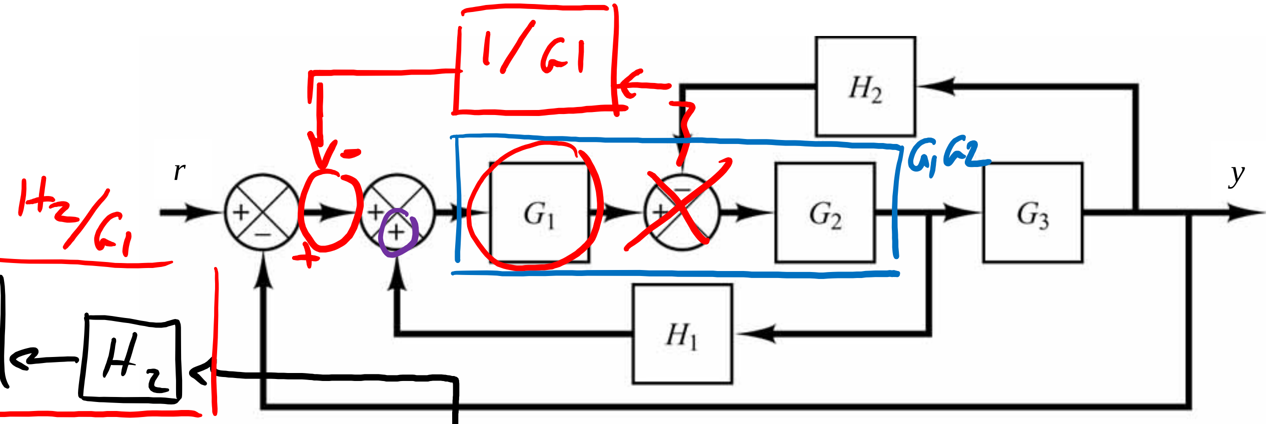
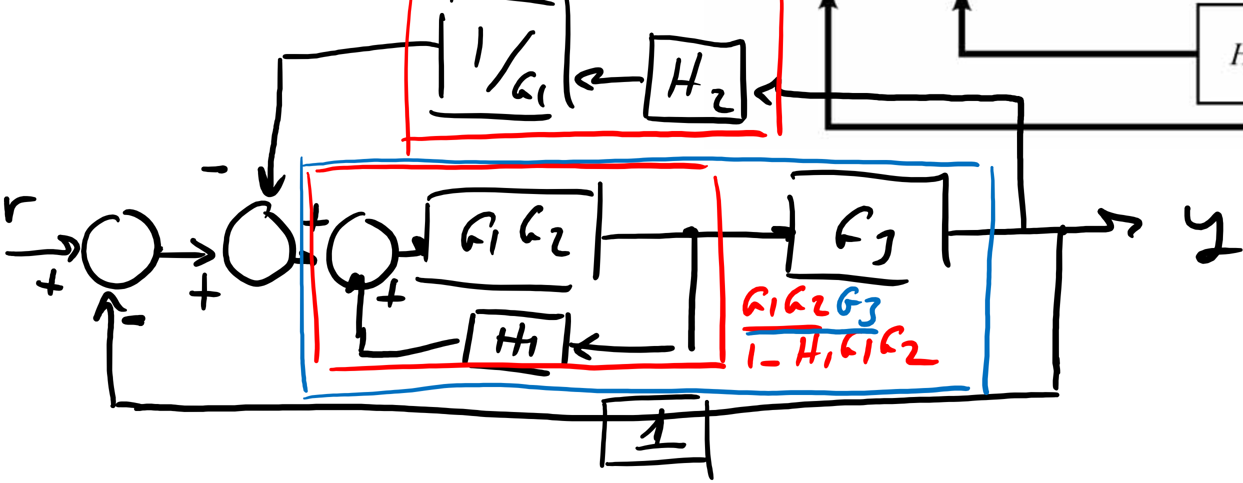
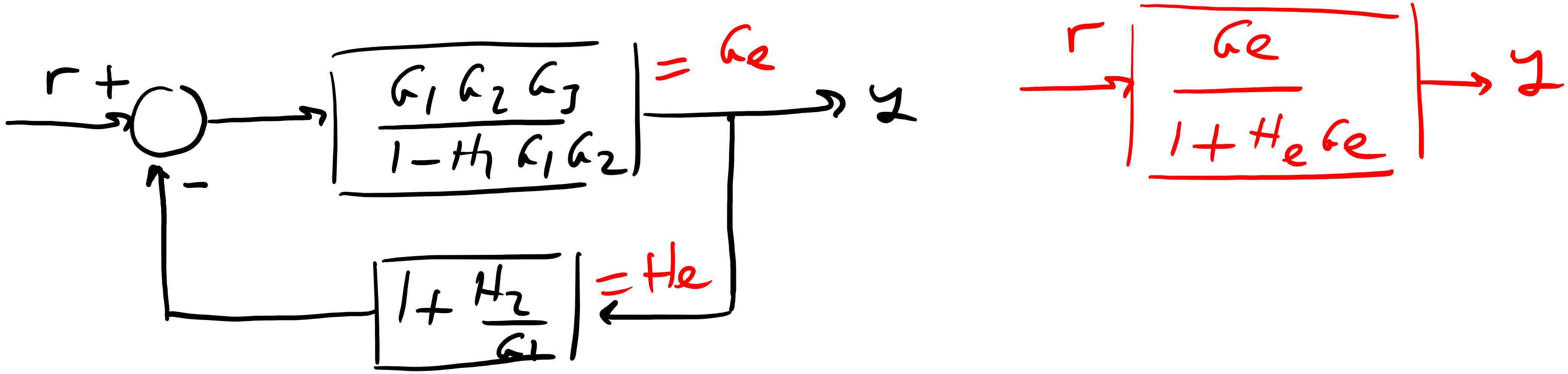
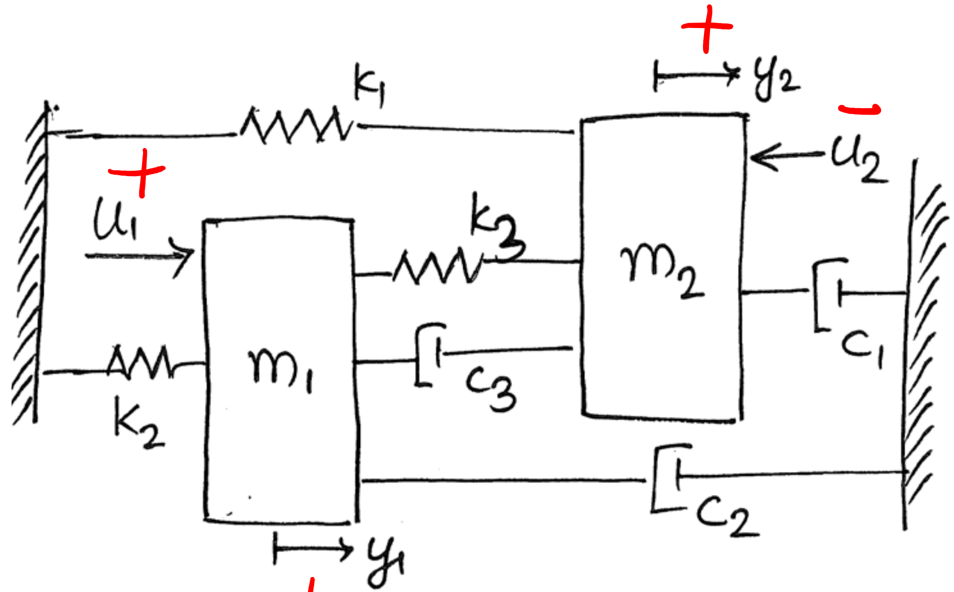
Please reduce the block diagram to find the relationship between r and y.







