

1) a) Steady adiabatic flow has $h_{01} = h_{02}$

$$\text{or } \frac{\gamma}{\gamma-1} \frac{P_1}{\rho_1} \left[1 + \frac{\gamma-1}{2} M_1^2 \right] = \frac{\gamma}{\gamma-1} \frac{P_2}{\rho_2} \left[1 + \frac{\gamma-1}{2} M_2^2 \right]$$

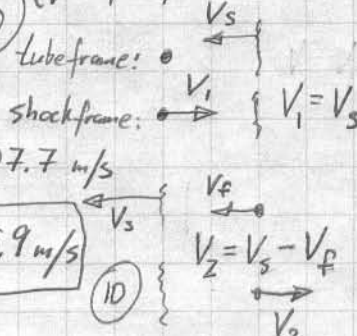
b) Isentropic flow has $\frac{P_2}{P_1} = \left(\frac{\rho_2}{\rho_1} \right)^\gamma$ (10)

2) a) For static quantities across the shock $()_1 = ()_i$, $()_2 = ()_f$ (10)

Given: $\frac{P_2}{P_1} = \frac{P_f}{P_i} = 1.8$, from shock table $\rightarrow \frac{\rho_2}{\rho_1} = \frac{\rho_f}{\rho_i} = 1.516$, so $P_f = 1.516 \text{ kJ/m}^3$

b) From shock table for $\frac{P_2}{P_1} = 1.8$, $M_1 = 1.30 = \frac{V_1}{a_1}$, and $a_1 = \sqrt{\frac{\gamma P_1}{\rho_1}} = \sqrt{\frac{1.4 \cdot 10^5}{1}} = 374 \text{ m/s}$

In shock frame $V_1 = M_1 \cdot a_1 = 1.3 \cdot 374 \text{ m/s} = 486.4 \text{ m/s} = V_s$ (10)



c) From shock table for $\frac{P_2}{P_1} = 1.8$, $M_2 = 0.786$, and $a_2 = \sqrt{\frac{\gamma P_2}{\rho_2}} = 407.7 \text{ m/s}$

$V_2 = M_2 \cdot a_2 = 0.786 \cdot 407.7 \text{ m/s} = 320.46 \text{ m/s}$, $V_f = V_s - V_2 = 165.9 \text{ m/s}$ (10)

d) $P_{0f} = P_f \left[1 + \frac{\gamma-1}{2} M_2^2 \right]^{\frac{\gamma}{\gamma-1}} = 2.706 \times 10^5 \text{ Pa}$ (10)

or using shock table for $\frac{P_2}{P_1} = 1.8$: $\frac{P_{02}}{P_1} = 2.714$, $P_{0f} = P_{02} = P_i \cdot \frac{P_{02}}{P_1} = 2.71 \times 10^5 \text{ Pa}$

e) In tube frame, $M_f = \frac{V_f}{a_2} = \frac{165.9 \text{ m/s}}{407.7 \text{ m/s}} = 0.407$, $P_{0f} = P_f \left[1 + \frac{\gamma-1}{2} M_f^2 \right]^{\frac{\gamma}{\gamma-1}} = 2.017 \times 10^5 \text{ Pa}$ (10)

3) a) Given: $\frac{P_{02}}{P_1} = \frac{P_{stag}}{P_{00}} = \frac{3 \text{ atm}}{1 \text{ atm}} = 3.0$, from shock table $\rightarrow M_1 = M_{\infty} = 1.38$ (10)

b) Given $\frac{P_{02}}{P_1} = \frac{3 \text{ atm}}{2 \text{ atm}} = 1.5$ not on shock table (subsonic flow, no shock).

Using isentropic table for $\frac{P_0}{P} = 1.5 \rightarrow M_1 = M_{\infty} = 0.78$ (10)

c) For shock $M_1 = 1.38$, $\frac{P_{02}}{P_{01}} = 0.963$, $\frac{P_2}{P_1} = 2.055$

$\therefore P_{01} = \frac{P_{02}}{P_{02}/P_{01}} = \frac{3 \text{ atm}}{0.968} = 3.10 \text{ atm}$ (10)

$P_2 = P_1 \cdot \frac{P_2}{P_1} = 1 \text{ atm} \cdot 2.055 = 2.055 \text{ atm}$

