Code: AE11 **JUNE 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. A second-order system with damping ratio of 0.4 acting on a unit-step input will produce a maximum overshoot of about

(A) 25% **(B)** 45%
(C) 65% **(D)** 85%

b. The number of counter clockwise encirclements (N) of the critical point(–1+j0) in the signal-flow graph shown in Fig.1b is

(A) 3 **(B)** 2
(C) 0 **(D)** 1

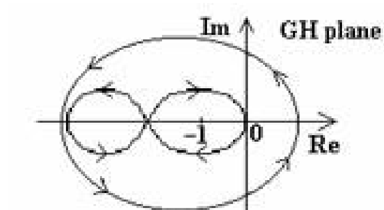

Fig. 1b

c. A mass M initially at rest acted upon by a force F(t) as shown in Fig.1c is described by

(A) $M\frac{d^2v}{dt^2} = F$ **(B)** $M\frac{d^2x}{dt^2} =$

(C) $M\frac{dx}{dt} = F$ **(D)** $Mv = F$

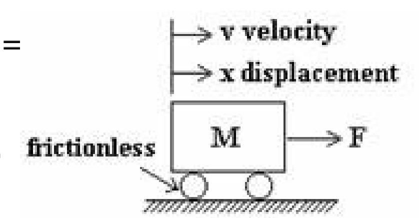

Fig.1c

d. The transfer function of a dead-time element is

(A) $\tau_D s$ **(B)** $\frac{s}{\tau_D}$

(C) $e^{-\frac{\tau_D}{s}}$ **(D)** $e^{-s\tau_D}$

e. A synchro transmitter-receiver pair is most widely used in feedback control systems as

(A) frequency detector **(B)** error detector
(C) modulator **(D)** amplifier

f. The transfer function from $\theta(t)$ to $e(t)$ for a tachogenerator of sensitivity K_t has the form $\frac{E(s)}{\theta(s)} =$

(A) K_t (B) $\frac{s}{K_t}$

(C) $\frac{K_t}{s}$ (D) sK_t

g. The LVDT is primarily used for the measurement of

(A) displacement (B) velocity

(C) acceleration (D) humidity

h. Consider the function $F(s) = \frac{5}{s(s^2+s+2)}$, where $F(s)$ is the Laplace transform of f(t). $\lim_{t\to\infty} f(t)$ is equal to

(A) 5. (B) $\frac{5}{2}$.

(C) zero. (D) infinity.

i. Routh-Hurwitz criterion applied to the characteristic equation $s^3+2s^2+3s+6=0$ shows that the system is

(A) absolutely stable (B) unstable

(C) marginally stable (D) conditionally stable

j. A system for which the steady state error is a finite constant for a unit step input is of type

(A) 1 (B) 2

(C) 0 (D) 1 or 2

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

Q.2 a. Consider the mechanical system of Fig.2a. Obtain the transfer function $G(s) = \frac{X(s)}{F(s)}$, assuming zero initial conditions. Draw the corresponding electric network using the force-voltage analogy. **(8)**

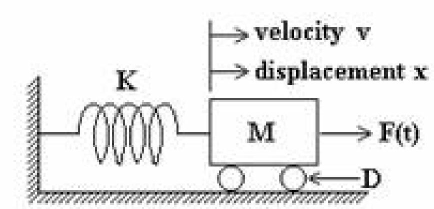

Fig.2a

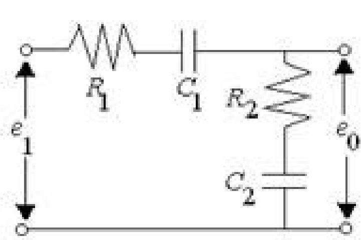

Fig.2b

b. Obtain the transfer-function model as the overall block-diagram for the electric network of Fig.2b and also its mechanical equivalent. **(8)**

Q.3 a. By block-diagram reduction technique, obtain the overall transfer function for Fig.3a. **(8)**

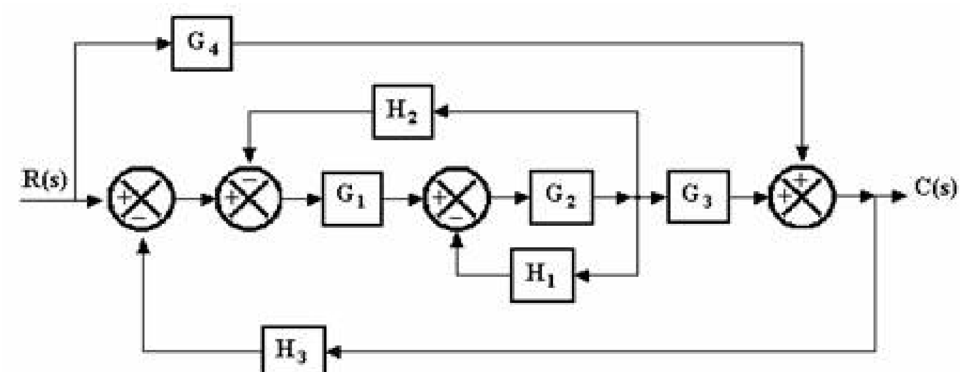

Fig.3a

b. Draw the equivalent signal-flow graph for the block-diagram of Fig.3b, and then apply Mason's general gain rule to get the overall transfer function. **(8)**

