國立清華大學命題紙

八十八學年度 動力機械工程 系（所） 乙 組碩士班研究生招生考試

科目 控制系統 科號 1301 共 6 頁第 1 頁 *請在試卷【答案卷】內作答

[1] Select from the followings properties/goals which can be achieved only by feedback design but not by open-loop control:（答錯倒扣）(10%)

(a)tracking a command signal,

(b)rejecting/suppressing the effects of disturbance on the output,

(c)stabilizing an unstable plant,

(d)eliminating the effects of undershoot/delay,

(e)reducing performance variation due to plant model uncertainties.

[2] Consider a close-loop control system whose overall transfer function is

$$\frac{y(s)}{r(s)} = T(s) = 110000\frac{(s+0.1)}{(s+0.11)(s^2+12s+100)(s+1000)}$$

Select from the following statements which are true:（答錯倒扣） (5%)

(a) The settling time is $t_s \approx \frac{4.6}{6}$ seconds.

(b) The settling time is $t_s \approx \frac{4.6}{0.11}$ seconds.

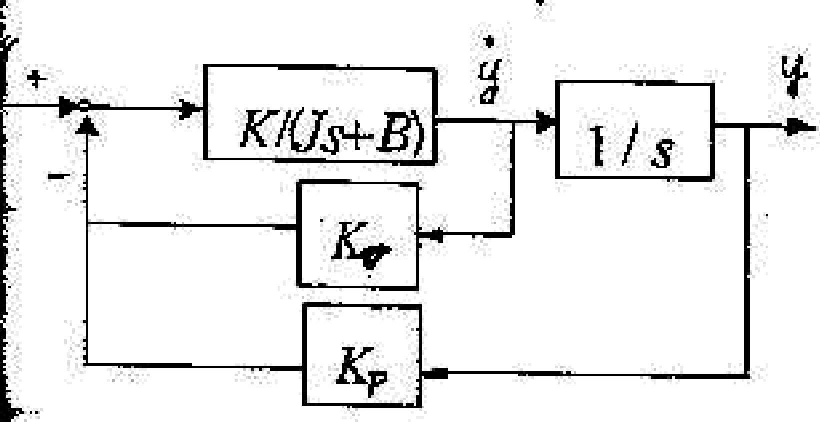
(c) The rise time is $t_r \approx \frac{1.8}{10}$ seconds.

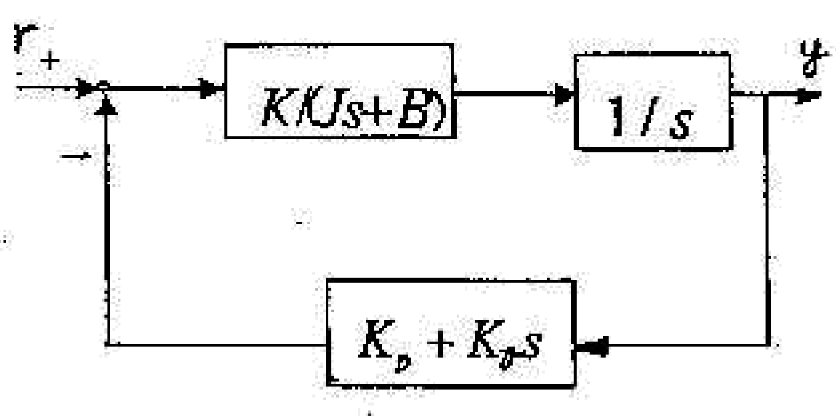
(d) The rise time is $t_r \approx \frac{1.8}{0.11}$ seconds.

(e) The close-loop system is overdamped.

[3] Shown below is a motor control system with position and tachometer feedback, where K_p and K_v are constants.

(a)Please show that the above system is, in theory, equivalent to the following control system with a PD controller allocated in the feedback path. (5%)



