Subiect Engleză – C

① $H_P = \frac{1}{s^2}$

PD ideal : $H_{PD}(s) = V_R(1 + T_d s)$; $V_R = 1$.

$\Rightarrow H_{PD}(s) = 1 + T_d s$

$\gamma_k^* = 60^\circ$.

$T_d = ?$ $m_k = ?$

$\gamma_k^* = \angle H_{des}(j\omega_t) + \pi$

$\angle H_R(j\omega_t) + \angle H_f(j\omega_t) = -180^\circ + \overset{60^\circ}{\gamma_k} = -120^\circ$

$arctg(T_d \omega_t) + \angle H_f(j\omega_t) = -120^\circ$

$\angle H_R(j\omega_t) + \underbrace{\angle H_f(j\omega_t)}_{180} = -180^\circ + 60^\circ$

$\Rightarrow \angle H_R(j\omega_t) = 60^\circ$

$$\begin{cases} arctg(T_d \omega_t) = 60^\circ \Rightarrow T_d \cdot \omega_t = 1{,}73 \\ |H_R(j\omega_t)| = \frac{1}{|H_f(j\omega_t)|} \end{cases}$$

$$\begin{cases} T_d \cdot \omega_t = 1{,}73 \\ \sqrt{(T_d \cdot \omega_t)^2 + 1} = \omega_t^2 \end{cases}$$

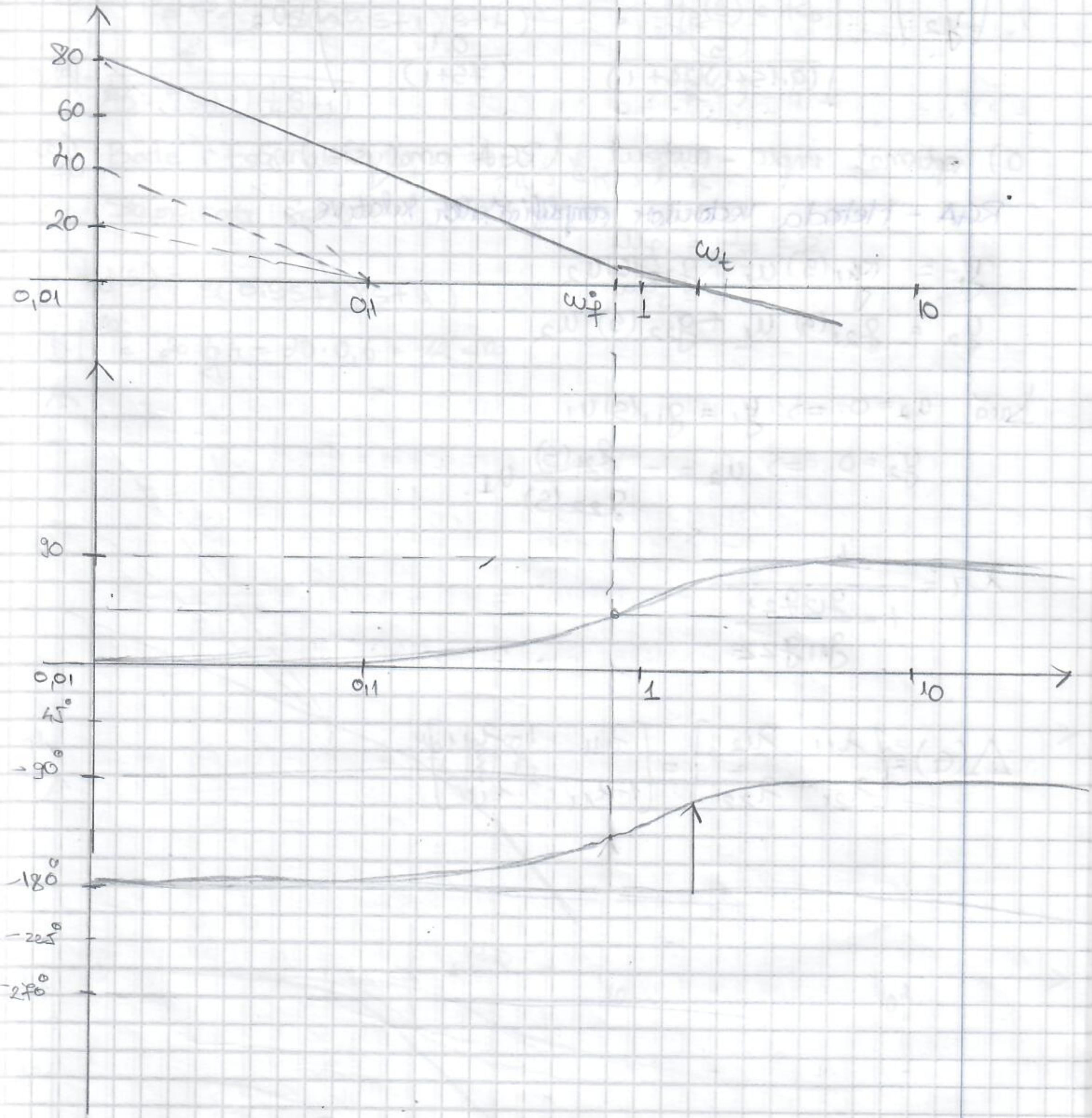
$T_d^2 \cdot \omega_t^2 + 1 = \omega_t^4$

$3 + 1 = \omega_t^4 \Rightarrow \omega_t^4 = 4 \Rightarrow \omega_t^2 = 2 \Rightarrow \omega_t \cong$

