THE INSTITUTION OF ENGINEERS, SRI LANKA

IESL ENGINEERING COURSE PART III EXAMINATION - SEPTEMBER 2011

323 Control Systems Engineering

Time allowed : 03 hours

Answer 5 questions by selecting at least one question from each section.

Section A

Question 1

(i) Explain the following with examples

a. Open loop control systems

b. Non linear Control systems

c. Discrete control Systems

(ii) A mechanical system is shown in fig. Q1. Obtain the transfer function stating the assumptions (if any).

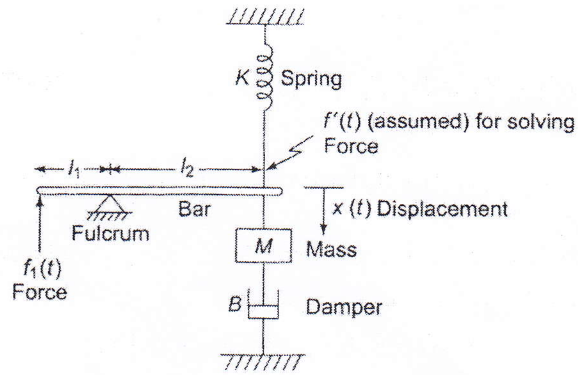

Fig. Q1

Question 2

(i) Map poles and zeros in the s plane for the following transfer function and comment about the stability.

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(ii) Transfer function of a control system is depicted by the following equation.

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In case of a unity feedback, find the steady state error for a unit ramp input.

Question 3

A feedback control system has the following open-loop transfer function

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(i) Sketch the root locus by obtaining asymptotes, breakaway point and imaginary axis cross-over point.

(ii) A compensating element having a transfer function C(s)=(s+2) is now included in the open-loop transfer function. If the breakaway point is -0.56, sketch the new root locus. Comment on stability of the system with, and without the compensator.

Section B

Question 4

Following figure shows a spring damper system.

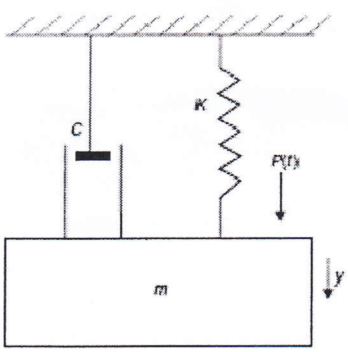

Fig. Q4

(i) Write the state equation and output equation for the spring mass damper system.

(ii) Given: m= 1 kg, C = 3 Ns/m, K = 2 N/m, u(t) =0.

Evaluate,

a. the characteristic equation, its roots, 0 $_1$ and 2the
b. transition matrices 3 (s) and 3 (t)
c. the transient response of the state variables from the set of initial conditions4444444445 !6#$ %64789 45(0)=0.

Question 5

(i) Determine whether the following system is completely controllable and observable.

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} -2 & 0 \\ 3 & -5 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \end{bmatrix} \mathbf{u}$$

$$y = \begin{bmatrix} 1 & -1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

(ii) Critically evaluate the following statements.

a. It is always good to have feedback control than open loop control.

b. PID gains could be set to very high values so that the response matches the input.

c. State space based control analysis is only preferred when the system is simple.

Section C

Question 6

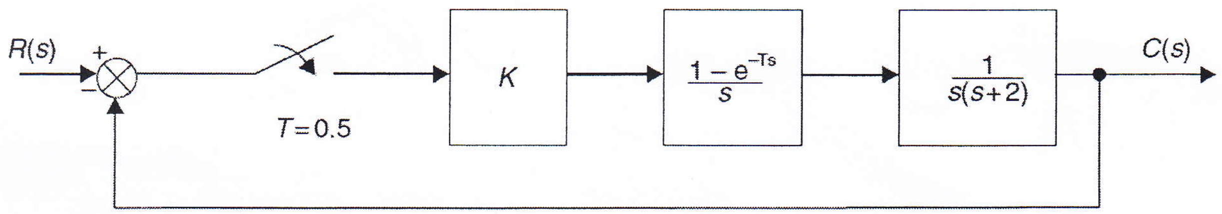

Fig. Q6.

(i) Fig.Q6. shows a digital control system. When the controller gain K is unity and the sampling time is 0.5 seconds, determine

a. the open-loop pulse transfer function

b. the closed-loop pulse transfer function

c. the difference equation for the discrete time response

d. the sketch of the unit step response assuming zero initial conditions

e. the steady-state value of the system output

Question 7

(i) Why would relays be used in place of PLCs?

(ii) Explain why ladder logic outputs are coils?

(iii) You are required to control the water level of a water tank within pre-defined set limits. You are supplied with two water level detectors, several indicator lamps, several relays, water pump and a PLC. Show how the components should be physically connected. Clearly state any assumptions made.

(iv) Draw the RLL diagram and explain how it works.

Common Laplace and z-transforms

	$f(t)$ or $f(kT)$	$F(s)$	$F(z)$
1	$\delta(t)$	1	1
2	$\delta(t-kT)$	e^{-kTs}	z^{-k}
3	$1(t)$	$\frac{1}{s}$	$\frac{z}{z-1}$
4	t	$\frac{1}{s^2}$	$\frac{Tz}{(z-1)^2}$
5	e^{-at}	$\frac{1}{(s+a)}$	$\frac{z}{z-e^{-aT}}$
6	$1-e^{-at}$	$\frac{a}{s(s+a)}$	$\frac{z(1-e^{-aT})}{(z-1)(z-e^{-aT})}$
7	$\frac{1}{a}(at-1+e^{-at})$	$\frac{a}{s^2(s+a)}$	$\frac{z\{(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})\}}{a(z-1)^2(z-e^{-aT})}$
8	$\sin\omega t$	$\frac{\omega}{s^2+\omega^2}$	$\frac{z\sin\omega T}{z^2-2z\cos\omega T+1}$
9	$\cos\omega t$	$\frac{s}{s^2+\omega^2}$	$\frac{z(z-\cos\omega T)}{z^2-2z\cos\omega T+1}$
10	$e^{-at}\sin\omega t$	$\frac{\omega}{(s+a)^2+\omega^2}$	$\frac{ze^{-aT}\sin\omega T}{z^2-2ze^{-aT}\cos\omega T+e^{-2aT}}$
11	$e^{-at}\cos\omega t$	$\frac{(s+a)}{(s+a)^2+\omega^2}$	$\frac{z^2-ze^{-aT}\cos\omega T}{z^2-2ze^{-aT}\cos\omega T+e^{-2aT}}$