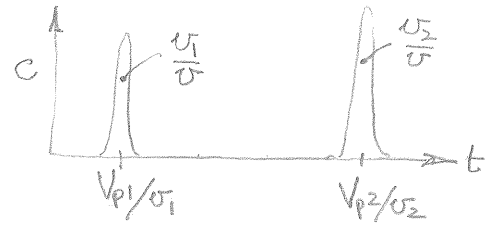
12.1 This looks like two plug flow units side by side. From Fig 1 with $V_{total} = 1 m^3$ and $v = 1 m^3/s$ we have

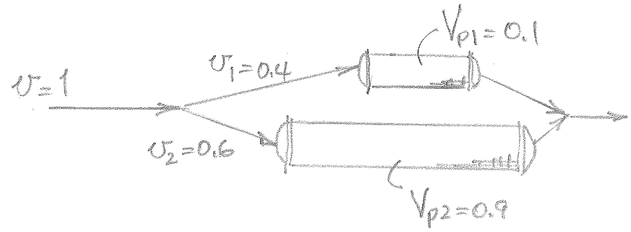
$$v_1 = \frac{16}{16+24} = 0.4 \; m^3/min$$

$$v_2 = \frac{24}{16+24} = 0.6 \; m^3/min$$

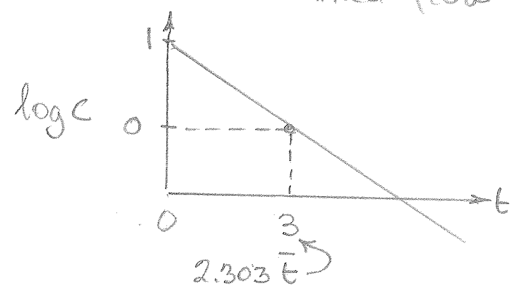
$$V_{p1} = \bar{t}_1 v_1 = (0.25)(0.4) = 0.1 \; m^3$$

$$V_{p2} = \bar{t}_2 v_2 = (1.5)(0.6) = 0.9 m^3$$





12.3 This looks like a mixed flow unit. Look at Fig. 2



Here $2.303\,\bar{t} = 3$ or $\bar{t} = 1.3$ min } from experiment

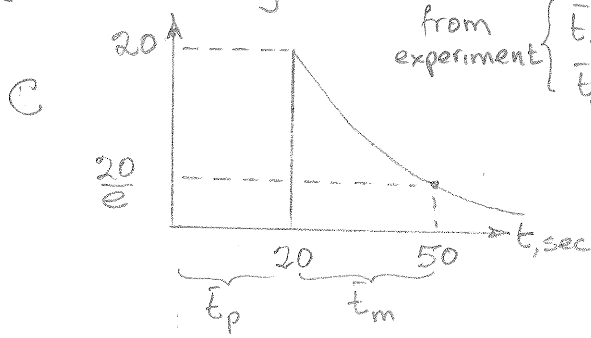
But we know that

$$\bar{t} = \frac{V}{v} = \frac{1m^3}{1m^3/min} = 1 \; min$$

or less if there is dead space

What does this mean? Either the tracer used is not a proper tracer — denser than the fluid, adsorbs on the walls of the vessel, etc — or something else is wrong. Check the experiment

12.5 Again look at Fig 1

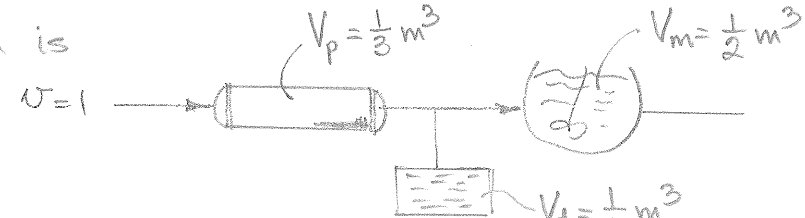


from experiment $\left\{ \begin{array}{l} \bar{t}_p = 20 \\ \bar{t}_m = 30 \end{array} \right\} \bar{t}_{active} = 50 \, s$

