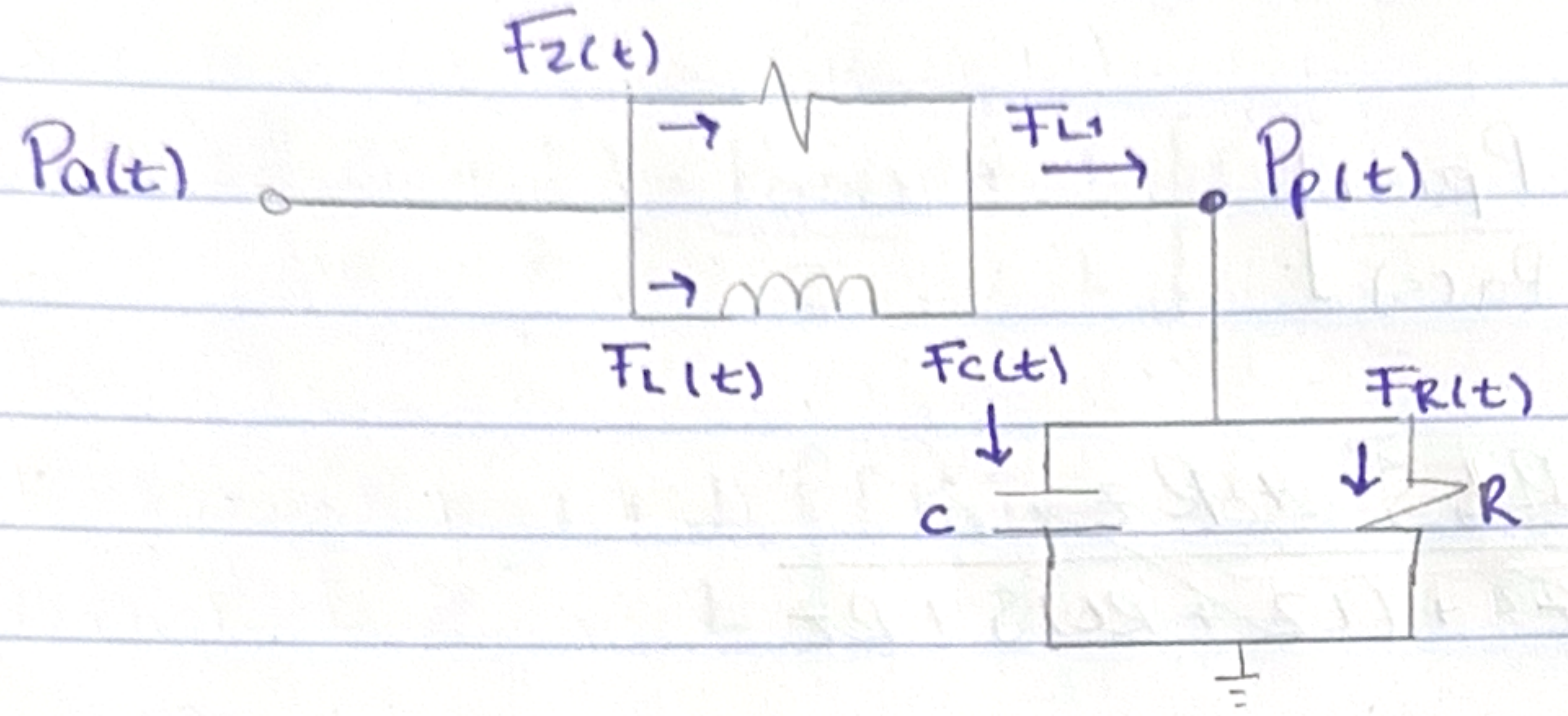
10-oct-2025

Práctica 5.4 Sistema cardiovascular



→ Ecuación principal

$$Fa(t) = F_Z(t) + F_C(t) = F_C(t) + F_R(t)$$

$$F_Z(t) = \frac{Pa(t) - P_p(t)}{Z} \qquad F_C(t) = \frac{C\,dP_p(t)}{dt}$$

$$F_L(t) = \frac{1}{L}\int [Pa(t) - P_p(t)]\,dt \qquad F_R(t) = \frac{P_p(t)}{R}$$

→ Procedimiento algebraico

$$\frac{Pa(t)}{Z} - \frac{P_p(t)}{Z} + \frac{1}{L}\int [Pa(t) - P_p(t)]\,dt = \frac{C\,dP_p(t)}{dt} + \frac{P_p(s)}{R}$$

$$\left(\frac{1}{Z} + \frac{1}{LS}\right) Pa(s) = \left(CS + \frac{1}{R} + \frac{1}{Z} + \frac{1}{LS}\right) P_p(s)$$

$$\to Pa(s) = \frac{Cs + \frac{1}{R} + \frac{1}{Z} + \frac{1}{LS}}{\frac{1}{Z} + \frac{1}{LS}}$$

$$\frac{Ls + Z}{LZS} = \frac{CLZS^2 + LZS + RLS + RZ}{RLZS} P_p(s)$$

$$\frac{P_p(s)}{Pa(s)} = \frac{\frac{Ls + Z}{LZS}}{\frac{CLZS^2 + LZS + RLS + RZ}{RLZS}}$$

←

→ Error en estado estacionario

$$e(s) = \lim_{s \to 0} s\, P_a(s) \left[1 - \frac{P_p(s)}{P_a(s)} \right]$$

$$= \lim_{s \to 0} s * \frac{1}{s} \left[1 - \frac{\cancel{RLS} + RZ}{\cancel{CLRZ^2} + \cancel{(LZ + RL)S} + RZ} \right]$$

$$= 1 - \frac{RZ}{RZ} = 0V$$

→ Estabilidad en lazo abierto

$$\lambda_{1,2} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$a = CLRZ$

$b = LZ + RL$

$c = RZ$

$$\lambda_{1,2} = \frac{-(LZ + RL) \pm \sqrt{(LZ + RL)^2 - 4CLR^2Z^2}}{2CLRZ} = \frac{(-)(\ )}{+}$$

El sistema tiene una respuesta estable porque $Re\, \lambda_{1,2} < 0$

→ Modelo de ecuaciones integro - diferenciales

$$P_p(t)\left(\frac{1}{R}+\frac{1}{Z}\right)=\frac{P_a(t)}{Z}+\frac{1}{L}\int[P_a(t)-P_p(t)]\,dt-\frac{C\,d\,P_p(t)}{dt}$$

$$P_p(t)=\left(\frac{P_a(t)}{Z}+\frac{1}{L}\int[P_a(t)-P_p(t)-\frac{C\,dP_p(t)}{dt}\right)\frac{ZR}{Z+R}$$