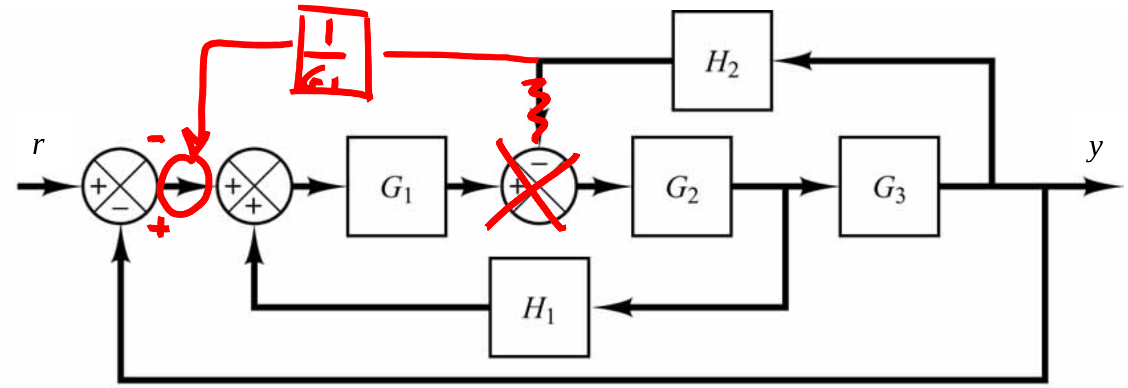
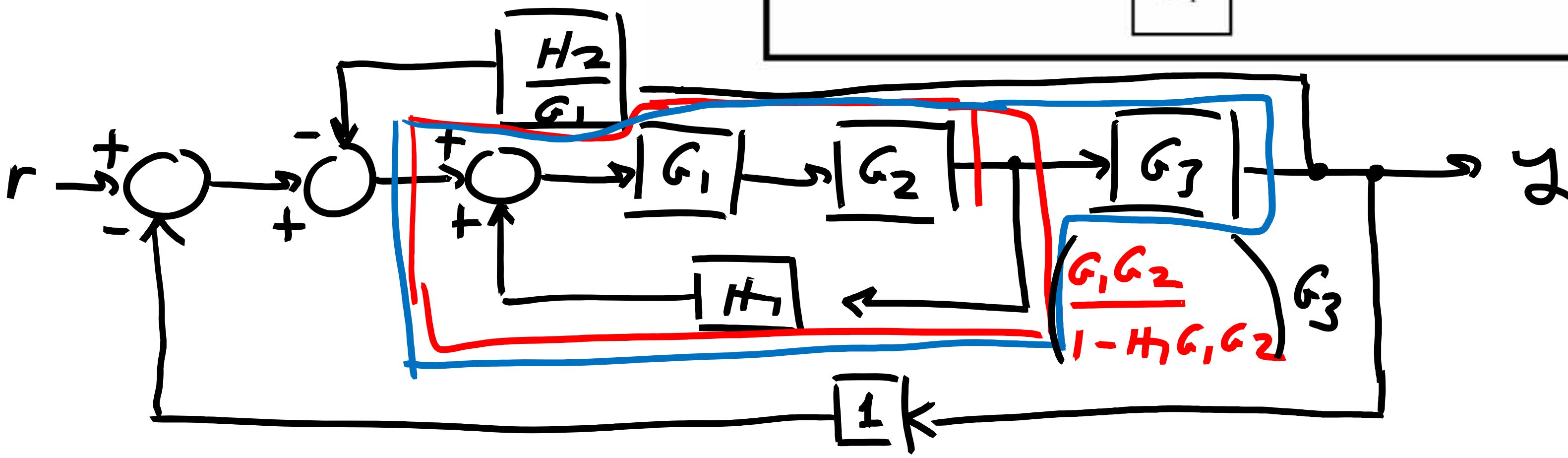
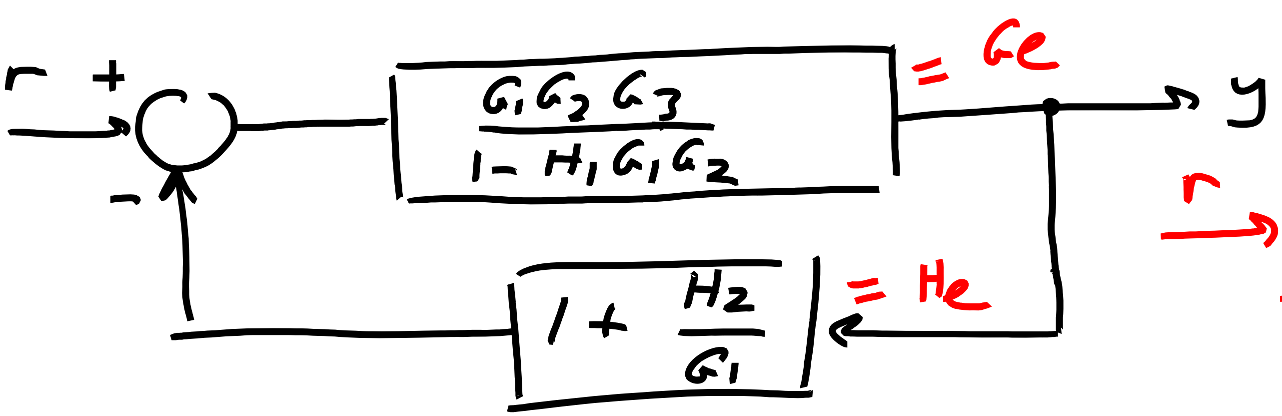
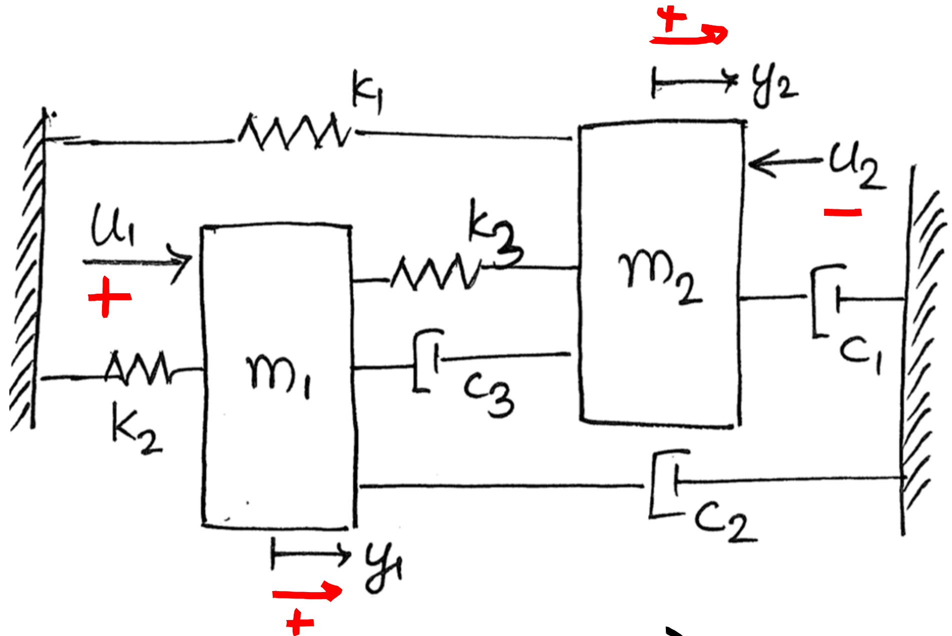
Please reduce the block diagram to find the relationship between r and y.







