Name : ……………………………………………………………

Roll No. : ………………………………………………………….

Invigilator's Signature : ……………………………………….

CS/B.Tech/EEE/NEW/SEM-6/EEE-602/2013

2013

CONTROL SYSTEM

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.

Semilog graph sheet will be supplied by the institution.

GROUP – A
(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following :

$10 \times 1 = 10$

i) The characteristic equation of a system is given by $s^2 + 8s + 16 = 0$. The system is

a) overdamped b) underdamped

c) critically damped d) undamped.

ii) In terms of Bode Plot, a system is stable if

a) Gain Margin = Phase Margin

b) both Gain Margin and Phase Margin are positive

c) both Gain Margin and Phase Margin are negative

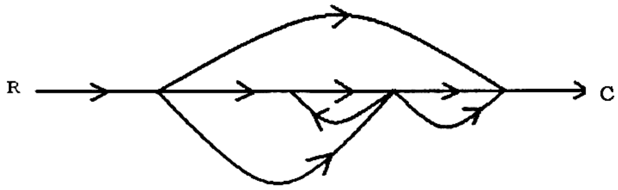
d) Phase Margin is negative and Gain Margin is positive.

iii) The settling time of a second order system on 2% basis is given by

a) $t_s = \frac{4}{\xi\omega_n}$ b) $t_s = \frac{\xi\omega_n}{4}$

c) $t_s = \frac{4\xi}{\omega_n}$ d) $t_s = 4\xi\omega_n$.

iv) The number of forward paths in the signal flow graph shown below is



a) 1 b) 5

c) 3 d) 2.

v) An *ac* servomotor is basically a

a) universal motor

b) two-phase induction motor

c) three-phase induction motor

d) repulsion motor.

vi) For a dynamic system given by $\frac{d^2y}{dt^2} + 5\frac{dy}{dt} + 4y = \frac{3dx}{dt} + x$, the transfer function is

a) $\frac{3s^2 + s}{s^2 + 5s + 4}$ b) $\frac{3(s+1)}{(s+1)(s+4)}$

c) $\frac{3s+1}{(s+3)(s+1)}$ d) $\frac{3s+1}{(s+1)(s+4)}$.

vii) The function $\frac{(1+sT_1)}{s(1+sT_2)}$ at a very high frequency will have an asymptotic slope of

a) 40 dB/decade b) – 20 dB/decade

c) – 40 dB/decade d) 20 dB/decade.

viii) If the unit step response of a system is $10\,t\,e^{-t}$, then the transfer function is given by

a) $\frac{10s^2}{(s+1)}$ b) $\frac{10}{s(s+1)^2}$

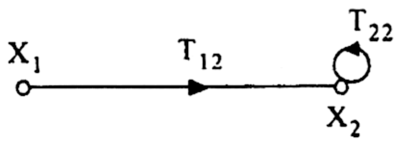
c) $\frac{10s}{(s+1)^2}$ d) $\frac{10}{(s+1)^2}$.

ix) If the transfer function of a network is given by $\frac{(1+0\cdot5s)}{(1+s)}$, then it is a

a) lead-lag network b) lag network

c) lag-lead network d) lead network.

x) From the figure shown below, the transfer function of the signal flow graph is



a) $\frac{T_{12}}{1-T_{22}}$ b) $\frac{T_{22}}{1-T_{12}}$

c) $\frac{T_{12}}{1+T_{22}}$ d) $\frac{T_{22}}{1+T_{12}}$.

xi) For the transfer function $G(s).H(s)=\frac{1}{s(s+1)(s+0\cdot5)}$, the phase crossover frequency is

a) 0·5 rad/sec b) 0·707 rad/sec

c) 1·732 rad/sec d) 2 rad/sec.

xii) $[-a \pm jb]$ are the complex conjugate roots of the characteristic equation of a second order system. Its damping coefficient and natural frequency will be respectively

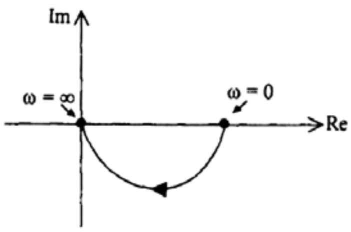
a) $\dfrac{b}{\sqrt{a^2 + b^2}}$ and $\sqrt{a^2 + b^2}$

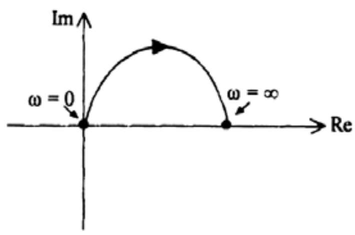
b) $\dfrac{b}{\sqrt{a^2 + b^2}}$ and $a^2 + b^2$

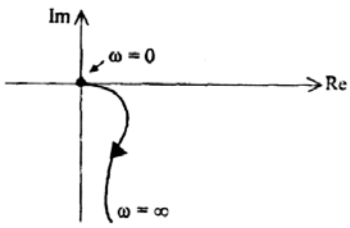
c) $\dfrac{a}{\sqrt{a^2 + b^2}}$ and $\sqrt{a^2 + b^2}$

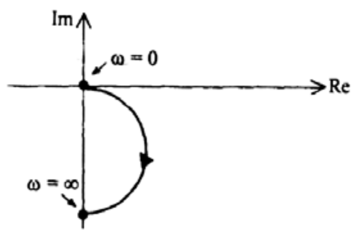
d) $\dfrac{a}{\sqrt{a^2 + b^2}}$ and $a^2 + b^2$.

xiii) The transfer function of a system is given by $G(s) = \dfrac{s}{1+s}$. The Nyquist plot of the system is

a)


b)


c)


