Quiz 2
BIOE5060: Biomolecular Dynamics and Control
April 28, 2015
(82 points)

Name:

Instructions

- You must work alone and must not consult with anyone else within or outside the class.
- The quiz is open-book, open-notes. You may use any websites or published resources.
- Submit your solutions as a single PDF via email to a.asthagiri@neu.edu by 5 p.m. on April 29, 2015.
- Name the file as 'BIOE5060Qz2 - your_last_name.pdf'.
- To be fair to all students, some of whom may not have access to particular office hour time slots, I will not hold office hours during the quiz period. If you have questions, you may submit them to a.asthagiri@neu.edu by e-mail. I will attempt to respond as soon as possible. Clearly, asking a question with just one or two hours before the solutions are due would not be a good strategy.
- Good luck!

1. Non-linear second-order system. *(40 pts)* Consider a coupled, non-linear system described by the following model:

$$\dot{x} = x\,(3 - x - 2y) \tag{1}$$
$$\dot{y} = y\,(2 - x - y) \tag{2}$$

Identify the fixed point(s) and determine whether the point(s) are stable or unstable. Show your work for partial credit.

2. Non-linear first-order system. *(20 pts)* One of the goals of the class was to analyze systems without detailed calculations and simulations. Consider the system given by $\dot{x} = x - \cos x$. Let a, b, c,... denote the fixed point(s). Without calculating the values of the fixed point(s) and using just pen and paper, sketch the phase portrait, indicate approximately where the fixed point(s) is/are and assess the stability of the fixed point(s). Explain your reasoning for partial credit.

3. True/False *(2 pts each, 22 total)*. Please circle true or false below and submit this paper along with your solutions to the first two problems.

(a) *True/False*. Consider a phase portrait and vector field for a second-order system. For points on a nullcline, the vector field points either toward or away from a fixed point.

(b) *True/False*. Negative feedback can be a source of oscillations.

(c) *True/False*. Positive feedback can be a source of switch-like, ultrasensitive behavior.

(d) *True/False*. Hysteresis is a pre-requisite for irreversible switching.

(e) *True/False*. A time lag in a negative feedback can lead to oscillations.

(f) *True/False*. Bashor et. al. designed a synthetic negative feedback loop by using leucine zipper domains to recruit an engineered version of the negative regulator, Msg5, onto the scaffold, Ste5.

(g) *True/False*. As one way to modulate the strength of the feedback, Bashor et. al. used Fus3-responsive promoters of two different strengths to drive the expression of the engineered Msg5.

(h) *True/False*. The cdc2-cyclin B signal is regulated by both positive and negative feedback.

(i) *True/False*. Slow and fast positive feedback loops are often found interlinked. This allows the system output to respond quickly to the input and remain more stable even when the input is short-lived.

(j) *True/False*. Positive feedback loops always generate hysteresis.

(k) *True/False*. Single-variable, first-order systems can never exhibit oscillations, even if it is a non-linear system.

Thanks for making the first iteration of this course a rewarding experience.
Have an enjoyable summer!