1. $C(s) = K$

$$G(s) = \frac{5}{(s+2)(s+3)(s+4)}$$

$$G_{MF}(s) = \frac{5K}{s^3+9s^2+26s+24+5K}$$

$$\begin{array}{llll}
s^3: & 1 & 26 & \\
s^2: & 9 & 24+5K & \\
s: & \frac{9\cdot 26-24-5K}{9} & 0 & \\
s^0: & 24+5K & 0 &
\end{array}$$

$$\begin{cases} 24+5K>0 \\ \frac{9\cdot 26-24-5K}{9}>0 \end{cases}$$

$$K > -\frac{24}{5} = -4{,}8$$

$$5K < 234 - 24$$

$$K < 42$$

2 $$C(s) = \frac{K_p s + K_i}{s}$$

$$D(s) = \frac{1}{s^2}$$

$$G(s) = \frac{1}{ms + b}$$

$$G_D(s) = \frac{G(s)}{1 + C(s)\,G(s)}$$

$$G_D(s) = \frac{s}{ms^2 + (b + K_p)s + K_i}$$

$$\frac{Y(s)}{D(s)} = \frac{s}{ms^2 + (b + K_p)s + K_i}$$

$$E(s) = Y(s)$$

$$e_\infty = \lim_{t \to \infty} y(t) = \lim_{s \to 0} sY(s) =$$

$$\lim_{s \to 0} s\left(\frac{s}{ms^2+(b+K_p)s+K_i}\right) \cdot \frac{1}{s^2} =$$

$$\lim_{s \to 0} \frac{1}{s(ms+b+K_p)+K_i} = \frac{1}{K_i}$$

③ $$F(Y,V,U) = K_F \frac{U^2}{(Y_{max}-Y)^2}$$

$$F(Y,V,U) = K_F \frac{\left(\frac{mg}{K_F}\right)\cancel{(Y_{max}-Y_0)^2}}{\cancel{(Y_{max}-Y_0)^2}} +$$

$$2K_F \sqrt{\frac{mg}{K_F}} \frac{\cancel{(Y_{max}-Y_0)}}{(Y_{max}-Y_0)^2} \left(U - \sqrt{\frac{mg}{K_F}}(Y_{max}-Y_0)\right) +$$

$$2K_F \frac{\frac{mg}{K_F}(y_{max}-y_0)^2}{(y_{max}-y_0)^{\cancel{3}}}(y-y_0)$$

$$F(y,v,u) = mg + \frac{2\sqrt{K_F mg}}{(y_{max}-y_0)}\delta u + \frac{2mg}{(y_{max}-y_0)}\delta y$$

$$\dot{y} = v = v - v_0 = \delta v$$

$$m\dot{v} = \cancel{mg} + \frac{2\sqrt{K_F mg}}{(y_{max}-y_0)}\delta u + \frac{2mg}{(y_{max}-y_0)}\delta y$$

$$- bv - \cancel{mg}$$

$$A = \begin{bmatrix} 0 & 1 \\ \frac{2mg}{y_{max}-y_0} & -b \end{bmatrix} \quad B = \begin{bmatrix} 0 \\ \frac{2\sqrt{K_F mg}}{(y_{max}-y_0)} \end{bmatrix}$$

(4) $$G_F = \frac{600}{(s+10)(s+20)(s^2+2s+4)}$$

$P_1 = -10$

$P_2 = -20$

$$P_{3,4} = \frac{-2 \pm 2\sqrt{3}i}{2} = -1 \pm \sqrt{3}i$$

$\hookrightarrow$ Polos dominantes

$10 \geq 5 \times -(-1)$

$20 \geq 5 \times -(-1)$

Logo:

$$G_{a,3x} \approx \lim_{s \to 0} G_F \cdot \frac{1}{s^2+2s+4} = \frac{3}{4} \cdot \frac{1}{s^2+2s+4}$$

$$Y(s) = \frac{3 \cdot 4^{-1}}{s^2 + 2s + 4} R(s)$$

$$\lim_{s \to 0} G_F(s) = \frac{600}{10 \cdot 20 \cdot 4} = \frac{3}{4}$$

Degrau unitário:

$$e_\infty = \lim_{s \to 0} \frac{1}{1 + G_F(s)} = \frac{1}{1 + \frac{3}{4}} = \frac{4}{7}$$

$$2 \xi w_n = 2$$

$$w_n^2 = 4 \qquad w_n = 2 \rightarrow \xi = \frac{1}{2}$$

$$t_r\Big|_{10\%}^{90\%} = \frac{2{,}16 \cdot \frac{1}{2} + 0{,}6}{2} = \frac{1{,}68}{2} = 0{,}84$$

$$t_s\Big|_{2\%} = \frac{3{,}9}{\xi w_n} = \frac{3{,}9}{1} = 3{,}9$$

(5) $R\dot{q} + Cq = v(t)$

$$C(s) = \frac{K_p s + K_i}{s}$$

$$F(s) = \frac{K_i}{K_p s + K_i}$$

$$G(s) = \frac{1}{Rs + C}$$

$$G_F(s) = F(s)\left(\frac{C(s)G(s)}{1 + C(s)G(s)}\right)$$

$$G_F(s) = \frac{K_i}{K_p s + K_i}\left(\frac{K_p s + K_i}{Rs^2 + (C + K_p)s + K_i}\right)$$

$$G_F(s) = \frac{K_i/R}{s^2 + \left(\frac{K_p + C}{R}\right)s + \frac{K_i}{R}}$$

$$\frac{K_i}{R} = \omega_n^2 \qquad K_i = \omega_n^2 R$$

$$\left(\frac{K_p + C}{R}\right) = 2\xi\omega_n \qquad K_p = 2\xi\omega_n R - C$$

$$M_p = e^{-\frac{\pi\xi}{\sqrt{1-\xi^2}}}$$

$$t\Big|_0^{100\%} = \frac{\pi - \arccos\xi}{\omega_n\sqrt{1-\xi^2}}$$