國 立 清 華 大 學 命 題 紙

九十一學年度 動力機械工程學 系（所） 乙 組碩士班研究生招生考試

科目 控制系統 科號 1401 共 5 頁第 1 頁 *請在試卷【答案卷】內作答

Note: Assuming whatever variables or parameters if necessary.

Prob.1 Consider a two-mass-spring-damper system with two possible inputs, u_1 and u_2, the masses, M and m, the effective damping, b, and the effective stiffness, k, are given and as shown in Figure 1.

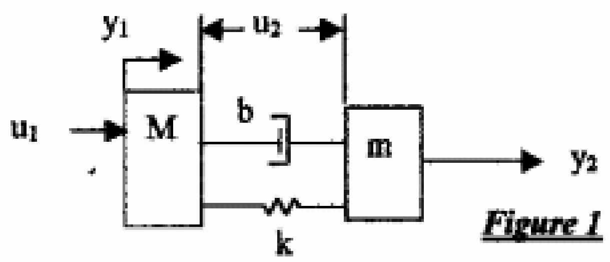

Figure 1

(a) Find $Y_1(s)/U_1(s)$ and $Y_2(s)/U_1(s)$, for $u_2=0$. (4%)

(b) Find $Y_1(s)/U_2(s)$ and $Y_2(s)/U_2(s)$, for $u_1=0$. (4%)

(c) Find $[Y_2(s)-Y_1(s)]/U_2(s)$. (4%)

(d) As a control engineer, you wish to reduce the relative vibration between M and m, a controller, u_2 needs to be designed to serve this purpose. If the specifications for transient response are critical damping (i.e. the damping ratio is one) with a specified natural frequency ω_n, then what is the control law to form u_2? (8%)

Prob.2 Considered a dynamic system with transfer function G(s), where R(s0 is theinput, while Y(s) is the output, we wish to improve its performance in rejecting a constant disturbance D. Inserting an integrator, 1/s, is always a good choice for this purpose. Choose from the two possible structures as shown below, which one will attenuate the disturbance much effectively than the other? Briefly describe your reasoning. (10%)

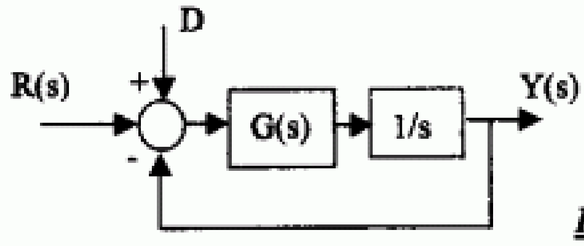

Figure 2(a)

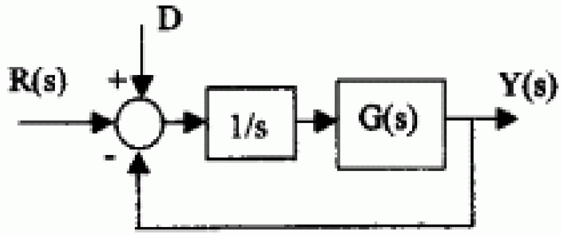

Figure 2(b)

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Prob.3 Choose from the following SEVEN INCORRECT statements, and briefly explain why (28%)

(a) It is impossible to improve the tracking performance by an open-loop control system .

(b) It is impossible to achieve disturbance rejection by an open-loop control.

(c) As compared with a P control, a PI controller improves the steady state error at the cost of a smaller damping ratio when the bandwidth of the control system is about the same.

(d) If the control system has two right-half plane zero, then it causes only time delay but no undershoot in step responses.

(e) In a feedback control system, if the plant has a pure integrator and the controller also has a pure integrator, then the steady state error tracking a parabola command is bounded.

(f) A D-term should be introduced into a PID controller when the response speed is too slow.

(g) The PID parameters obtained from the Z-N tuning formula results in an over-damped control system (i.e., $\varsigma > 1$).

(h) The performance of a feedback system is insensitive to plant uncertainty, but sensitive to sensor nonlinearity.

(i) A PI controller pushes the root locus of a control system towards the right-hand-side on the complex plane (as compared with a P control).

(j) An unstable plant may become stable when feedback control is introduced, and the undershoot effect in a plant can be removed by feedback control.

(k) In a real control system where G(s) represents the plant (including the sensor and the actuator) with a bandwidth about 10 rad/sec and $D(s) = K\dfrac{1+(s/z)}{1+(s/p)}$ represents the controller to be implemented by a micro-processor, K can be chosen as large as 100 in order to yield a closed-loop bandwidth of around 100 rad/sec.

(l) When saturation occurs to a control system, the equivalent DC gain of the loop transfer function (i.e., open-loop system transfer function) tends to decrease.

(m) A Phase lead controller improves the phase plot of the loop transfer function, but not necessarily the resultant phase margin.

(n) To apply the Nyquist stability criterion, we need to know the number and locations of RHP poles and RHP zeros of the plant.