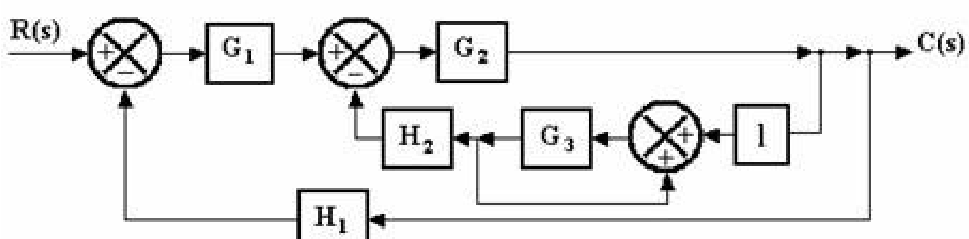

Fig.3b

Q.4 a. The characteristic equation of a control system is given as $s^4 + ks^3 + s^2 + s + 1 = 0$. Determine the range of 'k' for stability using Routh-Hurwitz criterion. **(8)**

b. The closed-loop transfer-function of a second order system is given by $\frac{C(s)}{R(s)} = \frac{\omega_n^2}{s^2 + 2\xi\omega_n s + \omega_n^2}$, where ω_n is the undamped natural frequency and ξ the damping ratio. Show that for a unit step input r(t)=u(t), the output c(t) may be represented as the sum of steady-state and transient response. **(8)**

Q.5 a. The open-loop transfer function of a system is $G(s) = \frac{K}{s(s+2)}$. Sketch the root-locus on a graph-sheet and indicate the points for K=0,1,2. Find the damping ratio ξ for K=2. Is the system stable for K=2? **(8)**

b. For a feedback control system with open-loop transfer function G(s) and feedback H(s), derive the expression for steady-state error e_{ss}. Obtain e_{ss} in terms of position error constant K_p, velocity error constant K_v and acceleration error constant K_a, respectively, for input r(t)=u(t), t u(t) and $t^2/2$. **(8)**

Q.6 a. Using Nyquiest Criterion, determine whether the closed-loop system is stable: $G(s)H(s) = \frac{10}{(s+1)(2s+1)}$. **(10)**

b. The block-diagram of a remote position control of a ship's rudder is given in Fig.6b. Write the overall transfer-function and determine the damping ratio ξ and the natural frequency ω_n of the system. **(6)**

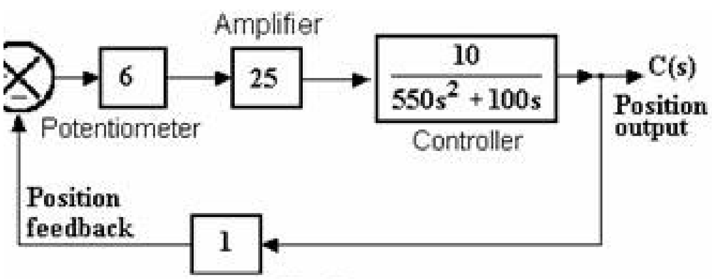

Fig.6b

Q.7 a. A control system $G(s)H(s) = \frac{K(1+0.1s)}{s(1+0.2s)(1+s)}$ has unity feedback. Draw the Bode plots on a semilog graph sheet and determine:
(i) gain crossover frequency and phase-margin
(ii) phase crossover frequency and gain margin **(10)**

b. Fig.7b shows the Bode asymptote plot. Determine the open-loop transfer function G(s) of the system. **(6)**

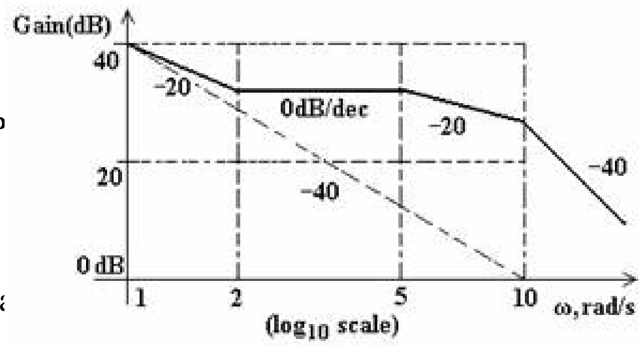

Fig.7b

Q.8 a. Describe the P … neters of the controller affect the performance … **(8)**

b. Obtain the tr … of Fig.8b in terms of the system time constant … Draw the pole-zero plot of the transfer function. **(8)**

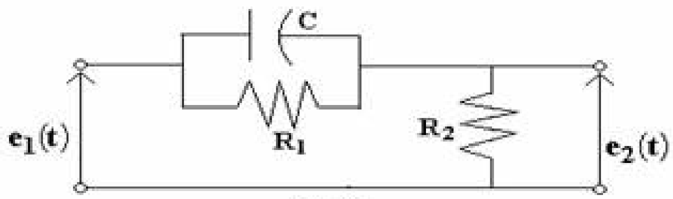

Fig.8b

Q.9 Write short note on any **TWO**:-

(i) Synchronous transmitter
(ii) Controller tuning
(iii) Digital computer as compensation devices. **(8 + 8)**