ii. Sketch the bode plot for the transfer function **7**

$$G(s) = \frac{1000}{s(1+0.1s)(1+0.001s)}$$

Determine:

(a) Gain cross over frequency (b) Phase cross over frequency

(c) G.M and P.M (d) Stability of the given system

OR iii. Draw the root locus for a system whose open loop transfer function is given by $G(s)H(s) = \frac{K}{s(s+4)(s^2+4s+20)}$. Show all the salient points on the locus. **7**

Q.5 i. Describe different type of compensator used in control system **3**

ii. Compare the characteristics of phase lead and phase lag networks used for control system compensation **7**

OR iii. Design the lag compensator for a system whose open loop transfer function is $G(s) = \frac{K}{s(s+1)(s+4)}$ **7**

To meet the following specifications:

(a) Damping ratio=0.5 (b) Settling time t_s=10 sec

(c) Velocity error constant $K_V \geq 5$.

Q.6 i. Consider the following matrix **3**

$\dot{x}=\begin{bmatrix} 0 & 1 \\ -6 & -5 \end{bmatrix}$ $x(0)=\begin{bmatrix} 1 \\ 0 \end{bmatrix}$

Find the state transition matrix, also determine x(t).

ii. Write the state equations $\frac{d^3c}{dt^3} + 6\frac{dc}{dt} + 5c(t) = r(t)$. Also draw the state variable diagram. **7**

OR iii. A system characterized by the transfer function $\frac{y(s)}{u(s)} = \frac{2}{(s^3+6s^2+11s+6)}$. **7**

Find the state and output equation in matrix form and also test the controllability and observability of the system.

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Enrollment No.....

Faculty of Engineering

End Sem (Odd) Examination Dec-2019

EE3CO15 / EX3CO15 Linear Control System

Programme: B.Tech. Branch/Specialisation: EE/EX

Duration: 3 Hrs. **Maximum Marks: 60**

Note: All questions are compulsory. Internal choices, if any, are indicated.Answers of Q.1 (MCQs) should be written in full instead of only a, b, c or d.

Q.1 i. A system can be completely described by a transfer function if it is **1**

(a) Nonlinear and continuous

(b) Linear and time-varying

(c) Nonlinear and time invariant

(d) Linear and time invariant

ii. A.C. servomotor resembles **1**

(a) Two phase induction motor (b) Three phase induction motor

(c) Direct current series motor (d) Universal motor

iii. The velocity error constant of a stable canonical feedback system is given by **1**

(a) $\lim_{s\to 0} G(s)$ (b) $\lim_{s\to 0} sG(s)$ (c) $\lim_{s\to 0} s^2G(s)$ (d) None of these

iv. The solution of differential equation $\frac{d^2y}{dt^2} + 2\frac{dy}{dx} + 2y = 3$ **1**

(a) Oscillatory (b) Overdamped

(c) Underdamped (d) Critically damped

v. Using Routh's criterion, the number of roots in the right half s-plane for the characteristic equation: S4+2S3+2S2+3S+6=0 is **1**

(a) One (b) Two (c) Three (d) Four

vi. Which of the following describes correctly the effect of adding a zero to the system? **1**

(a) System becomes oscillatory.

(b) Root locus shifts toward imaginary axis.

(c) Relative stability of the system increases

(d) Operating range of K for stable operation decreases

vii. The transfer function of a phase-lead compensator is given by: **1**
$G(s) = \frac{1+3Ts}{1+Ts}$ Where T>0
What is the maximum shift provided by such a compensator?
(a) 90^0 (b) 60^0 (c) 45^0 (d) 30^0

viii. Consider the following statements: **1**
I. Bandwidth is increased
II. Peak overshoot in the step response is increased
Which of these are the effects of using lead compensation in a feedback system?
(a) I only (b) II only
(c) Both I and II (d) Neither I nor II

ix. The system $\dot{x}=Ax+Bu$ with A=$\begin{bmatrix}-1 & 2\\ 0 & 2\end{bmatrix}$, B=$\begin{bmatrix}0\\1\end{bmatrix}$ is **1**
(a) Stable and controllable. (b) Stable but Uncontrollable.
(c) Unstable but controllable. (d) Unstable and uncontrollable.

x. The system matrix of a linear time invariant continuous time system is given by A=$\begin{bmatrix}0 & 1\\ -3 & -5\end{bmatrix}$ **1**
(a) s2+5s+3=0 (b) s2-3s+5=0
(c) s2+3s+5=0 (d) s2+s+2=0

Q.2 i. Obtain the system equation and find the value of $X_2(s)/F(s)$ for the system shown in Fig.1 **3**

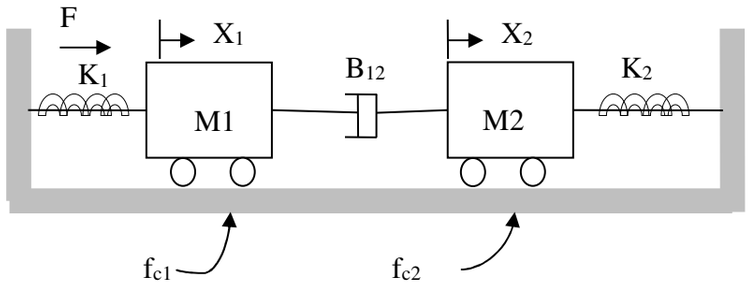

Fig .1

ii. Determine the transfer function C_1/R_1, C_2/R_2, C_1/R_2, C_2/R_1 from the block diagram shown in Fig.2 **7**

