University of Mumbai

Examination 2020- Inter Cluster

Program: BE Instrumentation Engineering

Curriculum Scheme: Revised 2016

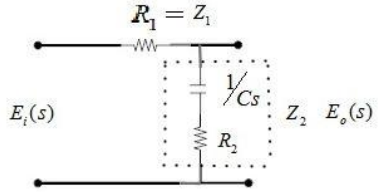
Examination: Third Year Semester V

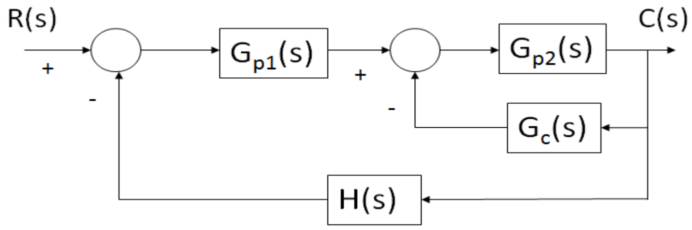
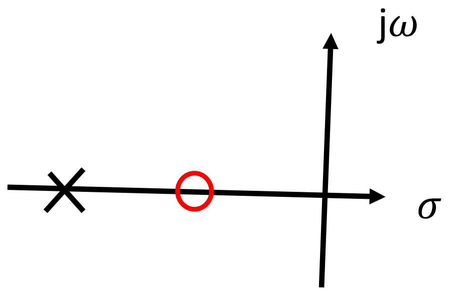
Course Code and Course Name: ISC503 : Control System Design

Time: 2hour Max. Marks: 80

Q1. MCQs 40 marks
20 MCQs of **2 marks each** based entire syllabus. **All the questions are compulsory**
Q2 and Q3. Subjective Questions (Total 40 marks) **20 marks each**
Either 5 marks or 10 marks sub questions will be asked with internal options.
In a few exceptional courses/subjects (as per the requirement of the subject) even a 20 mark question may be asked.
Note:
1. Internal options will be provided in the subjective questions
2. The sub questions in Q2 and Q3 will be asked on multiple modules and based on the maximum syllabus.
3. Referring to subjective/descriptive answers, students have to write question wise answers using paper and pen. Answers of Q2 and Q3 along with the sub questions, if any, has to be scanned, by the student appearing for the said examination, as one document (separate for Q2 and Q3) in pdf format and has to be uploaded in appropriate location of respective questions of either Google form, MS form or any other LMS.
4. Additional 15 minutes will be provided for scanning and uploading the answers of respective questions.

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

Q1.	Figure below shows a compensating network  above network is called
Option A:	Phase lag network
Option B:	Phase-lead-lag network
Option C:	Phase-lead network
Option D:	Phase correcting network

Q2.	Figure below shows which type of compensation 
Option A:	Series-parallel compensation
Option B:	Series compensation
Option C:	Parallel compensation
Option D:	Simple compensation
Q3.	Figure below shows a pole-zero plot for which compensator 
Option A:	Lag
Option B:	Lead
Option C:	Lag-lead
Option D:	Cascade Lag

Q4.	The performance of a feedback control system in terms of frequency performance measures can be described by
Option A:	Resonance peak, resonant frequency, bandwidth, Gain margin and phase margin of the system
Option B:	Peak time, maximum overshoot, and dead time
Option C:	Peak time, rise time, and bandwidth
Option D:	Peak overshoot, peak time and settling time
Q5.	The compensator required to improve the steady-state response of a system is
Option A:	Lag
Option B:	Lead
Option C:	Lag-lead
Option D:	Cascade Lag
Q6.	Which among the following is a disadvantage of modern control theory?
Option A:	Implementation of optimal design
Option B:	Necessity of computational work
Option C:	Transfer function can also be defined for different initial conditions
Option D:	Analysis of all systems take place

