Exercícios recomendados

- 6.10, 6.11, 6.12, 6.15, 6.18, 6.19
- 6.25, 6.27, 6.28 (a i...xi), 6.29a, 6.32a, 6.37(a, b, d), 6.39 (a, b, c, d, f, i), 6.42, 6.45, 6.47 (a, b, c),
- 6.48 (a, b, c, d)

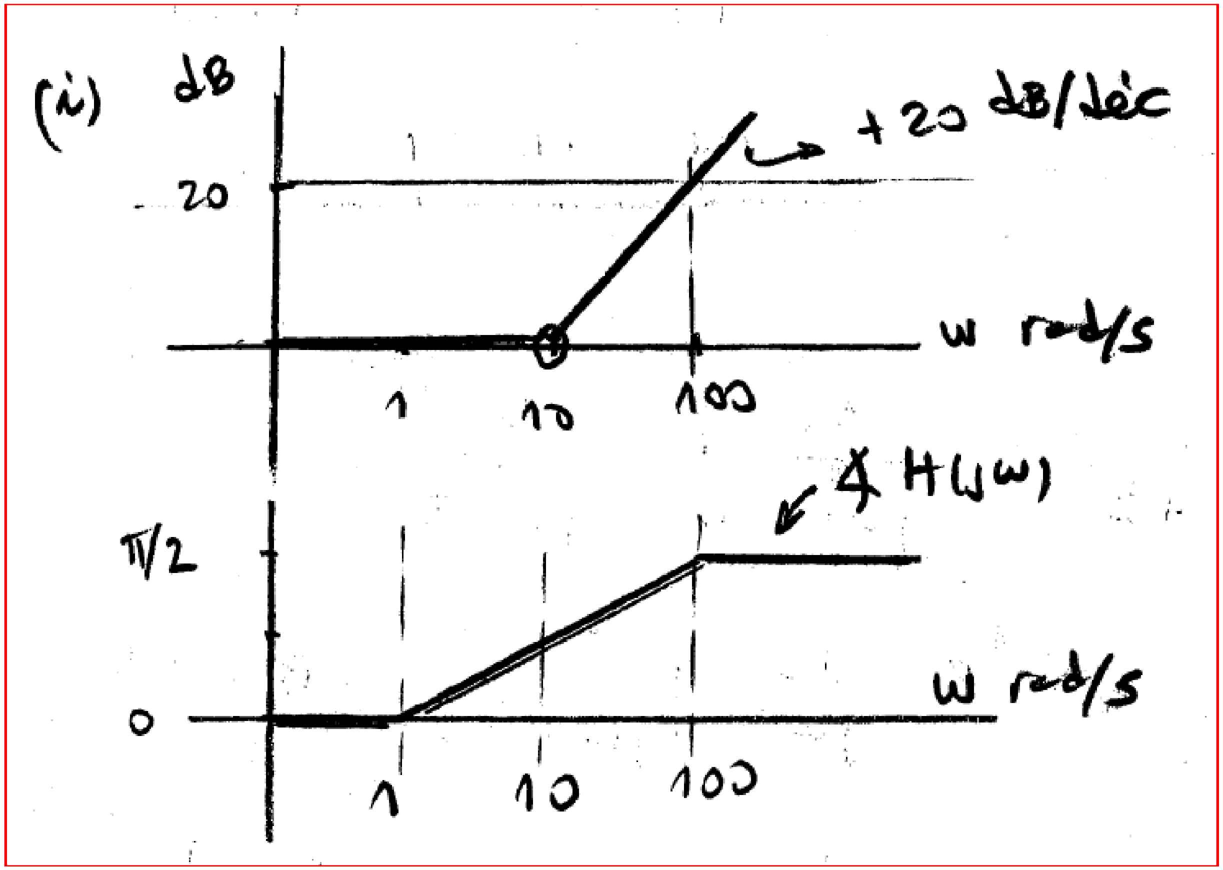
  corrigir livro

  $$y[n] = b_0 x[n] + b_1 x[n-1] + b_2 x[n-2] + b_3 x[n-3]$$

$\boxed{6.28}$ (a) $H(j\omega) = 1 + \frac{j\omega}{10}$

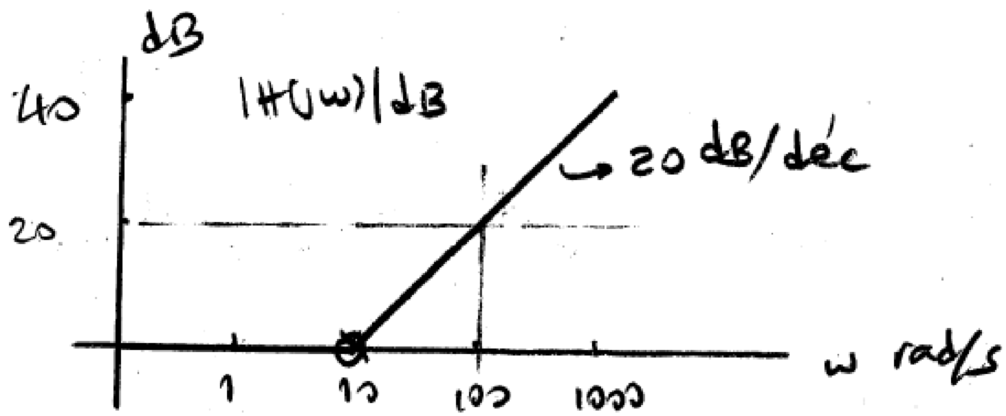
$$|H(j\omega)| = \sqrt{1+(\omega/10)^2}$$

$$\angle H(j\omega) = tg^{-1}(\omega/10)$$

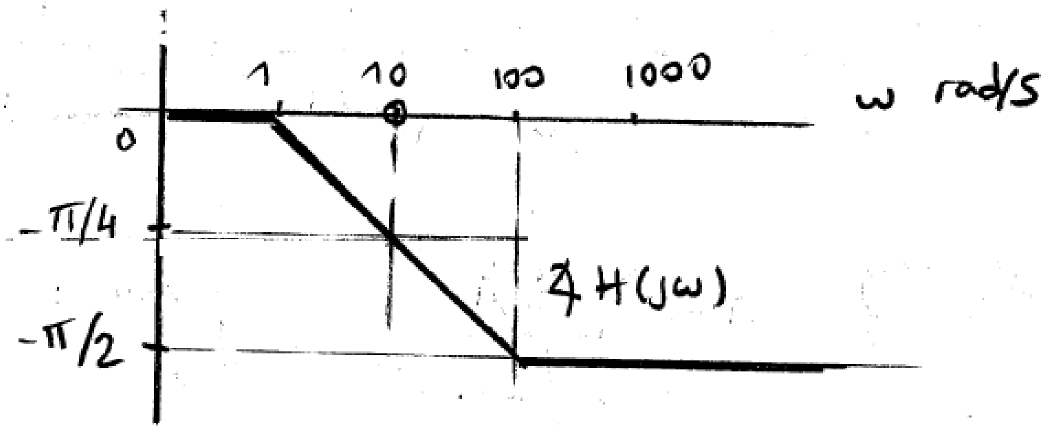


$\boxed{6.28}$ (a)