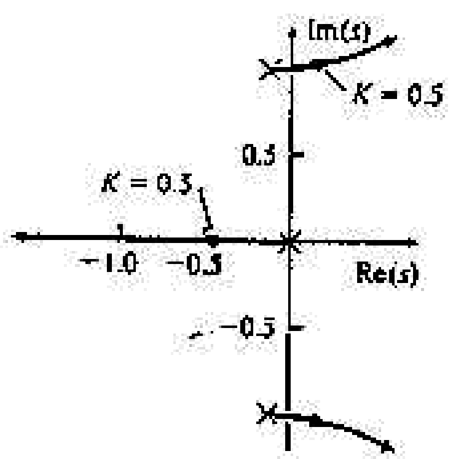


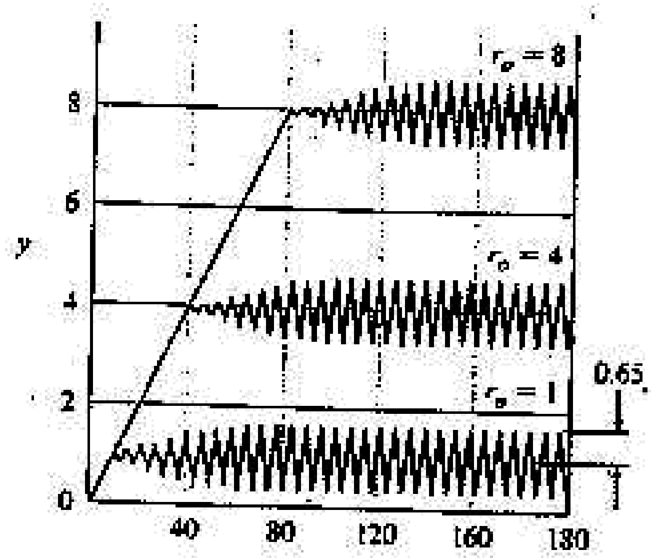
(b) Since it is expensive to directly measure the velocity signal using a tachometer, please explain why a tachometer is so widely used instead of a PD controller. (5%)

[4] Using the concept of root locus, please explain why pole-zero cancellations on the right-half-plane between a plant and the controller is not allowed. (5%)

[5] Please match the following step responses of unity feedback control systems with their associated root locus, and briefly explain why. (6%)

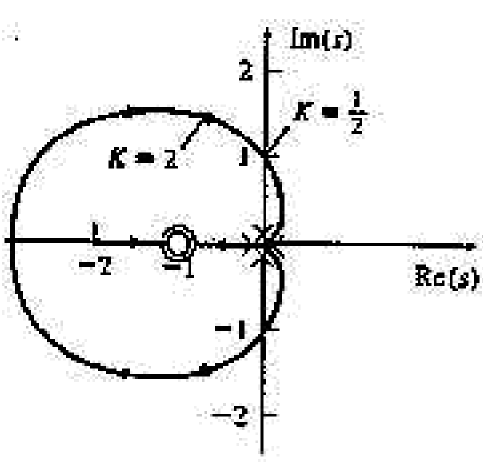
(1)

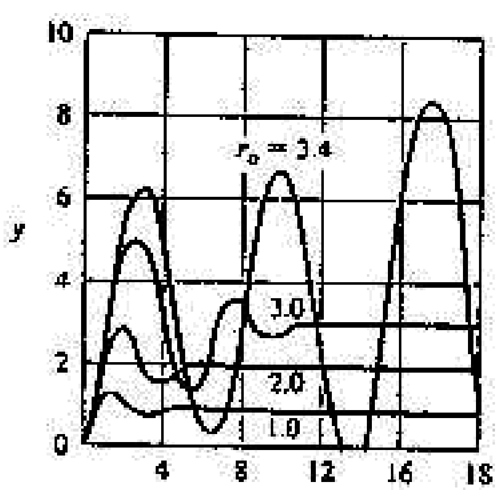




(A)

(2)





(B)

[6] Please match the following step responses of unity feedback control systems with the Bode plots of their associated loop transfer functions. Please notice that (a)all plants are stable, and (b)the gain slopes of each loop transfer function are as indicated on the Bode plots. (12%)

