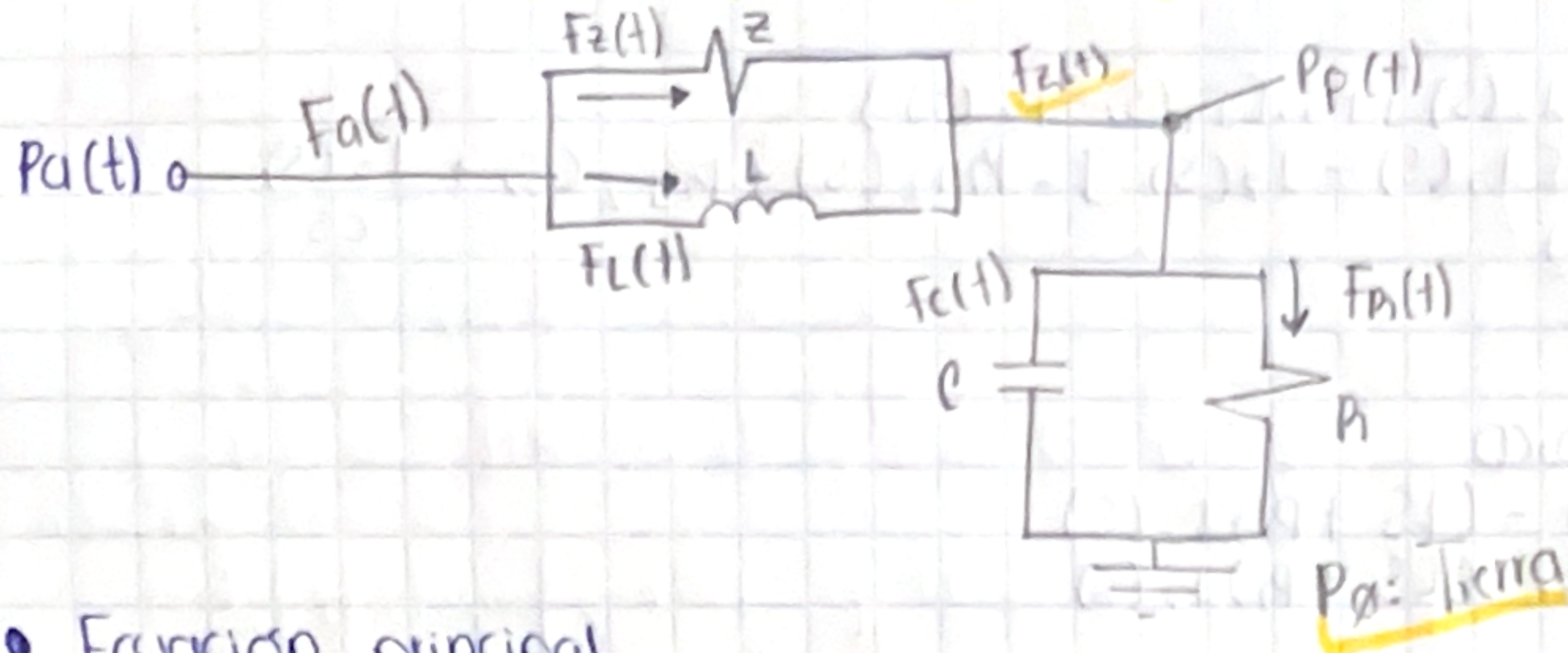
10-Octubre-2025

Practica 5.4. Sistema Cardiovascular.



- Ecuacion principal

$Fa(t) = Fz(t) + F_L(t) = Fc(t) + F_R(t)$

$Fz(t) = \frac{Pa(t) - Pp(t)}{z}$

$F_L(t) = \frac{1}{L}\int [Pa(t) - Pp(t)]\,dt$

$Fc(t) = \frac{C\,dPp(t)}{dt}$

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

- Procedimiento algebraico

$T = \frac{Pa(t)}{z} - \frac{Pp(t)}{z} + \frac{1}{L}\int [Pa(t) - Pp(t)]\,dt = \frac{C\,dPp(t)}{dt} + \frac{Pp(t)}{R}$

$\frac{Pa(s)}{z} - \frac{Pp(s)}{z} + \frac{Pa(s) - Pp(s)}{LS} = CSPp(S) + \frac{Pp(S)}{R}$

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

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

$\frac{Pp(s)}{Pa(s)} = \frac{\frac{LS + Z}{LZS}}{\frac{CLS^2 + (LZ + RL)S + RZ}{RLZS}}$

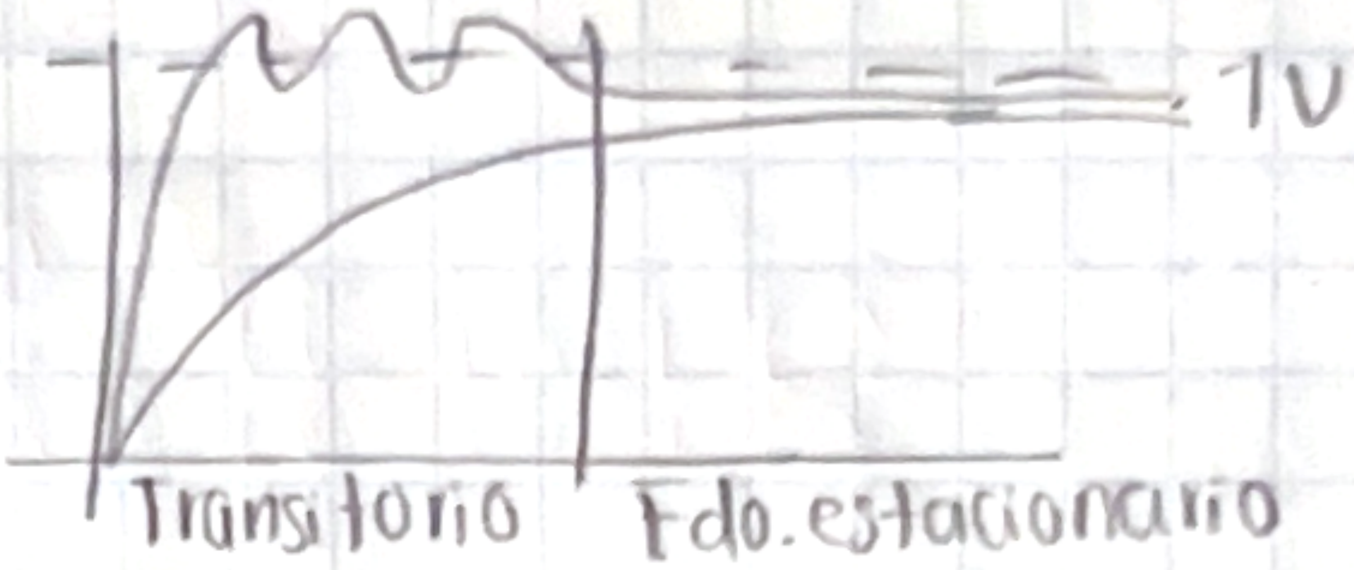
$= \frac{RLS + RZ}{CLRZS^2 + (LZ + RL)S + RZ}$

- Error en estado estacionario

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

$$= \lim_{s \to 0} s * \frac{1}{s} \left[1 - \frac{RLs + Rz}{CLRz\, s^2 + (LZ+RL) s + Rz}\right]$$

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



- Estabilidad en lazo abierto → Usando la función de transferencia

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

$a = CLRZ$
$b = LZ + RL$
$c = RZ$

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

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

- Modelo de ecuaciones integro-diferenciales. → A partir de la función de transferencia

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

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

- Simulink