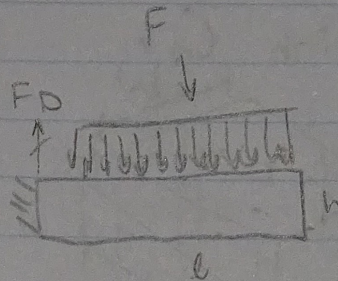
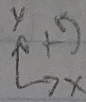
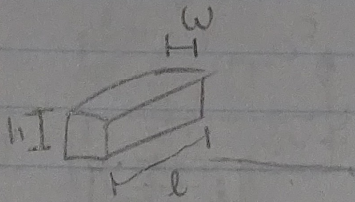
$$h = \sqrt[3]{\frac{2(250 \text{ lbf})(1)^3(4)12}{3(600,000 \text{ psi})(.005)(1 \text{ in})}}$$

$$h = \sqrt[3]{\frac{2Fl^3 SF \cdot 12}{3E\delta w}}$$

$$h = 0.874 \text{ in}$$

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Section D:

Known

$F = 250 \text{ lbf}$

$SF = 4$

$E = 600 \text{ ksi}$

unknown

h

w

l

Assume negligible shear

Model as cant. beam

Assume $l = 1 \text{ in}$ Assume $h = 0.60 \text{ in}$ Target $w < 0.5 \text{ in}$

$$\delta = \frac{wl^3}{8EI}$$

$$I = \frac{bh^3}{12} \quad b = w$$

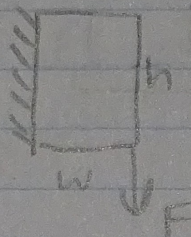
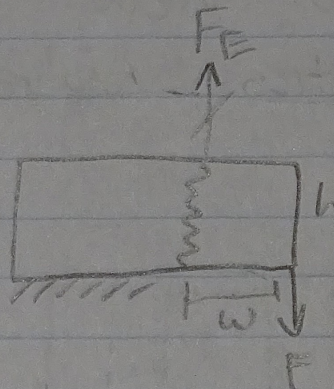
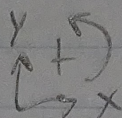
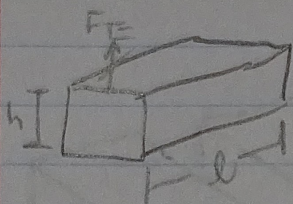
$$I = \frac{Fl^3}{8SE} = \frac{wh^3}{12}$$

$$w = \frac{(250 \text{ lbf})(1 \text{ in})^3}{8(600 \text{ ksi})(600 \text{ psi})(0.60)^2}$$

$$w = \frac{Fl^3 12}{8SEh^2}$$

$$w = 0.347 \text{ in}$$

Section E:

known

$F = 250 \text{ lbf}$

$SF = 4$

$E = 600 \text{ ksi}$

unknown h w l

Assume negligible shear

Model as cantilever

Assume $l = 1 \text{ in}$ Assume $w = 0.347 \text{ in}$

$$\frac{\delta}{SF} = \frac{wl^3}{3EI} \quad \begin{matrix} w=F \\ l=w \end{matrix}$$

