S J P N Trust's

# Hirasugar Institute of Technology, Nidasoshi.

*Inculcating Values, Promoting Prosperity*

Approved by AICTE, Recognized by Govt. of Karnataka and Affiliated to VTU Belagavi.

E&C Engg. Dept.
Exam.
Internal Assessment
Even Sem(2017-18)

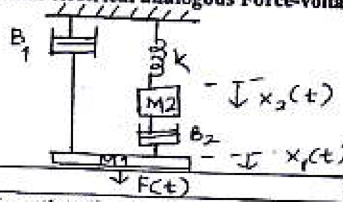
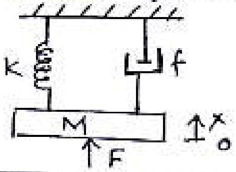
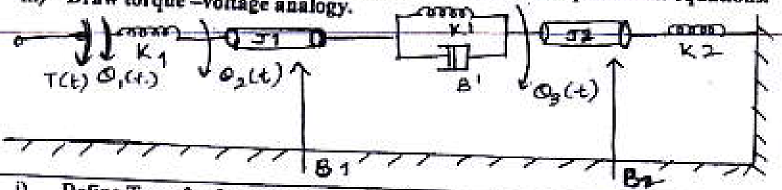
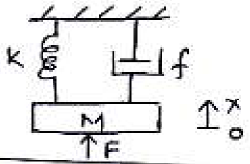
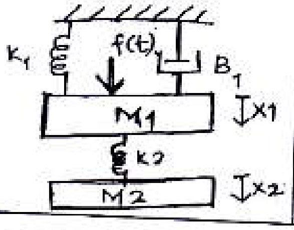
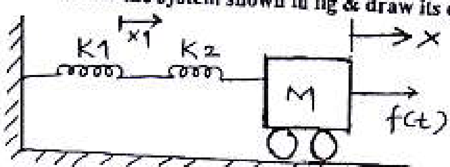
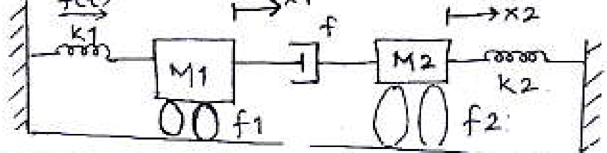
## FIRST INTERNAL ASSESSMENT

Sem: IV ( EC)
Date: 06/03/2018

Sub: Control systems
Time: 11-12 p.m

Sub. Code: 15EC43
Max. Marks: 25

*Note: Answer two full questions, draw sketches wherever necessary.*

| Q. No | | Description of Question | Marks | CO | RBT Level |
|---|---|---|---|---|---|
| 1 | a | i) **Define Control System.** ii) **Explain linear & non-linear control system.** | 6 | 211 .1 | L1,L2 ,L3 |
| | b | **For the mechanical system shown in fig :**<br>i) **Draw equivalent mechanical network.** ii) **Write equilibrium equations.**<br>ii) **Obtain electrical analogous Force-voltage & Force-current analogy & write equations.**<br> | 7 | 211 .1 | L1,L2 ,L3 |
| | | **OR** | | | |
| 2 | a | i) **Differentiate the concept of open loop & closed loop systems with a example.**<br>ii) **For the mechanical system shown in fig draw the free body diagram & write the force equation.**<br> | 6 | 211 .1 | L1,L2 ,L3 |
| | b | **For the mechanical system shown in fig :**<br>i) **Draw equivalent mechanical network** ii) **Write equilibrium equations.**<br>iii) **Draw torque –voltage analogy.**<br> | 7 | 211 .1 | L1,L2 ,L3 |
| 3 | a | i) **Define Transfer function of a linear time invariant system.**<br>ii) **Find the Transfer function of the mass-spring-dashpot system.**<br> | 6 | 211 .1 | L1,L2 ,L3 |
| | b | **For the mechanical system shown in fig .**<br>i) **Obtain the equations of motion for masses M1 & M2.**<br>ii) **Find the transfer function** $x2(s)/F(S)$<br> | 6 | 211 .1 | L1,L2 ,L3 |
| | | **OR** | | | |
| 4 | a | **Obtain transfer function of the system shown in fig & draw its electrical analogy.**<br> | 6 | 211 .1 | L1, L2, L3 |
| | b | **Obtain the nodal equations for the system shown in figure & draw its electrical analogy based on F-I Analogy.**<br> | 6 | 211 .1 | L1, L2, L3 |

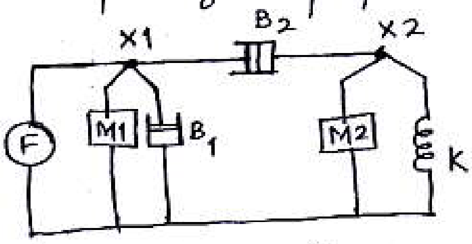
Course coordinator Module coordinator HOD

# SCHEME OF EVALUATION

| Sem : IV<sup></sup>th | Subject : Control systems | Sub Code : 15EC43 | Date : 6/3/2018 |
|---|---|---|---|

| Q. No. | Bit | Description | Marks | CO's | RBT LEVEL |
|---|---|---|---|---|---|
| 1 | a) i) | Definition | 2+4 | 211.1 | L3 |
| | ii) | Linear & Non-linear Control system principle of Superposition & homogeneity | | | |
| | b) | (see below) | 2+2+3 | 211.1 | L3 |
| 2 | a) | open loop & closed loop differentiation ; Feedback Action | 2+4 | 211.1 | L3 |

**1 b)**




Node 1: $F = M_1 s^2 X_1 + B_1 s X_1 + B_2 s (X_1 - X_2)$

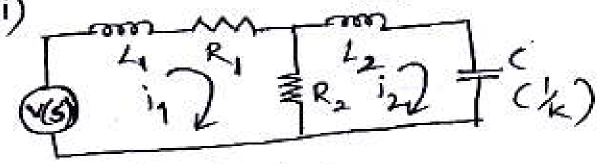
Node 2: $0 = M_2 s^2 X_2 + K X_2 + B_2 s (X_2 - X_1)$

F-V Analogy

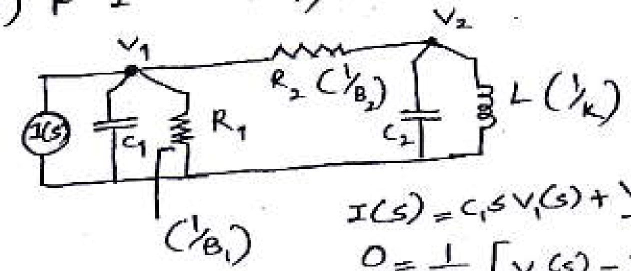
$V(s) = L_1 s I_1(s) + R_1 I_1(s) + R_2 [I_1(s) - I_2(s)]$

