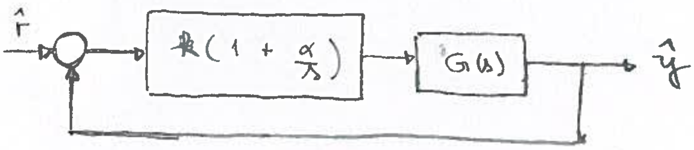


$k > 0$ e $\alpha > 0$

1) $G(s) = \dfrac{1}{(s+1)^2}$

$$1 + k \cdot \frac{s+\alpha}{s(s+1)^2} = 0$$

Nyquist

$$\Im m \; \frac{\alpha + j\omega}{j\omega(1-\omega^2+2j\omega)} = 0$$

$$\Re e \; \frac{\alpha + j\omega}{1-\omega^2+2j\omega} = 0$$

$$\Re e \; (\alpha + j\omega)(1-\omega^2-2j\omega) = 0$$

$$\alpha(1-\omega^2) + 2\omega^2 = 0$$

$$(2-\alpha)\omega^2 + \alpha = 0$$

$$\omega = \pm\sqrt{\frac{\alpha}{\alpha-2}} \rightarrow \text{estabilidade}$$

$$\boxed{0 < \alpha < 2}$$

Routh

s^3	1	$1+k$
s^2	2	αk
s	$2+2-\alpha k$	
1	αk	

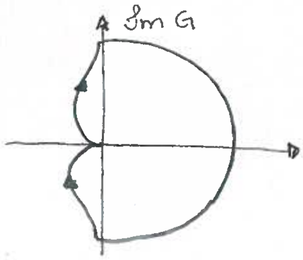
estabilidade

$$2 + 2k - \alpha k > 0$$

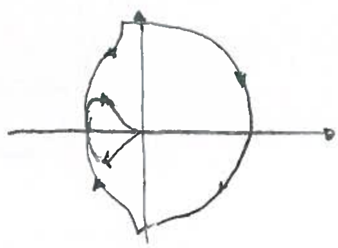
$$\alpha < 2 + \frac{2}{k}$$

$$\therefore \boxed{0 < \alpha < 2}$$

b) $\alpha < 2$



$\alpha > 2$



c) $\alpha = 9/4$

$$\omega = \sqrt{\frac{9/4}{9/4 - 2}} = \sqrt{9} = 3 \text{ rad/s}$$

$$G(s) = \frac{s + 9/4}{s(s+1)^2} = \frac{\frac{s}{9/4} + 1}{s(s+1)^2} \cdot \frac{9}{4}$$

$$|G(j3)| = \frac{3/9/4}{3 \cdot 3^2} \cdot \frac{9}{4} = \frac{1}{9}$$

$$-\frac{1}{k} < -\frac{1}{9} \rightarrow \boxed{k < 9}$$ → Aproximação assintótica do Bode.

Routh

$$\frac{9}{4} < 2 + \frac{2}{k}$$

$$\frac{2}{k} > \frac{1}{4} \rightarrow \boxed{k < 8}$$

② $G(s) = \dfrac{1}{(s+1)(s+2)}$

a) $1 + k \cdot \dfrac{s+\alpha}{s(s+1)(s+2)} = 0$

$$s^3 + 3s^2 + (2+k)s + \alpha k = 0$$

Tabela de Routh:

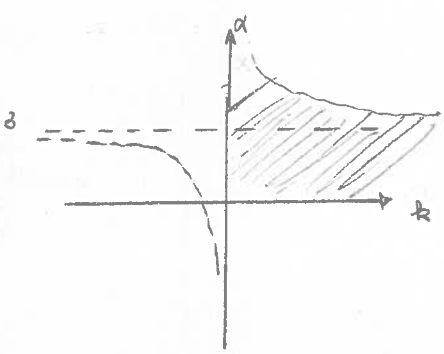
s^3	1	$2+k$
s^2	3	αk
s	$6+3k-\alpha k$	
1	αk	

