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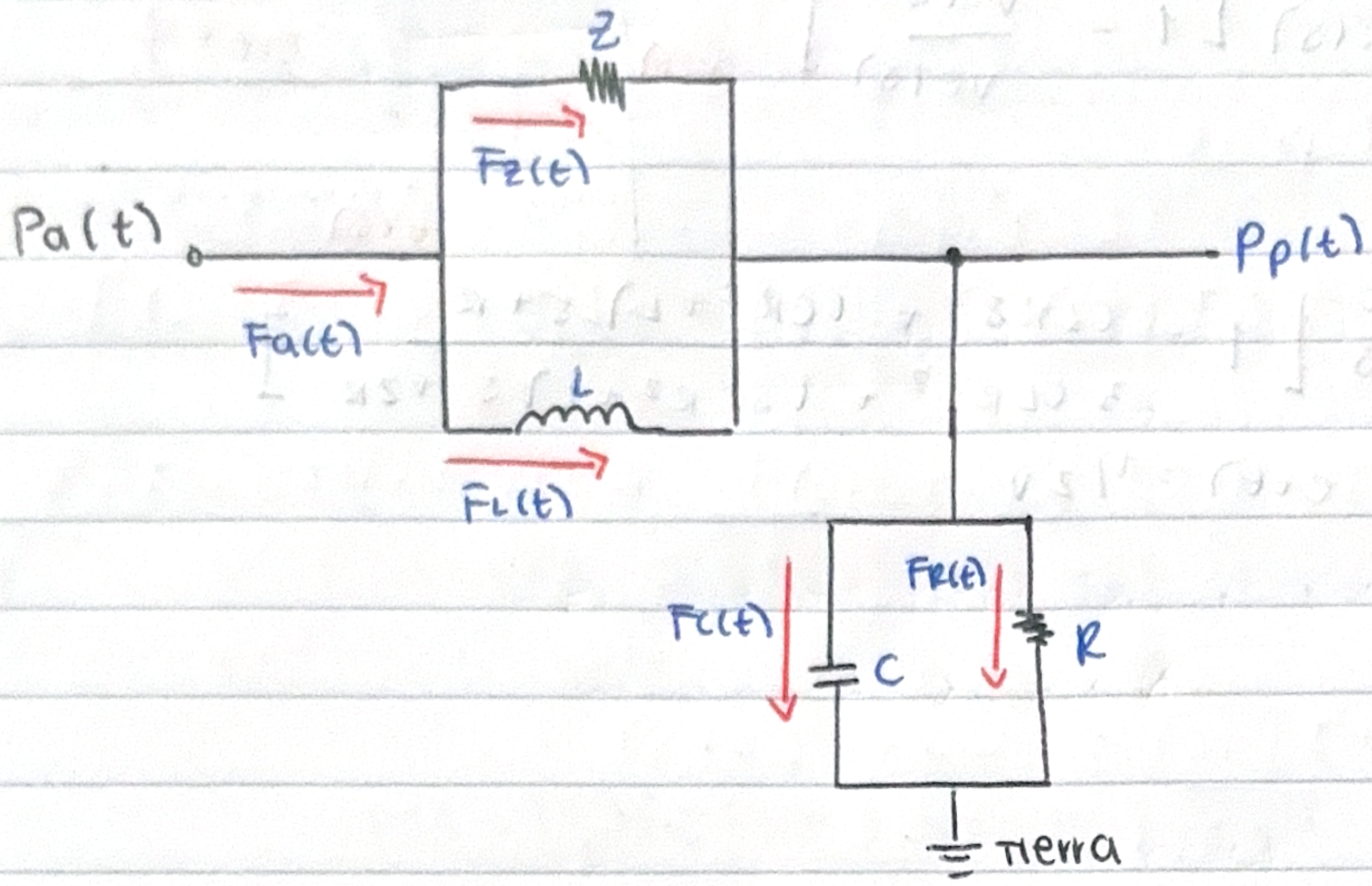
Práctica 5.4 : Sistema cardiovascular