$T_d = \frac{1{,}73}{\omega_t} = \frac{1{,}73}{1{,}41} \Rightarrow T_d = 1{,}22$

$$H_{deg}(s) = H_p(s) \cdot H_{pd}(s) = \frac{1}{s^2} \cdot (1 + 1{,}22s) = \frac{1 + 1{,}22s}{s^2}$$

$$\omega_f^0 = \frac{1}{1{,}22} = 0{,}81$$



$$\angle 1 + 1{,}22 j\omega - \angle (j\omega)^2 = -\pi$$

$$\operatorname{arctg} 1{,}22\,\omega_{-\pi} = 0 \Rightarrow \omega_{-\pi} = 0$$

$$m_k = \left| \frac{1 + 1{,}22 j\omega}{(j\omega)^2} \right|_{\omega = 0} \Rightarrow \frac{\sqrt{(1{,}22\omega)^2 + 1}}{\omega^2} = \infty$$

$$G(\cdot)$$

(2)

$$\begin{pmatrix} y_1 \\ y_2 \end{pmatrix} = \begin{pmatrix} \dfrac{0{,}7}{(0{,}5s+1)(10s+1)} & \dfrac{\overset{k_{12}}{3}}{(6s+1)(0{,}7s+1)} \\ \dfrac{\overset{k_{21}}{5}}{(0.1s+1)(2s+1)} & \dfrac{0{,}1}{(7s+1)} \end{pmatrix} \begin{pmatrix} u_1 \\ u_2 \end{pmatrix}$$

a) optimal input - output (RGA analysis)

RGA - Metoda vectorilor amplificărilor relative

$$y_1 = g_{11}(s)\,u_1 + g_{12}(s)\,u_2$$
$$y_2 = g_{21}(s)\,u_1 + g_{22}(s)\,u_2$$

Dacă $u_2 = 0 \Rightarrow y_1 = g_{11}(s)\,u_1$

$y_2 = 0 \Rightarrow u_2 = -\dfrac{g_{21}(s)}{g_{22}(s)}\,u_1$.

$$\lambda_{11} = \frac{1}{1 - \dfrac{g_{12}g_{21}}{g_{11}g_{22}}}$$

$$\Lambda(G) = \begin{bmatrix} \lambda_{11} & \lambda_{12} \\ \lambda_{21} & \lambda_{22} \end{bmatrix} = \begin{bmatrix} \lambda_{11} & 1-\lambda_{11} \\ 1-\lambda_{11} & \lambda_{11} \end{bmatrix}$$

Subiect 2015

(1) $H_f(s) = \dfrac{1}{s(0{,}5s+1)(s+4)}$; $H_R(s) = k_p$

$H_f(s) = \dfrac{\cancel{1}}{\cancel{4}s(0{,}5s+1)(\frac{1}{4}s+1)}$ $\qquad H_R(s) = 4$

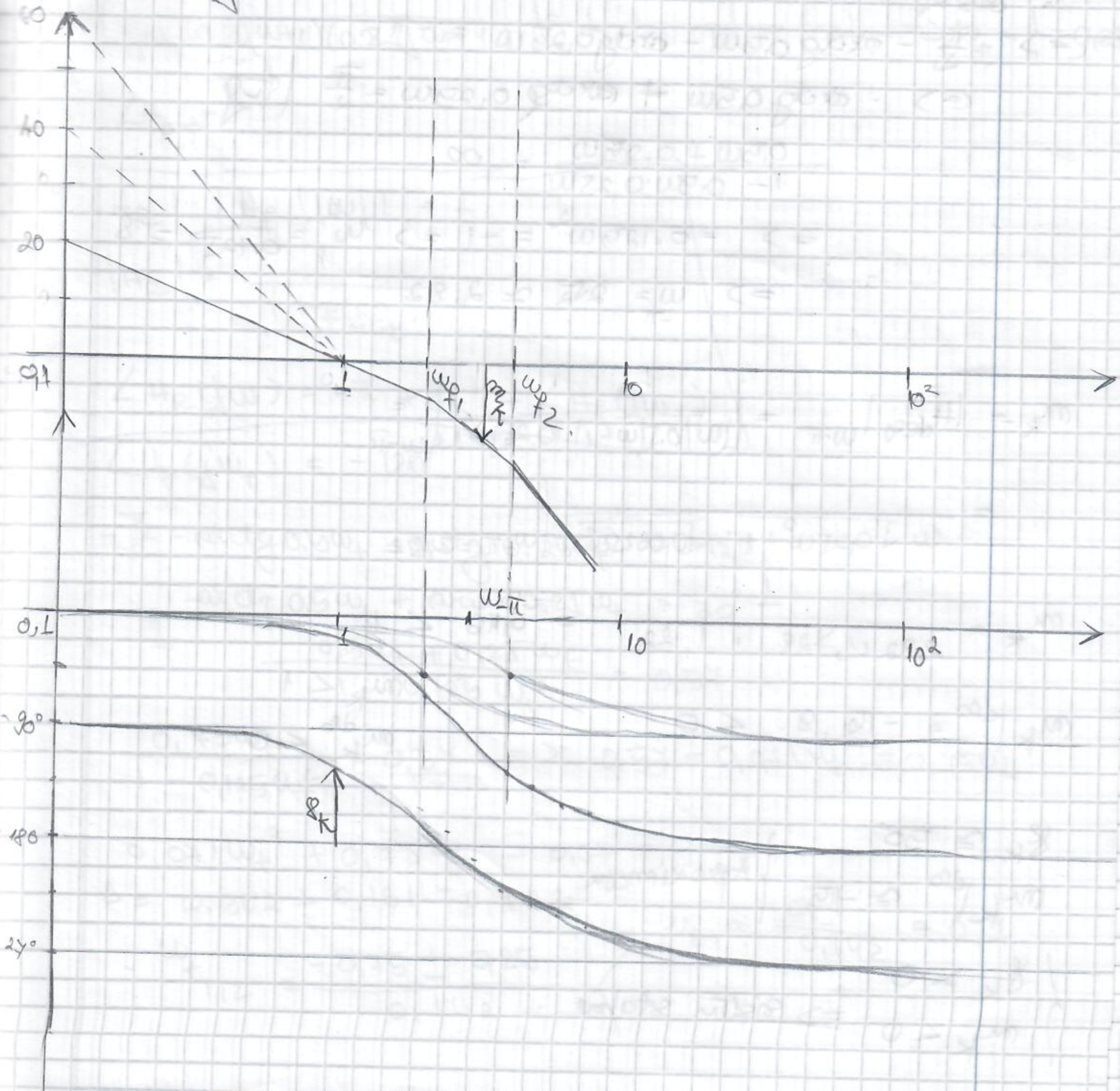
a) Bode. Estimați ω_t, $\omega_{-\pi}$, γ_k, m_k