$0 = L_2 s I_2(s) + \frac{1}{sC} I_2(s) + R_2 [I_2(s) - I_1(s)]$

i)



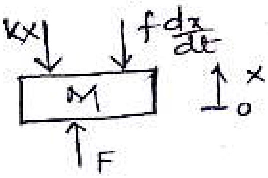

ii) F-I Analogy




$I(s) = C_1 s V_1(s) + \frac{V_1(s)}{R_1} + \frac{1}{R_2}[V_1(s) - V_2(s)]$

$0 = \frac{1}{R_2}[V_2(s) - V_1(s)] + C_2 s V_2(s) + \frac{1}{sL} V_2(s)$

**2 a)** open loop & closed loop differentiation ; Feedback Action




$F = M\frac{d^2x}{dt^2} + f\frac{dx}{dt} + Kx$

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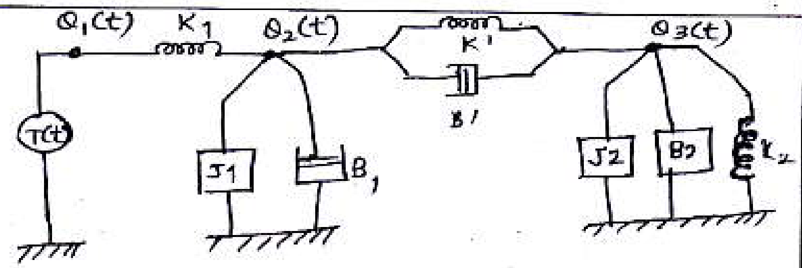
# SCHEME OF EVALUATION

| Sem : IV th | Subject : Control Systems | Sub Code : 15EC43 | Date : 06/03/2018 | | |
|---|---|---|---|---|---|
| **Q. No.** | **Bit** | **Description** | **Marks** | **CO's** | **RBT LEVEL** |
| 2 | b) | see below | 2+5 | 211.1 | L3 |
| 3 | a) | see below | 2+4 | 211.1 | L3 |

**2 b)**




$$T(s) = K_1[\theta_1(s) - \theta_2(s)]$$

$$0 = K_1[\theta_2(s) - \theta_1(s)] + J_1 s^2 \theta_1(s) + B_1 s\, \theta_2(s) + K'[\theta_2(s) - \theta_3(s)] + B' s[\theta_2(s) - \theta_3(s)]$$

$$0 = K'[\theta_3(s) - \theta_2(s)] + B' s[\theta_3(s) - \theta_2(s)] + J_2 s^2 \theta_3(s) + B_2 s\, \theta_3(s) + K_2 \theta_3(s)$$

T-V Analogy

$$V(s) = \frac{1}{C_1}[q_1(s) - q_2(s)]$$

$$0 = \frac{1}{C_1}[q_2(s) - q_1(s)] + L_1 s^2 q_2(s) + R_1 s q_2(s)] + \frac{1}{C'}[q_2(s) - q_3(s)] + R' s[q_2(s) - q_3(s)]$$

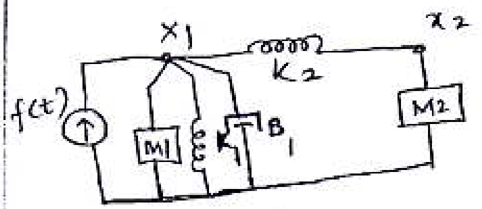
$$0 = \frac{1}{C'}[q_3(s) - q_2(s)] + R' s[q_3(s) - q_2(s)] + L_2 s^2 q_3(s) + R_2 s\, q_3(s) + \frac{1}{C_2} q_3(s)$$

**3 a)**

i) Transfer function definition

ii) $$G(s) = \frac{X(s)}{F(s)} = \frac{1}{Ms^2 + fs + K}$$

**b)**



## SCHEME OF EVALUATION

| Sem : IV | Subject : Control Systems | Sub Code : 15EC43 | Date : 6/3/2018 | | |
|---|---|---|---|---|---|
| **Q. No.** | **Bit** | **Description** | **Marks** | **CO's** | **RBT LEVEL** |
| 3 | b | Node $x_1$ $M_1\frac{d^2x_1}{dt^2}+B_1\frac{dx_1}{dt}+K_1x_1+K_2(x_1-x_2)=f(t)$ | 2+4 | 211.1 | L3 |
| 4 | a) | (see below) | 2+4 | 211.1 | L3 |

**3 b)**

Node $x_1$ $\quad M_1\frac{d^2x_1}{dt^2}+B_1\frac{dx_1}{dt}+K_1x_1+K_2(x_1-x_2)$

$= f(t)$

Node $x_2$ $\quad M_2\frac{d^2x_2}{dt}+K_2(x_2-x_1)=0$

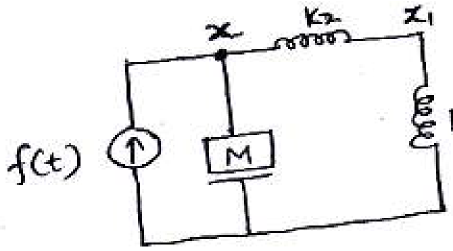
Taking L.T on both sides

$$[M_1s^2+B_1s+K_1+K_2]\,X_1(s)-K_2X_2(s)=F(s)$$

$$M_2s^2X_2(s)+K_2X_2(s)-K_2X_1(s)=0$$

$$\frac{X_2(s)}{F_2(s)}=\frac{K_2}{\Delta} \qquad \Delta=(M_1s^2+B_1s+K_1+K_2)(M_2s^2+K_2)-K_2^2$$

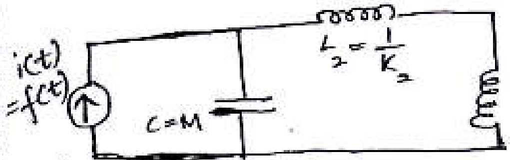
**4 a)**




Node $x$: $\quad M\ddot{x}+K_2(x-x_1)=f(t)$

Node $x_1$: $\quad K_1x_1=K_2(x-x_1)$

$$\therefore \frac{X(s)}{F(s)}=\frac{1}{Ms^2+\frac{K_1K_2}{K_1+K_2}}$$

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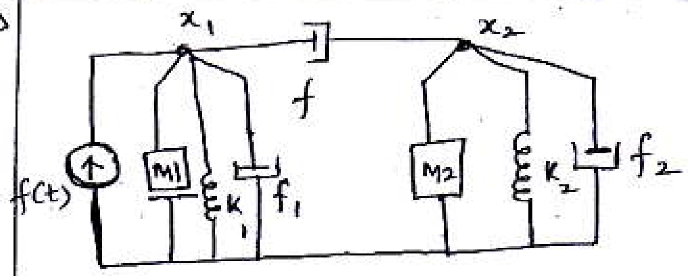
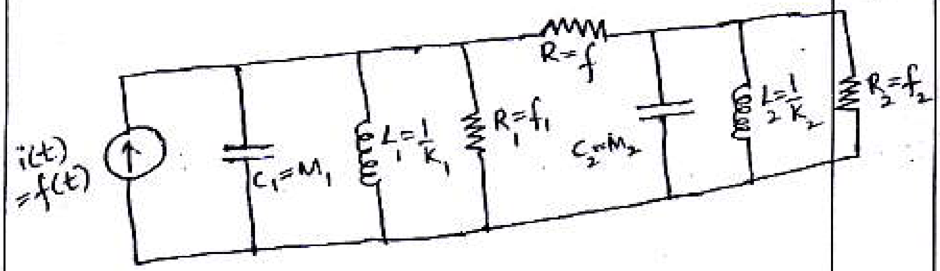
# SCHEME OF EVALUATION

