```
注意事項：
1. 本試題共 4 題，配分共 100 分。
2. 請標明大題、子題編號作答，不必抄題。
3. 全部答案均須在答案卷之答案欄內作答，否則不予計分。
```

1. Consider an unstable system $\ddot{x} = x + u$, we want to control it now. Let

$$U(s) = \frac{K(s+a)}{s+10} X(s),$$

   (a) (10%) Select a and K so that the system will display a rise time of about 2 second, and no more than 25% overshoot.

   (b) (15%) Sketch the root locus as K varies from $-\infty$ to 0 for your design.

2. A unity-feedback system with a cascade controller and precompensator is considered, the block diagram is shown in Fig. 1. Give a plant with transfer function $G(s) = \frac{(s-2)}{(s+1)(s-1)}$.
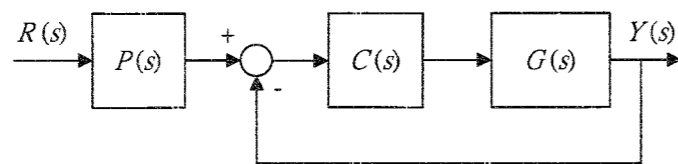

Fig. 1

   (a) (10%) Design the first-order $C(s)$ such that the three poles of the overall system are -3, -2±j.

   (b) (15%) Design a precompensator such that the designed system in part (a) will track asymptotically step-reference inputs.

3. Consider the plant model

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 3 \end{bmatrix} u = AX + Bu,$$

$$y = \begin{bmatrix} 5 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}.$$

   (a) (10%) Design a full state observer to estimate the state of the plant, and describe the model of the observer. Place the eigenvalues of the observer at s=-15.

   (b) (10%) Using the plant model and the observer in the above, implement state feedback such that the roots of det[sI-A+BK] are located at s=-5. Determine the state model of the closed-loop system.

   (c) (10%) Evaluate the eigenvalues of the closed-loop system.

4. An RLC network is shown in Fig. 2. Define the state variable as $x_1(t)=i_L(t)$, $x_2(t)=v_c(t)$ and the outputs as $y(t)=v_c(t)$.
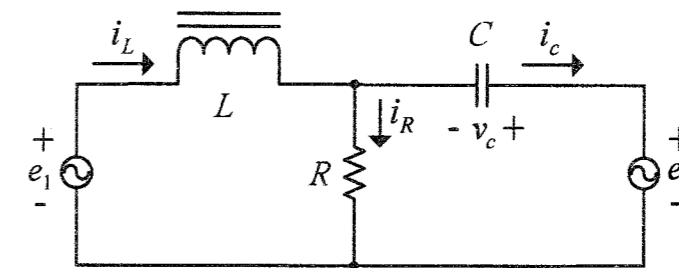

Fig. 2

   (a) (10%) Determine the differential equations. (Using KCL and KVL)

   (b) (10%) Obtain the dynamical equation.