a) Find the differential equation(s) that model this system.
b) Identify state variables, and represent your model in the state-space form.



A)

Mass 1:

$$m_1\ddot{y}_1 = u_1 - k_2(y_1-0) - k_3(y_1-y_2) - c_3(\dot{y}_1-\dot{y}_2) - c_2(\dot{y}_1-0)$$

Mass 2:

$$m_2\ddot{y}_2 = -u_2 - k_1(y_2-0) - c_1(\dot{y}_2-0) - k_3(y_2-y_1) - c_3(\dot{y}_2-\dot{y}_1)$$

B) Mass 1:

$$m_1\ddot{y}_1 = u_1 - k_2\underline{y_1} - k_3\underline{y_1} + k_3 y_2 - c_3\underline{\dot{y}_1} + c_3\dot{y}_2 - c_2\underline{\dot{y}_1}$$

$$\boxed{m_1\ddot{y}_1 = u_1 - (k_2+k_3)y_1 + k_3 y_2 - (c_2+c_3)\dot{y}_1 + c_3\dot{y}_2}$$

Mass 2:

$$m_2 \ddot{y}_2 = -u_2 - (k_1+k_3)y_2 + k_3 y_1 - (c_1+c_3)\dot{y}_2 + c_3 \dot{y}_1$$

