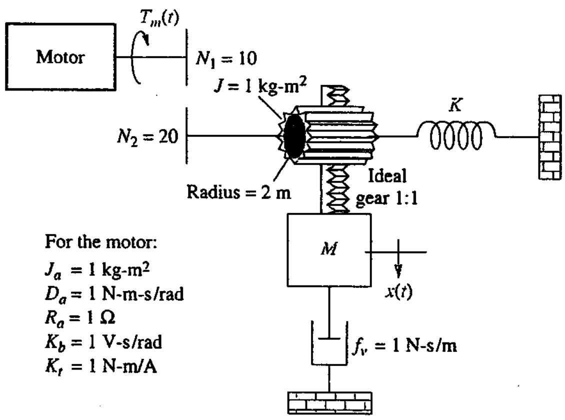
國立臺灣科技大學
九十三學年度碩士班考試試題
系所組別：自動化及控制研究所丙組
科 目：控制系統

題目共有六大題，總分一百分，題號請標示清楚。

1. **(20%)** For an electromechanical system, shown in following figure,



(a) **(10%)** Please derive the transfer function $G(s) = X(s)/T_m(s)$.

(b) Find M **(5%)** and K **(5%)** to yield $x(t)$ with 10% overshoot ($\varsigma = 0.6$) and 10 seconds settling time (2% error) for a step input in motor torque, $T_m(t)$.

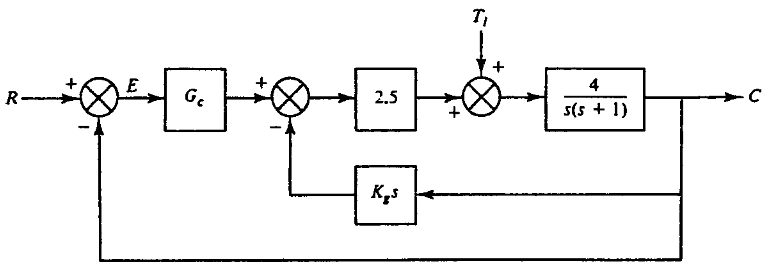
2. **(15%)** For a unity negative feedback system with the open loop transfer function

$$G(s) = \frac{K(s+1)}{s^3 + as^2 + 2s + 1}$$

(a) (10%) Use Routh-Hurwitz criterion to determine the stable conditions of this system and draw the stable margin in $K-a$ plane.

(b) (5%) If this control system has poles at $s = j\omega$ and no poles in the right half s-plane, the system is limited stable with oscillation frequency $\omega = 2rad/\sec$. Determine the values of K and a.

3. **(15%)** The motor position servo control system with a load disturbance T_l is shown in following figure, which has been extended to include velocity feedback.

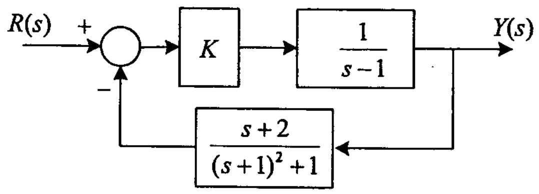


(a) (10%) If $G_c = K_c$ is a control gain, find K_g and K_c to obtain a system with damping ratio 0.5 and 5% steady-state error for step disturbance input torque T_l.

(b) (5%) If we want the steady-state error reduce to 1 % or reduce to zero, how to adjust the gain or design the controller G_c.

國立臺灣科技大學
九十三學年度碩士班考試試題
系所組別：自動化及控制研究所丙組
科　　目：控制系統

4. (20%) Consider the system as



(a) **(5%)** Find the range of the gain K for stable closed-loop system using Routh criterion.
(b) **(7%)** Plot the root-locus diagram of the closed-loop poles from K=0 to K=∞, and verify the results in (a)
(c) **(8%)** Plot the Nyquist diagram, and verify the results in (a) and (b).

(Note: $\tan^{-1}(1/2)=26.6^\circ$, $\tan^{-1}(1/\sqrt{2})=35.3^\circ$, $\tan^{-1}(\sqrt{2})=54.7^\circ$,

$x^3+3.5x^2+2x+1=0 \Rightarrow x=-2.93,\ -0.28\pm j0.51$)

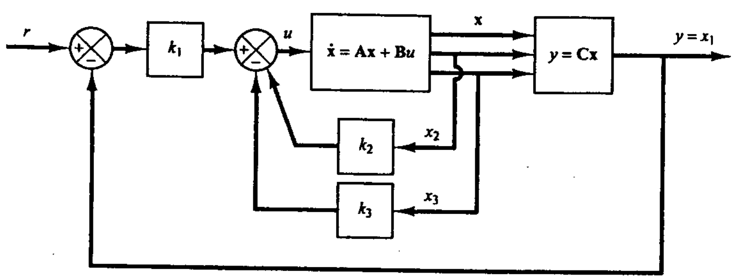
5. (15%) Consider a unity feedback system with the plant as $G(s)=\dfrac{2000}{s(s+5)(s+10)}$.

The required specifications are: (1) $K_V \geq 50$, (2) phase margin $\phi_M \geq 45^\circ$, (3) the bandwidth not be affected too much for noise suppression.

(a) **(10%)** Determine the required gain compensation K to satisfy specification (1).
(b) **(5%)** What kind of the compensation is necessary?

(Note: $w_g\sqrt{w_g^2+25}\sqrt{w_g^2+100}=2500 \Rightarrow w_g=12.12$, $\tan^{-1}(2.42)=67.58^\circ$, $\tan^{-1}(1.212)=50.48^\circ$)

6. (15%) Consider the type 1 servo system shown in the following figure



Matrix **A**, **B** and **C** are given by $\mathbf{A}=\begin{bmatrix}0&1&0\\0&0&1\\0&-5&-6\end{bmatrix}$, $\mathbf{B}=\begin{bmatrix}0\\0\\1\end{bmatrix}$, $\mathbf{C}=\begin{bmatrix}1&0&0\end{bmatrix}$.

(a) **(10%)** Determine the feedback gain k_1, k_2 and k_3 such that the closed-loop poles located at

$$s=-2+j4,\quad s=-2-j4,\quad s=-10$$

(b) **(5%)** Derive the state equations for the designed closed-loop system.