GEORGIA INSTITUTE OF TECHNOLOGY

COLLEGE OF ENGINEERING

BMED3300 - BIOTRANSPORT

QUIZ 1 (SPRING 2014) - ETHIER

STUDENT NAME: Solution

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

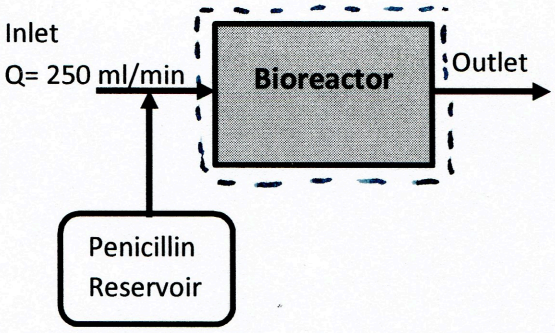
Reminder: for questions requiring numerical answers, units are <u>required</u> and worth 50%

Question	Maximum Mark	Actual Mark
1	6	
2	6	
Total	**12**	

Maximum possible marks are 12. However, the quiz will be marked out of 10, i.e. if you get 8/12, that is equivalent to 80%.

Reynolds transport theorem: $\frac{dB_{system}}{dt} = \frac{\partial}{\partial t}\int_{cv} \rho\beta \; dVol + \int_{cs} \rho\beta \, \mathbf{v} \bullet \hat{\mathbf{n}} \, dS$

1. A bioreactor of volume V = 5 liters is supplied with nutrients and oxygen by media entering the bioreactor through an inlet at flow rate $Q = 250\ ml/min$. The incoming media has the antibiotic penicillin added to it from a reservoir. Unfortunately, a researcher makes a mistake one day, and partway through an experiment (when the penicillin concentration in the bioreactor is uniformly 30 ng/ml), he refills the penicillin reservoir with a solution that has a penicillin concentration **10x** higher than normal. The volume flow rate of penicillin and media into the bioreactor are not affected. Assume that the bioreactor is well-mixed. Suppose that we wish to know the concentration of penicillin in the bioreactor 20 minutes after the mistake happens.



   a. Is this problem steady or unsteady? State why this is the case.
   b. State the physical principle you would use to solve this problem.
   c. Draw a suitable control volume on the picture above.

Note that you do not need to solve the problem; you only need to answer the questions above, which are part of your GIM analysis.

Do your GIM analysis here

(a) Unsteady. (1) $\dot{g}$ penicillin has not changed, but the reservoir concentration of penicillin has ↑. Thus, in penicillin into the bioreactor has ↑. Thus, penicillin conc in bioreactor will ↑. (1)

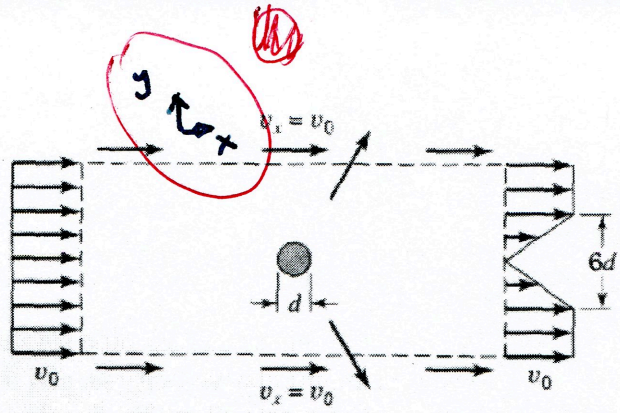
(b) Conserve mass of media (1) to get $\dot{g}_{in} = \dot{g}_{out}$
Conserve mass of penicillin (1)

(c) see above (2)

just stating "conserve mass" is worth 0.

6/6

2. The pressure on the control volume illustrated at right is constant. The x components of velocity are as illustrated. We want to determine the force exerted on the cylinder by the fluid. Assume incompressible flow.



   a. Carry out a GIM analysis for this problem. Your analysis should include the physical principle(s) you would use to solve this problem. Please also add any labels to the diagram that will be useful. Explain why the control volume is suitable.
   b. The density of the flowing fluid is doubled. What effect does this have on the force exerted on the cylinder by the fluid, and why?

Note that you do not need to solve the problem; you only need to answer the questions above.

Do your GIM analysis here (part a)

- Principles: conserve mass of flowing fluid (1)
  balance x-momentum (see axes) (1) — must show axes.
- Problem is steady (1)
- CV boundaries are where velocities/flowrates are known or where we want to know them. Front/back of CV cut cylinder so give force due to fluid on cylinder. (1)

(b)

$$\Sigma F_x = \frac{\partial}{\partial t}\int_{CV} \rho v_x \, dVol + \int_{CS} \rho v_x (\underline{v}\cdot\hat{n}) dA$$

ρv_x → 0 steady (1)

There is only one force. All v's are unaffected (conserve mass). ∴ Force will increase by 2x when density increases by 2x. (1)

(6)