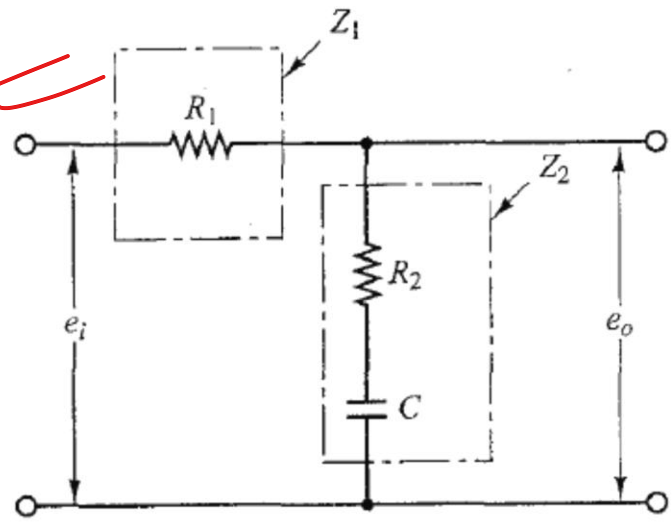
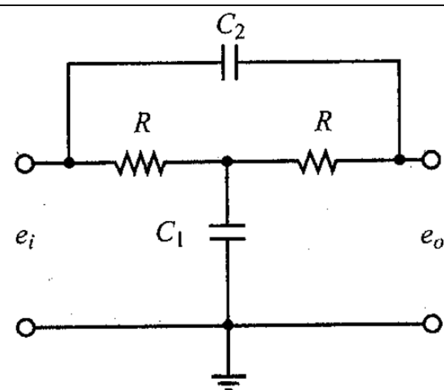
$T(x_1) = \dot{x}_1 + x_1(t)$ $\quad a_1 T(x_1) + a_2 T(x_2)$

$T(x_2) = \dot{x}_2 + x_2(t)$ $\quad a_1\dot{x}_1 + a_2\dot{x}_2 + a_1x_1(t) + a_2x_2(t)$

$T(a_1x_1 + a_2x_2)$

OPEN ELECTIVE: Basic Linear Control Systems

	Sample Questions of 5 marks	Marks
1)	Determine if the system $y(t) = \dot{x} + x(t)$ is time-invariant, linear, causal, and/or memoryless?	**5**
2)	Solve the following differential equation using the Laplace Transform method: $\dot{y} - 2y = 2x$, with, $x(t) = u(t)$, $y(0) = -1$.	**5**
3)	Find the initial value of $\frac{df(t)}{dt}$ for $F(s) = \mathfrak{L}[f(t)] = \frac{2s+1}{s^2+s+1}$	**5**
4)	Determine whether the system characterized by the differential equation $\ddot{y}(t) - \dot{y}(t) + 2y(t) = x(t)$ is stable or not? Assume zero initial conditions.	5
5)	The unit impulse response of an LTI system is the unit step function $u(t)$. Find the response of the system to an excitation $e^{-at}u(t)$.	5
6)	The response of an LTI system to a step input, $u(t)$, is $y(t) = (1 - e^{-2t})u(t)$. Find the response of the system to an input $x(t) = 4u(t) - 4u(t-1)$. $T(s)$	5
7)	Find state equations for the following system $\ddot{y}(t) + 2\dot{y}(t) + 4y(t) = 2u(t)$.	5
8)	Determine if the system $\dot{y}(t) + 4ty(t) = 2x(t)$ is time-invariant, linear, causal, and/or memoryless?	5
9)	Find state equations for the following system $\ddot{y}(t) - 4y(t) = u(t)$.	5
10)	Find the unit impulse response of the system characterized by the following differential equation $\dot{y} + ay = x$. Assume zero initial condition.	5
11)	With the help of a schematic diagram define the different variables and control variables associated with an closed-loop control system.	5
12)	Why PID controller is called a “Gain-Reset-Preact Controller”?	5
13)	Describe, stating the assumption, the Ziegler Nichols method of PID controller tuning based on unit step test.	5
14)	Explain the Ziegler Nichols method of PID controller tuning based on critical gain test	5
15)	For a type-0 system, explain how PI-controller can eliminate the steady-state offset while P-controller can only reduce it.	5
16)	Explain with example, “Direct acting” and “Reverse Acting” mode of process control.	5
17)	What are the main advantages of Closed-loop Control Systems over Open-loop Control?	5
18)	“Modeling is a compromise between complexity and accuracy”: Justify.	5

