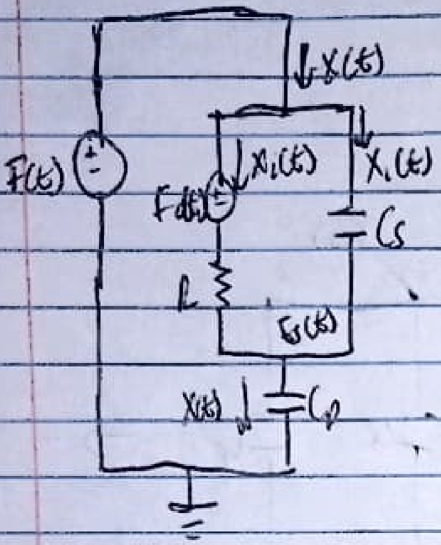
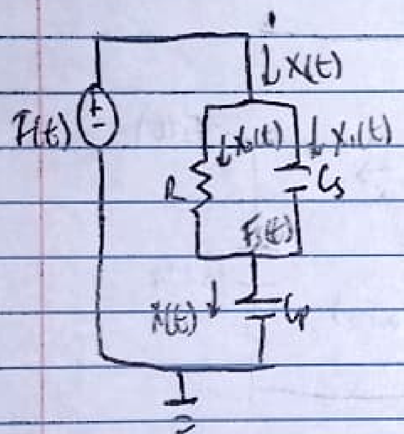
Sistema musculoesquelético



$X_2(t) = X(t) - X_1(t)$



Análisis por superposición

$X(t) = X_1(t) + X_2(t)$

$X(t) = C_p \frac{dFs(t)}{dt}$

$X_1(t) = Cs \frac{d[F(t) - Fs(t)]}{dt}$

$X_2(t) = \frac{F(t) - F(s)}{R}$

$$C_p \frac{dF_s(t)}{dt} = Cs \frac{d[F(t) - Fs(t)]}{dt} + \frac{F(t) - Fs(t)}{R}$$

$\frac{Fs(s)}{F(s)}$

Transformada de Laplace

$$C_p s\, Fs(s) = Cs\, s[F(s) - Fs(s)] + \frac{F(s) - Fs(s)}{R}$$

$$C_p s Fs(s) + C_s s Fs(s) + \frac{Fs(s)}{R} = Cs\, s F(s) + \frac{F(s)}{R}$$

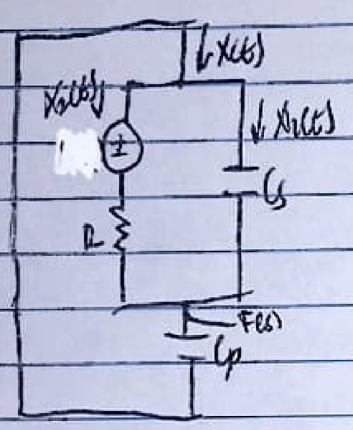
$$[C_p Fs(s) + CsFs(s)]s + \frac{Fs(s)}{R} = Cs\, s F(s) + \frac{F(s)}{R}$$

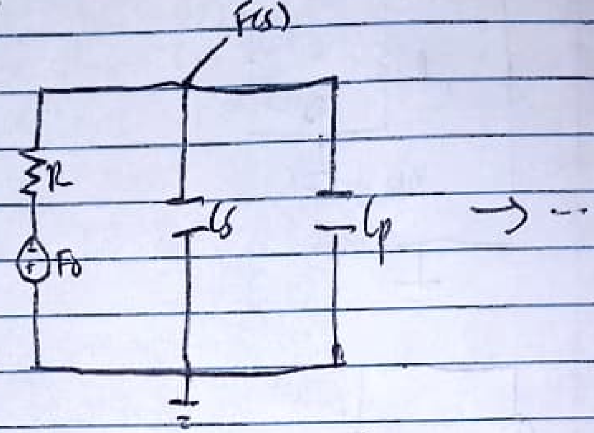
$$Fs(s)\left[(C_p + C_s)s + \frac{1}{R}\right] = F(s)\left[Cs\,s + \frac{1}{R}\right]$$