| Sem : IV | Subject : Control Systems | Sub Code : 15EC43 | Date : 6/3/18 | | |
|---|---|---|---|---|---|
| **Q. No.** | **Bit** | **Description** | **Marks** | **CO's** | **RBT LEVEL** |
| 4 | b) | (see below) | 3+3 | 211.1 | L3 |




Node $x_1$ $\quad M_1\ddot{x}_1 + f_1\dot{x}_1 + f(\dot{x}_1 - \dot{x}_2) + K_1x_1 = f(t)$

Node $x_2$ $\quad M_2\ddot{x}_2 + f_2\dot{x}_2 + K_2x_2 = f(\dot{x}_1 - \dot{x}_2)$



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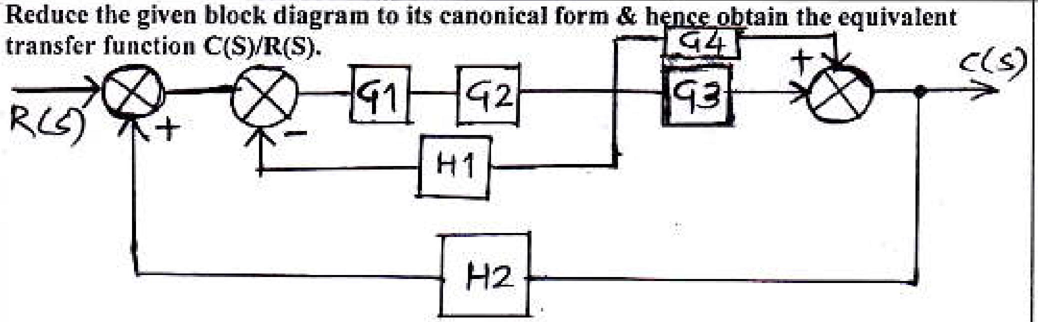
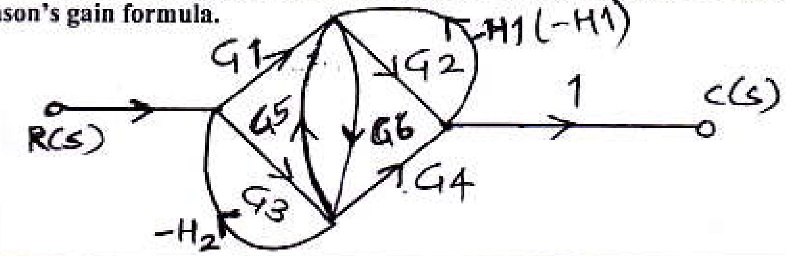
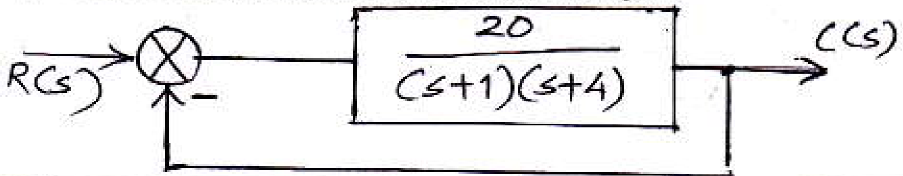
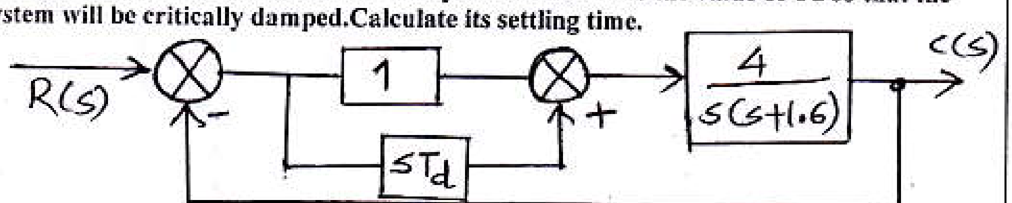
E&C Engg. Dept.
Exam.
Internal Assessment
Even Sem(2017-18)

# SECOND INTERNAL ASSESSMENT

Sem: IV ( EC) | Sub: Control systems | Sub. Code: 15EC43
Date: 12/04/2018 | Time: 11-12 p.m | Max. Marks: 25

*Note: Answer two full questions, draw sketches wherever necessary.*

| Q. No | | Description of Question | Marks | CO | RBT Level |
|---|---|---|---|---|---|
| 1 | a | Reduce the given block diagram to its canonical form & hence obtain the equivalent transfer function C(S)/R(S).   | 6 | 211.1 | L3 |
| | b | For the Signal flow graph shown in fig determine the transfer function C(s)/R(s) using Mason's gain formula.   | 7 | 211.1 | L3 |
| OR | | | | | |
| 2 | a | List the standard test signals & explain with diagrams. Describe the time response of first order systems with appropriate graphs & equations. Also find what is the steady state error. | 6 | 211.2 | L3 |
| | b | i) Explain the following time response specifications. 1. Delay time $t_d$ 2. Rise time $t_r$ 3. Peak tiime $t_p$ 4. Peak Overshoot $M_p$ 5. Settling time $t_s$ 6. Steady-state error ess.<br>ii) With diagram describe the concept of PI Controller. | 7 | 211.2 | L3 |
| 3 | a | i) The closed loop T.F of a 2 $^{nd}$ order system is given as $T(S)=100/[S^2+10S+100]$. Determine damping ratio, $\omega_n$ of Oscillation, $T_s$ & Mp.<br>ii) For the system shown in fig Obtain the closed loop T.F, damping ratio, $\omega_n$ & expression for the O/P response if subjected to unit step I/P.   | 6 | 211.2 | L3 |
| | b | i) The loop T.F of a feedback control system is given by $G(S)H(S) = 100/[S^2(S+4)(S+12)]$. Determine the static error coefficient.<br>ii) A System has 30% Mp & Ts of 5 Sec for an unit step i/p. Determine 1) T.F 2) Tp 3) O/P Response. | 6 | 211.2 | L3 |
| OR | | | | | |
| 4 | a | The figure shows PD Controller for the system . Determine the value of Td so that the system will be critically damped. Calculate its settling time.   | 6 | 211.2 | L3 |
| | b | What is the response of Second order system to the unit step i/p taking the example of servomechanism. | 6 | 211.2 | L3 |

