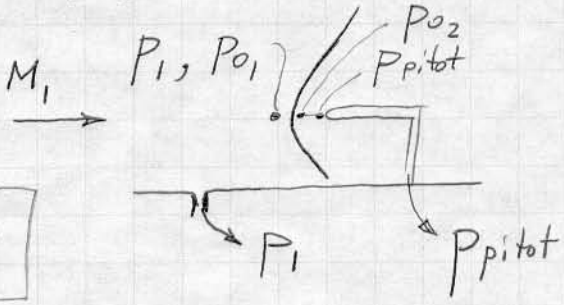
UE Fluids F15 Solution S'08

a) Anderson 8.16

Static $p = 0.1$ atm, Pitot $p_{p,tot} = 1.13$ atm

Since $\frac{p_{p,tot}}{p} = 11.3 > \left[1 + \frac{\gamma-1}{2}1^2\right]^{\frac{\gamma}{\gamma-1}} = 1.89$

the flow is clearly supersonic. $p_{p,tot} = p_{o_2}$ behind bow shock.



From Anderson App. B,

$\frac{p_{p,tot}}{p_1} = \frac{p_{o_2}}{p_1} = 11.3$ occurs at $\boxed{M_1 = 2.9}$

b) Anderson 8.17

Across a shock, $h_{o_1} = h_{o_2}$

$$h_1\left[1 + \tfrac{\gamma-1}{2}M_1^2\right] = h_2\left[1 + \tfrac{\gamma-1}{2}M_2^2\right]$$

$$\cancel{c_p}\, T_1\left[1 + \tfrac{\gamma-1}{2}M_1^2\right] = \cancel{c_p}\, T_2\left[1 + \tfrac{\gamma-1}{2}M_2^2\right]$$

From App. B for $M_1 = 36$:

$M_2 = 0.3787$, $\frac{T_2}{T_1} = 252.9$

$$T_{o_2} = T_2\left(1 + \tfrac{\gamma-1}{2}M_2^2\right) = T_1 \cdot \frac{T_2}{T_1}\left[1 + \tfrac{\gamma-1}{2}M_2^2\right] = 300\text{K} \cdot 252.9\left[1 + 0.2 \cdot 0.3787^2\right]$$

$$\boxed{T_{o_2} = 78046\text{ K}}$$ toasty

This result is surely invalid, since air will no longer be a perfect gas at this temperature, due to ionization and/or chemical changes. So the shock relations used to get this result are not valid.