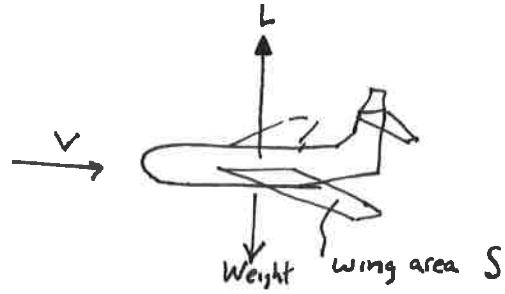
FAQS for HW 1

Units:

$$\rho = \frac{PM}{\bar{R}T} = 1\,\frac{lbf}{in^3}\;\Big|\;\frac{28.97\ lbm}{lbmol}\;\Big|\;\underbrace{\frac{R\ lbmol}{1545.34\ ft\ lbf}}_{\bar{R}\text{ is universal gas constant}}\;\Big|\;\frac{}{K}\;\Big|\;\underbrace{\frac{slug}{32.174\ lbm}\;\Big|\;\frac{144\ in^2}{ft^2}}_{\text{If your density is} \approx 5 \text{ times too low, here is the problem!}}$$

$$= \left[slug/ft^3\right]$$

Aircraft Lift



$$L = \tfrac{1}{2}\rho V^2 C_L S$$

For an identical aircraft

$$\tfrac{1}{2}\rho_1 V_1^2 \underbrace{C_{L_{max}}} S = W = L = \tfrac{1}{2}\rho_2 V_2^2 \underbrace{C_{L_{max}}} S$$

same

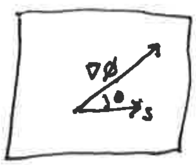
Thus

$$\rho_1 V_1^2 = \rho_2 V_2^2 \implies \frac{V_2}{V_1} = \sqrt{\frac{\rho_1}{\rho_2}}$$

Velocity ratio scales with $\sqrt{\rho_1/\rho_2}$

Directional Derivative

$$\nabla\phi\cdot s = \nabla_s\phi = (s\cdot\nabla)\phi =$$



$$= |\nabla\phi||s|\cos\theta$$

this needs to be 1, since S is a unit vector

Particle in tube

$x = \int u\,dt$, so you could find $\frac{DT}{Dt}$ with calculus and substitution in 1D.

Or, be generic and use the substantial derivative.

$$\frac{DT}{Dt} = \frac{\partial T}{\partial t} + V\cdot\nabla T$$