Menoufiya University Faculty of Engineering Shebin El-Kom Department: Mech. Power Eng. Second Semester Examination Academic Year: 2014-2015	Subject: Automatic Control Code: MPE 422 Year: 4th Year Time Allowed: 3 hours, **90 Marks** Date: حديث 23 May 2015

Allowed Tables and Charts: *None*

Please, Answer all the following Questions

Question (1) **(28 Marks)**

(a) What is a Servomechanism as a control term (one illustrated example)? ***(4 Marks)***

(b) When a control system is described as a linier system?. ***(4 Marks)***

(c) The closed-loop transfer function of a control system is given by:

$\frac{C(s)}{R(s)} = \frac{1}{(s^3+b_1s^2+b_2s+b_3)}$, the Hurwitz determinants are computed as D1= 6, D2= 60, and D3= 360.

(i) Evaluate the coefficients b1, b2, and b3 . ***(4 Marks)***

(ii) Find the unit step response of the system; i.e. final value of c if R (s) = $\frac{1}{s}$. ***(3 Marks)***

(iii) Knowing that one of the closed-loop poles=-1, find the other two poles. ***(3Marks)***

(iv) Find c(t), if the system is subjected to an impulse input; i.e. R(s) =1. ***(4 Marks)***

Hint: if F(s)= $\frac{1}{s+a}$, then f(t) = e^{-at}

(d)A feedback control system has a characteristic equation: $s^3+(4+K)s^2+6s+16+8K=0$ The parameter, K, must be positive. Using Routh's stability table, evaluate the maximum value of K that can be tuned before the system becomes unstable. When K is equal to the maximum value, the system oscillates. Determine the frequency of oscillation. ***(6 Marks)***

Question (2) **(20 Marks)**

(a) Which properties that we may get when both polar and Bode plots are drawn for any control system? ***(4 Marks)***

(b) Draw Polar Plot for a plant transfer function $G(s) = \frac{30}{s(1+3s)(1+5s)}$ after computing intersection of the curve and the vertical asymptote with real axis. ***(8 Marks)***

(c) Draw Bode Plots for G(s), then detect both gain- and phase margins graphically.

Hint: for $F(j\omega) = \frac{1}{1+j\tau\omega}$, you may obtain $\phi = -\tan^{-1}(\tau\omega)$. ***(8 Marks)***

Question (3) **(22 Marks)**

(a) Discuss briefly the benefits of introducing a feedback (four only) to a control system? ***(4 Marks)***

(b) It is required to place the poles of a system using a series compensator (controller), Gc(s), and the Diophantine equation for the plant $G_p(s) = \frac{s+3}{s^3+s^2+10}$. The desired closed-loop poles are -3, -6, and as many factors of (s+10) as you need to the desired pole polynomial to find a proper controller.

(18 Marks)

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Question (4) **(20 Marks)**

(a) Define the controllability of a control system; explain how it can be used in transforming state-variable representation of a control system from one form to another. ***(5 Marks)***

(b) The input-output transfer function of a plant $G_p(s)=\frac{Y(s)}{U(s)}=\frac{4}{s^3+5s^2+4}$ **may be represented into physical state-variable form as:**

$$\dot{x}=\begin{bmatrix}0 & 1 & 0\\ 0 & -1 & 2\\ 0 & 0 & -4\end{bmatrix}x+\begin{bmatrix}0\\0\\2\end{bmatrix}u, \text{ and } y=[1\ 0\ 0]\,x$$

(i) Deduce the phase-variable representation of the given system. ***(6 Marks)***

(ii) compute the controllability matrices for both representations; hence, compute the transformation matrix, P_p**, between both forms based on these controllability matrices.** ***(6 Marks)***

(iii) Design the state-variable feedback controller gain, k^T**, with forward gain, K=1, that can be used to place the poles of the closed-loop system at s=-2, -3, and -10** ***(3 Marks)***

NOTE: For plant description in phase-variable form, the appropriate values of k_p **is easily found from the relation** $k_p=(d-a)/K$**. Where d is the column vector of coefficients of the desired nth-order polynomial that the closed-loop poles to be located. While (a) is the vector of coefficients of characteristic equation of the plant,** $k^T = k_p^T * P_p$

G O O D   L U C K