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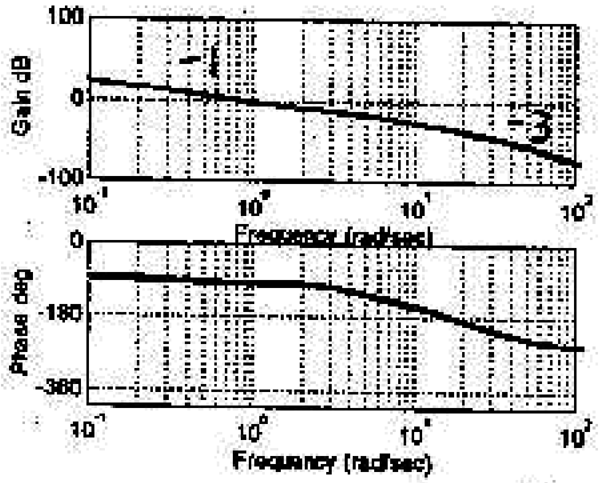
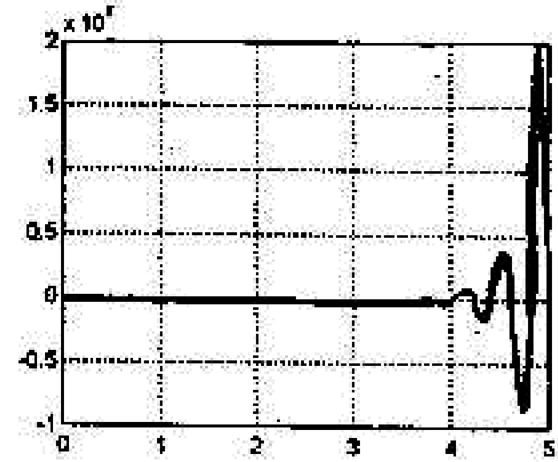
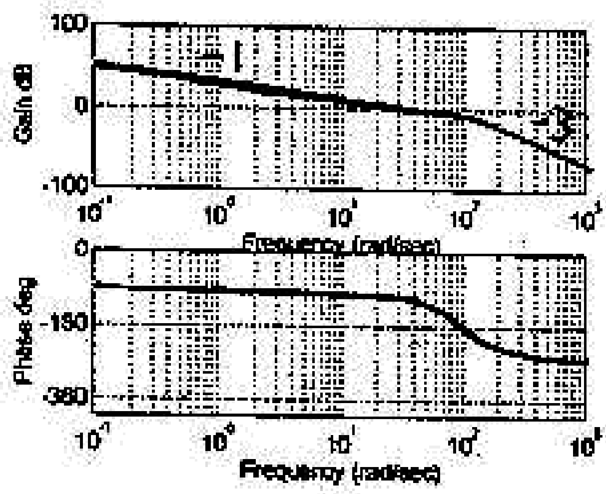
科目 控制系統 科號 1301 共 6 頁第 3 頁 *請在試卷【答案卷】內作答



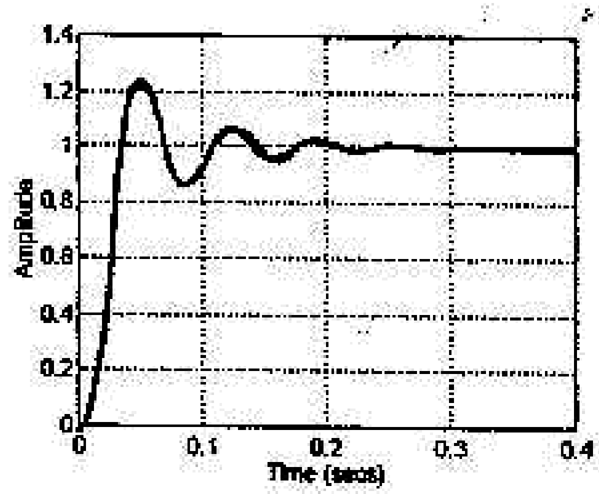
(1)



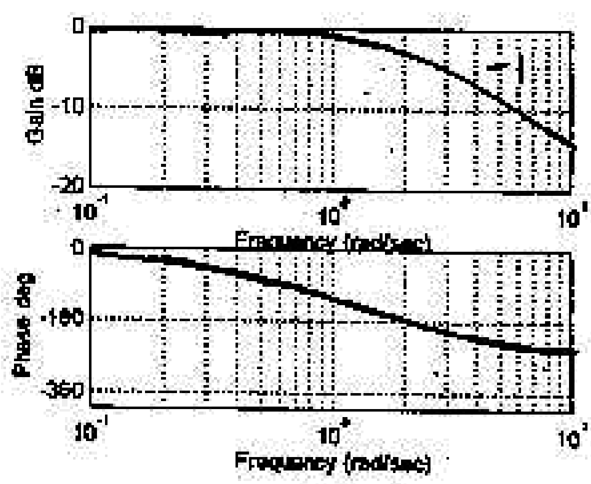
(A)



