DipIETE – ET (OLD SCHEME)

Code: DE15 **Subject: CONTROL ENGINEERING**
Time: 3 Hours **DECEMBER 2009** **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 the best alternative in the following: (2 × 10)

a. Marginally stable systems

(A) Are also classed as unstable system
(B) Have one of the pole lying in R.H.S. of s-plane
(C) Equal numbers of zeros and poles
(D) none of the above

b. The transfer function of a system is $\frac{1000}{(1+0.1s)(1+0.01s)}$, the corner frequencies are

(A) 0.1 and 0.01 **(B)** 10 and 100
(C) 0.1 and 0.01 and 1000 **(D)** none of these

c. The maximum phase shift that can be provided by a lead compensator with the transfer function $G(s)=\frac{1+6s}{1+2s}$ is:

(A) 15^{o} **(B)** 30^{o}
(C) 45^{o} **(D)** 60^{o}

d. The mechanical system is given in Fig.1 below:

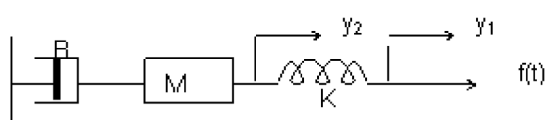


Fig.1

The equation for mass *M* is:

(A) $M\frac{d^2y_1(t)}{dt^2}+B\frac{dy_1(t)}{dt}=K[y_2(t)-y_1(t)]$

(B) $M\frac{d^2y_2(t)}{dt^2}+B\frac{dy_2(t)}{dt}=K[y_2(t)-y_1(t)]$

(C) $M\frac{d^2y_1(t)}{dt^2}+B\frac{dy_1(t)}{dt}=K[y_1(t)-y_2(t)]$

(D) $M\frac{d^2y_2(t)}{dt^2}+B\frac{dy_2(t)}{dt}=K[y_1(t)-y_2(t)]$

e. The first two rows of Routh's tabulation of a fourth-order system are

s^4	1	10	5
s^3	2	20	

The number of roots of the system lying on the right half of the s-plane is

(A) 0 **(B)** 2
(C) 3 **(D)** 4

f. For a second-order system with the closed-loop transfer $T(s) = \frac{9}{s^2 + 4s + 9}$, the settling time for 2% band in seconds, is

(A) 1.5 **(B)** 2.0
(C) 3.0 **(D)** 4.0

g. Which of the following will not decrease as a result of negative feedback?

(A) Instability **(B)** Bandwidth
(C) Overall gain **(D)** Distortion

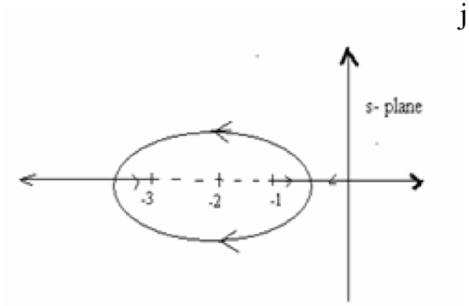
h. The Bode plot of the transfer function G(s) = s, is

(A) Zero magnitude and zero phase shift
(B) Constant magnitude and constant phase shift
(C) 6dB/octave and phase shift $\pi/2$
(D) -6dB/octave and phase shift $\pi/2$

i. The open loop transfer function of unity feedback control system is given by $G(s) = \frac{K}{s(s+1)}$, if the gain K is increased to infinity, then the damping ratio will tend to become

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

j. A root locus of a unity feedback system is shown in the given Fig. 2. The open loop transfer function of the system is



(A) $\frac{K}{s(s+1)(s+3)}$ **(B)** $\frac{K(s+1)}{s(s+3)}$
(C) $\frac{K(s+3)}{s(s+1)}$ **(D)** $\frac{Ks}{(s+1)(s+3)}$

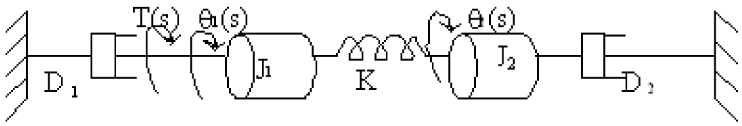
Fig.2

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

Q.2 a. Distinguish between

(i) Open loop control system and closed loop control system
(ii) Transfer function model and state space model **(6)**

b. Obtain the transfer function $\frac{\theta_2(s)}{T(s)}$ for the given mechanical system in Fig. 3:



