hw 5

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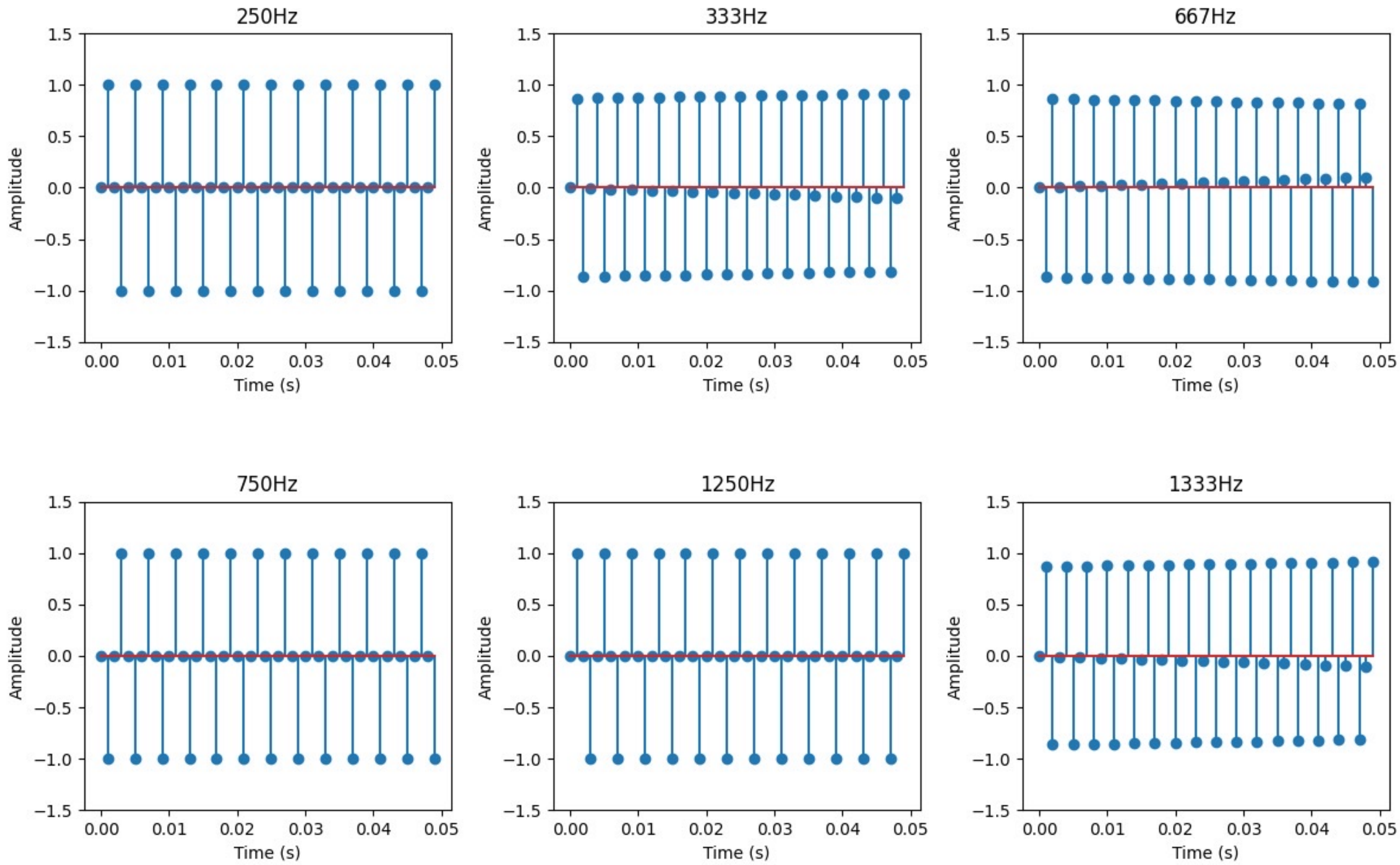
Question 1

Part A



Part B

1. 250 Hz: cycle every 4 samples: $\frac{1\text{ kHz}}{4} = 250\text{ Hz}$ ✓
2. 333 Hz: cycle every 3 samples: $\frac{1\text{ kHz}}{3} = 333\text{ Hz}$ ✓
3. 667 Hz: cycle every 3 samples: $\frac{1\text{ kHz}}{3} = 333\text{ Hz}$
4. 750 Hz: cycle every 4 samples: $\frac{1\text{ kHz}}{4} = 250\text{ Hz}$
5. 1250 Hz: cycle every 4 samples: $\frac{1\text{ kHz}}{4} = 250\text{ Hz}$
6. 1333 Hz: cycle every 4 samples: $\frac{1\text{ kHz}}{3} = 333\text{ Hz}$

Question 2

(a) $T_s = \frac{1}{f_s}$

$= \frac{1}{44.\text{kHz}}$

$= \boxed{22.7\,\mu s}$

(b) $V_{rms} = \frac{2}{\sqrt{2}} \pi A f t_{rms}$

$= \frac{2}{\sqrt{2}} \pi (1V)(7.04\text{kHz})(1\,\mu s)$

$= \boxed{31.28\,mV_{rms}}$

(c) $t_{rms} \leq \frac{\sqrt{2}}{\pi f (2^D - 1)}$

$2^D - 1 \leq \frac{\sqrt{2}}{\pi f t_{rms}}$

$2^D \leq \frac{\sqrt{2}}{\pi f t_{rms}} + 1$

$D \leq \log_2 \left(\frac{\sqrt{2}}{\pi f t_{rms}} + 1 \right)$

$\sim \boxed{D \leq 6 \text{ bits}}$

Question 3

(a) $\frac{50kHz}{128} = \boxed{391 Hz}$

(b) Nyquist frequency is the highest identifiable:

$$\frac{50\,kHz}{2} = \boxed{25kHz}$$

(c) ↑ sampling freq + = # FFT bins → $\boxed{\text{bin spacing increases.}}$

Bins get further apart: FFT freq. axis goes from $[0, f_s)$ and it splits into N bins. $\uparrow \frac{f_s}{=N} = \uparrow$ spacing

(d) $461 - 441 \rightarrow 21$ Hz of distinguishability

Bin spacing $< 5 \cdot 21 < 105$ Hz

$f_s \leq 128\,(105) \leq \boxed{13.44\ kHz}$