Stabilitate sistem

$H_d(s) = \dfrac{4}{s(0{,}5s+1)(s+4)}$; $\omega_{f_1} = \dfrac{1}{0{,}5} = 2$

$\omega_{f_2} = 4$

$k|^{dB} = 20\lg 4 = 20 \cdot 0{,}6 = 12$ dB



$$\left|\frac{1}{j\omega(0{,}5j\omega+1)(0{,}25j\omega+1)}\right| = 1 \Rightarrow \frac{1}{\omega} = 1 \Rightarrow \omega_t =$$

$$\gamma_k = \angle H_{des}(j\omega_t) + \pi = -\frac{\pi}{2} + \text{arctg}\, 0{,}5\omega_t + \text{arctg}\, 0{,}25\omega_t$$

$$\Rightarrow \gamma_k = \frac{\pi}{2} + \text{arctg}\, 0{,}5 + \text{arctg}\, 0{,}25$$

$$\gamma_k = \frac{\pi}{2} - 26.56 - 14{,}03 \cong 49{,}4$$

$$\omega_{-\pi} = ?$$

$$\angle H_{des}(j\omega) = -\pi$$

$$\Leftrightarrow -\frac{\pi}{2} - \text{arctg}\, 0{,}5\omega - \text{arctg}\, 0{,}25\omega = -\pi$$

$$\Leftrightarrow \text{arctg}\, 0{,}5\omega + \text{arctg}\, 0{,}25\omega = \frac{\pi}{2} \quad |\, \text{tg}$$

$$\frac{0{,}5\omega + 0{,}25\omega}{1 - 0{,}5\omega \cdot 0{,}25\omega} = \infty$$

$$\Rightarrow -0.125\omega^2 = -1 \Rightarrow \omega^2 = \frac{1}{0.125} = 8$$

$$\Rightarrow \omega_{-\pi} = 2\sqrt{2} \simeq 2{,}82$$

$$m_k = |H_{des}|_{\omega_{-\pi}} = \left|\frac{1}{j\omega(0{,}5j\omega+1)(0{,}25j\omega+1)}\right|_{\omega_{-\pi}} =$$

$$= \frac{1}{\omega\sqrt{0{,}25\omega^2+1}\cdot\sqrt{0{,}0625\omega^2+1}}\Bigg|_{\omega_{-\pi}=2{,}82}$$

$$m_k = \frac{1}{2{,}82 \cdot 1{,}728 \cdot 1{,}22} = 0{,}16 < 1.$$

$$m_k|^{dB} = -15{,}9 < 0$$

$m_k < 1$

$m_k^{dB} < 0$

$$\left.\begin{aligned} &\gamma_k \cong 50^\circ \\ &m_k|^{dB} \cong -15 \end{aligned}\right\} \text{Aproximativ}$$

$$\left\{\begin{aligned} &\gamma_k > 0 \\ &m_k < 0 \end{aligned}\right. \Rightarrow \text{sistem stabil.}$$

b) $H_R = V_R$? ai $\gamma_k^* = 60^\circ$!

$$H_F = \frac{1}{4s(0{,}5s+1)(0{,}25s+1)} \quad ; \quad H_R = k_p$$

$$H_{des} = \frac{k_p}{4} \frac{1}{s(s\,0{,}5+1)(0{,}25s+1)}$$

$$\gamma^* = \angle H_{des}(j\omega_t) + \pi$$

$$\angle H_F(j\omega_t) + \angle H_R(j\omega_t) = -180^\circ + 60^\circ$$

$$\angle H_R(j\omega_t) = +\frac{\pi}{2} + \operatorname{arctg} 0{,}5\omega_t + \operatorname{arctg} 0{,}25\omega_t - 180^\circ + 60$$

$$\left| \frac{1}{4j\omega\,(0{,}5j\omega+1)(0{,}25j\omega+1)} \right| = 1 . \quad \frac{1}{4\omega} = 1 \Rightarrow \omega_t = \frac{1}{4} = 0{,}25$$

$\Rightarrow \angle H_R =$

$$\boxed{\begin{cases} |H_R| \cdot |H_F(j\omega_t)| = 1 \\ |H_R| = \dfrac{1}{|H_F(j\omega_t)|} \\ \angle H_R(j\omega) = -\pi + \gamma_k - \angle H_F(j\omega_t) \end{cases}}$$

$$\angle H_F(j\omega_t) = -120^\circ$$

$$-\frac{\pi}{2} - \operatorname{arctg} 0{,}5\omega_t - \operatorname{arctg} 0{,}25\omega_t = -120$$

$$\operatorname{arctg} 0{,}5\omega_t + \operatorname{arctg} 0{,}25\omega_t = 30^\circ$$

$$\frac{0{,}5\omega_t + 0{,}25\omega_t}{1 - 0{,}125\omega_t^2} = 0{,}57$$

$$\frac{0{,}75\omega_t}{1 - 0{,}125\omega_t^2} = \frac{0{,}57}{1} \Rightarrow 0{,}57 - 0{,}071\omega_t^2 = 0{,}75\omega_t$$