$$\boxed{(ix)\quad H(j\omega) = 1 - \frac{j\omega}{10}}$$



$$|H(j\omega)| = \sqrt{1+(\omega/10)^2}$$



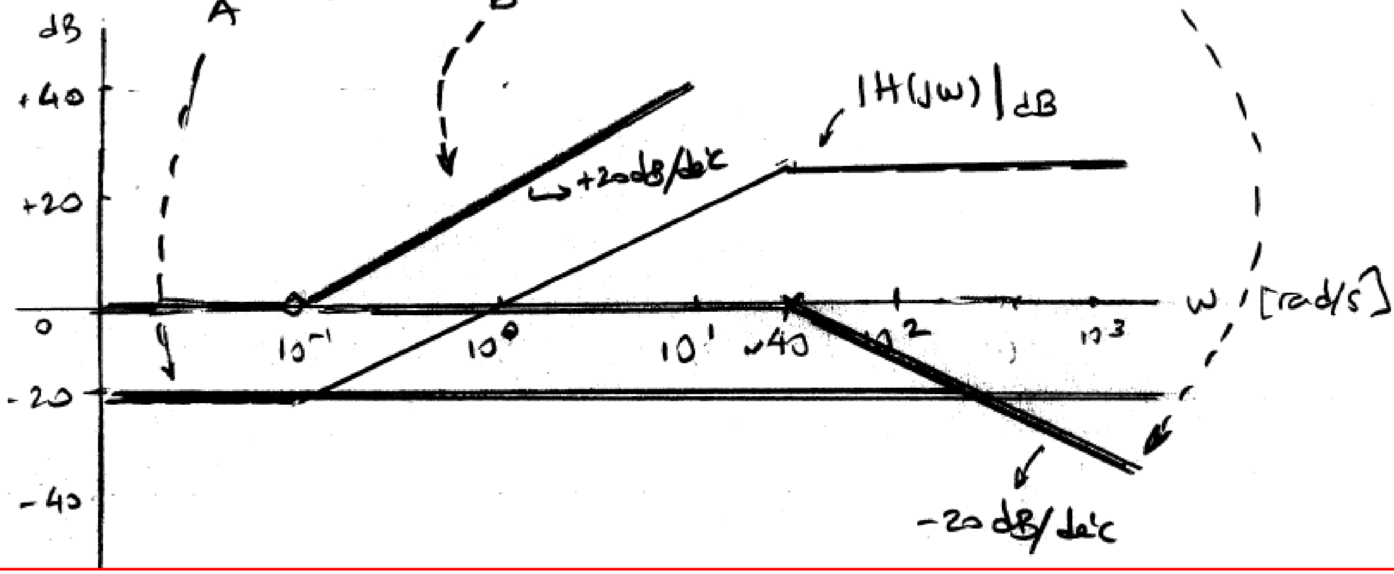
$$\angle H(j\omega) = tg^{-1}(-\omega/10)$$

$$= -tg^{-1}(\omega/10)$$

$\boxed{6.10}$ a) $H(j\omega) = 40\,\dfrac{j\omega + 0{,}1}{j\omega + 40} = 40\,(j\omega + 0{,}1) \times \dfrac{10}{10} \times \dfrac{1 \quad \cancel{\div 40}}{(j\omega + 40) \div 40}$

$$= \frac{1}{10}\,\frac{j\omega \times 10 + 1}{j\omega/40 + 1} = \frac{1}{10}\,\frac{j\omega/0{,}1 + 1}{j\omega/40 + 1}$$

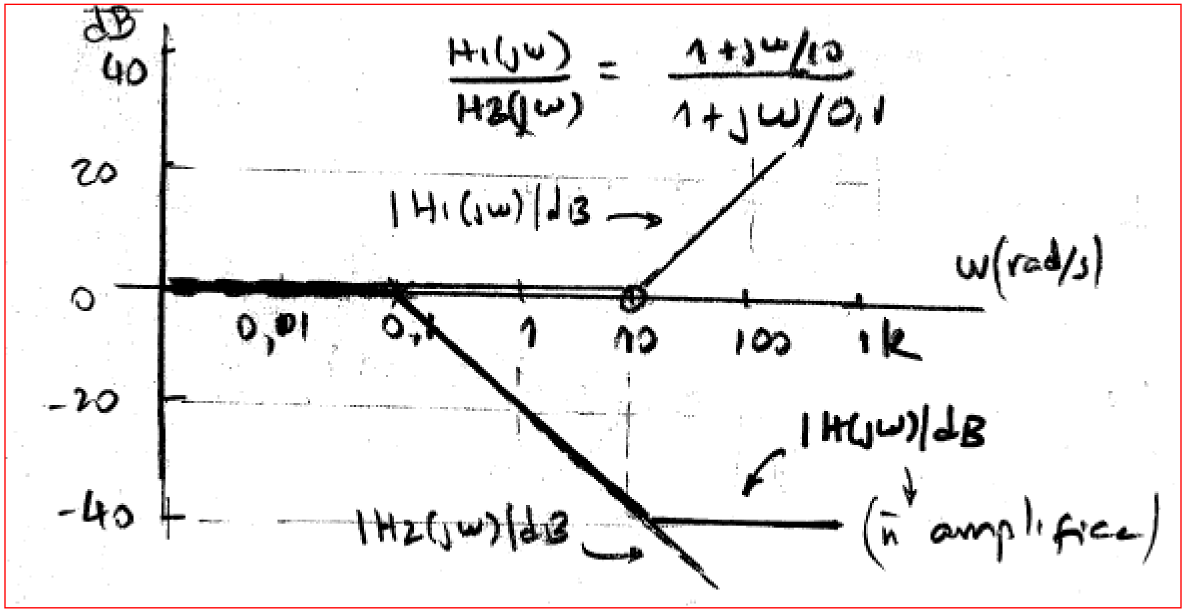
$$H(j\omega)\big|_{dB} = \underbrace{\overbrace{20 \log 10^{-1}}^{-20\,dB}}_{A} + \underbrace{20 \log\left(1 + j\omega/0{,}1\right)}_{B} - \underbrace{20 \log\left(1 + j\omega/40\right)}_{C}$$