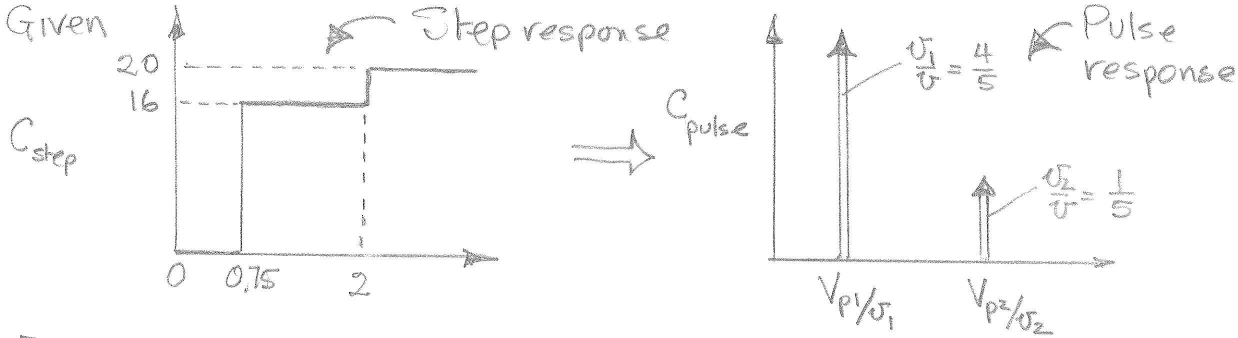
$\bar{t}_{total} = \frac{V}{v} = 60 \, s$

$\therefore \bar{t}_{dead} = 10 \, s$

Thus our model is



12.7 Given



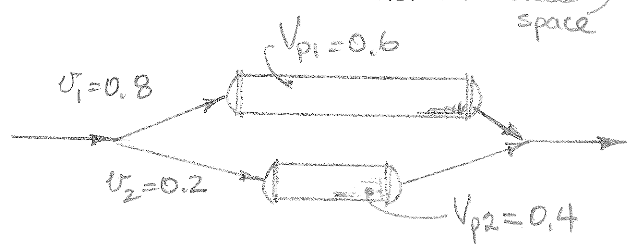
From the pulse response curve

$v_1 = \frac{4}{5} v = 0.8$ $\qquad V_{p1} = v_1(0.75) = 0.8(0.75) = 0.6$

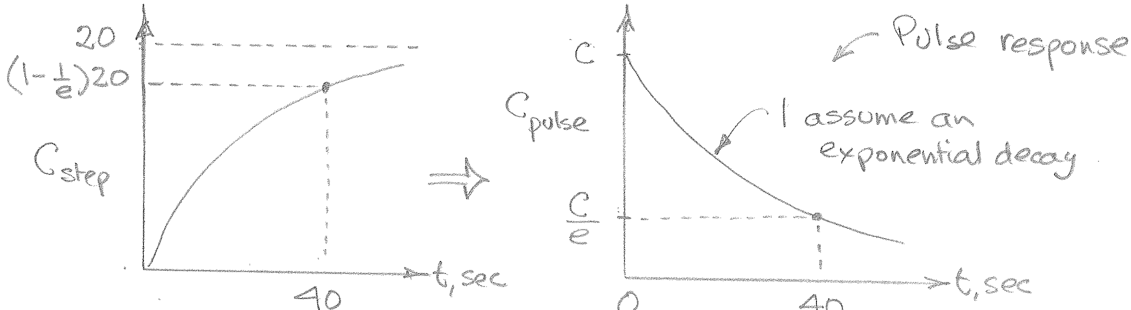
$v_2 = \frac{1}{5} v = 0.2$ $\qquad V_{p2} = v_2(2) = 0.2(2) = 0.4$