$$0{,}071\omega_t^2 + 0{,}75\omega_t - 0{,}57 = 0$$

$$\Delta = 0{,}562 + 0{,}161 = 0{,}723$$

$$\omega_{t_{1,2}} = \frac{-0{,}75 \pm 0{,}85}{0{,}142} \quad \omega_{t_1} = \frac{0{,}1}{0{,}142} = 0{,}7$$

$$|H(j\omega_t)|\Big|_{\omega_t=0,7}$$

$$\left|\frac{1}{4j\omega(0.5j\omega+1)(0,25j\omega+1)}\right|_{\omega_t=0.7} =$$

$$= \frac{1}{4\omega\sqrt{0.25\omega^2+1}\cdot\sqrt{0{,}0625\omega^2+1}}\Big|_{\omega_t=0.7} = \frac{1}{2{,}8\cdot 1{,}059\cdot 1{,}03} = \frac{1}{3{,}05}$$

$$|H(j\omega_t)| = \frac{1}{3{,}05}$$

$$K_p = \frac{1}{|H(j\omega_t)|} = 3{,}05 .$$

c) $H_R = K_p$ ai $m_k = 6$ dB

$$\boxed{\begin{gathered}\angle H_d(j\omega_{-\pi}) = -\pi \\ |H_R(j\omega_{-\pi})| = \frac{m_k}{|H_p(j\omega_{-\pi})|}\end{gathered}}$$

$$|H_d(j\omega_{-\pi})| = m_k$$

$$\angle H_R(j\omega_{-\pi}) = -\pi - \angle H_p(j\omega_{-\pi})$$

$$\angle H_p(j\omega_{-\pi}) = -\pi$$

$$\angle \frac{1}{4j\omega(0{,}5j\omega+1)(0,25\omega+1)} = -\pi$$

$$-\frac{\pi}{2} - \mathrm{arctg}\,0{,}5\omega_{-\pi} - \mathrm{arctg}\,0{,}25\omega_{-\pi} = -\pi$$

$$\mathrm{arctg}\,0{,}5\omega_{-\pi} + \mathrm{arctg}\,0.25\omega_{-\pi} = \frac{\pi}{2}$$

$$\Rightarrow 1 - 0{,}125\omega_{-\pi}^2 = 0 \Rightarrow \omega_{-\pi} = 2{,}82$$

$$\left|H_f(j\omega_{-\pi})\right|_{\omega_{-\pi}=2,82}$$

$$\left|\frac{1}{4j\omega(0,5j\omega+1)(0,25j\omega+1)}\right|_{\omega_{-\pi}=2,82} = \frac{1}{4\omega\sqrt{0,25\omega^2+1}\cdot\sqrt{0,0625\omega^2+1}}$$

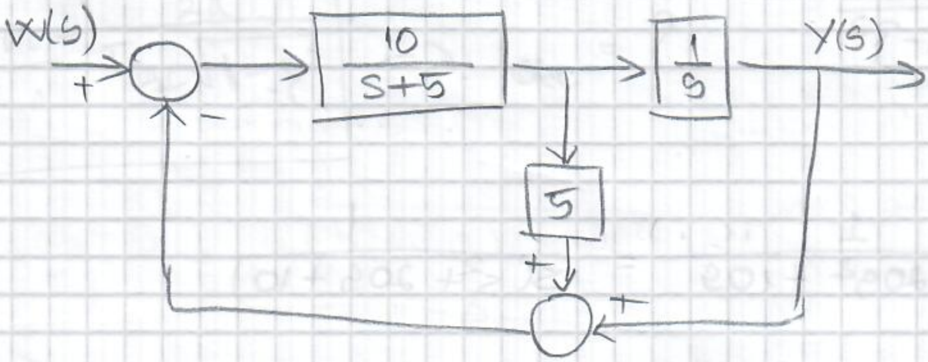
$$= \frac{1}{11,28\cdot 1,728\cdot 1,223} = \frac{1}{23,8385}$$

$$K_p = \frac{m_k}{|H_f(j\omega)|} = 1,99\cdot 23,8385 = 47,56$$

$$m_k = 10^{\frac{6}{20}} = 1,99$$

kai matlab => $m_k = -5,88$.

(2)



fdt. a sist în buclă închisă ?

ε_{stp}, ε_{stv}, t_s, σ ?

$$H_d(s) = \frac{10}{s(s+5)}$$

$$H_{des}(s) = \frac{5\cdot 10}{s+5} + \frac{10}{s(s+5)} = \frac{50s+10}{s(s+5)}$$

$$H_0(s) = \frac{H_d(s)}{1+H_{des}(s)} = \frac{10}{s^2+55s+10}$$

$$\varepsilon_{stp} = \frac{1}{1+\lim\limits_{s\to 0} H_d(s)} = \frac{1}{1+\underbrace{\lim\limits_{s\to 0} \frac{10}{s(s+5)}}_{\infty}} = 0$$

$$\varepsilon_{stv} = \frac{1}{\lim\limits_{s\to 0} s \cdot H_d(s)} = \frac{1}{\lim\limits_{s\to 0} \cancel{s} \cdot \frac{10}{\cancel{s}(s+5)}} = \frac{1}{2} = 0,5$$

$$H_0 = \frac{10}{s^2+55s+10} = \frac{\omega_m^2}{s^2+2\cdot\xi\cdot\omega_m\cdot s+\omega_m^2}$$

$\omega_m^2 = 10 \Rightarrow \omega_m = 3,16$

$2\cdot\xi\cdot\omega_m = 55 \Rightarrow \xi = \frac{55}{2\cdot 3,16} = 8,7$

$t_r \cong \frac{4}{3\omega_m} = 0,14$ sec.

