Pitch and loudness

The held note from the last page is a sine wave, the simplest interesting signal there is. Almost every other signal in this course is built out of sines, so it's worth getting comfortable with the sine's four knobs before you move on.

The sine wave's knobs

$$v(t) = A\sin(2\pi f t + \phi) + V_{\mathrm{DC}}$$

Each symbol in the formula is a knob you could turn on a synthesizer. The table also lists the period T, which isn't a separate knob, because the frequency sets it:

Symbol	Name	Musical intuition	What it means
A	Amplitude	Loudness	How far the wave swings from its center (volts)
f	Frequency	Pitch	How many cycles the wave completes per second (hertz, Hz)
$T = 1/f$	Period	Length of one "beat"	How long one cycle lasts (seconds)
ϕ	Phase	Where in the beat you start	How far the wave is shifted sideways, which sets where in its cycle it starts
V_{DC}	DC offset	No musical equivalent (a mixing desk calls this "bias")	The center line the wave rides on

If you turn the amplitude knob up, the note gets louder but its pitch stays the same. If you turn the frequency knob up, the pitch rises but the loudness stays the same. The two are independent, which is why the formula gives them separate symbols.

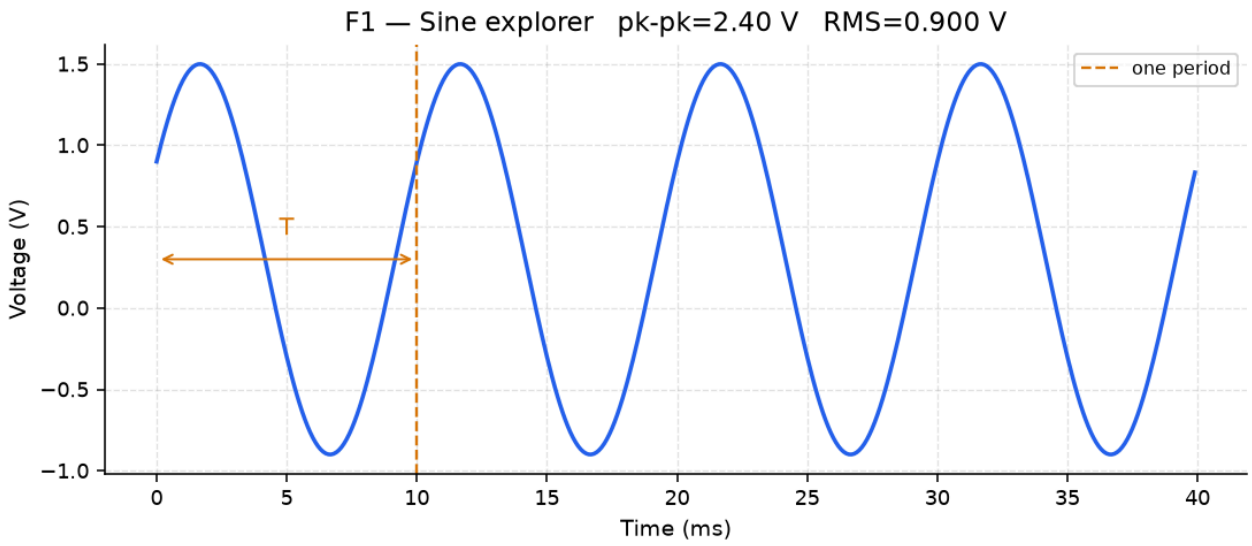


Figure 1: F1 — Sine explorer

Two ways to measure “how loud”

- **Peak-to-peak** is the full vertical swing of the wave, from its highest point to its lowest. For a pure sine it’s $2A$, because the wave swings A above its center line and A below it.
- **RMS** (“root mean square”) measures the signal’s effective strength. For a sine with no DC offset, $\mathrm{RMS} = A/\sqrt{2} \approx 0.707\,A$. The power a signal delivers into a resistor depends on its RMS value, not its peak, which is why a multimeter reports RMS rather than amplitude when you measure an AC voltage.

In Lab 01, Part 3, you’ll read the period, peak-to-peak and RMS off the F1 explorer, and then compute the same three numbers in your own script, working out the period from $T = 1/f$ and measuring the other two from an array of samples.

Why an engineer cares

Outside music, the same quantities come up all the time in circuit work:

Quantity	Everyday use
Amplitude compared with the supply rails	Headroom: whether the signal will clip
DC offset	The bias, or operating point, of a circuit (AD103 will make this precise)
Frequency	Bandwidth budgets and sampling rates
RMS	The number your multimeter reports and your power calculations use

Next: A family of waveforms