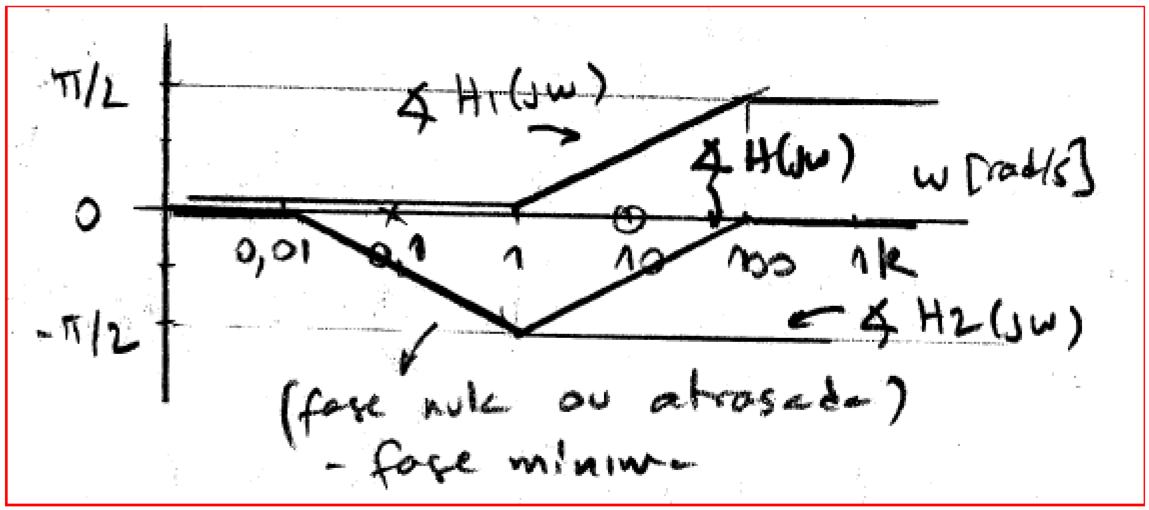


$\boxed{6.29}$ a) (i)

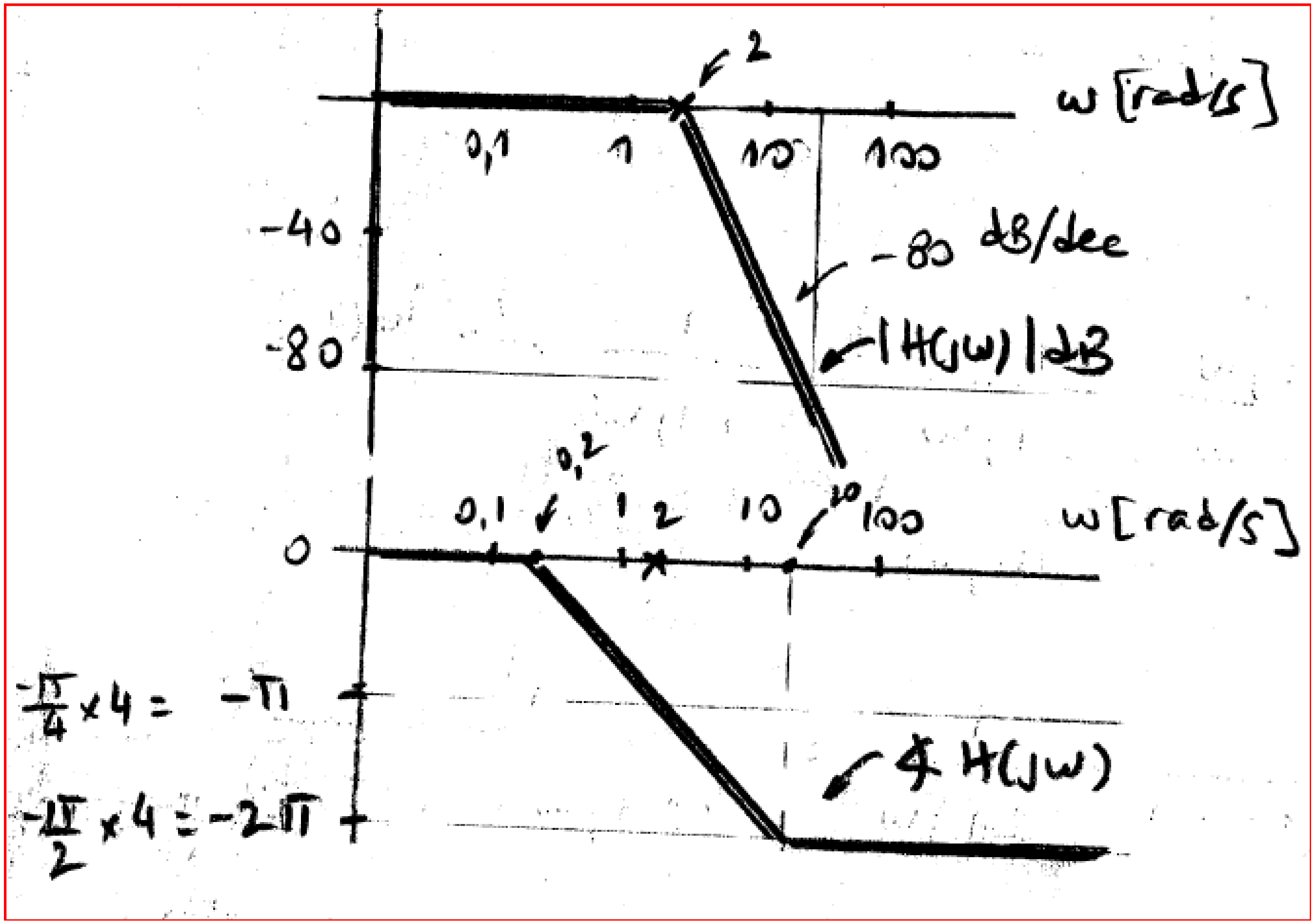
$$H(j\omega) = \frac{1 + j\omega/10}{1 + 10j\omega}$$

$$\frac{H_1(j\omega)}{H_2(j\omega)} = \frac{1 + j\omega/10}{1 + j\omega/0,1}$$





$\boxed{6.28}$ (a) (iii) $H(j\omega) = \dfrac{16}{(j\omega+2)^4} = \dfrac{16/16}{\left(\frac{j\omega+2}{2}\right)^4} = \dfrac{1}{(1 + j\omega/2)^4}$



$\boxed{6.11}$ 2ª ordem padrão: $H(jw) = \dfrac{w_n^2}{(jw)^2 + 2\xi w_n (jw) + w_n^2}$

