

ECE-521 Control Systems II
Homework 6

Due at the beginning of class, Tuesday January 25, 2005

For this homework you will need the state model files from the class website for the one, two, and three degree of freedom systems.

1) One degree of freedom system.

a) Implement a state variable feedback system that forces the system to be a type one system for the one degree of freedom system with the state model on the web. You should construct a Simulink model (probably just modify one that you have) and a Matlab driver (modify one that you have). You should generate a neatly labeled graph displaying the position and velocity of the cart, the amplitude of the control signal, and the output of the system (you should already have this.) Turn in your Matlab code and Simulink.

b) Utilizing an lqr controller, the last Q penalty value is a penalty on the new (augmented) state. Using the command $k = \text{lqr}([0.1 \ 0 \ 1], 10)$ you should get the results displayed in Figure 1. Turn in your plot.

c) Change the penalty on the new state to 10, then 100, then 1000. How does the response of the system change? How are the feedback gains changed? Turn in all of these (neatly labeled) plots.

d) Utilize Matlab's **place** command to place the poles at $[-5 \ -10 \ -15]$ and $[-5 \ -10 \ -500]$. Does the system respond the way you think it should? That is, if the dominant poles of a system don't move the response of the system should not change. Does the response of the system change? Turn in your plots.

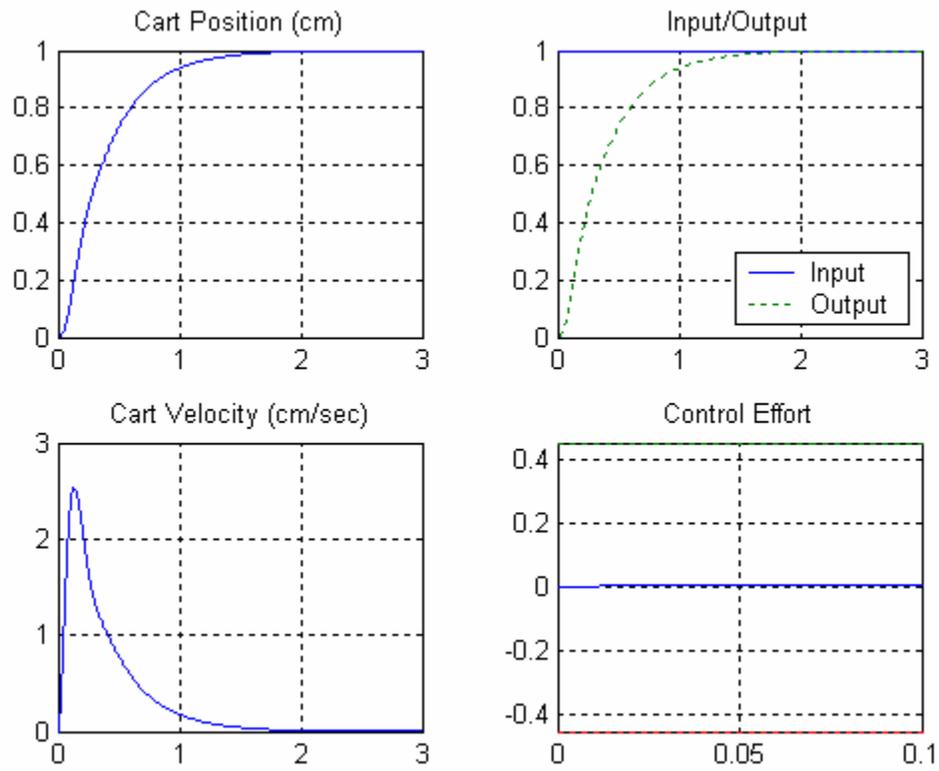


Figure 1. Step response of type one system using lqr algorithm.

