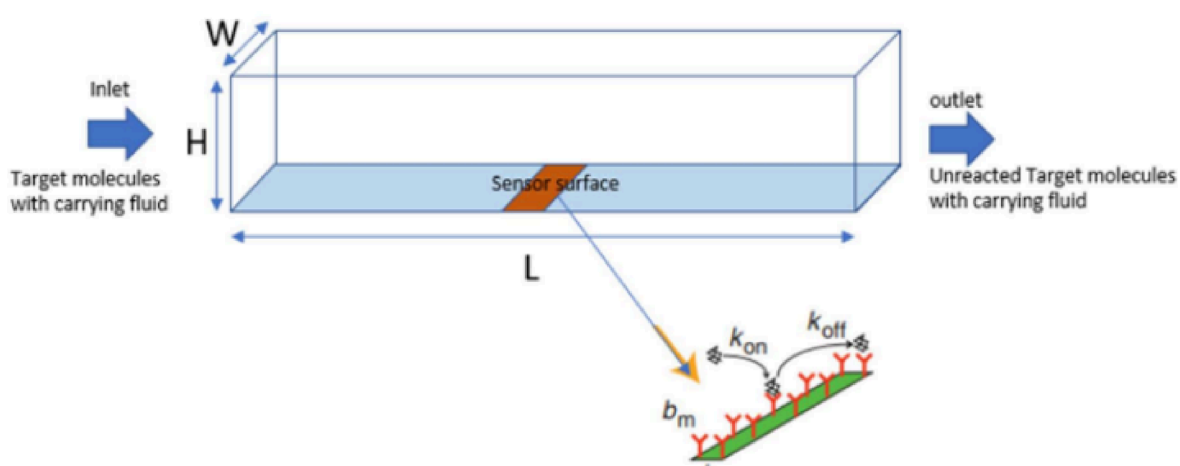
CODE THE PROBLEM

The development of miniaturized devices using microfluidics for point-of-care diagnosis has garnered significant interest across multiple sectors including healthcare, environmental monitoring, food quality assessment, drug development, and forensic analysis. These microfluidic devices rely predominantly on chemical reaction-based sensing principles.

A general 2-dimensional schematic of biosensor is shown below.



The typical process involves the entry of target molecules requiring detection into an inlet along with a carrier fluid. These molecules then flow over the sensor surface positioned at the bottom plate of the device. On this surface, receptor molecules, depicted in orange, are immobilized. These receptors have the capability to detect target molecules by forming complexes with them through chemical reactions. Any target molecules that remain unreacted are carried further along the channel and exit through the outlet.

Consider the following information for such biosensor:

Assume fully developed unidirectional uniform flow throughout the channel (no velocity variation).

Inlet volumetric flow rate of fluid containing target molecules: 0.5 μL/min.

L= 1000μm, H= 50 μm, W=50μm

Molecular diffusivity of target molecules, **D** = 10^{-9} m^2 /s

Concentration of target molecules at inlet (**C_0**): 10^{-5} mole/m^3

Surface density of immobilized receptor molecules (**b_m**): 10^{-7} mole/m^2

Surface reaction details:

$$\frac{\partial b}{\partial t} = k_{on} c_s (b_m - b) - k_{off} b,$$

b = instantaneous surface density of target-receptor complex

C_s in the reaction is the target concentration just above the sensor surface, which is a function of time.

Forward rate constant, **b_{on}** = 10^5 m^3 /mol.s, backward rate constant, **k_{off}**= 0.1s^{-1}

Write a code which should render the following:

Surface concentration (mol/ m^2) on sensor as a function of time. (t = 0 to 10000s). Provide plot for the same.

(Hint: solve for 2-dimensional domain, along the width W assume all physical quantities are uniform).

You will be assessed on the basis on your approach not the final solution.