Code: A-11 **Subject: CONTROL ENGINEERING**

December 2005

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. For type-one system the steady-state error due to step input is equal to

(A) infinite. **(B)** zero.
(C) Finite constant. **(D)** indeterminate.

b. Consider the equation $2s^4 + s^3 + 3s^2 + 5s + 10 = 0$. This equation has___ roots in the right half of s-plane.

(A) one **(B)** two
(C) three **(D)** four

c. The transfer function of a phase-lead compensator is given as $G_c(s) = \frac{1+3Ts}{1+Ts}, T > 0$. The maximum phase-shift provided by this compensator is

(A) $90°$. **(B)** $60°$.
(C) $45°$. **(D)** $30°$.

d. The transfer function of a P-D controller is

(A) $k_p + k_d s$. **(B)** $k_p + \frac{k_d}{s}$.
(C) $\frac{k_p}{s} + k_d s$. **(D)** $k_p + k_d$.

e. The Nyquist plot of $G(j\omega)H(j\omega)$ of a system encloses the $(-1, j0)$ point in the GH-plane, the gain margin of the system in dB is

(A) greater than zero (B) zero
(C) less than zero (D) infinite

f. Consider the function $F(s) = \frac{2.5}{s(s^2 + s + 1)}$ where F (s) is the Laplace transform of f (t). $\lim_{t \to \infty} f(t)$ is equal to

(A) 5 (B) 2.5
(C) zero (D) infinity

g. For a type-2 system, the steady-state error due to ramp input is equal to

(A) zero. (B) finite constant.
(C) infinite. (D) indeterminate.

h. For a tachometer, if $\theta(t)$ is the rotor displacement, e (t) is the output voltage and k_t is the tachometer constant, then the transfer function is defined as

(A) $k_t s^2$. (B) $\frac{k_t}{s}$.
(C) $k_t s$. (D) k_t.

i. The system matrix of a l.t.i (linear time-invariant) continuous time system is given by $A = \begin{bmatrix} 0 & 1 \\ -3 & -5 \end{bmatrix}$, the characteristic equation of the system is given by

(A) $s^2 + 5s + 3 = 0$. (B) $s^2 - 3s - 5 = 0$.
(C) $s^2 + 3s + 5 = 0$. (D) $s^2 + s + 2 = 0$.

j. Given a unity feedback control system with $G(s) = \frac{K}{s(s+4)}$, the value of K for a damping ratio of 0.5 is

(A) 1. (B) 16.
(C) 4. (D) 8.

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

Q.2 a. Explain
(i) The steady-state error.
(ii) The type of a control system. **(4)**

b. Determine the steady-state error for a unit-step, unit ramp and parabolic input $\left[\left(t^2/2\right)U(t)\right]$ for the unity-feedback control system whose open-loop transfer function is given as $G(s) = \frac{10(s+1)}{s^3(s+5)(s+6)}$. **(12)**

Q.3 Obtain the unit-impulse and the unit-step responses of a unity feedback control system whose open-loop transfer function is
$G(s) = \frac{2s+1}{s^2}$. What are the steady-state values of the outputs? **(16)**

Q.4 a. Define the terms
(i) gain margin (ii) phase margin. **(4)**

b. Consider the unity-feedback control system whose open-loop transfer function is $G(s) = \frac{as+1}{s^2}$. Determine the value of 'a' so that the phase margin is $45°$. **(12)**

Q.5 a. Explain in brief the effect of adding a pole or a zero in the left half of s-plane in the open-loop transfer function $G(s)H(s)$ of a control system on the root-locus diagram. **(4)**

b. Determine the range of 'K' for the stability of a unity-feedback control system whose open-loop transfer function is $G(s) = \frac{K}{s(s+1)(s+2)}$. **(12)**

Q.6 a. Discuss the effects of P, I and P+I controllers on a second order system. **(4)**

b. Consider the closed-loop control system whose open-loop transfer function is $G(s)H(s) = \frac{Ke^{-2s}}{s}$. Find the maximum value of 'K' for which the system is stable. **(12)**

Q.7 A unity feedback system has an open-loop transfer function of $G(s) = \frac{10000}{s(s+10)^2}$.
(i) Determine the magnitude of $G(j\omega)$ in dB at an angular frequency of $\omega = 20$ rad/sec.
(ii) Determine the phase-margin in degrees.
(iii) Determine the gain margin in dB. Is the system stable? **(5+5+6)**

Q.8 A unity-feedback system has the plant transfer function $G_p(s) = \frac{1}{(s+1)(2s+1)}$.

(i) Determine the frequency at which the plant has a phase-lag of 90°.

(ii) An integral controller with transfer function $G_c(s) = \frac{K}{s}$ is placed in the feed forward path of this system. Find the value of K such that the compensated system has an open-loop gain margin of 2.5. **(8 + 8)**

Q.9 a. Using block diagram reduction rules, convert the block diagram of Fig.1 to a single loop. **(12)**

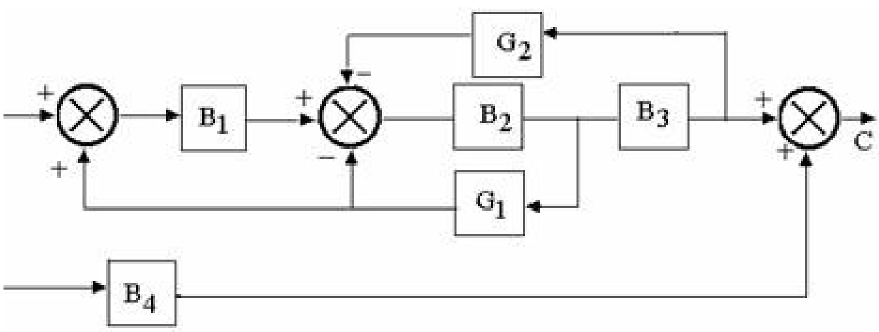

Fig.1

b. Determine $\frac{C}{R}$ for the system in Fig.1. **(4)**