系所組別： 航空太空工程學系丙組
考試科目： 自動控制

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1. (20%) Assume you are given the system as shown in Figure 1:

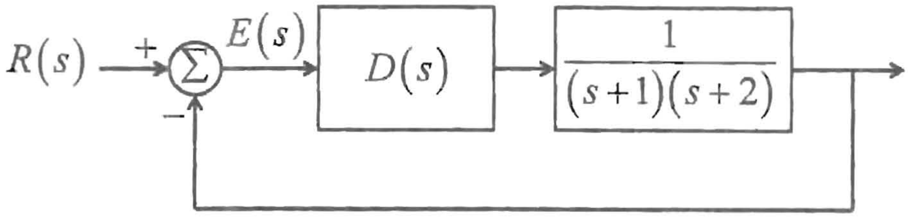

Figure 1

Your job is to design a compensator, $D(s)$ that meets the following specs:

- The closed-loop system has poles at $s=-2\pm 1j$
- The steady-state error due to a step input equals 0.1
- No poles or zeros of $D(s)$ can be faster than $s=-2$.

What is your $D(s)$?

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2. (30%) The feedback control system shown in Figure 2 is to be designed to satisfy the following specifications: (1) steady-state error of less than 10% to a ramp reference input, (2) maximum overshoot for a unit step input is less than 5%, and (3) 1% settling time of less than 3 sec.

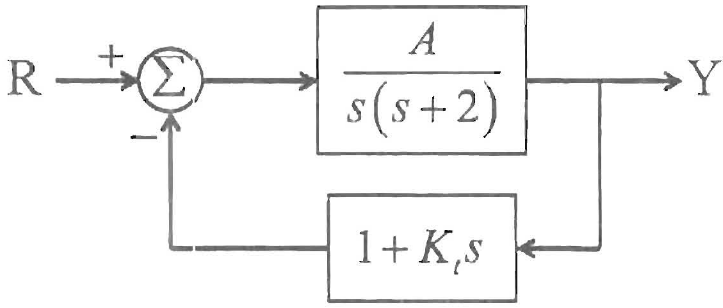

Figure 2

(a) Compute the closed-loop transfer function.

(b) Sketch the region in the complex plane where the closed-loop poles may lie (i.e. the region that meets the specifications).

(c) What does specification (1) imply about the possible values of A?

(d) What does specification (3) imply about the closed-loop poles?

(e) Find the error due to a unit ramp input in terms of A and K_t.

(f) Suppose $A = 32$. Find the value of K_t that yields closed-loop poles on the right-hand boundary of the feasible region. Does this choice for K_t satisfy the desired specifications?

(g) Using $A = 32$ and the value for K_t computed in part (f), estimate the settling time of the system.

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3 . Consider a closed-loop control system shown in Figure (3) with the open-loop transfer function $G(s) = \dfrac{b_2 s^2 + b_1 s^1 + b_0}{s^n (a_3 s^3 + a_2 s^2 + a_1 s^1 + a_0)}$, $a_0 \neq 0$, $b_0 \neq 0$ and $k = 1$.

The plot of the frequency response $G(j\omega)$ for $\omega > 0$ is shown in Figure (4).

5%(a). $n = ?$

10%(b). Suppose that the Nyquist path in the s plane encloses the entire right-half s plane, draw a complete Nyquist plot in the G plane.

5% (c).If $G(s)$ has one zero and two poles in the open right-half s plane, is the closed-loop system stable?

5%(d). Are there any closed-loop poles which are on the imaginary axis ? Why ?

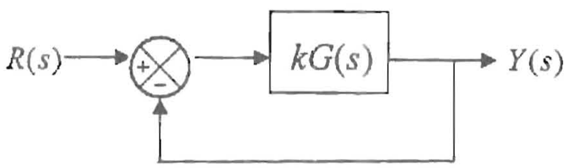

Figure (3)

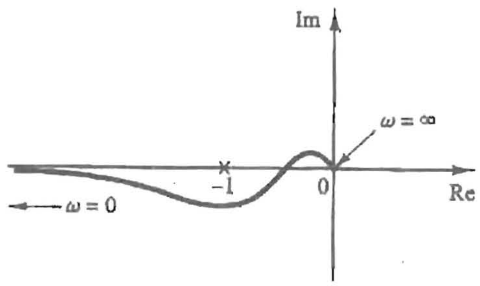

Figure (4)

4 . Consider a closed-loop control system shown in Figure (3) with the open-loop transfer function $G(s) = \dfrac{20}{s(s+1)(s+5)}$, $k > 0$. The Bode diagram of $G(s)$ is shown in Figure (5) and the Bode diagram of closed-loop transfer function $M(s) = \dfrac{Y(s)}{R(s)}$ with $k = 1$ is shown in Figure (6).

5%(a). What is the gain margin GM of the closed-loop system ?

5%(b). What is the phase margin PM of the closed-loop system ?

5%(c). What is the resonant frequency ω_r of the closed-loop system ?

10%(d)., What is the gain margin of the closed-loop system if we set $k = 10$.

