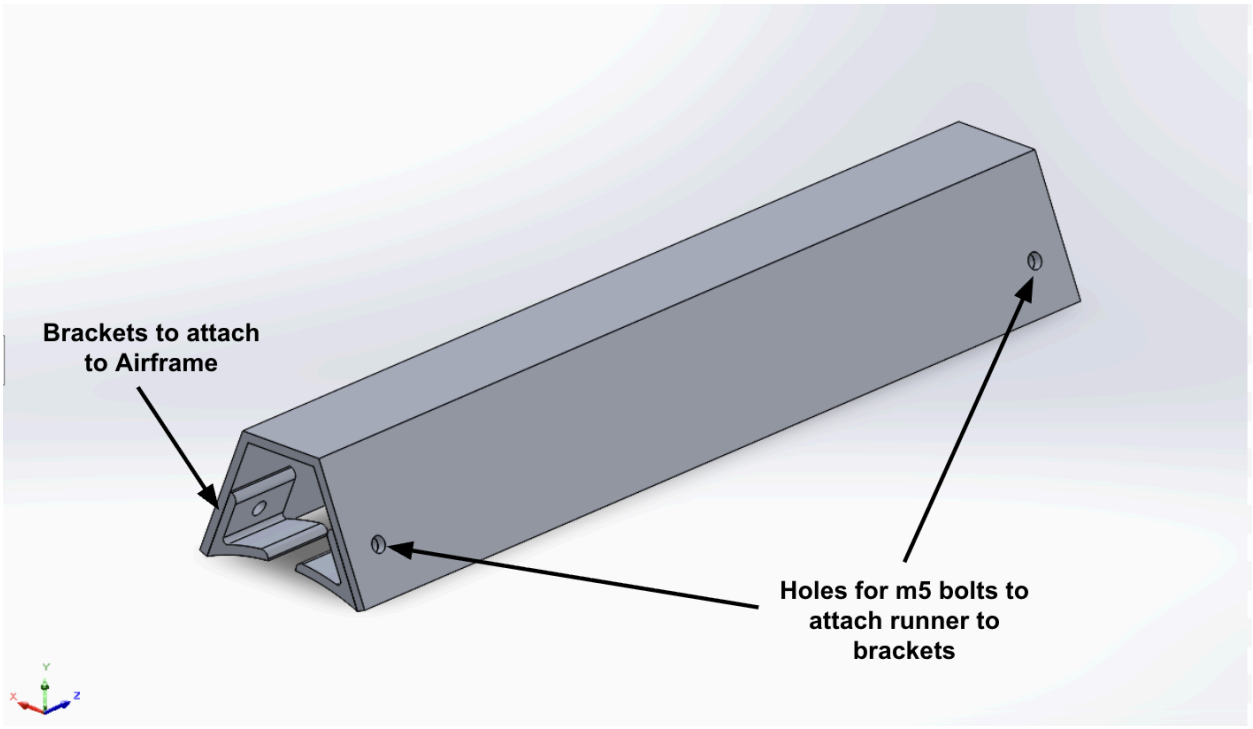
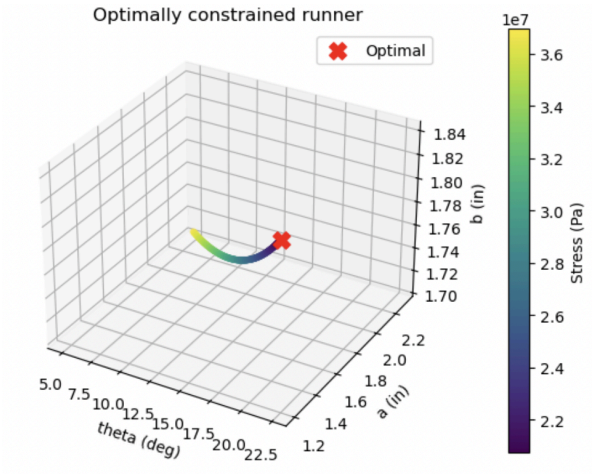


