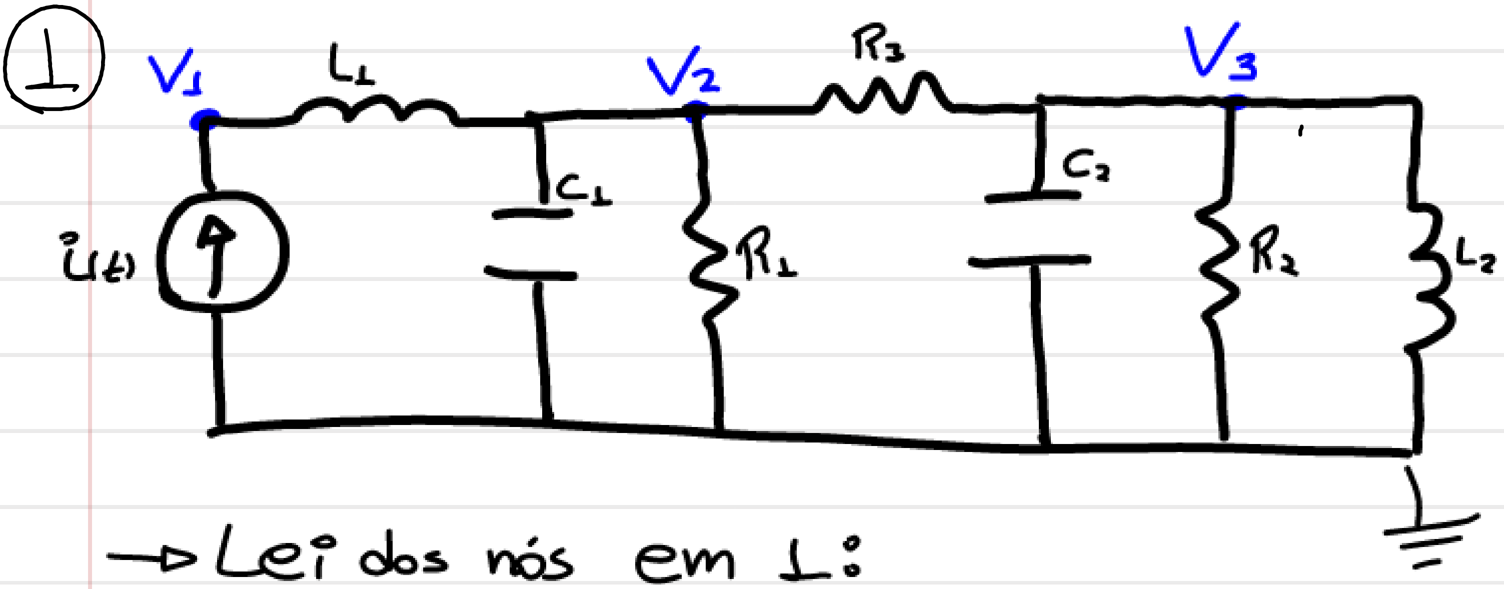
1



→ Lei dos nós em 1:

$$(V_2 - V_1) \cdot \frac{1}{L_1 D} = i(t)$$

$$V_2 \cdot \frac{1}{L_1 D} - V_1 \frac{1}{L_1 D} = i(t)$$

→ Lei dos nós ponto 2:

$$V_2\left(C_1 D + \frac{1}{R_1}\right) + (V_3 - V_2)\frac{1}{R_3} - (V_2 - V_1)\frac{1}{L_1 D} = 0$$

$$V_3 \cdot \frac{1}{R_3} + V_2\left(C_1 D + \frac{1}{R_1} - \frac{1}{R_3} - \frac{1}{L_1 D}\right) + V_1 \frac{1}{L_1 D} = 0$$

→ Lei dos nós ponto 3:

$$V_3\left(C_2 D + \frac{1}{R_2} + \frac{1}{L_2 D}\right) - (V_3 - V_2)\frac{1}{R_3} = 0$$

$$V_3\left(C_2 D + \frac{1}{R_2} + \frac{1}{L_2 D} - \frac{1}{R_3}\right) + V_2 \frac{1}{R_3} = 0$$

- Analogias

1) $$V_2 \cdot \frac{1}{L_1 D} - V_1 \frac{1}{L_1 D} = i(t)$$

$$\theta_2 \cdot K_1 - \theta_1 K_1 = T$$

2) $$V_3 \cdot \frac{1}{R_3} + V_2\left(C_1 D + \frac{1}{R_1} - \frac{1}{R_3} - \frac{1}{L_1 D}\right) + V_1 \frac{1}{L_1 D} = 0$$

$$\dot{\theta}_3 \cdot b_3 + \ddot{\theta}_2 M_1 + \dot{\theta}_2 (b_1 - b_3) \underbrace{- \theta_2 \cdot K_1 + \theta_1 \cdot K_1}_{-T} = 0$$

$$\ddot{\theta}_2 M_1 + \dot{\theta}_2 (b_1 - b_3) + \dot{\theta}_3 \cdot b_3 = T$$

3) $$V_3\left(C_2 D + \frac{1}{R_2} + \frac{1}{L_2 D} - \frac{1}{R_3}\right) + V_2 \frac{1}{R_3} = 0$$

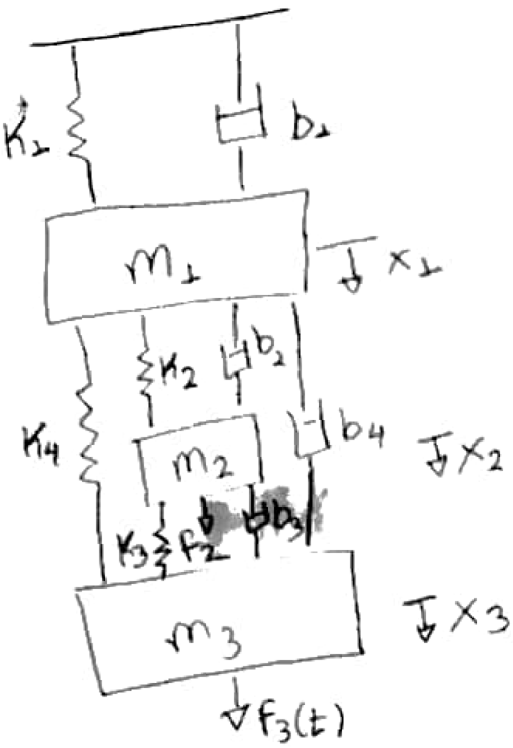
$$\ddot{\theta}_3 M_2 + \dot{\theta}_3 b_2 + \theta_3 K_2 - \dot{\theta}_3 b_3 + \dot{\theta}_2 b_3 = 0$$

$$\ddot{\theta}_3 M_2 + \dot{\theta}_2 b_3 + \dot{\theta}_3 b_2 - \dot{\theta}_3 b_3 + \theta_3 K_2 = 0$$

$$\begin{bmatrix} M_1 & \\ & M_2 \end{bmatrix} \begin{bmatrix} \ddot{\theta}_2 \\ \ddot{\theta}_3 \end{bmatrix} + \begin{bmatrix} (b_1 - b_3) & b_3 \\ b_3 & (b_2 - b_3) \end{bmatrix} \begin{bmatrix} \dot{\theta}_2 \\ \dot{\theta}_3 \end{bmatrix} + \begin{bmatrix} 0 & 0 \\ 0 & K_2 \end{bmatrix} \begin{bmatrix} \theta_2 \\ \theta_3 \end{bmatrix} = \begin{bmatrix} T \\ 0 \end{bmatrix}$$

