Grading sheet companion
The control of an inverted pendulum

AAE 364L

Objectives/Goals/Purposes

This experiment consists of four parts. What are the objectives of each part? Becoming familiar with equipments and Simulink is not an objective of the experiment. Also, since a controller is already designed in pre-lab, designing a controller is not an objective here either. *Variables cannot be used here since you have yet to define them.*

Intended Methods

How would you achieve your objectives? What kind of inputs do you feed into the system and what kind of outputs do you measure? Do not go into specific details. That is what the procedure section is for.

Definition of Variables

What are the variables you use in your report? Include only those variables that you use and mention. Extra variables that are not mentioned in your report are of no interest to the reader.

Schematic and Description of Apparatus

Include picture(s) of the apparatus and schematic(s) describing how your variables are defined. Describe how the apparatus is connected, how you feed the inputs and how the outputs are measured. What can be fed in and what can be measured? What are the restrictions or limitations of the apparatus?

Procedure of Experiments

Any scientific experiment must be repeatable. Describe in detail the important steps and the size of the inputs you feed into the apparatus. What do you measure? How long do you measure data? Buffer size, specific name of variables you use in MATLAB, name of your Simulink scopes, logging in and out of computer, starting program, opening file are of no interest to the reader.

Results

All numbers must be accompanied by proper units. Writing a number without unit is meaningless and NO CREDIT will be given. All numbers must have only reasonable significant digits. For example, $m = 1.23456789$ *kg is not reasonable since we have no instrument that can measure mass*

accurate to 10^{-8} *kg. All parameters must be either in tables or equations. Plots of data are not results. Describe what kind of data each table contains. Data that are not related must not be in the same table.*

Analysis and Discussion

Regarding the plot, the time simulation and experiment start must coincide. It is standard to have system response start at time zero. Data must be valid for all the time shown. Only meaningful data can be included. All plots must have proper labels with units and legends. Legends must not lie over the data. Lines must be distinguishable. Data shown in the same figure must be of the same type. For example, position and angle cannot be plotted on the same graph.

Regarding analysis, include only equations that you use and refer to. Mention only equations that explain what you are doing to the reader. You are not writing a text book, so be brief and get right to the point. Quality of writing is not proportional to the number of equations used. Clearly separate the facts (shown in data) and your opinions (what can be concluded and supported by data).

What are the equations of motion? What are the linearized equations of motion? What are the equilibrium points? Which equilibrium point is of interest here? Describe state variables. Define the state vector. What is the input and what are the outputs? Specify system matrices A, B, C, D corresponding to your input and output. The system matrices A, B, C, D for long and medium pendulum are not the same. Specified both sets of them.

Part (i): What is(are) the objective(s) of your controller? How did you design your controller? What assumption(s) is(are) made when you use a linear controller to control a nonlinear system? What is the motivation behind the poles location that you chose? What is the motivation behind Q and R that you chose, that is, why did you choose to penalize particular state or control input more than others? Give the plots of position and angle, from simulation and experiment, when the system is given initial condition [0,0.2,0,0]. Give the plots of position and angle, from simulation and experiment, when the pendulum is tapped, that is, when the system is given initial condition $[0,0,0,\dot{\alpha}(0)]$. How do you determine $\dot{\alpha}(0)$? How are these plots generated? Which set of gains give you better system response? Define what you mean by "better".

Part (ii): What is(are) the objective(s) of your controller? How did you design your controller? What is the motivation behind Q and R that you chose, that is, why did you choose to penalize particular state or control input more than others? Give the plots of position and angle, from simulation and experiment, when the position command is given by the step of -0.2 meters for the first 5 seconds and the step of 0.2 meters after that. How are these plots generated? Is the system response to this particular command acceptable to you? Define what you mean by "acceptable".

Main Points

What did you do in this experiment? What can be concluded from data obtained? Be brief, this is not the place to put in details. Do your controllers achieve the design objective(s)? Are their performance acceptable under the conditions you test? If not, recommend ways to improve the design

methodology, or others design specification. Which design methods do you prefer, pole placement or LQR? Why?

Theoretical/Experimental Limitations

What assumptions have you made in order to analyze your system? What kinds of responses or system properties can be analyzed theoretically but cannot be generated in the real experiment? What can you do and cannot do experimentally, and why? In any scientific experiment, it is always assumed that human error factor is minimal. Thus human error is not a limitation of your experiment.

Personal Lessons Learned and Suggestions for Improvement

If you have nothing to say here, you must state that you have no suggestion at this point. Leaving this part unanswered is equivalent to submitting an incomplete report. Say something constructive, something that will help improve learning experience of students who will take this course next semester.

We have already spent about $60,000 on these equipments, so please do not suggest buying more expensive equipments. If you know of other companies that produce superior equipments with lower or competitive price, please let us know. Please do not suggest something that cannot be done, such as having the entire apparatus in vacuum to eliminate the disturbance from the air.

In this particular experiment, we already know that the gears are made of plastic and are easily broken. So please do not suggest buying new gears. We also know that pole placement is a trial-error and a very tedious task.