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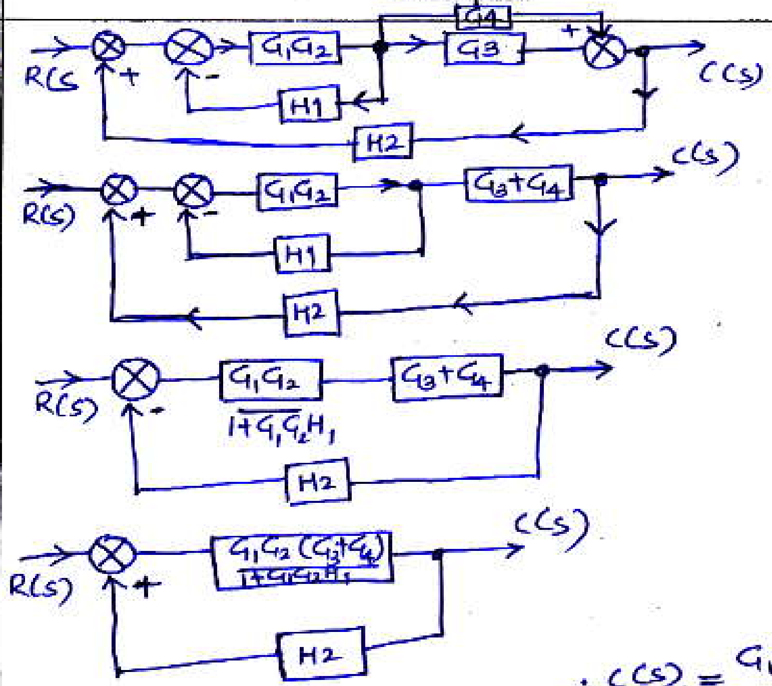
| ECE |
|---|
| Academic |
| IA Scheme |
| AY: 2017-18 (Odd) |

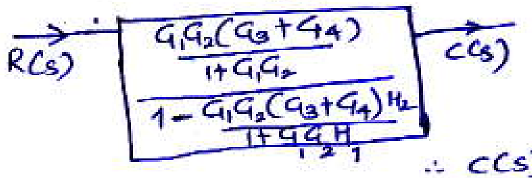


## - IA SCHEME OF EVALUATION

| Sem : IV | Subject : Control Systems | | Sub Code : 15EC43 | Date : 12/04/2018 |
|---|---|---|---|---|
| Q. No. | Bit | Description | Marks | Mapped CO's |
| 1 | a) | (block diagram reduction, see below) | 6 | 211.1 L3 |
| 2 | b) | (signal flow graph, see below) | 7 | 211.1 L3 |

**1 a)**




$$\therefore \frac{C(s)}{R(s)} = \frac{\frac{G_1G_2(G_3+G_4)}{1+G_1G_2}}{\frac{1+G_1G_2H_1-G_1G_2(G_3+G_4)H_2}{1+G_1G_2}}$$

$$\therefore \frac{C(s)}{R(s)} = \frac{G_1G_2(G_3+G_4)}{1+G_1G_2H_1-G_1G_2(G_3+G_4)H_2}$$

**2 b)**

No of forward paths = K = 4

$T_1 = 1.G_1G_2.1 = G_1G_2$

$T_2 = 1.G_3G_4.1 = G_3G_4$

$T_3 = 1.G_1.G_6.G_4.1 = G_1G_6G_4$

$T_4 = 1.G_3G_5G_2.1 = G_2G_3G_5$

Individual loops are

$L_1 = -G_2H_1 \quad L_2 = -G_3H_2 \quad L_3 = G_5G_6$

$L_4 = -G_4H_1G_6 \quad L_5 = -G_1G_6H_2$

Combination of two non touching loops are

i) $L_1$ & $L_2$

ii) No combination of three non touching loops

~~$L_1$ & $L_2$~~

Course Coordinator

Module Coordinator

HOD

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| ECE Dept. |
|---|
| Exam. |
| IA Scheme Evaluation |
| Even Sem (2017-18) |



# SCHEME OF EVALUATION

Sem : IV | Subject : Control Systems | Sub Code : 15EC43 | Date : 12/04/2018

| Q. No. | Bit | Description | Marks | CO's | RBT LEVEL |
|---|---|---|---|---|---|
| | | $\Delta = 1-(L_1+L_2+L_3+L_4+L_5)+(L_1L_2)$ | | | |
| | | $= 1-[(-G_2H_1-G_3H_2+G_5G_6-G_4G_6H_1-G_1G_6H_2)] + [(-G_2H_1)(-G_3H_2)]$ | | | |
| | | $\Delta = 1+G_2H_1+G_3H_2-G_5G_6+G_4G_6H_1+G_1G_6H_2 + G_2G_3H_1H_2$ | | | |
| | | For all forward paths all the loops are touching hence $\Delta_1=\Delta_2=\Delta_3=\Delta_4=1$ | | | |
| | | Hence $\frac{C(s)}{R(s)} = \frac{\sum T_K\Delta_K}{\Delta} = \frac{T_1\Delta_1+T_2\Delta_2+T_3\Delta_3+T_4\Delta_4}{\Delta}$ | | | |
| | | $= \frac{G_1G_2+G_3G_4+G_1G_6G_4+G_2G_3G_5}{1+G_2H_1+G_3H_2-G_5G_6+G_5G_6H_1+G_1G_6H_2+G_2G_3H_1H_2}$ | | | |
| 2 | a) | Step signal:- is a signal whose value changes from one level to another level A in zero time. Mathematical representation of step function is $r(t)=Au(t)$; $u(t)=1;\ t>0$, $=0;\ t<0$. In L.T form $R(s)=\frac{A}{s}$ | 6 | 211.2 | L3 |
| | | Ramp signal:- is a signal which starts at a value of zero & increases linearly with time. Mathematically $r(t)=At;\ t>0$, $=0;\ t<0$. In L.T $R(s)=A/s^2$ | | | |
| | | Parabolic signal: Mathematical representation of a parabolic signal is $r(t)=At^2/2;\ t>0$, $=0;\ t<0$. In L.T form $R(s)=A/s^3$ | | | |
| | | Impulse signal:- is defined as a signal | | | |