②

a)



$$T = \frac{m_1 \dot{x}_1^2}{2} + \frac{m_2 \dot{x}_2^2}{2} + \frac{m_3 \dot{x}_3^2}{2}$$

$$V = \frac{1}{2}\left[K_1 \cdot x_1^2 + K_2(x_2 - x_1)^2 + K_3(x_3 - x_2)^2 + K_4(x_3 - x_1)^2\right]$$

$$R = \frac{1}{2}\left[b_1 \dot{x}_1^2 + b_2(\dot{x}_2 - \dot{x}_1)^2 + b_3(\dot{x}_3 - \dot{x}_2)^2 + b_4(\dot{x}_3 - \dot{x}_1)^2\right]$$

$$L = \frac{1}{2}\left[m_1 \dot{x}_1^2 + m_2 \dot{x}_2^2 + m_3 \dot{x}_3^2\right] - \frac{1}{2}\left[K_1 x_1^2 + K_2(x_2 - x_1)^2 + K_3(x_3 - x_2)^2 + K_4(x_3 - x_1)^2\right]$$

↳ Para x_1

$$\frac{\partial L}{\partial \dot{x}_1} = m_1 \dot{x}_1 \Rightarrow \frac{d}{dt}\left(\frac{\partial L}{\partial \dot{x}_1}\right) = m_1 \ddot{x}_1$$

$$\frac{\partial L}{\partial x_1} = -\left[K_1 \cdot x_1 - K_2(x_2 - x_1) - K_4(x_3 - x_1)\right] = -\left[x_1(K_1 + K_2 + K_4) + x_2(-K_2) + x_3(-K_4)\right]$$

$$\frac{\partial R}{\partial \dot{x}_1} = b_1 \dot{x}_1 - b_2(\dot{x}_2 - \dot{x}_1) - b_4(\dot{x}_3 - \dot{x}_1) = \dot{x}_1(b_1 + b_2 + b_4) + \dot{x}_2(-b_2) + x_3(-b_4)$$

- Eq. dif:

$$m_1 \ddot{x}_1 + (b_1 + b_2 + b_4)\dot{x}_1 + (-b_2)\dot{x}_2 + (-b_4)\dot{x}_3 + (K_1 + K_2 + K_4)x_1 + (-K_2)x_2 + (-K_4)x_3 = 0$$

↳ Para x_2:

$$\frac{\partial}{\partial t}\left(\frac{\partial L}{\partial \dot{x}_2}\right) = m_2 \ddot{x}_2$$

$$\frac{\partial L}{\partial x_2} = -\left[+K_2(x_2-x_1) - K_3(x_3-x_2)\right] = -\left[(-K_2)x_1 + (K_2+K_3)x_2 + (-K_3)x_3\right]$$

$$\frac{\partial R}{\partial \dot{x}_2} = \left[b_2(x_2-x_1) - b_3(x_3-x_2)\right] = \left[(-b_2)x_1 + (K_2+K_3)x_2 + (-b_3)x_3\right]$$

• Eq. Diferencial

$$m_2\ddot{x}_2 + (-K_2)x_1 + (K_2+K_3)x_2 + (-K_3)x_3 + (-b_2)\dot{x}_1 + (b_2+b_3)\dot{x}_2 + (-b_3)\dot{x}_3 = f_2$$

↳ Para x_3

$$\frac{\partial}{\partial t}\left(\frac{\partial L}{\partial \dot{x}_3}\right) = m_3 \ddot{x}_3$$

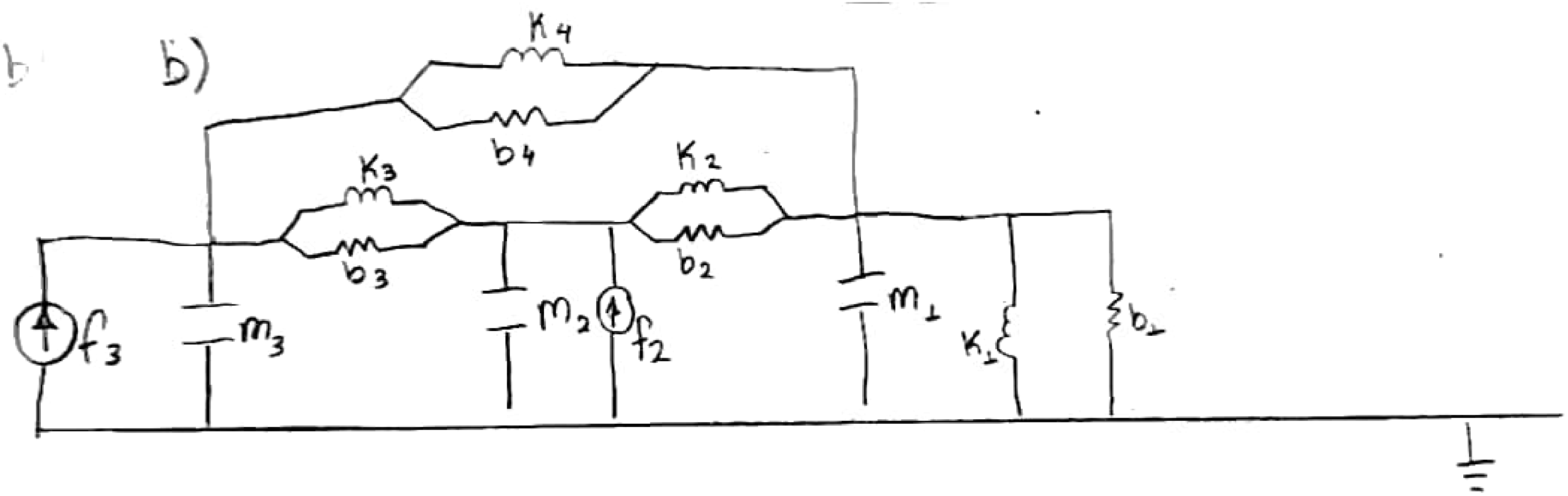
$$\frac{\partial L}{\partial x_3} = -\left[K_3(x_3-x_2) + K_4(x_3-x_1)\right] = -\left[(-K_4)x_1 + (-K_3)x_2 + (K_3+K_4)x_3\right]$$

$$\frac{\partial R}{\partial \dot{x}_3} = \left[b_3(\dot{x}_3-\dot{x}_2) + b_4(\dot{x}_3-\dot{x}_1)\right] = \left[(-b_4)\dot{x}_1 + (-b_3)\dot{x}_2 + (b_3+b_4)\dot{x}_3\right]$$