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

(3) $H(s) = \frac{1}{s^3+20s^2+10s} = \frac{1}{s(s^2+20s+10)}$

a) $k_c = ?$ ai sist. la limita de stabilitate

$T_{ok} = ?$

$\begin{cases} \varphi_k = 0 \\ m_k^{dB} = 0 \end{cases}$ sau $\begin{cases} \varphi_k = 0 \\ m_k = 1 \end{cases}$

$\Delta = 400 - 40 = 360$

$|H_d(j\omega)| = 0 \Leftrightarrow \left|\frac{k_c}{j\omega(20j\omega+10-\omega^2)}\right| = 0$

$\Leftrightarrow$

$$\angle H_f(j\omega_{-\pi}) = -\pi$$

$$\angle \frac{1}{j\omega(20j\omega + 10 - \omega^2} = -\pi$$

$$-\frac{\pi}{2} - \operatorname{arctg} \frac{20\omega}{10-\omega^2} = -\pi \Rightarrow \operatorname{arctg} \frac{20\omega}{10-\omega^2} = \frac{\pi}{2}$$

$$\Leftrightarrow 10 - \omega_{\pi}^2 = 0 \Rightarrow \omega_{-\pi} = \sqrt{10} \cong 3{,}16$$

$$m_k = |H_d(j\omega_{-\pi})| = \frac{k}{\omega\sqrt{(10-\omega^2)^2 + (20\omega)^2}} = 0^{dB}$$

$$\Leftrightarrow \frac{k}{\omega\sqrt{(10-\omega^2)^2 + (20\omega)^2}} = 1.$$

$$\Rightarrow k_c = 3{,}16 \cdot 63{,}2 \Rightarrow k_c = 199{,}7$$

$$\boxed{\omega_m = \frac{2\pi}{T_{osc}\sqrt{1-\xi^2}}} \Rightarrow T_{osc} = ?$$

$\boxed{\text{Subiect A}}$

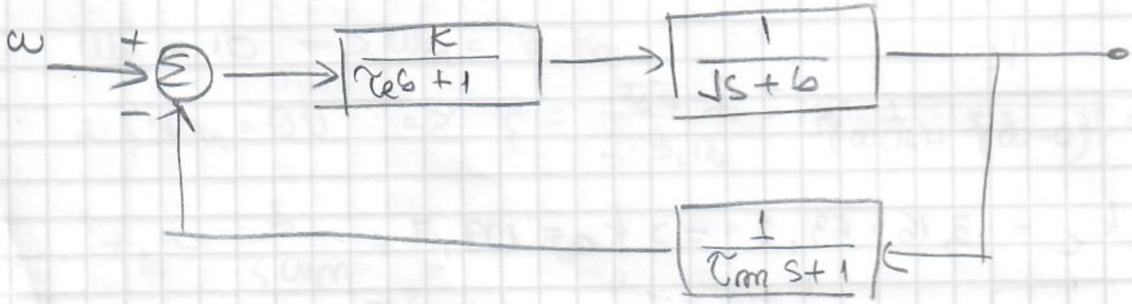
① $\tau_m = 0{,}5$ sec

$\tau_r = \frac{J}{b} = 4$ sec.

$b = 1$ N sec/m.

$\tau_e = 1$ sec

a) $k = ?$ ai $\varepsilon_{step} < 7\%$



$$H_d(s) = \frac{k}{s+1} \cdot \frac{1}{4s+1} = \frac{k}{(s+1)(4s+1)}$$

$$H_{des}(s) = H_d(s) \cdot H_r(s) = \frac{k}{(s+1)(4s+1)(0{,}5s+1)} =$$

$$\varepsilon_{step} = \frac{1}{1 + \lim\limits_{s \to 0} H_d(s)} = \frac{1}{1 + \lim\limits_{s \to 0} \frac{k}{4s^2 + 5s + 1}} = \frac{1}{1+k} < 0{,}07$$

$$\frac{1}{1+k} < \frac{0{,}07}{1} \Leftrightarrow \frac{1}{1+k} < \frac{7}{100}$$

$$\Rightarrow k > \frac{93}{7} \Rightarrow k \underset{\text{sau}}{\geq} 13{,}28$$

(2) $H_f(s) = \dfrac{1}{s(0.1s+1)}$

a) $H_{R_1}(s)$ – metoda simetriei

k_p, T_i, T_d ?

$$H_{de}^{*}(s) = H_R(s) \cdot H_f(s) = \frac{4T_\Sigma s + 1}{8T_\Sigma^2 s^2 (T_\Sigma s + 1)}$$

$$H_R(s) = \frac{H_{de}^{*}(s)}{H_f(s)}$$

$\Rightarrow T_\Sigma = 0.1$

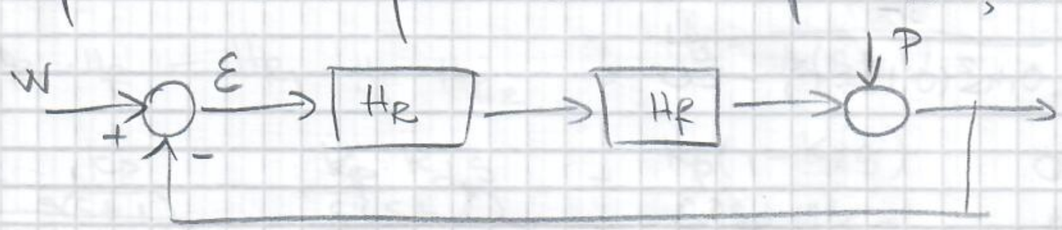
$$H_{de}^{*}(s) = \frac{0.4s+1}{0{,}08 \cdot s^2 (0.1s+1)}$$

$$H_R(s) = \frac{0.4s+1}{0{,}08 \cdot s^2 \cancel{(0.1s+1)}} \cdot \frac{s\cancel{(0.1s+1)}}{1} = \frac{0{,}4s+1}{0{,}08s}$$