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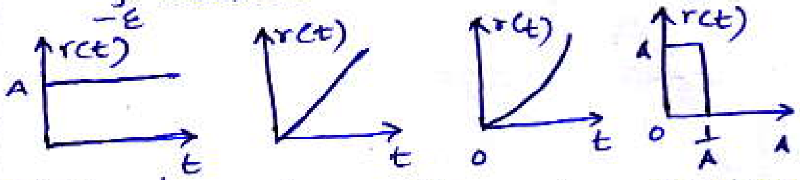
## SCHEME OF EVALUATION

| Sem : | | Subject : | Sub Code : | Date : | | |
|---|---|---|---|---|---|---|
| Q. No. | Bit | Description | | Marks | CO's | RBT LEVEL |

which has zero value everywhere except at $t=0$, where its magnitude is infinite, Generally called $\delta$-function & has following Property

$$\delta(t)=0\,;\ t\neq 0$$

$$\int_{-\varepsilon}^{+\varepsilon}\delta(t)\,dt=1 \quad \varepsilon \text{ tends to zero.}$$

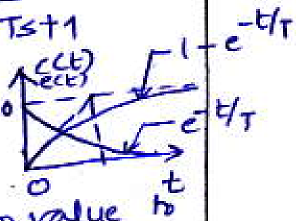



First order system: O/p response is given by

$$C(s)=\frac{1}{s(Ts+1)}=\frac{1}{s}-\frac{T}{Ts+1}$$

Taking inverse L.T, we get

$$c(t)=1-e^{-t/T}$$




O/p rises exponentially from zero value to final value of unity.

Initial slope of curve at $t=0$ is given by

$$\left.\frac{dc}{dt}\right|_{t=0}=\left.\frac{1}{T}e^{-t/T}\right|_{t=0}=\frac{1}{T}$$

$T \rightarrow$ time constant of the system.

$$e_{ss}=\lim_{t\to\infty}e(t)=0 \leftarrow$$ System tracks the unit step I/p with zero steady state error.

| Q. No. | Bit | Description | Marks | CO's | RBT LEVEL |
|---|---|---|---|---|---|
| 2 | b) i) | 1. Delay time $t_d$: It is the time required for the response to reach 50% of the final value in 1st attempt. | 5 + 2 | 211.2 | L3 |
| | | 2. Rise time $t_r$:- It is the time required for the response to rise from 10% to 90% | | | |

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## SCHEME OF EVALUATION IA-

| Sem : | | Subject : | Sub Code : | Date : | |
|---|---|---|---|---|---|
| **Q. No.** | **Bit** | **Description** | **Marks** | **CO's** | **RBT LEVEL** |

3. peak time $t_p$ :- It is the time required for the response to rise from 10% to 90% of the final value for overdamped systems & 0 to 100% of final value for underdamped systems.

4. peak overshoot $M_p$ :- It indicates the normalized diff betw the time response peak & the steady o/p & is defined as

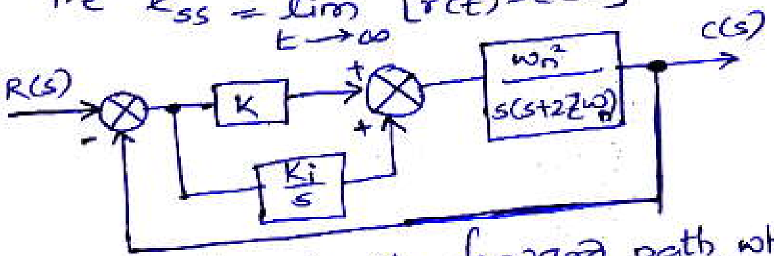
$$\text{peak Percent overshoot} = \frac{c(t_p) - c(t_\infty)}{c(\infty)} \times 100\%$$

5. settling time $t_s$ :- It is the time required for the response to reach & stay within a specified tolerance band of its final value.

6. steady state error $e_{ss}$ :- It indicates the error between the actual o/p & desired o/p as t tends to infinity.

i.e $e_{ss} = \lim_{t \to \infty} [r(t) - c(t)]$

2 b ii) L3




A controller in the forward path, which changes the controller I/p to the proportional + integral of the error signal is called PI controller.

I/p to Controller $= K e(t) + K_i \int e(t)\,dt$

Taking Laplace $= K E(s) + \frac{K_i}{s} E(s)$

$= E(s)\left[K + \frac{K_i}{s}\right]$

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ECE Dept.
Exam. Scheme
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Page. No. /

## SCHEME OF EVALUATION IA-

Sem : | Subject : | Sub Code : | Date :

| Q. No. | Bit | Description | Marks | CO's | RBT LEVEL |
|---|---|---|---|---|---|
| 3 | a) i) | comparing the denominator of T(s) with $s^2+2\xi\omega_n s+\omega_n^2$, we get<br>$\omega_n^2=100$, $\omega_n=10$ rad/sec<br>& $2\xi\omega_n=10$ $\therefore \xi=\frac{10}{2\omega_n}=0.5$<br>$\omega_d=\omega_n\sqrt{1-\xi^2} = 10\sqrt{1-(0.5)^2}=8.66$ rad/sec<br>$T_r=\frac{\pi-\theta}{\omega_d}=\frac{\pi-1.0471}{8.66}=0.24185$<br>$T_s=\frac{4}{\xi\omega_n}=\frac{4}{0.5\times10}=0.8$ sec.<br>$\%M_p=e^{-\pi\xi/\sqrt{1-\xi^2}}\times100=16.3\%$ | 6 | 211.2 | L3 |
| | ii) | $\frac{C(s)}{R(s)}=\frac{20}{s^2+5s+24}$<br>from denominator we have<br>$\omega_n^2=24$ $\omega_n=4.8989$ rad/sec<br>$2\xi\omega_n=5$ $\therefore \xi=0.51031$<br>$\omega_d=\omega_n\sqrt{1-\xi^2}=4.2129$ rad/sec<br>$c(t)=\frac{20}{24}\left[1-\frac{e^{-\xi\omega_n t}}{\sqrt{1-\xi^2}}\sin(\omega_d t+\theta)\right]$<br>$c(t)=\frac{20}{24}\left[1-1.1628e^{-2.5t}\sin(4.2129t+1.03)\right]$ | | | |
| | b) i) | Static error coefficients are<br>$K_p=\lim_{s\to0}G(s)H(s)=\lim_{s\to0}\frac{100}{s^2(s+4)(s+12)}=\infty$ | 6 | 211.2 | L3 |

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## SCHEME OF EVALUATION IA-

| Sem : | | Subject : | Sub Code : | Date : | | |
|---|---|---|---|---|---|---|
| **Q. No.** | **Bit** | **Description** | | **Marks** | **CO's** | **RBT LEVEL** |
| 3 | b) | $K_v = \lim_{s\to 0} sG(s)H(s) = \lim_{s\to 0} \frac{100s}{s^2(s+4)(s+12)} = \infty$ | | 3+3 | 211.2 | L3 |
| | | $K_a = \lim_{s\to 0} s^2 G(s)H(s) = \lim_{s\to 0} \frac{100s^2}{s^2(s+4)(s+12)} = \frac{100}{48}$ | | | | |
| | ii) | 1) $T.F = \frac{5}{s^2+1.6s+\omega_n^2}$ | | | | |
| | | 2) $T_p = \frac{\pi}{\omega_d} = 1.5045$ sec | | | | |
| | | 3) o/p response | | | | |
| | | $c(t) = 1 - \frac{e^{-\xi\omega_n t}}{\sqrt{1-\xi^2}} \sin(\omega_d t+\theta)$ | | | | |
| | | $= 1 - 1.0708\, e^{-0.8t}$ | | | | |
| 4 | a) | $\frac{C(s)}{R(s)} = \frac{(1+sT_d)4}{s^2+1.6s+4T_d s+4} = \frac{(1+sT_d)4}{s^2+(1.6+4T_d)s+4}$ | | 6 | 211.2 | L3 |
| | | $T_s = \frac{4}{1\times 2} = 2$ sec | | | | |

