注意：考試開始鈴響前，不得翻閱試題，

並不得書寫、畫記、作答。

國立清華大學 110 學年度碩士班考試入學試題

系所班組別：動力機械工程學系

乙組(電機控制組)

科目代碼：1202

考試科目：控制系統

—作答注意事項—

1. 請核對答案卷（卡）上之准考證號、科目名稱是否正確。
2. 考試開始後，請於作答前先翻閱整份試題，是否有污損或試題印刷不清，得舉手請監試人員處理，但不得要求解釋題意。
3. 考生限在答案卷上標記「⬇ 由此開始作答」區內作答，且不可書寫姓名、准考證號或與作答無關之其他文字或符號。
4. 答案卷用盡不得要求加頁。
5. 答案卷可用任何書寫工具作答，惟為方便閱卷辨識，請儘量使用藍色或黑色書寫；答案卡限用 2B 鉛筆畫記；如畫記不清（含未依範例畫記）致光學閱讀機無法辨識答案者，其後果一律由考生自行負責。
6. 其他應考規則、違規處理及扣分方式，請自行詳閱准考證明上「**國立清華大學試場規則及違規處理辦法**」，無法因本試題封面作答注意事項中未列明而稱未知悉。

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　　*請在【答案卷】作答

Q1

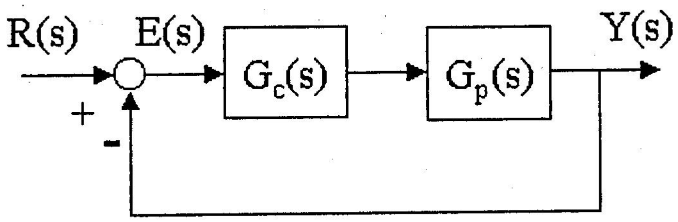

Figure 1

where $G_p(s) = \frac{4}{s(s+10)}$

Design a controller $G_c(s) = K_c(\frac{s+a}{s+b})^2$ for $G_p(s)$ to satisfy the specifications

(i) overshoot = 4.32%. (ii) settling time t_s =1.53 sec

(a) Under the conditions of $min(|b-a|)$ and $|a| > |b|$, please give your controller (K_c, a, b) to satisfy above specifications. (10pts)

(b) Use Nyquist Criterion, $Z=N+P$, to figure out the stability of the closed-loop system with the controller $G_c(s)$ satisfying with (a). (Notes: To get points, you must get the correct controller, draw the correct Nyquist plot of $G_c(s)G_p(s)$ and give the correct values of Z, N, and P.) (10pts)

(c) What is the steady-state error of ($r(t)$-$y(t)$) responding to unit ramp input on R(s)? (5pts)

(d) What is the Gain Margin (G.M.) for (b)? (5pts)

Q2

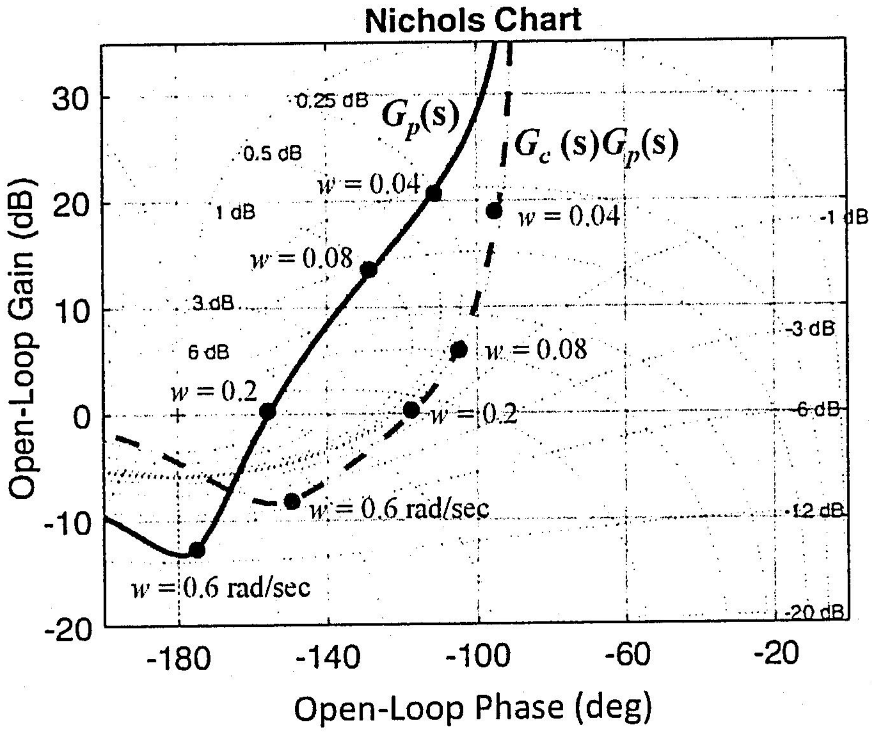

Figure 2

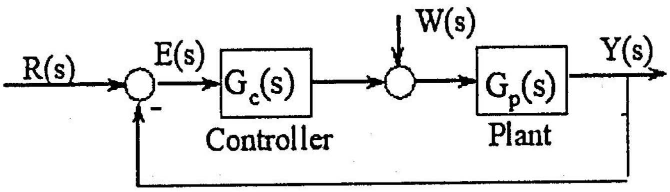

Figure 3

The system block diagram and the related Nichols Charts are shown above.

