SRN

PES UNIVERSITY

PES University, Bengaluru

UE15EC335

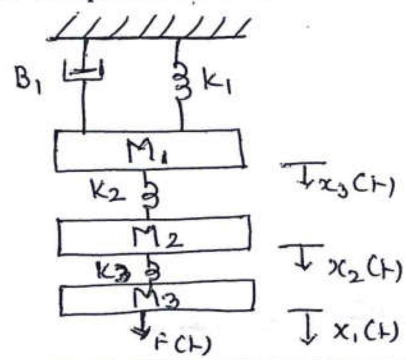
(Established under Karnataka Act No. 16 of 2013)

Dec 2019: END SEMESTER ASSESSMENT B.Tech. ECE VI Semester
ESA
UE15EC335 - CONTROL SYSTEMS

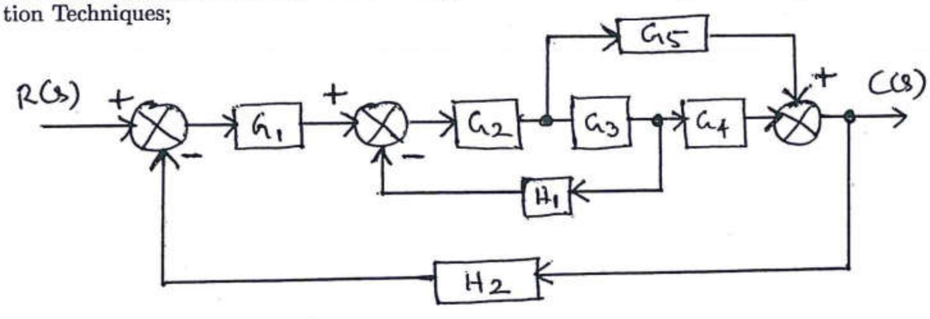
Time: 3 hours — *Answer All Questions* — Max Marks: 100

1

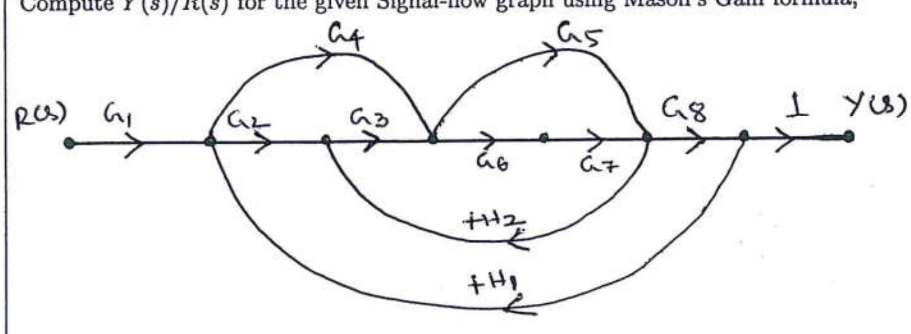
a For the given physical system, draw the equivalent mechanical network. Derive the governing differential equations and express them in s-domain using Laplace Transforms assuming zero initial conditions. Draw the equivalent Force - Current and Force - Voltage Analogous circuits; **6m**

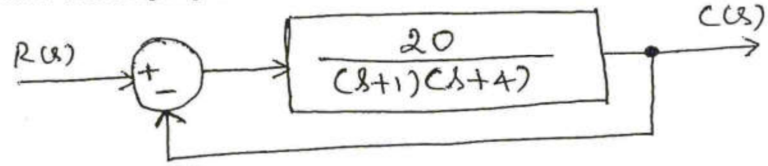
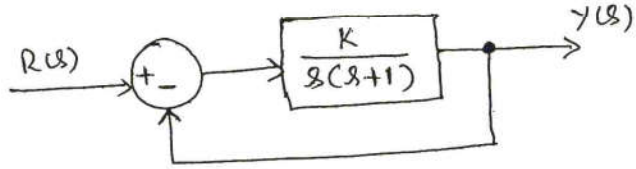


b Evaluate $C(s)/R(s)$ for the given Block diagram architecture using Block Diagram Reduction Techniques; **7m**



c Compute $Y(s)/R(s)$ for the given Signal-flow graph using Mason's Gain formula; **7m**



<table>
<tr><td rowspan="3">2</td><td>a</td><td>Consider the closed-loop system shown below. Evaluate the closed-loop transfer function, damping ratio, natural frequency and give the expression for output response if the system is subjected to Unit Step Input.

