$M\ddot{y} = F(t) - b_F\dot{y} - mg$

$F(t) = K_F \cdot \omega_F(t) = 1E\text{-}2 \cdot \omega_F(t)$

$\tau_F(t) = 2\,i(t)$

$J_F\,\dot{\omega}(t) = \tau_F(t) - b_F \cdot \omega_F(t)$

$2E\text{-}3\,\dot{\omega}(t) = 2i(t) - 4E\text{-}3\,\omega_F(t)$

$F(t) = 1E\text{-}2 \cdot \dfrac{-2E\text{-}3\,\dot{\omega}(t) + 2\,i(t)}{4E\text{-}3}$

$F(t) = \dfrac{-2E\text{-}3\,\dot{\omega}(t) + 2\,i(t)}{4E\text{-}1}$

$F(0) = \dfrac{-2E\text{-}3\,\dot{\omega}(0) + 2\,i(0)}{4E\text{-}1}$

$F(0) = \dfrac{2\,i_0}{.4}$

$F(0) = 5\,i_0$

$\|$

$9.8 \cdot .5 = 5\,i_0$

$i_0 = .98\,A$

$\tau_{F0} = 1.96\ N\cdot m$

$\omega_{F0} = \dfrac{1.96}{b_F} = \dfrac{1.96}{4E\text{-}3} = 490\ \dfrac{rad}{s}$

$F_0 = 490 \cdot 1E\text{-}2 = 4.9\ N$

$M\ddot{y} = F(t) - b_F\dot{y}$

$\mathcal{L}\left[M\ddot{y} = F(t) - b_F\dot{y}\right]$

$\Rightarrow M \cdot s^2 Y(s) = F(s) - b_F \cdot s\,Y(s)$

$F(t) = K_F \cdot \omega_F(t)$

$\mathcal{L}\left[F(t) = K_F \cdot \omega_F(t)\right]$

$\Rightarrow F(s) = K_F \cdot W_F(s)$

$J_F\,\dot{\omega}(t) = \tau_F(t) - b_F \cdot \omega_F(t)$

$\mathcal{L}\left[J_F\,\dot{\omega}(t) = \tau_F(t) - b_F \cdot \omega_F(t)\right]$

$\Rightarrow J_F \cdot s\,W_F(s) = \tau(s) - b_F\,W_F(s)$

$\Rightarrow (J_F s + b_F)\,W_F(s) = \tau(s)$

$\Rightarrow \omega_F(s) = \dfrac{\tau(s)}{J_F s + b_F}$

$\tau_F(t) = K_\tau \cdot i(t)$

$\mathcal{L}\left[\tau_F(t) = K_\tau \cdot i(t)\right]$

$\tau_F(s) = K_\tau \cdot I(s)$

$W_F(s) = \dfrac{K_\tau \cdot I(s)}{J_F s + b_F}$

$F(s) = \dfrac{K_F \cdot K_\tau \cdot I(s)}{J_F \cdot s + b_F}$

$M \cdot s^2 Y(s) = F(s) - b_F \cdot s\,Y(s)$

$\Rightarrow M \cdot s^2 Y(s) = \dfrac{K_F \cdot K_\tau \cdot I(s)}{J_F s + b_F} - b_F \cdot s\,Y(s)$

$(M s^2 + b_F s)\,Y(s)$

$\dfrac{Y(s)}{I(s)} = \dfrac{K_F \cdot K_\tau}{(M s^2 + b_F s)(J_F s + b_F)}$

$= \dfrac{1E\text{-}2 \cdot 2}{(.5 s^2 + 5 s)(2E\text{-}3 s + 4E\text{-}3)}$

$= \dfrac{2E\text{-}2}{.001 \cdot 5\,s(s+2)(s+10)}$

$= \dfrac{20}{s(s+2)(s+10)}$

$C(s) = K_c$

$P(s) = \dfrac{20}{s(s+2)(s+10)}$

Design specs:

$OS \approx 4.3\%,\ t_s = 2.5$ (?)

