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

$F(t) = K_f \cdot w_p(t) = 1E{-2} \cdot w_p(t)$

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

$J_p\,\dot{w}(t) = \tau_p(t) - b_p \cdot w_p(t)$

$2E{-3}\,\dot{w}(t) = 2i(t) - 4E{-3}\,w_p(t)$

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

$F(t) = \frac{-2E{-3}\,\dot{w}(t) + 2i(t)}{4E{-1}}$

$F(0) = \frac{-2E{-3}\,\dot{w}(0) + 2i(0)}{4E{-1}}$

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

$F(0) = 5\,i_0$

$\parallel$

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

$i_0 = .98\,A$

$\tau_{p_0} = 1.96\ N\cdot m$

$w_{p_0} = \frac{1.96}{b_p} = \frac{1.96}{4E{-3}} = 490\ \frac{rad}{s}$

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

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

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

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

$F(t) = K_f \cdot w_p(t)$

$L\left[F(t) = K_f \cdot w_p(t)\right]$

$\Rightarrow F(s) = K_f \cdot W_p(s)$

$J_p\,\dot{w}(t) = \tau_p(t) - b_p \cdot w_p(t)$

$L\left[J_p\,\dot{w}_p(t) = \tau_p(t) - b_p \cdot w_p(t)\right]$

$\Rightarrow J_p \cdot s\,W_p(s) = \tau(s) - b_p\,W_p(s)$

$\Rightarrow (J_p s + b_p)\,W_p(s) = \tau(s)$

$\Rightarrow w_p(s) = \frac{\tau(s)}{J_p s + b_p}$

$\tau_p(t) = k_\tau \cdot i(t)$

$L\left[\tau_p(t) = k_\tau \cdot i(t)\right]$

$\tau_p(s) = k_\tau \cdot I(s)$

$w_p(s) = \frac{k_\tau \cdot I(s)}{J_p \cdot s + b_p}$

$F(s) = \frac{K_f \cdot K_\tau \cdot I(s)}{J_p \cdot s + b_p}$

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

$\Rightarrow M \cdot s^2 Y(s) = \frac{K_f \cdot k_\tau \cdot I(s)}{J_p \cdot s + b_p} - b_F \cdot s\,Y(s)$

$(Ms^2 + b_F s)\,Y_s = \frac{K_f \cdot k_\tau \cdot I(s)}{J_p \cdot s + b_p}$

$Y(s) = \frac{K_f \cdot k_\tau \cdot I(s)}{(Ms^2 + b_F \cdot s)(J_p s + b_p)}$

$\frac{Y(s)}{I(s)} = \frac{K_f \cdot k_\tau}{(Ms^2 + b_F \cdot s)(J_p s + b_p)}$

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

$= \frac{2E{-2}}{.001 \cdot s(s+2)(s+10)}$

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

$C(s) = K_c$

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

Design specs;

