Problem 1 - Palm 5.2

$$
\begin{aligned}
q_i = \text{input},\ h_1,\ h_2 &= \text{outputs} \\
q_1 &= \text{Change of mass tank 1} = A_1\dot{h}_1\rho \\
q_2 &= \text{Change of mass tank 1} = A_2\dot{h}_2\rho \\
q_{R1} &= \frac{P_1}{R_1} = \frac{\rho g h_1}{R_1} \\
q_{R2} &= \frac{P_2}{R_2} = \frac{\rho g h_2}{R_2}
\end{aligned}
$$

Conservation of Mass

$$
\begin{aligned}
q_1 &= q_i - q_{R1} = A_1\dot{h}_1\rho = q_i - \frac{\rho g h_1}{R_1} \\
A_1\dot{h}_1\rho + \frac{\rho g h_1}{R_1} &= q_i \\
q_2 &= q_{R1} - q_{R2} = A_2\dot{h}_2\rho = \frac{\rho g h_1}{R_1} - \frac{\rho g h_2}{R_2} \\
A_2\dot{h}_2 + \frac{g}{R_2}h_2 &= \frac{g}{R_1}h_1
\end{aligned}
$$

Problem 2 - Palm 5.5

$$
\begin{aligned}
A = 20\ ft,\ \delta &= 1.94\ slugs/ft^3 \\
R_L = \frac{25000}{ft\ s},\ \nu &= 2x10^{-5} lb - sec/ft^2
\end{aligned}
$$

1)

$$
\begin{aligned}
h_0 &= 30\ ft \\
A\rho\dot{h} + \frac{\rho g h}{R_L} &= 0 \\
\tau &= \frac{A\rho R_L}{\rho g} = \frac{AR_L}{g} = \frac{20 * 25000}{32.2}\frac{ft^2 s^2}{ftsft} = 15528s = 4.31\ hrs \\
4\tau &= 17.25\ hrs
\end{aligned}
$$

2)

$$
\begin{aligned}
h_{ss} &= \frac{\rho q_i R_l}{\rho g} = \frac{0.1 * 25000}{32.2} = 77.64\ ft \\
h(t) &= 77.64(1 - e^{-\frac{t}{\tau}}) \\
1 - e^{-\frac{t}{\tau}} &= \frac{1}{3} \\
t(1/3) &= -\tau \ln(2/3) = 1.75\ hrs
\end{aligned}
$$

Problem 3 - Palm 5.24

Using conservation of energy

$$\begin{aligned}
\frac{d}{dt}C_1T_1 &= q - q_1 = q - \frac{1}{R_1}(T_1 - T_2) \\
C_1\dot{T}_1 + \frac{1}{R_1}T_1 &= q + \frac{1}{R_1}T_2 \\
\frac{d}{dt}C_2T_2 &= q1 - q_o = \frac{1}{R_1}(T_1 - T_2) - \frac{1}{R_2}(T_2 - T_o) \\
C_2\dot{T}_2 + T_2\left(\frac{1}{R_1} + \frac{1}{R_2}\right) &= \frac{1}{R_1}T_1 + \frac{1}{R_2}T_o
\end{aligned}$$