

JK LAKSHMIPAT UNIVERSITY, JAIPUR

INSTITUTE OF ENGINEERING AND TECHNOLOGY

End Term Examination (Regular/ Backlog), November-December 2017

B. Tech in ECE Engineering, Semester III

Roll No.....

COURSE CODE: ECE 304

Time: 3 hours

Max. Marks: 100

COURSE TITLE: Control Systems

Instructions to students:

1. Do not write anything other than your roll number on question paper.
2. Assume suitable data wherever required and mention it clearly.
3. Writing appropriate units, nomenclature, and drawing neat sketches/schematics/ flow chart wherever, required are an integral part of the answer.

Q.1A Objective type multiple choice questions (10 questions @ 1 mark)

10

- i. The phase margin of a system with the open loop transfer function,

$$G(s) = \frac{(1-s)}{(1+s)(3+s)}$$

- (a) 68.3° (b) 90° (c) 0° (d) ∞

- ii. A unity feedback system has an open loop transfer function of $G(s) = \frac{10000}{s(s+10)^2}$.

The system is

- (a) stable (b) unstable (c) marginally stable (d) cannot determined

- iii. A second order system has maximum overshoot of 40% and period of oscillation 0.25 sec when subjected to unit step input. The resonant peak and resonant frequency are respectively

- (a) 1.86, 24.11 rad/sec
(b) 1.86, 25.11 rad/sec
(c) 1.94, 24.11 rad/sec
(d) 1.94, 25.11 rad/sec

- iv. The bandwidth of the system given in question (iii) is

- (a) 12.36 rad/sec
(b) 38.36 rad/sec
(c) 26.67 rad/sec
(d) None of the above

- v. An octave frequency range is specified by

(a) $\frac{\omega_2}{\omega_1} = 8$

(b) $\frac{\omega_2}{\omega_1} = 6$

(c) $\frac{\omega_2}{\omega_1} = 7$

(d) $\frac{\omega_2}{\omega_1} = 2$

- vi. The points in the s-plane where the function doesn't exist is called
 (a) Analytic point (b) singular point
 (c) nonexistence point (d) none of these
- vii. The polar plot touches the negative real axis only at the origin the gain margin is
 (a) 0 (b) ∞ (c) negative (d) positive
- viii. The forward path transfer function of unity feedback transfer function is

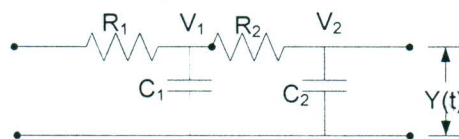
$$G(s) = \frac{k(s+2)}{(s^2+1)(s+4)(s-1)}$$

 The range of K that will make the system stable
 Is (a) $-12 < K < 2$ (b) $-33 < K < 2$ (c) $K > 2$ (d) Unstable
- ix. When a system is excited by an unbounded input and produces an unbounded output
 (a) The system is stable
 (b) Unstable
 (c) Conditionally stable
 (d) Nothing can be said about stability
- x. For a strictly proper transfer function, the order of the numerator is
 (a) Equal to that of denominator
 (b) Greater than that of denominator
 (c) Smaller than the denominator
 (d) Not related to the denominator

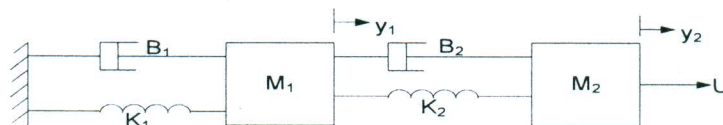
Q.2 Short answer type questions (4 questions @ 2.5 marks)

10

- i. The unit step response of a system is $e^{-5t}U(t)$. Then the impulse response is?
- ii. Determine the transfer for the system shown below.

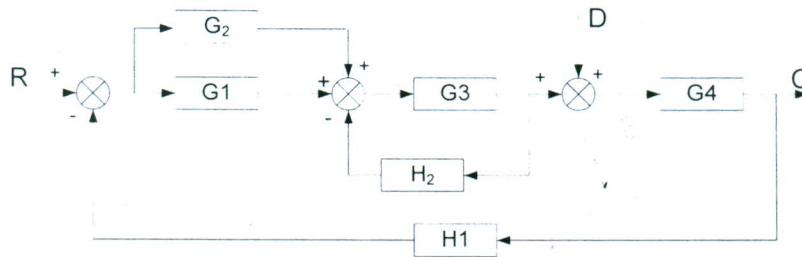


- iii. Determine the mathematical model equations for a mechanical system shown below



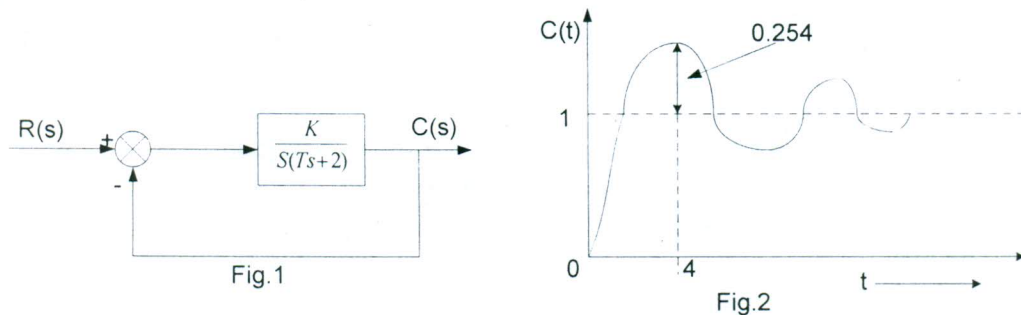
- iv. What is principle of argument?

