Code: A-11 **Subject: CONTROL ENGINEERING**
Time: 3 Hours **June 2006** **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-2 system, the steady-state error due to ramp input is equal to

(A) zero. **(B)** finite constant.
(C) infinite. **(D)** one.

b. The Nyquist plot of a system passes through (-1, jo) point, the phase margin of the system is

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

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

(A) $\tan^{-1}\left(\frac{a-1}{a+1}\right)$. **(B)** $\tan^{-1}\left(\frac{a+1}{a-1}\right)$.
(C) $\cos^{-1}\left(\frac{a-1}{a+1}\right)$. **(D)** $\sin^{-1}\left(\frac{a-1}{a+1}\right)$.

d. Given the matrix $A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix}$, its eigenvalues are:

(A) all negative and different **(B)** two are negative
(C) one is negative **(D)** all are negative with two of them being equal

e. The impulse response of a second-order under-damped system starting from rest is given by $c(t) = 12.5e^{-6t}\sin 8t$. The natural frequency and the damping factor of the system are respectively

(A) 10 and 0.6 **(B)** 10 and 0.8

(C) 8 and 0.6 **(D)** 8 and 0.8

f. In the system in Fig.1, $x(t) = \sin t$. In the steady-state, the response y (t) will be

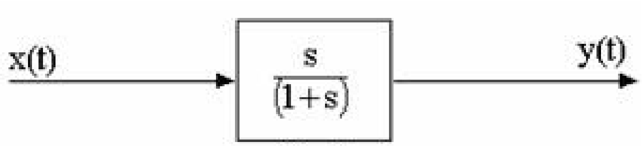

Fig.1

(A) $\frac{1}{\sqrt{2}} \sin(t - 45^\circ)$ **(B)** $\frac{1}{\sqrt{2}} \sin(t + 45^\circ)$

(C) $\frac{1}{\sqrt{2}} e^{-t} \sin t$ **(D)** $\sin t - \cos t$

g. The steady-state error co-efficient for a system are given by $k_p = \infty, k_v = \infty$ and $k_a =$ finite constant. The system is a

(A) type 0 system. **(B)** type 1 system.
(C) type 2 system. **(D)** type 3 system.

h. The input to a controller in a control system is

(A) sensed signal. **(B)** error signal.
(C) desired variable value. **(D)** servo signal.

i. The rotor terminals of a synchro-transmitter is energised with

(A) $1 - \phi$ a.c. voltage. **(B)** $2 - \phi$ a.c. voltage.
(C) $3 - \phi$ a.c. voltage. **(D)** D.C. voltage.

j. The transfer function of a first-order electrical system is $G(s) = \frac{10}{1 + 2s}$. The time-constant of the system is

(A) 10 seconds. **(B)** $\frac{1}{10}$ second.

(C) 2 seconds. **(D)** $\frac{1}{2}$ second.

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

Q.2 Find the gains $\frac{Y_5}{Y_1}$ and $\frac{Y_2}{Y_1}$ for the signal-flow graph shown in Fig.2. **(16)**

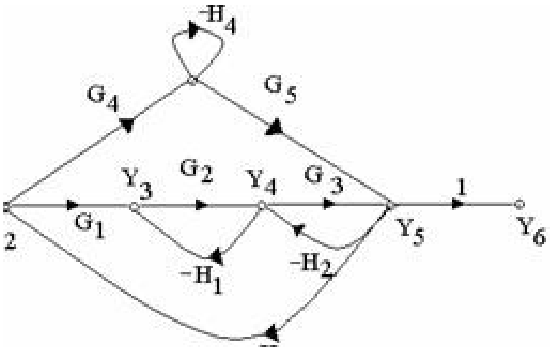

Fig.2

Q.3 a. Show that the root loci for a control system with $G(s) = \frac{K(s^2 + 6s + 10)}{(s^2 + 2s + 10)}, H(s) = 1$ are arcs of the circle centered at the origin with radius equal to $\sqrt{10}$. **(14)**

b. Examine the stability of the system with K = 1. **(2)**

Q.4 a. The loop transfer function for a control system is given as $G(s)H(s) = \frac{K}{(1+s)(1+10s)(1+20s)}$. Determine the steady-state error for a unit-step input, a unit-ramp input and a parabolic input. **(9)**

b. Examine the stability of the system with K = 1? **(7)**

Q.5 The specifications of a second-order control system with the closed-loop transfer function $\frac{C(s)}{R(s)} = \frac{\omega_n^2}{s^2 + 2\xi\omega_n s + \omega_n^2}$ are that the maximum overshoot must not exceed 10 percent and the rise time must be less than 0.1 second. Find the corresponding limiting values of M_p and bandwidth analytically. **(16)**

Q.6 The loop transfer function G(s) H(s) of a single-loop feedback control system is given as $G(s)H(s) = \frac{20}{s(1+0.1s)(1+0.5s)}$. Sketch the Nyquist plot of $G(j\omega)H(j\omega)$ for $\omega = 0$ to $\omega = \infty$. Determine the stability of the closed-loop system. **(16)**

Q.7 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. **(8)**

b. Prove that for BIBO stability, the roots of the characteristic equation must lie in the left-half of s-plane. **(8)**

Q.8 Find the unit-step response for the control system shown in Fig.3. **(16)**

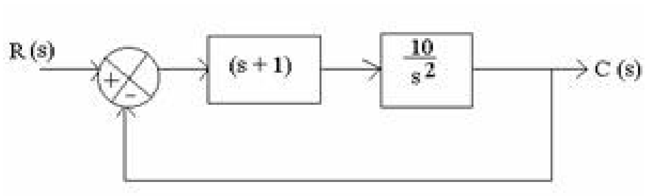

Fig. 3

Q.9 Write short notes on any **TWO** of the following:

(i) P-I-D Controller.
(ii) D.C. servo-motor.
(iii) Phase-lead compensation. **(16)**