$$H_R(s) = 5 + \frac{1}{0{,}08s} = 5\left(1 + \frac{1}{0.4s}\right)$$

$\Rightarrow k_p = 5 \; ; \; T_i = 0.4 \; , \; T_d = 0$

b) ~~Răspunsul la o perturbație în treaptă la ieșire~~

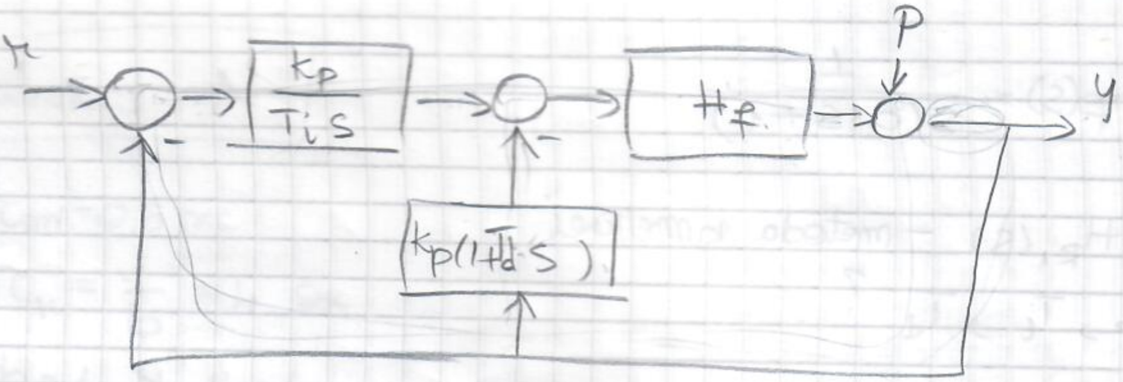


1.) $w(t) = 1(t)$

$P = 0$

$$\Rightarrow H_{owy} = \frac{H_R \cdot H_f}{1 + H_R \cdot H_f} = \frac{\dfrac{0.4s+1}{0{,}08s \cdot s(0{,}1s+1)}}{1 + \dfrac{0{,}4s+1}{0{,}08s^2(0{,}1s+1)}}$$

$$H_{owy} = \frac{0{,}04s+1}{0{,}08s^2(0{,}1s+1) + 0{,}4s + 1}$$

d). 

$k_p = 5,\ T_i = 0,4,\ T_d = 0$

$$H_d(s) = \frac{k_p}{T_i \cdot s}\cdot H_f = \frac{5}{0,4s}\cdot\frac{1}{s(0,1s+1)} = \frac{5}{0,4s^2(0,1s+1)}$$

$$H_{des}(s) = \frac{k_p}{T_i s}\cdot H_f - \cancel{\frac{k_p}{T_i s}}\cdot H_f \cdot k_p(1+T_d s)$$

$$= \frac{5}{0,4s^2(0,1s+1)} - \frac{\cancel{25}\,5}{\cancel{0,4}s^{2}(0,1s+1)} = \frac{-20}{0,4s^2(0,1s+1)}$$

$$H_{des}(s) = -50\cdot\frac{1}{s^2(0,1s+1)} \quad \Big| = \frac{5 - 5\cdot 0,4\, s}{0,04s^2(0,1s+1)}$$

I $w(t) = 1(t)$

$p = 0$ $\quad \Rightarrow H_{owy} = \frac{H_d}{1+H_{des}} \Rightarrow$

$$H_{owy} = \frac{5}{0,4s^2(0,1s+1) - 20}$$

II $w(t) = 0$

$p = 0,5(t)$ $\quad \Rightarrow H_{op}(s) = \frac{1}{1+H_{des}} = \frac{1}{\frac{0,4s^2(0,1s+1)+\dots}{0,4s^2(0,\dots}}$

$$H_{op} = \frac{0.4s^2(0.1s+1)}{0.04s^3+0.4s^2-2s+1}$$

$$H_{des} = \frac{1}{0,4s^2(0.1s+1)} - \frac{5}{s(0,1s+1)} = \frac{1-5\cdot 0.4\cdot s}{0.4s^2(0,1s+1)} = \dots$$

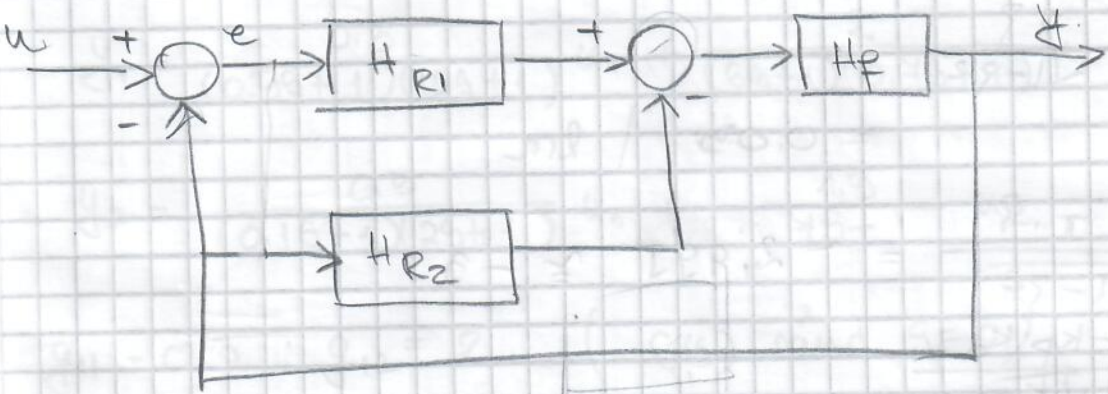
$$H_o = H_{opy} + H_{owy}$$

(3) $H_f(s) = \frac{1}{s(s+1)}$; $H_{R_1}(s) = k_p \rightarrow$ reg. P
$H_{R_2}(s) = k_d \cdot s \rightarrow$ reg. D

