Code: D-15 **Subject: CONTROL ENGINEERING**
Time: 3 Hours **Max. Marks: 100**

NOTE: There are 11 Questions in all.

- **Question 1 is compulsory and carries 16 marks. Answer to Q. 1. must be written in the space provided for it in the answer book supplied and nowhere else.**
- **Answer any THREE Questions each from Part I and Part II. Each of these questions carries 14 marks.**
- **Any required data not explicitly given, may be suitably assumed and stated.**

Q.1 Choose the correct or best alternative in the following: (2x8)

a. The D.C. gain of a system represented by the transfer function $G(s) = \frac{18(s+2)}{(s+4)(s+1.5)}$ is

(A) 12 **(B)** 6
(C) 15 **(D)** 9

b. The 2% settling time of a second order system with a damping ratio of 0.6 and a natural frequency of 5 rad/sec is _____

(A) 2.66 **(B)** 6.3
(C) 1.33 **(D)** 5.4

c. If the Laplace transform of f(t) is F(s), then the Laplace transform of $e^{-2t}f(t)$ is _____.

(A) F(2s) **(B)** $F\left(\frac{s}{2}\right)$
(C) $F(s+2)$ **(D)** $F(s-2)$

d. The main assumption made while deriving the transfer function an armature controlled DC servomotor is that _____.

(A) the armature inductance is zero.
(B) the armature resistance is infinite.
(C) the armature inductance is infinite.
(D) the armature resistance is zero.

e. The steady state error with a _____ controller and with a ramp input [that is, r(t) = t] for the system of Fig.1 will be non-zero ar finite.

(A) P + D.
(B) P + I.
(C) Proportional.
(D) P + I + D.

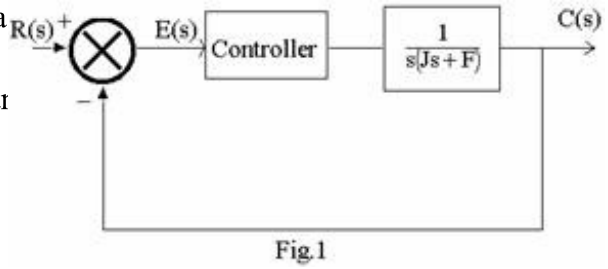


Fig.1

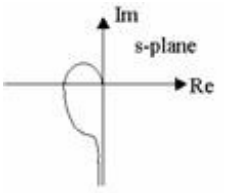
f. The asymptotic Bode plot of a system with $G(s) = \frac{10}{(s+1)(s+2)}$ shows that the gain margin will be

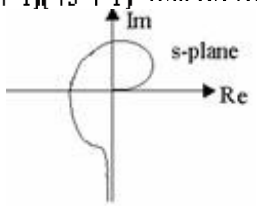
_____.

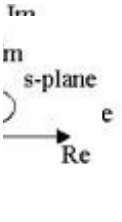
(A) 0 **(B)** ∞

(C) 5 **(D)** 2

g. The polar plot of $G(s) = \frac{K(0.5s+1)}{s^2(0.3s+1)(4s+1)}$ will be of the form _____.







(C) **(D)**

h. The drawback of a field controlled D.C. servomotor when compared to the armature controlled one is that _____.

(A) the armature inductance is zero. **(B)** field resistance is zero.

(C) it needs a constant voltage source. **(D)** it needs a constant current source.

PART I

Answer any THREE Questions. Each question carries 14 marks.

Q.2 a. Draw the schematic-cum-circuit diagram of a two-phase a.c. servomotor and derive its transfer function. State the assumptions made. **(8)**

b. Give the set-up of a synchro generator-control transformer combination and explain its operation. **(6)**

Q.3 a. Given the unity feedback system of Fig.2, derive the steady state error with a ramp input. **(6)**

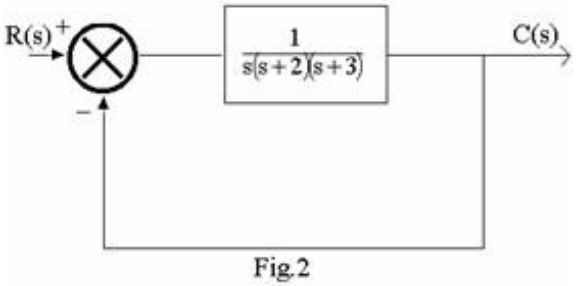


Fig.2

b. State whether the following are true or false and give a short amplifying note for each.

(i) In the system Fig.3, for an $\omega = 3\,rad/sec$ the phase of c(t) will be 135° behind r(t) and its magnitude will be $\sqrt{2}$ times that of r(t), with a K of 9.

