

An Instrument That Has to Be in Tune

Ratio and proportion, measurement, and the physical relationship between string length and pitch.

AGE RANGE

3rd grade and up

TIME NEEDED

About 20 minutes per child

THE BIG IDEA

A stretched string does not care what you want it to sound like, it only responds to its length and tension. Cut it in half and the pitch jumps up exactly one octave, every time, no exceptions. That reliability is what makes this a math lesson disguised as an instrument build: kids are not just gluing a box together, they are testing a ratio (1, then $\frac{1}{2}$, then $\frac{1}{4}$) against their own ears.

Plan for the build itself to take the bulk of the time, with the “does it actually work” tuning moment as the payoff at the end.

LEARNING OBJECTIVES

- Measure length accurately with a ruler, and mark fractions of a whole length.
- Understand ratio and proportion through the string-length-to-pitch relationship.
- Distinguish two separate variables that affect pitch: string length and string tension.
- Predict an outcome (what an octave, a half-length, or a quarter-length will sound like) before testing it.

MATERIALS

- ☐ A sturdy cardboard box per instrument, to act as the resonating body
- ☐ A wooden board (a paint stir stick or a thin furring strip works) to act as the neck
- ☐ Fishing line, one length per string, about 10 to 12 lb test
- ☐ Rulers, one per child
- ☐ A reference note source for tuning: a tuning fork, a phone tuner app, or a keyboard

PREP BEFORE KIDS ARRIVE

Pre-drill or pre-notch anchor points on the boxes and boards so kids are not handling drills or blades, sand any rough wood edges ahead of time, and pre-cut fishing line to a workable length (about 18 inches per string is comfortable to tie and tension by hand). Have your reference note source ready and tested.

BUILDING AND TESTING

1

Assemble the body

Attach the wooden board across the open top of the cardboard box so it spans the opening like a bridge. This board is what the string will run across, and the box underneath is what makes the pluck audible as a real tone instead of a dull thud.



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Photo: box and board assembled, before the string goes on

2

String it and anchor both ends

Tie one end of the fishing line to an anchor point, run it across the board, and tie off the other end. Snug it by hand, it does not need to be very tight yet, that comes during tuning.

3

Measure the full string length

Using the ruler, measure the length of string between the two anchor points. Write this number down and label it “1”, this is the baseline ratio everything else will be compared against.

4

Establish the reference pitch

Play the reference note (tuning fork, app, or keyboard) and pluck the open string. Adjust the tension at the anchor until the open string roughly matches the reference pitch. This is “tuning,” and it is a good moment to point out that tension is a second way to change pitch, separate from length.

5

Predict, then test the half-length point

Ask the child to guess: “If I press the string exactly halfway along its length, what do you think will happen to the sound?” Then measure and mark the halfway point, press or fret the string there, and pluck. It should sound one octave higher, the same note, just higher. This is ratio $1/2$.



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Photo: measuring and marking the halfway point

6

Predict, then test the quarter-length point

Repeat at one quarter of the full length. This should sound another octave higher still, two octaves above the open string. This is ratio $1/4$.

7

Optional: try a musical ratio

For kids who want more, mark $2/3$ of the length (a perfect fifth) or $3/4$ of the length (a perfect fourth) and compare those sounds to the octave jumps. These are less dramatic than the octave, which is exactly the point, smaller ratio changes make smaller pitch changes.

DISCUSSION QUESTIONS

- Why does cutting the length in half raise the pitch by a whole octave, rather than just a little bit?
- What is the difference between changing a string's length and changing its tension? Do they both change pitch the same way?
- If you kept halving the length again and again, what would happen to the pitch each time?

IF SOMETHING ISN'T WORKING

- String sounds dull or thuddy rather than ringing: it likely needs more tension, tighten gradually and re-test.
- The octave jump sounds off: double check the halfway mark was measured from the same two anchor points used for the full length, not from the edge of the box.
- Line keeps slipping at the anchor: a couple of extra wraps and a simple double knot usually solves it.

EXTENSIONS FOR OLDER OR FASTER KIDS

- Add a second string of a different thickness and compare how gauge affects tone at the same length and tension.
- Mark out a full set of fret points for a scale and try to play a simple recognizable tune.
- Graph predicted pitch ratio against measured string length for several fret points, and see how closely the pattern holds.

**Handle the fishing line with care**

Fishing line under tension can slip and snap back, and pulling it taut with bare fingers wrapped around it can pinch or cut skin. Have kids pluck rather than pull, and handle tensioning and knot-tying yourself or closely supervise it. Pre-sand any wood edges so splinters are not a concern, and keep cutting tools (if used to trim excess line) with the facilitator only.