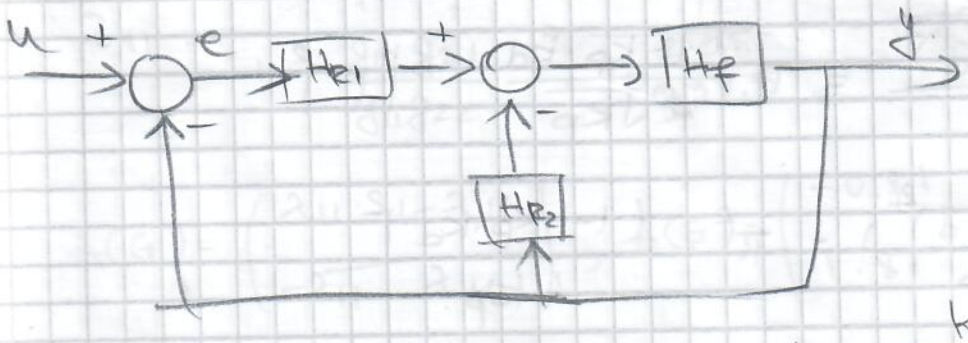
$\sigma = 5\%$

$t_r = 0{,}5$ sec.

$k_p, k_\Delta = ?$



$H_{deg} = H_{R1} \cdot H_f + H_{R1} \cdot H_{R2} \cdot H_f$.



$H_{R_1} \cdot H_f - H_{R_1} \cdot H_f \cdot H_{R_2}$; $H_d = \frac{k_p}{\Delta(s+1)}$

$$H_{des} = \frac{k_p}{s(s+1)} - \frac{k_p \cdot k_d s}{s(s+1)} = \frac{k_p(1-k_d s)}{s(s+1)}$$

$$H_o(s) = \frac{k_p}{s(s+1) + k_p(1-k_d s)} = \frac{k_p}{s^2 + (1-k_p \cdot k_d)s + k_p}$$

$\Rightarrow \omega_n^2 = k_p \Rightarrow \omega_n = \sqrt{k_p}$

$2\omega_n \zeta = 1 - k_p \cdot k_d \Rightarrow 2\sqrt{k_p} \cdot \zeta = 1 - k_p \cdot k_d \Rightarrow \zeta = \frac{1-k_p \cdot k_d}{2\sqrt{k_p}}$

$$t_{tr} = \frac{4}{\zeta \omega_n} \Rightarrow \frac{4}{\frac{1-k_p \cdot k_d}{2}} = 0{,}5$$

$$\frac{8}{1-k_p \cdot k_d} = 0{,}5 \Rightarrow 1-k_p k_d = \frac{8}{0{,}5}$$

$$-k_p \cdot k_d = -15$$

$$\sigma = e^{-\frac{\pi\zeta}{\sqrt{1-\zeta^2}}} = 0{,}05$$

$$\Rightarrow e^{-\frac{\pi\zeta}{\sqrt{1-\zeta^2}}} = 0.05 \quad | \ln$$

$$-\frac{\pi \cdot \zeta}{\sqrt{1-\zeta^2}} = -2{,}995 \cong -3$$

$$+\frac{\pi \cdot \frac{1-k_p \cdot k_d}{2\sqrt{k_p}}}{\sqrt{1-\frac{(1-k_p \cdot k_d)^2}{4k_p}}} = +\frac{3}{1}$$

$$3\sqrt{1-\frac{(1-k_p \cdot k_d)^2}{4k_p}} = \pi \frac{1-k_p \cdot k_d}{2\sqrt{k_p}} \quad \Big| (\ )^2$$

$$9 - \frac{9(1-k_p k_d)^2}{4k_p} = \pi^2 \cdot \frac{(1-k_p \cdot k_d)^2}{4k_p}$$

$$\frac{(1-k_p k_d)^2}{4k_p}(9+\pi^2) = 9$$

$$\frac{(1-k_p \cdot k_d)^2}{4k_p} = \frac{9}{9+\pi^2}$$

$$\frac{16^2}{4k_p} = \frac{9}{9+\pi^2} \Rightarrow k_p = \frac{16^2(9+\pi^2)}{9 \cdot 4}$$

$$k_p \cong 134$$

$$k_d = -\frac{15}{134} \cong -0{,}11$$

1. MIMO

$$\begin{pmatrix} y_1 \\ y_2 \end{pmatrix} = \begin{pmatrix} \frac{0,3}{(0,5s+1)(10s+1)} & \frac{2}{(6s+1)(0,7s+1)} \\ \frac{0,5}{(0,1s+1)(2s+1)} & \frac{1,5}{7s+1} \end{pmatrix} \begin{pmatrix} u_1 \\ u_2 \end{pmatrix}$$

a) perechea intrare - ieșire optimă.

$$y_1 = \frac{0,3}{(0,5s+1)(10s+1)} u_1 + \frac{2}{(6s+1)(0,7s+1)} u_2$$

$$y_2 = \frac{0,5}{(0,1s+1)(2s+1)} u_1 + \frac{1,5}{7s+1} u_2$$

$g_{11} = 0,3$; $g_{12} = 2$ ($G(s)$ când $s=0$)

$g_{21} = 0,5$; $g_{22} = 1,5$

$$\lambda_{11} = \frac{1}{1 - \frac{g_{12} g_{21}}{g_{11} g_{22}}} = \frac{1}{1 - \frac{2 \cdot 0,5}{0,3 \cdot 1,5}} = -0,89$$

u

y

λ_{12}

$$A(G) = \begin{pmatrix} \lambda_{11} & 1-\lambda_{11} \\ 1-\lambda_{11} & \lambda_{11} \end{pmatrix}, \quad A(G) = \begin{pmatrix} -0,81 & 1,81 \\ 1,81 & -0,81 \end{pmatrix}$$

$$\lambda_{12} = 1,81 \Rightarrow y_2 = \frac{2}{(6s+1)(0,7s+1)} u_1$$

i) pt. y_1, poli în (-5) și (-1) și $\varepsilon_{stp} = 0$ Tipul control?

