University of Mumbai
Examination 2020- Inter Cluster

Program: BE Instrumentation Engineering

Curriculum Scheme: Revised 2012

Examination: Third Year Semester V

Course Code: ISC503 and Course Name: Control System Design

Time: 1hour Max. Marks: 50

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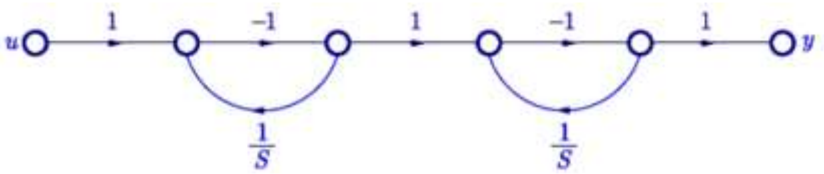
Note to the students:- All Questions are compulsory and carry equal marks .

Q1.	The value of dominant pole S_d is given by
Option A:	$S_d = -\xi\omega_n \pm j\omega_n\sqrt{(1-\xi^2)}$
Option B:	$S_d = -\xi^2{\omega_n}^2 \pm j{\omega_n}^2\sqrt{(1-\xi^2)}$
Option C:	$S_d = -\sqrt{\xi\omega_n} \pm j\omega_n\sqrt{(1-\xi^2)}$
Option D:	$S_d = -\xi^4{\omega_n}^4 \pm j{\omega_n}^4\sqrt{(1-\xi^2)}$
Q2.	The Lead-compensator has a
Option A:	Zero nearer to the origin
Option B:	Pole nearer to the origin
Option C:	Pole at the origin
Option D:	Zero at the origin
Q3.	Performance of a control system can be described in terms of
Option A:	Time-domain performance measures and not frequency-domain performance measures
Option B:	Frequency-domain performance measures and not time-domain performance measures
Option C:	Time-domain performance measures or frequency-domain performance measures
Option D:	Only time-domain performance measures.
Q4.	The Lag-compensator has a
Option A:	Zero nearer to the origin
Option B:	Pole nearer to the origin
Option C:	Pole at the origin
Option D:	Zero at the origin
Q5.	In frequency response approach, compensation network is used to alter and reshape the system's characteristics represented on an
Option A:	S-plane
Option B:	Root locus diagram
Option C:	Polar graph

Option D:	Bode plot
Q6.	The minimum number of states require to describe the second order differential equation is:
Option A:	1
Option B:	2
Option C:	3
Option D:	4
Q7.	Given the matrix $$\begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix}$$ the Eigen values are__________
Option A:	1
Option B:	1, 2, 3
Option C:	0
Option D:	-1, -2, -3
Q8.	For a system with the transfer function $$H(s) = \frac{s^3 + 8s^2 + 17s + 9}{s^3 + 6s^2 + 11s + 6}$$ The state model in the 1^{st} companion form is given by the matrices,
Option A:	$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} \quad B = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} \quad C = \begin{bmatrix} 9 & 17 & 8 \end{bmatrix}$
Option B:	$A = \begin{bmatrix} 0 & 0 & 1 \\ 0 & 1 & 0 \\ -6 & -11 & -6 \end{bmatrix} \quad B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \quad C = \begin{bmatrix} 8 & 17 & 9 \end{bmatrix}$
Option C:	$A = \begin{bmatrix} 0 & 1 & 0 \\ -6 & -11 & -6 \\ 0 & 0 & 1 \end{bmatrix} \quad B = \begin{bmatrix} 8 & 17 & 8 \end{bmatrix} \quad C = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$
Option D:	$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} \quad B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \quad C = \begin{bmatrix} 9 & 17 & 8 \end{bmatrix}$
Q9.	The state diagram of the system is shown in figure. A system is described by state variable equations: $\dot{x} = Ax + Bu$ and $y = Cx + Du$  So, the state variable equations of the system given in figure are given by,
Option A:	$\begin{bmatrix} \dot{x_1} \\ \dot{x_2} \end{bmatrix} = \begin{bmatrix} -1 & 0 \\ 1 & -1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} -1 \\ 1 \end{bmatrix} u$

