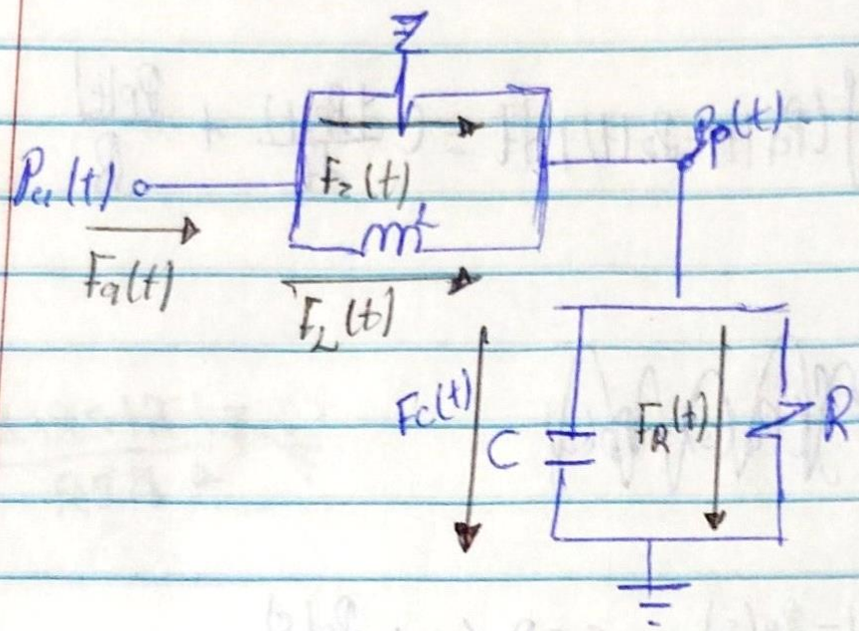
10/10/25

Práctica 5.4: Sistema cardiovascular



Ecuación Principal

$$F_a(t) = F_z(t) + F_L(t) = F_c(t) + F_R(t)$$

$$F_z(t) = \frac{P_a(t) - P_p(t)}{Z}$$

$$F_L(t) = \frac{1}{L} \int (P_a(t) - P_p(t))\, dt$$

$$F_c(t) = C \frac{dP_p(t)}{dt}$$

$$F_R(t) = \frac{P_p(t)}{R}$$

* Se sustuye en la ec. Principal

Procedimiento algebraico

$$\frac{P_a(t)}{2} = \frac{P_b(t)}{2} + \frac{1}{L}\int (P_a(t) - P_b(t))\,dt = C\frac{dP_b(t)}{dt} + \frac{P_b(t)}{R}$$

$$\frac{P_a(s)}{2} = \frac{P_b(s)}{2} + \frac{1}{Ls}(P_a(s) - P_b(s))$$

$$\frac{Cs}{1} \quad \frac{2sRL + 2R + Ls2}{Ls2R}$$

f. transferencia

$$\frac{P_a(s)}{2} = \frac{P_b(s)}{2} + \frac{P_a(s) - P_b(s)}{Ls} = 2CsP_b(s) + \frac{P_b(s)}{R}$$

$$\frac{RLs + R2}{2LRCs^2 + (L2 + R2)s + R2}$$

$$\frac{1}{R} + \frac{Ls + 2}{2Ls} = \frac{R2s + 2R}{R2Ls} + 2Ls$$

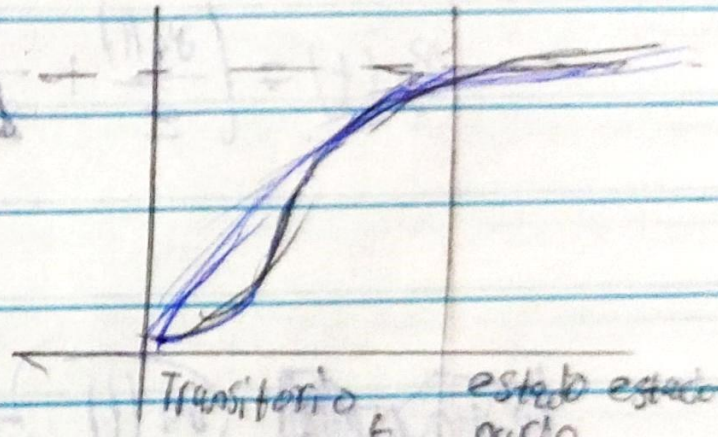
$$\left(\frac{1}{2} + \frac{1}{2s}\right) P_a(s) = \left(Cs + \frac{1}{R} + \frac{1}{2} + \frac{1}{Ls}\right) P_b(s)$$

$$\left(\frac{1}{2} + \frac{1}{2s}\right) P_a(s) = \left(\frac{2sRL + 2R + Ls2 + 1}{Cs2R}\right) P_b(s)$$

$$\frac{R2S + R2}{C2R2S^2 + (L2 + R2)S + R2}$$ ← función de transferencia

Error en estado estacionario

$$e(s) = \lim_{S \to 0} S\, P_4(S) \left[1 - \frac{P_P(S)}{P_4(S)} \right]$$



$$= \lim_{S \to 0} S \cdot \frac{1}{S} \left[1 - \frac{R2S^{\to 0} + R2}{C2R2S^{\to 0^2} + (L2 + R2)^{\to 0} + R2} \right]$$

$$= 1 - \frac{R2}{R2} = 0\,V$$

Estabilidad en lazo abierto $G = C_2 R_2$

$$\lambda_{1,2} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \qquad b = 2L + R_2 L$$

$$c = R_2$$

$$\lambda_{1,2} = \frac{-(2L + R_2 L) \pm \sqrt{(2L + R_2 L)^2 - 4 C_2 R_2 L^2}}{2 C_2 R_2 L} = \frac{(-1)(\;)}{4}$$

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

Ecuaciones integro-diferenciales

$$P_p(t)\left(\frac{L+R}{LR} + \frac{1}{L}\right) = \frac{P_a(t)}{L} + \frac{1}{L}\int (P_a(t) - P_p(t))\,dt - \frac{C_d dP_p(t)}{dt}$$

$$P_p(t) = \left(\frac{P_a(t)}{L} + \frac{1}{L}\int (P_a(t) - P_p(t))\,dt - \frac{C_d dP_p(t)}{dt}\right)\frac{LR}{L+R}$$