The University of Texas at Austin
Department of Electrical and Computer Engineering

EE362K: Introduction to Automatic Control – Fall, 2017

Problem Set 6

Suggested Reading: Chapters 8 & 9 of Åström & Murray

1. Find the transfer function between the input u and the output y for the following system from a) its state-space model and b) using Laplace Transforms. Do the two results agree?

$$\dddot{x} - 3x + 1\ddot{x} - 2\dot{x} = u$$
$$y = 2x + u$$

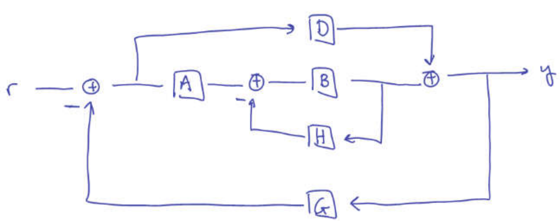
2. Industrial printers use a laser beam to produce quality text documents. The laser is often mounted on a belt drive that can be modeled to include both compliance and dampening.

$$Y(s) = \frac{15(s+50)}{s^2 + 110s + 1000} R(s)$$

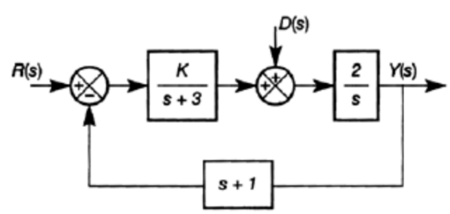
Where the input $r(t)$ would be the desired position for the laser.

(a) If $r(t)$ is a <u>unit</u> step input, find the output $y(t)$ and what is the final steady state value for the location of the laser head?
(b) Use MATLAB to determine the state-space model for the system and confirm that the eigenvalues of the state-space model **A** matrix are identical to the poles for the transfer function.
(c) Use the convolution equation to prove the transfer function given above can be attained from the state-space model.

3. Simplify the following block diagram.



Problem 3



Problem 4

4. Find the Transfer function for the given system if (a) D(s)=0 and (b) R(s)=0. For (c), write the transfer functions T(s)=Y(s)/R(s) if both are nonzero.

5. Sketch by hand the requested plots for the following functions. If specific values are not given, sketch the plots as a function of the k.

a) $T(s) = \dfrac{k}{s}$ (Bode, Polar)

b) $T(s) = \dfrac{20s(0.1s+1)}{(s+10)^2}$ (Bode, Polar)

6. By hand (using the step by step directions given in class), create the Root Locus for the following system. Verify your sketch using MATLAB and then use MATLAB to determine the gain values of interest (such as before or after a breakaway point). At these points, sketch the Bode (both magnitude and phase) plots for the closed loop system and verify your results using MATLAB.

$$C(s)G(s) = \frac{k(s^2 + 16s + 60)}{s(s^2 + 6s + 8)}$$

7. For the Plant given in problem 6, use MATLAB to simulate the response of the system at 3 different values of *k* of your own selection. If possible, select values of *k* where the system response is underdamped, overdamped, and unstable.

8. For the Plant given in Problem 6, is it possible to add a single pole in the left hand plane that its presence ensures that the system go unstable as $k \rightarrow \infty$? If so, use MATLAB to identify such a system and illustrate your answer.

9. What is the Transfer Function for a system described by the following Bode plot?