	$y = [1 \quad -1]\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + u$
Option B:	$\begin{bmatrix} \dot{x_1} \\ \dot{x_2} \end{bmatrix} = \begin{bmatrix} -1 & 0 \\ -1 & -1 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} -1 \\ -1 \end{bmatrix}u$ $y = [-11 \quad -1]\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + u$
Option C:	$\begin{bmatrix} \dot{x_1} \\ \dot{x_2} \end{bmatrix} = \begin{bmatrix} -1 & 0 \\ -1 & -1 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} -1 \\ 1 \end{bmatrix}u$ $y = [-1 \quad -1]\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} - u$
Option D:	$\begin{bmatrix} \dot{x_1} \\ \dot{x_2} \end{bmatrix} = \begin{bmatrix} -1 & -1 \\ 0 & -1 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} -1 \\ 1 \end{bmatrix}u$ $y = [1 \quad -1]\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} - u$
Q10.	Which of the following is correct with respect to the properties of the state transition matrix, $\emptyset(t)$?
Option A:	It is never singular
Option B:	It is non-continuous
Option C:	It does not have continuous derivatives
Option D:	$\emptyset(t,t) = -I \quad for\ all\ t$
Q11.	The system is said to be completely ______________ if every state $x(t_0)$ can be determined from the observation of y(t) over a finite time interval.
Option A:	Controllable
Option B:	Observable
Option C:	Cannot be determined
Option D:	Controllable and observable
Q12.	For the system, $\dot{x} = \begin{bmatrix} -2 & 0 \\ 0 & -1 \end{bmatrix}x + \begin{bmatrix} 3 \\ 1 \end{bmatrix}u$; which of the following statements is true?
Option A:	The system is controllable but unstable
Option B:	The system is uncontrollable and unstable
Option C:	The system is uncontrollable and stable
Option D:	The system is controllable and stable
Q13.	Consider the systems given by System 1: - $\dot{x} = \begin{bmatrix} -1 & 0 \\ 0 & -2 \end{bmatrix}x\ ; y = [1 \quad 3]x$ System 2: -$\dot{x} = \begin{bmatrix} -1 & 0 \\ 0 & -2 \end{bmatrix}x\ ; y = [0 \quad 1]x$
Option A:	System 1 & system 2 both are observable

