1) C 2) A 3) A 4) B 5) A

II a) $A_p = 0{,}5\,dB$ $A_s = 20\,dB$

$\omega_p = 2\pi \times 1k \rightarrow \Omega_p = 1$ $\omega_s = 2\pi \times 4k \rightarrow \Omega_s = 4$

$A_c(\Omega) = 10\log\left[1+\varepsilon^2 C_m^2(\Omega)\right]$

$A_c(1) = 0{,}5\,dB \Leftrightarrow \sqrt{10^{\frac{0{,}5}{10}}-1} = \varepsilon = 0{,}35$

$A_c(4) = 10\log\left(1+0{,}35^2\, C_m^2(\Omega)\right)$

$m=1 \rightarrow A_c(4) = 4.7$ ✗

$m=2 \rightarrow A_c(4) = 20.7$ ✓

$A_p = 0{,}5\,dB$

$\varepsilon = 0{,}35$

$m = 2$

$$T(s) = T(S)\Big|_{S=\frac{s}{\omega_p}} = \frac{K}{S^2+1.4255S+1.516}\Big|_{S=\frac{s}{\omega_p}} = \frac{\omega_p^2 \times 1.431}{s^2+1.425\,\omega_p s+1.516\,\omega_p^2} = \frac{5{,}65\times10^7}{s^2+8953s+5{,}98\times10^7} \;//$$

b) $A_c(\Omega) = 10\log\left(1+0.35^2(2\Omega^2-1)^2\right) = 0 \Leftrightarrow (2\Omega^2-1)^2 = 0 \Leftrightarrow \Omega = \sqrt{\frac{1}{2}} = \frac{\sqrt{2}}{2}$

$\omega = \Omega\,\omega_p = 4443\,rad/s \rightarrow 707\,Hz$

c) $Y_1 = Y_3 = Y_4 = \frac{1}{R}$

$Y_2 = sC_2$

$Y_5 = sC_5$

$$T(s) = -\frac{\frac{1}{R^2}}{\left(\frac{1}{R}+sC_2+\frac{1}{R}+\frac{1}{R}\right)sC_5+\frac{1}{R^2}} = -\frac{\frac{1}{R^2C_2C_5}}{s^2+\frac{3}{RC_2}s+\frac{1}{R^2C_2C_5}}$$

$\frac{3}{RC_2} = 8{,}886\times10^5 \Leftrightarrow C_2 = 750\,pF$

$\frac{1}{R^2C_2C_5} = 3{,}948\times10^{11} \Leftrightarrow C_5 = 167\,pF$

d) Malhas encaixadas ⇒ Menos sensibilidade

III

a) $$T(s) = \frac{6s}{s+5\times10^4} = \frac{6\,\frac{2}{T}(1-z^{-1})}{\frac{2}{T}(1-z^{-1})+5\times10^4(1+z^{-1})} = \frac{\frac{12}{T}-\frac{12}{T}z^{-1}}{\frac{2}{T}-\frac{2}{T}z^{-1}+5\times10^4+5\times10^4 z^{-1}} = \frac{1-z^{-1}}{1-0{,}778z^{-1}}\,5.334$$

$s = \frac{2}{T}\,\frac{1-z^{-1}}{1+z^{-1}}$

b) Filtro analógico é estável ⇒ Filtro digital é estável (Polos dentro do círculo unitário)

$y_n = (x_n - x_{n-1})\,5.334 + y_{n-1}\cdot 0.778$

$100kHz = \frac{f_s}{2} \Rightarrow A(z) = A(s)\Big|_{s\to\infty} = \frac{1}{6} \rightarrow -15.56\,dB$

c) $T(z) = \frac{0.5}{1+0.5z^{-1}-0.5z^{-2}}$

$y_n = 0{,}5x_n - 0.5y_{n-1} + 0.5y_{n-2}$

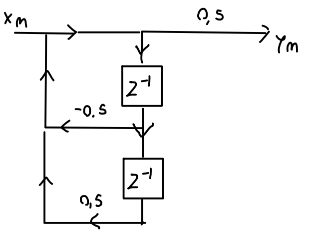
$y_n = 0{,}5\left(-x_n^0+2^{-1}x_n^1+2^{-2}x_n^2+2^{-3}x_n^3\right) +$

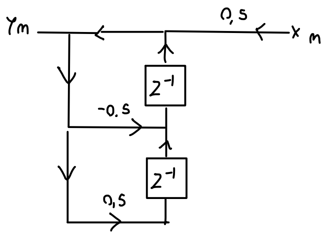
$-0{,}5\left(-y_{n-1}^0+2^{-1}y_{n-1}^1+2^{-2}y_{n-1}^2+2^{-3}y_{n-1}^3\right) +$

$+0{,}5\left(-y_{n-2}^0+2^{-1}y_{n-2}^1+2^{-2}y_{n-2}^2+2^{-3}y_{n-2}^3\right)$

0,5 x_n^j	−0,5 y_{n-1}^j	0,5 y_{n-2}^j		ROM
0	0	0	0	0 0 0 0
0	0	1	0,5	0 1 0 0
0	1	0	−0,5	1 1 0 0
0	1	1	0	0 0 0 0
1	0	0	0,5	0 1 0 0
1	0	1	1	0 1 1 1
1	1	0	0	0 0 0 0
1	1	1	0,5	0 1 0 0 //

d)





IV a)

$A = -K$

$$\beta = \left(\frac{sCR}{1 + sCR}\right)^3 \qquad A\beta = \frac{-K}{1 + \frac{3}{sCR} + \frac{3}{s^2C^2R^2} + \frac{1}{s^3C^3R^3}}$$

$A\beta = \underline{1}$

$$\operatorname{Im}\{A\beta\} = 0 \qquad \frac{3}{\omega CR} - \frac{1}{\omega^3 C^3 R^3} = 0 \Leftrightarrow 3 = \frac{1}{\omega^2 C^2 R^2} \Leftrightarrow \omega = \frac{1}{\sqrt{3}RC} = 5{,}774 \times 10^3 \text{ rad/s} \Rightarrow 918{,}9 \text{ Hz}$$

$$\operatorname{Re}\{A\beta\} = 1 \qquad \frac{-K}{1 - \frac{3}{\omega^2 c^2 R^2}} = 1 \Leftrightarrow -K = 1 - \frac{3}{\frac{R^2c^2}{3R^2C^2}} \Leftrightarrow K = 8$$