Q7.	Single-input, single-output system has the state variable representation as, $\dot{\boldsymbol{x}} = \begin{bmatrix} \mathbf{0} & \mathbf{1} \\ \mathbf{-5} & \mathbf{-10} \end{bmatrix} \boldsymbol{x} + \begin{bmatrix} \mathbf{1} \\ \mathbf{0} \end{bmatrix} \boldsymbol{u}$ **y** = $[\mathbf{0} \quad \mathbf{10}]\boldsymbol{x}$ The transfer function of the system is, $T(s) = \frac{Y(s)}{U(s)}$
Option A:	$T(s) = \dfrac{-5}{s+5}$
Option B:	$T(s) = \dfrac{-50}{s^3 + 5s^2 + 50s}$
Option C:	$T(s) = \dfrac{-50}{s^2 + 5s + 5}$
Option D:	$T(s) = \dfrac{-50}{s^2 + 10s + 5}$
Q8.	For the system with transfer function, $$\boldsymbol{T(s) = \frac{1}{s^2 + 3s + 2}}$$ The state space representation in diagonal canonical form is given by:
Option A:	$\begin{bmatrix} \dot{x_1} \\ \dot{x_2} \end{bmatrix} = \begin{bmatrix} -1 & 0 \\ 0 & -2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u$ $y = [1 \quad -1] \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$
Option B:	$\begin{bmatrix} \dot{x_1} \\ \dot{x_2} \end{bmatrix} = \begin{bmatrix} -1 & 0 \\ -2 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u$ $y = [1 \quad -1] \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$
Option C:	$\begin{bmatrix} \dot{x_1} \\ \dot{x_2} \end{bmatrix} = \begin{bmatrix} -1 & 0 \\ 0 & -2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u$ $y = [2 \quad -1] \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$
Option D:	$\begin{bmatrix} \dot{x_1} \\ \dot{x_2} \end{bmatrix} = \begin{bmatrix} -1 & 1 \\ 0 & -2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u$ $y = [1 \quad -1] \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$
Q9.	For a system with the transfer function $$H(s) = \frac{s^2 + 7s + 2}{s^3 + 9s^2 + 26s + 24}$$ The state model in the 1st companion form is given by the matrices,

Option A:	$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -9 & -26 & -24 \end{bmatrix}$ $B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$ $C = [2 \quad 7 \quad 1]$
Option B:	$A = \begin{bmatrix} 0 & 0 & -24 \\ 1 & 0 & -26 \\ 0 & 1 & -9 \end{bmatrix}$ $B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$ $C = [2 \quad 7 \quad 1]$
Option C:	$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -24 & -26 & -9 \end{bmatrix}$ $B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$ $C = [2 \quad 7 \quad 1]$
Option D:	$A = \begin{bmatrix} -24 & -26 & -9 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$ $B = \begin{bmatrix} 2 \\ 7 \\ 1 \end{bmatrix}$ $C = [0 \quad 0 \quad 1]$
Q10.	Consider the system, $x = A\dot{x} + Bu$ where, A= $\begin{bmatrix} 0 & 5 \\ 0 & 0 \end{bmatrix}$ $and \quad B = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$ The associated state transition matrix is:
Option A:	$\emptyset(t) = \begin{bmatrix} 1 & 5t \\ 1 & 1 \end{bmatrix}$
Option B:	$\emptyset(t) = \begin{bmatrix} 1 & 0 \\ 5t & 1 \end{bmatrix}$
Option C:	$\emptyset(t) = \begin{bmatrix} 1 & 5t \\ 0 & 1 \end{bmatrix}$
Option D:	$\emptyset(t) = \begin{bmatrix} 1 & 5t & -t \\ 0 & 1 & t \\ 0 & 0 & 1 \end{bmatrix}$
Q11.	The condition for complete output controllability is decided by the matrix O_c if and only if the rank of matrix O_c is ***m***. Where O_c matrix is given as
Option A:	$[CB \quad CAB \quad CA^2B \ \ldots \ CA^{n-1}B]$
Option B:	$[CB \quad CAB \quad CA^2B \ \ldots \ CA^{n-1}B \quad D]$
Option C:	$[B \quad AB \quad A^2B \ \ldots \ A^{n-1}B]$
Option D:	$[B \quad AB \quad A^2B \ \ldots \ A^{n-1}B \quad D]$
Q12.	System is said to be detectable if
Option A:	for a partially controllable system, if the uncontrollable modes are stable and the controllable modes are unstable.
Option B:	for a partially controllable system, if the uncontrollable modes are unstable and the controllable modes are stable.
Option C:	for a partially observable system, if the unobservable modes are stable and the observable modes are unstable.
Option D:	for a partially observable system, if the unobservable modes are unstable and the observable modes are stable.
Q13.	The system is represented by $\dot{x} = Ax + Bu$ & $y = Cx + Du$ where