Option B:	System 1 is not completely state observable but System 2 is completely state observable
Option C:	System 1 is completely state observable but System 2 is not completely state observable
Option D:	System 1 & system 2 both are not observable
Q14.	The system is represented by $\dot{x} = Ax + Bu$ where $A = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 1 & 0 \\ 1 & -4 & 3 \end{bmatrix};\ B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$ And desired poles are $s = -10, s = -2 \pm j4$ Find state feedback gain matrix K as $u = -Kx$.
Option A:	$K = [199 \quad 55 \quad 8]$
Option B:	$K = [1 \quad -6 \quad 31]$
Option C:	System is not controllable so system cannot be stabilized by any K using state feedback control.
Option D:	System is not observable so system cannot be stabilized by any K using state feedback control.
Q15.	Transformation Approach to Obtain State Observer Gain Matrix Ke is given as
Option A:	$K_e = \left(\begin{bmatrix} a_{n-1} & a_{n-2} \ldots a_1 & 1 \\ a_{n-2} & a_{n-3} \ldots 1 & 0 \\ \vdots & \vdots \quad \ldots \quad \vdots & \vdots \\ a_1 & 1 \ldots \quad 0 & 0 \\ 1 & 0 \quad \ldots 0 & 0 \end{bmatrix} [C^* \mid A^*C^* \mid \ldots \mid (A^*)^{n-1}C^*] \right) \begin{bmatrix} \alpha_n - a_n \\ \alpha_{n-1} - a_{n-1} \\ \vdots \\ \alpha_1 - a_1 \end{bmatrix}$
Option B:	$K_e = \left(\begin{bmatrix} a_{n-1} & a_{n-2} \ldots a_1 & 1 \\ a_{n-2} & a_{n-3} \ldots 1 & 0 \\ \vdots & \vdots \quad \ldots \quad \vdots & \vdots \\ a_1 & 1 \ldots \quad 0 & 0 \\ 1 & 0 \quad \ldots 0 & 0 \end{bmatrix} [C^* \mid A^*C^* \mid \ldots \mid (A^*)^{n-1}C^*] \right)^{-1} \begin{bmatrix} \alpha_n - a_n \\ \alpha_{n-1} - a_{n-1} \\ \vdots \\ \alpha_1 - a_1 \end{bmatrix}$
Option C:	$K_e = \begin{bmatrix} \alpha_n - a_n \\ \alpha_{n-1} - a_{n-1} \\ \vdots \\ \alpha_1 - a_1 \end{bmatrix} \left(\begin{bmatrix} a_{n-1} & a_{n-2} \ldots a_1 & 1 \\ a_{n-2} & a_{n-3} \ldots 1 & 0 \\ \vdots & \vdots \quad \ldots \quad \vdots & \vdots \\ a_1 & 1 \ldots \quad 0 & 0 \\ 1 & 0 \quad \ldots 0 & 0 \end{bmatrix} [C^* \mid A^*C^* \mid \ldots \mid (A^*)^{n-1}C^*] \right)^{-1}$
Option D:	$K_e = \begin{bmatrix} \alpha_n - a_n \\ \alpha_{n-1} - a_{n-1} \\ \vdots \\ \alpha_1 - a_1 \end{bmatrix} \left(\begin{bmatrix} a_{n-1} & a_{n-2} \ldots a_1 & 1 \\ a_{n-2} & a_{n-3} \ldots 1 & 0 \\ \vdots & \vdots \quad \ldots \quad \vdots & \vdots \\ a_1 & 1 \ldots \quad 0 & 0 \\ 1 & 0 \quad \ldots 0 & 0 \end{bmatrix} [C^* \mid A^*C^* \mid \ldots \mid (A^*)^{n-1}C^*] \right)$
Q16.	The compensator G(s) =5(1+0.3s)/(1+0.1s) would provide a maximum phase shift of:
Option A:	20^0
Option B:	45^0
Option C:	60^0
Option D:	30^0
Q17.	Bode plot are preferred for compensation when the specifications are in terms of …………… and ……………….

Option A:	phase margin, settling time
Option B:	phase margin, bandwidth
Option C:	phase margin, maximum overshoot
Option D:	Resonant peak, bandwidth
Q18.	In a frequency domain design of a lead compensator, the alpha parameter is calculated as -
Option A:	$\alpha = (1 - \sin\phi_m)/(1+\sin\phi_m)$
Option B:	$\alpha = (1 + \sin\phi_m)/(1+\sin\phi_m)$
Option C:	$\alpha = (1 + \sin\phi_m)/(1-\sin\phi_m)$
Option D:	$\alpha = (1 - \sin\phi_m)/(1-\sin\phi_m)$
Q19.	Derivative error compensation:
Option A:	Improvement in transient response
Option B:	Reduction in steady state error
Option C:	Reduction is settling time
Option D:	Increase in damping constant
Q20.	According to Ziegler-Nichols second method of tuning of PID controller –
Option A:	$K_P = 0.16Kcr$, $T_I = 0.05Pcr$, $T_D = 0.125Pcr$
Option B:	$K_P = 0.6Kcr$, $T_I = 0.55Pcr$, $T_D = 0.0125Pcr$
Option C:	$K_P = 0.6Kcr$, $T_I = 0.5Pcr$, $T_D = 0.125Pcr$
Option D:	$K_P = 0.65Kcr$, $T_I = 0.05Pcr$, $T_D = 0.125Pcr$
Q21.	If $\dot{x} = \begin{pmatrix} -1 & 0 \\ 0 & -2 \end{pmatrix} x$ and $x(0) = \begin{pmatrix} 2 \\ 1 \end{pmatrix}$, then which one of the following is the solution $x(t)$?
Option A:	$x(t) = \begin{pmatrix} 2e^{-t} \\ e^{-2t} \end{pmatrix}$
Option B:	$x(t) = \begin{pmatrix} e^{-t} \\ 2e^{-2t} \end{pmatrix}$
Option C:	$x(t) = \begin{pmatrix} 2e^{-2t} \\ e^{-t} \end{pmatrix}$
Option D:	$x(t) = \begin{pmatrix} e^{-2t} \\ e^{-t} \end{pmatrix}$
Q22.	If $\dot{x} = \alpha x + \beta u$ with $x(0) = x_0$ then which one of the following is the solution $x(t)$?
Option A:	$x(t) = e^{\alpha t}x_0 + \int_0^t e^{\alpha(t-\tau)}\beta u(\tau)d\tau$
Option B:	$x(t) = e^{\alpha t}x_0 + \int_0^t e^{\beta(t-\tau)}\alpha u(\tau)d\tau$
Option C:	$x(t) = e^{\beta t}x_0 + \int_0^t e^{\beta(t-\tau)}\alpha u(\tau)d\tau$

