BENG 122A Biosystems and Control

FINAL PROJECT

Choose a biological system to design, analyze, simulate and explore using MATLAB, SIMULINK, and the principles discussed in class. Build a mathematical representation and explore its dynamics and response to perturbations. The system should include at least seven components such as summing points, sensors, controllers, control elements, feedback and/or feedforward loops, and a SIMULINK model of the plant. You may do the following:

(1) Describe the control system and its components in relevant physical detail. You will need to consult a physiology text, research literature, or other resources.

(2) Focus on an appropriately limited aspect of the control system involving one or two control loops. Draw and label the block diagram in the time domain. Define the imaginary boundary between your system and the rest of the universe. State all assumptions.

(3) Quantitatively describe the performance goals and any realistic operational constraints.

(4) Develop a simple model of the system using SIMULINK. Describe the physical phenomena involved in the assumptions. Justify your model. Propose and justify models of the other components. Linearize if necessary and cast the system in terms of deviation variables.

(5) Take the Laplace transform of all the elements and recast the block diagram in transfer function notation.

(6) Reduce the block diagram to its simplest equivalent. Give the overall transfer function. Explain and justify and simplifications.

(7) Using a realistic range of values for the parameters determined from the literature, perform a sensitivity analysis, systematically examining the effect of system parameters and component models on the output. Use the Bode analysis approach to summarize results. Determine the conditions for system stability.

(8) Identify errors that may be present in your simulation. Describe the conditions under which they become significant.

(9) Compare your simulation results with physiological observations. Does the behavior make sense? Comment on any differences.

(10) Describe a clinical syndrome that corresponds to a modified version of your system. Explain what the modification is and what it corresponds to pathologically. Simulate pathologic behavior with the modified version of your system.

(11) Discuss the use of your simulation as an alternative to actual physiologic experimentation. What are its advantages and limitations?

Work in groups of 5, not more. Write up your results in a group report about 4 pages long (0.5-1 inch margins, 10 pt. Times, double column, single space), including figures and tables as appropriate, and including references. Organize the report with appropriate headings and subheadings, consistent with the style of the *IEEE Engineering in Medicine and Biology Conference* (EMBC). Summarize your results in a 200-word abstract on the first page. List all group members. Cite references appropriately in the style of *IEEE EMBS*. Hand in the report on or before December 9th. The report will be graded on accuracy, thoroughness, the soundness of your approach, organization, writing and apparent understanding. Be prepared to summarize your efforts to that point in a 10-minute group presentation in class during the lecture times in the last week of classes.

EXAMPLES OF FINAL PROJECT TOPICS
Discuss with instructor and TAs

Blood pressure control
Blood pressure control during surgery by pump-administered medications
Blood glucose control in hyperglycemia
Blood glucose control in hypoglycemia
Stroke volume control in the artificial heart
Control of gene expression
Control of protein synthesis in cells or bioreactors
Body temperature control in hypo- or hyperthermia
CO2 control of breathing rate
O2 control of cell metabolism
Control of clotting time by pump-administered medications
Management of Parkinson's by controllable stimulator
Robotic surgery
Light avoidance reflex
Balance maintenance
Many other options available