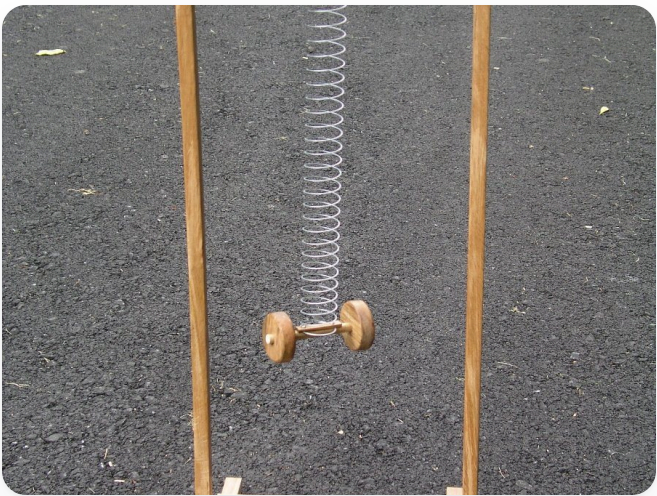


EQUIPMENT BUILD PLAN SOUND & WAVES

Slinky Wilberforce Pendulum

Half a Slinky hangs from a wooden frame with a dowel and two sliding wooden wheels as the bob. Once it is tuned, the energy trades back and forth between bouncing and twisting several times before the pendulum stops. It is a striking, nearly silent demonstration of resonance and coupled oscillations, and a quick tape-and-clay version can be made in minutes.

Written from Bruce's original workshop handout. Bruce's final review of this plan is in progress.



<div>DIFFICULTY</div> <div>Intermediate</div>	<div>BUILD TIME</div> <div>2-3 hours (frame version); 15 minutes (simple version)</div>
<div>COST</div> <div>About \$10</div>	<div>SAFETY</div> <div>Adult build / supervision</div>
<div>GOOD FOR</div> <div>Teachers, Makers, Families</div>	

What it shows

Pull it down and let go: within a few bounces the up-and-down motion turns completely into twisting, then back again.

Key ideas: resonance, coupled oscillators, energy transfer, simple harmonic motion, moment of inertia

Safety (Adult build / supervision). An adult should cut the spring and do the sawing and drilling. Cut spring ends can be sharp; bend them in or cover them with tape.

ALSO IN BRUCE'S BOOK

A version of this device appears in *If You Build It, They Will Learn* (NSTA Press).

About the book

CONSTRUCTION

Build it

Materials

- ☐ **Slinky (metal), small or large** · 1
Cut in half; a whole one is far too long
- ☐ **Wooden dowel** · 10 in
The cross bar of the bob
- ☐ **Wooden wheels or blocks, 2-3 in** · 2
Drilled so they slide along the dowel
- ☐ **Wood for the frame** · About 6 ft total
Two uprights, a top beam and a base with feet
- ☐ **Thin wood strips** · 2
Clamp the spring to the beam and to the dowel
- ☐ **Wood screws** · 4
- ☐ **Short dowel pegs** · 2
On top of the beam for storing the wheels
- ☐ **Duct tape** · As needed

Tools

Saw

Drill with bits to suit the dowel

Screwdriver

Wire cutters (for cutting the spring)

1

Build the frame

Make a tall rectangular frame from two uprights, a top beam and a base with feet. Size it to the spring: it must be tall enough for the spring and bob to bounce freely without hitting the base.



2

Add storage pegs

Glue two short dowel pegs into the top of the beam. The wooden wheels drop onto these when the pendulum is not in use.



3

Cut the spring

Cut the Slinky roughly in half. You will adjust the working length later.

4

Attach the spring to the beam

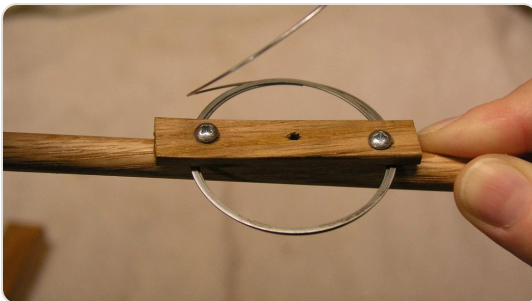
Lay a few coils of the top of the spring against the underside of the beam and clamp them with a wood strip and two screws. How many coils you gather under the strip sets the hanging length.



5

Attach the dowel

Fasten the bottom coils of the spring to the middle of the 10 in dowel the same way, with a wood strip and two screws (or tape the dowel across the bottom four coils).



6

Prepare the wheels

Drill a hole through the center of each wheel or block so it slides along the dowel with a little friction, then slide one onto each end.

7

Set the length

Hang the bob and adjust how much spring is clamped at the top until the bouncing motion fits comfortably inside the frame.

8

Tune it

Start with both wheels close to the spring. Pull the bob down a short way and release. Move the wheels outward in small, equal steps and test again until the bouncing changes completely into twisting and back.

Level the dowel

Check that the dowel hangs level. If it tilts, move one wheel slightly closer to the center than the other.

THE PHYSICS

How it works

A weight on a spring can oscillate in two ways: bouncing up and down, and twisting back and forth. Each motion has its own natural frequency. Bouncing depends on the mass and the spring's stiffness; twisting depends on how spread out the mass is (its moment of inertia) and the spring's resistance to twisting.

A coil spring links the two motions: when it stretches it also untwists slightly, and when it twists it changes length slightly. So each bounce gives the twisting motion a tiny push.

When the two natural frequencies match, those tiny pushes always arrive at the right moment and add up, just like pushing a swing. The energy flows completely into twisting, then back into bouncing, again and again. Sliding the wheels outward increases the moment of inertia and slows the twisting until it matches the bounce. That is the tuning.

Using it

- Ask the class to predict what will happen after release, then watch for the moment the bouncing stops and the twisting takes over.
- Count how many bounces it takes to change over (typically 6-10), and how many times it switches back and forth before it stops.
- Mistune it on purpose by moving the wheels in or out. The transfer becomes partial and messy, which shows why the frequencies must match.
- Start it twisting instead of bouncing and see whether the energy flows the other way.
- Link it to other resonance examples: coupled pendulums, a child on a swing, a wine glass and a singer's note.

GO FURTHER

Variations

- Quick version: duct-tape a dowel to one end of a short piece of Slinky and a tongue depressor to the other, tape the tongue depressor to a meterstick, and hang the meterstick

between two desks. Lumps of clay on the dowel ends replace the wooden wheels and are squeezed in or out to tune it.

- A larger version using a full-size Slinky and heavier blocks.

IF IT DOESN'T WORK

Troubleshooting

IF THIS HAPPENS

It only bounces and never twists much

TRY THIS

The wheels are not in the right place. Move them outward in small equal steps; if it over-twists, move them back in.

IF THIS HAPPENS

It wobbles sideways

TRY THIS

Pull straight down and release gently, and make sure the dowel hangs level.

IF THIS HAPPENS

The bob hits the base

TRY THIS

Gather more coils under the top clamp to shorten the spring, or pull down less.

IF THIS HAPPENS

Exact spring length is hard to pin down

TRY THIS

That is normal. The right length depends on the weight of your wheels, so expect to adjust by trial.