KENYATTA UNIVERSITY

UNIVESITY EXAMINATIONS 2011/2012

SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN COMPUTER ENGINEERING

SCE 318 CONTROL SYSTEMS II

DATE: MONDAY, 16TH APRIL 2012 **TIME:** 2.00 P.M – 4.00 P.M

INSTRUCTIONS

(i) This paper contains **FIVE (5)** questions.
(ii) Answer question **ONE** and any other **TWO** questions.

Question One

1. (a) With reference to **Fig Q.1 (a)** explain

i) the differentiate between reference input $R_1(s)$ and disturbance input $R_2(s)$ *[2marks]*

ii) the importance of the control action $U(s)$ *[2marks]*

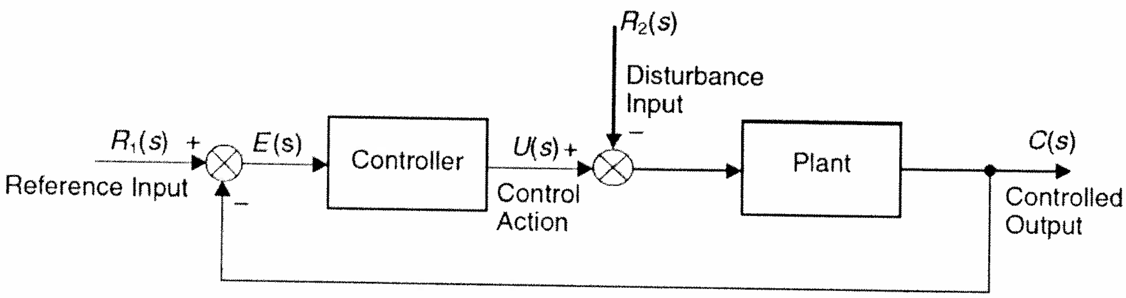


Fig Q.1 (a)

(b) Given a proportional controller with a proportional gain constant K_1 and a plant with first order dynamics of the form $G(s) = \frac{K}{1+Ts}$ in **Fig Q.1(a)** above, show that when $r_1(t)$ is a unit step and $r_2(t)$ is zero, the steady state response is given by; *[5marks]*

$$c(t) = \left.\left(\frac{K_1 K}{1+K_1 K}\right)\right|_{t\to\infty}$$

(c) In Q.1 (b) above explain the condition for the system to have zero steady state error *[2 marks]*

(d) State and explain the two Ziegler – Nichols methods of tuning PID controllers *[4 marks]*

(e) Draw a pole region to satisfy a design problem having the following two specifications

i) Overshoot $\leq 5\%$

ii) Settling time of $\leq 9s$ *[4marks]*

(f) Define rise time and explain how one would choose poles in s - plane to achieve the shortest rise time. *[3 marks]*

(g) In relation to the concept of dominant pole, explain the effect of introducing a pole to a second order system as shown below *[4marks]*

$$G_o(s) = \frac{1}{\left(s^2 + 1.2s + 1\right)\left(1 + \frac{s}{a}\right)}$$

(h) Consider the system $G_o(s) = \dfrac{k(s+4)}{s^2 + (k+1)s + 4k - 2}$. Explain the condition for $G_o(s)$;

To be stable *[2marks]*

To have zero position error *[2marks]*

Question Two

2. (a) Derive the control law of a proportional plus integral (PI) controller *[3marks]*

(b) A block diagram for a liquid level process control system is shown in **Fig Q.2 (b).** The system parameters are

$A = 2m^2$ $\quad R_f = 15 s/m^2$ $\quad K_1 = 1$

$H_1 = 1V/m$ $\quad K_v = 0.1 m^3/sV$

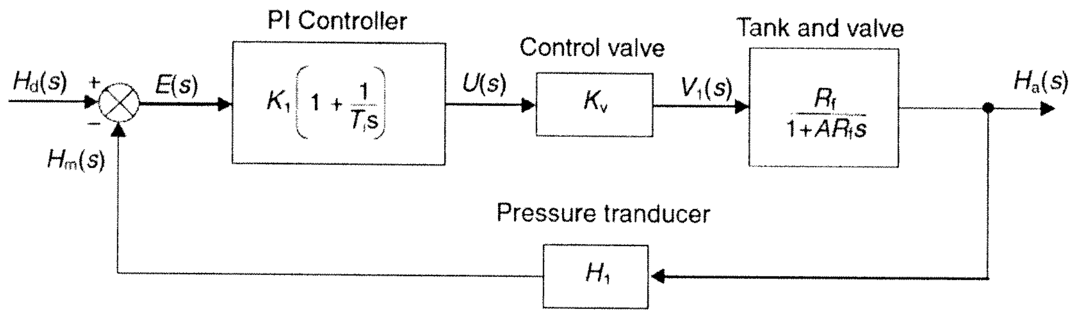


Fig Q.2 (b)

i) Find the values of the integral action time T_i and the damping ratio ξ when the undamped natural frequency ω_n is $0.1 rad/s$. *[10marks]*

ii) Find an expression for the time response of the system when there is a step change of $h_d(t)$ from 0 to $4m$. Assume zero initial conditions. *[7marks]*