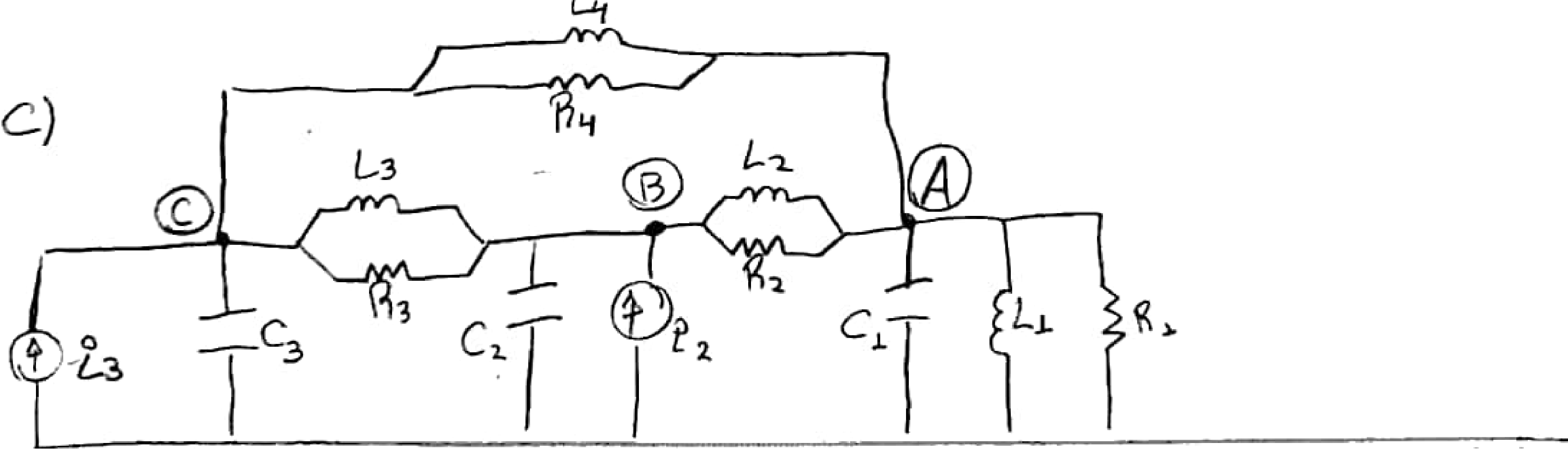
• Eq. Dif:

$$m_3\ddot{x}_3 + (-b_4)\dot{x}_1 + (-b_3)\dot{x}_2 + (b_3+b_4)\dot{x}_3 + (-K_4)x_1 + (-K_3)x_2 + (K_3+K_4)x_3 = f_3$$

b)


K4
b4
K3
b3
K2
b2
f3
m3
m2
f2
m1
K1
b1

c)


L4
R4
L3
R3
L2
R2
C
B
A
i3
C3
C2
i2
C1
L1
R1

d) ↳ Para o Ponto A

$$(V_B - V_A)\left(\frac{1}{L_2 D} + \frac{1}{R_2}\right) + (V_C - V_A)\left(\frac{1}{L_4 D} + \frac{1}{R_4}\right) = V_A\left(C_1 D + \frac{1}{L_1 D} + \frac{1}{R_1}\right)$$

$$m_1 \ddot{x}_1 + (b_1 + b_2 + b_4)\dot{x}_1 + (-b_2)\dot{x}_2 + (-b_4)\dot{x}_3 + (K_1 + K_2 + K_4)x_1 - K_2 x_2 - K_4 x_3 = 0$$

↳ Para o Ponto B

$$-V_A\left(\frac{1}{L_2 D} + \frac{1}{R_2}\right) + V_B\left(\frac{1}{L_2 D} + \frac{1}{R_2} + \frac{1}{L_3 D} + \frac{1}{R_3} + C_2 D\right) - V_C\left(\frac{1}{L_3 D} + \frac{1}{R_3}\right) = i_2$$

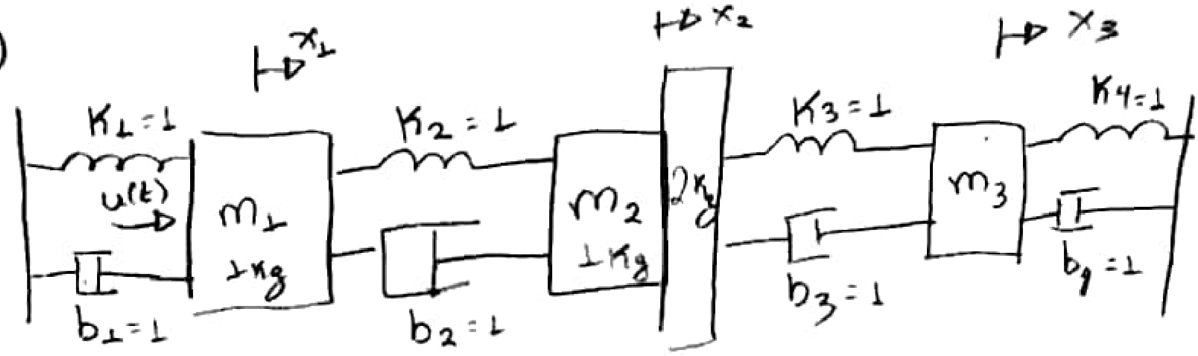
$$m_2 \ddot{x}_2 - b_2 \dot{x}_1 + (b_2 + b_3)\dot{x}_2 - b_3 \dot{x}_3 - K_2 x_1 + (K_2 + K_3)x_2 - K_3 x_3 = f_2$$

↳ Para o Ponto C

$$-V_A\left(\frac{1}{L_4 D} + \frac{1}{R_4}\right) - V_B\left(\frac{1}{L_3 D} + \frac{1}{R_3}\right) + V_C\left(\frac{1}{L_3 D} + \frac{1}{R_3} + \frac{1}{L_4 D} + \frac{1}{R_4}\right) = i_3$$

$$m_3 \ddot{x}_3 - b_4 \dot{x}_1 - b_3 \dot{x}_2 + (b_3 + b_4)\dot{x}_3 - K_4 x_1 - K_3 x_2 + (K_3 + K_4)x_3 = f_3$$

③



a) $T=\frac{1}{2}\left(m_1\dot{x}_1^2+m_2\dot{x}_2^2+m_3\dot{x}_3^2\right)$

$$V=\frac{1}{2}\left[K_1x_1^2+K_2(x_2-x_1)^2+K_3(x_3-x_2)^2+K_4x_3^2\right]$$

$$L=T-V$$

$$R=\frac{1}{2}\left[b_1\dot{x}_1^2+b_2(\dot{x}_2-x_1)^2+b_3(\dot{x}_3-\dot{x}_2)^2+K_4\dot{x}_3^2\right]$$

↳ Para m_1

$$\frac{\partial}{\partial t}\left(\frac{\partial L}{\partial \dot{x}_1}\right)=m_1\ddot{x}_1$$

$$\frac{\partial L}{\partial x_1}=-\left[K_1x_1-K_2(x_2-x_1)\right]$$

$$\frac{\partial R}{\partial \dot{x}_1}=\left[b_1\dot{x}_1-b_2(\dot{x}_2-\dot{x}_1)\right]$$