(a) Design a controller $G_c(s)$ for the plant $G_p(s)$ shown above to results in no change in gain crossover frequency. The controller is in the form of

$$G_c = K_c\left(\frac{s+a}{s+b}\right)^2 \quad \text{where } \frac{b}{a}=2$$. Give values of (K_c, a, b). (10pts)

(b) What is the maximum phase, ϕ_m, provided by the controller $G_c(s)$?(5pts)

(c) What is the phase margin PM for the system shown in Figure 3? (5pts)

(Notes: (b) will counted only when (a) is correct! (c) will counted only when (b) is correct!)

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Q3

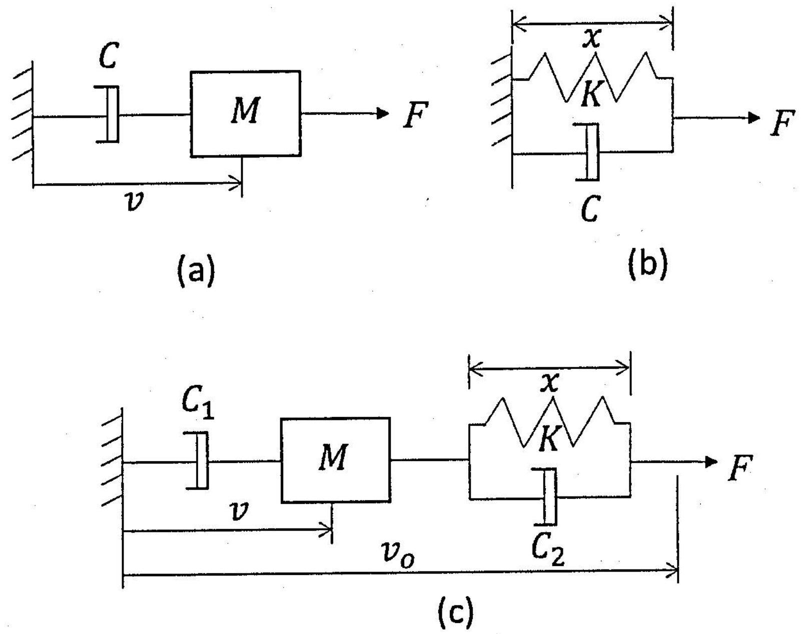

Figure 4

(a) Derive the state equation for the system in Fig. 4(a). In this figure, C represents a linear damper which generates a reaction force proportional to its velocity (with C being the proportional constant), M is a mass, and F is the applied force input. You should use the velocity of mass, v, as the state variable.(3pts)

(b) Derive the state equation for the system in Fig. 4 (b). In this figure, in addition to the damper (C) and the force input F, K represents a linear spring (with K being the spring constant). You should use the deformation of the spring, x, as the state variable. (3pts)

(c) Derive the state equations and the output equation for the system in Fig. 4 (c) using x and v as the state variables and the endpoint velocity v_0 as the output. (6pts)

(d) Find the condition relating M, K, C_1, and C_2 that renders the system in Fig. 4 (c) uncontrollable. Also find the condition that results in an unobservable system. (8pts)

Q4

In this problem, the control of an unstable, non-minimum-phase plant $G(s) = \frac{Y(s)}{U(s)} = \frac{s-1}{s-2}$ is considered.

(a) Derive the state equation and the output equation of the plant. (3pts)

(b) For the system you derived in (a), design a state feedback control law to place the closed-loop pole at -2. (5pts)

(c) For the system you derived in (a), design an observer that has the observer pole located at -10. (7pts)

(d) Combine the results in (b) and (c) and derive a dynamic compensator for the system. What is the control transfer function $C(s) = -\frac{U(s)}{Y(s)}$? (8pts)

(e) Consider the control system in Fig.5 with the $C(s)$ you derived in (d). Roughly sketch the root locus of the system as $0 < K < \infty$. Where does the root locus intersect with the imaginary axis and what is the corresponding K? (7pts)

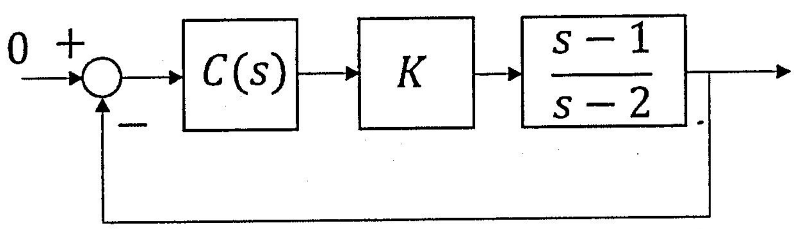

Figure 5