

EQUIPMENT BUILD PLAN

MOTION & FORCES

Stringless Pendulum Tracks

Each of three short curved tracks follows the exact arc swept by a pendulum with a period of 1, 2 or 3 seconds. A ball rolling in each track rocks back and forth like a pendulum bob. Side by side, they show students why longer pendulums swing more slowly: the longer the pendulum, the flatter its path.

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

What it shows

Three balls roll back and forth on three curved tracks, and you can see the 1, 2 and 3 second pendulums keeping their beat without a single string.

Key ideas: pendulum period, pendulum length, acceleration on a slope, simple harmonic motion



DIFFICULTY	BUILD TIME
Intermediate	3-4 hours
COST	SAFETY
About \$15-25	Adult build / supervision
GOOD FOR	
Teachers, Makers	

Safety (Adult build / supervision). The curved blocks are cut with a band saw, jigsaw or scroll saw and the metal track with a hacksaw: adult work with eye protection. Smooth cut metal edges with sandpaper or a file before use.

Build it

Materials

- ☐ **Wood stock for the curved blocks** · 3 pieces, each at least 8 in long
- ☐ **Board for the base** · 1
Wide enough for all three blocks side by side
- ☐ **Metal shelving track (shelf standard)** · Three 8 in pieces
- ☐ **Small screws** · About 15
One every 2 in along each track
- ☐ **Wood screws** · 6
To fasten the blocks to the base from underneath
- ☐ **Balls** · 3
Bruce uses pool balls
- ☐ **Paper for templates** · 3 large sheets

Tools

Band saw, jigsaw or scroll saw

Hacksaw

Drill with pilot and countersink bits

Screwdriver

Clamps

Metric tape measure

Fine sandpaper

Long string, a heavy weight, a pencil and masking tape (to draw the arcs)

1

Know the three lengths

A pendulum with a 1 second period is 24.9 cm long, a 2 second pendulum is 99 cm (four times longer), and a 3 second pendulum is 224 cm (nine times longer). Add 0.5 cm to each to allow for the thickness of the metal track: 25.4 cm, 99.5 cm and 224.5 cm.

2

Set up the drawing pendulum

Anchor a long string under a heavy weight on the floor. Tape a sheet of paper to the floor and draw a horizontal and a vertical line on it. Position the paper so the point where the lines cross is 25.4 cm from the edge of the weight.

3

Draw the first arc

Wrap the string a few times around a pencil tip and adjust it so the pencil passes through the crossing point. Swing the pencil to draw the arc on the paper.

4

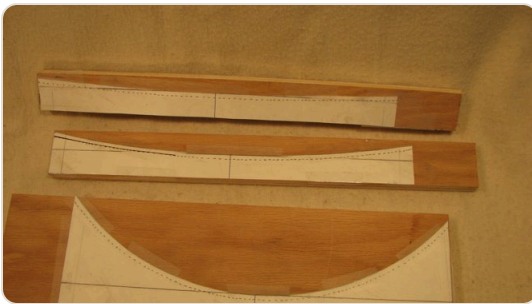
Draw the other two arcs

Repeat on new sheets with the string set to 99.5 cm and 224.5 cm.

5

Lay out the blocks

Bruce makes every track 8 in long. Center an 8 in strip of paper on each arc, 4 in to each side of the low point, and mark the ends. Draw the block sides down from those marks, then draw the bottom edge 1 in below the low point of the arc.



6

Cut the blocks

Tape each template to the wood and cut out the three curved blocks.



7

Space them on the base

Set the blocks on the base with a ball on each and move them apart until the balls cannot touch. Trim the base to size.



8

Fasten the blocks

Clamp each block in place, drill pilot holes up through the base, and drive countersunk wood screws into the blocks.



9

Cut and bend the tracks

Cut three 8 in pieces of shelving track. The metal bends easily: shape each roughly to its block and clamp it tight against the curve.



10

Screw down the tracks

Fasten each track with small screws every 2 in. Tightening the screws pulls the track to the shape of the curve.



Smooth and test

Smooth the track edges with fine sandpaper. Release a ball near the end of each track and watch the rhythm.



THE PHYSICS

How it works

A pendulum bob moves along an arc of a circle whose radius is the pendulum's length. A ball rolling in a track with that same curve follows the same path and rocks back and forth the same way, with no string needed.

A longer pendulum traces a flatter arc. On a flatter path the slope is gentler, so the ball accelerates less and takes longer to get back and forth. That is why the period gets longer as the pendulum gets longer.

The period is proportional to the square root of the length. To double the period you need four times the length; to triple it, nine times. That is why the tracks are 24.9, 99 and 224 cm pendulums.

The rolling balls are a bit slower than true pendulums, because some energy goes into spinning the ball and some is lost to friction. All three are slowed in about the same proportion, so the 1 : 2 : 3 rhythm is still easy to see.

Using it

- Release balls on the steepest and middle tracks together: the steep-track ball goes back and forth twice for every once on the middle track.
- Compare the steepest and flattest tracks: three swings to one.
- Compare the middle and flattest tracks: three swings on the middle track for every two on the flattest.
- Hang real string pendulums of the same three lengths next to the tracks and compare.
- Ask students to predict how long a pendulum with a 4 second period would need to be (16 times the 1 second length).

GO FURTHER

Variations

- Make the tracks longer than 8 in for larger swings, keeping the same curves.
- Add a fourth track for a 4 second pendulum (about 397 cm plus 0.5 cm).

IF IT DOESN'T WORK

Troubleshooting

IF THIS HAPPENS

The ratios don't come out clean.

TRY THIS

Release the balls from small amplitudes and check that the track follows the curve closely, with screws every 2 in.

IF THIS HAPPENS

The balls stop quickly.

TRY THIS

Sand and polish the track edges; burrs and screw heads above the rolling surface cause drag.

IF THIS HAPPENS

The 3 second track barely moves the ball.

TRY THIS

That flat curve needs a smooth, level base. Check that the base sits flat on the table.

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