Register Number:……………………..

B.E DEGREE EXAMINATIONS: NOV/DEC 2014

(Regulation 2009)

Fifth Semester

MECHATRONICS ENGINEERING

MCT 109: Control Systems

Time: Three Hours   **Maximum Marks: 100**

Answer all the Questions:-

PART A (10 x 1 = 10 Marks)

1. Electrical time-constant of an armature-controlled dc servomotor is
    a) equal to mechanical time-constant
    b) smaller than mechanical time-constant
    c) larger than mechanical time-constant
    d) not related to mechanical time-constant

2. If the Laplace transform of error e (t) is given as $[8(s + 3) / s(s + 10)]$ then the steady state value of the error works out as _____.
    a) 3.6
    b) 1.8
    c) 3.2
    d) 2.4

3. The impulse response of a LTI system is a unit step function, then the corresponding transfer function is
    a) $1/s$
    b) $1/s^2$
    c) 1
    d) s

4. For a type one system, the steady – state error due to step input is equal to
    a) infinite
    b) zero
    c) 0.25
    d) 0.5

5. Frequency range of bode magnitude and phase are decided by
    a) The lowest and highest important frequencies of dominant factors of the open-loop transfer function
    b) The lowest and highest important frequencies of all the factors of the open-loop transfer function
    c) Resonant frequencies of the second order factors
    d) Resonant frequencies of the first order factors

6. If the bode phase plot just grazes the 180 line without crossing it at either very low frequencies or very high frequencies, it implies that
    a) The phase margin is negative
    b) The phase margin is positive
    c) The gain margin can be either positive or negative extremely large
    d) The system is always unstable

7. If the Nyquist plot of the loop transfer function G(s) H(s) of a closed-loop system encloses the (-1, j0) point in the G(s) H(s) plane, the gain margin of the system is
    a) zero
    b) greater than zero
    c) less than zero
    d) infinity

8. A system with gain margin close to unity or a phase margin close to zero is
    a) highly stable
    b) oscillatory
    c) relatively stable
    d) unstable

9. The desired phase margin by using a lead compensator can be obtained
   a) In the first iteration
   b) In the second iteration
   c) In the third iteration
   d) In a number of iteration that may vary in each case

10. The main characteristic of a lag compensator is
    a) It is a first-order system with a zero and pole
    b) The zero is larger than the pole
    c) It is a low pass filter
    d) All the above

PART B (10 x 2 = 20 Marks)

11. Name two types of electrical analogous for mechanical system.
12. What is servomotor?
13. Define BIBO stability.
14. List the time domain specifications.
15. List out the different frequency domain specifications.
16. What are the main advantages of Bode plot?
17. How will the breakaway point & break in point be determine?
18. Define Relative stability.
19. What are types of compensation?
20. What are the merits of lag lead network?

PART C (5 x 14 = 70 Marks)

21. a) Choose the dynamic equation with respect to the mechanical system given in Fig.1. Then using force-voltage analogy, obtain the equivalent electrical network.

Legend
K_1, K_2 spring constants
B_1 viscous friction damping coefficient
M_1, M_2 inertial constants of masses
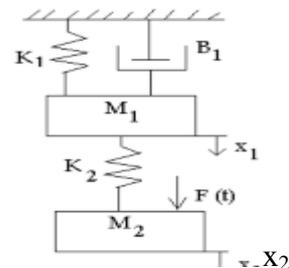x_1, x_2 displacements
F (t) .. Force.

Fig.1

(OR)

   b) Determine the transfer function C(s) / R(s) for the block diagram shown in Fig.2 using signal flow graph method.
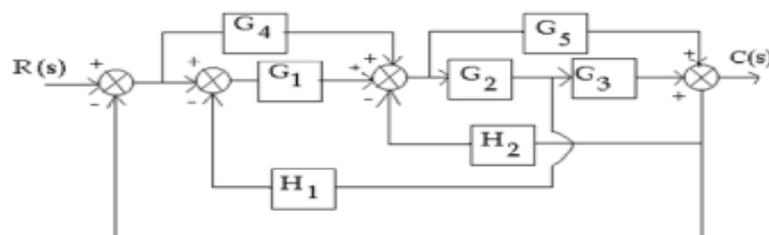

