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Paper Code : EC-503

CONTROL SYSTEM

Time Allotted : 3 Hours | *Full Marks* : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following : $10 \times 1 = 10$

   i) If there is no overshoot in a system, then the damping ratio is

   a) 1 b) 0

   c) 0·5 d) ∞

   ii) Derivative error control

   a) increases the overshoot

   b) decreases the overshoot

   c) increases the steady state error

   d) decreases the steady state error.

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iii) The characteristic equation of 2nd order system is $s^2 + 6s + 25 = 0$. The system is

a) underdamped b) overdamped

c) undamped d) critically damped.

iv) Root loci of a system has three asymptotes. The system can have

a) three poles & one zero

b) four poles & two zeros

c) five poles & two zeros

d) six poles & four zeros.

v) If the Nyquist plot of a certain feedback system crosses the negative real axis at –0·1, the gain margin of the system is given by

a) 0·1 b) 10

c) 100 d) 5.

vi) A is an $n \times n$ matrix. Then the system to be stable, the rank of the controllability matrix should be

a) n b) $> n$

c) $\geq n$ d) $\leq n$.

vii) Area under a unit impulse function is

a) infinite b) unity

c) zero d) not determined.

viii) Velocity error of a system occurs due to

a) unit step input

b) unit ramp input

c) unit impulse input

d) unit parabolic input.

ix) The transfer function of a lag compensator is $D(s) = \frac{1 + \alpha\tau s}{1 + \tau s}$, $\tau > 0$. The value of α is given by

a) $\alpha = 1$ b) $\alpha > 1$

c) $\alpha < 1$ d) α is a constant.

x) The Routh-Hurwitz criterion gives

a) relative stability b) absolute stability

c) transient response d) step response.

xi) The state transition matrix $\phi(t)$ possesses which of the following properties ?

a) $\phi(0) = I$

b) $\phi^{-1}(t) = \phi(-t)$

c) $\phi(t_2 - t_1)\phi(t_1 - t_0) = \phi(t_2 - t_0)$ for any t_0, t_1, t_2

d) all of these.

xii) The phase crossover frequency (W_p) is a frequency at which the angle of $G(jW_p)$ should be equal to

a) 0° b) 90°

c) 180° d) 270°.

GROUP – B

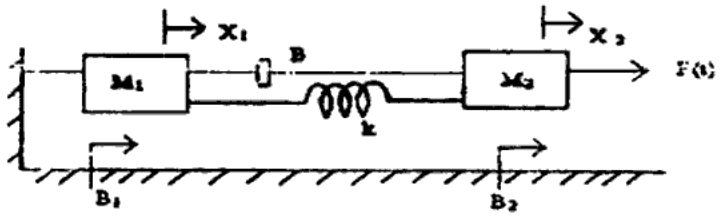
(Short Answer Type Questions)

Answer any *three* of the following. 3 × 5 = 15

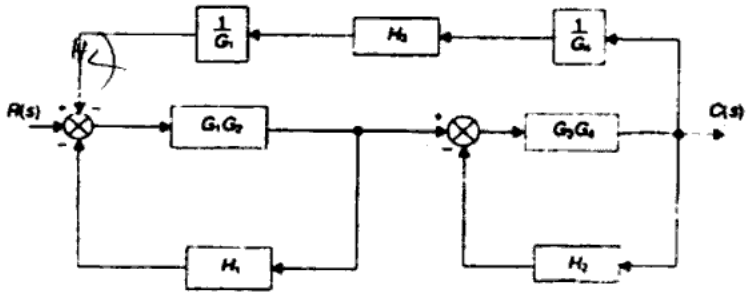
2. The unity feedback heat treatment system has open loop transfer function $G(s) = \frac{10000}{(s+1)(0 \cdot 5s+1)(0 \cdot 02s+1)}$.

The output set point is 500°C. What is the steady state temperature ?

3. Obtain the transfer function of the mechanical system shown below, taking X_2 as output.

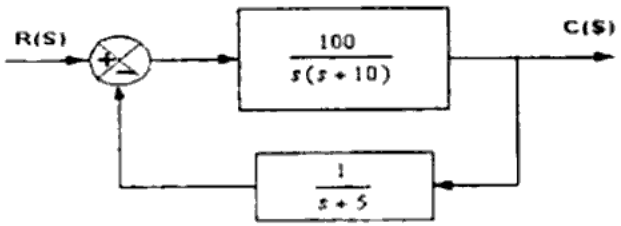


4. Find the overall transfer function of the system given below :



5. Utilize the Routh table to determine the number of roots of the following polynomial in the right half of S plane. Comment on the stability of the system : $S^5 + 6S^4 + 15S^3 + 44S + 24$.

6. Find the error constants K_p, K_v, K_a of the following system :



GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. $3 \times 15 = 45$

7. a) Compute state transition matrix of $A = \begin{bmatrix} 0 & 1 \\ -3 & -4 \end{bmatrix}$.

   b) A system is characterized by transfer function $G(s) = \frac{Y(s)}{U(s)} = \frac{2}{s^3 + 6s^2 + 11s + 6}$. Find the state equation & output equation in matrix form. Test the controllability & observability of the system.

   5 + 10

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8. Sketch the root locus diagram as K is varied from zero to infinity for the system whose open loop transfer function is given by $G(S)H(S) = \frac{k}{S(S+4)(S^2+4S+20)}$.

   Evaluate the value of K at the point where the root locus crosses the imaginary axis. Also determine the frequency at this point.

9. a) Construct the Bode Plot for a unity feedback control system having

   $$G(S) = \frac{36(0 \cdot 2S + 1)}{S^2(0 \cdot 5S + 1)(0 \cdot 01S + 1)}.$$

   b) From the plot obtain the gain margin, phase margin, gain crossover frequency, phase crossover frequency.

   c) Comment on the closed loop stability of the system.

   8 + 5 + 2

10. a) State and explain Nyquist criteria for study of control system.

    b) The open loop transfer function of closed loop system is $G(S)H(S) = \frac{120}{S(S+3)(S+5)}$. Draw the Nyquist plot and hence find out whether the system is stable or not.

    c) What are the advantages of Nyquist plot ? 4 + 9 + 2

11. a) What is compensation ? What is a compensated system ? What is a compensator ?

    b) Write short notes on P, PI & PID controller. 6 + 9

12. a) Consider the closed loop transfer function (CLTF) given by $\frac{C(s)}{R(s)} = \frac{W_n^2}{s^2 + 2\varepsilon W_n + W_n^2}$. Determine the value of ε and W_n so that the system responds to a step input with approximately 5% overshoot and with a settling time of 2 sec.

    b) The open loop transfer function of a unity feedback control system is given by $G(s) = \frac{k(s+2)}{s^3 + \beta s^2 + 4s + 1}$. Determine the value of k and β such that the closed loop unit step response has $W_n = 3$ rad/sec & $\varepsilon = 0{\cdot}2$. 7 + 8