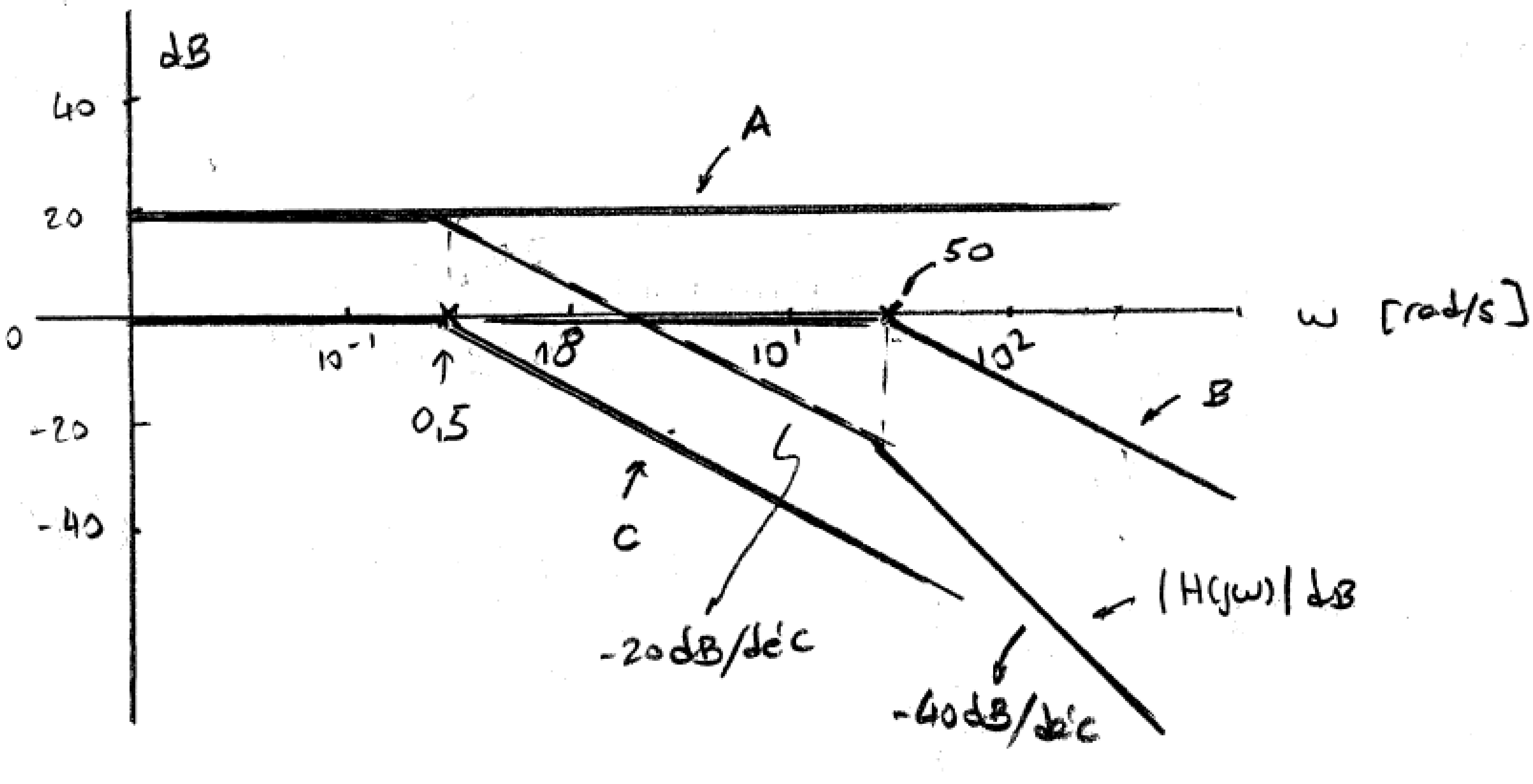
a) $H(jw) = \dfrac{250}{(jw)^2 + \underbrace{50{,}5}_{= 2\xi \cdot 5} \cdot jw + \underbrace{25}_{w_n^2}} = \dfrac{(5^2) \times 10}{(jw)^2 + \underbrace{2 \times 5{,}05}_{\xi} \times \underbrace{5}_{w_n} \cdot jw + 5^2}$

(superamortecido) $\rightarrow$ 2 pólos reais

$$H(jw) = \frac{250}{(jw + 50)(jw + 0{,}5)} = 250 \times \frac{1 \div 50}{(jw + 50) \div 50} \times \frac{1 \div 0{,}5}{(jw + 0{,}5) \div 0{,}5}$$

$$= \overbrace{\frac{250}{\underbrace{50 \times 0{,}5}_{10}}}^{A} \; \overbrace{\frac{1}{\frac{jw}{50} + 1}}^{B} \; \overbrace{\frac{1}{\frac{jw}{0{,}5} + 1}}^{C}$$

$$H(j\omega) = \overbrace{\underbrace{\frac{250}{50 \times 0{,}5}}_{10}}^{A} \; \overbrace{\frac{1}{\frac{j\omega}{50} + 1}}^{B} \; \overbrace{\frac{1}{\frac{j\omega}{0{,}5} + 1}}^{C}$$



$\boxed{6.15}$ (a) $\dfrac{d^2y(t)}{dt^2} + \dfrac{4\,dy(t)}{dt} + 4\,y(t) = x(t)$

$$\Updownarrow \mathcal{L}$$

$$s^2Y(s) + 4sY(s) + 4Y(s) = X(s)$$

$$H(s) = \frac{Y(s)}{X(s)} = \frac{1}{s^2 + 4s + 4}$$

pólos: $s = \dfrac{-4 \pm \sqrt{4^2 - 4\times 4}}{2} = -2$ (dupl $\Delta = 0 \therefore$ criticamente amortecido

