Code: AE11 **DECEMBER 2008** **Subject: CONTROL ENGINEERING**
Time: 3 Hours **Max. Marks: 100**

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.**
- **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 best alternative in the following: (2x10)

a. If force-current and velocity-voltage are analogous pairs, then mass is paired with

(A) Capacitance **(B)** Inductance
(C) Resistance **(D)** Conductance

b. The system with input-output

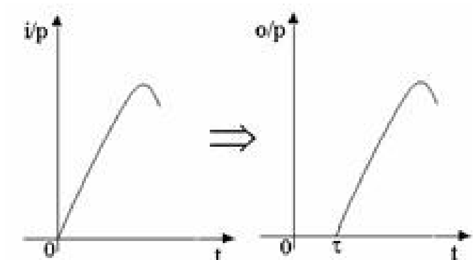

Fig.1

(A) linear elements
(B) active elements
(C) dead-time elements
(D) ideal elements

c. The controller of gain K_c and rate-time T_D as in Fig.2 refers to

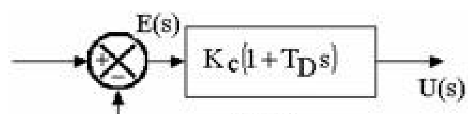

Fig.2

(A) PID
(B) PD
(C) PI
(D) Integral controller

d. If for all possible initial states $x(o), x(t)$ eventually decays to zero as $t \to \infty$, then the system is

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

e. The radii of constant-M circles reduce monotonically and the centres located on the negative real axis shift towards $(-1+j0)$ point when

(A) M = 1 **(B)** M > 1
(C) M < 1 **(D)** M = 0

f. Control applications using synchros require good sensitivity which has the units

(A) V **(B)** rpm

(C) $V/rad - s^{-1}$ (D) V/deg

g. Consider a function $F(s) = \frac{1}{s(s+1)}$ where $L[f(t)] = F(s)$ then $\lim_{t \to \infty} f(t)$ equal to

(A) zero (B) one
(C) infinite (D) none of the above

h. Large power applications like earth station antenna drives for tracking satellites generally use

(A) ac servo motors (B) dc servo motors
(C) small motors (D) single-phase motors

i. For a standard second-order system described by $s^2 + 2\zeta\omega_n s + \omega_n^2$, the term $1/\zeta\omega_n$ indicates

(A) time-constant (B) damping factor
(C) natural frequency (D) none of the above

j. The root-locus drawn in Fig.3 refers to an open-loop transfer function G(s) =

(A) $\frac{K}{s+1}$

(B) $\frac{K}{(s+1)(s+2)}$

(C) $\frac{K}{s(s+1)(s+2)}$

(D) $\frac{K}{s(s+2)}$

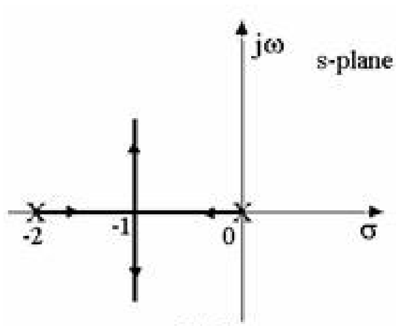

Fig.3

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

Q.2 a. For the mechanical system of Fig.4, draw the free body diagram and write the associated equations of motion. Draw the electrical equivalent circuit using F(t)→voltage and $\frac{dx}{dt} \rightarrow$ current analogy. **(8)**

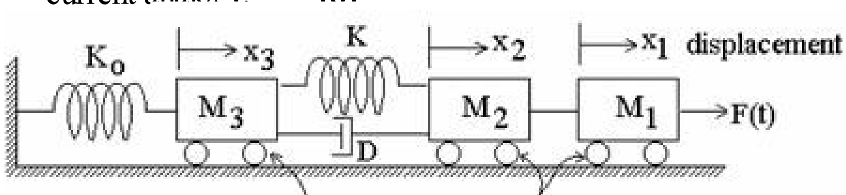

Fig. 4

b. Write the transfer funct network of Fig.5 and deriv network.

