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1.061 / 1.61 Transport Processes in the Environment
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1.061/1.61: Homework # 3 [10 pt total]

Problem 1 [3 pts]

Why do some rooms smell more than others do – even when the same sources of smell exist in each [dirty laundry, perfume, mildew, smoke]? Estimate the residence time of the air in your bedroom with uncertainty. Give a clear description of the bases for your estimate – including methods of direct observation, models, and assumptions. Comment on the limitations of each, and how the limitations might affect your estimate.

Problem 2 [4 pts]

You have been asked to assess a newly constructed wetland that is 40-m x 300-m. The design flow depth and rate are $h = 1\text{-m}$ and $Q = 0.1\text{ m}^3/\text{s}$, respectively. You release 300 g of dye at the inlet of the wetland and record the concentration of dye at the outlet.

t [hr]	C [$\mu\text{g/l}$]	t [hr]	C [$\mu\text{g/l}$]
0	0	22	5
2	0	24	0
4	5	26	15
6	10	28	30
8	50	30	40
10	60	32	40
12	20	34	30
14	10	36	20
16	5	38	20
18	5	40	10
20	0		

- What is the total mass of dye observed to exit the wetland?
- Plot the Residence Time Distribution
- Find the mean hydraulic residence time, T_R , and the mean detention time, T_{det} .
- Describe the flow pattern within the wetland based on the results in a), b), and c)?
- The wetland plants can uptake phosphorus at a rate of $K = 0.05\text{ hr}^{-1}$. What fraction of phosphorus load entering the wetland is removed?
- What is the maximum phosphorus removal that one could achieve in this wetland? How would you achieve it?

Problem 3 [3 pts] Phosphorus loading from the surrounding watershed has caused a small lake to become eutrophic. Using the measurements given below, do you expect the phosphorus levels in the epilimnion will increase, decrease, or stay the same over time. The surface area of the lake is $2 \times 10^4 \text{ m}^2$. The diffusivity across the thermocline is $D_Z = 2.0 \times 10^{-6} \text{ m}^2/\text{s}$. Measured river inflow is $Q = 0.1 \text{ m}^3/\text{s}$. The measured phosphorus concentration at the inflow and outflow is $100 \mu\text{g}/\text{l}$ and $50 \mu\text{g}/\text{l}$, respectively.