• Eq dif

$$m_1\ddot{x}_1+(b_1+b_2)\dot{x}_1-b_2\dot{x}_2+(K_1+K_2)x_1-K_2x_2=u$$

↳ Para m_2

$$\frac{\partial}{\partial t}\left(\frac{\partial L}{\partial \dot{x}_2}\right)=m_2\ddot{x}_2$$

$$\frac{\partial L}{\partial x_2}=-\left[K_2(x_2-x_1)-K_3(x_3-x_2)\right]$$

$$\frac{\partial R}{\partial \dot{x}_2}=\left[b_2(\dot{x}_2-\dot{x}_1)-b_3(\dot{x}_3-\dot{x}_2)\right]$$

• Eq dif:

$$m_2\ddot{x}_2-K_2x_1+(K_2+K_3)x_2-K_3x_3-b_2\dot{x}_1+(b_2+b_3)\dot{x}_2-b_3x_3$$

↳ Para m_3

$$\frac{\partial}{\partial t}\left(\frac{\partial L}{\partial \dot{x}_3}\right) = m\ddot{x}_3$$

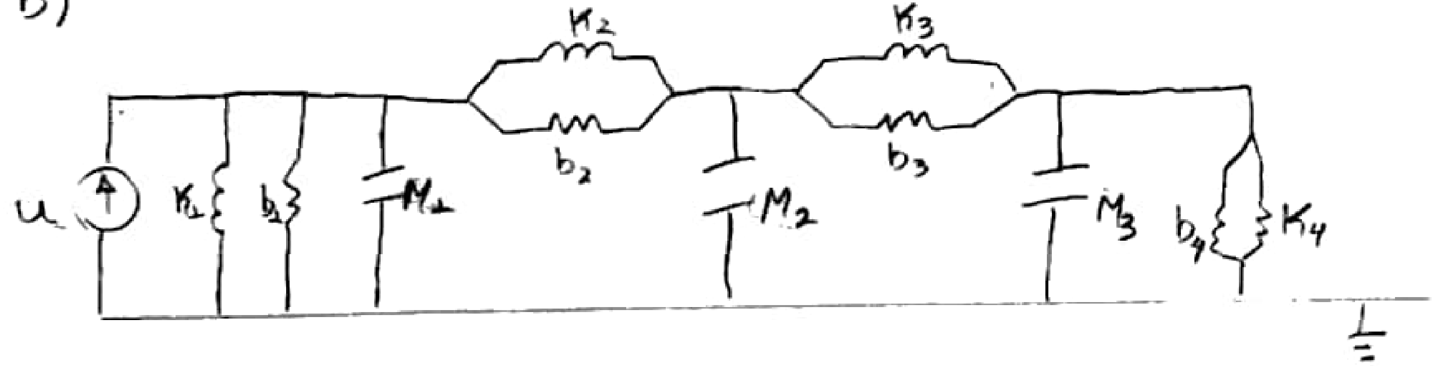
$$\frac{\partial L}{\partial x_3} = -\left[K_3(x_3 - x_2) + K_4 x_3\right]$$

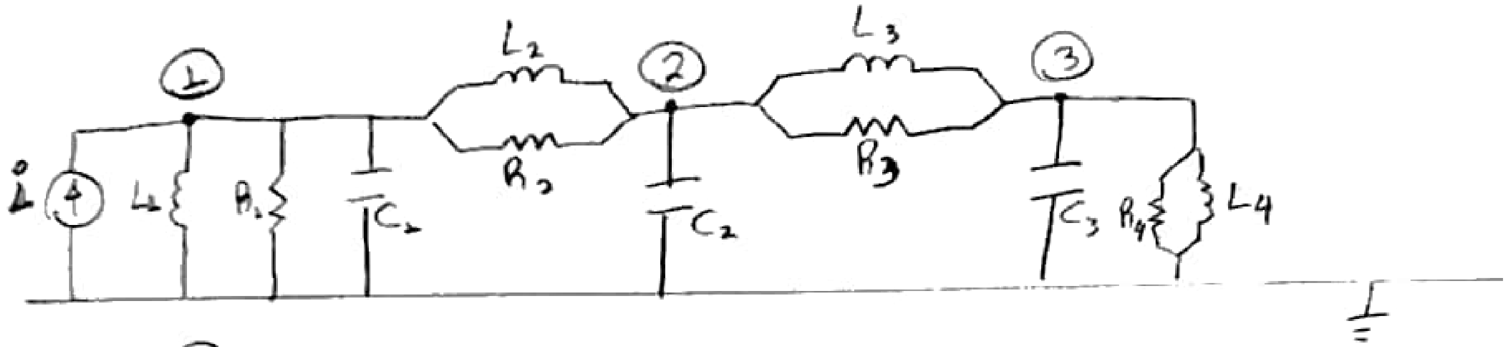
$$\frac{\partial R}{\partial \dot{x}_3} = \left[b_3(\dot{x}_3 - \dot{x}_2) + b_4 \dot{x}_3\right]$$

↳ Eq. dif.

$$m\ddot{x}_3 - b_3\dot{x}_2 + (b_3 + b_4)\dot{x}_3 - K_3 x_2 + (K_3 + K_4)x_3 = 0$$

b)





↳ Ponto 1

$$V_1\left(\frac{1}{L_1D}+\frac{1}{R_1}+C_1D+\frac{1}{L_2D}+\frac{1}{R_2}\right)-V_2\left(\frac{1}{L_2D}+\frac{1}{R_2}\right)=i$$

$$m_1\ddot{x}_1+(b_1+b_2)\dot{x}_1-b_2\dot{x}_2+(K_1+K_2)x_1-K_2x_2=u$$

↳ Ponto 2

$$V_2\left(C_2D+\frac{1}{L_2D}+\frac{1}{R_2}+\frac{1}{L_3D}+\frac{1}{R_3}\right)-V_1\left(\frac{1}{L_2D}+\frac{1}{R_2}\right)-V_3\left(\frac{1}{L_3D}+\frac{1}{R_3}\right)=0$$

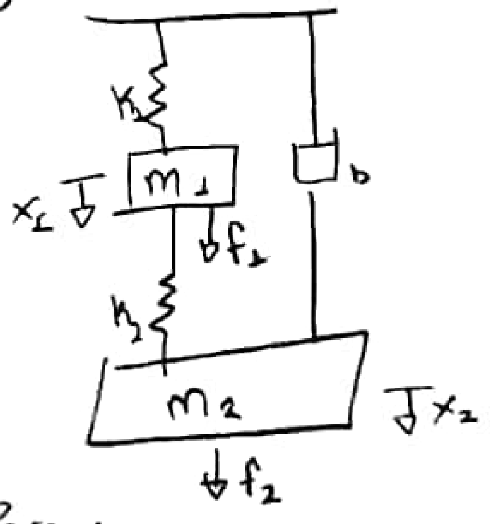
$$m\ddot{x}_2-b_2\dot{x}_1+(b_2+b_3)\dot{x}_2-b_3\dot{x}_3-K_2x_1+(K_2+K_3)x_2-K_3x_3=0$$

↳ Ponto 3

$$V_3\left(C_3D+\frac{1}{L_3D}+\frac{1}{R_3}+\frac{1}{L_4D}+\frac{1}{R_4}\right)-V_2\left(\frac{1}{L_3D}+\frac{1}{R_3}\right)=0$$

$$m\ddot{x}_3-b_3\dot{x}_2+(b_3+b_4)\dot{x}_3-K_3x_2+(K_3+K_4)x_3=0$$

④



a) $T=\frac{1}{2}(m_1\dot{x}_1^2+m_2\dot{x}_2^2)$

$V=\frac{1}{2}(x_1^2K_1+(x_2-x_1)^2K_2)$

$R=\frac{1}{2}b\cdot x_2^2$

$L=T-V$

↳ Para x_1

$\frac{\partial}{\partial t}\left(\frac{\partial L}{\partial \dot{x}_1}\right)=m_1\ddot{x}_1$