Output variables: y_1, y_2

Control inputs: u_1, u_2

State variables:

$x_1 = y_1$

$\boxed{x_2 = \dot{y}_1}$

$x_3 = y_2$

$\boxed{x_4 = \dot{y}_2}$

$$\begin{pmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \\ \dot{x}_4 \end{pmatrix} = \begin{bmatrix} 0 & 1 & 0 & 0 \\ \frac{-(k_2+k_3)}{m_1} & \frac{-(c_2+c_3)}{m_1} & \frac{k_3}{m_1} & \frac{c_3}{m_1} \\ 0 & 0 & 0 & 1 \\ \frac{k_3}{m_2} & \frac{c_3}{m_2} & \frac{-(k_1+k_3)}{m_2} & \frac{-(c_1+c_3)}{m_2} \end{bmatrix} \begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{pmatrix} + \begin{bmatrix} 0 & 0 \\ 1/m_1 & 0 \\ 0 & 0 \\ 0 & \frac{-1}{m_2} \end{bmatrix} \begin{pmatrix} u_1 \\ u_2 \end{pmatrix}$$

Derivatives of state vars:

$$\dot{x}_1 = \dot{y}_1 = 1\,x_2$$

$$\dot{x}_2 = \ddot{y}_1 = \frac{1}{m_1}\left(1 \cdot u_1 - (k_2+k_3)\overset{x_1}{y_1} + k_3 \overset{x_3}{y_2} - (c_2+c_3)\overset{x_2}{\dot{y}_1} + c_3 \overset{x_4}{\dot{y}_2}\right)$$

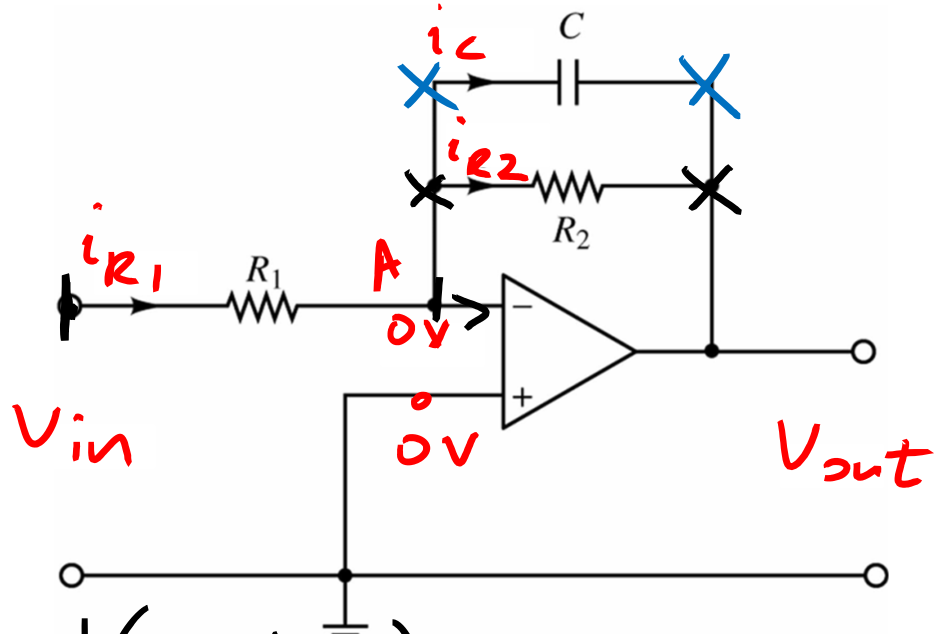
$$\dot{x}_3 = \dot{y}_2 = 1\,x_4$$

$$\dot{x}_4 = \ddot{y}_2 = \frac{1}{m_2}\left(-u_2 - (k_1+k_3)x_3 + k_3 x_1 - (c_1+c_3)x_4 + c_3 x_2\right)$$

output eqn

$$\begin{pmatrix} y_1 \\ y_2 \end{pmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{pmatrix}$$

Please find the differential equation(s) that model the electrical system shown.



$$i_- = i_+ = 0$$

KCL @ A :

$$i_{R_1} = i_{R_2} + i_C$$

$$\frac{V_{in} - 0}{R_1} = \frac{0 - V_{out}}{R_2} + C\frac{d(0 - V_{out})}{dt}$$

$$\boxed{\frac{V_{in}}{R_1} = -\frac{V_{out}}{R_2} - C\frac{dV_{out}}{dt}}$$