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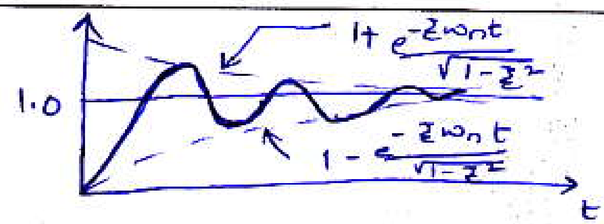
## SCHEME OF EVALUATION IA-

| Sem : | | Subject : | Sub Code : | Date : | | |
|---|---|---|---|---|---|---|
| **Q. No.** | **Bit** | **Description** | | **Marks** | **CO's** | **RBT LEVEL** |
| 4 | b) |  | | | | |
| 4 | b) | (see below) | | 6 | | |



$$\frac{C(s)}{R(s)} = \frac{K_v}{\tau s^2+s+K_v} = \frac{K_v/\tau}{s^2+\frac{1}{\tau}s+\frac{K_v}{\tau}}$$

Standard form $\frac{C(s)}{R(s)} = \frac{\omega_n^2}{s^2+2\zeta\omega_n s+\omega_n^2}$

$$\zeta = \frac{1}{2\sqrt{K_v\tau}} = \frac{f}{2\sqrt{(KJ)}}$$

$\omega_n$ = undamped natural freq $= \sqrt{K_v/\tau} = \sqrt{\frac{K}{J}}$

characteristic equation $q(s)=0$

For unit step I/p o/p response is given by

$$C(s) = \frac{\omega_n^2}{s\left[s+\zeta\omega_n - j\omega_n\sqrt{1-\zeta^2}\right]\left[s+\zeta\omega_n + j\omega_n\sqrt{1-\zeta^2}\right]}$$

$$c(t) = \left.\frac{\omega_n^2}{s^2+2\zeta\omega_n s+\omega_n^2}\right|_{s=0} + 2R_e\left[\left.\frac{\omega_n^2}{s\left[s+\zeta\omega_n - j\omega_n\sqrt{1-\zeta^2}\right]}\right|_{s=-\zeta\omega_n-j\omega_n\sqrt{1-\zeta^2}}\right] e^{-\zeta\omega_n t} e^{-j\omega_n\sqrt{(1-\zeta^2)}t}$$

$$= 1 - \frac{e^{-\zeta\omega_n t}}{\sqrt{1-\zeta^2}} \sin\left[\omega_n\sqrt{(1-\zeta^2)}\,t + \tan^{-1}\frac{\sqrt{1-\zeta^2}}{\zeta}\right];\ t>0$$

Steady-state value of $c(t)$ is given as $C_{ss} = \lim_{t\to\infty} c(t) = 1.$

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E&C Engg. Dept.
Exam.
Internal Assessment
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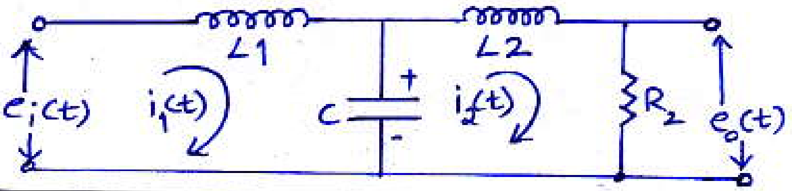
## THIRD INTERNAL ASSESSMENT

Sem: IV ( EC) | Sub: Control systems | Sub. Code: 15EC43
Date: 19/05/2018 | Time: 11-12 noon | Max. Marks: 25

***Note: Answer two full questions, draw sketches wherever necessary.***

| Q. No | | Description of Question | Marks | CO | RBT Level |
|---|---|---|---|---|---|
| 1 | a | i) Write the necessary condition for Stability.<br>ii) $S^6 + 4S^5 + 3S^4 - 16S^2 - 64S - 48 = 0$ . Find the number of roots of this equation with +ve real part,zero real part & -ve real part. | 6 | 211.3 | L3 |
| | b | For unity feedback system,<br>$G(s) = \dfrac{K}{S(1+0.4S)(1+0.25S)}$.<br>Find range of values of K,marginal value of K, & frequency of sustained oscillation. | 7 | 211.3 | L3 |
| | | **OR** | | | |
| 2 | a | i) Explain the basic concepts of Root Locus .<br>ii) Explain Angle & Magnitude condition Criterion. | 6 | 211.3 | L3 |
| | b | Sketch the root locus for the system with $G(S)H(S) = \dfrac{K(S+4)}{S(S^2+2S+2)}$ | 7 | 211.3 | L3 |
| 3 | a | i) With neat figures explain signal reconstruction by ZOH method.<br>ii) Obtain the state model of the given electrical network in standard form.<br> | 6 | 211.5 | L3 |
| | b | With diagram explain sampled data control system. | 6 | 211.5 | L3 |
| | | **OR** | | | |
| 4 | a | With example explain state space representation using physical variables. | 6 | 211.5 | L3 |
| | b | Construct the state model using physical variables if the system is described by differential equation.<br>$\dfrac{d^3y(t)}{dt^3} + 4\dfrac{d^2y(t)}{dt^2} + 7\dfrac{dy}{dt} + 2y(t) = 5u(t)$ | 6 | 211.5 | L3 |

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## SCHEME OF EVALUATION

| Sem : IV | Subject : Control systems | Sub Code : 15EC43 | Date : 19/05/2018 | | |
|---|---|---|---|---|---|
| **Q. No.** | **Bit** | **Description** | **Marks** | **CO's** | **RBT LEVEL** |
| 1 | a i), ii) | (see below) | 3+3 | 211.3 | L3 |

**1 a i)** Necessary condition for stability:—

1) None of the coefficients can be zero or negative unless one (or more than one) of the following occurs.

1) one or more roots have +ve real parts
2) a root (or roots) at origin, i.e $s_k = 0$ & hence $a_n = 0$;
3) $\sigma_l = 0$ for some $l$, which implies the presence of roots on the $j\omega$-axis.