$\frac{\partial L}{\partial x_1}=-\left[x_1K_1-(x_2-x_1)K_2\right]$

$\frac{\partial R}{\partial \dot{x}_1}=0$

• Eq. dif:

$m_1\ddot{x}_1+(K_1+K_2)x_1-K_2x_2=f_1$ //

↳ Para x_2

$\frac{\partial}{\partial t}\left(\frac{\partial L}{\partial \dot{x}_2}\right)=m_2\ddot{x}_2$

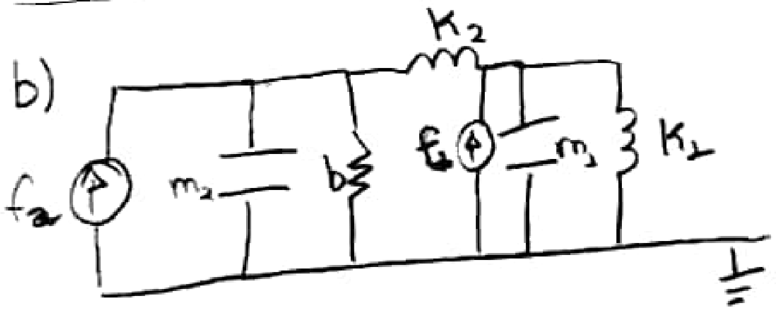
$\frac{\partial L}{\partial x_2}=-\left[(x_2-x_1)K_2\right]$

$\frac{\partial R}{\partial \dot{x}_2}=b\dot{x}_2$

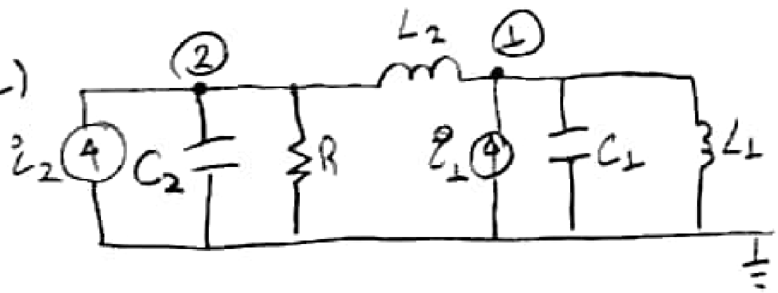
• Eq. dif

$m_2\ddot{x}_2-K_2x_1+K_2x_2+b\dot{x}_2=f_2$ //

b)



c)



↳ Ponto ①

$$V_1\left(C_1 D + \frac{1}{L_1 D} + \frac{1}{L_2 D}\right) - V_2\left(\frac{1}{L_2 D}\right) = i_1$$

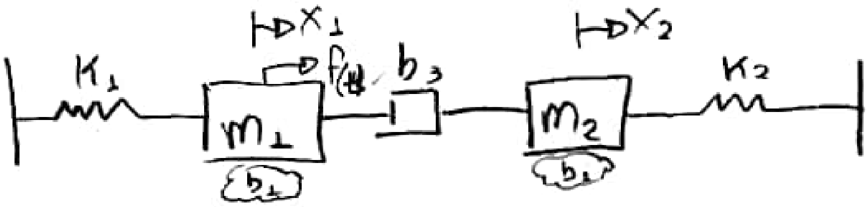
$$m_1 \ddot{x}_1 + (K_1 + K_2)x_1 - K_2 x_2 = f_1$$

↳ Ponto ②

$$V_2\left(C_2 D + \frac{1}{R} + \frac{1}{L_2 D}\right) - V_1 \frac{1}{L_2 D} = i_2$$

$$m_2 \ddot{x}_2 + b_2 \dot{x}_2 - K_2 x_1 + K_2 x_2 = f_2$$

5



a) $T = \frac{1}{2}(m_1 \dot{x}_1 + m_2 \dot{x}_2)$

$V = \frac{1}{2}(K_1 x_1^2 + K_2 x_2^2)$

$R = \frac{1}{2}(b_1 \dot{x}_1^2 + b_3(\dot{x}_2 - \dot{x}_1)^2 + b_2 \dot{x}_2^2)$

$L = T - V$

→ Para x_1:

$\frac{\partial}{\partial t}\left(\frac{\partial L}{\partial \dot{x}_1}\right) = m_1 \ddot{x}_1$

$\frac{\partial L}{\partial x_1} = -\left[K_1 x_1\right]$

$\frac{\partial R}{\partial \dot{x}_1} = \left[b_1 \dot{x}_1 - b_3(\dot{x}_2 - \dot{x}_1)\right]$

• Eq Dif:

$m_1 \ddot{x}_1 + (b_1 + b_3)\dot{x}_1 - b_3 \dot{x}_2 + K_1 x_1 = f$

→ Para x_2

$\frac{\partial}{\partial t}\left(\frac{\partial L}{\partial \dot{x}_2}\right) = m \ddot{x}_2$

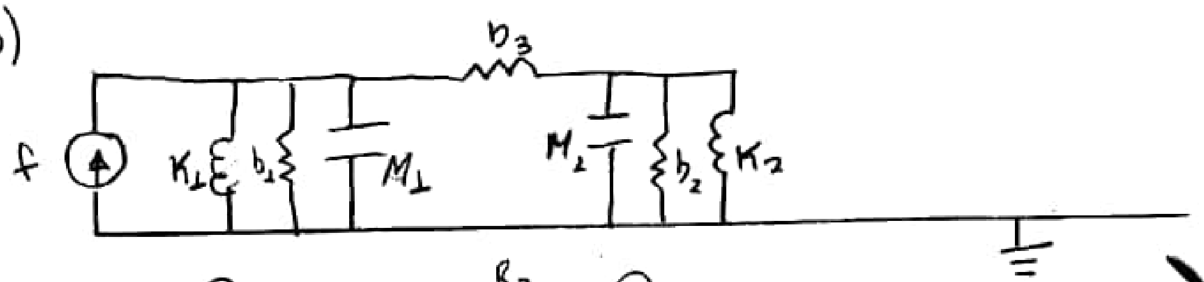
$\frac{\partial L}{\partial x_2} = -\left[K_2 x_2\right]$

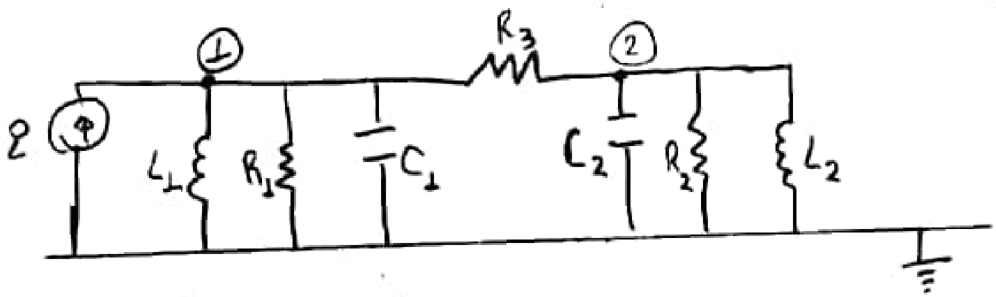
$\frac{\partial R}{\partial \dot{x}_2} = b_2 \dot{x}_2 + b_3(\dot{x}_2 - \dot{x}_1)$