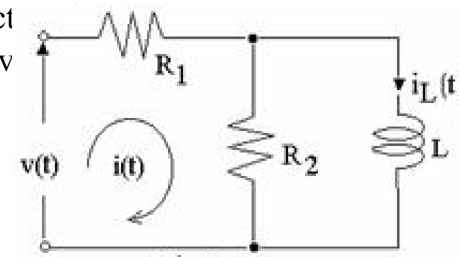

Fig.5

Q.3 a. Reduce the block-diag to find $\frac{C(s)}{R(s)}$. **(8)**

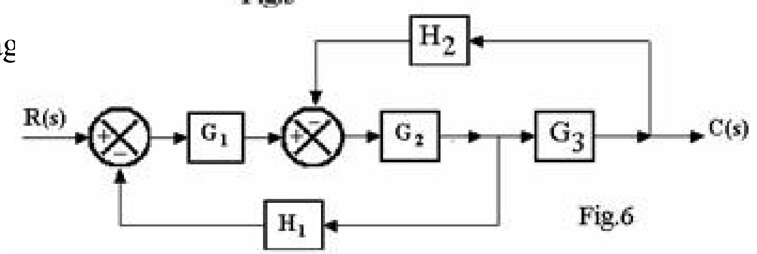

Fig.6

b. Use Mason's gain rule to obtain the overall transfer function of the signal-flow graph of the block-diagram of Fig.7. **(8)**

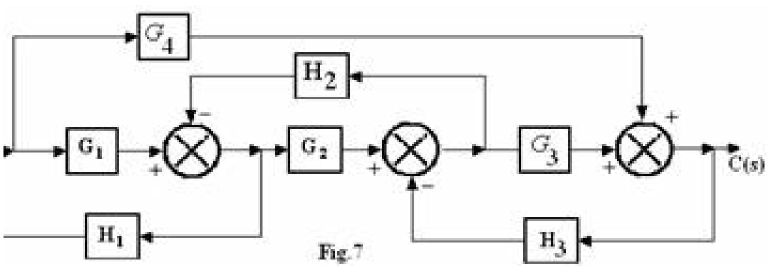

Fig.7

Q.4 a. Apply Routh-Hurwitz criterion to find the greatest value of K that can keep the system of Fig.8 stable. Also state Routh-Hurwitz criterion for stability of a feedback control system. **(10)**

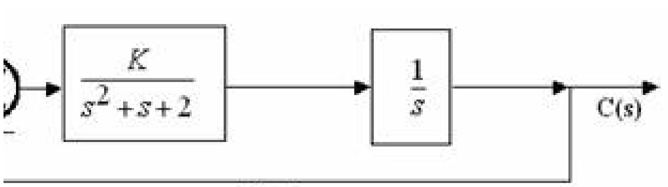

Fig.8

b. Discuss the various time domain performance specification of a typical second-order system with unit input excitation. **(6)**

Q.5 a. Sketch the root-locus on a graph sheet for a control system with $G(s)H(s)=\frac{K(s+4)(s+6)}{s(s+2)}, H(s)=1$. Mark the points of intersection with the real-axis. **(8)**

b. The block diagram of a servo system shown in Fig.9 has K = 10. Determine the values of a and b, if the time-constant is 0.1s and damping ration $\zeta = 0.5$.
(8)