Ecuación principal

$$F_a(t) = F_Z(t) + F_L(t) = F_C(t) + F_R(t)$$

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

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

Procedimiento

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

$$\frac{P_a(s)}{Z} - \frac{P_p(s)}{Z} + \frac{P_a(s) - P_p(s)}{Ls} = Cs\,P_p(s) + \frac{P_p(s)}{R}$$

$$\left(\frac{1}{Z} + \frac{1}{Ls}\right) P_a(s) = \left(Cs + \frac{1}{R} + \frac{1}{Z} + \frac{1}{Ls}\right) P_p(s)$$

$$\frac{LS+Z}{LSZ} \quad Pa(s) = \frac{CRLZS^2 + LZS + RLS + RZ}{RLZS} \quad (Pp(s))$$

$$\frac{Pp(s)}{Pa(s)} = \frac{\dfrac{LS+Z}{\cancel{L}ZS}}{\dfrac{[CLRZ]S^2 + [LZ + LR]S + RZ}{\cancel{L}RSZ}}$$

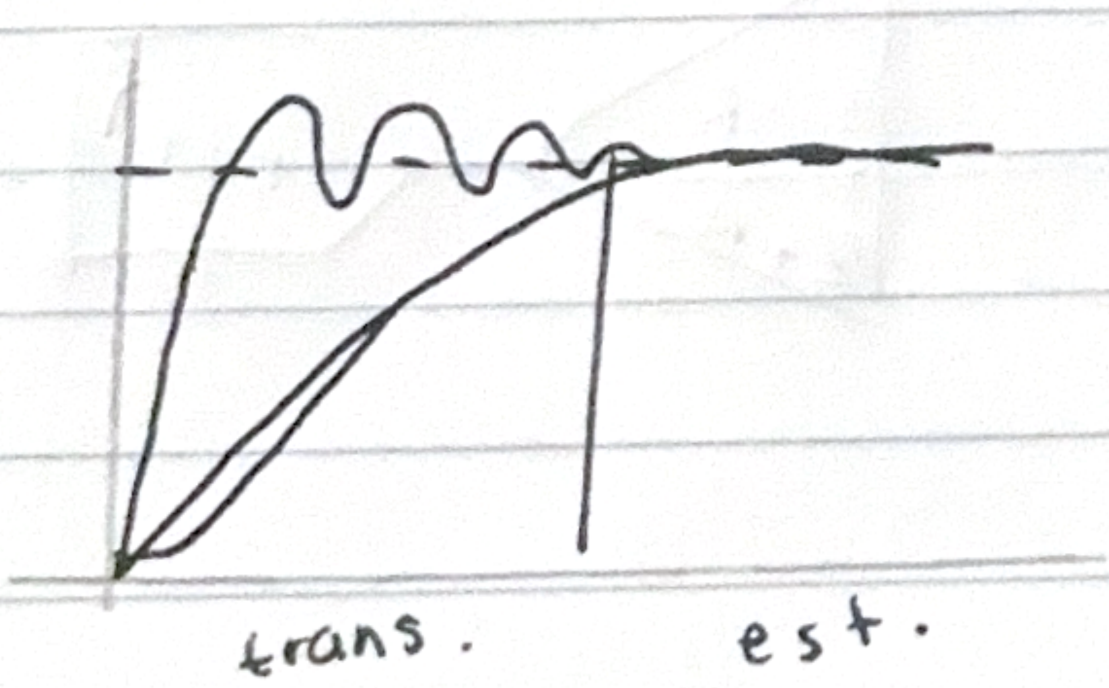
$$\frac{Pp(s)}{Pa(s)} = \frac{LRS + RZ}{[CLRZ]S^2 + [LZ + LR]S + RZ}$$

Función de transferencia

Error en estado estacionario

$$e(s) = \lim_{s \to 0} s \; Pa(s) \left[1 - \frac{Pp(s)}{Pa(s)} \right]$$

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



Estabilidad en lazo abierto

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

$a = CLRZ$

$b = LZ + RL$

$c = RZ$

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

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

Modelo de ecuaciones integro-diferenciales

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

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