Question Three

3. (a) State the steps involved in the design using root locus method *[4 marks]*

(b) Consider a plant with the transfer function

$$G(s) = \frac{s+4}{(s+2)(s-1)}$$

Design (using the root locus of $1 + kG(s) = 0$ and the desired pole region) a system to meet the following specifications *[16marks]*

1. Position error $\leq 10\%$
2. Overshoot $\leq 5\%$
3. Settling time $\leq 4.5\,\text{sec}$
4. Rise time as small as possible

Question Four

4. (a) Differentiate between a *minimum phase* transfer function and a *non minimum phase* transfer function *[4marks]*

(b) Derive the control law of a proportional plus integral pus derivative (PID) controller *[3marks]*

(c) Derive the frequency response of a second order system *[5marks]*

(d) Plot bode gain and bode phase plot of the transfer function below *[8 marks]*

$$G(s) = \frac{50s+100}{s(s^2+4s+100)}$$

Question Five

5. (a) Explain the following

i) The concept of state *[2 marks]*

ii) State variables *[1 marks]*

iii) State space *[1 marks]*

iv) Phase plane *[1 marks]*

(b) For the RLC network shown in **Fig Q.5 (b)** write down the state equations when the state variable are;

i) $v_2(t)$ and $\dot{v}_2$ *[4 marks]*

ii) $v_2(t)$ and $i(t)$ *[4 marks]*

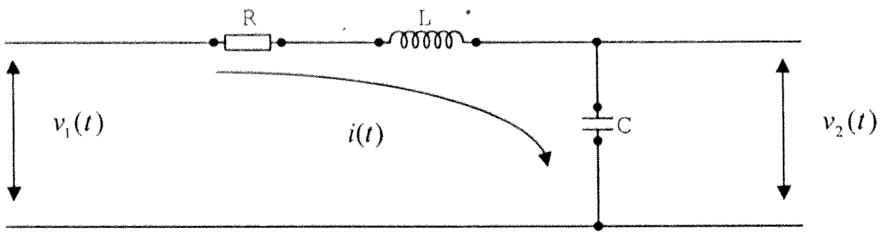


Fig Q.5(b)

(c) For the two mass system shown in **Fig Q.5 (c)** find the state and the output equation when the state variables are the position and velocity of each mass *[7 marks]*