Sample Questions of 10 marks	
For a standard 2nd order system find the expressions for time-response (indicate respective pole locations) for (i) over-damped and (ii) undamped condition.	5+5
For a standard 2nd order system find the expressions for time-response (indicate respective pole locations) for (i) under-damped and (ii) critically damped condition.	5+5
 Obtain the transfer function, $E_o(s)/E_i(s)$, for the network shown in Figure. $e_i = R_1 I(t) + R_2 I(t) + \frac{1}{C}\int I(t)\,dt$ $e_o = \frac{1}{C}\int I(t)\,dt = \frac{1}{Cs} I(s)$	**8**
Consider an LTI system given by the transfer function: $$G(s) = \frac{s^2 + 9s + 15}{s^3 + 7s^2 + 16s + 4}$$ Obtain the state-space model of the system in the phase variable canonical form. Draw the corresponding block diagram indicating the individual states.	**8+4**
~~Obtain the transfer function, $E_o(s)/E_i(s)$, for the bridged-T-network shown in Figure.~~ 	**10**
Draw the asymptotic Bode magnitude plot for the system having a transfer function $$G(s) = \frac{20s}{(s+1)(s+3)^2(s+10)}$$ $w = 1, w = 3 \quad w = 10$	**10**

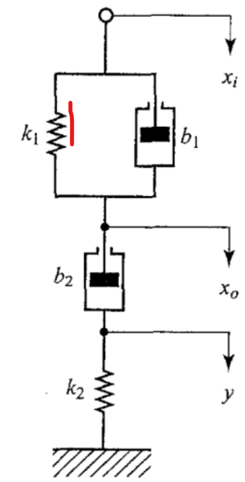
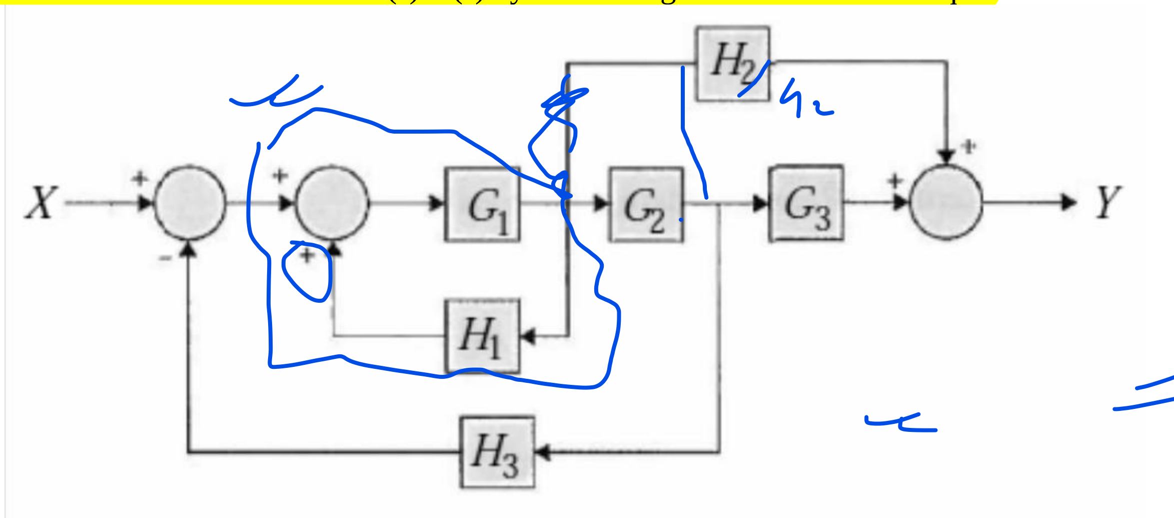
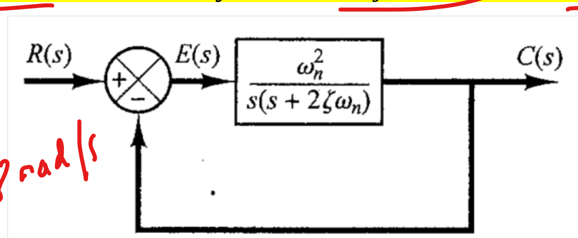
$20\log_{10}\frac{2}{9}$

