Solution to Problem 1.3

Question 1

t (day)	t (sec)	C_{max}	0.6 C_{max}	σ (m)
1	86400	13.5	8.1	3.0
4	345600	6.8	4.1	6.0

Assuming you released the dye in a very thin horizontal layer, such that initially $\sigma = 0$, then:

$$\sigma = \sqrt{2Dt} \quad \Rightarrow \quad D = \frac{\sigma^2}{2t}.$$

Thus, our two estimates of D are:

$$D_1 = \frac{(3.0\ \text{m})^2}{2(86400\ \text{s})} = 5.2\times10^{-5}\ \text{m}^2\text{s}^{-1}, \quad \text{and}$$

$$D_2 = \frac{(6.0\ \text{m})^2}{2(345600\ \text{s})} = 5.2\times10^{-5}\ \text{m}^2\text{s}^{-1}.$$

Therefore, the estimated diffusion coefficient of the dye is **$5.2 \times 10^{-5}\ m^2s^{-1}$.**

Question 2

We must consider the boundaries of the tank when the width of the cloud (4σ) is 40 m.

That is, when:

$$4\sqrt{2Dt} = 40 \quad \Rightarrow \quad Dt = 50\ \text{m}^2.$$

Using our value of D above, the boundaries of the tank become important when

$$t = \frac{50\ \text{m}^2}{5.2\times10^{-5}\ \text{m}^2\text{s}^{-1}} = 9.6 \times 10^5\ \text{s} = \textbf{11.1 days.}$$