Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.Tech(ICE/OLD)/SEM-4/IC-401/2013

2013
BASIC CONTROL THEORY

Time Allotted : 3 Hours *Full Marks :* 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following : $10 \times 1 = 10$

i) In force-voltage analogy, mass is analogous to

a) charge b) current

c) inductance d) resistance.

ii) The roots of the characteristics are same as

a) closed loop zeros b) closed loop poles

c) open loop poles d) open loop zeros.

iii) The type and order of the unity feedback system with the following open loop transfer function

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

is

a) 3, 2 b) 1, 2

c) 1, 3 d) 0, 3.

iv) The characteristic equation of a second order system is $s^2 + 6s + 25 = 0$.

The system is

a) underdamped b) overdamped

c) undamped d) critically damped.

v) A system has some roots with real parts equal to zero but none with + *ve* real part. The system is

a) relatively stable b) absolutely stable

c) marginally stable d) absolutely unstable.

vi) The value of K at which the root locus crosses the imaginary axis makes the system

a) stable b) underdamped

c) marginally stable d) unstable.

vii) Root loci of a system have three asymptotes. The system can have

a) 6 poles and 3 zeros b) 3 poles and 1 zero

c) 4 poles and 2 zeros d) 6 poles and 1 zero.

viii) A system has 4 poles and one zero. Its high frequency asymptote in its magnitude plot has a slope of

a) – 100 dB/decade b) 100 dB/decade

c) – 60 dB/decade d) 60 dB/decade.

ix) A system has a transfer function $\frac{1-s}{1+s}$. It is known as

a) low pass system

b) high pass system

c) all pass system

d) minimum phase system.

x) The gain cross-over frequency is greater than phase cross over frequency in case of

a) stable system

b) unstable system

c) marginally stable system

d) underdamped system.

xi) State variable approach converts an *n*th order system into

a) *n* second order differential equation

b) two differential equations

c) *n* first order differential equation

d) a lower order system.

xii) The origin for the investigation of closed-loop stability in relation to Nyquist criterion is

a) $-1 + j0$ b) $1 - j0$

c) $0 + j1$ d) $-1 - j1$.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. $3 \times 5 = 15$

2. Explain the function of a PID controller enumerating the benefits of using it.

3. Derive the transfer function of an armature controlled *dc* motor.

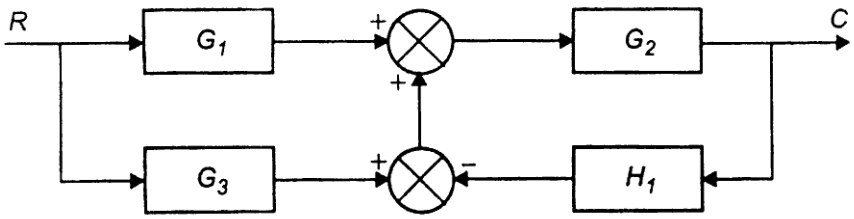
4. A feedback control system is described as

$$G(s) = \frac{50}{s(s+2)(s+5)}, \quad H(s) = \frac{1}{s}$$

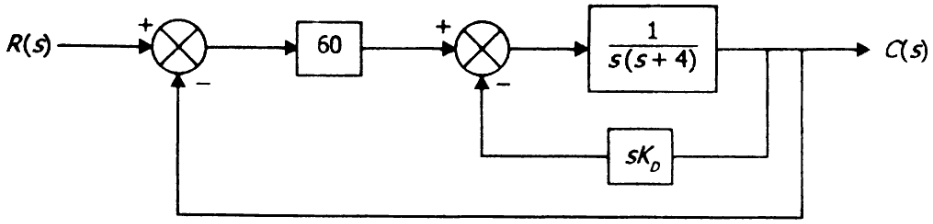
a) Evaluate the static error constants K_p, K_v and K_a for the system.

b) Determine steady state error for a unit step input and ramp input. 3 + 2

5. Obtain the overall transfer function for the block diagram shown in the following figure :



6. Following figure shows a unity feedback system. Calculate ξ and ω_n when $K_D = 0$. Also determine K_D when $\xi = 0{\cdot}6$.



GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. 3 × 15 = 45

7. a) Derive the expression regarding to the time response of a typical second-order underdamped system having unit step input. Draw the response curve.

b) A second order servo system has poles at $s = -1 + j2$, $s = -1 - j2$ and zero at $s = -1 + j0$ and $s = -1 - j0$. Its steady state output for a unit step input is 2. Determine the transfer function.

c) The maximum overshoot for a unity feedback control system having its forward path transfer function $G(s) = \frac{K}{s(sT+1)}$ is to be reduced from 60% to 20%. The system input is a unit sep function. Determine the factor by which K should be reduced to achieve aforesaid reduction. 7 + 3 + 5

8. a) State Routh stability criterion.

b) Mention the difficulties that may arise in applying Routh stability criterion.

c) What do you mean by relative stability ?

d) The open loop transfer function of a unit feedback control system is given by

$$G(s) = \frac{K(s+1)}{s^3 + as^2 + 2s + 1}$$

The above system oscillates with frequency ω , if it has poles on $s = +j\omega$ and $s = -j\omega$ and no poles in the right half s-plane. Determine the values of K and a, so that the system oscillates at a frequency 2 radian/sec.

e) The open loop transfer function of a unity feedback control system is given by

$$G(s)\,H(s) = \frac{K}{s(s^2 + 8s + 32)}$$

Find :

(i) the number and angle centroid of asymptotes

(ii) angle of departure.

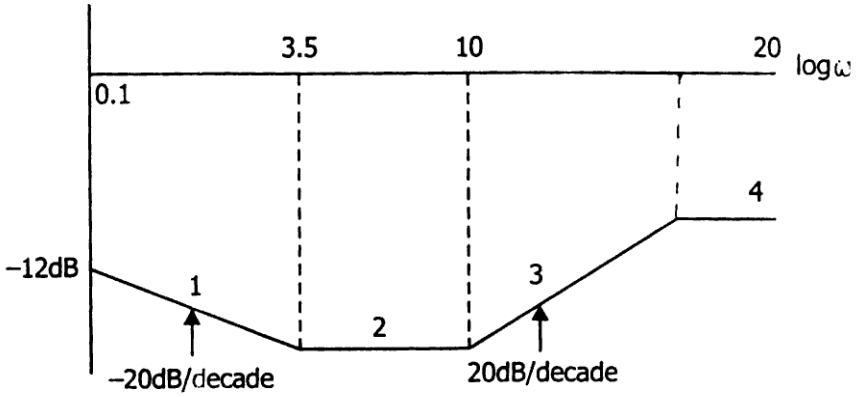
(iii) the break-away point

(iv) the condition for marginal stability.

1 + 2 + 1 + 6 + 5

9. a) Explain minimum phase, non-minimum phase and all transfer function.

b) Determine the transfer function of the system whose Bode plot is shown below :



c) State and explain Nyquist criterion.

d) A unity feedback control system has open loop transfer function $G(s)\,H(s) = \dfrac{12}{s\,(s+1)\,(s+2)}$

Draw the Nyquist plot and determine closed loop stability. Calculate gain margin also. 3 + 4 + 2 + 6

10. a) Define state and state variable of a control system.

b) Define state transition matrix and list the properties of it.

c) Obtain the state transition matrix of the following system :

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

d) The transfer function of a system is given by

$$\frac{Y(s)}{U(s)} = \frac{s^2 + 3s + 2}{s^3 + 9s^2 + 26s + 24}$$

Determine the state model. Use direct decomposition method. 2 + 3 + 5 + 5

11. Write short notes on any *three* of the following : 3 × 5

a) Determination of GM and PM from Bode plot

b) Effect of adding a zero to a second order system

c) Performance indices

d) Polar plot

e) Frequency domain specifications.