- Q.3A Determine the ratio $\frac{C}{R}$, $\frac{C}{D}$ and the total output for the system given below using block diagram reduction technique. 05



- Q.3B Determine the range of values of K ($K > 0$) such that the characteristics equation $s^3 + 3(K + 1)s^2 + (7K + 5)s + (4K + 7) = 0$ Has roots more negative by $s = -1$ 05

- Q.4A When the system shown in the fig.1 is subjected to a unity step input, the system output responds as shown in fig.2. Determine the value of K and T from the response curve. 05

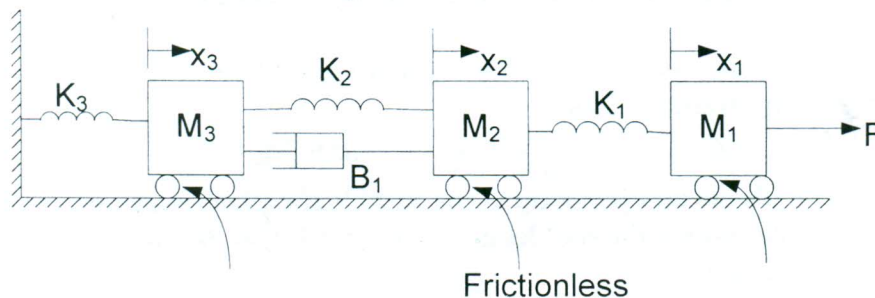


- Q.4B The closed loop transfer function of an antenna control system is given by 05

$$G(s) = \frac{K}{s^4 + 6s^3 + 30s^2 + 60s + K}$$

- Determine the range in which K must lie for the system to be stable
- What should be the upper limit on K if all poles of $G(s)$ are required to be on the left of the line $\sigma = -1$

- Q.5A First draw a mechanical equivalent circuit then draw the electrical analogous circuits using f-v and f-i analogy for the mechanical system shown below. 05



- Q.5B The open loop transfer function of unity feedback control system is given by 05

$$G(s) = \frac{K_A K_e K_m}{s(1+sT)} \text{ where } K_e = 20, K_A = 5$$

Further, the system response to unity step input is given by

$$C(t) = 1.25e^{-10t} + 0.25e^{-50t}$$

Obtain

- (i) Closed loop transfer function
- (ii) Determine T, K_m
- (iii) Damping ratio
- (iv) Velocity error to unit ramp input.

- Q.6A Consider the following set of equations: 05

$$X_1 = a_{11} X_1 + a_{12} X_2 + a_{13} X_3 + u$$

$$X_2 = b_{11} X_1 + b_{12} X_2 + b_{13} X_3$$

$$X_3 = c_{11} X_1 + c_{12} X_2 + c_{13} X_3$$

Draw the signal flow graph. Here U is input signal hence derive the transfer function using Mason's Gain formula.

- Q.6B The characteristics polynomial of a system is $s^7 + 9s^6 + 24s^5 + 24s^4 + 24s^3 + 23s^2 + 15s + 15 = 0$. Determine the location of roots on the s-plane and hence the stability of the system. 05

OR

- Q.6B A unity feedback system has the forward transfer function 05

$$G(s) = \frac{K_1(2s + 1)}{s(5s + 1)(1 + s)^2}$$

The input $r(t) = 1 + 6t$ is applied to the system. Determine the minimum value of K_1 if the steady state error is to be less than 0.1.

- Q.7A The open loop transfer function of a unity feedback system is $G(s) = \frac{K}{s(sT+1)}$, where K and T are positive constant. By what factor should the amplifier gain K be reduced, so that the peak overshoot of unit step response of the system is reduced from 75% to 25%. 10

OR

- Q.7B The open loop transfer function of a unity feedback system is given by 10

$$G(s) = \frac{(1 + 0.2s)(1 + 0.025s)}{s^3(1 + 0.005s)(1 + 0.001s)}$$

Sketch the polar plot and plot and determine the phase margin.

- Q.8 A simplified form of the loop transfer function of an airplane without an autopilot in the longitudinal mode is 10

$$G(s) = \frac{K(s+a)}{s(s-b)(s^2 + \zeta\omega_n s + \omega_n^2)}, \quad a > b, b \geq 0$$

Such a system involving an open loop in the right half s-plane may be conditionally stable. Sketch the root locus when $a=b=1$, $\zeta = 0.5$, $\omega_n = 4$. Find the range of K for stability.

- Q.9A The open loop transfer function of a unity feedback system is given by 10

$$G(s) = \frac{K}{s(1 + sT_1)(1 + sT_2)}$$

Derive the expression for gain K in terms of T_1, T_2 and specified gain margin K_g .

- Q.9B Draw the Nyquist plot for the system whose open loop transfer function is 10

$$G(s) = \frac{K}{s(s+2)(s+10)}$$

Determine the range of K for which closed loop system is stable.

OR

- Q.9B Sketch the Bode plot for a unity feedback system characterized by the open loop transfer function. 10

$$G(s) = \frac{1000}{s^2(s+2)(s+5)} \quad \text{Find}$$

- (a) Gain margin
- (b) Phase margin
- (c) Stability of the system

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Best of luck!!!