Subject: CONTROL ENGINEERING

Time: 3 Hours **Max. Marks: 100**

JUNE 2011

NOTE: There are 9 Questions in all.

- **Question 1 is compulsory and carries 20 marks. Answer to Q.1 must be written in the space provided for it in the answer book supplied and nowhere else.**
- **The answer sheet for the Q.1 will be collected by the invigilator after 45 Minutes of the commencement of the examination.**
- **Out of the remaining EIGHT Questions answer any FIVE Questions. Each question carries 16 marks.**
- **Any required data not explicitly given, may be suitably assumed and stated.**

Q.1 Choose the correct or the best alternative in the following: (2×10)

a. What is the important feature of servomotor?

(A) Current –voltage characteristics
(B) Speed-current characteristics
(C) Speed-voltage characteristics
(D) Speed-torque characteristics

b. What is the use of compensation network?

(A) Improvement in transient response
(B) Improvement in accuracy
(C) Decrease the system error constant
(D) None of the above

c. The laplace transform of unit step function is

(A) zero **(B)** one
(C) 1/s **(D)** s

d. What is the phase relationship between reference and control voltage in case of servomotor?

(A) in phase **(B)** out of phase 90^0
(C) out of phase180^0 **(D)** none of these

e. If the system has non repeated poles on the jω-axis, the system is

(A) stable **(B)** unstable
(C) marginally stable **(D)** Conditionally stable

f. The transfer function of the given block diagram (Fig.1) is

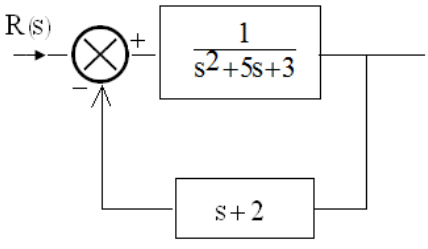

Fig.1

(A) s^2+5s+3

(B) $s+\frac{2}{s^2}+5s+3$

(C) $\frac{1}{s^3+7s^2+13s+6}$

(D) $s^3+7s^2+13s+\frac{6}{s}+2$

g. The open loop transfer function has 4 poles and 1 zero. The number of branches of root locus is

(A) 4 **(B)** 1
(C) 5 **(D)** 3

h. The open loop transfer function of system is $G(s)H(s)=\frac{K(s+2)}{s(s+3)(s+4)}$. Its centroid is at s=

(A) -2.5 **(B)** -4
(C) -4.5 **(D)** 0

i. The eigen values of the state model are the same as the

(A) closed loop poles **(B)** open loop poles
(C) both **(A)** & **(B)** **(D)** none of above

j. An n x m matrix is said to be non-singular if the rank of the matrix r is

(A) r=n **(B)** r.n
(C) r=n/2 **(D)** 2n

Answer any FIVE Questions out of EIGHT Questions.
Each question carries 16 marks.

Q.2 a. Explain servomechanism with suitable example. **(4)**

b. Distinguish between open loop control system and closed loop control system with suitable example. **(4)**

c. Draw the mechanical equivalent network, write the system equations and find $F(s)/X_2(s)$ of the system shown in Fig.2. **(8)**

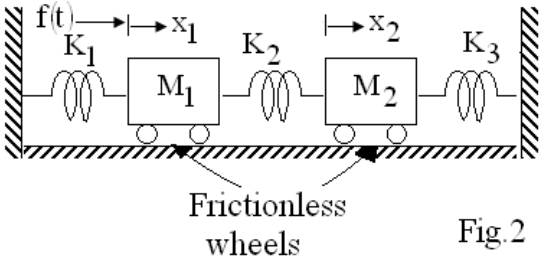

Fig.2

Q.3 a. Simplify the block diagram (Fig.3) to its minimum and calculate its transfer function. **(8)**

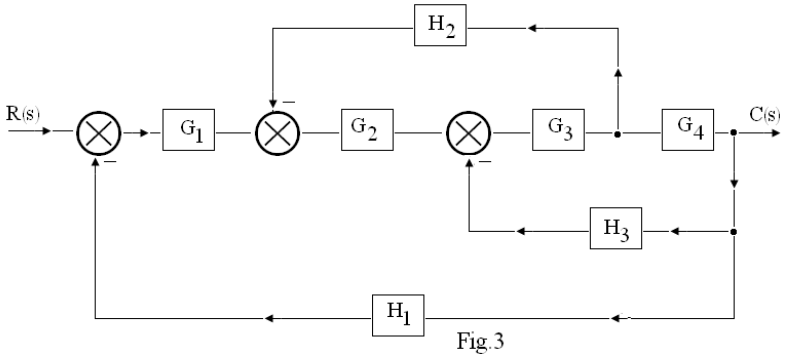

Fig.3

b. Find the overall transfer function by using Mason's gain formula for the signal flow graph (Fig.4). **(8)**