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:

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

b)

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

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

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

output variables: $y_1, y_2 \leftarrow$

control inputs: u_1, u_2

State variables

$$\rightarrow x_1 = y_1 \leftarrow$$
$$x_2 = \dot{y}_1$$
$$\rightarrow x_3 = y_2 \leftarrow$$
$$x_4 = \dot{y}_2$$

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

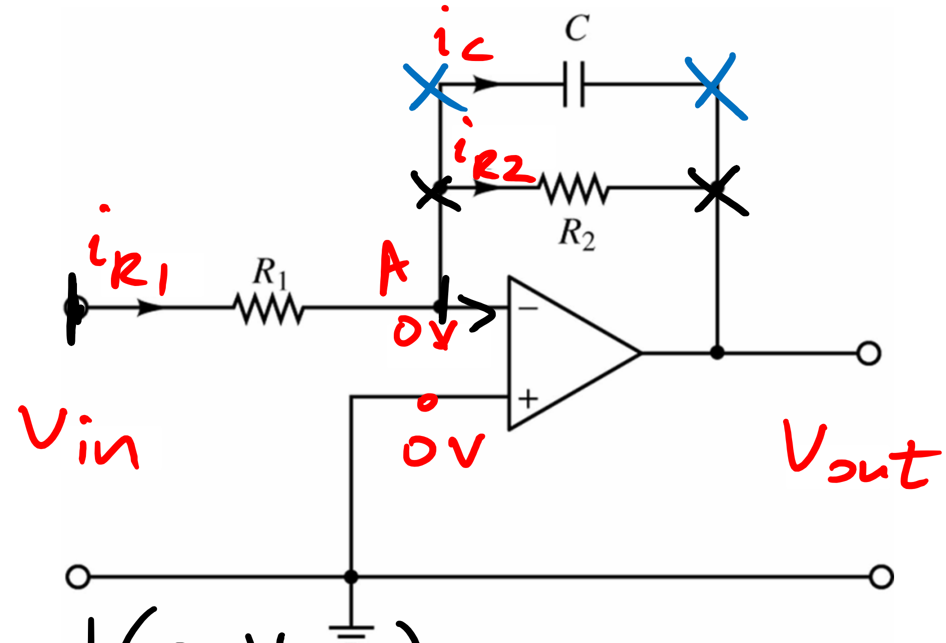
Derivatives of state variables

$$\dot{x}_1 = \dot{y}_1 = x_2$$
$$\dot{x}_2 = \ddot{y}_1 = \frac{1}{m_1}\left[1 \cdot u_1 - (k_2+k_3)\overset{x_1}{y_1} + k_3 \overset{x_3}{y_2} - (c_2+c_3)\overset{x_2}{\dot{y}_1} + c_3 \overset{x_4}{\dot{y}_2}\right]$$
$$\dot{x}_3 = \dot{y}_2 = x_4$$
$$\dot{x}_4 = \ddot{y}_2 = \frac{1}{m_2}\left[(-1)\, u_2 - (k_1+k_3)\overset{x_3}{y_2} + k_3 \overset{x_1}{y_1} - (c_1+c_3)\overset{x_4}{\dot{y}_2} + c_3 \overset{x_2}{\dot{y}_1}\right]$$

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

output eqn.

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



$$i_- = i_+ = 0$$

KCL @ A:

$$i_{R1} = i_{R2} + i_c$$

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

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