2) Two degree of freedom system.

a) Implement a state variable feedback system that forces the system to be a type one system for the two degree of freedom system with the state model on the web. You should construct a Simulink model (probably just modify one that you have) and a Matlab driver (modify one that you have). You should generate a neatly labeled graph displaying the position and velocity of both carts, the amplitude of the control signal, and the output of the system (you should already have this.) Turn in your Matlab code and Simulink.

b) Utilizing an lqr controller, the last Q penalty value is a penalty on the new (augmented) state. Using the command $k = \text{lqr}([0.1 \ 0 \ 0.1 \ 0 \ 1], 10)$ and controlling the position of the first cart you should get the results displayed in Figure 2. Turn in your plot.

c) Using the command $k = \text{lqr}([0.1 \ 0 \ 0.1 \ 0 \ 1], 10)$ and controlling the position of the second cart you should get the results displayed in Figure 3. Turn in your plot.

d) Change the penalty on the new state to 10, then 100, then 1000 in part (c) How does the response of the system change? How are the feedback gains changed? Turn in all of these (neatly labeled) plots.

e) Utilize Matlab's **place** command to place the poles at $[-5 \ -10 \ -15 \ -20 \ -25]$ and $[-5 \ -10 \ -15 \ -20 \ -2500]$. Does the system respond the way you think it should? That is, if the dominant poles of a system don't move the response of the system should not change. Turn in your plots.

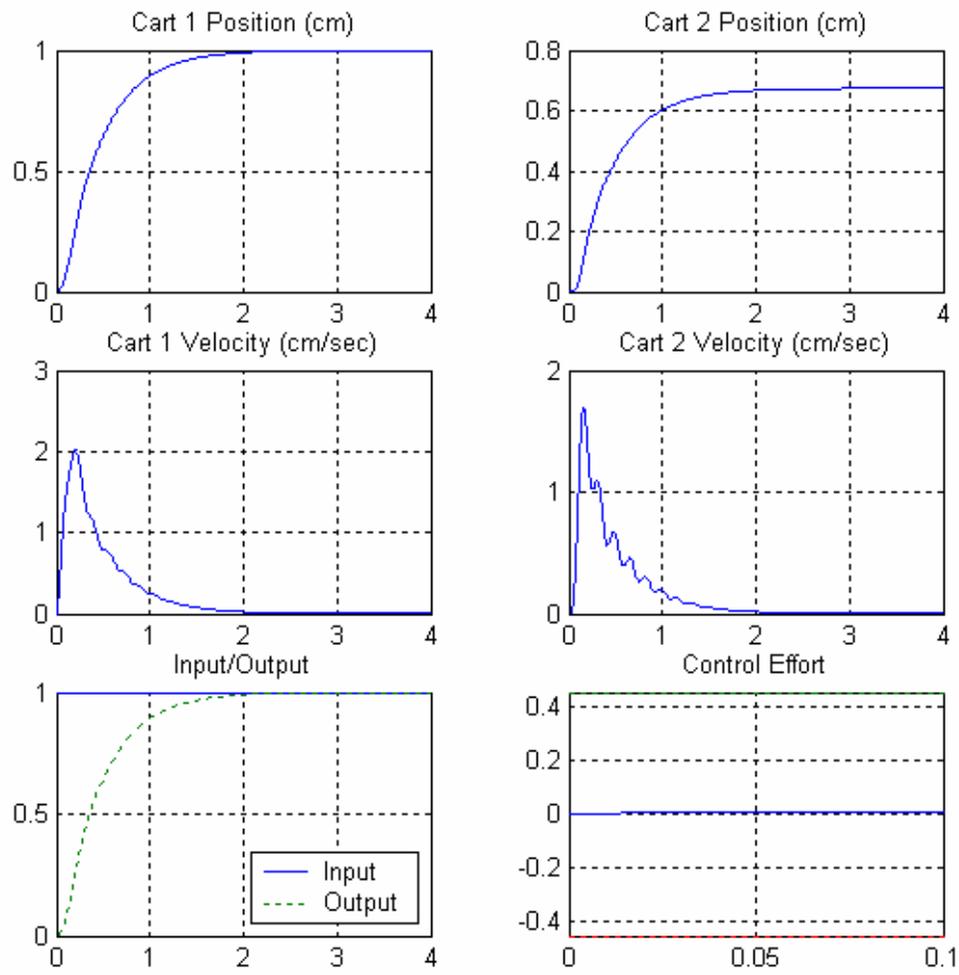


Figure 2. Step response of a two degree of freedom system using the lqr command. The position of the first cart is being controlled.