$.043 = e^{-\pi \frac{a}{\beta}}$

$2.5 \approx \dfrac{5}{a}$

$a = 2$

$Ln(.043) = -\pi \cdot \dfrac{2}{\beta}$

$1 = \dfrac{2}{\beta}$

$\beta = 2$

$s = -a \pm j\beta$

$s = -2 \pm 2j$

$G(s) = C(s) \cdot P(s)$

$= K_c \dfrac{20}{s(s+2)(s+10)}$

Evans

$K_E = 20 \cdot K_c$

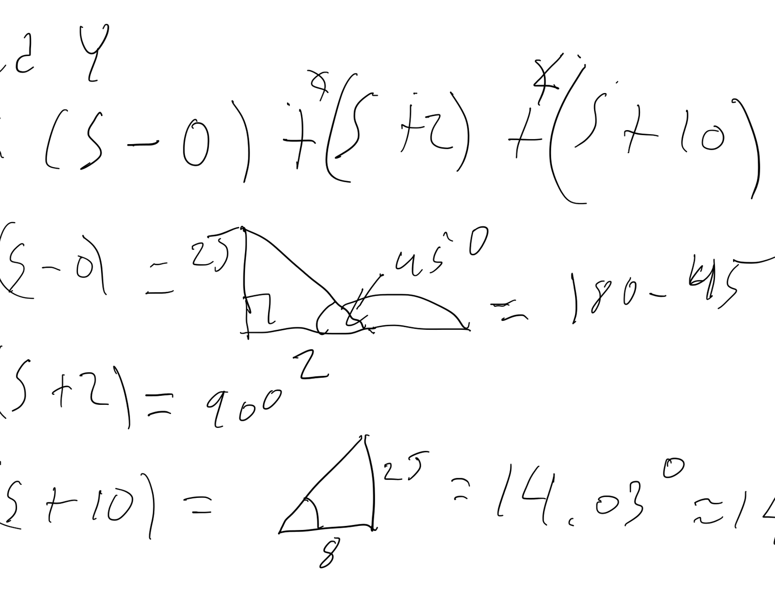
$\dfrac{KE}{s(s+2)(s+10)} = -1$

$n = 3$

$m = 0$

$\rightarrow \dfrac{s + (s-2) + (s-10)}{n-m} =$

$\sigma_c = \dfrac{0 + -2 - 10}{3} = -4$



Find γ

$\angle(s-0) + \angle(s+2) + \angle(s+10) = 180 - \gamma$

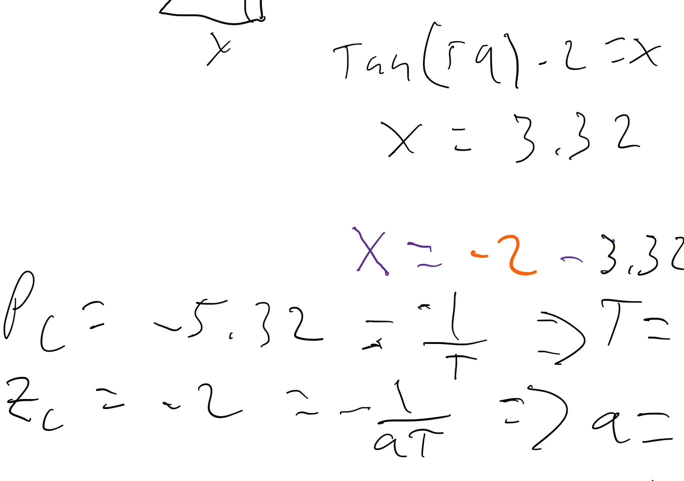
$\angle(s-0) = 45^\circ = 180 - 45 = 135^\circ$

$\angle(s+2) = 90^\circ$

$\angle(s+10) = 14.03^\circ \approx 14^\circ$

$135 + 90 + 14 = 180 - \gamma$

$\gamma = 59^\circ$



$59 = Tan^{-1}\left(\dfrac{x}{2}\right)$

$Tan(59) \cdot 2 = x$

$x = 3.32$

$X = -2 - 3.32 = -5.32$

$P_c = -5.32 = -\dfrac{1}{T} \Rightarrow T = \dfrac{1}{5.32} = .188$

$Z_c = -2 = -\dfrac{1}{aT} \Rightarrow a = \dfrac{1}{.188 \cdot 2} = 2.66$

$C(s) = a K_c \dfrac{s + \frac{1}{aT}}{s + \frac{1}{T}}$

$C(s) = 2.66 K_c \dfrac{s + 2}{s + 5.32}$

$G(s) = C(s) \cdot P(s)$

$\Rightarrow 2.66 K_c \dfrac{s+2}{s+5.32} \cdot \dfrac{20}{s(s+2)(s+10)}$

$KE = \dfrac{|s+10| \cdot |s+2| \cdot |s+0|\,|s+5.32|}{|s+2|}$

$\dfrac{|s+10| \cdot \cancel{|s+2|} \cdot |s+0|\,|s+5.32|}{\cancel{|s+2|}}$

$= \left(\sqrt{8^2+2^2}\right)\left(\sqrt{2^2+2^2}\right)\left(\sqrt{3.32^2+2^2}\right)$

$= 90.4$

$K_E = 20 \cdot 2.66 \cdot K_c$

$K_c = \dfrac{90.4}{20 \cdot 2.66}$

$K_c = 1.7$