University of California, Berkeley
College of Engineering
Department of Electrical Engineering and Computer Sciences

EE128 `Fall 2000, Hsu

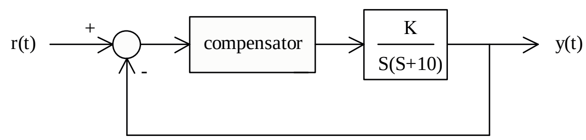
FINAL EXAM

(1) The following equation is a dynamic model of a nonlinear system. The variables *u* and *y* represent, respectively, the input and output of the system. Linearize this system about the point x1=1, x2=0, and u=1 and put the linearized system in the standard linear state equation form. (10%)

$$\dot{x}_1 = \cos(x_2)x_1^3 - x_1 u$$
$$\dot{x}_2 = x_2 x_1 - x_2 u$$
$$y = x_1^2 - u^2$$

(2) What is a PID controller? Use a second-order plant as an example, explain the purpose and the effects of each feedback term in a PID controller and explain how you will tune each term by experiment. (10%)

(3) Design a lead compensator for the following closed loop system where K=1000 so that the phase margin is at least 45 degree. (10%)



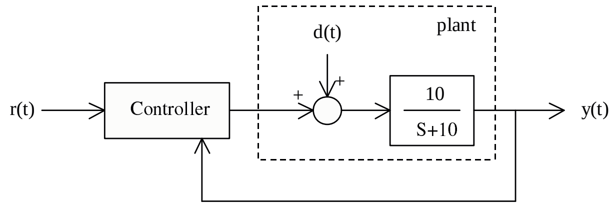
(4) Design a state feedback controller with reference input for the following system. The closed loop transfer function should have poles at -1 and -2 and a DC gain from a reference input to *y* is 1.(10%)

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 0 & -1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$
$$y = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

(5) Is the system below observable? If it is not, find an initial state $\begin{bmatrix} x_1(0) \\ x_2(0) \end{bmatrix}$ and show that, with this initial state, output y(t) is zero for all t>0, if u(t)=0 for all t>0. (15%)

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 2 & -1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$
$$y = \begin{bmatrix} 2 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

(6) Consider the following system where d(t) is a disturbance input.. This disturbance is a steady 60Hz sinusoidal signal with unknown amplitude and phase. Explain <u>in detail</u> how to design a controller that, at steady state, completely rejects the effect of the disturbance d(t) on the output y(t) while keeping the transfer function $\frac{y(s)}{r(s)} = \frac{10}{s+10}$. The only available feedback signal is y(t). You don't need to give numerical values for every variables in your design. For those variables without values, you must explain how you will determine the value for each of them by including the equation that should be used to determine the variable values.



(7)The sampling frequency of the following discrete equation is 1kHz. Find the natural frequency (in Hz) and the percentage overshoot of the step response of this system. (10%)

$$\begin{bmatrix} x_1(k+1) \\ x_2(k+1) \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 0.64 & -1.6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

(8) The continuous time transfer function 1/(S+1) is discretized by way of forward approximation (i.e., Euler's rule) at 10Hz. What is the error (in percentage) of the discretized system's magnitude response at the frequency of 1 rad/sec with respect to the magnitude response of its continuous time counterpart at the same frequency ? (10%)

(9) Discretize the following state equation at 1 second sampling interval. The input variable u(k) is held constant between samples. (15%)

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 0 & -1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u$$

$$y = \begin{bmatrix} 0 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$