淡江大學 100 學年度碩士班招生考試試題

65-1

系別：航空太空工程學系　　　　科目：自　動　控　制

考試日期：2 月 28 日(星期一) 第 2 節　　　　本試題共　3 大題，　2 頁

本試題雙面印刷

1. Consider the lever-damper system shown in Figure 1, which consists of a mass, m, connected to an excitation base by a spring of stiffness k and two dampers in parallel with the same viscous damping coefficient $c/2$. Let $z(t)$ and $x(t)$ be the displacement of excitation base and the mass respectively. Moreover, assuming that (1) the **oscillations are small**, so that the **linear theory** is applicable, (2) gravitational force can be ignored.

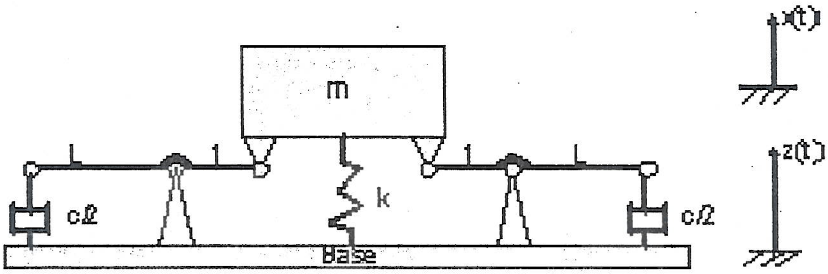

Figure 1. Lever-damper system

(a) (10%) Derive the equation of motion of the system.

(b) (5%) Determine the transfer function $G(s) = X(s)/Z(s)$ of the system, where $X(s)$ and $Z(s)$ are the Laplace transform of x(t) and z(t) respectively.

(c) (10%) Let m=2 kg , k=1.5x10^3 N/m , c=36 kg/s , L=2 m, and assume that the base moves harmonically, i.e., $z(t) = 0.1\sin(2t), t \geq 0$. Find the **steady state** response of the mass m, $x_{ss}(t) = \lim_{t\to\infty} x(t)$.

2. A **negative unity feedback** system has an open-loop transfer function $G(s) = \frac{1.25}{s^2+s+1.25}$.

(a) (10%) The desired closed-loop performance specifications are: damping ratio ζ =0.707, natural frequency $\omega_n = \sqrt{8}$. Where should the closed-loop poles be located?

(b) (10%) Design a **PD controller** that satisfies the above performance specifications. Also sketch the closed-loop system block diagram.

(c) (5%) What will be the steady-state error of your compensated system to a **unit step** input?

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3. Consider the following closed-loop system,

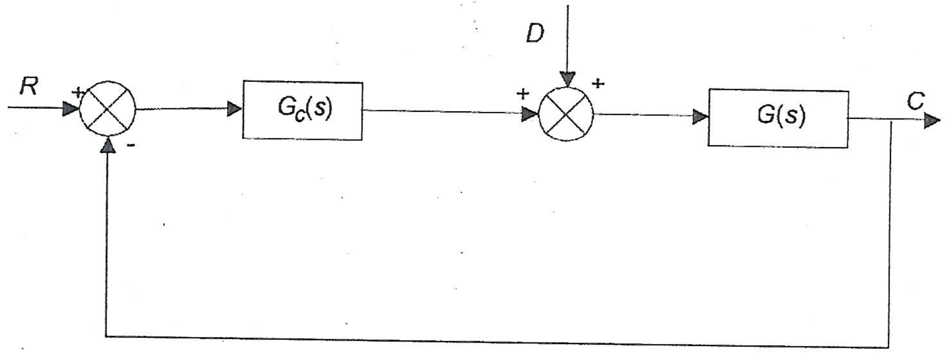

Figure 2 Close-loop system

where the controller $G_c(s) = K$, the system G(s) is represented by the pole-zero map shown Figure 3, and the steady state of the impulse response of the system is 1, that is $\lim_{t\to\infty} g(t) = 1$, $g(t) = \mathcal{L}^{-1}[G(s)]$.

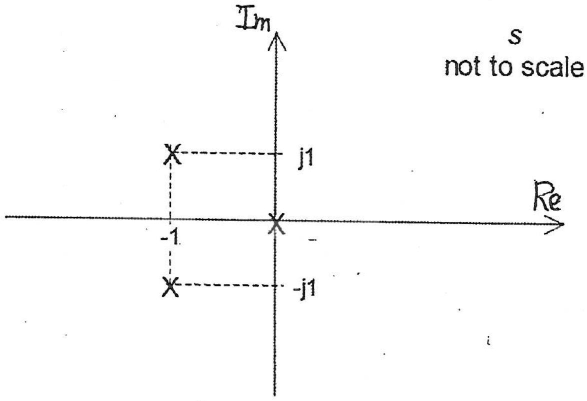

Figure 3 pole-zero map of G(s)

(a) (10%) Determine $G(s)$ then draw the root-locus of the system for $K > 0$.

(b) (10%) Calculate K_c, the value of K for which the closed-loop system becomes critically stable.

(c) (10%) Sketch the complete Nyquist plot of $G(s)$. Clearly show $0^+, +j\infty, -j\infty, 0^-$ and the direction of increasing frequency. Then indicate the range of K for a stable closed-loop system.

(d) (10%) Consider a unity disturbance step input, i.e. $R(s) = 0, D(s) = \frac{1}{s}$. The design specifications require the steady-state step disturbance response $c_{ss} = \lim_{t\to\infty} c(t) < 0.1$. Will the proportional controller work? If so, give the controller design; if not, give an explanation.

(e) (10%) For the controller obtained in part (c), use **straight line approximation** to draw the Bode diagram of $G_c(s)G(s)$. Then estimate the **gain margin** and **phase margin** of the closed-loop system.

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