GEORGIA INSTITUTE OF TECHNOLOGY

COLLEGE OF ENGINEERING

BMED3300 – BIOTRANSPORT

QUIZ 4 (SPRING 2014) – ETHIER

STUDENT NAME: Key

GTID NUMBER: ______

RECITATION SECTION: ______

(Section E is Wednesdays at 2 pm; Section F is Wednesdays at 1 pm)

Closed Book
All non-communicating calculator types allowed
Time allotted: 15 minutes
Do all work in this booklet

Reminder: for questions that require numerical answers, units are required and worth 50%

Question	Maximum Mark	Actual Mark
1	2	
2	8	
Total	10	

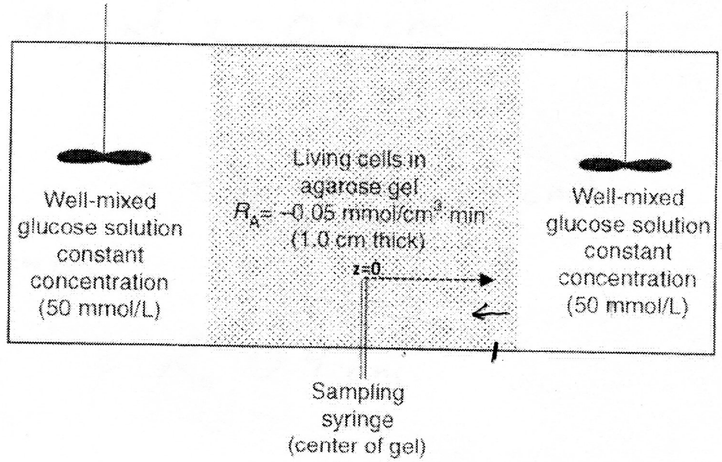
Consider the experiment show below where a slab of the cell-immobilized gel of 1.0 cm thickness is placed within a well-mixed aqueous solution of glucose maintained at a concentration of c_o = 50 mM. The glucose consumption within the cell-immobilized gel proceeds by a zero-order process given by:

$$R_A = -0.05 \text{ mM/min}$$

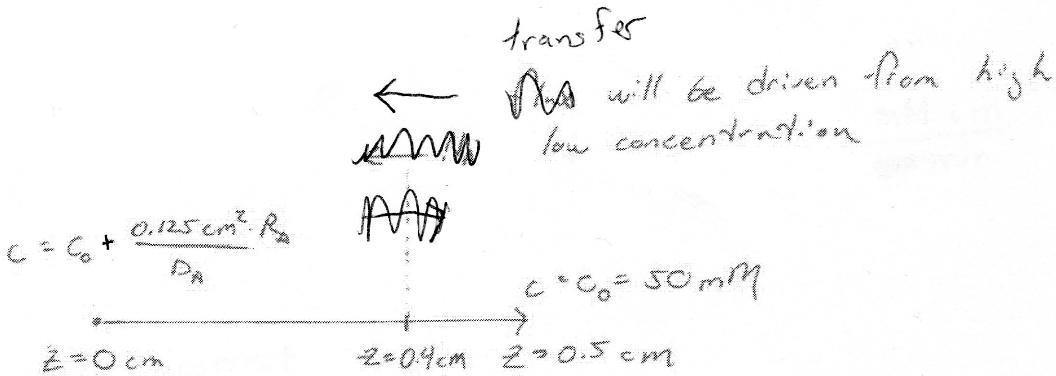
The solubilities of the glucose in both the water and the gel are the same; that is, the concentration of glucose on the water side of the water-gel interface is equal to the concentration of glucose on the gel side of the water-gel interface.

You are given a known steady-state concentration profile of glucose that arises from this geometry:

$$c_A(z) = c_o - \frac{R_A}{D_A}\left(\frac{z^2}{2} - 0.125cm^2\right)$$



1) Draw a diagram of the system and indicate the directionality of the glucose flux inside the gel ~~10 mm~~ ~~1mm~~ away from the gel-liquid interface.
1,0 mm



TO mA

2) Derive an expression for the flux of glucose inside the gel ~~1 mm~~ away from the gel-liquid interface.

$$N_A = -D \frac{\partial c}{\partial z} \quad \text{Fick's 1}^{\text{st}} \text{ Law} \qquad +2$$

if $c_A = c_0 - \frac{R_A}{D_A}\left(\frac{z^2}{2} - 0.125 \text{ cm}^2\right)$

then first find $\frac{\partial c}{\partial z}$

$$\frac{\partial c}{\partial z} = -\frac{R_A z}{D_A} \qquad + \cancel{3}\ 4$$

evaluating N_A at $z = 0.4$ cm:

$$N_A \Big|_{z=0.4\text{ cm}} = -D_A \cdot \left(-\frac{R_A}{D_A} \cdot 0.4 \text{ cm}\right)$$

$$= R_A \cdot 0.4 \text{ cm}$$

$$= -0.05 \frac{\text{mM}}{\text{min}} \cdot 0.4 \text{ cm} = -0.02 \frac{\text{mmol}}{\text{cm}^2 \text{min}} \qquad + \cancel{4}\ 2$$

or

$$\frac{\text{mM cm}}{\text{min}}$$

-2 if sign incorrect.

Definition of ∇ and ∇^2 operators in different coordinate systems:

Cartesian:

$$\nabla = \mathbf{e}_x \frac{\partial}{\partial x} + \mathbf{e}_y \frac{\partial}{\partial y} + \mathbf{e}_z \frac{\partial}{\partial z}$$

$$\nabla^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}$$

Cylindrical:

$$\nabla = \mathbf{e}_r \frac{\partial}{\partial r} + \mathbf{e}_\theta \frac{1}{r}\frac{\partial}{\partial \theta} + \mathbf{e}_z \frac{\partial}{\partial z}$$

$$\nabla^2 = \frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial}{\partial r}\right) + \frac{1}{r^2}\frac{\partial^2}{\partial \theta^2} + \frac{\partial^2}{\partial z^2}$$

Spherical:

$$\nabla = \mathbf{e}_r \frac{\partial}{\partial r} + \mathbf{e}_\theta \frac{1}{r}\frac{\partial}{\partial \theta} + \mathbf{e}_\varphi \frac{1}{r\sin\theta}\frac{\partial}{\partial \varphi}$$

$$\nabla^2 = \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial}{\partial r}\right) + \frac{1}{r^2 \sin\theta}\frac{\partial}{\partial \theta}\left(\sin\theta\frac{\partial}{\partial \theta}\right) + \frac{1}{r^2 \sin^2\theta}\frac{\partial^2}{\partial \varphi^2}$$