• Eq. Dif:

$m_2 \ddot{x}_2 - b_3 \dot{x}_1 + (b_2 + b_3)\dot{x}_2 + K_2 x_2 = 0$

b)





→ Nó 1

$$V_1\left(\frac{1}{L_1 D}+\frac{1}{R_1}+C_1 D+\frac{1}{R_3}\right)-V_2\frac{1}{R_3}=i$$

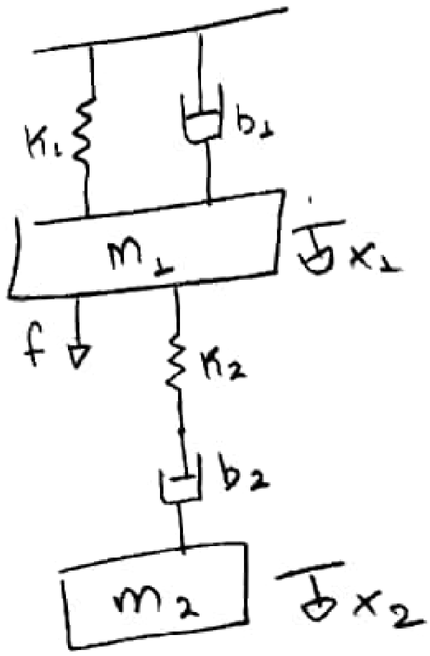
$$M_1\ddot{x}_1+(b_1+b_3)\dot{x}_1-b_3\dot{x}_2+K_1x_1=f$$

→ Nó 2

$$V_2\left(\frac{1}{R_3}+C_2D+\frac{1}{R_2}+\frac{1}{L_2D}\right)-V_1\left(\frac{1}{R_3}\right)=0$$

$$M_2\ddot{x}_2-b_3\dot{x}_1+(b_2+b_3)\dot{x}_2+K_2x_2=0$$

⑥



a) $T = \frac{1}{2}(m_1 \dot{x}_1^2 + m_2 \dot{x}_2^2)$

$V = \frac{1}{2}\left[K_1 x_1^2 + K_2 (x_2 - x_1)^2\right]$

$R = \frac{1}{2}\left[b_1 \dot{x}_1^2 + b_2 (\dot{x}_2 - \dot{x}_1)^2\right]$

$L = T - V$

↳ Para x_1:

$\frac{\partial}{\partial t}\left(\frac{\partial L}{\partial \dot{x}_1}\right) = m_1 \ddot{x}_1$

$\frac{\partial L}{\partial x_1} = -\left[K_1 x_1 - K_2(x_2 - x_1)\right]$

$\frac{\partial R}{\partial \dot{x}_1} = b_1 \dot{x}_1 - b_2(\dot{x}_2 - \dot{x}_1)$

• Eq. Dif

$m_1 \ddot{x}_1 + (b_1 + b_2)\dot{x}_1 - b_2 \dot{x}_2 + (K_1 + K_2)x_1 - K_2 x_2 = f$

↳ Para x_2:

$\frac{\partial}{\partial t}\left(\frac{\partial L}{\partial \dot{x}_2}\right) = m \ddot{x}_2$

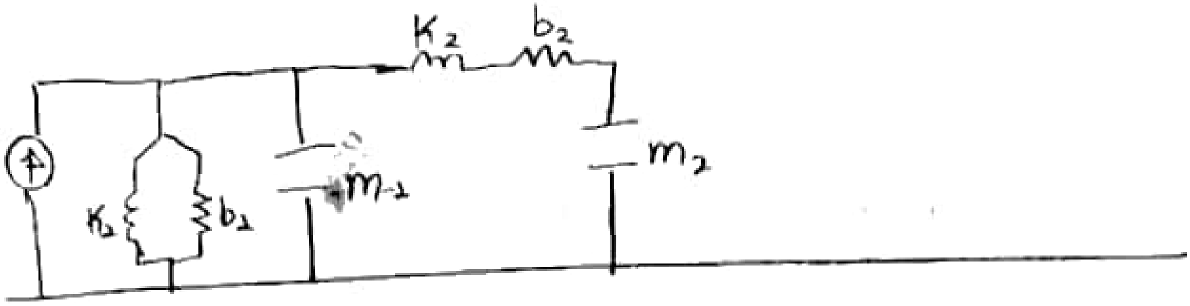
$\frac{\partial L}{\partial x_2} = -\left[K_2(x_2 - x_1)\right]$

$\frac{\partial R}{\partial \dot{x}_2} = b_2(\dot{x}_2 - \dot{x}_1)$

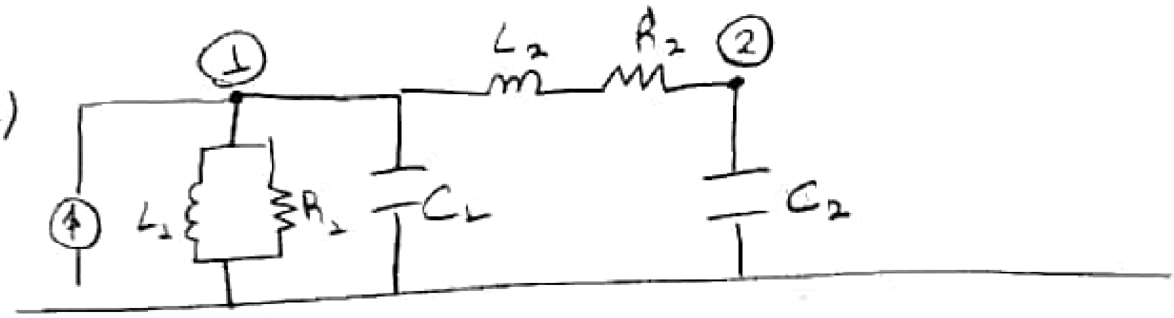
• Eq. dif:

$m \ddot{x}_2 - b_2 \dot{x}_1 + b_2 \dot{x}_2 - K_2 x_1 + K_2 x_2 = 0$

b)



c)



d) ↳ Para ①

$$V_1\left(\frac{1}{L_1D}+\frac{1}{R_1}+\frac{1}{L_2D}+\frac{1}{R_2}+C_1D\right)-V_2\left(\frac{1}{L_2D}+\frac{1}{R_2}\right)=i$$