(10)

Q.3 a. Obtain the transfer function $\frac{C(s)}{R(s)}$ for the multi loop control system shown in Fig. 4 below. **(8)**

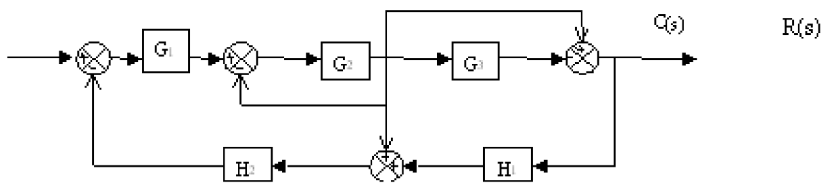


Fig.4

b. Draw a signal flow graph for the following set of equations: **(8)**

$$y_2 = a\,y_1 - g\,y_3$$
$$y_3 = e\,y_2 + c\,y_4$$
$$y_4 = b\,y_2 - d\,y_4$$

Hence find the gains $\frac{y_2}{y_1}$ and $\frac{y_3}{y_1}$

Q.4 a. A second order control system with proportional derivative controller is shown in the Fig. 5. Derive the expressions for it's: **(8)**

(i) Steady state error to step input
(ii) Natural frequency of oscillation
(iii) Damping frequency of oscillation

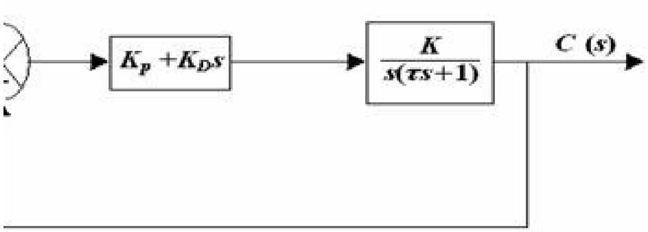


Fig. 5

b. Explain the following properties of the feedback control system: **(8)**

(i) Disturbance rejection
(ii) Insensitivity and robustness

Q.5 a. Sketch the root locus of the system having $G(s)H(s) = \dfrac{K(s+3)(s+4)}{s(s+2)}$ for $0 \le K \le \infty$ **(12)**

b. Define stability. Differentiate between absolute and relative stability. **(4)**

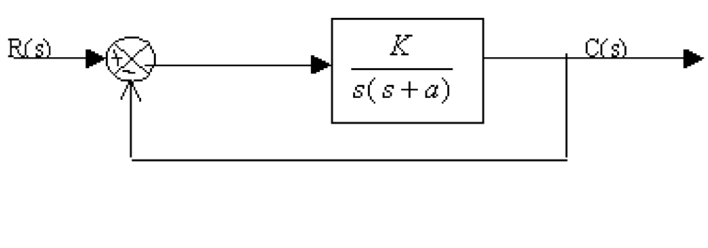
Q.6 a. The characteristic equation for a certain feedback control system is given by $s^4 + 20s^3 + 15s^2 + 2s + K = 0$ **(10)**

(i) Find the range of K for stability
(ii) What is the frequency in rad/sec at which the system will oscillate?
(iii) How many roots of the characteristic equation lie in the right half of the s-plane for $K = 5$?

b. List the performance specifications used in time domain. **(6)**

Q.7 a. Sketch the Nyquist plot for a system with $G(s)H(s) = \dfrac{10(s+3)}{s(s-1)}$. Comment on close loop stability by using Nyquist stability criterion. **(10)**

b. Consider the feedback control system shown in Fig. 6 below. Find the value of 'K' and 'a' to satisfy the Following specifications M_r=1.25 and ω_r =12.65 rad / sec. . **(6)**



Q.8 a. Write short notes on different type of compensation techniques. **(10)**

b. Explain Phase margin and gain margin. How these can be obtained from Bode plots? **(6)**

Q.9 a. Explain use of passive electric network for implementation of lag, lead and lag-lead compensators.

(8)

b. Obtain the transfer function model for armature controlled DC motor. **(8)**