Concordia University

Department of Computer Science & Software Engineering

SOEN 385 Control Systems and Applications

Final Exam

April 17, 2015

Time: 9:00-12:00

Instructions:

1) *This exam has 8 problems. Answer all questions.*
2) *Exam question sheet must be returned.*
3) *Students are allowed to use:*
   a) *one page **two-sided** crib sheet size 8.5" x 11".*
   b) *a calculator approved by the Faculty of Engineering and Computer Science*

Answer questions in the given order.

1) [5 pts] Represent the following transfer function in state space equations. Give your answer in vector-matrix form:

$$T(s) = \frac{(s^2 + 3s + 7)}{(s+1)(s^2 + 5s + 4)}$$

2) [8 pts] Find the transfer function $G(s) = Y(s) / R(s)$ for the following system represented in state space equations:

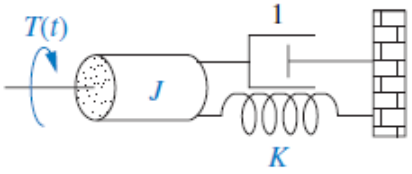
$$\dot{\mathbf{x}} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -3 & -2 & -5 \end{bmatrix} \mathbf{x} + \begin{bmatrix} 0 \\ 0 \\ 10 \end{bmatrix} r$$

$$y = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} \mathbf{x}$$

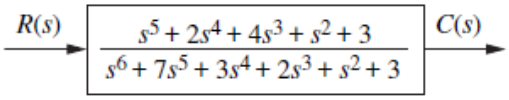
3) [10 pts] Find the following specifications: percentage overshoot, settling time, rise time, and peak time for the following system:

$$T(s) = \frac{14.145}{(s^2 + 1.34s + 2.8)}$$

4) [10 pts] Find J and K in the rotational system shown in the following figure to yield a *30%* overshoot and a settling time of *4* seconds for a step input torque.

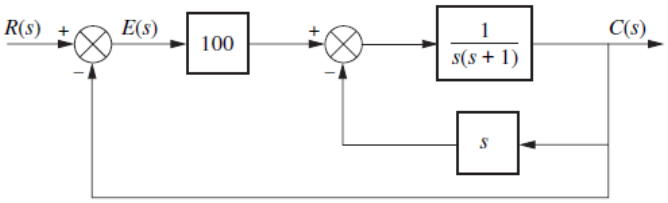


5) [8 pts] Write the differential equation for the system shown below and draw the signal flow graph:



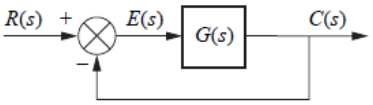
6) [12 pts] Find the total transfer function for the following system, then answer the following questions:

a) Is this system overdamped, underdamped, critically damped, undamped, or unstable?
b) Calculate all specifications of the system as in Question 3 above.



7) [12 pts] Given the following unit feedback system:

a) Find the range of K for which the system is stable.
b) What is the steady state error for unit step input?



where

$$G(s) = \frac{K(s^2 + 1)}{(s + 1)(s + 2)}$$

8) [15 pts] Given a unity feedback system that has the open loop transfer function:

$$G(s) = \frac{Y(s)}{U(s)} = \frac{K}{(s + 2)(s + 4)(s + 6)}$$

a) Sketch the root locus.
b) Indicate on the root locus graph the region in which the percentage overshoot is at most 10%.
c) Using a second order approximation, design the value of K to yield 10% overshoot for a unit-step input.

End of exam