</td><td>6m</td></tr>
<tr><td>b</td><td>Consider the system given below. Assuming $r(t) = 0.1\ t$ and it is desired that $e_{ss} \leq 0.005$, find the range of K for which the error is to be within specified limit, for the given system.

</td><td>6m</td></tr>
<tr><td>c</td><td>The open-loop transfer function of a unity feedback system is given by;
$$G(s) = \frac{K}{s(1+sT_1)(1+sT_2)}$$
Derive the expression for gain K in terms of T_1 and T_2 for the stability of the system.</td><td>8m</td></tr>
<tr><td rowspan="2">3</td><td>a</td><td>Sketch the Root Locus for a system whose open-loop transfer function is given by;
$$G(s)H(s) = \frac{K}{s(s^2+2s+2)}$$
Calculate the value / range of K for which the closed-loop system is (i) Unstable, (ii) Marginally stable and the frequency of sustained oscillations and (iii) Absolutely stable.</td><td>10m</td></tr>
<tr><td>b</td><td>A unity-feedback system has the following open-loop transfer function;
$$G(s)H(s) = \frac{80}{s(s+2)(s+20)}$$
Sketch the approximate Bode Magnitude and Phase plots. From the plots, evaluate Gain Cross-over frequency (ω_{gcf}), Phase Cross-over frequency (ω_{pcf}), Gain Margin and Phase Margin. Comment on the closed-loop stability.</td><td>10m</td></tr>
<tr><td rowspan="2">4</td><td>a</td><td>A feedback control system has the following open-loop transfer function;
$$G(s)H(s) = \frac{10}{s(s+1)(s+2)}$$
Obtain the Nyquist Plot; comment on the closed-loop stability while applying Nyquist Stability Criterion.</td><td>10m</td></tr>
<tr><td>b</td><td>A feedback control system has the following open-loop transfer function;
$$G(s)H(s) = \frac{20}{s(1+0.1s)^2}$$
It is desired to have a Phase margin of 65^0 for the closed loop system; design a suitable Lag-Compensator to achieve the same.</td><td>10m</td></tr>
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5	a	Consider the following transfer function; $$\frac{Y(s)}{R(s)} = \frac{2s^2 - 8s + 6}{s^3 - 8s^2 - 16s + 6}$$ Obtain the State-Space representation of the above transfer function in the Phase Variable Canonical Form.	5m
	b	Consider the following state-space representation of an $R - L - C$ network; $$\begin{aligned} \dot{X} &= AX + Bu \\ Y &= CX \end{aligned}$$ with $A = \begin{bmatrix} 0 & -1/C \\ 1/L & -R/L \end{bmatrix}$, $B = \begin{bmatrix} 1/C \\ 0 \end{bmatrix}$, $C = \begin{bmatrix} 0 & R \end{bmatrix}$ and $X = \begin{bmatrix} v_c \\ i_L \end{bmatrix}$ being the states. Obtain the equivalent Transfer function $V_0(s)/I_L(s)$.	5m
	c	Consider the following state-space representation of a system; $$\begin{aligned} \dot{X} &= AX + Bu \\ Y &= CX \end{aligned}$$ with $A = \begin{bmatrix} 1 & 2 \\ -5 & -10 \end{bmatrix}$, $B = \begin{bmatrix} -4 \\ 1 \end{bmatrix}$ and $C = \begin{bmatrix} 6 & -4 \end{bmatrix}$. Verify if the system is Controllable and Observable. Design a full-state feedback controller to place the closed-loop poles at $s_{1,2} = -1 + j, -1 - j$ and give the expression for the control law in terms of the actual states. It is also desired to design an observer for the above system such that the Observer poles are placed at $s_{1,2} = -10$. Design a suitable Observer Gain matrix to meet this requirement. Write the expression for the control law interms of the observed / estimated states.	10m