Solutions

2.1

- $N = 3.3 \times 8000/100 = 264 \rightarrow 265$ taps, delay 132 samples (16.5 ms).

2.2

- Blackman (-58 dB) is below -50 dB; the tabulated Hann and Hamming window sidelobes are not. These are window-spectrum levels, so the filter still needs its own frequency-response check.

2.3

- Type-I symmetry needs a centre tap: $h[n] = h[N-1-n]$ has an exact middle only when N is odd, giving whole-sample delay $(N-1)/2$.

3.1

- $N = 3.3 \times 1000/50 = 66 \rightarrow 67$ taps.
- Delay $(67-1)/2 = 33$ samples $= 33$ ms.
- $N = 31$: transition $3.3 \times 1000/31 = 106$ Hz – too wide (the design misses on sharpness).
- Verify: stopband at or below -43 dB and passband ripple $\leq \pm 0.05$ dB, both computed from the taps.

3.2

- Transition $5 \rightarrow 6$ kHz $= 1$ kHz wide.
- $N = 3.3 \times 48\,000/1000 = 158.4 \rightarrow 159$ taps.
- Delay $(159-1)/2 = 79$ samples at 48 kHz $= 1.65$ ms.
- Dropping first folds everything above 6 kHz into the kept band – aliasing is permanent; the fence goes up before the drop.
- At 48 kHz: $159 \times 48\,000 = 7.6$ M multiplies/s; polyphase runs the same taps at 12 kHz: 1.9 M/s – one quarter.