$$H(s) = \frac{1}{2^2}\,\frac{2^2}{s^2 + 2\cdot 2\cdot 1\cdot s + 2^2}$$

$\omega_n = 2$

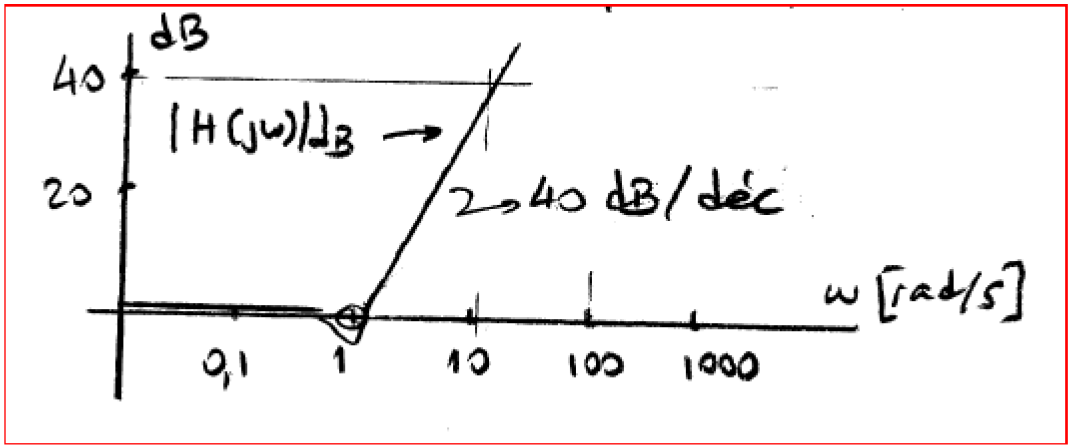
$\zeta = 1$

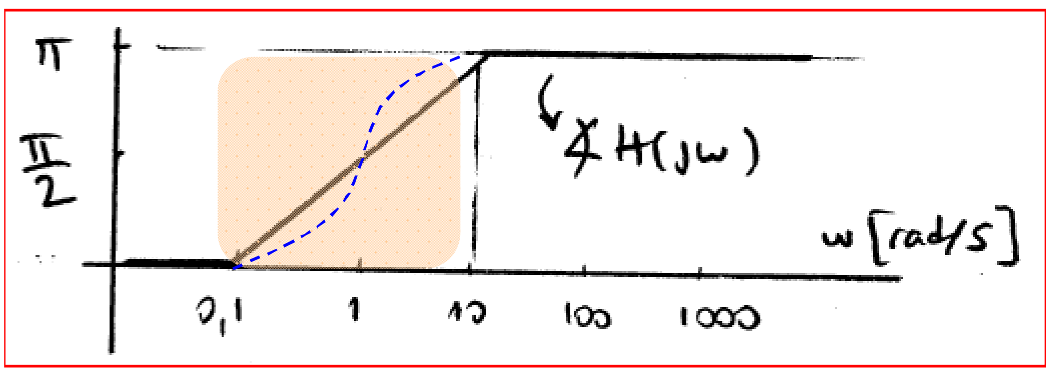
ω_n

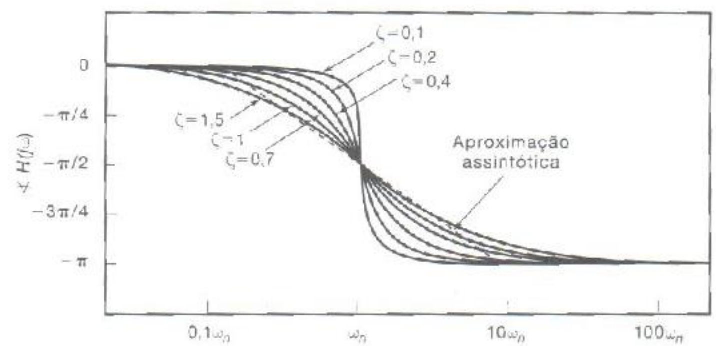
$\boxed{6.28}$ (a)

(ix) $H(j\omega) = 1 + j\omega + (j\omega)^2$

$\omega_n = 1 \qquad 1 = 2\zeta\omega_n \rightarrow \zeta = 1/2$



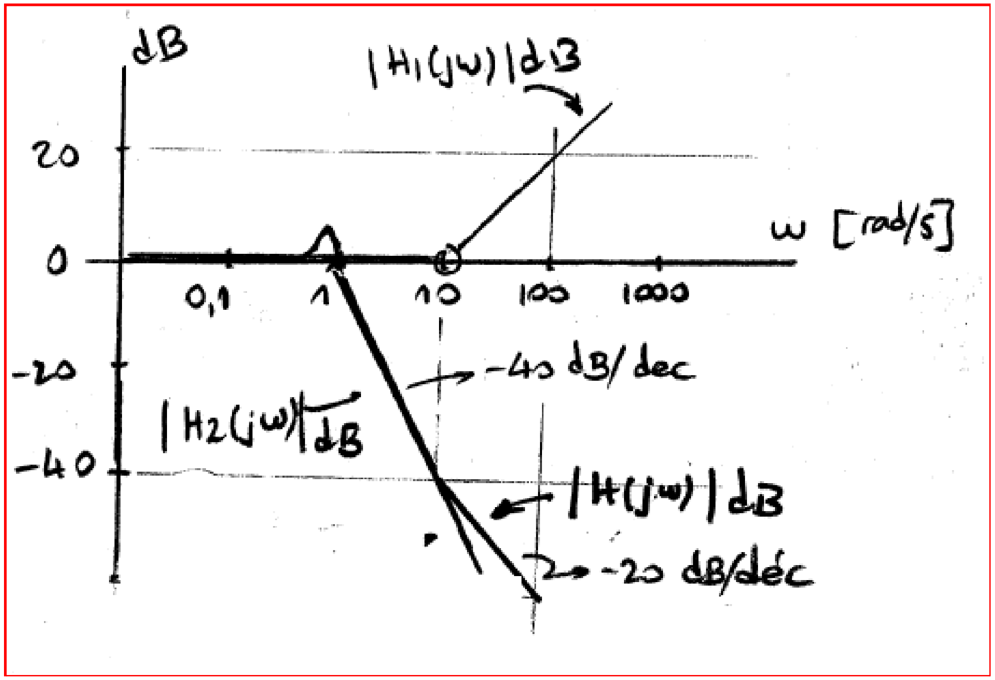


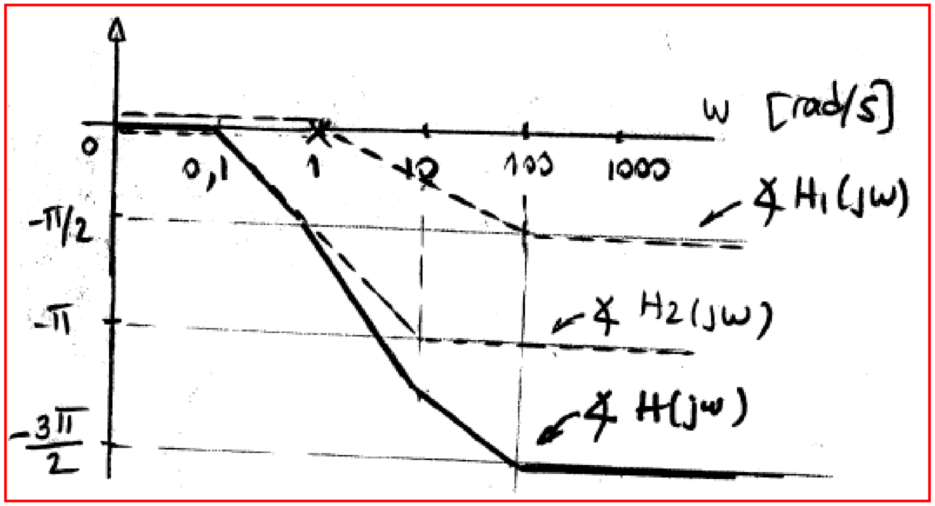


$\boxed{6.28}$

(viii) $H(j\omega) =$

$$= \frac{1 - j\omega/10}{(j\omega)^2 + \underbrace{j\omega}_{\zeta = 0{,}5} + \underbrace{1}_{\omega_n}} = \frac{H_1(j\omega)}{H_2(j\omega)}$$





