DECEMBER 2006

Code: D-15 **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. The output of a linear time-invariant system for a unit-step input is given by t^2e^{-t}. The transfer function is given by

(A) $\frac{s}{(s+1)^3}$ **(B)** $\frac{2s}{(s+1)^3}$

(C) $\frac{1}{s^2(s+1)}$ **(D)** $\frac{2}{(s+1)^2}$

b. The Laplace transform of a unit-ramp function is

(A) s **(B)** s^2

(C) $\frac{1}{s}$ **(D)** $\frac{1}{s^2}$

c. A plant with transfer function T(s) has output feedback with constant gain K applied to it.

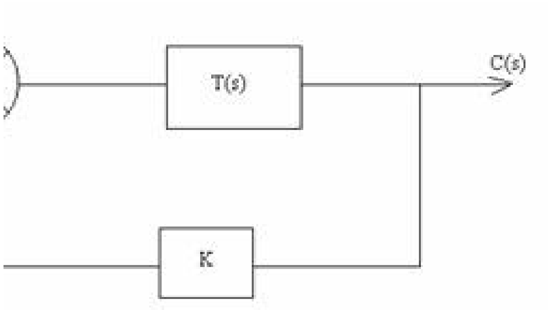

Fig.1

The effect of the feedback is to

(A) shift some zeros of T(s). **(B)** shift all zeros of T(s).
(C) shift all poles and zeros of T(s) **(D)** shift only the poles of T(s)

d. The characteristic equation of a closed-loop system is given by

$F(s) = s^4 + 4s^3 + 6s^2 + 8s + K = 0$. If the system is to be stable, K must lie in the range

(A) $-\infty < K \le 8$ **(B)** $8 \le K < \infty$
(C) $0 \le K < 8$ **(D)** $-8 \le K \le 8$

e. For a critically damped system, the following statement is not true:

(A) A decrease in the damping will cause oscillatory behaviour.
(B) The response to a unit step input converges asymptotically.
(C) The system is marginally stable.
(D) The step response never overshoots the final value.

f. A second-order system has the transfer function: $H(s) = \frac{25}{\left(s^2 + 6s + 25\right)}$. The damped natural frequency of oscillation is

(A) 5 **(B)** 4
(C) 3 **(D)** $\frac{5}{2\pi}$

g. If a unit step input is applied to a system with transfer function $H(s) = \frac{(s+3)}{\left(s^2 + 4s + 2\right)}$, the steady-state output converges to

(A) $\frac{3}{2}$ **(B)** 0
(C) 1 **(D)** ∞

h. If the poles of the transfer function of a system are lying on the imaginary axis in s-plane, the system is

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

i. The characteristic equation of a feedback-control system is $2s^4 + s^3 + 3s^2 + 5s + 10 = 0$. The number of roots in the right half of s-plane are

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

j. A unity feedback system has open-loop transfer function given by $G(s) = \frac{25}{s(s+6)}$. The peak overshoot in the unit-step response of the system is approximately equal to

(A) 5% **(B)** 20%
(C) 15% **(D)** 10%

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

Q.2 Consider the signal flow graph shown in Fig.2

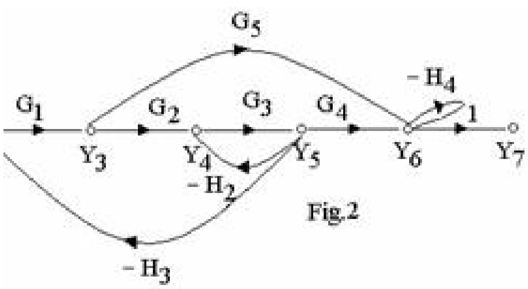

Fig.2

Find

(i) $\frac{Y_2}{Y_1}$ (ii) $\frac{Y_6}{Y_1}$ **(8+8)**

Q.3 a. Define the terms (i)gain margin and phase margin. How will you find them from Nyquist plot? **(10)**

b. Explain in brief:

(i) Constant M-Circles

(ii) Evaluation of closed-loop frequency response. **(6)**

Q.4 a. Discuss the effects of P, P-I, P-D and P-I-D controllers on a second-order system. **(8)**

b. 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. **(8)**

Q.5 Consider the closed-loop 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. **(16)**

Q.6 Write notes on any **<u>TWO</u>** of the following:-

(i) Uses of opamps for compensation.

(ii) Tuning of PID controllers.

(iii) Standard test signals. **(8+8)**

Q.7 a. Give a network that provides lead compensation for a typical control system and explain its features. **(8)**

b. Distinguish between derivative error and derivative output compensations. **(8)**

Q.8 A position control system with velocity feedback is shown in Fig.3. What is the response C(t) to unit-step input? **(16)**

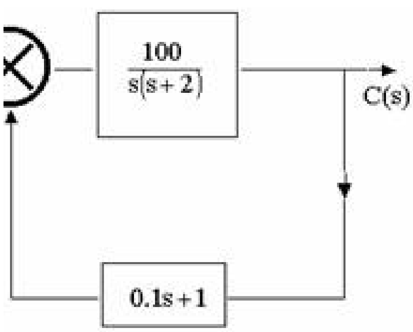

Fig. 3

Q.9 a. Sketch the root-loci for the system with $G(s) = \frac{K}{(s^2 + 2s + 2)(s^2 + 2s + 5)}, H(s) = 1$. Determine the exact points where the root-loci cross the $j\omega$-axis. **(12)**

b. Explain the terms: Rise time, Peak time and Steady state error as defined for a second-order system. **(4)**