Registration No : | | | | | | | | | | |

Total Number of Pages : 03 **B.Tech.**

PEE6J004

6th Semester Regular Examination 2017-18

CONTROL SYSTEM ENGINEERING - II

BRANCH : ELECTRICAL

Time : 3 Hours

Max Marks : 100

Q.CODE : C433

Answer Part-A which is compulsory and any four from Part-B.

The figures in the right hand margin indicate marks.

Part – A (Answer all the questions)

Q1 **Answer the following questions: *multiple type or dash fill up type*** **(2 x 10)**

a) A signal described by $x(t) = 100\sin 15t + 50\cos 25t$, and then sampling frequency based on sampling theorem is _______________.

b) The final value of the following pulse transfer function is __________.

$$f(z) = \frac{5z^3 - 4z^2 + 6z}{z^3 - 3z^2 + z}$$

c) The transfer function of Zero Order Hold circuit is ______________.

d) If $H(s) = \frac{1}{s(s+1)}$, then $H(z) =$ _______________.

e) A linear time-invariant continuous-time system described by

$$\frac{dX}{dt} = \begin{bmatrix} 2 & 1 \\ -1 & 1 \end{bmatrix} X + \begin{bmatrix} 1 \\ 2 \end{bmatrix} U$$

Is the system stable___________ (Yes/No)

f) The poles of the transfer function of a system lie at -1, -3 and -7. Then Eigen values of the system are ______________.

g) The expression to determine the transfer function for a system with state space representation $\dot{X} = AX + BU$ and $Y = CX + DU$ is ______________.

h) A network comprises of 2 inductors, 1 capacitors and 1 resistors. The current across different inductors are linearly independent and voltage across different capacitors is linearly independent as well. ______________no. of states are necessary to describe the network in state variable form.

i) For a nonlinear system, phase trajectory of a singular point will be _________ (Nodal point/ Saddle Point/Focus Point/ Vortex Point) type if the eigen values are $-4 \pm j7$

j) For a system described by Vander Pol's differential equation

$$\frac{d^2x}{dt^2} - \mu(1 - x^2)\frac{dx}{dt} + x = 0$$

The phase trajectory of the system exhibits a ______________ (stable/unstable) limit cycle behavior.

Q2 **Answer the following questions: *Short answer type*** **(2 x 10)**

a) State the difference between the 'Differential equation' and 'Difference equation'

b) What do you mean by aliasing in linear discrete data system?

c) What is the mapping function used to shift from S-plane to Z-plane?

d) State the Initial value theorem in the time domain of a function F(z) defined in z-domain.

e) Derive the expression for the Z-transform of unit ramp signal.

f) What do you understand by limit cycle?

g) What do you mean by output controllability and how is it different from state controllability?

h) What do you understand by Jump resonance?

i) Is the assessment of stability by direct method of Lyapunov's for linear systems conservative? Justify your answer.

j) What do you mean by phase plane and phase trajectory?

Part – B (Answer any four questions)

Q3 a) Solve the following difference equation by use of the z transform method: **(10)**

$$x(k+2)+5x(k+1)+6x(k)=0, \quad x(0)=0, \quad x(1)=1$$

b) Find the Z- transform of $x(t)= \boldsymbol{e^{at}Cos\ \omega t}$ **(5)**

Q4 a) Consider the following characteristic equation: **(10)**

$$z^3+2.1z^2+1.44z+0.32=0$$

Determine whether any of the roots of the characteristic equation lie outside the unit circle centered at the origin of the z plane.
Also, comment upon its stability.

b) Find the inverse z transform of the function by long division **(5)**

$$X(z)=\frac{2z+4}{(z-1)(z-0.3)}$$

Q5 a) Consider a control system with state model **(10)**

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix}=\begin{bmatrix}0 & 2\\ -3 & -5\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}+\begin{bmatrix}0\\ 1\end{bmatrix}[u]; \qquad \begin{bmatrix}x_1(0)\\ x_2(0)\end{bmatrix}=\begin{bmatrix}0\\ 1\end{bmatrix}, \text{u = unit step}$$

Compute the state transition matrix and therefrom find the state response, i.e., $x(t)$ for t>0.

b) A discrete-time system has state equation given by **(5)**

$$\boldsymbol{X(k+1)}=\begin{bmatrix}0 & 2\\ -6 & -7\end{bmatrix}\boldsymbol{X(k)}$$

Use Cayley-Hamilton approach to find out its state transition matrix.

Q6 a) A regulator system has the plant described by **(10)**

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix}=\begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ -1 & -5 & -6\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}+\begin{bmatrix}0\\ 0\\ 1\end{bmatrix}[u]$$

Design a state variable feedback controller which will place the closed loop poles at $-2 \pm j\,5$and-6.

b) Check the observability of the following system **(5)**

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix}=\begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ -6 & -11 & -6\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}+\begin{bmatrix}0\\ 0\\ 1\end{bmatrix}[u]$$

$$y=\begin{bmatrix}4 & 5 & 1\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}$$

Q7 **a)** Consider a matrix A given below **(10)**

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 3 & 0 & 2 \\ -12 & -9 & -6 \end{bmatrix}$$

i) Find out the eigen values
ii) Find out the eigen vectors
iii) Find out the modal matrix
iv) Find out the diagonalizedmatix

b) Derive the state space equation from the transfer function **(5)**

$$\frac{10(s-1)}{(s+4)(s^2+1)}$$

Q8 **a)** What are singular points in a phase plane? Explain the following types of singularity with sketches - Stable node, unstable node, saddle point, stable focus, unstable focus, vortex **(10)**

b) Draw the phase plane trajectory for a nonlinear system is described by **(5)**

$$\frac{d^2x}{dt^2} + sinx = 0.7$$

When the initial conditions are$x(0) = \pi/3$, $\dot{x}\,(0) = 0$. Use δ −method.

Q9 **a)** i) Define a) Stable system, b) Asymptotically stable system, andc) Globally asymptotically stable system **(10)**
ii) State and explain the Lyapunov's Theorem (direct method) for stability analysis.

b) Check the stability of the system described by **(5)**

$$\dot{x}_1 = x_2$$
$$\dot{x}_2 = -x_1 - x_1^2 x_2$$