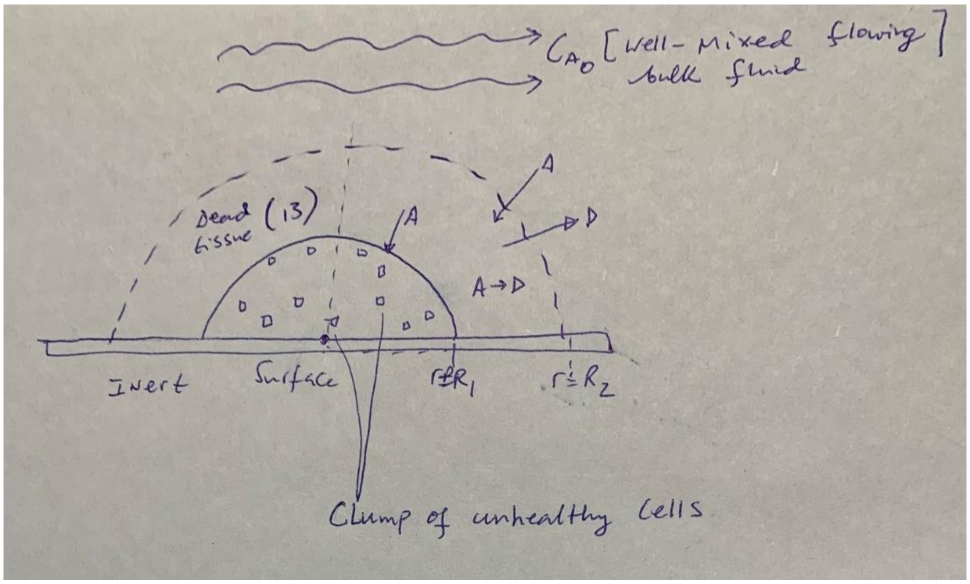
COMPREHENSIVE EXAMINATION – 2nd semester 2021-22

CHE G552- ADVANCED TRANSPORT PHENOMENA – 100 points

NOTE: Try to solve as much as you can. Make a logical approach. LAPTOPS/tabs are allowed only for note references, but internet surfing WILL LEAD TO EXPULSION FROM EXAM. Open Books, Open Notes. Precisely, don't lose your sanity! Good luck.

Question 1:



Consider the drug treatment system shown above. A hemisphere cluster of unhealthy cells is surrounded by a larger hemisphere of stagnant dead tissues (Species B), which is in turn surrounded by a flowing fluid. The bulk, well-mixed fluid contains a drug compound (Species A) of constant but dilute concentration C_{A0}

Drug A is also soluble in the unhealthy tissue but does not preferentially partition into it relative to the fluid. The drug, species A, enters the dead tissue and homes in on the unhealthy cells. At the unhealthy cell boundary ($r=R_1$), the flux of A to the unhealthy cells is diffusion limited. All metabolites of drug A produced by the unhealthy cells stay within the unhealthy cells itself. However, drug A can also degrade to inert metabolite D by the first-order reaction on C_A, i.e, A → D, that occurs only within the stagnant dead tissue.

(a). Simplify the general differential equation of mass transfer for drug A.

(b). Specify the final differential equation in terms of N_A and again in term of C_A.

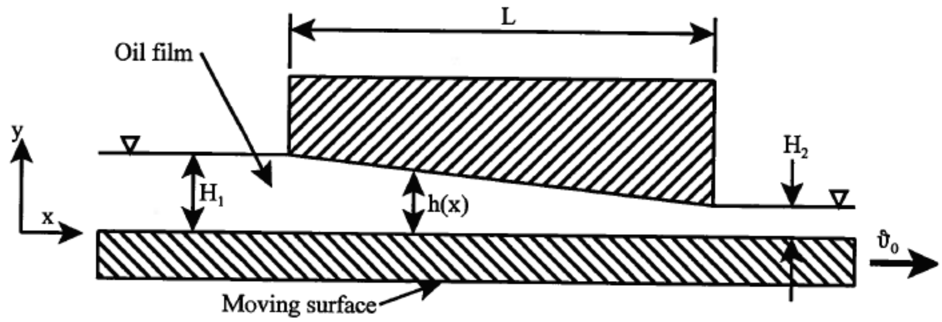
State all assumptions as necessary.

Question 2:

A common application of the type of flow in fluidic systems occurs when the gap h is not a constant but varies slightly along the x-axis. Under these conditions, the pressure gradient is no longer constant. The resulting geometry is then a slider bearing capable of supporting enormous loads if properly designed. If we assume that there is no flow in the z-direction and we regard the volumetric flow rate as a local value since h is now a function of x, it still must be the case that this flow rate is a constant in the x-direction. Clearly the flow velocity increases as the gap decreases. Then for unit width in the z-direction,

$$\frac{d}{dx}\left(h^3 \frac{\partial P}{\partial x}\right) = 6\mu\vartheta_0 \frac{dh}{dx}$$

For a channel of variable gap, h = h(x), the above equation determines the approximate pressure distribution provided dh/dx << 1. The bearing is hydrodynamic and not hydrostatic. Thus, assume that the load carrying capacity **is linearly related to the velocity.**



As shown in the above figure, a simple slider bearing has a uniform taper from the inlet, where the gap is $\mathbf{H_1}$, to the exit where the gap is $\mathbf{H_2}$. This gap is filled with oil of viscosity μ and density ρ. The upper surface is stationary and the lower surface moves at a steady velocity v_0. The thickness of the oil film at a location x measured relative to the leading edge of bearing is h(x)

(a) Show that the pressure gradient along the slider is given by

$$\frac{dP}{dx} = \frac{12\mu\vartheta_0}{h^3}\left(\frac{h}{2} - \frac{H_1 H_2}{H_1 + H_2}\right)$$

(b) If the pressure at each open end of the bearing is P_{atm} , sketch the pressure profile P =P(x) in the oil film. Find the location the maximum pressure and its value.

(c) If the bearing has dimension **b** normal to the plane of the sketch, what is the load carrying capacity of the upper block of the bearing?