1. (10%) Find the transfer function $\frac{V_{out}(s)}{V_{in}(s)}$ as shown in Fig. 1.

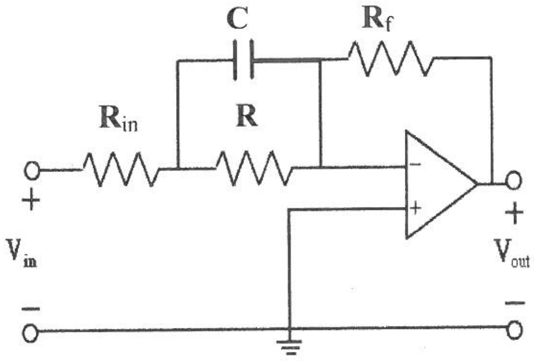

Fig. 1.

2. (20%) The block diagram of a control system is shown in Fig 2. The error signal is defined to be $e(t)$.

(a) Find the steady-state errors in terms of K and K_t when the following inputs are applied (i) $r(t)=u_s(t)$ (ii) $r(t)=tu_s(t)$

(b) Find the value of K and K_t so that the maximum overshoot is 10 percent and the settling time approximated as $t_s \approx \frac{3.2}{\xi w_n}$ is 0.05sec.

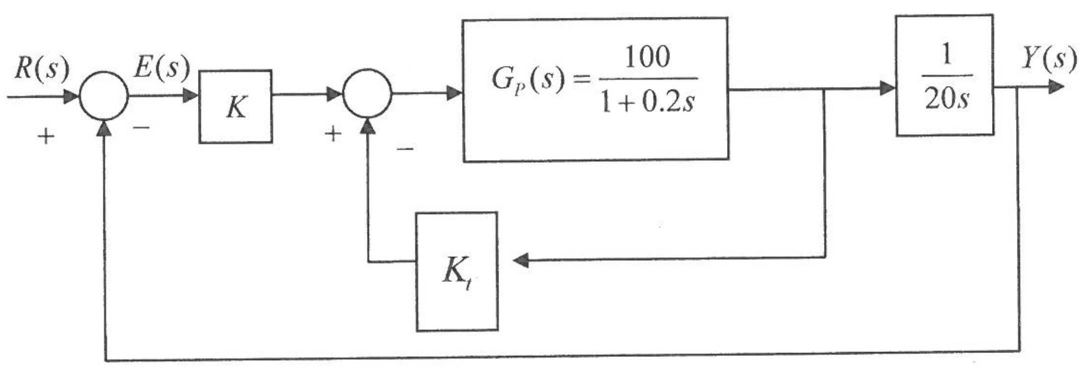

Fig. 2

3. (20%) Given the system $\frac{dx(t)}{dt}=Ax(t)+Bu(t)$, $y(t)=Cx(t)$

where $A=\begin{bmatrix}0 & 1\\ -1 & -3\end{bmatrix}$, $B=\begin{bmatrix}1\\ 2\end{bmatrix}$, $C=[1 \quad 1]$

(a) Determine the controllability and observability of the closed-loop system.

(b) Let $u(t)=-Kx(t)$, where $K=[k1 \quad k2]$. Determine if and how controllability and observability of the closed-loop system are affected by the elements of K.

4. (10%) The transfer function of a unity feedback control system is

$$G(s) = \frac{K}{s(s+6.54)}$$

Find the resonance peak M_r, resonance frequency w_r, and bandwidth BW of the closed-loop system with K=21.39.

5. (30%) The forward-path transfer function of a unity-feedback control system is given in the following. $G(s) = \frac{K}{(s+3)^3}$

(a) Construct the root loci of the characteristic equation of the closed-loop system for $K > 0$.

(b) Apply the Nyquist criterion to determine the range of K for stability and check the answer with the Routh-Hurwitz criterion.

(c) Find the value of K so that the phase margin of the system is 45°.

6. (10 %) Please prove that the following electric network is a phase-lag compensator $\frac{E_o(s)}{E_i(s)} = K\frac{s+a}{s+b}$, $a > b > 0$.