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

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

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

$a = 2$

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

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

$\beta = 2$

$s = -a \pm j\beta$

$s = -2 \pm 2j$

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

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

Evans

$K_E = 20 \cdot K_c$

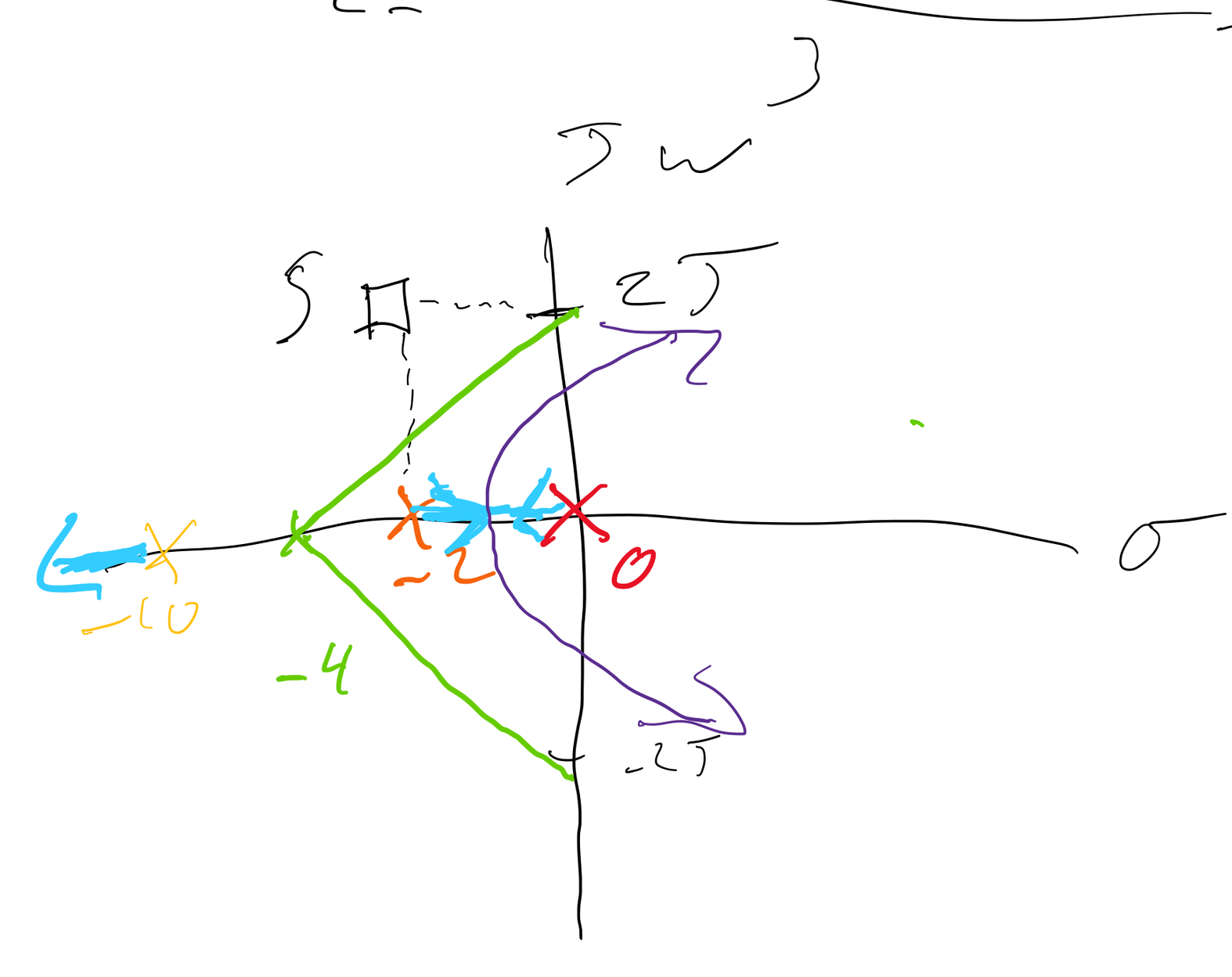
$\frac{K_E}{s(s+2)(s+10)} = -1$

$n = 3$

$m = 0$

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

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



Find γ

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

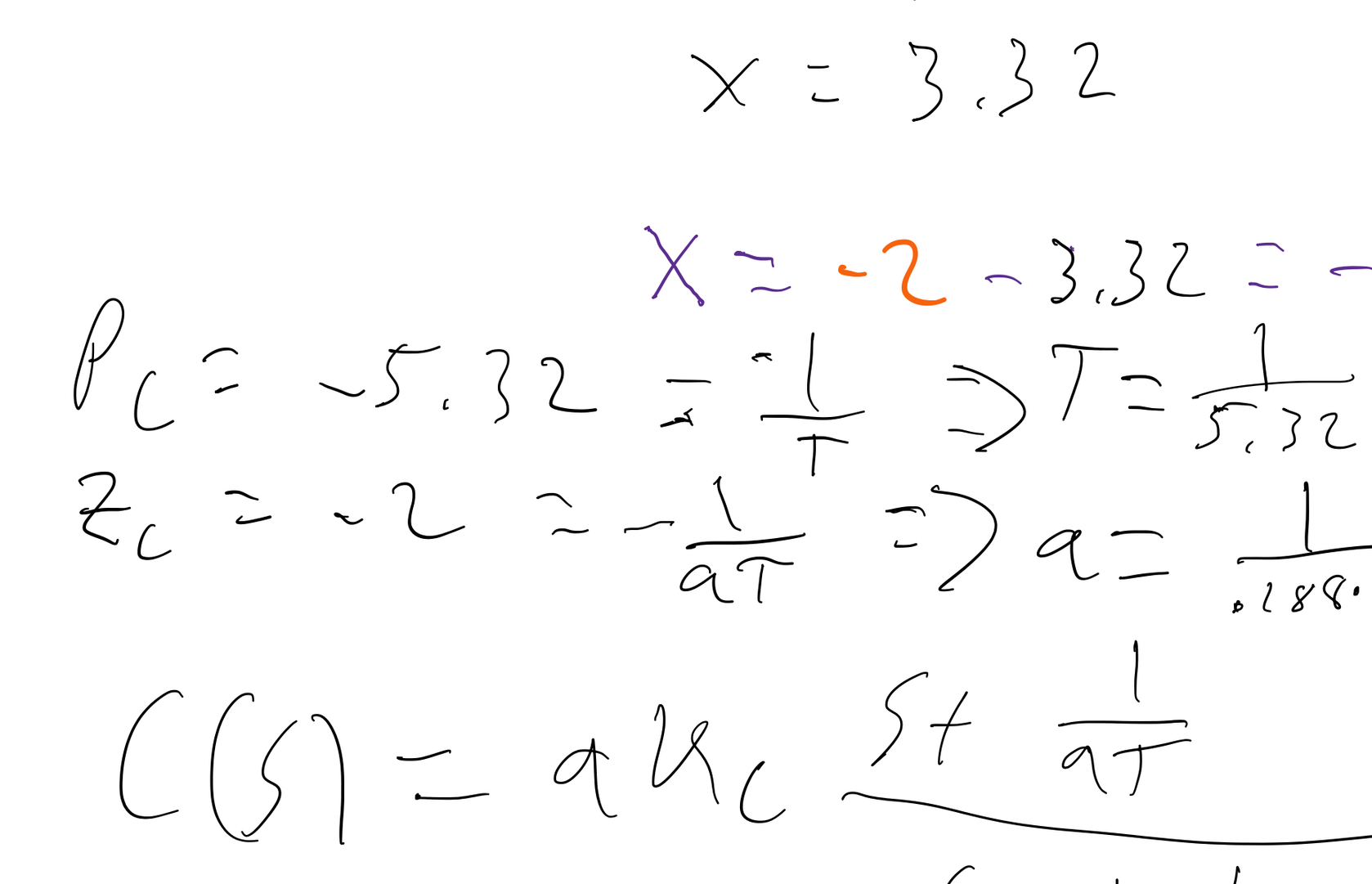
$\measuredangle(s-0) = 45^\circ = 180 - 45 = 135^\circ$

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

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

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

$\gamma = 59^\circ$



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

$Tan(59) \cdot 2 = x$

$x = 3.32$

$X = -2 - 3.32 = -5.32$

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

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

$C(s) = aK_c \frac{s + \frac{1}{aT}}{s + \frac{1}{T}}$

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

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

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

$K_E = \frac{|s+10| \cdot |s+2| \cdot |s+0|\,|s+5.32|}{|s+2|}$

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

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

$= 90.4$

$K_E = 20 \cdot 2.66 \cdot K_c$

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

$K_c = 1.7$