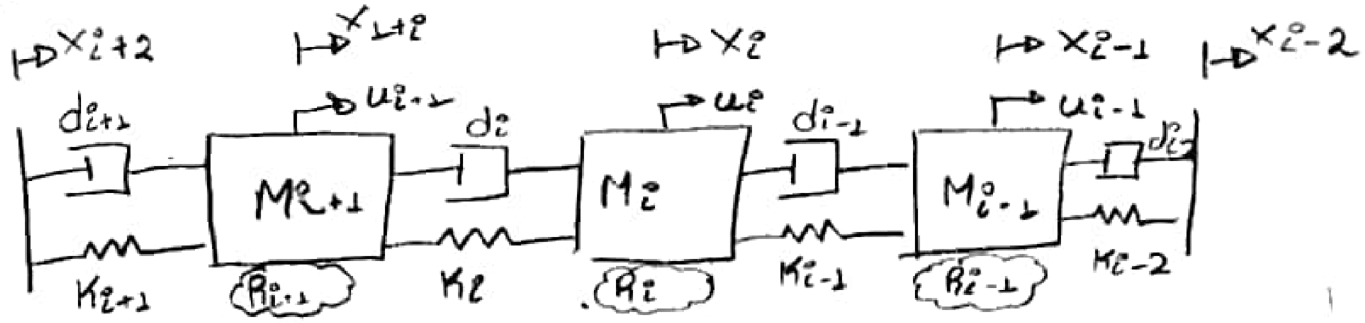
$$m_1\ddot{x}_1+(b_1+b_2)\dot{x}_1-b_2\dot{x}_2+(K_1+K_2)x_1-K_2x_2=f$$

↳ Para ②

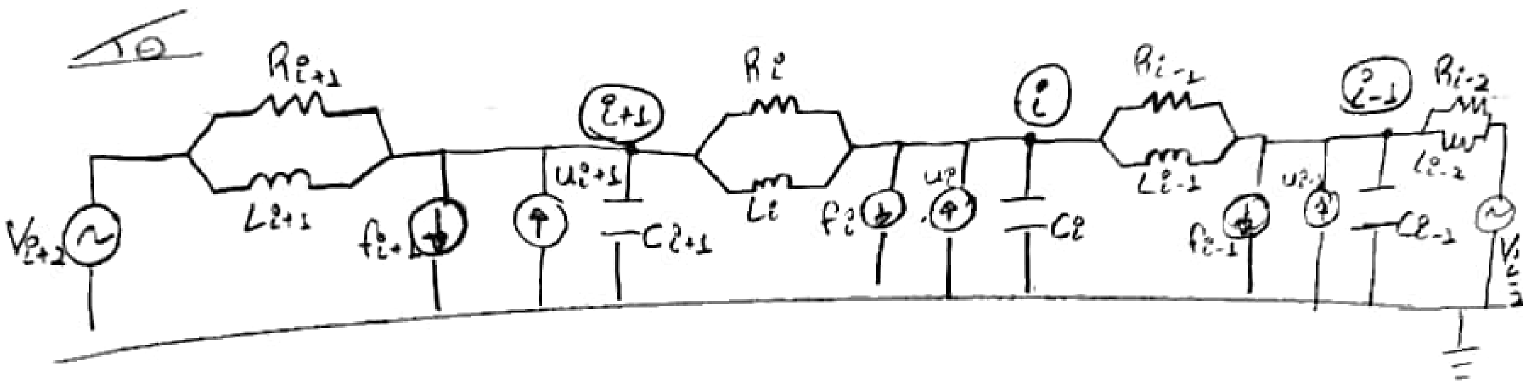
$$V_2\left(C_2D+\frac{1}{R_2}+\frac{1}{L_2D}\right)-V_1\left(\frac{1}{L_2D}+\frac{1}{R_2}\right)=0$$

$$m_2\ddot{x}_2-b_2\dot{x}_1+b_2\dot{x}_2-K_2x_1+K_2x_2=0$$

7



- temos a força: Peso · senθ agindo em cada vagão



↳ Para o nó $i-1$

$$V_{i-1}\left(\frac{1}{R_{i-2}}+\frac{1}{L_{i-2}D}+C_{i-1}+\frac{1}{R_{i-1}}+\frac{1}{L_{i-1}D}\right)-V_i\left(\frac{1}{R_{i-1}}+\frac{1}{L_{i-1}D}\right)-V_{i-2}\left(\frac{1}{R_{i-2}}+\frac{1}{L_{i-2}D}\right)=$$
$$=u_{i-1}-f_{i-1}$$

$$m_{i-1}\ddot{x}_{i-1}+(d_{i-2}+d_{i-1})\dot{x}_{i-1}+(K_{i-2}+K_{i-1})x_{i-1}-d_i\dot{x}_i-K_ix_i-d_{i-2}\dot{x}_{i-2}-K_{i-2}x_{i-2}=$$
$$u_{i-1}-R_{i-1}$$

↳ Para i:

$$V_i\left(\frac{1}{R_{i-1}}+\frac{1}{L_{i-1}D}+C_iD+\frac{1}{R_i}+\frac{1}{L_iD}\right)-V_{i-1}\left(\frac{1}{R_{i-1}}+\frac{1}{L_{i-1}D}\right)-V_{i+1}\left(\frac{1}{R_i}+\frac{1}{L_iD}\right)=u_i-f_i$$

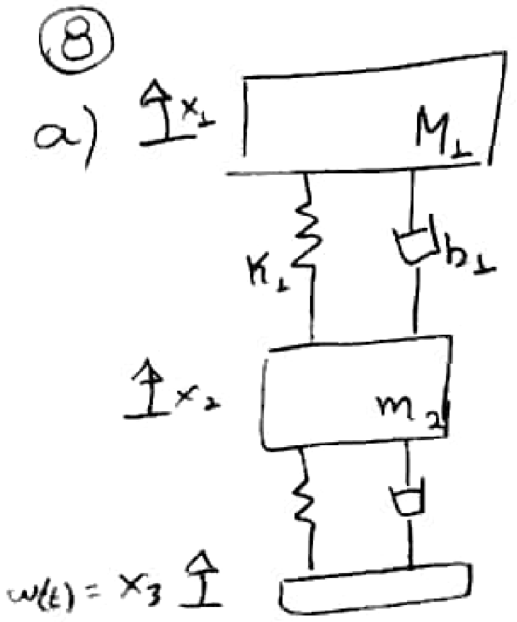
$$m_i\cdot\ddot{x}_i+(d_{i-1}+d_i)\dot{x}_i+(K_{i-1}+K_i)x_i-d_{i-1}\dot{x}_{i-1}-K_{i-1}x_{i-1}-d_i\dot{x}_{i+1}-K_ix_{i+1}=$$
$$=u_i-R_i$$

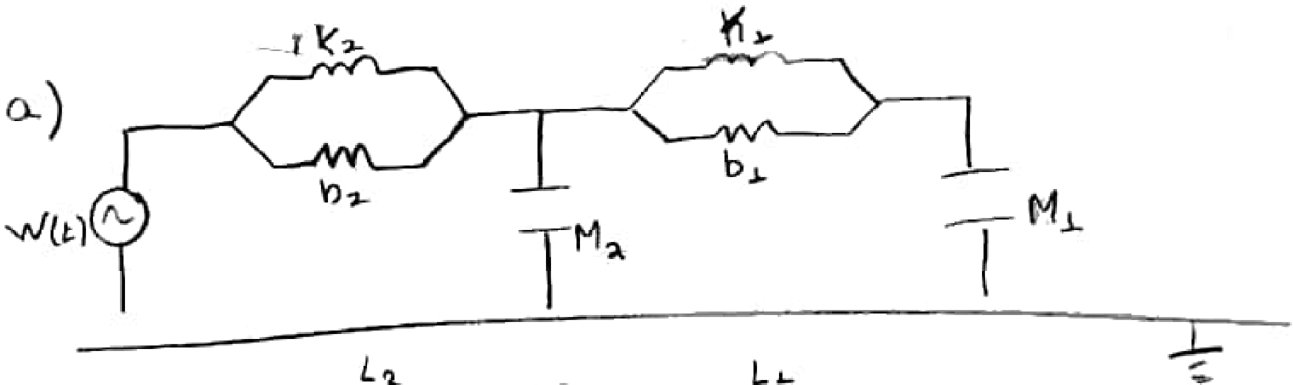
↳ Para $i+1$:

