**總分 100 分**

**1.** Consider a unity feedback control system as shown in Fig.1, where

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

(a) Please determine the range of $K$ for closed-loop stability. **(5%)**

(b) Sketch the root locus for $K>0$. **(5%)**

(c) If a step input is given, what value of $K$ will cause the smallest settling time. **(5%)**

(d) Find the steady state error $e_{ss}$ for a unit step input with the value of $K$ from (c). **(5%)**

(e) Make an approximate hand plot of the unit step response of the system with the value of $K$ from (c). **(5%)**

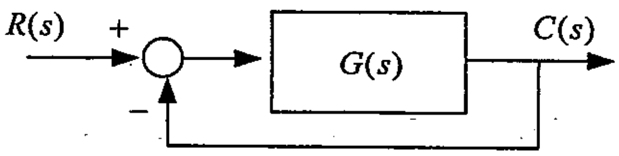

Fig.1

**2.** An active suspension system for vehicles has been proposed. The system uses a pneumatic actuator with the passive suspension system. The closed-loop control system is described as

$$\begin{aligned}\dot{\mathbf{x}}(t) &= \mathbf{A}\mathbf{x}(t) + \mathbf{B}u(t) \\ y(t) &= \mathbf{C}\mathbf{x}(t)\end{aligned} \quad \text{where } \mathbf{A} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -2k & -11 & -6 \end{bmatrix},\ \mathbf{B} = \begin{bmatrix} 0 \\ 0 \\ k \end{bmatrix},\ \mathbf{C} = \begin{bmatrix} 1 & 1 & 0 \end{bmatrix},\ \mathbf{x} = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

In order to make the system marginally stable,

(a) please determine the value of $k$, **(15%)**

(b) please determine the frequency of oscillation. **(10%)**

**3.** A motion control system is developed in Fig.2. Neglect friction force. The input force $u(t)$ is given to a vehicle and results in the displacement response $y$(t). The mass of vehicle $m$ is 1 kg. Define the state variables as $x_1 = y \quad x_2 = \dot{y}$ and the output variable $y(t)$.

(a) Derive the system model in differential equation and in state space form. **(10%)**

(b) Please design the state feedback controller as $u(t) = 2r(t) - \mathbf{K}\mathbf{x}(t)$ to make the closed-loop system with eigenvalues $-1 \pm j$, where $r(t)$ is reference input, $\mathbf{x}(t) = [x_1,\ x_2]^{\mathrm{T}}$ and $\mathbf{K}(t) = [k_1,\ k_2]$. **(10%)**

(c) Please sketch the control block diagram for the closed-loop control system in (b). **(5%)**

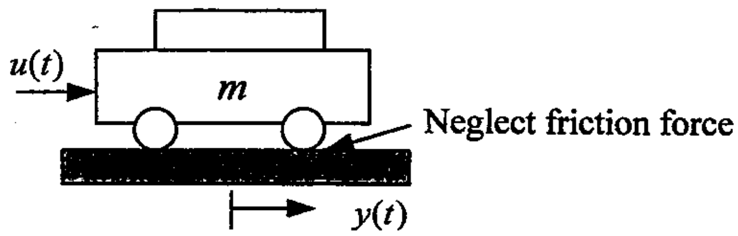


Fig. 2

**4.** Consider a flight control problem in frequency domain in Fig.3.

The characteristic equation is $s^2 + (K-2)s + (2K-3) = 0$

(a) Please find the system transfer function $G(s)$. **(7%)**

(b) Sketch the Nyquist plot. **(10%)**

(c) Find the range of $K$ for stability of the closed-loop system using Nyquist stability criterion. **(8%)**

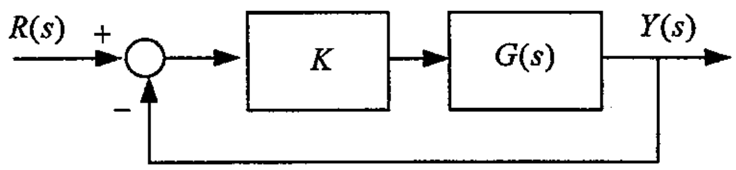


Fig. 3

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