Temo discreto: sistema 1ª ordem

$$y[n] - ay[n-1] = x[n], \qquad |a| < 1$$

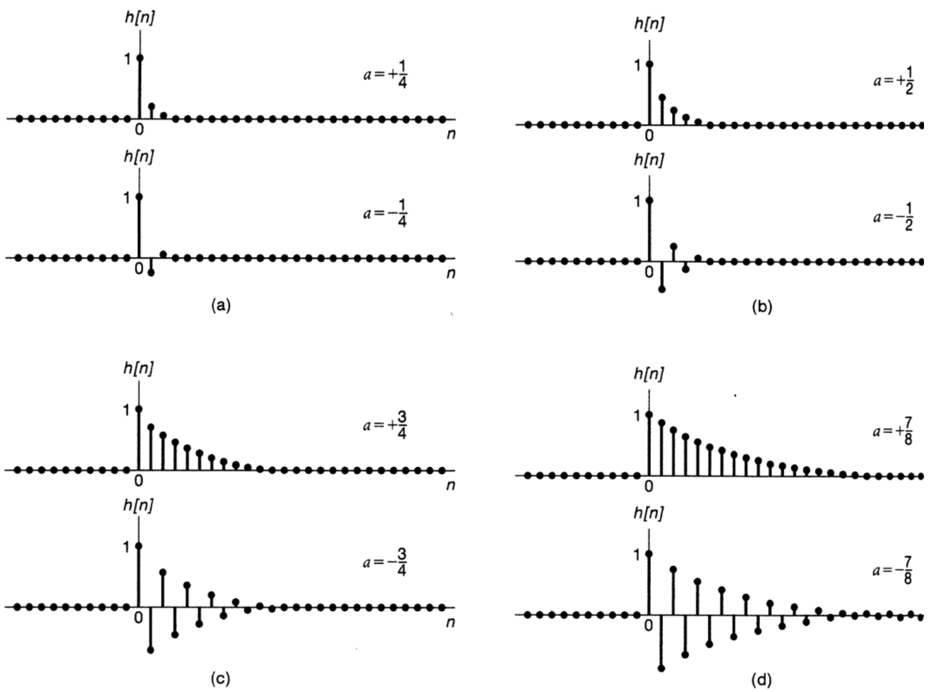
$$H(e^{j\varpi}) = \frac{1}{1 - ae^{-j\varpi}}$$

$$h[n] = a^n u[n]$$

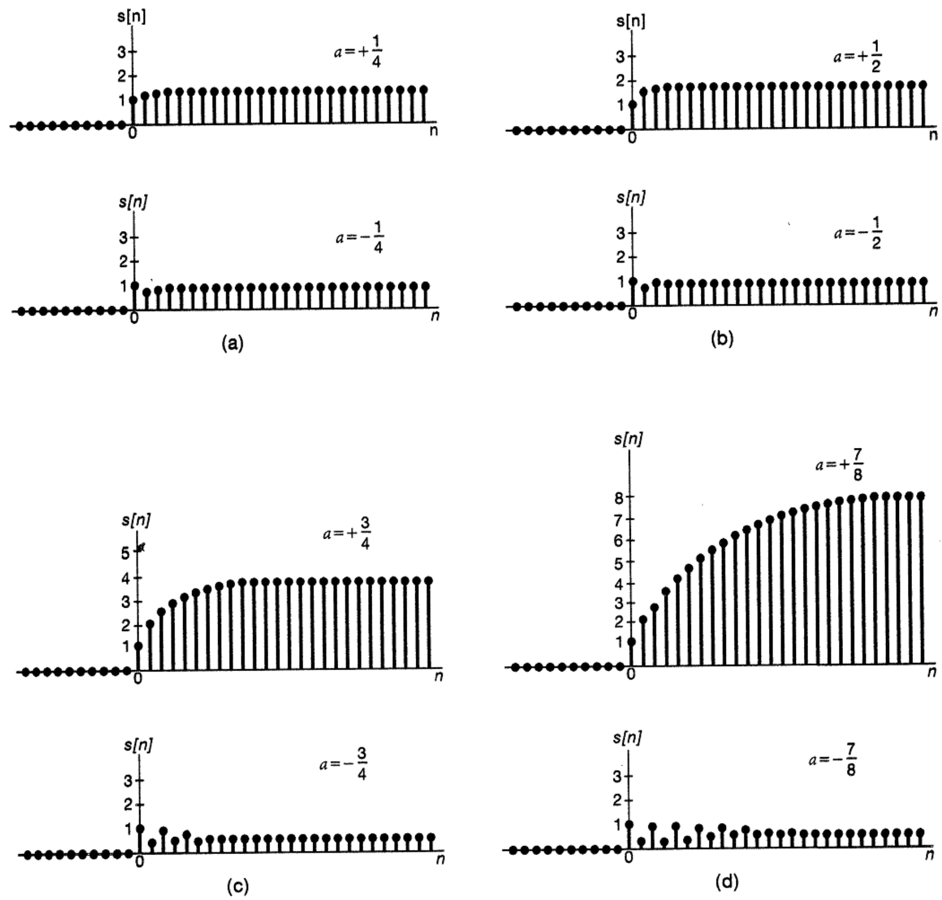
$$s[n] = h[n] * u[n] = \frac{1 - a^{n+1}}{1 + a} u[n]$$

