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1. 由题可知 $f_s = 10^4 \text{ Hz}$, $\Delta f \leq 10 \text{ Hz}$

$$\text{故 } N = \frac{f_s}{\Delta f} \geq \frac{10^4}{10} = 1000.$$

$$\text{即至少需采样 } t = N \cdot \frac{1}{f_s} = \frac{1000}{10^4} = 0.1 \text{ s}$$

$$\text{输入信号最高频率 } f_{\max} \leq \frac{f_s}{2} = 5000 \text{ Hz}$$

$$2. (a) \text{ 采样时间 } t = L \cdot \frac{1}{f_s} = 128 \times \frac{1}{40 \times 10^3} = 3.2 \times 10^{-3} \text{ s} = 3.2 \text{ ms}$$

$$(b) \quad \omega_s = \frac{2\pi}{L} = 2\pi \cdot \frac{\Delta f}{f_s} = 2\pi \times \frac{5 \times 10^3}{40 \times 10^3} = \frac{\pi}{4}$$

而信号 $x(n) = \sin(\omega_0 n)$ 的频谱冲激位置在

$$\omega_1 = \frac{\pi}{4} \text{ 和 } \omega_2 = 2\pi - \frac{\pi}{4} = \frac{7\pi}{4} \text{ 上.}$$

故在频域抽样时, 对应点位置为

$$n_1 = 128 \times \frac{\frac{\pi}{4}}{2\pi} = 16 \text{ 和 } n_2 = 128 \times \frac{\frac{7\pi}{4}}{2\pi} = 112.$$

$$3. \text{ 采样点数 } L = f_s \cdot t = 10 \times 10^3 \times 10 \times 10^{-3} = 100$$

$$\text{又 } \Delta \omega_{\min} = \frac{2\pi}{L} = \frac{\pi}{50}$$

$$\text{故 } \Delta f = \Delta \omega_{\min} \cdot \frac{f_s}{2\pi} = \frac{\pi}{50} \cdot \frac{10^4}{2\pi} = 100 \text{ Hz}$$

$$\text{由此知 } f_{2\min} = f_1 + \Delta f = 1100 \text{ Hz}$$

$$f_{2\max} = f_3 - \Delta f = 1900 \text{ Hz}$$