<Note : Reading data from the bode diagram is enough to answer questions (a),(b) and (c) .>

(continued)

(背面仍有題目,請繼續作答)

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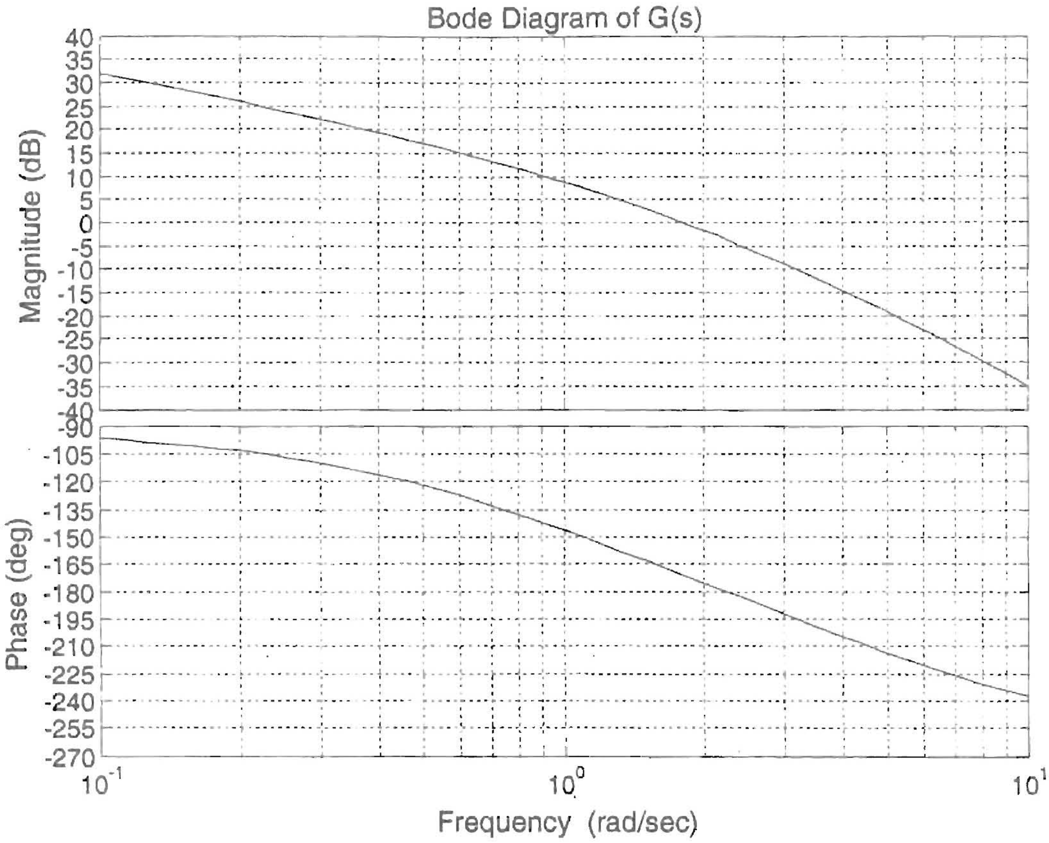

Figure (5)

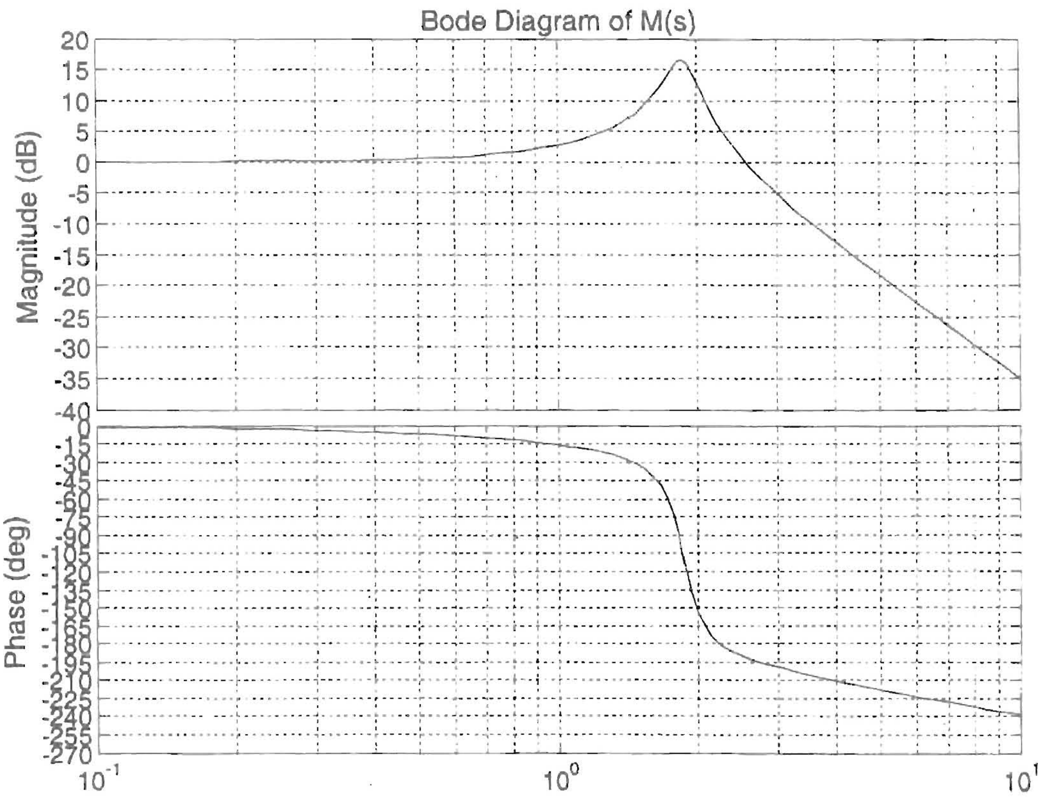

Figure (6)