Fig.2

22. a) The open loop transfer functions of three systems are given as

(i) $\dfrac{4}{(s+1)(s+2)}$ (ii) $\dfrac{2}{s(s+4)(s+6)}$ (iii) $\dfrac{5}{s^2(s+3)(s+10)}$

Determine respectively the positional, velocity and acceleration error constants for these systems. Also for the system given in (ii) determine the steady state errors with step input r(t) = u(t), ramp input r(t) = t and acceleration input r(t) = $(\frac{1}{2})\,t^2$

(OR)

b) (i) For the system shown Fig.3 determine the values of gain K_1 and velocity   (10) feedback constant K_2 so that the maximum overshoot with a unit step input is 0.25 and the time to reach the first peak is 0.8 sec. Thus obtain the rise time and settling time for 5% tolerance band.
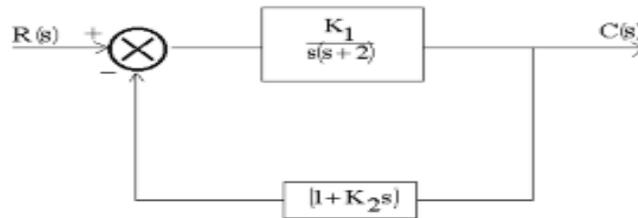
Fig.3

(ii) For the standard second order system shown in Fig.4, with r (t) = u (t) explain   (4) how the time domain specifications corresponding to resonant peak and bandwidth can be inferred.
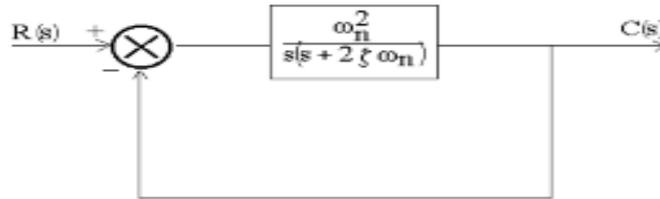
Fig.4

23. a) Consider the system shown in Fig.5. Draw the Bode plot of the open-loop transfer function G(s) with K = 1. Determine the phase margin and gain margin. Find the value of K to reduce the phase margin by 10^0.
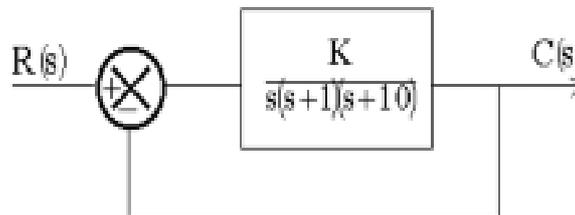
Fig.5

(OR)

b) The forward path transfer function of a Unity-feedback control system is given as

$$G(s) = \dfrac{K}{s(1+0.1s)(1+0.5s)}$$

Draw the Bode plot of G(s) and find the value of K so that the gain margin of the system is 20 dB.

24. a)   The loop transfer function of a single feedback-loop control system is given as

$$G(s)H(s) = \frac{K}{s(s+2)(s+10)}$$

Apply the Nyquist criterion and determine the range of values of K for the system to be stable.

(OR)

b)   Sketch the root locus diagram for a unity feedback system with its open loop function as

$$G(s) = \frac{K(s+3)}{s(s^2+2s+2)(s+5)(s+9)}.$$

Thus find the value of K at a point where the complex poles provide a damping factor of 0.5.

25. a)   A unity-feedback system has open-loop transfer function

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

(i) Using Bode plot, determine the phase margin of the system.
(ii) How should the gain be adjusted so that phase margin is 50°?
(iii) Determine the bandwidth of gain-compensated system.
The –3dB contour of the Nichols chart may be constructed using the following table.

Phase in degrees	0	- 30	- 60	- 90	-120	-150	-180	- 210
Magnitude in dB	7.66	6.8	4.18	0	- 4.18	- 6.8	- 7.66	- 6.8

(OR)

b)   (i)   The open-loop transfer function of a control system is   (6)

$$G(s)H(s) = \frac{10}{s(1+0.5s)(1+0.1s)}$$

Draw the Bode plot and determine the gain crossover frequency, and phase and gain margins.

(ii)   A lead compensator with transfer function   (8)

$$D(s) = \frac{1+0.23s}{1+0.023s}$$

is now inserted in the forward path. Determine the new gain crossover frequency,   phase margin and gain margin.

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