$0.22 =$

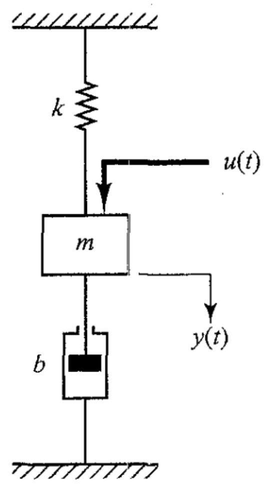
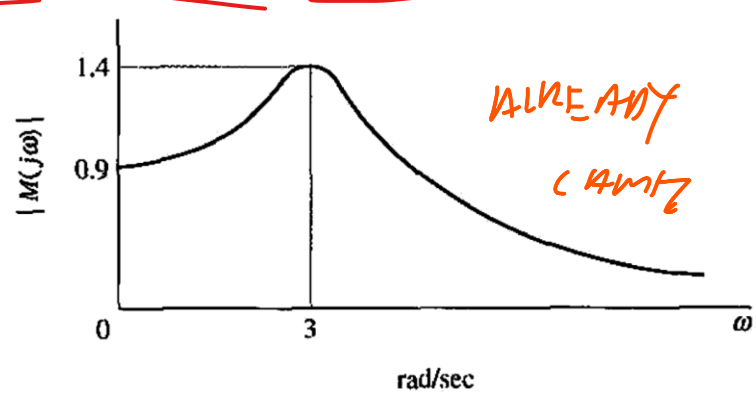
$20\log_{10}$

$G(s) = \frac{2}{9}\frac{s}{(1+s/3)(1+s/10)}$

$G(s) = \frac{20}{1\times3^2\times10\,(s/3+1)\cdot(s/10+1)}$

Obtain the transfer function, $X_o(s)/X_i(s)$, for the mechanical system shown in Figure. Obtain the analogous electrical network based on the *force-voltage* analogy. Already Done 	**5+5**
Obtain the transfer function Y(s)/X(s) by Block-diagram reduction technique. 	**10**
Consider the system shown in Figure, where the damping ratio and undamped natural frequency are 0.5 and 8 rad/sec, respectively. Obtain the rise time, peak time, maximum overshoot, and settling time, when the system is subjected to a unit-step input. $\zeta = 0.5$ $\omega_n = 8$ rad/s 	3+3+3+3
Consider the mechanical system shown in Figure. Assume that the system is linear. The external force $u(t)$ is the input to the system, and the displacement $y(t)$ of the mass is the output. The displacement $y(t)$ is measured from the equilibrium position in the absence of the external force.	4+4+4

$$\frac{1}{s}\left(\frac{\omega_n^2}{s^2+2\zeta\omega_n s+0}\right) \quad \frac{\omega_n^2}{s^2+2\zeta\omega_n s}$$

	(i) Obtain a state-space representation of the system. (ii) From state-space model obtain the transfer function. (iii) Obtain the analogous electrical network based on *force-current* analogy.  	
	Consider the system defined by $$\dot{\boldsymbol{x}} = \boldsymbol{A}\boldsymbol{x} + \boldsymbol{B}u, \quad y = \boldsymbol{C}\boldsymbol{x}$$ where $$\boldsymbol{A} = \begin{bmatrix} 2 & 1 \\ -3 & -4 \end{bmatrix}, \quad \boldsymbol{B} = \begin{bmatrix} 2 \\ 1 \end{bmatrix}, \quad \boldsymbol{C} = [1\ 1]$$ Obtain the Transfer function of the System. Transform the system equations into the controllable canonical form.	6+4
	The closed-loop frequency response of a second-order prototype system is shown in Figure. Sketch the corresponding unit-step response of the system. Indicate the values of the maximum overshoot, peak time, and the steady-state error due to a unit-step input.  	10
	Consider a control system in which a PID controller is used to control the plant $$G(s) = \frac{1}{s(s+2)(s+4)}$$ Determine the parameters of PID controller by Ziegler-Nichols tuning rule.	10