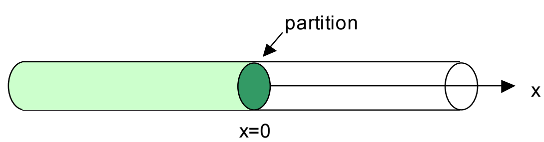
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Civil and Environmental Engineering
1.77 Water Quality Control

Problem Set 1 | Spring 2006 | Due February 23

1) An infinitely long cylinder with a diameter of 10 cm is filled with a stationary fluid. A mass input ($M = 0.1$ g CO_2) is introduced instantaneously at $t = 0$ and uniformly at the center of the tube ($x = 0$). Find the time for the CO_2 to reach a concentration (mass fraction) of 1 ppm at $x = 50$ cm for

   a) molecular diffusion in air
   b) molecular diffusion in water

2) An infinitely long partitioned cylinder is filled with stationary pure water on the right side of the partition, and water with an initial concentration $C_o = 10$ mg/l of dissolved CO_2 on the left. At time $t = 0$ the partition is removed.



   a) How long will it take the concentration of CO_2 at $x = 50$ cm to the right of the partition to reach 1 mg/l?

   b) By inducing turbulence in the system it is possible to increase the diffusion coefficient. Suppose we generate homogeneous and isotropic turbulence by oscillating a grid and that the turbulent diffusion coefficient is approximately 1 cm^2/s. How long would it now take the concentration of CO_2 (at 50 cm from the partition) to reach 1 mg/l?

3) Consider stationary fluid in an infinite cylinder of area A with a finite volume 2LA of dyed fluid having an initial concentration C_o enclosed between two partitions as shown. At $t = 0$, the partitions are removed. Express the concentration of dyed fluid at an arbitrary point x as a function of time and the molecular diffusivity.