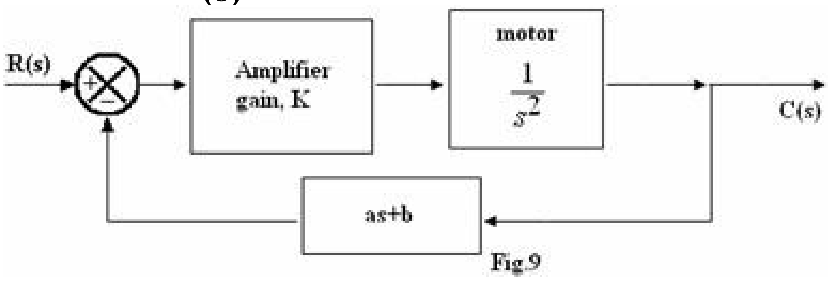

Fig.9

Q.6 a. For the open-loop transfer-function $G(s)H(s) = \frac{5}{s(s-1)}$, draw the Nyquist plot. Verify whether the system is stable. **(10)**

b. For the unity-feedback system $G(s)H(s) = \frac{8(s+1)(s+3)}{s(s+2)(s+4)}$ find the type of the system, the error constants K_p, K_v, K_a and the corresponding steady-state errors. **(6)**

Q.7 a. Draw Bode plots on a semilog graph sheet for $G(s)H(s) = \frac{K}{s(1+0.025s)(1+0.04s)}$, H(s) = 1. Find the value of K if the phase-margin is to be 45°. What is the corresponding gain-margin? **(10)**

b. An electronic pace-maker controlling the rate of heartbeat is shown in Fig.10

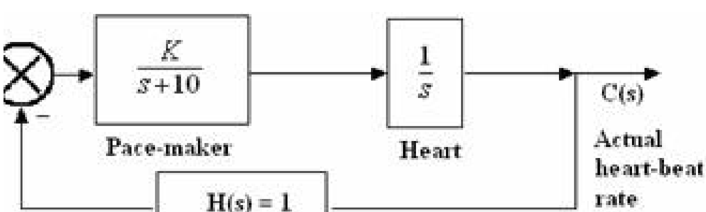

Fig.10

Determine the value of K to limit the steady-state error to 0.02 for a ramp input. **(6)**

Q.8 a. Discuss tunning of PID controller. **(6)**

b. Represent the following data on a graph sheet to show a frequency-response plot in Nichols coordinate system. Determine the phase-margin and the gain-margin. Also define the term phase-margin and gain-margin. **(10)**

Frequency,w, rad/s	0.2	0.5	0.78	1.25	2.2	3.0
Gain, dB	15	5	0	–7	–15	–21

Phase, deg.	–110	–120	–140	–160	–180	–190

Q.9 a. Consider the opamp circuit used as a compensator. (Fig.11) Show that

(i) $R_1C_1 > R_2C_2$ makes it a lead compensator.

(ii) $R_1C_1 < R_2C_2$ makes it a lag compensator. **(10)**

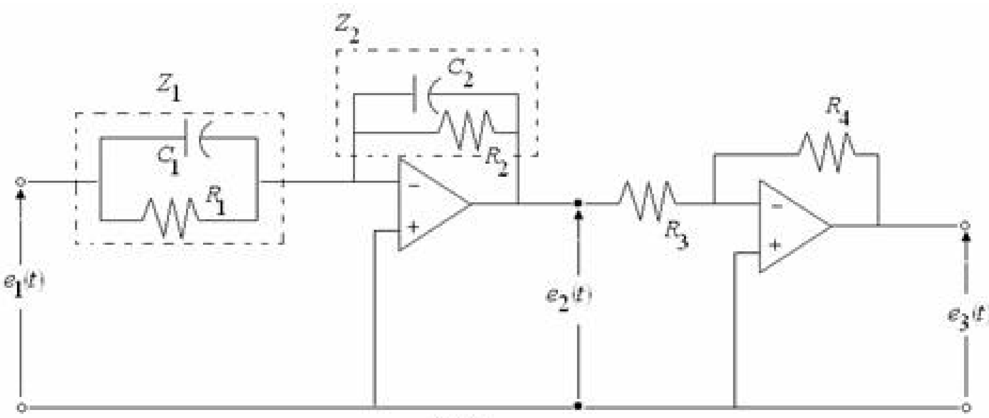

Fig.11

b. Explain phase-lead compensation. **(6)**