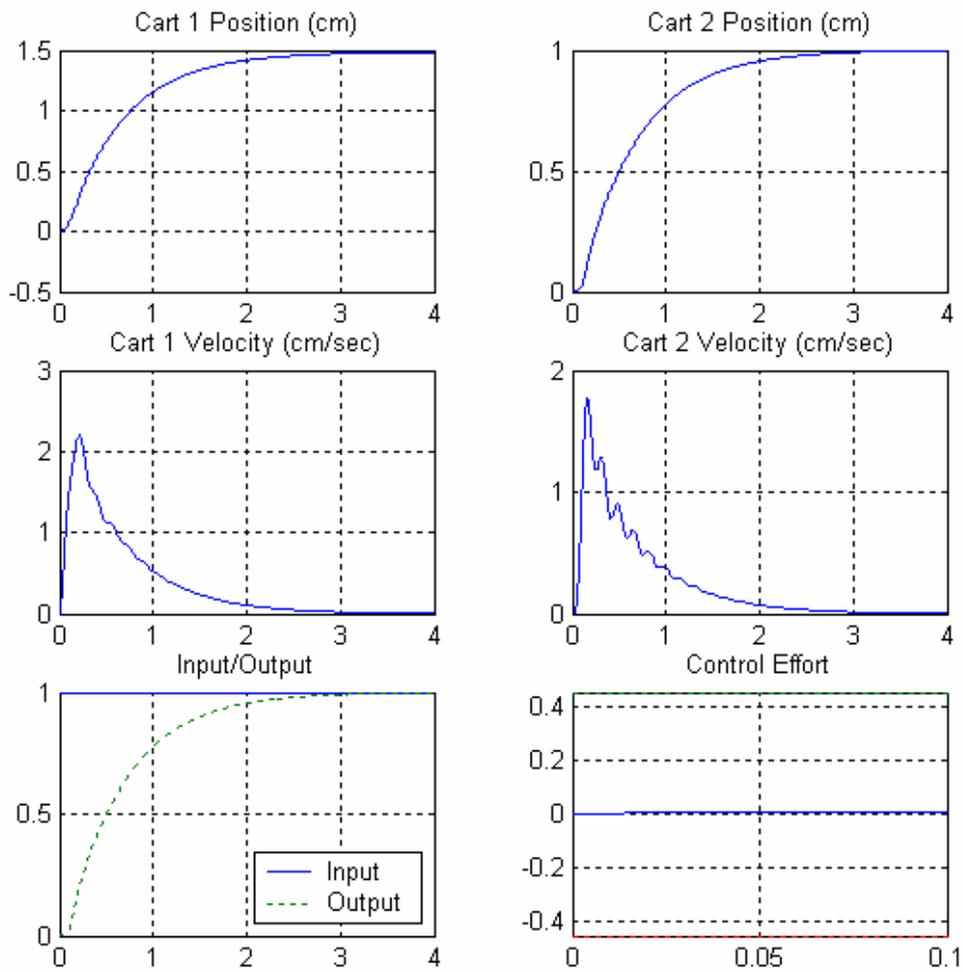


Figure 3. Step response of a two degree of freedom system using the lqr command. The position of the second cart is being controlled.

