Code: D-15 **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) zero. **(B)** finite constant.
(C) infinite. **(D)** indeterminate.

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

(A) One root **(B)** two roots
(C) three roots **(D)** four roots

c. The transfer function of a phase-lag controller is given by

(A) $\frac{1+aTs}{1+Ts}, a<1$. **(B)** $\frac{1+aTs}{1+Ts}, a>1$.
(C) $\frac{1-aTs}{1+Ts}, a<1$. **(D)** $\frac{1-aTs}{1+Ts}, a>1$.

d. The Nyquist plot of $G(j\omega)H(j\omega)$ of a system passes through the $(-1, j0)$ point in the $G(j\omega)H(j\omega)$ plane, the gain margin of the system is

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

e. 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) zero **(B)** $\frac{5}{2}$
(C) 5 **(D)** infinity

f. 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

g. The system matrix of a continuous time system is given by $A = \begin{bmatrix} 0 & 1 \\ -3 & -5 \end{bmatrix}$, the characteristic equation is given by

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

(C) $s^2 + 3s + 5 = 0.$ **(D)** $s^2 + s + 2 = 0$

h. The root-locus plot is constructed using

(A) the magnitude condition only.
(B) the magnitude and phase angle conditions.
(C) the phase angle condition alone.
(D) The asymptotes.

i. The unit step response of a second order underdamped system exhibits the peak overshoot of 15%. If the magnitude of the input is doubled, the peak overshoot will be

(A) 30% **(B)** 15%

(C) 7.5% **(D)** none of these.

j. In a second order system, the damping ratio of unity corresponds to the following condition:

(A) critically damped **(B)** over damped

(C) under damped **(D)** undamped

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

Q.2 Consider the system shown in Fig.2 below. For $\xi = 0.6$ and $\omega_n = 5\,\text{rad/sec}$. Obtain (i) rise time t_r (ii) peak time t_p (iii) maximum over shoot M_p and settling time ts (for the 2% criterion) when the system is subjected to a unit step input. **(16)**

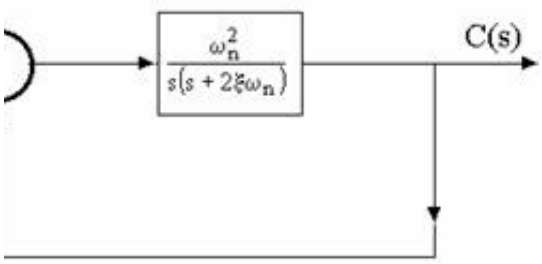

Fig.2

Q.3 Consider that a third-order control system has the characteristic equation $s^3 + 3408.3s^2 + 1204000\,s + 1.5\times10^7\,K = 0$. Find the condition on 'K' for the system to be stable. **(16)**

Q.4 The loop transfer function of a unity feedback control system is given by $G(s)H(s) = \frac{5}{s(s+1)(s+2)}$. Sketch the Nyquist plot and using it find out if the closed-loop system is stable. **(16)**

Q.5 The characteristic equation of a feedback control system is given by $s^3 + 4s^2 + 20s + K = 0$. Where K is a variable parameter. Sketch the root locus diagram of the system when 'K' takes all positive values from zero to infinity. Mark all salient points in the diagram. **(16)**

Q.6 a. Derive the Nyquist criterion of stability of a feedback control system whose open-loop transfer function is stable. **(8)**

b. What is meant by the terms "gain margin" and "phase-margin" of a control system? **(8)**

Q.7 A unity-feedback control system has an open-loop transfer function given by $G(s) = \frac{4}{s(s+2)}$. Determine the unit-step and unit-impulse responses for zero initial conditions. **(16)**

Q.8 Write short notes on any **TWO** of the following:-

(i) Constant M and N circles.
(ii) Phase-lead compensation.
(iii) Insensitivity and Robustness. **(16)**

Q.9 A feedback control system incorporating a dead-time element has the open-loop transfer function given by $G(s)H(s) = \frac{2}{s(s+2)}e^{-0.2\cdot s}$. Determine the gain and phase-margins of the system. **(16)**