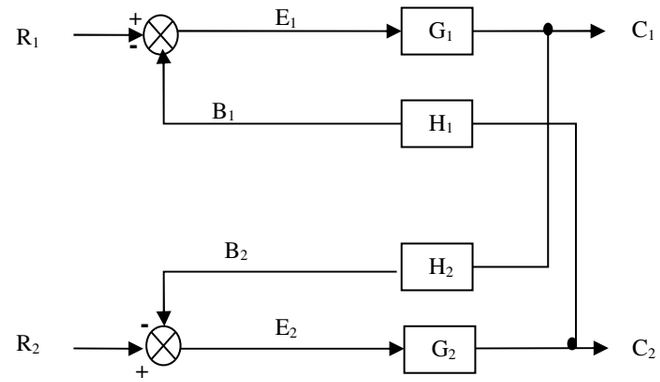

Fig.2

OR iii. Draw the block diagram and signal flow graph and find out the transfer function of the circuit shown in Fig.3 **7**

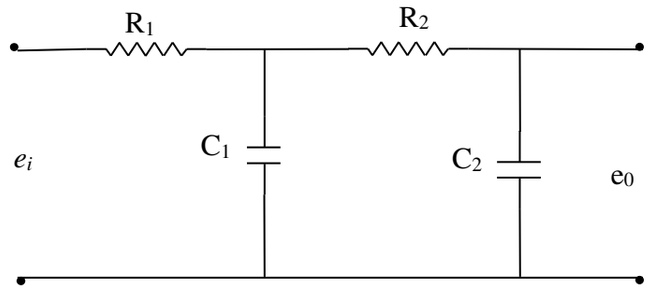

Fig.3

Q.3 i. Define static error coefficients in control system. **3**

ii. A unity feedback system is characterized by an open loop transfer function $G(s) = \frac{K}{s(s+20)}$. Determine the gain K so that the system will have a damping ratio of 0.6. For this value of K calculate settling time, peak overshoot and time to peak overshoot for a unit step input. **7**

OR iii. Derive the expression and response of the first order system with unit step input. **7**

Q.4 i. Define resonant peak, resonant frequency and bandwidth. **3**

Marking Scheme
EE3CO15 / EX3CO15 Linear Control System

Q.1 i. A system can be completely described by a transfer function if it is **1**
(d) Linear and time invariant

ii. A.C. servomotor resembles **1**
(a) Two phase induction motor

iii. The velocity error constant of a stable canonical feedback system is given by **1**
(b) $\lim_{s\to 0} sG(s)$

iv. The solution of differential equation $\frac{d^2y}{dt^2} + 2\frac{dy}{dx} + 2y = 3$ **1**
(c) Underdamped

v. Using Routh's criterion, the number of roots in the right half s-plane for the characteristic equation: S4+2S3+2S2+3S+6=0 is **1**
(b) Two

vi. Which of the following describes correctly the effect of adding a zero to the system? **1**
(c) Relative stability of the system increases

vii. The transfer function of a phase-lead compensator is given by: **1**
$G(s) = \frac{1+3Ts}{1+Ts}$ Where T>0
What is the maximum shift provided by such a compensator?
(d) 30^0

viii. Consider the following statements: **1**
I. Bandwidth is increased
II. Peak overshoot in the step response is increased
Which of these are the effects of using lead compensation in a feedback system?
(a) I only

ix. The system $\dot{x}=Ax+Bu$ with A=$\begin{bmatrix}-1 & 2\\ 0 & 2\end{bmatrix}$, B=$\begin{bmatrix}0\\1\end{bmatrix}$ is **1**
(c) Unstable but controllable.

x. The system matrix of a linear time invariant continuous time system is given by A=$\begin{bmatrix}0 & 1\\ -3 & -5\end{bmatrix}$ **1**
(a) s2+5s+3=0

Q.2	i.	Derive system equation	1.5 marks	**3**
		Value of $X_2(s)/F(s)$	1.5 marks	
	ii.	Determine the transfer function C_1/R_1,	1.5 marks	**7**
		C_2/R_2,	1.5 marks	
		C_1/R_2	2 marks	
		C_2/R_1	2 marks	
OR	iii.	Draw the block diagram	2 marks	**7**
		Signal flow diagram	2 marks	
		Transfer function of the circuit	3 marks	
Q.3	i.	Define static error coefficients in control system.		**3**
		Position error coefficient	1 mark	
		Velocity error coefficient	1 mark	
		Acceleration error coefficient	1 mark	
	ii.	Value of K	2 marks	**7**
		Settling time	2 marks	
		Peak overshoot	2 marks	
		Time to peak overshoot	1 mark	
OR	iii.	Derive the expression	4 marks	**7**
		Response of the first order system	3 marks	
Q.4	i.	Definition of		**3**
		Resonant peak	1 mark	
		Resonant frequency	1 mark	
		Bandwidth	1 mark	
	ii.	Determine:		**7**
		Sketch of bode plot	4 marks	
		Gain cross over frequency	0.5 mark	
		Phase cross over frequency	0.5 mark	
		G.M and P.M	1 mark	
		Stability of the given system	1 marks	
OR	iii.	Show all the salient points on the locus.		**7**
		Stepwise marking		
Q.5	i.	Type of compensator used in control system		**3**
		Series compensation	1 mark	
		Feedback compensation	1 mark	
		Load compensation	1 mark	
	ii.	Compare the characteristics of phase lead and phase lag networks used for control system compensation		**7**
OR	iii.	Root locus plot	4 marks	**7**
		Design	3 marks	
Q.6	i.	State transition matrix	2 marks	**3**
		Determine x(t)	1 mark	

	ii.	State equations	4 marks	**7**
		State variable diagram	3 marks	
OR	iii.	Find the state and output equation	3 marks	**7**
		Test controllability	2 marks	
		Test observability of the system	2 marks	

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