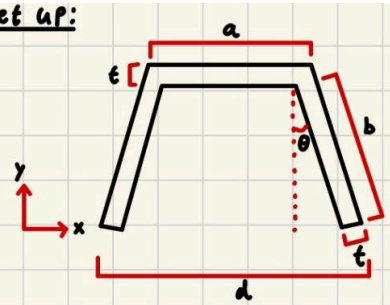
Runner Design

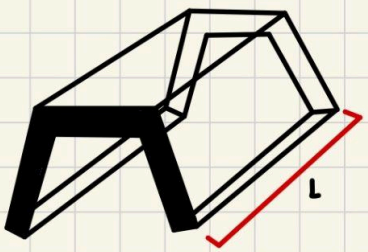



```
=== OPTIMAL DESIGN ===
theta          = 22.354 deg
a              = 1.202 in
b              = 1.838 in
c              = 2.6 in
t              = 0.125 in
sigma_vm       = 2.074e+07 Pa
F_max          = 9.306e+05 N
delta_t        = 6.448e-04
```

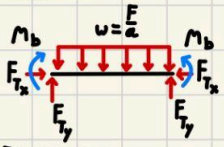
Optimization Code

Set up:





Top Piece:



Equilibrium:

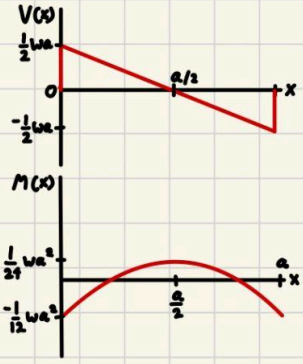
$\Sigma F_y = 2F_{T_y} - wa = 0$

$\rightarrow F_{T_y} = \frac{1}{2}wa$

$\frac{F_{T_x}}{F_{T_y}} = \tan\theta$

$\rightarrow F_{T_x} = \frac{wa}{2}\tan\theta$

Diagrams:



Bending stress:

$\sigma_B = -\frac{M_{max}\,y}{I}$

$M_{max} = \frac{1}{12}wa^2$

$y = \frac{t}{2}$

$I = \frac{1}{12}Lt^3$

$\sigma_B = \frac{-\frac{1}{24}wa^2 \cdot \frac{t}{2}}{\frac{1}{12}Lt^3}$

$= \boxed{-\frac{wa^2}{4Lt^2}}$

Normall stress:

$\sigma_N = \frac{F_{T_x}}{tL}$

$= \boxed{-\frac{wa\tan\theta}{2tL}}$

Stresses:

$\boxed{\begin{aligned}\sigma_x &= -\frac{wa^2}{4Lt^2} - \frac{wa\tan\theta}{2tL}\\ \sigma_y &\approx 0\\ \tau_{xy} &\approx 0\end{aligned}}$

Von Mises stress:

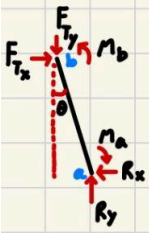
$\sigma_{vm} = \sqrt{\sigma_x^2 + \sigma_y^2 - \sigma_x\sigma_y + 3\tau_{xy}}$

$= |\sigma_x|$

$= \frac{wa^2}{4Lt^2} + \frac{wa\tan\theta}{2tL}$

$= \boxed{F\left(\frac{a}{4Lt^2} + \frac{\tan\theta}{2tL}\right)}$

Side Piece:



Equilibrium:

$\Sigma F_x = F_{T_x} - R_x = 0$

$\rightarrow F_{T_x} = R_x = \frac{wa}{2}\tan\theta$

$\Sigma F_y = R_y - F_{T_y} = 0$

$\rightarrow F_{T_y} = R_y = \frac{1}{2}wa$

Normall stress:

$F_N = \sqrt{F_{T_x}^2 + F_{T_y}^2}$

$= \frac{wa}{2}\sec\theta$

$\sigma_N = \frac{-F_N}{tL}$

$= -\frac{wa\sec\theta}{2tL}$

$= \boxed{-\frac{F\sec\theta}{2tL}}$

Buckling:

$P_{crit} = \frac{\pi^2 EI}{kl^2}$

$I = \frac{1}{12}Lt^3$

$P_{crit} = \frac{\pi^2 E \cdot \frac{1}{12}Lt^3}{\frac{1}{4}b^2}$

$= \boxed{\frac{3\pi^2 ELt^3}{b^2}}$

Hand Calcs