Important Note: 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and/or equations written eg, 42+8=50, will be treated as malpractice.

USN [| | | | | | | | |] **06ES43**

Fourth Semester B.E. Degree Examination, Dec.09/Jan.10

Control Systems

Time: 3 hrs. Max. Marks:100

Note: ***Answer any FIVE full questions, selecting at least TWO questions from each part.***

PART – A

a. For the systems shown in Fig. Q1(i) and Fig. Q1(ii) write the differential equations and obtain the transfer functions. **(04 Marks)**

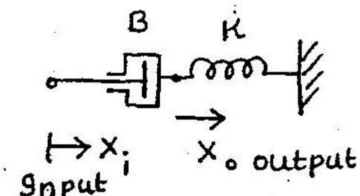

Fig. Q1(a)(i)

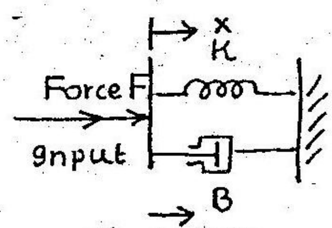

Fig. Q1(a)(ii)

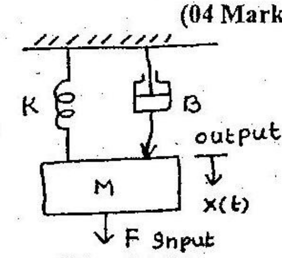

Fig. Q1(b)

b. i) Mass M shown in the mechanical system Fig. Q1(b) is subjected to a force of 1 Newton. Find the final displacement of mass. Take k = 1 N/m, B = 0.2 N-S/m, M = 1kg. **(08 Marks)**
ii) In vertically suspended mechanical system gravitational force 'g' not taken into consideration. Why? **(02 Marks)**

c. Find $G(s) = E_o(s)/T(s)$ for the system shown in Fig. Q1(c).

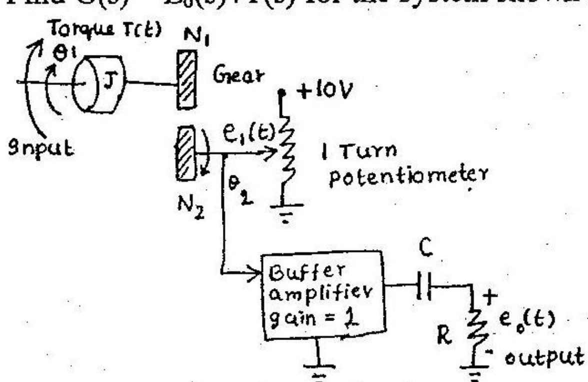

Fig. Q1(c)

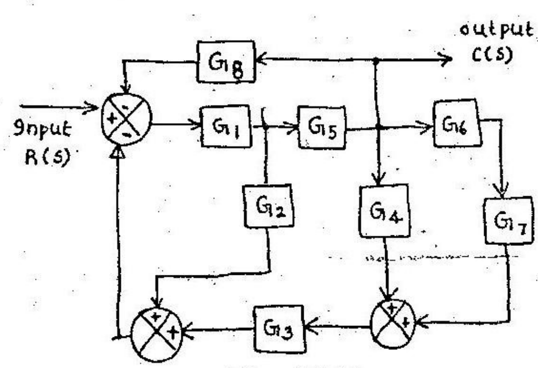

Fig. Q2(a)

(06 Marks)

a. Reduce the block diagram Fig. Q2(a) to a single block T(S) = C(S)/R(S). **(10 Marks)**

b. Using Mason's rule find the transfer function T(s) = C(S)/ R(S) for the system represented in Fig. Q2(b). **(10 Marks)**

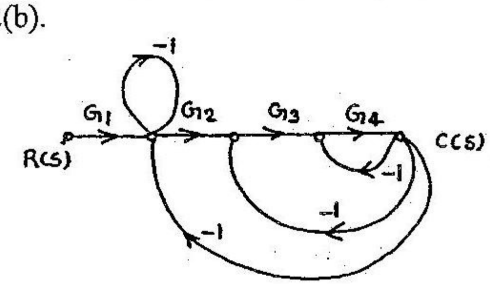

Fig. Q2(b)

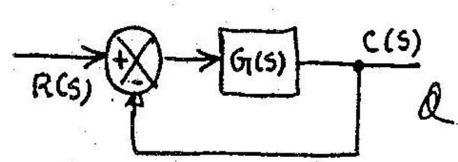

Fig. Q3(c)

3 a. Derive expression for 'peak time' tp for a system executing underdamped motion. **(06 Marks)**

b. The step response of a unity feed back control system is given by $c(t) = 1 - 1.66\, e^{-8t} \sin(6t + 37°)$

i) Find the closed loop transfer function.

ii) What is the corresponding open loop transfer function?

iii) Determine the complete output response for a unit step input, when the system is operated on open-loop. **(07 Marks)**

c. The unity feed back system of Fig. Q3(c), where,

$G(s) = \dfrac{k(s+\alpha)}{(s+\beta)^2}$ is to be designed to meet the following specifications. Steady-state error for a unit step input = 0.1; damping ratio = 0.5; natural frequency = $\sqrt{10}$ rad/sec. Find k, α and β. **(07 Marks)**

4 a. Using the Routh-Hurwitz criterion and the unity negative feed back system of Fig. Q3(c).