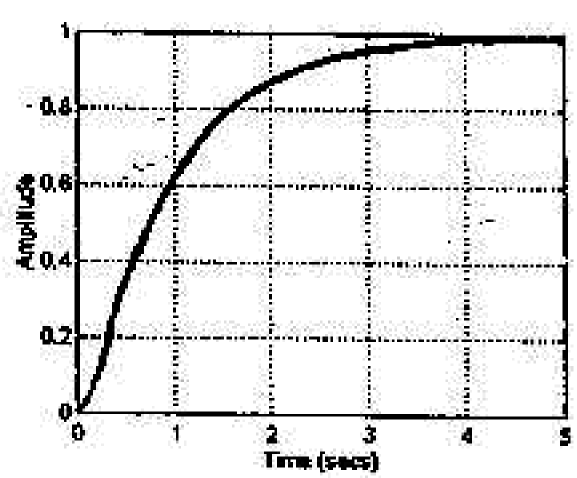
(2)



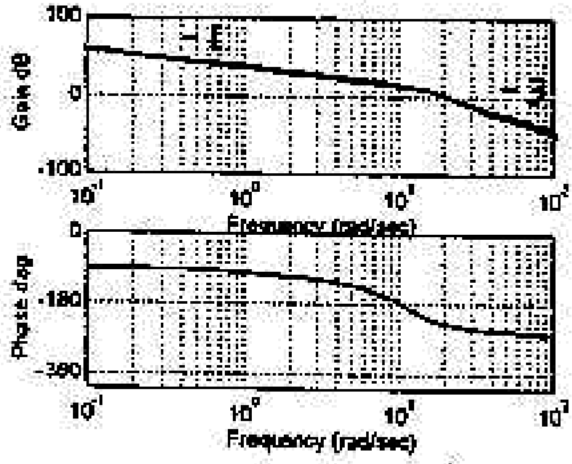
(B)



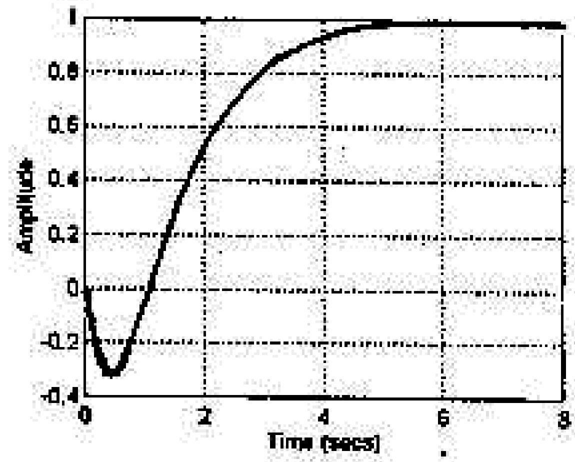
(3)



(C)



(4)



(D)

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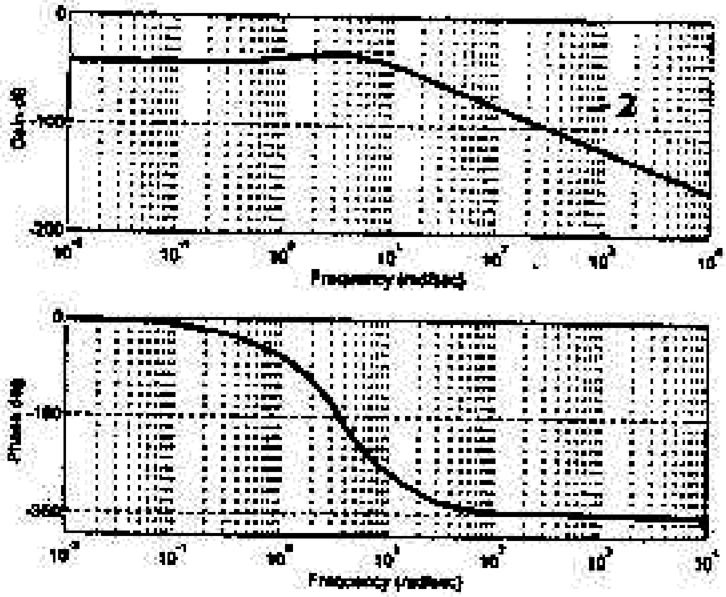
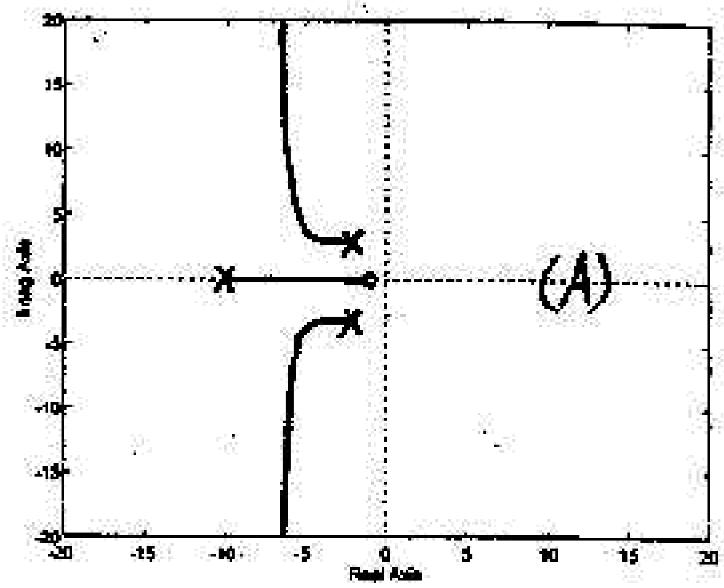
[7] In the followings there are three unity feedback control systems with stable plants. Please match the following loop transfer function (in the form of Bode plots) with their root locus. (12%)

