Bihar Engineering University, Patna
End Semester Examination - 2022

Course: B.Tech. | *Semester: V* | *Time: 03 Hours*
Code: 100502 | *Subject: Control systems* | *Full Marks: 70*

Instructions:-
(i) The marks are indicated in the right-hand margin.
*(ii) There are **NINE** questions in this paper.*
*(iii) Attempt **FIVE** questions in all.*
*(iv) Question No. **1** is compulsory.*

Q.1 ***Choose the correct option/answer of the following (Any seven question only):*** **[2 x 7 = 14]**

(a) The Laplace transform of $e^{-2t}\sin 2t$ is.
(i) $4/(s+2)^2+4$ (ii) $4/s^2+4$ (iii) $2/s^2+4s+8$ (iv) $2/s^2+4$

(b) The error detector element in a control system gives.
(i) The sum of the reference signal and feedback signal
(ii) The sum of the reference signal and output signal
(iii) The difference of the reference signal and output signal
(iv) The difference of the reference signal and the feedback signal

(c) The frequency at which the phase curve of a bode plot crosses -180° line is called
(i) Natural frequency (ii) Phase crossover frequency
(iii) Gain crossover frequency (iv) Corner frequency

(d) A system is said to be marginally stable if
(i) repeated poles lie on the imaginary axis
(ii) non-repeated poles lie on the imaginary axis
(iii) poles lie on the right hand side of s-plane
(iv) None of these

(e) If the characteristic equation of a system is given as, $s^4 + 5s^3+2s^2+5s+k=0$, then the range of 'k' for the system to be stable is
(i) $k > 1$ (ii) $k < 0$ (iii) $0 < k < 1$ (iv) $-1< k < 0$

(f) If an amplifier with resistive negative feedback has two left half planes poles in its open-loop transfer function then amplifier
(i) will always be unstable at high frequencies.
(ii) will be stable for all frequencies.
(iii) may be unstable, depending upon the feedback factor.
(iv) will oscillate at low frequencies.

(g) The type 0 system has ____ at the origin.
(i) no pole (ii) net pole (iii) simple pole (iv) two poles

(h) Position error constant of a system is measured when the input to the system is unit
(i) Parabolic (ii) Ramp (iii) Impulse (iv) Step

(i) The open loop transfer function of a unity feedback control system is given by $G(s) = 5 (S+1)/S^2 (S+2)$. The stability characteristics of the open loop configuration.
(i) Stable (ii) Unstable (iii) Conditionally stable (iv) Marginally stable

(j) The slope of $(1+j\omega)$ is
(i) +20db (ii) +40db (iii) -40db (iv) -20db

Q.2 (a) Sketch the Nyquist plot for a system having **[7]**

$$G(s)H(s) = \frac{10(1+0.9s)}{s^2(0.1s+1)(0.05s+1)}$$

In addition, comment on the closed-loop stability.

(b) Sketch the Bode plot for the system **[7]**

$$G(s)H(s) = \frac{Ke0.2s}{s(s+10)(1+0.5s)}$$

Determine the system gain K for the gain cross-over frequency to be 4 rad/s. What is the phase margin for this value of K?

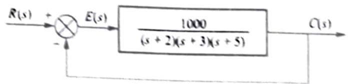
Q.3 (a) Find the transfer function of the given state-space model **[7]**

$$\dot{\mathbf{x}} = \begin{bmatrix} -2 & 0 & 1 \\ 1 & -2 & 0 \\ 1 & 1 & -1 \end{bmatrix} x + \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ 1 & 0 \end{bmatrix} u, \quad y = \begin{bmatrix} 2 & 1 & -1 \\ 0 & 1 & 0 \end{bmatrix} x$$

(b) Consider the state-space model of an LTI system with matrices **[7]**

$A = \begin{bmatrix} 0 & 1 \\ -6 & -5 \end{bmatrix}, B = \begin{bmatrix} 0 \\ 8 \end{bmatrix}$ Find the state transition matrix.

Q.4 (a) Find the numbers of poles in LHP, RHP and jω axis for the system below by R-H criterion and comment on stability: **[7]**



(b) For the unity feedback system the open loop transfer function is given by **[7]**

$$G(s) = \frac{K}{s(s+2)(s^2+6s+25)}$$

(i) Sketch the root locus for $0 \le k \le \infty$

(ii) At what value of 'K' the system becomes unstable

(iii) At this point of instability determine the frequency of oscillations of the system.

Q.5 (a) Explain P, PI and PID controllers. **[7]**

(b) A second order control system is represented by a transfer function given below: **[7]**

$$\frac{\theta(s)}{T(s)} = \frac{1}{Js^2+fs+K}$$

Where θ_0 is the proportional output and T is the input torque. A step input of 10 Nm is applied to the system and test results are given below: (a) $M_p = 6\%$, (b) $t_p =$ 1 sec and (c) The steady state value of the output is 0.5 radian. Determine the values of J,f and K

Q.6 (a) Consider a unity feedback system with forward path transfer function **[7]**

$$G(s) = \frac{K(s+2)}{s^3+ps^2+3s+2}$$

Having the oscillation of 2.5 rad/sec. Determine the values of $K_{marginal}$ and p. There are no poles in RHP.

(b) Draw root locus for the system having **[7]**

$G(s) = \frac{K}{s(s+2)(s+3)}$ and find the gain K for damping ratio $\xi = 0.341$.

Q.7 (a) Consider the transfer function **[7]**

$$G(s)H(s) = \frac{60}{(s+1)(s+2)(s+5)}$$

Using Nyquist stability criterion determine whether the close loop system is stable or not.

(b) Design a suitable phase lag compensating network for **[7]**

$$G(s) = \frac{K}{s(1+0.1S)(1+0.2S)}$$

To meet the following specifications $K_v = 30\ sec^{-1}$, P.M.$\ge 40°$

Q.8 (a) Apply Routh-Hurwitz criterion to determine the stability of the system whose characteristic equation is: **[7]**

$S^6 + 2s^5 + 8s^4 + 12s^3 + 20s^2 + 16s + 16 = 0$

(b) Find the steady-state error for the unity feedback system whose open loop transfer function is **[7]**

$G(s) = \frac{10}{s(s+10)}$, when the input is $r(t) = 10u(t) + 9tu(t)$.

Q.9 Write short notes on the following **[3.5x4=14]**

(i) Observability & controllability (ii) Gain margin & phase margin

(iii) PID Controller (iv) Effect of addition of zeros & poles on root locus