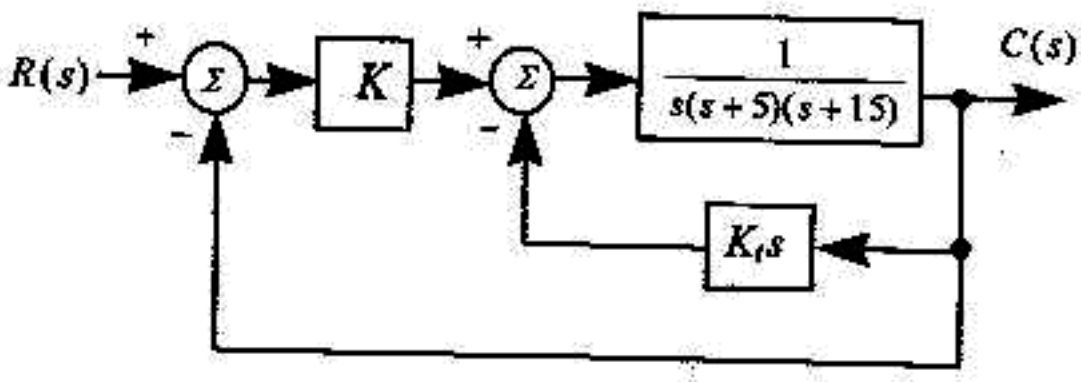
1. Consider the following two-loop feedback compensation system



please design the inner-loop feedback compensation (i.e., K_f) to yield a damping ratio of 0.8 for the inner-loop (in this case there are three complex poles at $0, -10 \pm j7.5$) and then design outer-loop feedback compensation (i.e., K) to yield a damping ratio of 0.6 for the closed-loop system (in this case there are three poles at $-10.93, -4.535 \pm j6.046$). (15%)

2. Given the following plant

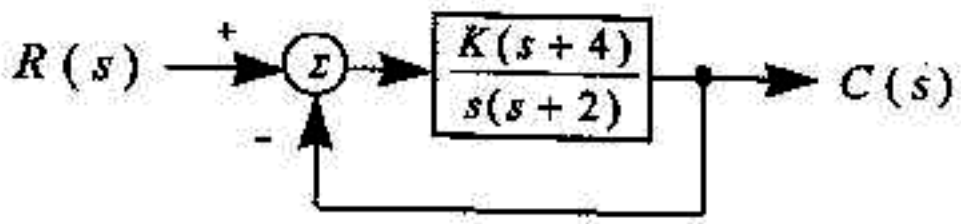
$$G(s) = \frac{20(s+5)}{s(s+1)(s+4)}$$

(1) please find the system's state-space equation, i.e.,

$$\dot{x} = Ax + Bu$$
$$y = Cx$$

(2) please find a state feedback $u = Kx$ to yield a 9.48% overshoot and a settling time of 0.74 seconds (in this case, the closed loop system has a desired characteristic equation $s^3 + 15.9s^2 + 136.08s + 413.1 = 0$). (20%)

3. (1) Construct the root-locus for the following system and determine the gain at $x = -4$ (where x denotes the real part of s) and at $x = -8$.



(2) Describe how to apply the root-locus method to design a controller and state what is the application constraint. (15%)

4. Given the following double integrator:

$$\frac{d^2y}{dt^2} = u$$

where y is the output and u is the input. Let

$$x^T = [x_1 \ x_2] = [y \ \dot{y}]$$

(1) Find the corresponding state equation and the output equation.
(2) Sampling the above system using a zero-order hold with sampling period T, find the corresponding discrete-time state equation and output equation. (20%)

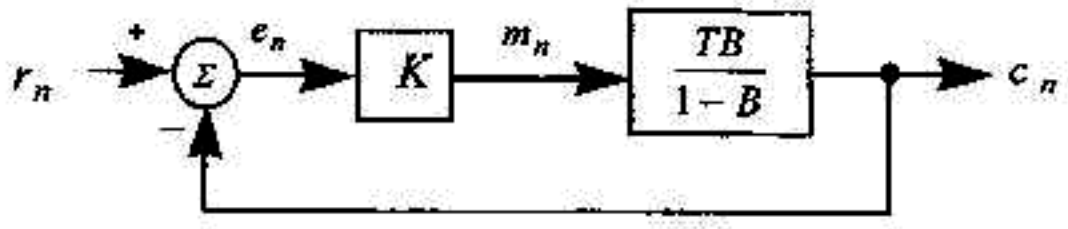
5. Given the following nonlinear differential equations:

$$12 = x_1 + 2\frac{dx_1}{dt} + x_1x_2$$

$$x_1 = 4\frac{dx_2}{dt} + x_2 + 5$$

where x_1 and x_2 are system states and the steady-state value of x_1 is positive. Find the small-signal differential equations using linearization technique. (10%)

6. Given the following discrete-time closed-loop control system:



where T is the sampling interval and B denotes a back shift operator, i.e., $Bm_n = m_{n-1}$. Find the condition of feedback gain K for the closed-loop system to be absolutely stable. (10%)

7. A sinusoidal signal with frequency= 60Hz is to be sampled into computer. If the sampling frequency is chosen to be 90Hz: (1) sketch the waveforms of the actual signal and the apparent signal; (2) find the frequency of this apparent low-frequency signal as a result of aliasing effect. (10%)