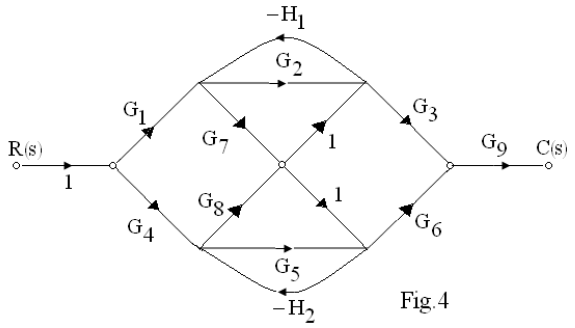

Fig.4

Q.4 a. Explain the working, construction and applications of stepper motor. **(3+3+2)**

b. Consider the speed control system of Fig.5 wherein the inner loop corresponds to motor back emf. The controller is an integrator with gain K observes that the load is inertia only.
(i) Determine the value of K for which steady state error to unit ramp input ($V_r(s)=1/s^2$) is less than 0.01rad/sec.
(ii) For the value of K found in part (i) determine, the sensitivity S^T_K, $T(s)= w(s)/V_r(s)$ .What will be the limiting value of S^T_K at low frequencies?**(8)**

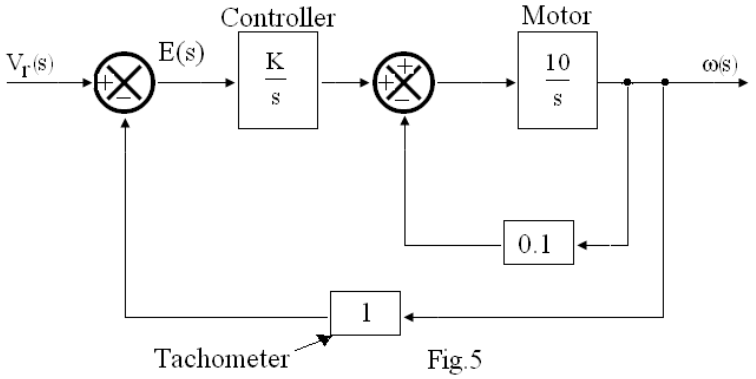

Fig.5

Q.5 a. A system has open loop transfer function as $G(s)H(s)=\frac{10}{s(s+5)}$. Find the undamped natural frequency, the damping ratio, the damped natural frequency, rise time, peak time, peak overshoot and the settling time with 2% criterion.**(8)**

b. For unity feedback system, system is marginally stable and oscillates with frequency rad/sec. Find K_{mar} and 'q'

$$G(s)H(s)=\frac{4}{s\left(s^2+qs+2K\right)}$$ **(8)**

Q.6 a. The loop transfer function of a unit feedback control system is $G(s)H(s)=\frac{K}{s(s+2)(s+5)}$. Sketch the root locus of the system and determine the value of K. **(8)**

b. Sketch the root loci for the unity feedback system with $G(s)=\frac{K(s+b)}{s(s+a)}$.

Assume b>a. **(8)**

Q.7 a. Sketch the Nyquist plot for a system with

$$G(s)H(s)=\frac{10(s+1)}{(2s+1)(1+0.1s)(1+0.02s)}$$

Draw Nyquist plot and find stability (condition for stable). **(8)**

b. The open loop transfer function of a unit feedback control system is

$$G(s)H(s)=\frac{170\left(\frac{s}{10}+1\right)}{s\left(1+\frac{s}{1.75}\right)\left(1+\frac{s}{60}\right)}$$

Sketch the bode plot of the system and determine (i) gain margin (ii) phase margin (iii) closed loop stability. **(8)**

Q.8 a. The loop transfer function of a unity feedback control system is $G(s)=\frac{10}{s(s+1)}$

Design a lead compensator such that the closed loop system will satisfy the following specifications:
Static velocity error constant = 20sec
Phase margin = 50^0
Gain margin $\geq$ 10dB **(10)**

b. Explain in brief what do you understand by phase lead compensator. Write effects and limitations of phase lead compensator. **(6)**

Q.9 a. Obtain the transfer function of the given state equation:

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix}=\begin{bmatrix}0 & 1 & 0\\ -1 & -1 & 0\\ 1 & 0 & 0\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}+\begin{bmatrix}0\\ 1\\ 0\end{bmatrix}u$$

$$y=\begin{bmatrix}x1 & x2 & x3\end{bmatrix}\begin{bmatrix}x1\\ x2\\ x3\end{bmatrix}$$ **(8)**

b. Consider the vector matrix differential equation as

$$\dot{x}=\begin{bmatrix}0 & 1\\ -2 & -3\end{bmatrix}x$$

Obtain the transition matrix. **(8)**