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Prob. 4 Shown below is the gain plot of a stable loop transfer function $L(j\omega)$, with the asymptotic lines and their slope indicated on the figure. Please answer the following questions:

(a) What are the K_P and K_V of the control system? (2%)

(b) At least how many poles are their in L(s)? (2%)

(c) Please write down the transfer function L(s) as a second order system with $|L(j\omega)|=6$ for ω=1rad/sec (3%)

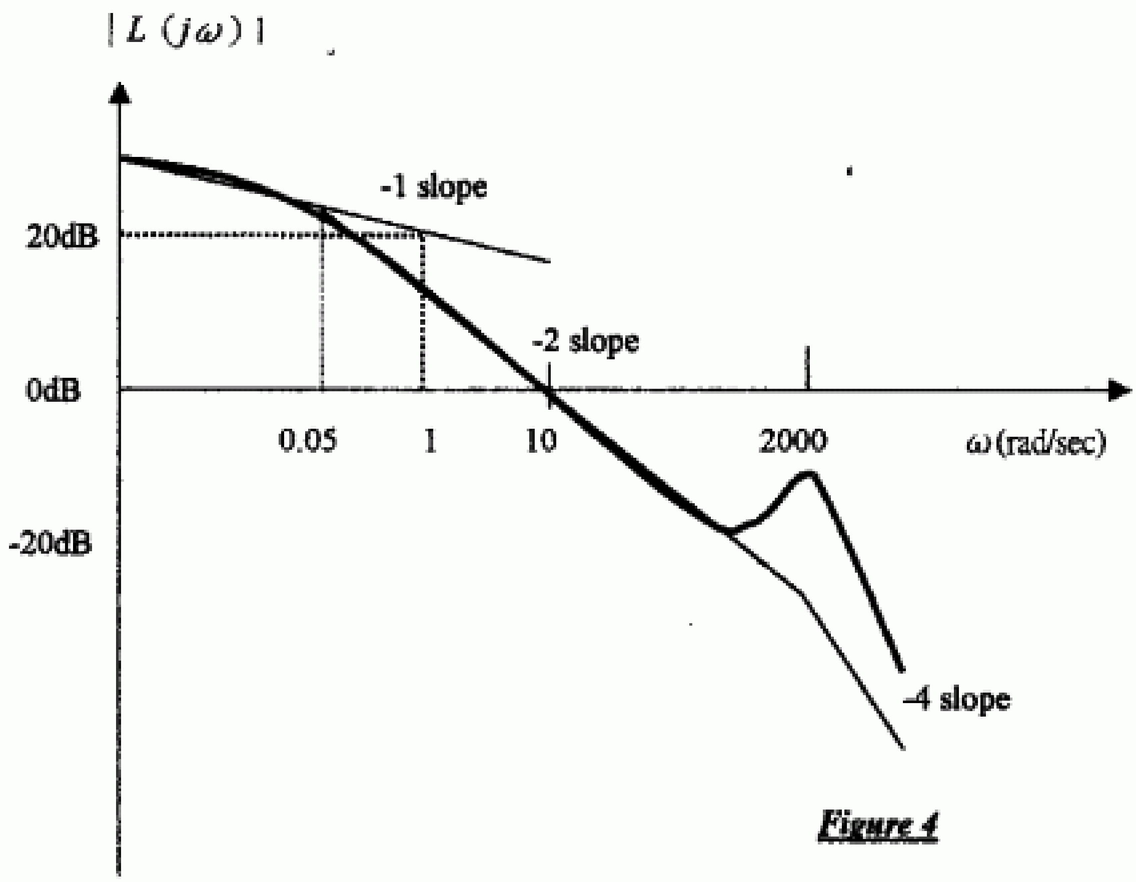

Figure 4

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Prob. 5

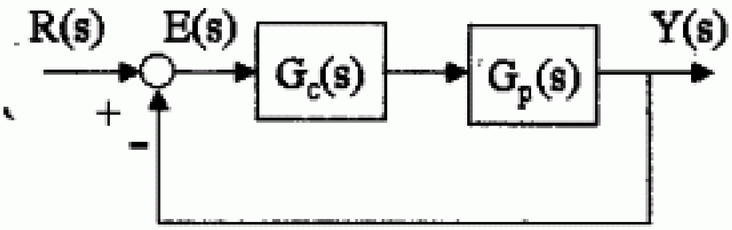

Figure 5

where $G_p(s) = \dfrac{1000(s+10)}{s(s+100)(s-10)}$

(a) For $G_c(s) = K > 0$, sketch the root locus with respect to K for above system. Be sure to specify the asymptotes on your plot if there is any. (6%)

(b) Find the range of K that stabilizes the close-loop system. (6%)