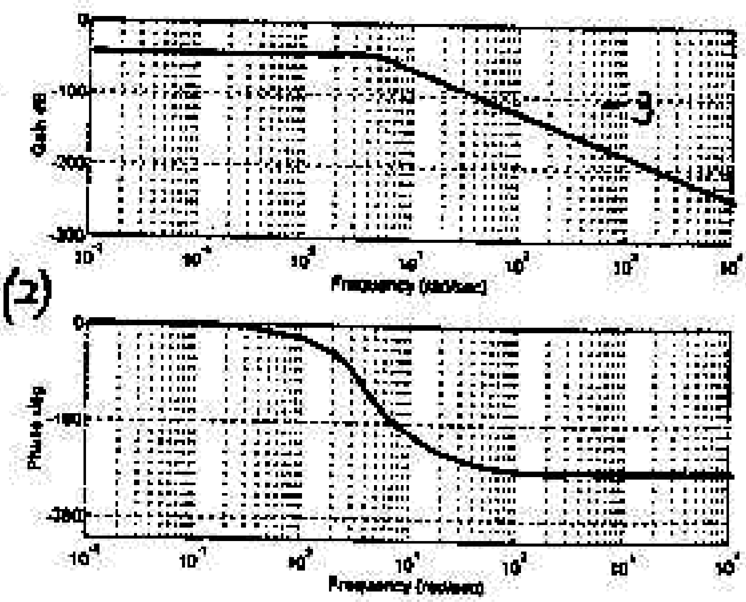
(1)

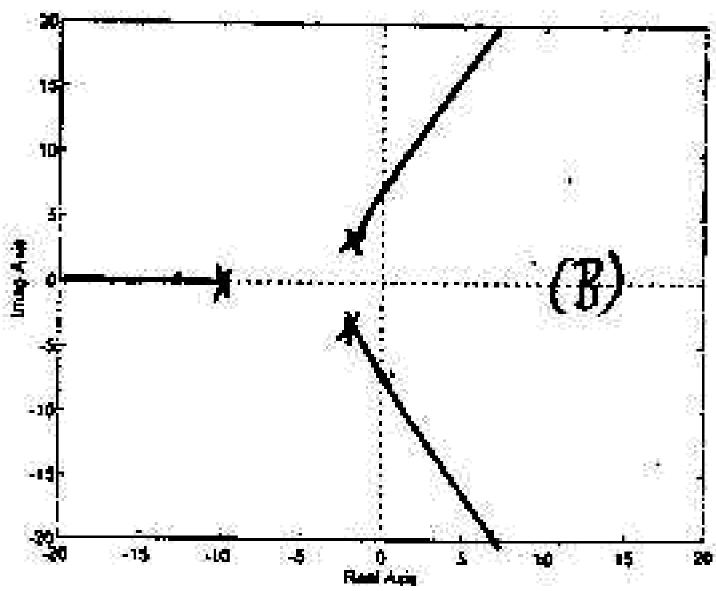




(A)

