1) $x_a(t) = 4 + 2\cos(150\pi t + \pi/3) + 4\,\text{sen}(350\pi t)$

$= 4 + 2\cos(150\pi t + \pi/3) + 4\cos(350\pi t - \pi/2)$

$x[n] = 4 + 2\cos\left(\frac{150}{200}\pi n + \frac{\pi}{3}\right) + 4\cos\left(\frac{350}{200}\pi n - \frac{\pi}{2}\right)$

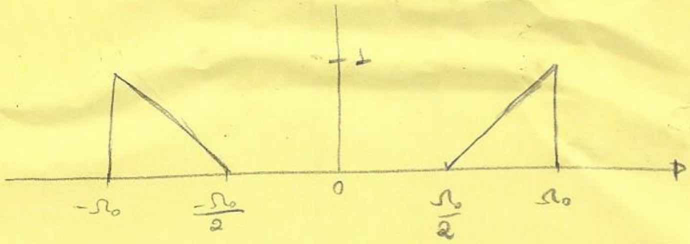
$$X(e^{j\omega}) = \sum_{k=-\infty}^{\infty} 2\pi\delta(\omega + 2\pi k) + \sum_{k=-\infty}^{\infty} 2\left[\pi e^{j\frac{\pi}{3}}\delta(\omega - \tfrac{3}{4}\pi + 2\pi k) + \pi e^{-j\frac{\pi}{3}}\delta(\omega + \tfrac{3}{4}\pi + 2\pi k)\right]$$

$$+ 4\sum_{k=-\infty}^{\infty}\left[\pi e^{-j\frac{\pi}{2}}\delta(\omega - \tfrac{7}{4}\pi + 2\pi k) + \pi e^{+j\frac{\pi}{2}}\delta(\omega + \tfrac{7}{4}\pi + 2\pi k)\right]$$

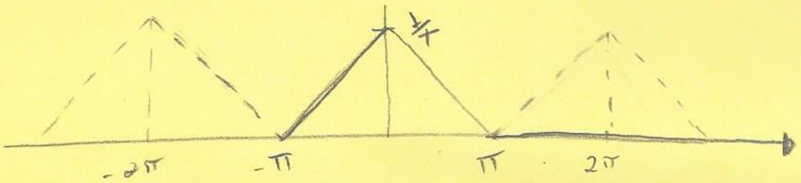
Para $|\omega| < \pi$

$$X(e^{j\omega}) = 8\pi\delta(\omega) + 2\pi\left(e^{j\frac{\pi}{3}}\delta(\omega - \tfrac{3}{4}\pi) + e^{-j\frac{\pi}{3}}\delta(\omega + \tfrac{3}{4}\pi)\right) + 4\pi\left(e^{-j\frac{\pi}{2}}\delta(\omega - \tfrac{7}{4}\pi) + e^{+j\frac{\pi}{2}}\delta(\omega + \tfrac{7}{4}\pi)\right)$$

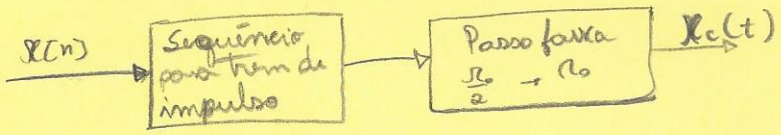
2) $T = \frac{2\pi}{\Omega_0}$



a)



b)



c) $T < \frac{\pi}{\Omega_0}$

3) $f_x = \frac{\pi}{8}$ rad

a) $T = \frac{1}{f_s}$; $f_s \geq 2B \Rightarrow T \leq \frac{1}{2B}$; $T_{MAX} = \frac{1}{2B}$

$T = \frac{1}{2 \cdot 5000} = 10^{-4}$

b) $f_s = 10\,kHz$

$\frac{\omega}{T} = 2\pi f_c \Rightarrow 10^4 \cdot \frac{\pi}{8} \cdot \frac{1}{2\pi} = f_c$

$f_c = 625\,Hz$

4)

m	$(2f_c - B)/m$	$(2f_c + B)/(m+1)$	Inversão
1	45kHz	27,5 kHz	S
2	22,5kHz	18,33 kHz	N
3	15 kHz	13,75 kHz	S
4	11,25kHz	11kHz	N
5	9 kHz	9,166 kHz	S

$f_c = 25 kHz$; $B = 5 kHz$

A partir de 5 réplicas começa a haver aliasing por não obedecer $f_S \geq 2B$.

5) $E_d = \sum_{n=-\infty}^{\infty} |x[n]|^2$

$$E_a = \int_{-\infty}^{\infty} |x_a(t)|^2 dt$$

Pelo teorema de Parseval:

$$E_d = \frac{1}{2\pi} \int_{-\pi}^{\pi} |X(e^{j\omega})|^2 d\omega \qquad E_a = \frac{1}{2\pi} \int_{-\infty}^{\infty} |X(j\Omega)|^2 dj\Omega$$

Para o caso de banda limitada e respeitando o teorema de Nyquist

$$E_d = \frac{T_s}{2\pi} \int_{\frac{-\Omega_0}{T_s}}^{\frac{-\Omega_0}{T_s}} |X(e^{j\omega})|^2 d\omega \qquad E_a = \frac{1}{2\pi} \int_{-\Omega_0}^{\Omega_0} |X(j\Omega)|^2 dj\Omega$$

$$\Omega_0 = \frac{\pi}{T_s}$$

Pela relação:

$$X(e^{j\omega}) = X(e^{j\Omega T}) = \frac{1}{T_s} \sum_{k=-\infty}^{\infty} X(j(\Omega - k\Omega_s))$$

Para um periodo:

$$X(e^{j\Omega T_s}) = \frac{1}{T_s} X(j\Omega)$$

$$E_d = \frac{T_s}{2\pi} \int_{-\Omega_0}^{\Omega_0} \left| \frac{X(j\Omega)}{T_s} \right|^2 d\Omega$$

$$= \frac{1}{T_s} \cdot \frac{1}{2\pi} \int_{\Omega_0}^{\Omega_0} |X(j\Omega)|^2 d\Omega = \frac{1}{T_s} E_a$$