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

JUNE 2007

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 the first order system described by the transfer function

$$\frac{Y(s)}{R(s)} = \frac{4}{2s+1}$$, the unit ramp response for r(t)=t is

(A) $4(t - 4 + 2e^{-t/2})$ **(B)** $2(t - 2 + 4e^{-t/4})$
(C) $3(2 - t + 4e^{-t/4})$ **(D)** $4(t - 2 + 2e^{-t/2})$

b. The feedback control system shown in Fig.1 is stable if the scalar gain factor K satisfies the condition:

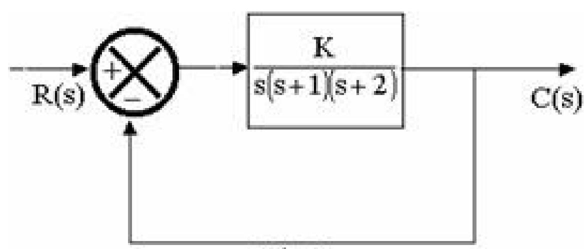

Fig.1

(A) $K > 0$.
(B) $K < 6$.
(C) $-\infty < K < \infty$.
(D) $0 < K < 6$

c. The open-loop transfer function of a feedback control system is given by $G(s)H(s) = \frac{10}{s(s+20)}$. The gain margin of the system is

(A) Infinity **(B)** 20 dB.
(C) 10 dB. **(D)** 2 dB.

c. In the system shown in Fig.2, $r(t) = \sin t, t \geq 0$. In steady-state C(t) is given by

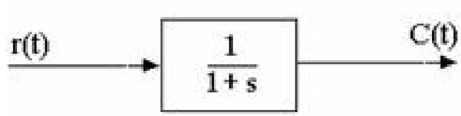

Fig.2

(A) $\sin(t - 45^\circ)$

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

(C) $\frac{1}{\sqrt{2}}\sin(t + 45^\circ)$

(D) $\sqrt{2}\,\text{Sin}\left(t-45^\circ\right)$

e. In feedback control system, the purpose of providing integral feedback is to

(A) improve the stability margin. **(B)** improve the transient response.
(C) reduce the steady-state error. **(D)** stabilize the unstable system.

f. A stable, type-0 unity-feedback control system has a position error constant equal to 1. The steady-state error for a unit step input will be

(A) 0 **(B)** 1
(C) 0.5 **(D)** 2

g. The characteristic equation of a linear unity feedback control system is given by $s^3+5s^2+4s+30=0$. The system is

(A) unstable. **(B)** stable.
(C) marginally stable. **(D)** conditionally stable.

h. In the signal flow graph shown in Fig.3, the number of pairs of non-touching loops is

(A) 1.
(B) 2.
(C) 3.
(D) 4.

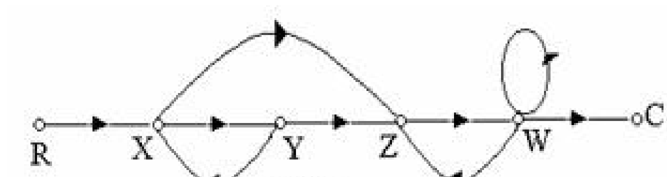

Fig.3

i. A system transfer function of the form $\frac{K}{(1+sT_1)}$ can be represented in the Bode plot at frequencies $\omega >> T_1$ by a slope of

(A) $8\ \text{dB}/\text{octave}$. **(B)** $-12\ \text{dB}/\text{decade}$.
(C) $-24\ \text{dB}/\text{decade}$. **(D)** $-20\ \text{dB}/\text{decade}$.

j. The impulse response of a linear time invariant system is given by $h(t)=Ke^{-\alpha t}$. The system can be characterized by

(A) first-order system. **(B)** second-order system.
(C) third-order system. **(D)** fourth-order system.

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

Q.2 a. Determine the values of K and p of the closed-overshoot in unit-step response is 25% and the peak time is 2 seconds.
(12)

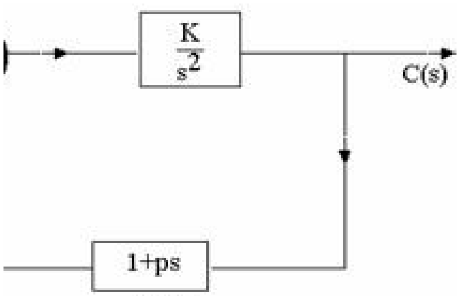

Fig.4

b. Find out the stability of the system when K=1 and p=1. **(4)**

Q.3 a. Find out the transfer function of an armature controlled D.C. servo-motor. **(12)**

b. What do you mean by the terms
   (i) type of control systems and
   (ii) steady-state error. **(4)**

Q.4 Consider a unity-feedback control system whose open-loop transfer function is $G(s)=\frac{0.4s+1}{s(s+0.6)}$.
   (i) Obtain the response to a unit-step input. **(8)**
   (ii) What is the rise time for this system? **(4)**
   (iii) What is the maximum overshoot? **(4)**

Q.5 Consider the system shown in Fig.5. Sketch the root loci as α varies from 0 to ∞. Determine the value of α such that the damping ratio of the dominant closed-loop poles is 0.5. **(16)**

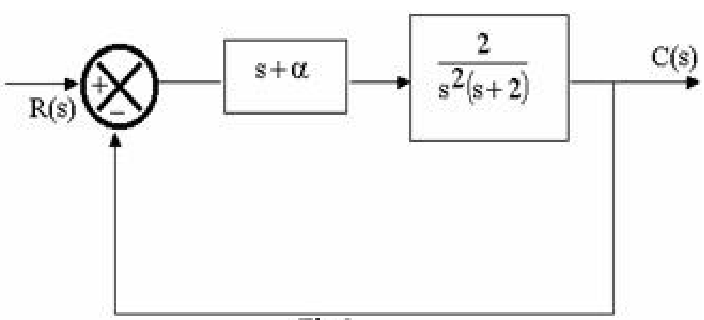

Fig.5

Q.6 a. Explain Nyquist stability criterion. **(4)**

b. Using Nyquist stability criterion find the critical value of K for the stability of closed-loop system having the following open-loop transfer function:

$$G(s)H(s) = \frac{K}{s(s+1)(2s+1)}.$$ **(12)**

Q.7 a. The open-loop transfer function of a feedback control system is given by $G(s)H(s) = \frac{K(1-s)}{(s+1)}$. Sketch a Nyquist locus for this system. Using the Nyquist stability criterion, determine the range of K for stability. **(12)**

b. What is the effect of feedback on stability of control system? **(4)**

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

(i) Synchros.

(ii) P-I-D controller.

(iii) Two-phase servo-motor. **(8+8)**

Q.9 a. The characteristic equation of a feedback control system is given as

$$s^4 + 20s^3 + 15s^2 + 2s + K = 0.$$

Determine the value of K so that the system is marginally stable and the frequency of sustained oscillation, if applicable. **(12)**

b. Discuss the effects and limitations of phase-lag compensation. **(4)**