B.E., DEGREE EXAMINATIONS: NOV/DEC 2012

Fifth Semester

MECHATRONICS ENGINEERING

MCT109: Control Systems

(Semi log graphs, polar graph sheet & ordinary graph sheets are to be supplied)

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

Answer all the Questions:-

PART A (10 x 1 = 10 Marks)

1. In a field controlled DC servomotor, the armature is supplied by ------------

   a) Constant current   b) Constant voltage

   c) Constant field flux   d) Both a & b

2. The force balance equation of an ideal spring element is ----------

   a) $F= B \dfrac{dx}{dt}$ b) $F = K \dfrac{dx}{dt}$

   c) $F= Kx$ d) $F= K \dfrac{\partial x}{\partial t}$

3. Mass is having ------------- relationship with natural frequency of 2nd order mechanical systems

   a) inversely proportional   b) proportional

   c) exponential   d) bimodal

4. If the damping ratio of a system is 0.75 and the natural frequency of oscillation is 12 rad/sec then what will be the peak overshoot

   a) 2.6%   b) 2.8%

   c) 3%   d) 2.4%

5. The expression of resonant peak of a second order system is given by

   a) $M_r = \dfrac{1}{2\zeta\sqrt{1-\zeta^2}}$ b) $M_r = \dfrac{\zeta}{2\sqrt{1-\zeta}}$

   c) $M_r = \dfrac{1}{\zeta\sqrt{1-\zeta^2}}$ d) $M_r = \dfrac{1}{2\zeta\sqrt{1-\zeta}}$

6. The corner frequency of a transfer function $\dfrac{1}{s}$ is ----

   a) 8 rad/sec   b) 1 Hz

   c) 1 rad/sec   d) none

7. A system with single root at origin is

   a) oscillatory   b) unstable

   c) stable   d) marginally stable

8. Centroid can be calculated using --------- formula; where n= number of poles, m = number of zeros.

   a) sum of poles- sum of zeros/ n-m
   b) sum of zeros-sum of poles/ n-m
   c) sum of poles- sum of zeros/ m-n
   d) sum of zeros- sum of poles/ m-n

9. Laplace transform of sin ωt

   a) $\dfrac{\omega}{\omega^2}$
   b) $\dfrac{\omega}{s+\omega}$
   c) $\dfrac{\omega}{s^2+\omega^2}$
   d) $\dfrac{1}{s^2+\omega^2}$

10. ------- plot helps for controller tuning as well as compensator design

    a) Polar plot
    b) Bode plot
    c) Nyquist plot
    d) a and b

PART B (10 x 2 = 20 Marks)

11. Write the torque balance equation of a dash-pot element.

12. Draw the force-current analogues circuit for the mechanical system given in Figure 1

Figure 1

13. Define rise time.

14. Define velocity error constant and what will be the steady state error in type 1 system for unit ramp input?

15. What is meant by corner frequency?

16. Define gain margin.

17. When does a system is called limitedly stable system?

18. Define Nyquist stability criterion.

19. What is meant by process lag?

20. Define lead lag.

PART C (5 x 14 = 70 Marks)

21. a) Derive the transfer function of an armature controlled DC motor.

(OR)

b) Convert the block diagram shown in Figure 2 to signal flow graph and find the transfer function using Mason's gain formula.
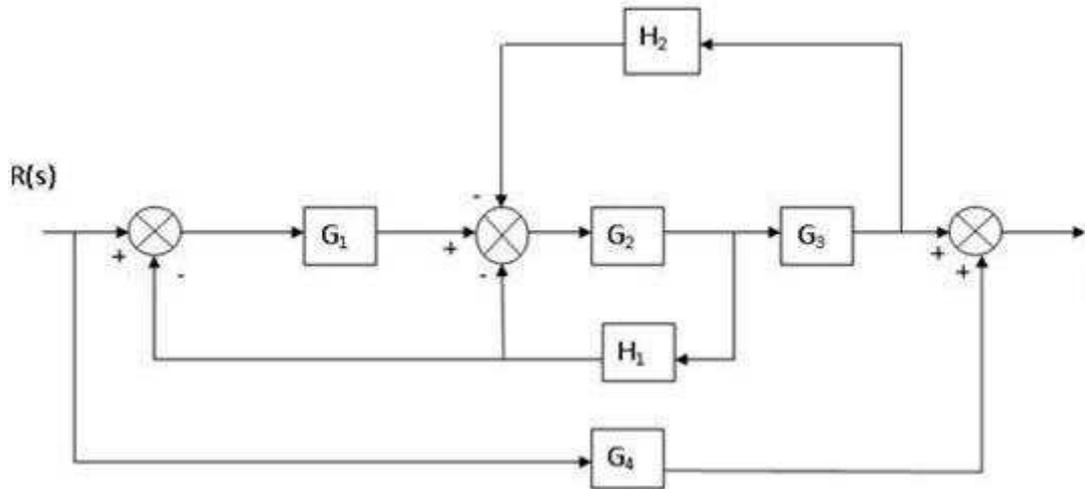

Figure 2

22. a) Derive the following time domain specifications for a second order system:

(i) Rise time (7)

(ii) Peak time (7)

(OR)

b) There are different process stations available in a petrochemical industry. The process stations are needed to be precisely controlled to manufacture different by-products from the crude oil. To manufacture naphtha from crude oil, the process station should be a unity feedback control system with an open loop transfer function of $G(s) = 10/s(s+2)$. If the input flow of crude oil to the station increased by a step of 12 units then what will be the rise time, percentage of overshoot and peak time of this process station. Assume the system is a linear one.

23. a) Obtain gain and phase cross over frequencies using bode plot for a transfer function $G(s) = \dfrac{10}{s\,(1+0.4s)(1+0.1s)}$

(OR)

b) Consider a unity feedback system having an open loop transfer function $G(s) = \dfrac{K}{s(1+0.2s)(1+0.05s)}$. Sketch the polar plot and determine the K value so that (i) gain margin is 18dB (ii) phase margin is 60°.

24. a) Check the stability of a system, whose characteristic equation is governed by $s^6 + s^5 + 3s^4 + 3s^3 + 3s^2 + 2s + 1 = 0$, use Routh Hurwitz method

<div align="center">**(OR)**</div>

b) Sketch a root locus of a unity feedback control system having an open loop transfer

function $G(s) = \dfrac{K}{s(s^2+4s+13)}$.

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

$G(s) = \dfrac{K}{s(0.1s+1)(0.2s+1)}$. The system is required to satisfy the following

performance specifications: 1) K_v= 30 2) Phase margin $\geq 40°$ 3) bandwidth $\omega_b = 5$ rad/sec. Choose a suitable compensation technique and justify why it was selected.

<div align="center">**(OR)**</div>

b) Consider a type 1 unity feedback system with an open loop transfer function

$G(s) = k/s(s+1)$. It is desired to have the velocity error constant K_v =10. Furthermore, phase margin of the system to be at least 45°. Design compensator using Bode plot.

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