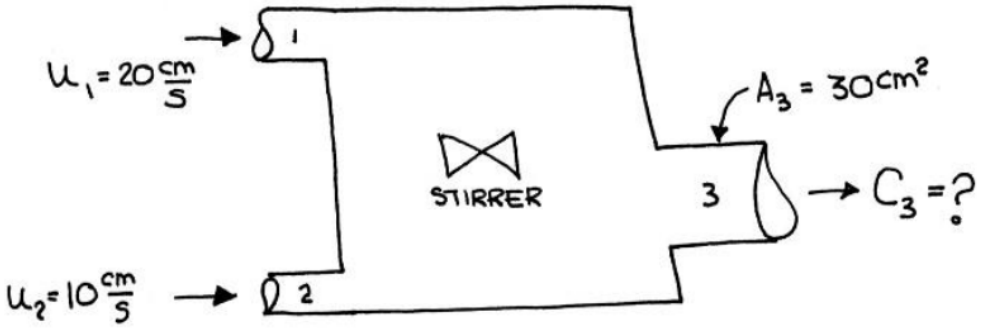
Instructions: Attempt all questions

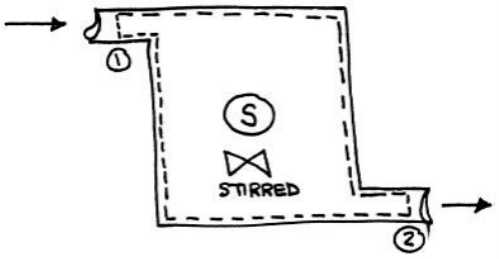
Problem 1



Two pipes, each of $10\,cm^2$ cross-section, carry water into a mixing chamber. The upper pipe carries water saturated in oxygen ($C_1 = 9\,mg/l$), and the lower pipe carries deoxygenated water ($C_2 = 0\,mg/l$). A stirrer within the chamber rapidly mixes the two streams, such that the concentration in the tank is spatially uniform. Assuming the system is at steady state, what is C_3?

Problem 2

A well-stirred tank is fed by an inlet pipe with cross-section, $A_1 = 10\,cm^2$. The inlet velocity is $U_1 = 10\,cm/s$. Inside the tank a plaster ball slowly dissolves supplying a steady source of calcium carbonate to the water, $S = +5\,g/s$. The outlet pipe area is the same as the inlet. There is no calcium carbonate in the inflow. At steady state, what is the outlet concentration?



Problem 3

Two water pipes of equal cross-section, $A = 20\,cm^2$, join to form a single pipe of cross-section, $A_3 = 40\,cm^2$. The two incoming pipes carry water of different temperature, $T_1 = 10\,^\circ\mathrm{C}$ and $T_2 = 20\,^\circ\mathrm{C}$, respectively. If the velocity in the two upstream pipes is the same, what is the temperature in the pipe downstream of the junction? Assume that all pipes are perfectly insulated.

Problem 4

A shallow river flows out of a shaded, wooded region into an open plain at $x = 0$. Once in the open region ($x > 0$) the river begins to receive solar radiation at $H_3 = 800\,watts\,m^{-2}$. If the river emerges from the forest at a constant temperature, T_0, find the gradient of temperature along the river, $\partial T/\partial x$, for $x > 0$. The river is $h = 1\,m$ deep, $b = 10\,m$ wide and flows at $U = 1\,ms^{-1}$. The diffusion coeffient is homogeneous and isotropic, $D = 0.1\,m^2 s^{-1}$.