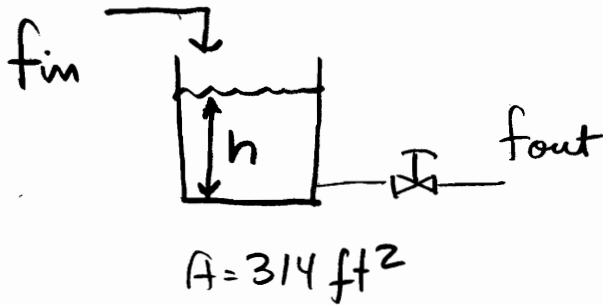


P1 Solution



$$314 \frac{dh}{dt} = f_{in} - 5\sqrt{h} \quad (2)$$

(a) SS : $f_{in}^{10} - 5\sqrt{h^s} = 0 \Rightarrow \underline{h^s = 4 \text{ ft}}$ (1)

(b) SS2 : $f_{in}^{20} - 5\sqrt{h^{s2}} = 0 \Rightarrow h^{s2} = 16 \text{ ft}$
 tank overflows (1)

(c) NL model \Rightarrow numerical integration
 (difficult without Matlab)

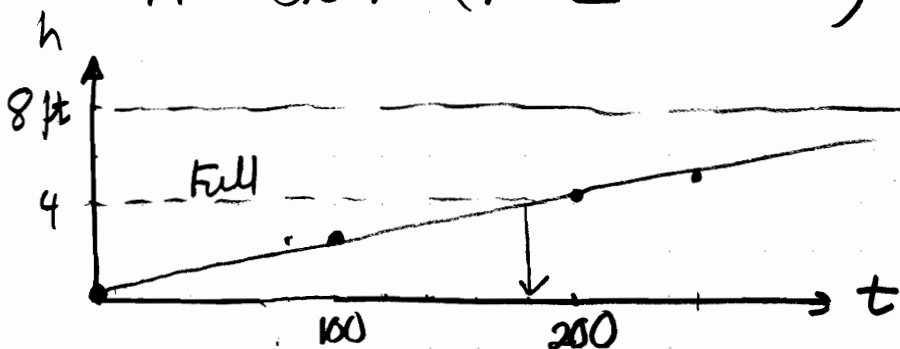
linearize

$$314 \frac{dh'}{dt} = f_{in}' - \underbrace{\frac{5}{2} \frac{1}{\sqrt{h^s}}}_{1.25} \cdot h' \quad (1)$$

251

$$\frac{314}{1.25} \text{ min} \cdot \frac{dh'}{dt} = -h' + 0.8 f_{in}'$$

$$h' = 0.8 \cdot 10 \left(1 - e^{-\frac{t}{251 \text{ min}}} \right); \quad h' = 4 \text{ at } t = 174 \text{ min}$$



(d)

$$314 \frac{dh}{dt} = f_{in} - C_v \sqrt{h}$$

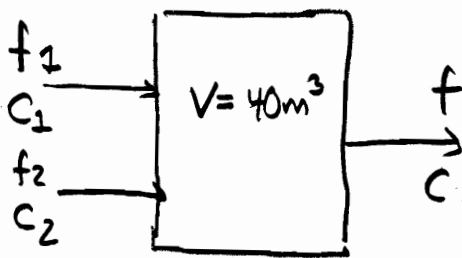
make $\frac{dh}{dt} = 0$ by $C_v = \frac{f_{in}}{\sqrt{h}}$

but now $h=4$ at all times

$$\Rightarrow C_v = \frac{f_{in}}{2} \quad (2)$$

check	$\frac{f_{in}}{2}$	C_v
	10	5
	20	10

P2 solution



ss model

$$\begin{cases} f_1^s + f_2^s = f^s \\ f_1^s \cdot c_1^s + f_2^s \cdot c_2^s = f^s \cdot c^s \end{cases}$$

$$\Rightarrow f_1^s = 1.6 \text{ m}^3/\text{min} \quad (2)$$

$$f_2^s = 2.4 \text{ m}^3/\text{min}$$

$$V \frac{dc}{dt} = f_1 c_1 + f_2 c_2 - (f_1 + f_2) c \quad (2)$$

linearize

(1)

$$V \frac{dc'}{dt} = f_1^s c_1' + c_1^s f_1' + f_2^s c_2' + c_2^s f_2' - (f_1^s + f_2^s) c' - c^s (f_1' + f_2')$$

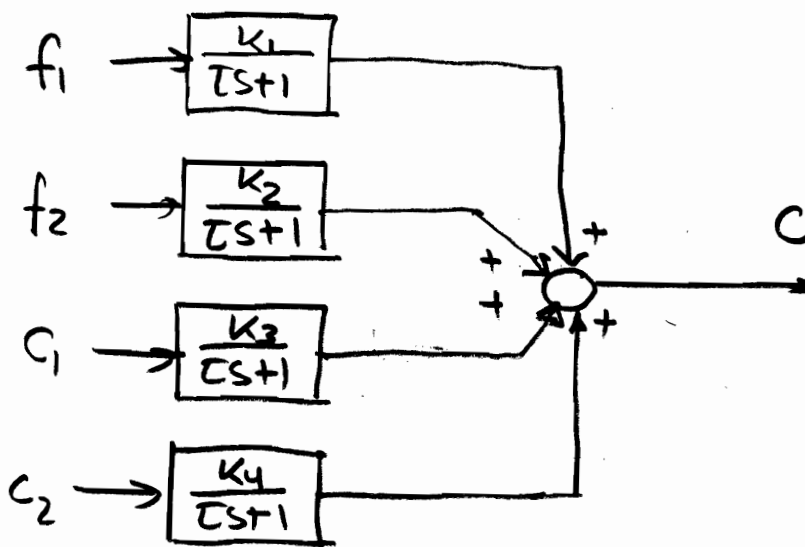
$$\tau \equiv \frac{V}{f_1^s + f_2^s} \frac{dc'}{dt} = -c' + \underbrace{\frac{c_1^s - c^s}{f_1^s + f_2^s}}_{k_1} f_1' + \underbrace{\frac{c_2^s - c^s}{f_1^s + f_2^s}}_{k_2} f_2' + \underbrace{\frac{f_1^s}{f_1^s + f_2^s}}_{k_3} c_1' + \underbrace{\frac{f_2^s}{f_1^s + f_2^s}}_{k_4} c_2'$$

$$(a) \quad C(s) = \frac{K_1}{\tau s + 1} f_1(s) + \frac{K_2}{\tau s + 1} f_2(s) + \frac{K_3}{\tau s + 1} C_1(s) + \frac{K_4}{\tau s + 1} \cdot C_2(s)$$

$$\tau = 70 \text{ min}; \quad K_1 = 7.5 \frac{\text{kg s/m}^3}{\text{m}^3/\text{min}}; \quad K_2 = -5 \frac{\text{kg s/m}^3}{\text{m}^3/\text{min}}$$

$$K_3 = 0.4; \quad K_4 = 0.6 \quad (2)$$

(b)



(R)

P3 Solution

Time domain process