3) Three degree of freedom system.

a) Implement a state variable feedback system that forces the system to be a type one system for the three degree of freedom system with the state model on the web. You should construct a Simulink model (probably just modify one that you have) and a Matlab driver (modify one that you have). You should generate a neatly labeled graph displaying the position and velocity of all three carts, the amplitude of the control signal, and the output of the system (you should already have this.) Turn in your Matlab code and Simulink.

b) Utilizing an lqr controller, the last Q penalty value is a penalty on the new (augmented) state. Using the command $k = \text{lqr}([0.1 \ 0 \ 0.1 \ 0 \ 0.1 \ 0 \ 1], 10)$ and controlling the position of the first cart you should get the results displayed in Figure 4. Turn in your plot.

c) Use the command $k = \text{lqr}([0.1 \ 0 \ 0.1 \ 0 \ 0.1 \ 0 \ 1], 10)$ and control the position of the second cart. Turn in your plot.

d) Using the command $k = \text{lqr}([0.1 \ 0 \ 0.1 \ 0 \ 0.1 \ 0 \ 1], 10)$ and controlling the position of the third cart you should get the results displayed in Figure 5. Turn in your plot.

e) Change the penalty on the new state to 10, then 100, then 1000 in part (c) How does the response of the system change? How are the feedback gains changed? Turn in all of these (neatly labeled) plots.