Prob. 6

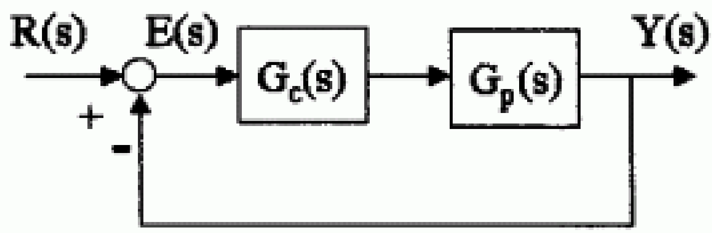

Figure 6

Where $G_p(s) = \dfrac{1}{s(s+2)(s+10)}$ and $G_c(s) = K$

(a) What value of K gives a Gain Margin of 20dB? (10%)

(b) What is the steady-state error on E(s) for a step input on R(s) with your K from (a)? (5%)

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Prob.7 A certain unity feedback system has open loop transfer function KDG and closed-loop transfer function T(s). Plots of Nyquist Diagrams, Frequency Responses and Step Responses for four systems are given in Figure 7. You are requested to match them up. Consider them numbered from 1-4, top to bottom. (8%)

Nyquist Diagram	Bode(T(jw))	Step Response
1	______	______
2	______	______
3	______	______
4	______	______

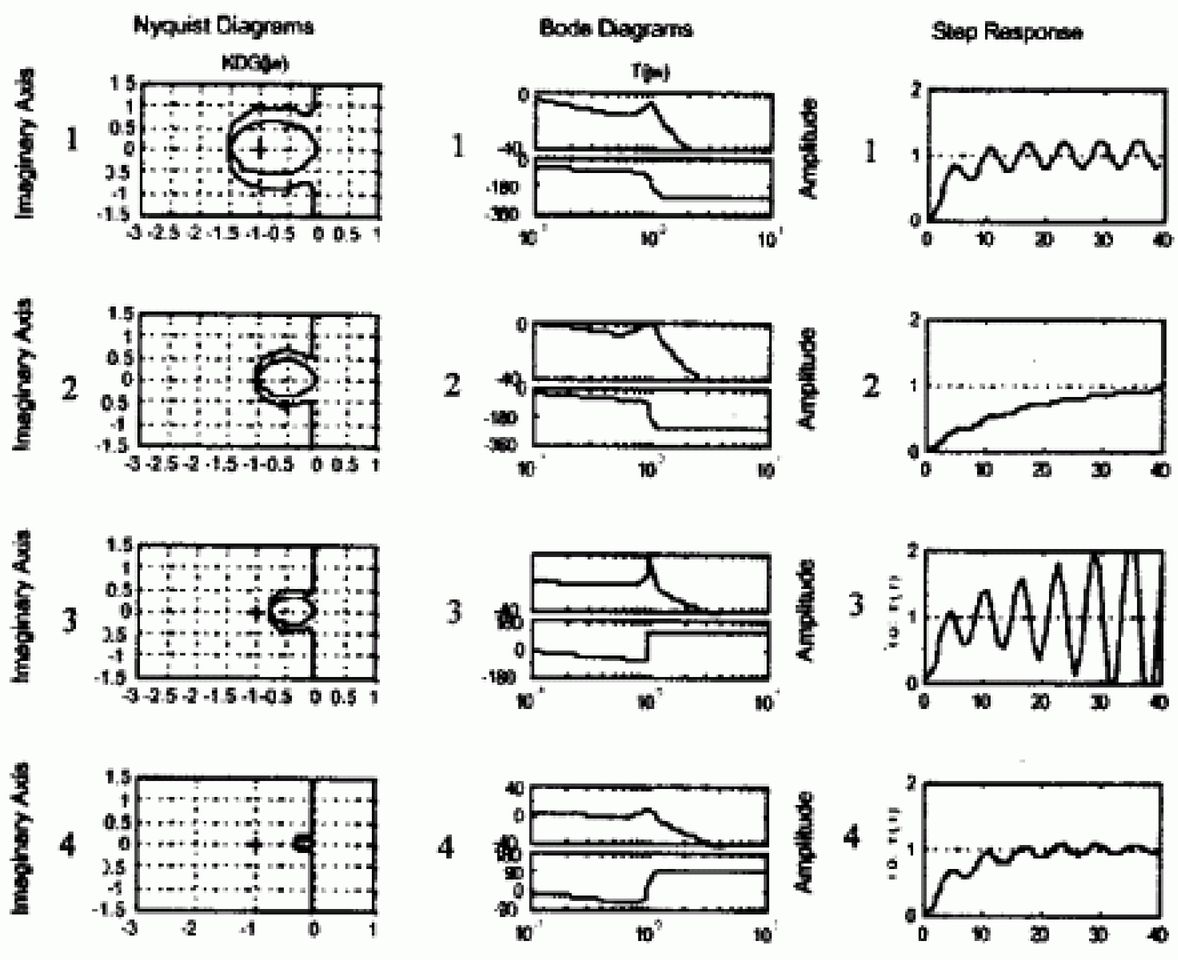

Figure 7

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