$$I = \frac{Fw^3}{3ES\delta} = \frac{lh^3}{12}$$

$$I = \frac{bh^3}{12} \quad b=l$$

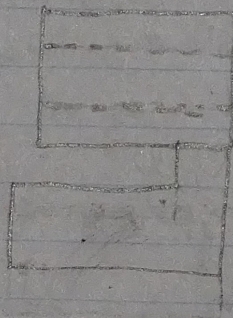
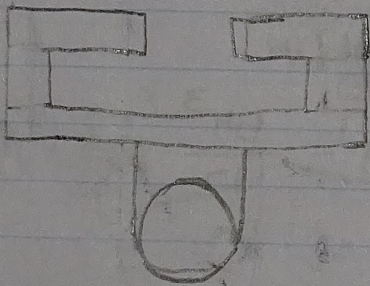
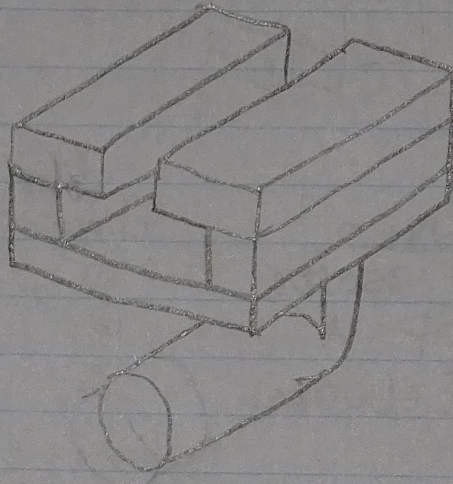
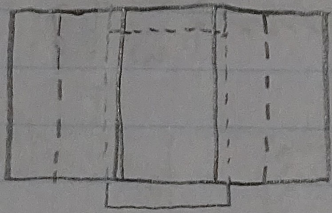
$$h = \sqrt[3]{\frac{(250 \text{ lbf})(.347 \text{ in})^3 12}{3(600,000 \text{ psi})(.005 \text{ in})(1 \text{ in})}}$$

$$h = \sqrt[3]{\frac{Fw^3 12}{3ES\delta l}}$$

$$h = 0.241 \text{ in}$$

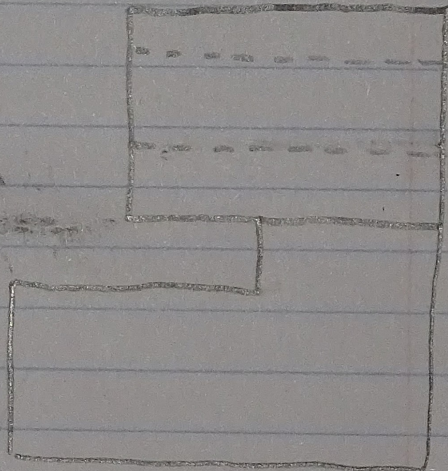
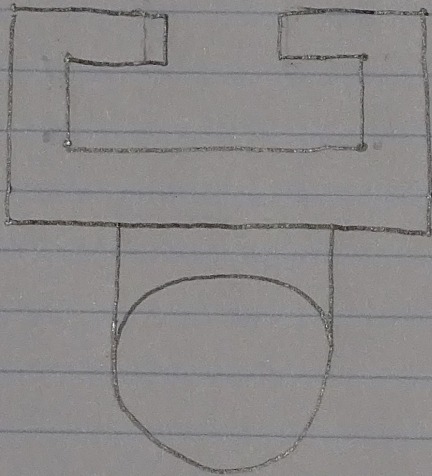
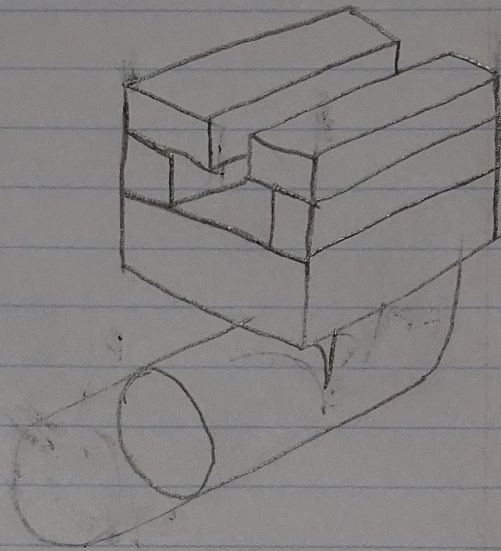
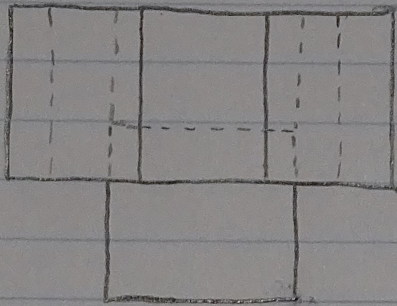
Multiview Sketches

Stress Analysis



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Stiffness Analysis



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