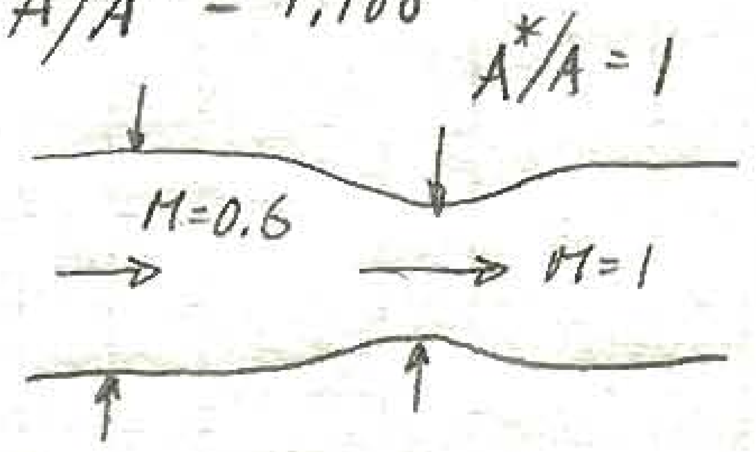
a) For the upstream section to be independent of the exit pressure, the duct must be choked.
We must have $M = 1$ at the throat, so $A^* = A_t$

From isentropic-flow table (Anderson App. A), for $M=0.6$, ... $A/A^* = 1.188$

So $\left[\dfrac{A_t}{A} = \dfrac{A^*}{A} = \dfrac{1}{1.188} = 0.84175\right]$



b) p_e must be reduced enough to reach $M=1$ at throat.

Since $A_e = A = 1.188\,A^*$, $M_e = 0.6$ (same as in test section)

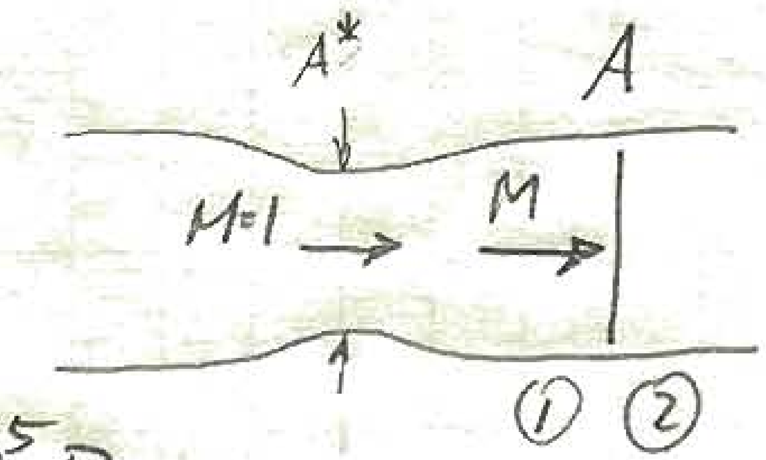
$p_{o_e} = p_r = 5\times10^5\,Pa$, $p_e = p_{oe}\left[1 + \frac{\gamma-1}{2}M_e^2\right]^{\frac{-\gamma}{\gamma-1}} = 0.784\,p_r = 3.92\times10^5\,Pa$

p_e can be lower than this, so $\boxed{p_e \le 3.92\times10^5\,Pa}$

The temperature T_r is irrelevant here (curveball!)

c) Flow is again choked, since we have a shock behind throat.

This time $A/A^* = 1/0.9 = 1.1111$



From table; $M_1 = 1.39$

$p_1 = p_r\left[1 + \frac{\gamma-1}{2}M_1^2\right]^{\frac{-\gamma}{\gamma-1}} = 0.319\,p_r = 1.59\times10^5\,Pa$

From normal-shock table (App. B), $\dfrac{p_2}{p_1} = 2.10$ (for $M_1 = 1.39$)

$\boxed{p_e = p_2 = 2.10\,p_1 = 3.35\times10^5\,Pa}$

From table: $M_2 = 0.745$ $\qquad T_0 = T_{0_1} = T_r = 300K^\circ$

$\boxed{T_2 = T_0\left[1 + \frac{\gamma-1}{2}M_2^2\right]^{-1} = 0.9\,T_r = 270\,K^\circ}$

Could also use shock temp. ratio $\dfrac{T_2}{T_1} = 1.25$, with $T_1 = T_0\left[1 + \frac{\gamma-1}{2}M_1^2\right]^{-1} = 216\,K^\circ$

$T_2 = 1.25\,T_1 = 270K^\circ$ same result.