Option D:	$x(t) = e^{\alpha t}x_0 + \int_0^t e^{\beta(t-\tau)}u(\tau)d\tau$
Q23.	If k is the dc gain of the system and r is the ratio of time constant τ and time delay θ, then Cohen-Coon tuning parameters k_p , τ_i and τ_d for PID controller are
Option A:	$k_p = \frac{r\left(1.33+\frac{1}{4r}\right)}{k}$, $\tau_i = \frac{40}{11+\frac{2}{r}}$ and $\tau_d = \frac{\theta\left(32+\frac{6}{r}\right)}{13+\frac{8}{r}}$
Option B:	$k_p = \frac{r\left(1.33+\frac{1}{4r}\right)}{k}$, $\tau_i = \frac{\theta\left(32+\frac{6}{r}\right)}{13+\frac{8}{r}}$ and $\tau_d = \frac{40}{11+\frac{2}{r}}$
Option C:	$k_p = \frac{k\left(1.33+\frac{1}{4r}\right)}{r}$, $\tau_i = \frac{\theta\left(32+\frac{6}{r}\right)}{13+\frac{8}{r}}$ and $\tau_d = \frac{40}{11+\frac{2}{r}}$
Option D:	$k_p = \frac{k\left(1.33+\frac{1}{4r}\right)}{r}$, $\tau_i = \frac{40}{11+\frac{2}{r}}$ and $\tau_d = \frac{\theta\left(32+\frac{6}{r}\right)}{13+\frac{8}{r}}$
Q24.	If system is a first order delay process $\frac{ke^{-\theta s}}{\tau s+1}$, then Ziegler-Nichols tuning parameters k_p and τ_i for PI controller are
Option A:	$k_p = \frac{0.9\theta}{k\tau}$ and $\tau_i = \frac{\theta}{3.33}$
Option B:	$k_p = \frac{0.9\theta}{k\tau}$ and $\tau_i = 3.33\theta$
Option C:	$k_p = \frac{0.9\tau}{k\theta}$ and $\tau_i = 3.33\theta$
Option D:	$k_p = \frac{0.9\tau}{k\theta}$ and $\tau_i = \frac{\theta}{3.33}$
Q25.	If system is a first order delay process $\frac{ke^{-\theta s}}{\tau s+1}$, then Ziegler-Nichols tuning parameters k_p , τ_i and τ_d for PID controller are
Option A:	$k_p = \frac{2\tau}{k\theta}$, $\tau_i = 0.5\theta$ and $\tau_i = 1.2\theta$
Option B:	$k_p = \frac{2\tau}{k\theta}$, $\tau_i = 1.2\theta$ and $\tau_i = 0.5\theta$
Option C:	$k_p = \frac{1.2\tau}{k\theta}$, $\tau_i = 0.5\theta$ and $\tau_i = 2\theta$
Option D:	$k_p = \frac{1.2\tau}{k\theta}$, $\tau_i = 2\theta$ and $\tau_i = 0.5\theta$