	$A = \begin{bmatrix} 0 & -1 & -1 & -3 \\ -9 & 2 & 6 & 9 \\ 4 & -2 & -5 & -4 \\ 3 & -1 & -2 & -4 \end{bmatrix}$; $B = \begin{bmatrix} 2 \\ -6 \\ 3 \\ 2 \end{bmatrix}$; $C = [1 \quad 1 \quad -1 \quad 4]$; $D = [0]$
Option A:	Given system is completely state controllable & observable.
Option B:	Given system is not completely state controllable neither completely state observable.
Option C:	Given system is completely state controllable but not completely state observable.
Option D:	Given system is not completely state controllable but completely state observable.
Q14.	The system is represented by $\dot{x} = Ax + Bu$ & $y = Cx + Du$ where $A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix}$; $B = \begin{bmatrix} 0 \\ 0 \\ 10 \end{bmatrix}$ And desired poles are $s = -10, s = -2 \pm j2\sqrt{3}$ Find state feedback gain matrix K as $u = -Kx$.
Option A:	$K = [154 \quad 45 \quad 8]$
Option B:	$K = [15.4 \quad 4.5 \quad 0.8]$
Option C:	$K = [154 \quad 45 \quad 8]^T$
Option D:	$K = [15.4 \quad 4.5 \quad 0.8]^T$
Q15.	The system is represented by $\dot{x} = Ax + Bu$ & $y = Cx + Du$ where $A = \begin{bmatrix} 0 & 20.6 \\ 1 & 0 \end{bmatrix}$; $B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$; $C = [0 \ 1]$ And desired poles are $s = -10, -10$ Determination appropriate observer gain matrix K_e.
Option A:	$K_e = [120.6 \quad 20]$
Option B:	$K_e = [20.6 \quad 120]$
Option C:	$K_e = \begin{bmatrix} 120.6 \\ 20 \end{bmatrix}$
Option D:	$K_e = \begin{bmatrix} 20.6 \\ 120 \end{bmatrix}$
Q16.	The transfer function of a simple RC network functioning as a compensator is – Gc(s) = (S + Zc)/(S + Pc) The condition for RC network to work as Lag Compensator is -
Option A:	Zc > Pc
Option B:	Pc > Zc
Option C:	Zc = Pc
Option D:	Pc = 0 and Zc = 1
Q17.	A phase lag compensator will
Option A:	Improve relative stability
Option B:	Increase the speed of response
Option C:	Increase bandwidth
Option D:	Increase overshoot

Q18.	A composite R-C network yielded the following transfer function when calculated from its components: $T(s) = 1+21s+20s^2/1+11s+10s^2$. This network can be used as which one of the following?
Option A:	Phase lead compensator
Option B:	Phase lag compensator
Option C:	Lag lead compensator
Option D:	None of the mentioned
Q19.	Resonant frequency ω_r and bandwidth $\omega_b$are measure of
Option A:	Relative stability
Option B:	Absolute stability
Option C:	Speed of response
Option D:	Steady-state error
Q20.	For a certain control system's critical gain is 30 and critical period is 2.81sec, then, what will be the Proportional gain, K_P, Integral gain, K_I and Derivative gain K_D of PID Controller?
Option A:	$K_P = 19.5, K_I = 13.811, K_D = 8.318$
Option B:	$K_P = 18, K_I = 12.811, K_D = 6.318$
Option C:	$K_P = 18.63, K_I = 12.811, K_D = 9.318$
Option D:	$K_P = 18.5, K_I = 14.811, K_D = 6.318$