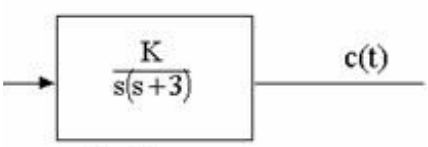


Fig.3

(ii) The absence of a resonant peak for a second order system indicates a highly damped response for the system. **(8)**

Q.4 a. Using Routh-Hurwitz criterion examine the stability of a system whose characteristic equation is given by $9s^5 + 4s^4 + 6s^3 + 5s^2 + 2s + 1 = 0$. **(6)**

b. Find out if any root of the characteristic equation exists to the right of an axis drawn at distance of 1 to the left of $j\omega$ axis. Give a step-by-step procedure for the same. **(8)**

Q.5 Sketch the root locus for the system given by $G(s) = \dfrac{K(s+1)}{s^2(s+2)(s+3)(s+5)}$ by following all the rules. Determine the information regarding

(i) intersection point of asymptotes on the real axis.
(ii) angles of departure at complex poles and
(iii) root loci on the real axis. **(14)**

Q.6 Obtain the signal flow diagram for the system of Fig.4 and determine the closed-loop transfer function from the graph.
(14)
(14)

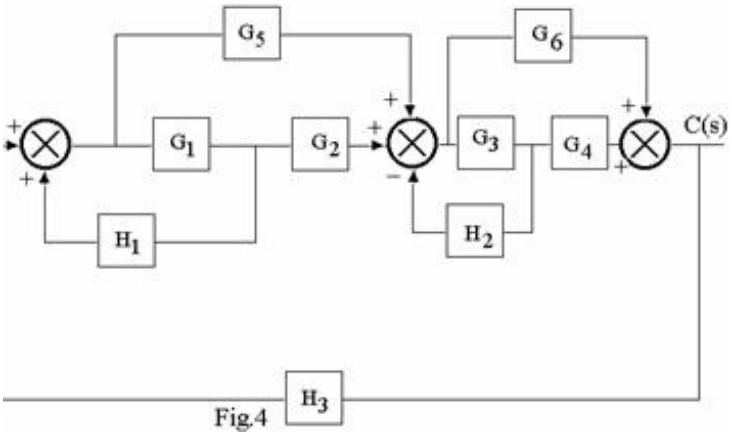


Fig.4

PART II
Answer any THREE Questions. Each question carries 14 marks.

Q.7 a. Write the Laplace transformed equation for the mechanical system of Fig.5 using force-voltage

analogy. **(8)**

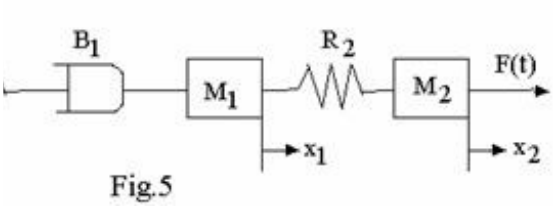


Fig.5

b. Give the relative advantages and disadvantages of the Nyquist plot and the root locus plot in determining the stability of a system. **(6)**

Q.8 Construct the Bode plots for the following transfer function and hence determine gain margin and gain crossover frequency

$$GH(j\omega) = \frac{12(j\omega+4)}{j\omega(j\omega+3)\left[(j\omega)^2+(j\omega)+2\right]}.$$ **(14)**

Q.9 For the system shown in Fig.6, find the settling time (2% criterion) and rise time if the system responds to a unit step input with
(i) maximum overshoot as 0.19 and (ii) time to reach the first peak as 0.58 sec. **(14)**

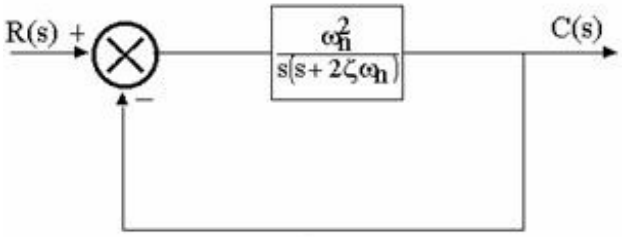


Fig.6

Q.10 a. State and explain Nyquist stability criterion. **(6)**

b. Using the Nyquist criterion determine any root of the characteristic equation in the right half of the s-plane for the following open loop function of a unity feedback control system $G(s) = \frac{10(s+3)}{(s+2)(s-2)}$. **(8)**

Q.11 Write notes on any **TWO** of the following:

(i) Nichol's chart.
(ii) Lag-Lead compensation.
(iii) Force-current analogy between mechanical and electrical systems. **(7 + 7)**