**ii)**

$$\begin{array}{c|cccc} s^6 & 1 & 3 & -16 & -48 \\ s^5 & 4 & 0 & -64 & 0 \\ s^4 & 3 & 0 & -48 & 0 \\ s^3 & 0 & 0 & 0 & \end{array}$$

$A(s) = 3s^4 - 48 = 0$

$\frac{dA}{ds} = 12s^3$

$$\begin{array}{c|cccc} s^6 & 1 & 3 & -16 & -48 \\ s^5 & 4 & 0 & -64 & 0 \\ s^4 & 3 & 0 & -48 & 0 \\ s^3 & 12 & 0 & 0 & 0 \\ s^2 & \epsilon[0] & -48 & 0 & 0 \\ s^1 & \frac{576}{\epsilon} & 0 & 0 & \\ s^0 & -48 & & & \end{array}$$

$\lim_{\epsilon \to 0} \frac{576}{\epsilon} = +\infty$

one sign change & system is unstable.

one root is RHS of s-plane. i.e with +ve real part.

$A(s) = 0$ for dominant roots

$A(s) = 3s^4 - 48 = 0$ put $s^2 = y$

$3y^2 = 48$ $\therefore y^2 = 16$ $y = \pm\sqrt{16} = \pm 4$

$s^2 = \pm 4$ $s^2 = -4$

$s = \pm 2$ $s = \pm 2j$ → Two roots on imaginary axis, i.e with zero real part.

6 roots as $n = 6$

+ve real part = 1

zero " " = 2

-ve " " = 6-2-1 = 3

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# SCHEME OF EVALUATION

| Sem : IV A | Subject : Control Systems | Sub Code : 15 EC43 | Date : 19/05/2018 | | |
|---|---|---|---|---|---|
| Q. No. | Bit | Description | Marks | CO's | RBT LEVEL |
| 1 | b) | (see below) | 3+4 | 211.3 | L3 |
| 2 | a) | (see below) | 6 | 211.3 | L3 |

**1 b)**

$$G(s) = \frac{K}{s(1+0.4s)(1+0.25s)}$$

characteristic eqn $1+G(s)H(s)=0$

$$1+\frac{K}{s(1+0.4s)(1+0.25s)}=0$$

$$0.1s^3+0.65s^2+s+K=0$$

Routh array.

$$\begin{array}{c|cc} s^3 & 0.1 & 1 \\ s^2 & 0.65 & K \\ s^1 & \frac{0.65-0.1K}{0.65} & 0 \\ s^0 & K & \end{array}$$

$0.65-0.1K>0$

$0<K<6.5$

Marginal values of K

$0.65-0.1K_{mar}=0 \quad K_{mar}=6.5$

$A(s)=0.65s^2+K=0 \leftarrow$ at marginal.

$s^2=-10 \quad (\because K=6.5)$

$s=\pm j3.162$ freq of oscillations $=3.162$ rad/sec

**2 a)**

The characteristic equation is

$1+G(s)H(s)=0$

i.e $G(s)H(s)=-1$

Angle condition $G(s)H(s)=-1+j0$

Equating angles of both sides

$\angle G(s)H(s)=\pm(2q+1)180° \quad q=0,1,2$

$\angle G(s)H(s)$ for any value of 's' which is the root of equation $[1+G(s)H(s)=0]$ is

$=\pm(2q+1)180° \quad q=0,1,2$

$=$ odd multiple of $180°$

Magnitude condition:

$G(s)H(s)=-1$ are equated then we get a magnitude condition

$|G(s)H(s)|=|-1+j0|=1$

## SCHEME OF EVALUATION

| Sem : | | Subject : | Sub Code : | Date : | | |
|---|---|---|---|---|---|---|
| Q. No. | Bit | Description | | Marks | CO's | RBT LEVEL |
| 2 | b) | poles $p=3$ $z=1$ $N=p=3$ | | 7 | 211.3 | L3 |

starting pts of branches $s=0, -1+j, -1-j$
Terminating " 1 for branch is finite zero at $s=-4$
∴ $p-z = 3-1 = 2$ & branches approaching to $\infty$

$\theta_1 = 90^\circ$ centroid $\sigma = \dfrac{0-1-1-(-4)}{2}$
$\theta_2 = 270^\circ$
$= 1$

step 5: No breakaway points
step 6: Intersection with imaginary axis

$1 + G(s)H(s) = 0$

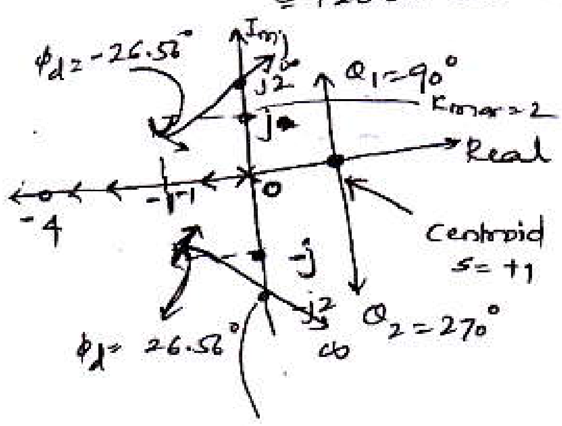
$$1 + \frac{K(s+4)}{s(s^2+2s+2)} = 0$$

Routh's array:

$$\begin{array}{c|cc} s^3 & 1 & K+2 \\ s^2 & 2 & 4K \\ s^1 & \frac{4-2K}{2} & 0 \\ s^0 & 4K & \end{array}$$

$4-2K=0$
$K_{mar} = +2$ making row of $s^1$ as row of zeros.
$A(s) = 2s^2 + 4K = 0$
$s = \pm j2$

Step 7:- $\phi_d = -26.56^\circ$ at $s = -1+j$
$= +26.56^\circ$ at $s = -1-j$




$K_{mar} = +2$

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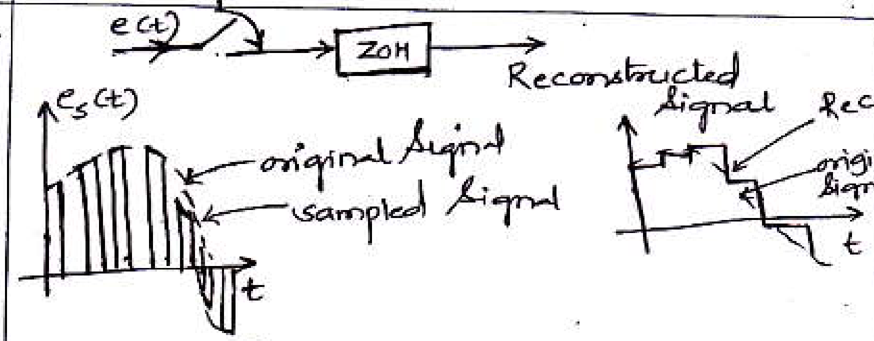
| Exam. |
| IA Scheme Evaluation |
| Even Sem (2017-18) |