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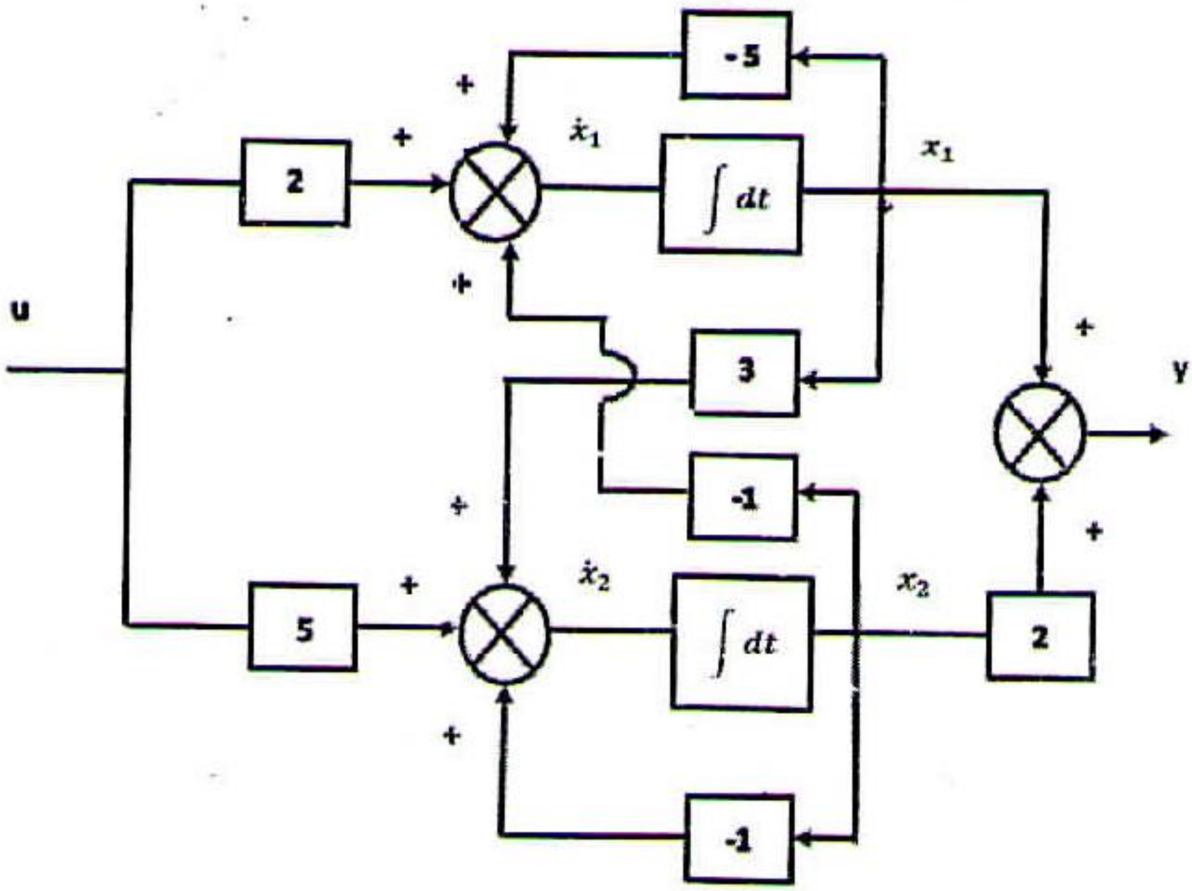
Q2.	Solve any four Questions out of Three 5 marks each
A	Construct the Vandermonde matrix M for system having following eigen values $\lambda_1, \lambda_1. \lambda_1, \ldots, \lambda_1, \lambda_{m+1}, \lambda_{m+2}, \ldots, \lambda_n$ **(Eigenvalue λ_1 of multiplicity of m)**
B	For system shown in figure below obtain State model 
C	Obtain the state space representation for following system in diagonal form $$G(s) = \frac{1}{s^2 + 0.3s + 0.02}$$

D	Obtain the transfer function for the following system. $$\dot{x} = \begin{bmatrix} 0 & 1 \\ -3 & -4 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$ $$y = [1 \ 0] x$$
E	For the system $$G(s) = \frac{s+1}{s(s+3)}$$ check if $s = -2$ pole is on root locus or not.
F	Write Cayley Hamilton theorem. Check if it holds for the matrix $F = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}$.
Q3.	**Solve any Two Questions out of Three** **10 marks each**
A	Check for the controllability and observability of the system, $$\dot{z}_1 = -z_1 + u$$ $$\dot{z}_2 = -2z_2 + z_3$$ $$\dot{z}_3 = -2z_3 + u$$ $$y = z_1 + z_3$$ using Kalman's tests.

B	For the unity F/B system with PID Controller is used to control the system, the plant T.F. is $G(s) = \frac{1}{s(s+1)(s+5)}$. Determine PID Controller.
C	Diagonalise the following matrix $A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & -3 & 3 \end{bmatrix}$