Estabilidade

$$\boxed{6 + k(3-\alpha) > 0}$$

b) $6 > k(\alpha - 3)$

$$\alpha - 3 < \frac{6}{k} \rightarrow \boxed{\alpha < 3 + \frac{6}{k}}$$



$k(3-\alpha) > -6$

(1) $\alpha > 3 \rightarrow k < 6/\alpha-3$

(2) $\alpha < 3 \rightarrow k > 6/\alpha-3$

3) $G(s) = \dfrac{2}{(s+2)^2}$ $\quad \alpha = 5$

$$1 + k\,\frac{2(s+5)}{s(s+2)^2} = 0$$

$$1 + \mu\,\frac{(s+5)}{s(s+2)^2} = 0 \qquad c/\ \mu = 2k$$

$$k = \frac{\mu}{2}$$

$$N'(s)\cdot D(s) - D'(s)\,N(s) = 0$$

$$2s^3 + 19s^2 + 40s + 20 = 0$$

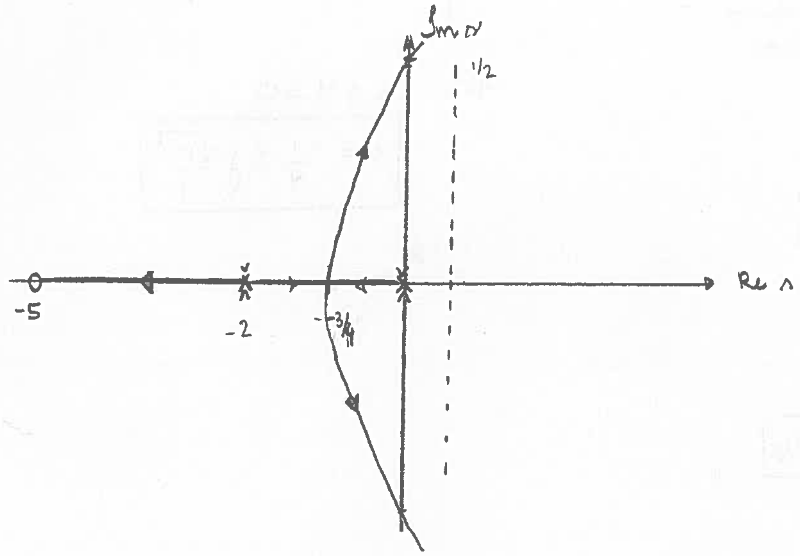
	2	19	40	20
−2	2	15	10	0

$$2s^3 + 15s + 10 = 0$$

$$s = \frac{-15 \pm \sqrt{225-80}}{4} = \frac{-15 \pm \sqrt{145}}{4}$$

$$s \cong -\frac{3}{4} \qquad s \cong -\frac{27}{4}$$

b)



$$\sigma = \frac{-4-(-5)}{2} = \frac{1}{2}$$

$$1 + \mu \frac{s+5}{s(s+2)^2} = 0$$

$$s^3 + 4s^2 + (4+\mu)s + 5\mu = 0$$

s^3	1	$4+\mu$
s^2	4	5μ
s	0	
1	5μ	

$\longrightarrow 16 + 4\mu - 5\mu \rightarrow \boxed{\mu_{osc} = 16}$

$\boxed{k_{osc} = 8}$

$$4s^2 + 80 = 0$$

$$s^2 + 20 = 0$$

$$s = \pm j 2\sqrt{5} \cong \pm j 4{,}5$$

c) $\mu_{min} = \frac{3}{4} \cdot \left(\frac{5}{4}\right)^2 \cdot \frac{4}{17} \cong \frac{1}{3}$

$\boxed{k_{min} \cong \frac{1}{6}}$ $\quad \boxed{k_{0{,}707} \cong \frac{1}{4}}$

4) $\alpha = 2 \quad k = \frac{3}{4} \quad G(s) = \frac{1}{(s+1)^2}$

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

$C(s) = \frac{3}{4}\left(1 + \frac{2}{s}\right) \qquad F(s) = \frac{3s+6}{4s^3+8s^2+7s+6}$

	4	8	7	6
$-3/2$	4	2	4	0

$$4s^2 + 2s + 4 = 0$$

$$\boxed{s = -\frac{1}{4} \pm j\frac{\sqrt{15}}{4}}$$

) $F_{ap}(s) = \frac{\beta s + \alpha}{2s^2 + s + 2} \qquad F_{ap}(0) = F(0)$ $\quad \boxed{\alpha = 2}$

$F'_{ap}(0) = \frac{\beta \cdot 2 - \alpha}{4}$

$F'(0) = \frac{3 \cdot 6 - 7 \cdot 6}{36} = \frac{-2}{3} \rightarrow \boxed{\beta = -1/3}$

$$\boxed{F_{ap}(s) = \frac{-\frac{1}{3}s + 2}{2s^2 + s + 2}}$$