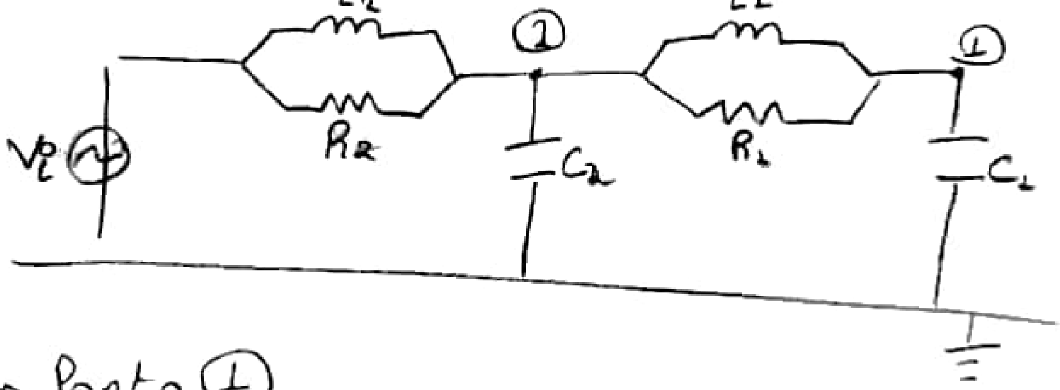
$$V_{i+1}\left(\frac{1}{R_i}+\frac{1}{L_iD}+C_{i+1}D+\frac{1}{R_{i+1}}+\frac{1}{L_{i+1}D}\right)-V_i\left(\frac{1}{R_i}+\frac{1}{L_iD}\right)-V_{i+2}\left(\frac{1}{R_{i+1}}+\frac{1}{L_{i+1}D}\right)=u_{i+1}-f_{i+1}$$

$$m_{i+1}\ddot{x}_{i+1}+(d_i+d_{i+1})\dot{x}_{i+1}+(K_i+K_{i+1})x_{i+1}-d_i\dot{x}_i-K_ix_i-d_{i+1}\dot{x}_{i+2}-K_ix_i=u_{i+1}-R_{i+1}$$

8







→ Ponto 1

$$V_1\left(\frac{1}{L_1D}+\frac{1}{R_1}\right)+V_1C_1D - V_2\left(\frac{1}{L_1D}+\frac{1}{R_1}\right)=0$$

$$m_1\ddot{x}_1 + b_1\dot{x}_1 - b_1\dot{x}_2 + K_1x_1 - K_1x_2 = 0$$

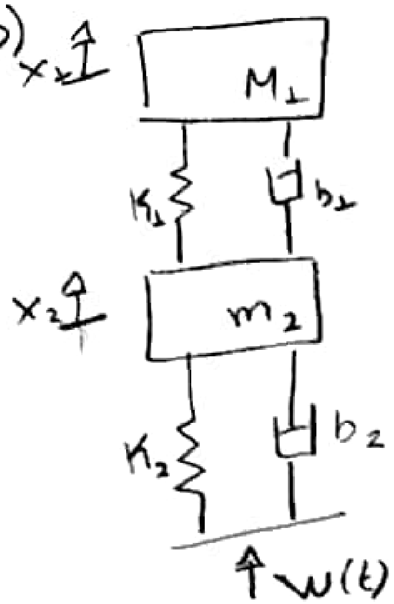
→ Ponto 2

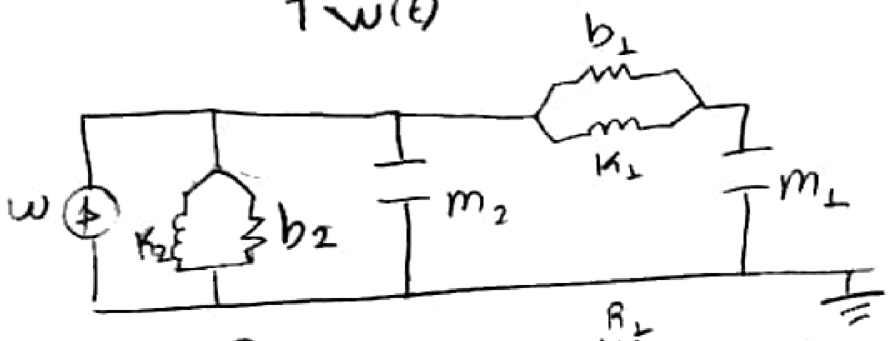
$$V_2\left(C_2D+\frac{1}{L_2D}+\frac{1}{R_2}+\frac{1}{L_1D}+\frac{1}{R_1}\right)-V_1\left(\frac{1}{L_1D}+\frac{1}{R_1}\right)-V_t\left(\frac{1}{L_2D}+\frac{1}{R_2}\right)=0$$

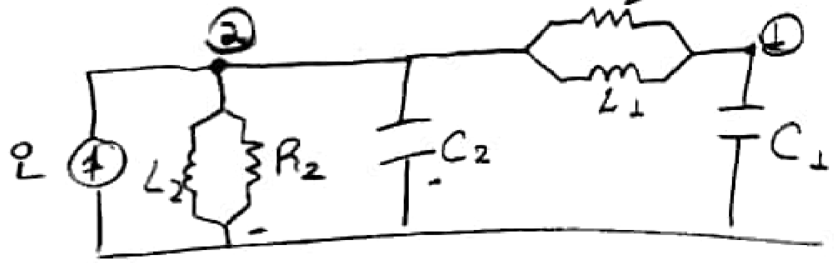
$$m_2\ddot{x}_2 - b_1\dot{x}_1+(b_1+b_2)\dot{x}_2-K_1x_1+(K_1+K_2)x_2=b_2\dot{w}+K_2w$$

8

b)







↳ Ponto 1

$$V_1\left(C_1 D + \frac{1}{L_1 D} + \frac{1}{R_1}\right) - V_2\left(\frac{1}{R_1} + \frac{1}{L_1 D}\right) = 0$$

$$m_1 \ddot{x}_1 + b_1 \dot{x}_1 - b_1 \dot{x}_2 + K_1 x_1 - K_1 x_2 = 0$$

↳ Ponto 2

$$V_2\left(C_2 D + \frac{1}{L_1 D} + \frac{1}{R_1} + \frac{1}{L_2 D} + \frac{1}{R_2}\right) - V_1\left(\frac{1}{R_1} + \frac{1}{L_1 D}\right) = i$$

$$m_2 \ddot{x}_2 - b_1 \dot{x}_1 + (b_1 + b_2)\dot{x}_2 - K_1 x_1 + (K_1 + K_2) x_2 = w$$