Solutions

2.1

- $10 \log_{10}(128) = 21.1$ dB.

2.2

- $\Delta f = f_s/N \leq 0.5$ Hz $\rightarrow N \geq 4000 \rightarrow 2.0$ s of data.

2.3

- It tunes to the test signal (overfitting): the detector passes the lab tone and fails the world – measurement, not memorisation, is the method.

3.1

- $\Delta f \leq 2$ Hz $\rightarrow N \geq 2000 \rightarrow N = 2048$ (power of two): $\Delta f = 1.953$ Hz ✓.
- Latency: 2048 samples / 4000 Hz = 0.512 s – misses the 0.5 s line by 12 ms × (the trade the margin table must show).
- Bin: $440/1.953 = 225.28 \rightarrow$ bin 225, exact frequency 439.45 Hz, quantisation error 0.55 Hz ✓ inside ±2.
- Processing gain $10 \log_{10}(1024) = 30.1$ dB $\rightarrow$ decision-bin SNR $-6 + 30.1 = 24.1$ dB ✓.

3.2

- Defects: no measured values (PASS is a claim, not a number); no margins (nothing to audit); silent goals (lines measured in code but not reported).
- $N = 900$ at 1 kHz: $\Delta f = 1.111$ Hz – the 1 Hz line FAILS with a -0.111 Hz margin, which the table must show.
- Change: every row lists spec, measured value, and signed margin – no unnumbered PASS.