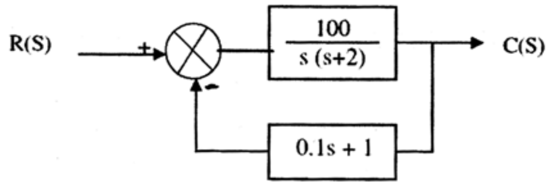
d)


GROUP – B

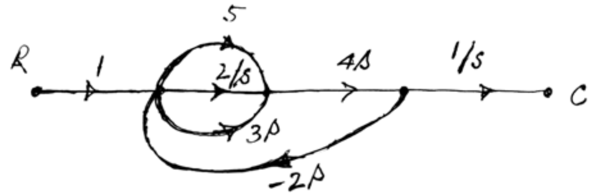
(Short Answer Type Questions)

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

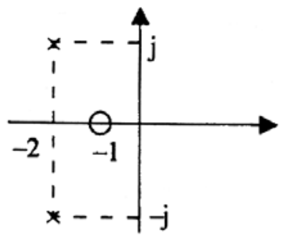
2. In the following feedback control system, if the input is a unit step, determine the response $c(t)$.



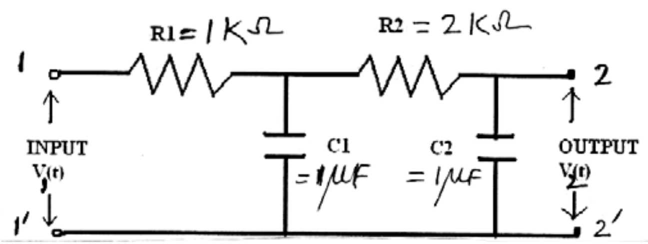
3. In the signal flow graph shown below, find the value of C/R ratio.



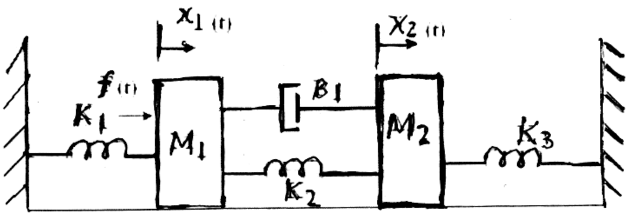
4. A transfer function $G(s)$ has the pole-zero plot as shown in the figure below. The *dc* gain is 2. Determine the transfer function.



5. Determine the transfer function for the electrical system given below :



6. Obtain the mathematical model and hence the transfer function $x_2(s)/F(s)$ for the following system :



7. Sketch the Bode-plot $G(s) = \dfrac{100(s+10)}{(s+20)(s+100)}$.

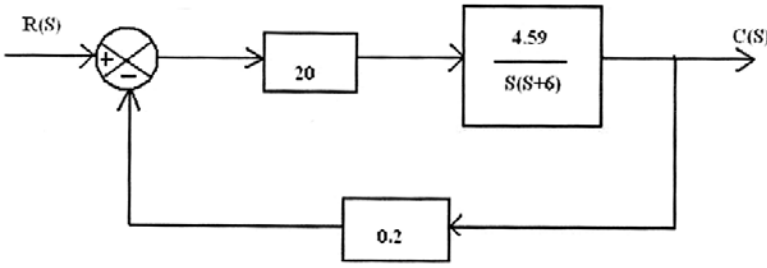
(You may use a semilog graph sheet, if you wish. It is not compulsory.)

GROUP – C

(Long Answer Type Questions)

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

8. a) For the system given below, determine (i) ω_n and ω_d, (ii) μ_p and (iii) settling time for 2% tolerance band for a step input.



b) The open loop transfer function of a unity feedback control system is $G(s) = \dfrac{20}{s(s+2)}$. Determine the steady state error when the input is $r(t) = a_0 + a_1 t$.

9. Sketch the Nyquist plot for the open loop transfer function $G(s)H(s) = \dfrac{10k}{s(s+1)(s+100)}$. Determine the stability limit of the closed loop system.

10. Sketch the root locus plot for the open loop transfer function of a unity feedback control system given by $G(s)H(s) = \dfrac{k}{s(s+1)(s+3)}$.

    a) Determine the value of k for the damping ratio $\xi = 0{\cdot}5$.

    b) Determine the value of k for marginal stability.

    c) Find the frequency of sustained oscillation at marginal stability condition. 5 + 5 + 5

11. a) For the following system obtain a state-space equation using controllable canonical form :

$$G(s) = \frac{10(s+4)}{s(s+3)(s+1)}$$

    b) For the system described below, obtained the solution for $u(t)$ = unit step.

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u(t)$$

    Find the resolvant matrix and the state transition matrix.

    c) Check for the controllability and observability of the system given by

$$\dot{X} = \begin{bmatrix} 1 & -1 \\ 1 & -1 \end{bmatrix} \dot{X} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} U \ , \ Y = [1 \ \ 0] X$$

5 + 5 + 5

12. A unity feedback control system has an open loop transfer function of $G(S) = \frac{A}{S(ST+1)}$.

a) By what factor should the amplifier gain be adjusted such that the damping factor is increased from 0·2 to 0·6 ?

b) By what factor should the amplifier gain be adjusted such that the overshot of the unit step response is reduced from 80% to 20% ?

c) If $A = 2$, $T = 1$, then find the steady state error of the system for the following input :

$r(t) = 1 + 2t + t^2$ 5 + 5 + 5

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

a) *AC* servomotor

b) Synchro as a torque transmitter

c) Effects of poles and zeros on transient response of a system

d) Routh-Hurwitz criterion for determination of stability of a system

e) Use of Nichol's chart and *M*-circle

f) Necessity of PID control.

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