note: no dead space

So the flow model is



12.9

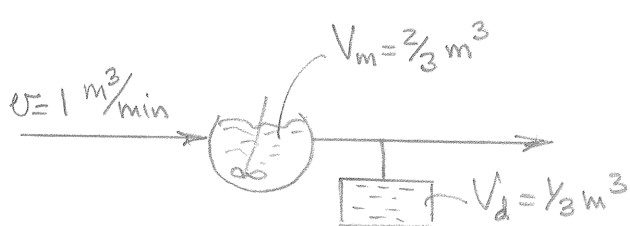


For mixed flow alone this should be 60sec. However, this curve comes out early, meaning dead spaces are present. This tracer curve shows that $\bar{t} = 40$ sec, thus

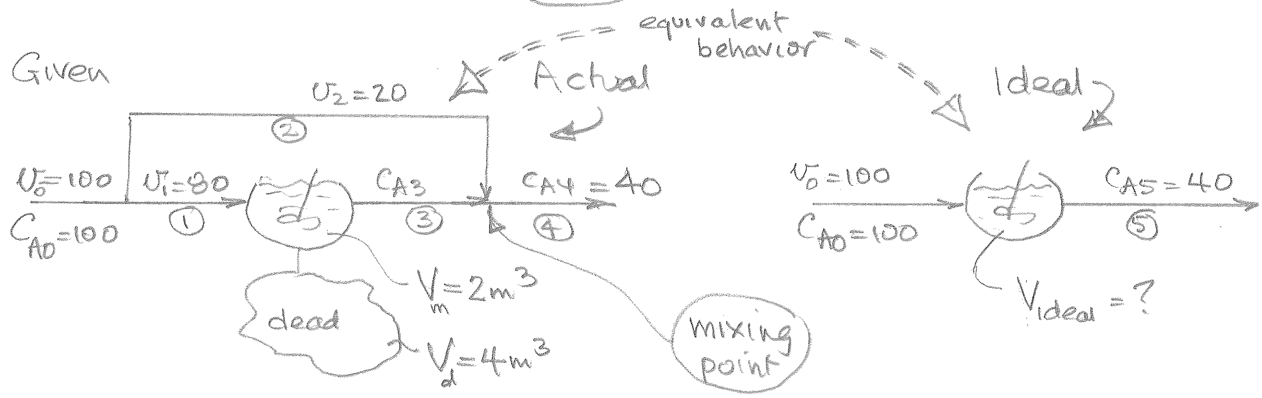
$V_m = 2/3 \, m^3$

$V_d = 1/3 \, m^3$

and our flow model is



12.11 Given



First let $C_{A0} = 100$, $v_0 = 100$ } It is not necessary to do this, but this assumption makes the calculations simpler.

Now take a material balance about the mixing point

$$v_2 C_{A2} + v_3 C_{A3} = v_4 C_{A4}$$

or

$$20(100) + 80 C_{A3} = 100(40)$$

or

$$C_{A3} = \frac{100(40) + 20(100)}{80} = 75$$

Next evaluate the rate constant k from the actual $2m^3$ MFR.

For a 2^{nd} order reaction

$$A + B \longrightarrow R + S \quad \ldots \quad C_{A0} = C_B$$

we have

$$\tau = \frac{V}{v} = \frac{C_{A0} - C_{A3}}{k C_{A3}^2}$$

or

$$k = \frac{C_{A0} - C_{A3}}{C_{A3}^2} \cdot \frac{v}{V} = \frac{100 - 75}{(75)^2} \cdot \frac{80}{2} = 14.222$$

Finally, for the ideal reactor

$$\frac{V_{ideal}}{v} = \frac{C_{A0} - C_{A5}}{k C_{A5}^2}$$

or

$$V_{ideal} = \frac{C_{A0} - C_{A5}}{k C_{A5}^2} \cdot v = \frac{100 - 40}{14.22 (40)^2} \cdot 100 = 0.2637 \, m^3$$

This is so much smaller than $6 m^3$