

EQUIPMENT BUILD PLAN

MOTION & FORCES

Giant Newton's Cradle

A row of pool balls hangs on nylon string from a wooden frame. Lift and drop one ball and one ball flies out the far end; drop two and two fly out. Bruce's favorite large version uses arcade pool balls, which are easy to drill, and a simple tack-in-the-hole trick for adjusting each string.

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>3-4 hours</div>
<div>COST</div> <div>About \$40 (depends on the balls)</div>	<div>SAFETY</div> <div>Adult build / supervision</div>
<div>GOOD FOR</div> <div>Teachers, Makers</div>	

What it shows

Swap the desk toy's tiny steel balls for billiard balls and the whole class can see momentum pass down the line.

Key ideas: conservation of momentum, conservation of energy, elastic collisions, Newton's third law

Safety (Adult build / supervision). Pool balls are heavy and can pinch fingers between them; keep fingers out of the line of balls. Build the frame sturdy enough that it cannot tip. An adult should do the drilling, holding each ball firmly in a cradle or vise.

CONSTRUCTION

Build it

Materials

- ☐ **Pool balls (billiard balls)** · 5
Bruce bought his from an arcade supplier; croquet balls work for an even larger version
- ☐ **Nylon string** · About 20 ft
- ☐ **Lumber for a frame** · As needed
Two parallel top rails on uprights, with a base
- ☐ **Thumbtacks** · About 10
Lock the strings in the frame holes

Tools

Drill with 1/8 in bit

Saw

Clamps or a padded vise

Ruler and square

Glue for the strings (such as epoxy or super glue)

1

Drill the balls

Drill a small (1/8 in) hole about 1/2 in deep into each ball, aimed at the center.

2

Glue in the strings

Glue the middle of a length of nylon string into each hole, so two ends come up from every ball. Let the glue cure fully.

3

Build the frame

Build a sturdy frame with two parallel top rails. The rails should be far enough apart that each ball hangs from a V of string, which keeps it swinging in one plane.

4

Drill the rails

Drill a row of small holes through each rail, spaced exactly one ball diameter apart, so the hanging balls just touch.

5

Hang the balls

Bring each string end up through its hole in the rail and push a thumbtack into the hole to pinch the string in place.

6

Align them

Adjust each string (pull the tack, slide the string, push the tack back) until all the balls hang at the same height in a straight, touching line.

7

Test

Lift one end ball and let it drop. Fine-tune until a single ball leaves the far end cleanly.

THE PHYSICS**How it works**

When the moving ball strikes the row, it stops and its momentum (mass times velocity) is passed through the touching balls as a compression wave to the last ball, which swings out.

Two quantities are conserved in a nearly elastic collision like this: momentum and

Using it

- Drop one ball, then two, then three, and ask students to predict how many will fly out each time.
- Ask why two balls at half speed never come out. Work through

kinetic energy. The only way to satisfy both with identical balls is for the same number of balls to leave as arrived, at the same speed. That is why one ball in sends one ball out, not two balls at half speed.

Each collision loses a little energy to sound, heat and slight deformation, so the swings slowly die away. Harder, more elastic balls keep it going longer.

momentum and energy to show why.

- Lift one ball on each end and release them together.
- Compare balls of different materials and discuss which collisions are closer to elastic.

GO FURTHER

Variations

- Croquet balls for an even larger version.
- Bruce has also experimented with water balloons and frozen water balloons in place of hard balls.

IF IT DOESN'T WORK

Troubleshooting

IF THIS HAPPENS

Balls wobble or twist after impact

TRY THIS

Make sure each ball hangs from a V of two strings and that all the strings are the same length.

IF THIS HAPPENS

Several balls move after the first collision

TRY THIS

The balls are not in a straight line or are not touching. Re-level them with the tacks.

IF THIS HAPPENS

A string pulls out of a ball

TRY THIS

Re-drill slightly deeper and use a stronger glue.