Code: AE11 **Subject: CONTROL ENGINEERING**
Time: 3 Hours **Max. Marks: 100**

DECEMBER 2007

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. Consider the function $F(s) = \frac{\omega}{(s^2 + \omega^2)}$
where F(s) = Laplace transform of f(t). The final value of f(t) is equal to

(A) zero **(B)** infinite
(C) one **(D)** none of the above

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

(A) infinite **(B)** zero
(C) finite constant **(D)** none of the above

c. Consider the equation $2s^4 + s^3 + 3s^2 + 5s + 10 = 0$. The equation has _____ roots in the right half of s-plane.

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

d. 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)** $\frac{1-aTs}{1+Ts}, a > 1$

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

(A) $K_p + K_d \cdot s$ **(B)** $K_p + \frac{K_d}{s}$
(C) $\frac{K_p}{s} + K_d \cdot s$ **(D)** None of the above

f. The Nyquist plot of a system passes through the (–1, j0) point, the gain margin of the system is

(A) greater than 1 **(B)** less than 1
(C) zero **(D)** Equal to 1

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

(A) zero **(B)** finite constant
(C) infinite **(D)** None of the above

h. Given the matrix $A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix}$, the eigen values of A are

(A) –1, –2, –3 **(B)** –1, 2, –3

(C) 0, 0, –6 **(D)** –6, –11, –6.

i. 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) $K_t \cdot s^2$ **(B)** $\frac{K_t}{s}$.
(C) $K_t \cdot s$ **(D)** K_t.

j. 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)** $s^2 + s + 2 = 0$

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

Q.2 a. Define the transfer function of a linear-time invariant system in terms of its differential equation model. What is the characteristic equation of the system. **(8)**

b. (i) Explain Mason's gain formula for signal flow graph.

(ii) For the electrical circuit shown in Fig.1 find the transfer function $\frac{E_o(s)}{E_i(s)}$ **(8)**

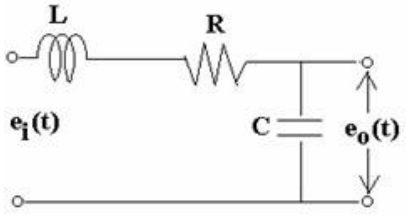

Fig. 1

Q.3 a. State and explain the Nyquist stability criterion. **(6)**

b. Consider the unity feedback system whose open-loop transfer function is $G(s) = \frac{Ke^{-0.8s}}{(s+1)}$. Using the Nyquist stability criterion, determine the critical value of 'K' for stability. **(10)**

Q.4 a. Define the terms
(i) bounded-input, bounded-output (BIBO) stability.
(ii) asymptotic stability **(8)**

b. (i) Discuss Routh's stability criterion.
(ii) The characteristic equation of a control system is given by

$$s^3 + 2s^2 + s + 2 = 0$$

Determine the stability of the system. **(8)**

Q.5 a. Reduce the feedback system given in Fig.2 to an equivalent unity feedback system **(8)**

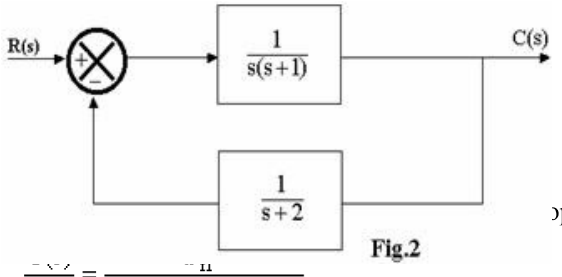

Fig.2

b. ...op transfer function as $\frac{C(s)}{R(s)} = \frac{\omega_n^2}{s^2 + 2\xi\omega_n s + \omega_n^2}$, derive the expression for unit step response, assuming it to be an underdamped system. **(8)**

Q.6 a. Consider the system shown in Fig.3. Sketch the root loci and show that a part of the root locus is circular for $K \geq 0$. **(12)**

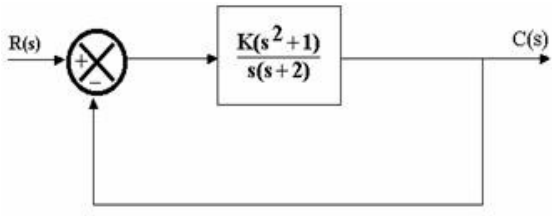

Fig.3

b. Explain why root locus always orignates from an open loop pole ad terminates at open loop zero or infinity. **(4)**

Q.7 Determine the values of K and k of the closed-loop system shown in Fig.4 so that the maximum overshoot in unit-step response in 25% and the peak time is 2 seconds. Assume that $J = 1\ Kg-m^2$. **(16)**

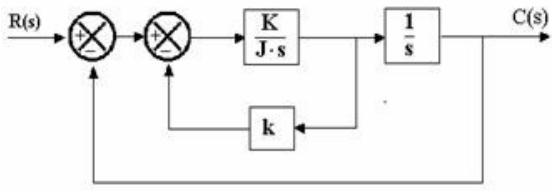

Fig. 4

Q.8 a. Sketch the polar plot of the transfer function given as $G(s)H(s) = \frac{K}{s(s+1)(s+3)}$ with K=5. Determine the gain margin and phase margin. **(12)**

b. Discuss the effect of increasing the value of K to 10. **(4)**

Q.9 Write short notes on any **TWO** of the following:
(i) Cascade Lag-lead compensation
(ii) Hydraulic actuators
(iii) Synchros **(16)**