**Problem 1 [4pts]:** Consider a river channel of depth \( h = 1 \text{ m} \) and mean flow speed \( U = 1 \text{ m/s} \). The bed is a source chemical through dissolution. The equilibrium concentration is \( C_0 \). Which concentration profile would you expect to see in the channel. Defend your answer with clearly stated scaling arguments. The kinematic viscosity is \( \nu = 10^{-6} \text{ m}^2 \text{s}^{-1} \), and a typical molecular diffusion would be \( 10^{-9} \text{ m}^2 \text{s}^{-1} \).

\[ Z \]

\[ h \]

\[ \delta_s \]

\[ C_0 \]

\[ C \]

**Problem 2 [6 pts]:** A container filled with water is \( h = 40 \text{-cm} \) high and has a base area of \( 100 \text{ cm}^2 \). At \( t = 0 \) a lid is placed on the container. The lid is filled with solid CaSO\(_4\) and fits snugly to the water surface. The water in the container is stirred gently, such that the laminar sub-layer is \( \delta_s = 0.1 \text{ cm} \) at every surface. Outside the laminar sub-layer the diffusivity of all substances is \( D_s = 0.01 \text{ cm}^2 \text{s}^{-1} \). Estimate the total of calcium [in grams] in the water column at \( t = 6 \text{ hours} \). The molecular diffusivity of Ca\(^{++}\) in water is \( D_m = 8 \times 10^{-10} \text{ m}^2 \text{s}^{-1} \). The solubility product for CaSO\(_4\) is

\[ K_{sp} = \left[ \frac{[Ca^{++}] [SO_4^{--}]}{[CaSO_4(S)]} \right] = 230 \frac{\text{mol}^2}{\text{m}^6} \]

a) Write an expression for the calcium concentration, \( C(z) \), in the water at \( t = 6 \text{ hrs} \). **Beware:** you must account for the no-flux boundary at the bottom of the container.

b) Find the total mass of calcium in the water at \( t = 1 \text{ hr} \).