# Index of FFT lab on Intuition Drill

## Lab 1 — Meet the Players: $f_0$, $f_s$, and N

**Focus:** How signal frequency ($f_0$), sampling frequency ($f_s$), and number of samples (N) connect.
**Goal:** Understand $\Delta f = f_s / N$ and how it decides bin spacing.
**Drill:** Pick N = 8, $f_s$ = 8 Hz → $\Delta f$ = 1 Hz. Place a 2 Hz sine and see it *exactly* in bin 2.

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## Lab 2 — When the Bins Fit Like Lego

**Focus:** Perfect bin alignment (integer multiples of $\Delta f$).
**Goal:** See how a signal with exactly $k \cdot \Delta f$ Hz frequency lands in one bin with no leakage.
**Drill:** Keep $f_s$ = 32 Hz, N = 8 → $\Delta f$ = 4 Hz. Try signals at 4 Hz, 8 Hz, 12 Hz.

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## Lab 3 — When the Lego Bricks Don’t Fit

**Focus:** Spectral leakage.
**Goal:** Observe what happens when $f_0$ is *not* a bin frequency.
**Drill:** With $f_s$ = 32 Hz, N = 8 → $\Delta f$ = 4 Hz, put $f_0$ = 5 Hz and see the spread in bins.

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## Lab 4 — The Window Effect

**Focus:** Why the FFT assumes the signal repeats forever.
**Goal:** Show how the rectangular window causes leakage, and how Hamming/Hann windows reduce it.
**Drill:** Use same 5 Hz case from Chapter 3, compare no window vs. Hann.

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## Lab 5 — Time–Frequency Tradeoff

**Focus:** How N controls resolution.

**Goal:** See Δf get smaller as N grows, improving your ability to separate close frequencies.
**Drill:** Compare N = 8 vs. N = 64 for two signals at 10 Hz and 11 Hz.

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## Lab 6 — The Mirror World

**Focus:** Positive and negative frequencies.
**Goal:** Understand fftfreq output and symmetry for real signals.
**Drill:** Plot np.fft.fftfreq and watch bins > $f_s/2$ become negative.

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## Lab 7 — Phase is Not Just Decoration

**Focus:** Interpreting FFT phase output.
**Goal:** Connect time-domain shift with phase change in frequency domain.
**Drill:** Delay a sine wave by ¼ cycle and see a 90° phase shift in its bin.

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## Lab 8 — DC: The Quiet Tenant at 0 Hz

**Focus:** Why bin 0 means “average value.”
**Goal:** Add a constant offset to your signal and see it appear only at bin 0.
**Drill:** Sine wave vs. sine wave + 3.

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## Lab 9 — Aliasing: Folding Beyond Nyquist

**Focus:** What happens when $f_0 > f_s/2$.
**Goal:** Show how high-frequency signals masquerade as lower ones.
**Drill:** $f_s$ = 32 Hz, generate $f_0$ = 20 Hz and 28 Hz; watch folding.

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# Lab 10 — Building the FFT Reflex

**Focus:** Putting it all together to read FFT plots like a story.

**Goal:** Predict before running: location, height, width, and phase of peaks.

**Drill:** Randomly choose $f_0$, $f_s$, N — predict FFT outcome, then verify.