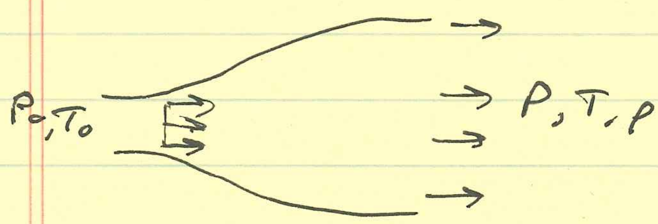
Problem 3



$T_0 = 500\,K$

$P_0 = 10\text{ atm}$

$P = 1\text{ atm}$

$T, \rho = ?$

$$\frac{P_0}{P} = \left(\frac{T_0}{T}\right)^{\gamma/\gamma-1} \Rightarrow \left(\frac{P_0}{P}\right)^{\frac{\gamma-1}{\gamma}} = \frac{T_0}{T} \Rightarrow T = T_0\left(\frac{P_0}{P}\right)^{\frac{1-\gamma}{\gamma}}$$

$$\gamma = 1.4 \Rightarrow \frac{1-\gamma}{\gamma} = \frac{-0.4}{1.4} = -0.2857$$

$$T = (500\,K)\left(\frac{10}{1}\right)^{-0.2857}$$

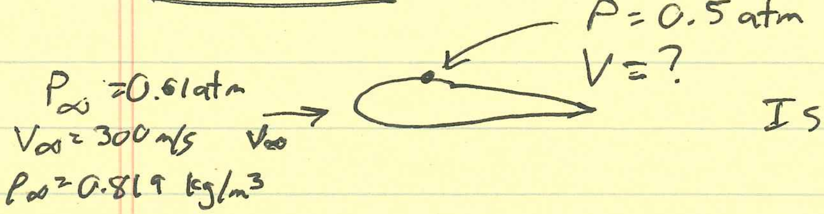
$$\boxed{T = 259\,K}$$

<u>Equation of state:</u> $P = \rho R T \Rightarrow \rho = \dfrac{P}{RT}$

$$\rho = \frac{(101{,}325\ N/m^2)}{(287)(259\,K)}$$

$$\boxed{\rho = 1.36\ kg/m^3}$$

Problem 4



Isentropic flow

Find $T_\infty \rightarrow$ find $T_{0,\infty} \rightarrow$ find V

Equation of state: $\quad P_\infty = \rho_\infty R T_\infty \rightarrow T_\infty = \dfrac{P_\infty}{\rho_\infty R}$

$$T_\infty = \frac{(0.61\,\text{atm})(101,325\ \text{N/m}^2)}{(1\,\text{atm})(0.819\ \text{kg/m}^3)(287)}$$

$$T_\infty = 262.95\ \text{K}$$

Energy equation: $\quad c_p T_{0,\infty} = c_p T_\infty + \dfrac{V_\infty^2}{2}$

$$T_{0,\infty} = T_\infty + \frac{V_\infty^2}{2c_p} = (262.95\ \text{K}) + \frac{(300\ \text{m/s})^2}{2(1004.5)}$$

$$T_{0,\infty} = 307.75\ \text{K}$$

Isentropic Relations: $\quad \boxed{T_{0,\infty} = T_0}$ and $\dfrac{P}{P_\infty} = \left(\dfrac{T}{T_\infty}\right)^{\gamma/\gamma-1}$

$$T = T_\infty \left(\frac{P}{P_\infty}\right)^{\frac{\gamma-1}{\gamma}}$$

$$T = (262.95\ \text{K})\left(\frac{0.5\ \text{atm}}{0.61\ \text{atm}}\right)^{\frac{\gamma-1}{\gamma}} \leftarrow \frac{0.4}{1.4}$$

$$T = 248.43\ \text{K}$$

Energy equation: $\quad c_p T_0 = c_p T + \dfrac{V^2}{2} \rightarrow V = \sqrt{2c_p(T_0 - T)}$

$$v = \sqrt{2(1004.5)(307.75 - 248.43)}$$

~~$V = 345$~~ ~~m/s~~ $\boxed{V = 345.2 \text{ m/s}}$

Problem 5

(7.10)

Bernoulli way: $P_\infty + \frac{1}{2}\rho V_\infty^2 = P + \frac{1}{2}\rho V^2$

$$\frac{2(P_\infty - P)}{\rho} + V_\infty^2 = V^2$$

$$V = \sqrt{\frac{2(P_\infty - P)}{\rho_\infty} + V_\infty^2}$$

$$V = \sqrt{\frac{2(0.61 - 0.5)(101325\ N/m^2)}{(0.819\ kg/m^3)} + (300\ m/s)^2}$$

$$V = 342.4\ m/s$$

$$\%\text{error} = \left(\frac{V_{act} - V}{V_{act}}\right) \cdot 100$$

$$\boxed{\%\text{error} = 0.81\ \%}$$

Problem 6

(7.11)

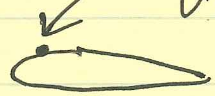
$p_\infty = 0.61\,\text{atm}$

$V_\infty = 300\,m/s$

$\rho_\infty = 0.819\,kg/m^3$

$p = 0.3\,\text{atm}$

$V = ?$



Isentropic flow

$T_\infty = 262.95\,K$

$T_{o,\infty} = 307.75\,K$

$$T = T_\infty \left(\frac{p}{p_\infty}\right)^{\frac{\gamma-1}{\gamma}} = (262.95\,K)\left(\frac{0.3\,\text{atm}}{0.61\,\text{atm}}\right)^{\left(\frac{0.4}{1.4}\right)}$$

$$T = 214.69\,K$$

Energy: $V = \sqrt{2c_p(T_o - T)}$

$$V = \sqrt{2(1004.5)(307.75 - 214.69)}$$

$$\boxed{V = 432.4\,m/s}$$