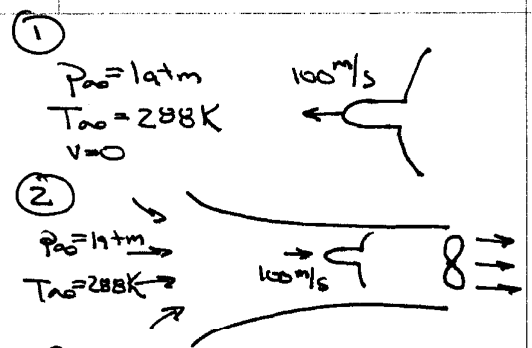
Given: Two flows
1) plane flying @ 100 m/s into still air
2) model in wind tunnel, air drawn in from room w/ $V_{test\ section} = 100$ m/s



Find: a) p_o air relative to plane case ①
b) p at point on plane where air is at rest relative to plane ①
c) p_o of air in test section relative to model ②
d) p air in test section when moving @ $V_{test\ sect.}$

Assume: Air is cpg/tpg w/ $\gamma = 1.4$; isen. flow; no external work on air before it gets to plane; air in room is at rest

Analysis:

a) $p_{o①}$ - can't use Bernoulli (v too large)

isen. flow

$$p_o/p_\infty = \left(\frac{T_o}{T_\infty}\right)^{\gamma/\gamma-1} \Rightarrow p_o = p_\infty \left(\frac{T_o}{T_\infty}\right)^{\gamma/\gamma-1}$$

$$\text{w/ } \frac{T_o}{T_\infty} = 1 + \frac{\gamma-1}{2} M^2 \quad ; \quad M = \frac{V_p}{a} \cong \frac{V_p}{20\sqrt{T(K)}\ m/s}$$

$$= 1 + \frac{1.4-1}{2}\left(\frac{100^2\ (m/s)^2}{20^2\ 288\ (m/s)^2}\right)$$

$$= 1.017$$

$$\therefore \quad p_o = 1\text{atm}\,(1.017)^{1.4/0.4} = 1.06\text{atm}$$

b) $p_①$ at stag. point:
if flow comes to rest isen. with respect to plane then $p = p_o$ with respect to plane

$$p = p_o = 1.06\text{atm}$$

c) $p_{o②}$: We know vel. of air is at rest with respect to model plane when air is sitting in room.

$\therefore$ p_o with respect to model $= p_{\infty(rest)} = 1$atm $\neq$ above answer (1.06)

d) p_{test}: air will accel. into tunnel, so p & T will drop.

still use $(P/P_0) = (T/T_0)^{\gamma/\gamma-1}$

From energy conserv. $\frac{V_{test}^2}{2} = C_p(T_0 - T_{test})$

$$T_{test}/T_0 = 1 - \frac{1}{2}\frac{V_{test}^2}{C_p T_0}$$

$C_p = \frac{\gamma}{\gamma-1}R$

$$= 1 - \frac{\gamma-1}{2}\frac{V_{test}^2}{\gamma R T_0}$$

$$= 1 - \frac{0.4}{2}\frac{(100\,m/s)^2}{20^2\,(288)(m/s)^2}$$

$$= 0.983$$

$$\Rightarrow \underline{\underline{P_{test}}} = 1atm\,(0.983)^{1.4/0.4} = \underline{\underline{0.941atm}}$$

Implications:

When working with stagnation pressures, it's important to remember that it depends on relative speed of flow with respect to <u>your</u> object (or what ever is reference frame of your problem).