$G(s)\dfrac{k(s+4)}{s(s+1)(s+2)}$

Find the following :

i) The range of k that keeps the system stable

ii) The value of k that makes the system oscillate

iii) The frequency of oscillation, when k is set to the value that makes the system oscillate. **(10 Marks)**

b. State and prove the theorem on bounded-input pounded-output BIBO stability. **(10 Marks)**

PART – B

5 a. Sketch the general shape of the root locus for each of the open-loop pole-zero plots shown in Figs. Q5(a). **(05 Marks)**

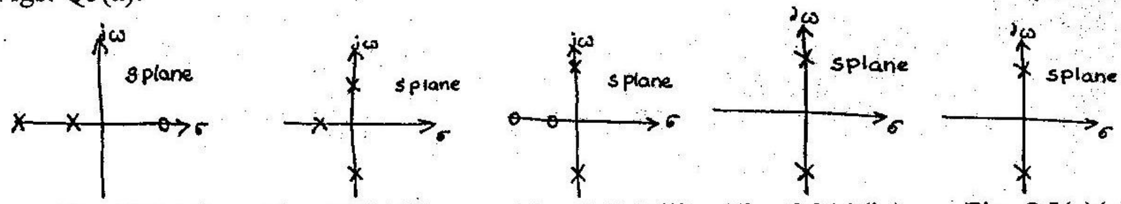

Fig. Q5(a)(i) Fig. Q5(a)(ii) Fig. Q5(a)(iii) Fig. Q5(a)(iv) Fig. Q5(a)(v)

b. Given : $G(s) = \dfrac{k(s+1)}{(s+2)(s+3)(s+4)}$ for a negative unity feed back system.

i) Sketch the root locus with necessary calculations. Show at least one TEST POINT on the complex plane on the root locus, where criterion is satisfied.

ii) If k = 10, where are the roots? **(15 Marks)**

6 a. The following polar Nyquist plots are sketches of the map of the positive imaginary axis of the s plane. None of the G(s) H(s) functions have poles in the right half plane. Figs. 6(a)(i) and (ii).

i) Complete each plot-i.e. add the map of the negative imaginary axis and any required closing circular arcs.

ii) Is the system stable?

iii) What is the system type number?

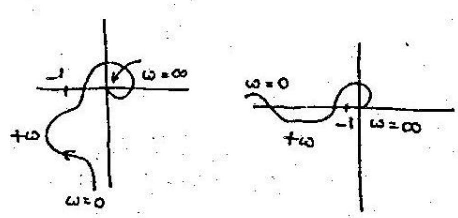

Fig. Q6(a)(i) Fig. Q6(a)(ii) **(06 Marks)**

b. Briefly explain frequency domain specifications. **(06 Marks)**

c. A negative feed back system is characterized by: $G(s) = \dfrac{k}{s(s+\alpha)}$, H(s) = 1. Find the values of k and α so that resonant peak $M_r = 1.04$ and resonant frequency $W_r = 11.55$ rad /sec. **(08 Marks)**

7 a. Draw the Bode diagram for the open loop transfer function:

$G(s)\frac{100}{s(0.01s+1)^2}$. i) Is the system stable? ii) Record the gain crossover frequency, phase cross over frequency, gain margin and phase margin. **(12 Marks)**

b. Sketch typical i) Root locus ii) Nyquist and iii) Bode plots, given open loop transfer function, $G(s)\,H(s) = \frac{k}{s}$. Is the system stable? What is gain margin? **(08 Marks)**

8 a. Distinguish modern control theory from classical control theory. **(08 Marks)**

b. Define :i) State ii) State space iii) State variables. **(06 Marks)**

c. The following equation defines a separately excited DC motor in the form of differential equation:

$$w + \left(\frac{B}{J}\right)\frac{dw}{dt} + \left(\frac{k^2}{LJ}\right)w = \left(\frac{k}{LJ}\right)V$$

The above equation in state space form is as follows :

$$\begin{bmatrix} \ddot{w} \\ w \end{bmatrix} = p\begin{bmatrix} \dot{w} \\ w \end{bmatrix} + Q\ V$$

Find p matrix, if V is voltage input and w is angular velocity. **(06 Marks)**

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