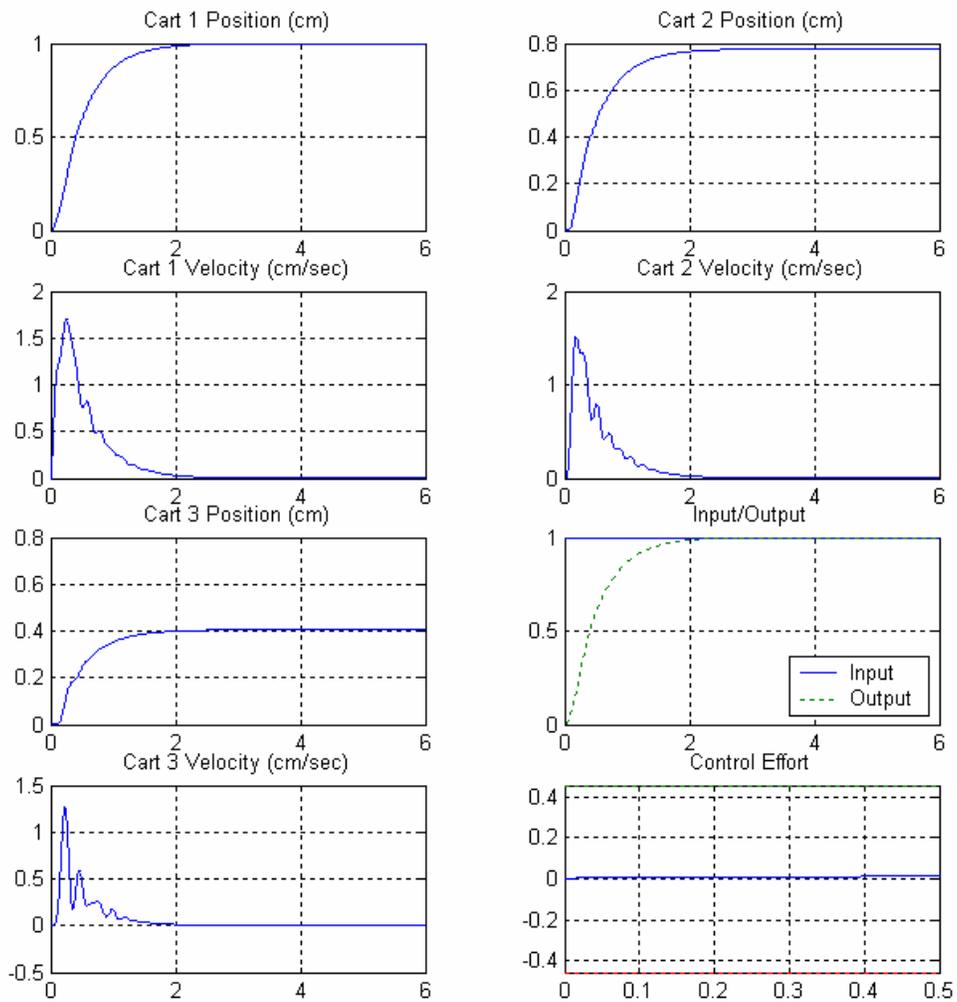


Figure 4. Step response of a three degree of freedom system using the lqr command. The position of the first cart is being controlled.

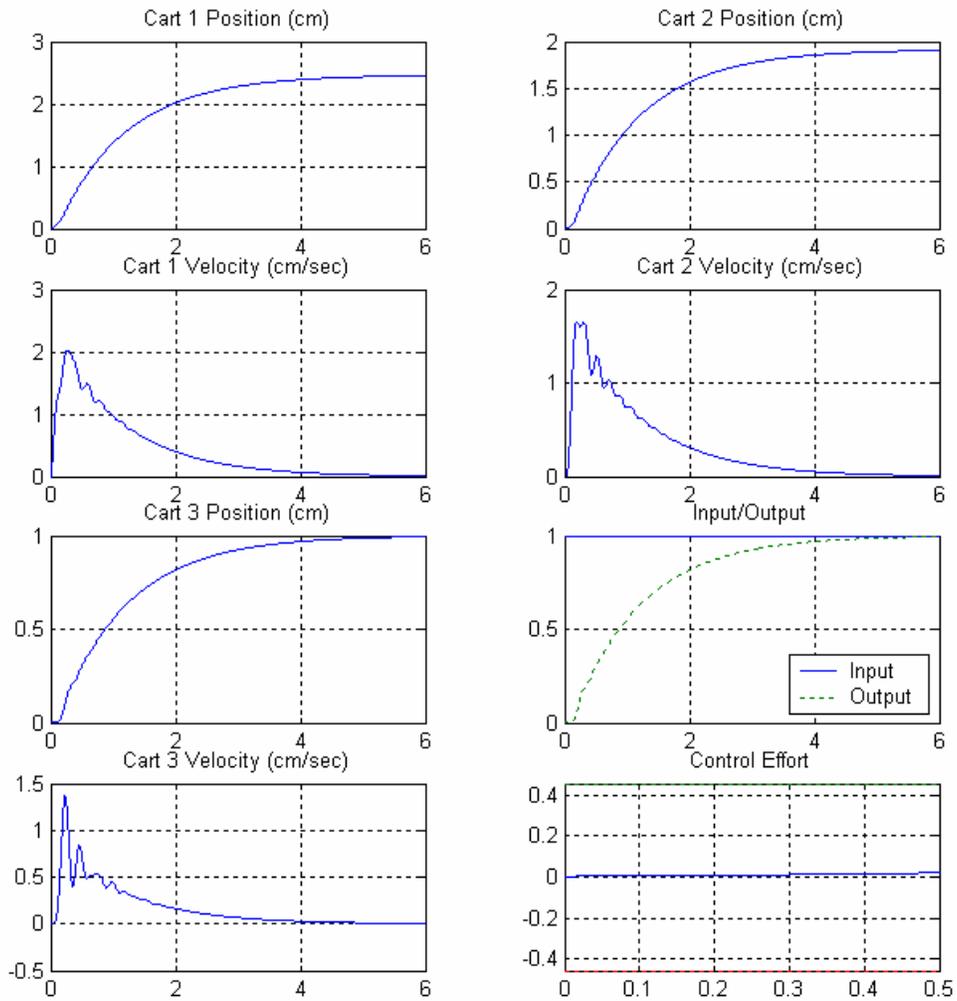


Figure 5. Step response of a three degree of freedom system using the lqr command. The position of the third cart is being controlled.