Temo discreto: sistema 1ª ordem

Resp ao impulso



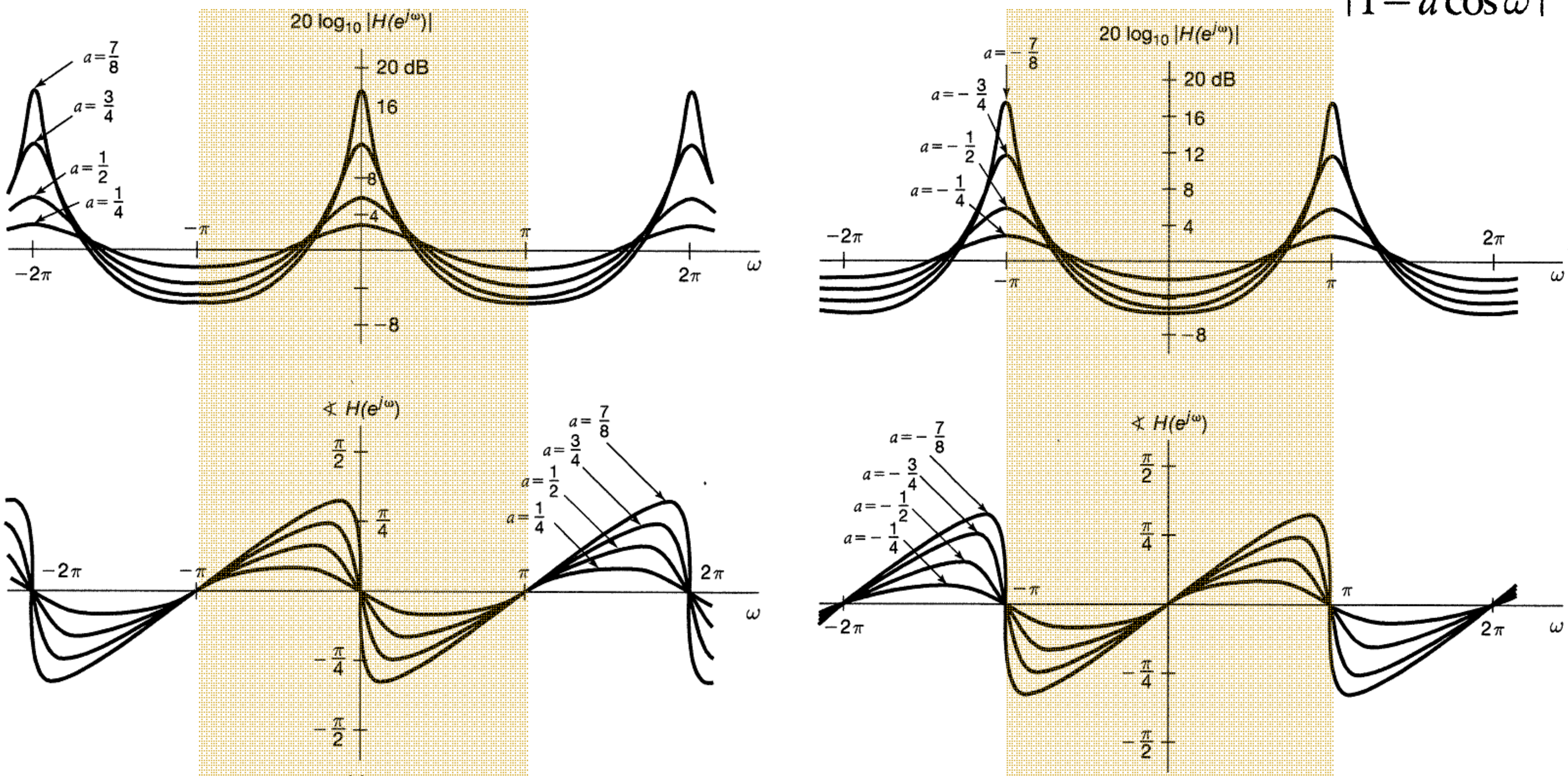
Resp ao degrau



Temo discreto: sistema 1ª ordem resposta em frequência diagrama de Bode

$$\left|H(e^{j\omega})\right| = \frac{1}{(1+a^2-2a\cos\omega)^{1/2}}$$

$$\sphericalangle H(e^{j\omega}) = -\mathrm{tg}^{-1}\left[\frac{a\,\mathrm{sen}\,\omega}{1-a\cos\omega}\right].$$



$\boxed{6.39}$ (a) $H(e^{jw}) = 1 + \frac{1}{2} e^{-jw} = \underbrace{1 + \frac{1}{2} \cos w}_{re} - j \underbrace{\frac{1}{2} \operatorname{sen} w}_{im}$

$$|H(e^{jw})|^2 = \left(1 + \frac{1}{2} \cos w\right)^2 + \left(\frac{1}{2} \operatorname{sen} w\right)^2 =$$

$$= 1 + \cos w + \frac{1}{4} \cos^2 w + \frac{1}{4} \operatorname{sen}^2 w = 1 + \cos w + \frac{1}{4} (\underbrace{\operatorname{sen}^2 w + \cos^2 w}_{=1})$$

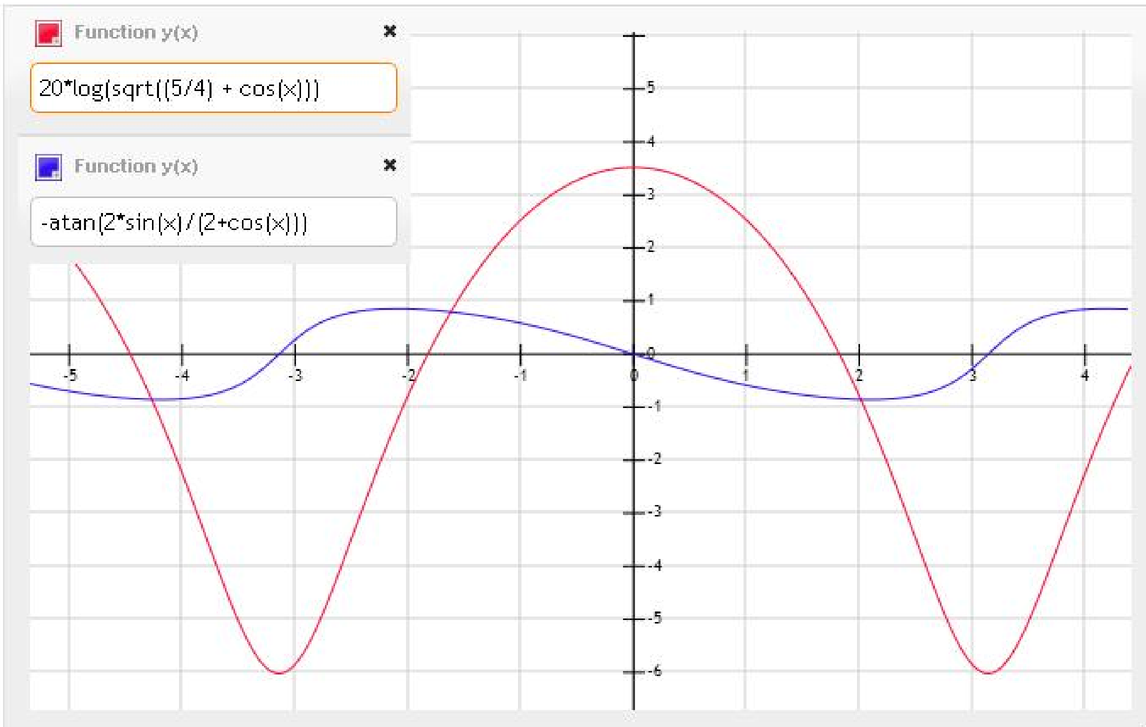
$$\boxed{|H(e^{jw})| = \sqrt{\frac{5}{4} + \cos w}}$$