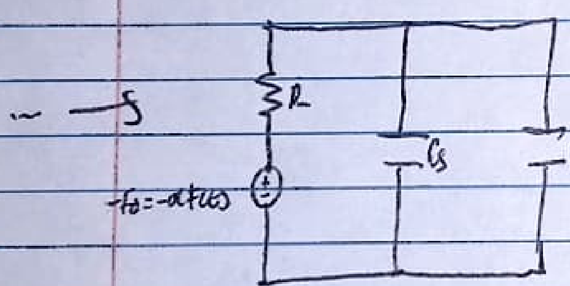
$$Fs(s)\left[\frac{(C_p + C_s)Rs + 1}{R}\right] = F(s)\left[\frac{CsRs + 1}{R}\right]$$

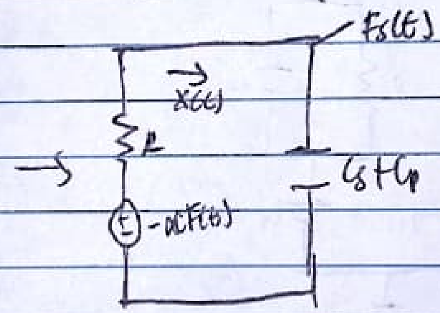
$$\frac{F_S(S)}{F(S)} = \frac{\frac{C_sRS+1}{\cancel{R}}}{\frac{(C_p+C_s)RS+1}{\cancel{R}}} = \frac{C_sRS+1}{(C_p+C_s)RS+1}$$

$$F_{S_1}(S) = \frac{C_sRS+1}{(C_p+C_s)RS+1}F(S)$$









$$-\alpha F(t) = Rx(t) + \frac{1}{C_s+C_p}\int x(t)\,dt \rightarrow F(t) = \frac{Rx(t)+\frac{1}{C_s+C_p}\int x(t)\,dt}{-\alpha}$$

$$F_S(t) = \frac{1}{C_s+C_p}\int x(t)\,dt$$

Transformada de Laplace

$$-\alpha F(S) = Rx(S) + \frac{x(S)}{(C_s+C_p)S}$$

$$F_S(S) = \frac{x(S)}{(C_s+C_p)S}$$

$$F(S) = \frac{Rx(S) + \frac{x(S)}{(C_s+C_p)S}}{-\alpha}$$

$$F(S) = \frac{R(C_s+C_p)S+1}{(C_s+C_p)S}\frac{x(S)}{-\alpha}$$

$$\frac{F_S(S)}{F(S)} = \frac{\cancel{\frac{x(S)}{(C_s+C_p)S}}}{\frac{R(C_s+C_p)S+1}{-\alpha(C_s+C_p)S}\cancel{x(S)}}$$

$$\frac{F_S(S)}{F(S)} = \frac{-\alpha}{R(C_s+C_p)S+1}$$

$$F_{S_2}(S) = \frac{-\alpha}{R(C_s+C_p)S+1}F(S)$$

Función de transferencia

$$F_S(s) = F_{S_1}(s) + F_{S_2}(s)$$

$$F_S(s) = \frac{C_S R_S + 1\, F(s)}{R(C_p + C_S)S + 1} - \frac{\alpha F(s)}{R(C_p + C_S)S + 1}$$

$$F_S(s) = \frac{C_S R_S + 1 - \alpha}{R(C_p + C_S)S + 1} F(s)$$

$$\frac{F_S(s)}{F(s)} = \frac{C_S R_S + 1 - \alpha}{R(C_p + C_S)S + 1}$$ → Función de transferencia

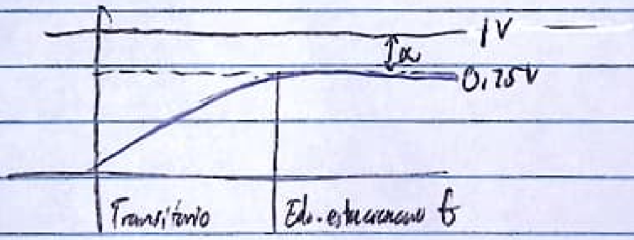
Error en estado estacionario

$$e(s) = \lim_{s \to 0} sF(s)\left[1 - \frac{F_S(s)}{F(s)}\right]$$

$$e(s) = \lim_{s \to 0} s \cdot \frac{1}{s}\left[1 - \frac{C_S R_S + 1 - \alpha}{R(C_S + C_p)S + 1}\right]$$

$$e(s) = \alpha$$

$$e(t) = \alpha V$$



Estabilidad en lazo abierto

$$R(C_p + C_S)S + 1 = 0$$

$$\lambda = -\frac{1}{R(C_p + C_S)}$$

El sistema presenta una respuesta estable

$$Re\, \lambda < 0$$