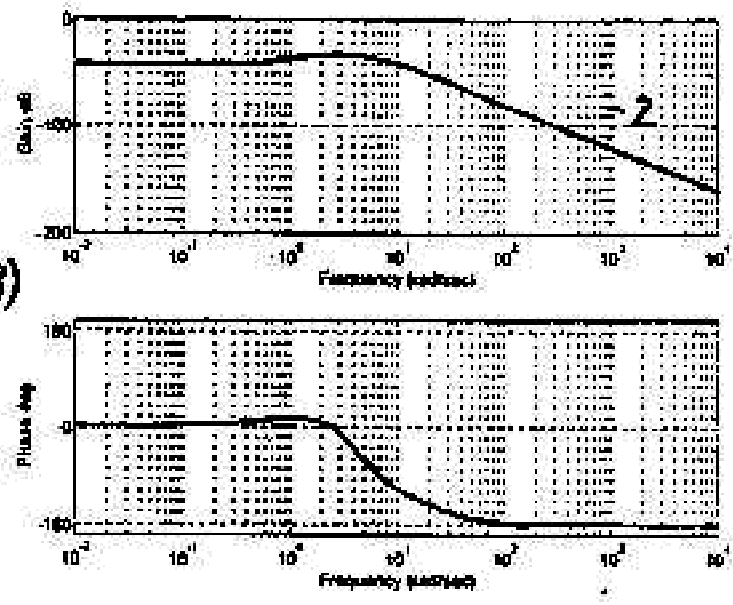
(2)

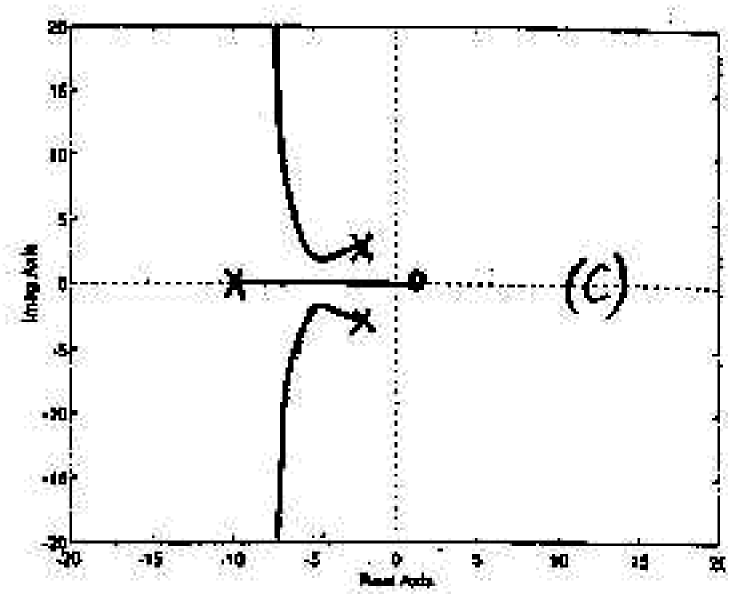




(B)

(3)





(C)

[8] For a single-input single-output dynamic system, the relation between the input and the output of the system can be described by a set of equations given as follows,

$$\dot{X}_p = FX_p + Gu,$$

$$y \;= HX_p.$$

Compared to an output feedback control system, one can measured the states X_p and feedback to the input to form a new closed-loop control system. This control system is basically achievable based upon some assumptions on the controllability and observability of the open-loop system.

(1) Please describe the definition of the controllability and observability in short sentences. (5%)

(2) Why do we need the assumptions to be true in this case ?(5%)

(3) What can we do if the assumptions are true ? (3%)

(4) Given the feedback law as $u = r\text{-}K^T X_p$ with K being column gain vector, please derive the new state equations of the closed-loop system in terms of K. (2%)

[9] For the F and G matrices in problem [8] given as follows,

$$F = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -2 & 3 & 0 \end{bmatrix}, \quad G = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}.$$

Please calculate the gains in K vector if the eigenvalues of the closed-loop system are required as {-1+j1, -1-j1, -4}. Do the calculation step by step with clear descriptions. (10%)

[10] Give the state description matrices in control-canonical from for the transfer function given as follow,

$$G(s) = \frac{s-1}{s(s^2+3s+2)}. \text{ (5\%)}$$

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[11] In the late 19th century, A. M. Lyapunov treated the stability of dynamic systems in state-variable form and gave his interpretations on the stability of the systems.

(1) Please describe in your words about the dynamic systems being Lyapunov-stable and asymptotically stable. (4%)

(2) Taking a pendulum as an example, a mass M is hung under a point in space by a mass-less string in length L. How to define the stability of the pendulum in the sense of Lyapunov's stability ? (3%)

(3) Give your rationale for the finding a Lyapunov function for a non-linear system to test the stability. For example, why in quadratic form with some weight matrices ? (3%)