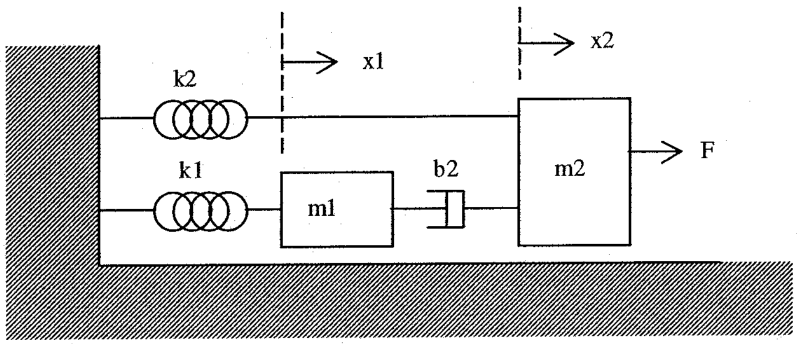
EE 128 Midterm Exam

You must show your work.
No credit will be given to correct answer without work shown.
Write your name on <u>all</u> extra paper!

Fall 2004

(1) Consider the following mechanical system where **m1** and **m2** are the masses of the blocks, **k1** and **k2** are spring constants, **b2** is the damper constant, and **F** is the applied force. Assume the surface is frictionless. Input to the system is the force **F** and the output of the system is the speed of **m1**. Derive a state-variable model for this system (12%)



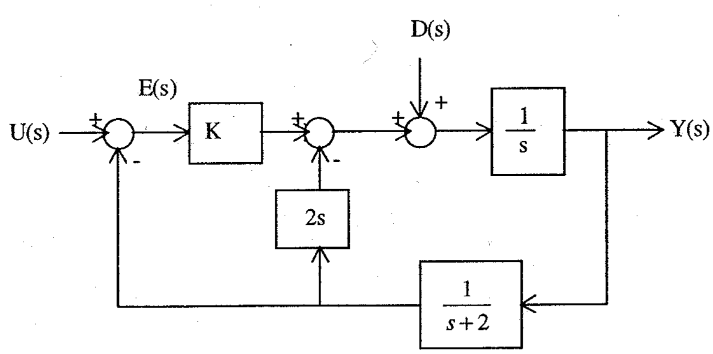
(2) A nonlinear system is modeled by the following differential equation where u is the input variable. The output variable of the system is $y = (q+1)u$

$$\ddot{q} + (\dot{q} + q)q - 1 = u$$

(2.a) Write a <u>nonlinear</u> state equation for this system. (6%)
(2.b) List all the equilibrium state(s) of the system with $u=0$. (6%)
(2.c) Linearize the system at all equilibrium states found in (2.b). The linearized equation should be in the linear state variable form (i.e., the matrix form). (8%)

(3) Consider the following system where u is the input, y is the output and d is the disturbance.

(3.a) Find the transfer function from U(s) to Y(s). (8%)
(3.b) Find the value of K such that the damping ratio of the complex poles of the closed-loop system is 0.5. (6%)

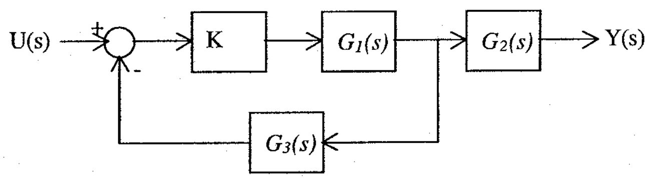


(4) Consider the following feedback system.

(4.a) What is the relationship, if any, between the poles of the transfer function from U(s) to Y(s) and the poles and zeros of $G_1(s)$, $G_2(s)$, and $G_3(s)$? You must explain your answer. (4%)

(4.b) What is the relationship, if any, between the zero of the transfer function from U(s) to Y(s) and the poles and zeros of $G_1(s)$, $G_2(s)$, and $G_3(s)$? You must explain your answer. (4%)

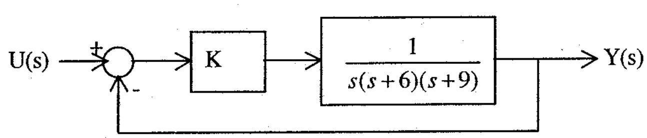
(4.c) How are the zeros of the transfer function from U(s) to Y(s) affected by the value of K as it varies from 0 to ∞? You must explain your answer. (4%)



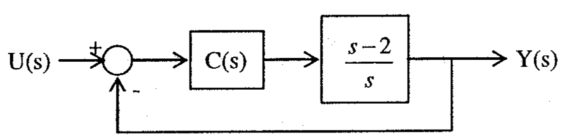
(5) Consider the following unity feedback system.

(5.a) Sketch the root locus. Specifically, you must show: asymptotes and break away point (10%)

(5.b) Find the maximum value of K that gives the closed loop system all real poles. (6%)



(6) Consider the following unity feedback system.



(6.a) Assume C(s)= K (a constant), sketch the Nyquist plot (does not need to be precise). You must show the direction of the plot and the encirclement. (6%)

(6.b) Assume C(s)=K, prove that the system is unstable for all positive K. (You may use any method you learned from this class). (6%)

(6.c) Design a compensator C(s) that stabilizes the system.
Hint: C(s) should have 1 pole, 1 zero, and a gain term K. Use the root locus concept to determine the location of pole and zero. You can then select a value for K. Your design should not involve pole-zero cancellation. You must prove that your design results in a stable closed loop system. (12%)