$$y_1 = \frac{0,5}{(0,1s+1)(2s+1)} u_2$$

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

$$\left.\begin{aligned} H_0(s) &= \frac{1}{(s+5)(s+1)} = \frac{1}{s^2+6s+5} \\ \varepsilon_{stp} = 0 \Rightarrow H_0(s) &= \frac{\omega_n^2}{s^2 + 2\xi \omega_n s + \omega_n^2} \end{aligned}\right\} \Rightarrow H_0(s) = \frac{5}{s^2+6s+5}$$

$$H_0(s) = \frac{H_d(s)}{1+H_d(s)} \Rightarrow H_d(s) = \frac{H_0(s)}{1-H_0(s)}$$

$$H_d(s) = \frac{5}{s^2+6s}$$

$$H_d(s) = H_f(s) \cdot H_R(s) \Rightarrow H_R(s) = \frac{H_d(s)}{H_f(s)}$$

$$H_R = \frac{2s^2+21s+10}{s^2+6s} = \frac{10}{6} \cdot \frac{0.1s+1}{s} \cdot \frac{2s+1}{\frac{1}{6}s+1}$$

ii) pt y_2, $\varepsilon_{st} = 0$ și $\sigma < 5\%$

Una dintre metodele lui Kessler.

$\sigma < 5\% \Rightarrow$ Met Modulului

$$H_f(s) = \frac{2}{(6s+1)(0.7s+1)} \Rightarrow T_\Sigma = 0.7$$

$$H_d^* = H_f \cdot H_R = \frac{1}{2T_\Sigma s(T_\Sigma s+1)}$$

$$H_R(s) = \frac{H_d^*}{H_f}$$

$$H_d^* = \frac{1}{1.4s(0.7s+1)}$$

$$H_R = \frac{6s+1}{2.8s} = \frac{6}{2.8} + \frac{1}{2.8s} \Rightarrow PI$$

iii) pol în -10 și $\varepsilon_{stp} = 0$

$$H_0 = \frac{1}{s+10};\ \varepsilon_{stp} = 0 \rightarrow H_0 = \frac{1}{s(s+10)}$$

$$\Delta p = p_1 - p_2 \quad ; \quad R_p = \frac{\Delta p}{Q}$$

$$dQ_{me} = \rho \cdot w \cdot r \cdot dr \cdot d\varphi \quad \Big| \; Q_m = 2\pi \int_0^{\frac{d}{2}} \rho \cdot w \cdot r \cdot dr \cdot \quad (4)$$

$$\Delta p = \lambda \cdot \frac{l}{d} \cdot \frac{w^2}{2} \cdot \rho = \frac{64}{w} \cdot \frac{\nu}{d} \cdot \frac{l}{d} \cdot \frac{w^2}{2} \cdot \rho$$

$$w = \frac{d^2}{32 \cdot \mu \cdot l} \cdot \Delta p \Rightarrow \cancel{Q_{me} = \rho}$$

$$Q_m = 2\pi \int_0^{\frac{d}{2}} \rho \cdot \frac{d^2}{32 \mu \cdot l} \cdot \Delta p \cdot r \cdot dr =$$

$$= 2\pi \cdot \rho \cdot \frac{d^2}{32 \mu \cdot l} \cdot \Delta p \left(\frac{r^2}{2} \Big|_0^{\frac{d}{2}} \right.$$

$$= 2\pi \cdot \rho \cdot \frac{d^2}{32 \mu l} \cdot \Delta p \left(\frac{\frac{d^2}{4}}{2} \right) = \cancel{2}\pi \cdot \rho \cdot \frac{d^2}{32 \cdot \mu \cdot l} \cdot \Delta p \cdot \frac{d^2}{\cancel{8}4}$$

$$Q_m = \rho \cdot \frac{d^4 \cdot \pi}{128 \cdot \mu \cdot l} \cdot \Delta p$$

$$R_p = \frac{\Delta p}{Q} \Rightarrow \qquad R_p = \cancel{\Delta p} \cdot \frac{128 \cdot \mu \cdot l}{\pi \rho \cdot d^4 \cdot \cancel{\Delta p}}$$

$$\Rightarrow R_p = \frac{128 \cdot \mu \cdot l}{\pi \cdot \rho \cdot d^4}$$

$$\Delta p = \frac{64}{Re_{cr}} \cdot \frac{l}{d} \cdot \frac{w^2}{2} \cdot \rho = \frac{64}{w} \cdot \frac{\frac{\mu}{\rho}}{d} \cdot \frac{l}{d} \cdot \frac{w^2}{2} \cdot \rho$$

$$\frac{\cancel{64}}{Re_{ch}} = \frac{\cancel{64} \cdot \mu}{w \cdot d \cdot \rho} \qquad \frac{64}{w} \cdot \frac{\mu}{d \cdot \rho}$$

$$Re_{ch} = \frac{w \cdot d \cdot \rho}{} \qquad Re_{ch} \cdot \mu = w \cdot d \cdot \rho$$

$$\frac{w}{1} = \frac{d^2 \cdot \Delta p}{32 \cdot \mu \cdot l} \Rightarrow d^2 \cdot \Delta p = w \cdot 32 \cdot \mu \cdot l$$

$$\Delta p = \frac{w \cdot 32 \cdot \mu \cdot l}{d^2} = \frac{32 \cdot w \cdot \frac{w^2 \cdot d \cdot \rho}{Re_{ch}} \cdot l}{d^2}$$

$$\Delta p = R_p \cdot Q = \frac{128 \cdot \mu \cdot l}{\pi \cdot d^4 \cdot \rho} \cdot$$