$$\measuredangle H(e^{jw}) = tg^{-1} \frac{-\frac{1}{2} \operatorname{sen} w}{1 + \frac{1}{2} \cos w}$$

$$\boxed{\measuredangle H(e^{jw}) = -tg^{-1} \frac{\operatorname{sen} w}{2 + \cos w}}$$

$$|H(e^{jw})| = \sqrt{\frac{5}{4} + \cos w}$$

$$\measuredangle H(e^{jw}) = -tg^{-1} \frac{\operatorname{sen} w}{2 + \cos w}$$



http://www.fooplot.com

$\boxed{6.45}$ (i) $$H_1(e^{jw}) = \frac{1}{(1-\frac{1}{2}e^{-jw})(1-\frac{1}{3}e^{-jw})(1-\frac{1}{4}e^{-jw})}$$

obs: $a^n u[n] \leftrightarrow \frac{1}{1-ae^{-jw}}$

$a = +\frac{1}{2}$ $\quad$ $a = +\frac{1}{3}$ $\quad$ $a = +\frac{1}{4}$

$\therefore$ $h[n]$ não tem termo oscilatório

(ii) $$H_2(e^{jw}) = \frac{1}{\underbrace{(1+\frac{1}{2}e^{-jw})}_{a=-\frac{1}{2}}(1-\frac{1}{3}e^{-jw})(1-\frac{1}{4}e^{-jw})}$$

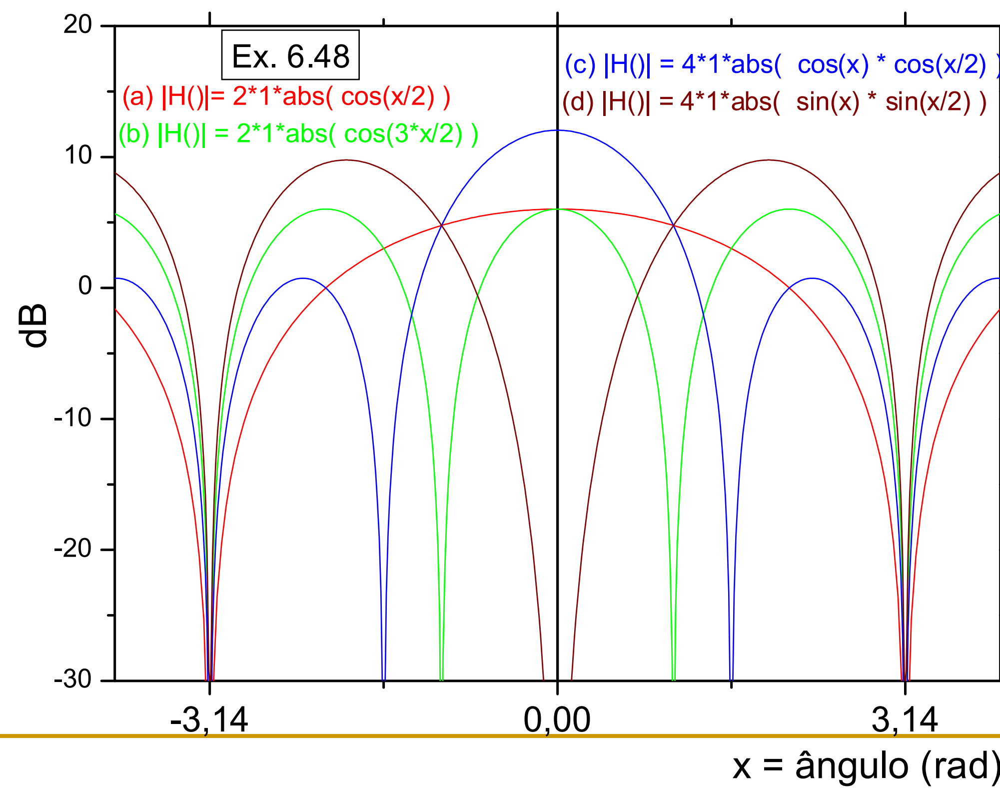
$a = -\frac{1}{2}$ $\therefore$ termo $(-\frac{1}{2})^n . u[n]$ é oscilatório

$\boxed{6.48}$ $y[n] = b_0 \cdot x[n] + b_1 \cdot x[n-1] + b_2\, x[n-2] + b_3\, x[n-3]$

a) $b_0 = b_3 = 0$, $b_1 = b_2$

$y[n] = b_1 \cdot \{x[n-1] + x[n-2]\} \xrightarrow{\mathcal{F}} Y(e^{jw}) = b_1 \left[e^{-jw} + e^{-2jw}\right] \cdot X(e^{jw})$

$$\boxed{H_a(e^{jw}) = b_1 \cdot e^{-j\frac{3w}{2}} \left[e^{jw/2} + e^{-jw/2}\right]} = \boxed{2 b_1 \cdot \cos\left(\frac{w}{2}\right) \cdot \underbrace{e^{-j3w/2}}_{\text{fase linear}}}$$



$\boxed{6.48}$ (c) $b_0 = b_1 = b_2 = b_3$

$$y[n] = b_0 \{ x[n] + x[n-1] + x[n-2] + x[n-3] \}$$

$$\Updownarrow \mathcal{F}$$

$$Y(e^{j\omega}) = b_0 \{ \underset{e^{j\omega 0}}{1} + \overbrace{e^{-j\omega} + e^{-2j\omega}}^{A} + e^{-3j\omega} \} X(e^{j\omega})$$

$$H_3(e^{j\omega}) = b_0 \{ \underbrace{e^{-j\frac{3\omega}{2}} [e^{j\frac{3\omega}{2}} + e^{-j\frac{3\omega}{2}}]}_{A} + \underbrace{e^{-j\frac{3\omega}{2}} [e^{+j\frac{\omega}{2}} + e^{-j\frac{\omega}{2}}]}_{B} \} \times \frac{2}{2}$$

$$H_3(e^{j\omega}) = 2b_0 \cdot e^{-j\frac{3\omega}{2}} \left[\cos(\underbrace{\tfrac{3\omega}{2}}_{a+b}) + \cos(\underbrace{\tfrac{\omega}{2}}_{a-b}) \right]$$

$$= 2 b_0 \, e^{-j\frac{3\omega}{2}} \times 2\cos(\overset{a}{\omega}) \cdot \cos(\overset{b}{\tfrac{\omega}{2}})$$

$$\boxed{H_3(e^{j\omega}) = 4 b_0 \cos(\omega) \cdot \cos\left(\tfrac{\omega}{2}\right) e^{-j3\omega/2}}$$

(fase linear)

$\cos(a+b) + \cos(a-b) = 2\cos(a) \cdot \cos(b)$

$a + b = 3\omega/2$

$a - b = \omega/2$

$2a = 2\omega \rightarrow a = \omega$

$b = \omega/2$