## SCHEME OF EVALUATION

| Sem : | | Subject : | Sub Code : | Date : | | |
|---|---|---|---|---|---|---|
| Q. No. | Bit | Description | | Marks | CO's | RBT LEVEL |
| 3 | a i) | (see below) | | 6 | 211.5 | L3 |
| | | | | 3+3 | 211.5 | L3 |
| | | | | 3+3 | 211.5 | L3 |

**3 a i)**




**3 a ii)**

$u(t) = e_i(t) = I/p \quad y(t) = O/p = e_o(t)$

State variables $x_1(t) = i_1(t)$, $x_2(t) = i_2(t)$, $x_3(t) = V_c(t)$ writing the equations

$$e_i(t) = L_1 \frac{di_1(t)}{dt} + V_c(t)$$

$$\dot{x}_1(t) = \frac{1}{L_1} u(t) - \frac{1}{L_1} x_3(t)$$

$$\dot{x}_2(t) = \frac{1}{L_2} x_3(t) - \frac{R_2}{L_2} x_2(t)$$

$$\dot{x}_3(t) = \frac{1}{C} x_1(t) - \frac{1}{C} x_2(t)$$

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 0 & -\frac{1}{L_1} \\ 0 & -\frac{R_2}{L_2} & \frac{1}{L_2} \\ \frac{1}{C} & -\frac{1}{C} & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} \frac{1}{L_1} \\ 0 \\ 0 \end{bmatrix} u(t)$$

$$\dot{x}(t) = Ax(t) + Bu(t) \qquad e_o(t) = i_2(t) R_2$$

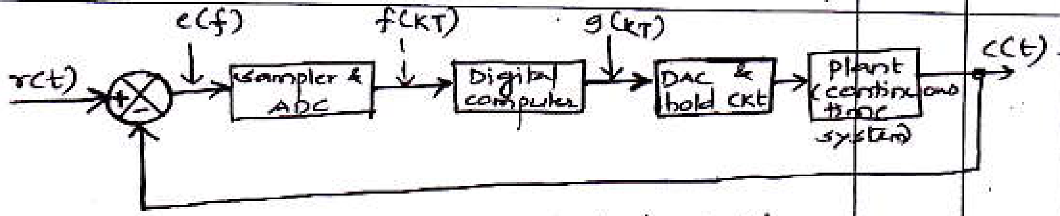
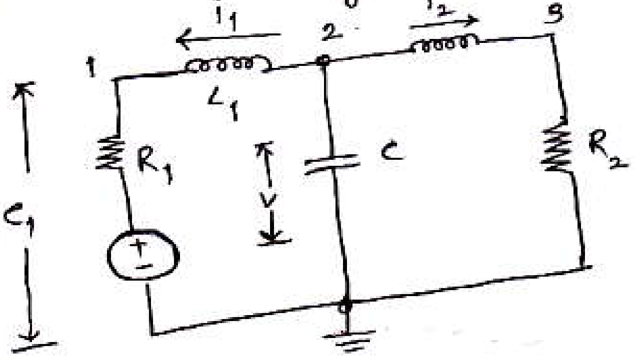
$$y(t) = x_2(t) R_2$$

$$y(t) = \begin{bmatrix} 0 & R_2 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} \qquad y(t) = Cx(t) + Du(t)$$

$$D = 0$$

Staff In-Charge

## SCHEME OF EVALUATION

| Sem : IV | Subject : | Sub Code : | Date : | | |
|---|---|---|---|---|---|
| **Q. No.** | **Bit** | **Description** | **Marks** | **CO's** | **RBT LEVEL** |
| 3 | b) |  A sampler & ADC is needed at the computer input. The sampler converts the continuous time error signal into a sequence of pulses which are then expressed in numerical code. Numerically coded o/p data of digital computer are decoded into continuous time signal, by DAC & hold circuit. The overall system is hybrid in which the signal is in sampled from in the digital controller & in continuous from. such system is referred to as a sampled data control system. | 2+4 | 211.5 | L3 |
| 4 | a) |  $x_1(t) = v(t)$ <br> $x_2(t) = i_1(t)$ <br> $x_3(t) = i_2(t)$ <br> Differential equations governing the behaviour of RLC N/w are <br> $i_1 + i_2 + C\frac{dv}{dt} = 0$ | 6 | 211.5 | L3 |

Staff-In Charge

Module Coordinator

# SCHEME OF EVALUATION

| Sem : VIII | Subject : Real Time operating system | Sub Code : 10EC842 | Date : 19/05/2018 | | |
|---|---|---|---|---|---|
| **Q. No.** | **Bit** | **Description** | **Marks** | **CO's** | **RBT LEVEL** |

$$L_1\frac{di_1}{dt}+R_1i_1+e-V=0$$

$$L_2\frac{di_2}{dt}+R_2i_2-V=0$$

$$\frac{dv}{dt}=-\frac{1}{C}i_1-\frac{1}{C}i_2$$

$$\frac{di_1}{dt}=\frac{1}{L}v-\frac{R_1}{L_1}i_1-\frac{1}{L_1}e$$

$$\frac{di_2}{dt}=\frac{1}{L_2}v-\frac{R_2}{L_2}i_2$$

I/p $u(t)=e(t)$

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix}=\begin{bmatrix}0 & -\frac{1}{C} & -\frac{1}{C}\\ -\frac{1}{L_1} & -\frac{R_1}{L_1} & 0\\ \frac{1}{L_2} & 0 & -\frac{R_2}{L_2}\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}+\begin{bmatrix}0\\ -\frac{1}{L_1}\\ 0\end{bmatrix}u$$

Assume that voltage & current thro' $R_2$ are O/p variables $y_1$ & $y_2$. O/p Eqn's are

$$\begin{bmatrix}y_1\\ y_2\end{bmatrix}=\begin{bmatrix}0 & 0 & R_2\\ 0 & 0 & 1\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}$$

| Marks | CO's | RBT LEVEL |
|---|---|---|
| 6 | 211.5 | L3 |

**4 | b)**

$$x_1(t)=y(t)$$

$$x_2(t)=\dot{x}_1(t)=\dot{y}(t)=\frac{dy(t)}{dt}$$

$$x_3(t)=\dot{x}_2(t)=\ddot{y}(t)=\frac{d^2y(t)}{dt^2}$$

$$\dot{x}_1(t)=x_2(t)$$

$$\dot{x}_2(t)=x_3(t)$$

$$\dot{x}_3(t)=-2x_1(t)-7x_2(t)-4x_3(t)+5u(t)$$

$$\dot{x}(t)=Ax(t)+Bu(t)$$

$$A=\begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ -2 & -7 & -4\end{bmatrix}\quad B=\begin{bmatrix}0\\ 0\\ 5\end{bmatrix}$$

$$y(t)=x_1(t)$$

$$y(t)=C(x(t))+Du(t)$$

$$C=\begin{bmatrix}1 & 0 & 0\end{bmatrix}\quad D=6$$