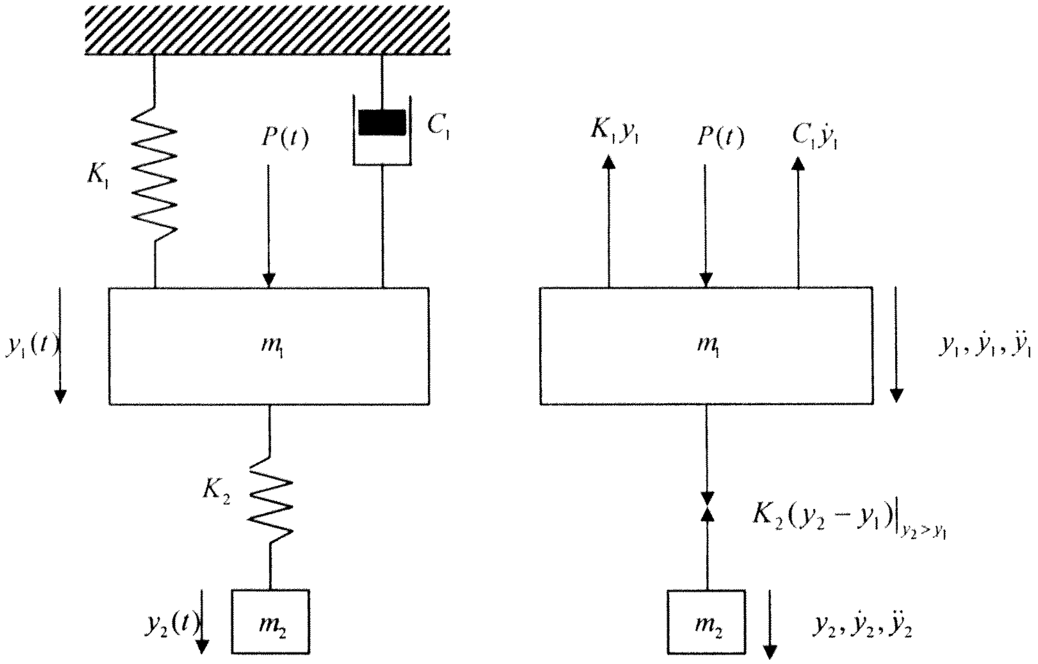
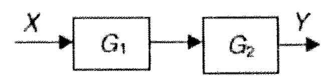
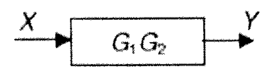
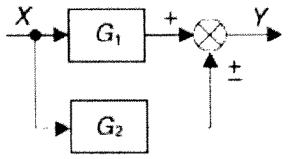
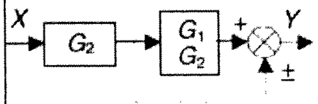
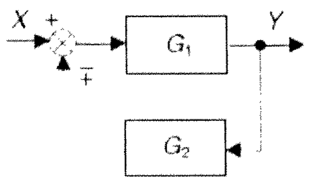
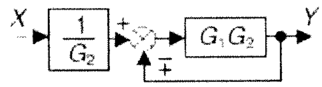
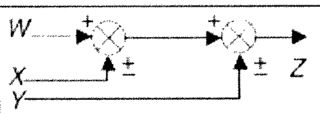
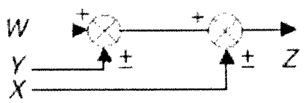
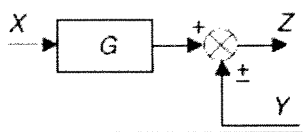
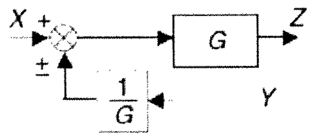
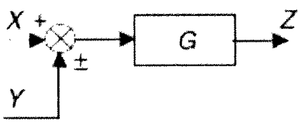
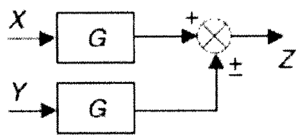
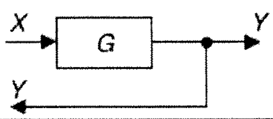
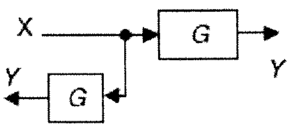
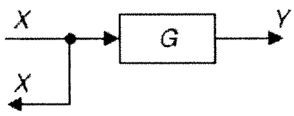
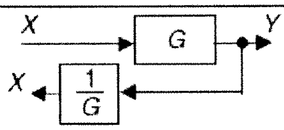


Fig Q.5 (c)

Table 1 Block diagram transform theorems

Transformation	Equation	Block diagram	Equivalent block diagram
1. Combining blocks in cascade	$Y=(G_1G_2)X$		
2. Combining blocks in parallel; or eliminating a forward loop	$Y=G_1X \pm G_2X$		
3. Removing a block from a forward path	$Y=G_1X \pm G_2X$		
4. Eliminating a feedback loop	$Y=G_1(X \pm G_2Y)$		
5. Removing a block from a feedback loop	$Y=G_1(X \pm G_2Y)$		
6. Rearranging summing points	$Z=W \pm X \pm Y$		
7. Moving a summing point ahead of a block	$Z=GX \pm Y$		
8. Moving a summing point beyond a block	$Z=G(X \pm Y)$		
9. Moving a take-off point ahead of a block	$Y=GX$		
10. Moving a take-off point beyond a block	$Y=GX$		

Time function $f(t)$		Laplace transform $\mathscr{L}[f(t)]$ $F(s)$
1	unit impulse $\delta(t)$	1
2	unit step 1	$1/s$
3	unit ramp t	$1/s^2$
4	t^n	$\dfrac{n!}{s^{n+1}}$
5	e^{-at}	$\dfrac{1}{(s+a)}$
6	$1 - e^{-at}$	$\dfrac{a}{s(s+a)}$
7	$\sin \omega t$	$\dfrac{\omega}{s^2+\omega^2}$
8	$\cos \omega t$	$\dfrac{s}{s^2+\omega^2}$
9	$e^{-at} \sin \omega t$	$\dfrac{\omega}{(s+a)^2+\omega^2}$
10	$e^{-at}(\cos \omega t - \dfrac{a}{\omega} \sin \omega t)$	$\dfrac{s}{(s+a)^2+\omega^2}$