

EQUIPMENT BUILD PLAN

MOTION & FORCES

Identical Curved Tracks

Two identical curved tracks sit side by side, each marked with letters along its length. The question printed on the side asks which starting point gets a ball to the bottom first. Releasing two balls from different letters shows that the time is nearly the same from every point, the same property that makes a pendulum keep steady time.

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

What it shows

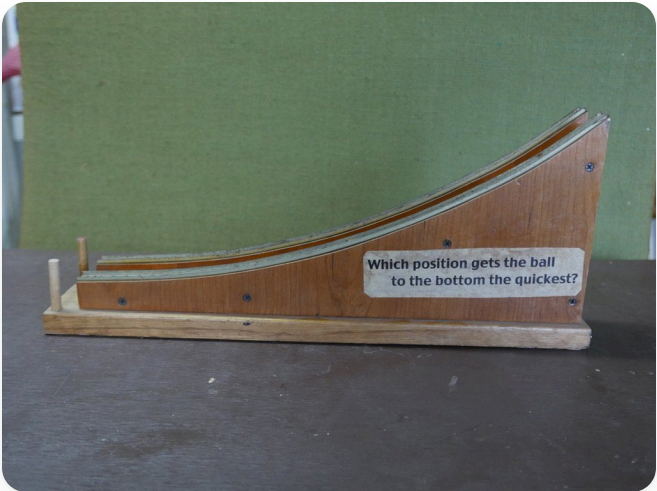
Release one ball from near the top of a curved track and another from near the bottom, and they hit the end at the same moment.

Key ideas: acceleration, pendulum motion, isochronism, potential and kinetic energy

Safety (Adult build / supervision). The curved supports are cut on a band saw or saber saw and the metal track is cut with a hacksaw: adult work with eye protection. Sand or file cut metal edges smooth before use.

CONSTRUCTION

Build it



DIFFICULTY	BUILD TIME
Intermediate	4-5 hours
COST	SAFETY
About \$20-30	Adult build / supervision
GOOD FOR	
Teachers, Makers	

Materials

- ☐ **Plywood for the curved supports** · Enough for two supports, each built up from three layers
About 3/4 in plywood
- ☐ **Plywood or board for the base** · 1
Wide enough for both tracks side by side
- ☐ **Metal shelving track (shelf standard)** · Two pieces, the length of the curve
- ☐ **Small screws** · About 20
- ☐ **Wood block and two dowel pins** · 1 block, 2 pins
Removable stop at the bottom of the tracks
- ☐ **Wooden or printed letters** · A set of about 7 per track (A-G)
- ☐ **Two identical balls** · 2
Steel balls or large marbles
- ☐ **Wood glue, varnish** · As needed

Tools

Band saw or saber saw

Hacksaw

Drill with small bits

Screwdriver

Clamps

Sandpaper (medium and fine) and metal polish

String, pencil and a nail or pin (to draw a large arc)

1

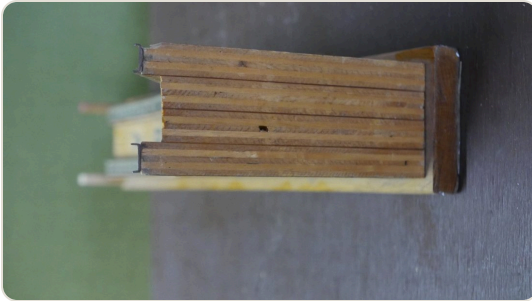
Draw the curve

Use a string and pencil pinned at a center point to draw an arc with a radius of 3 to 4 ft.
Use only about a 25 degree section of the circle, starting from the lowest point.

2

Cut the curved supports

Cut the uprights from plywood with a band saw or saber saw. If your saw is big enough, screw all the pieces together and cut them at once; otherwise cut one and use it as the pattern for the rest.



3

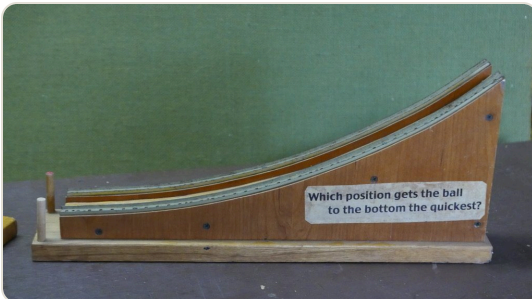
Keep the curves identical

The two tracks must have exactly the same curve. Sand the pieces smooth but don't change the shape of the original curve while sanding.

4

Mount the supports

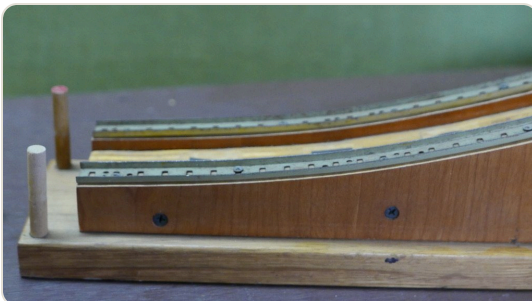
Fasten the two curved supports side by side on the base, far enough apart that the balls won't touch.



5

Attach the tracks

Cut two pieces of shelving track to length. Bend each to the curve and fasten it with small screws; the screws pull the track tight against the wood.



6

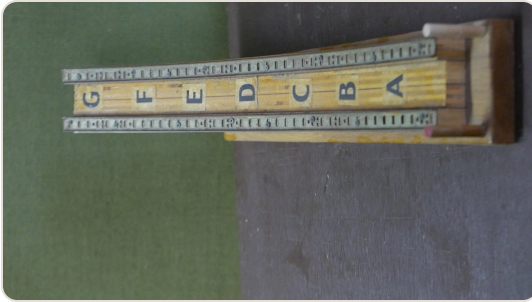
Smooth the tracks

Sand and polish the track surfaces so the balls roll smoothly.

7

Add the letters

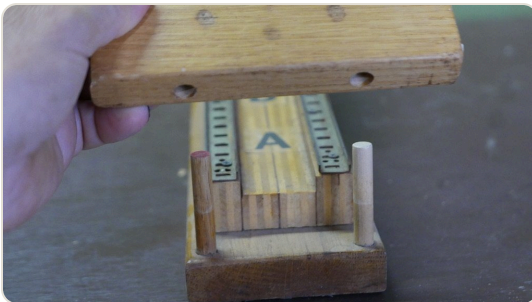
Glue the letters along each track at matching positions, A at the bottom to the highest letter at the top, then varnish over them.



8

Make the removable stop

Make a wooden stop block that sits on two pins at the bottom end so the balls strike it with a click. Keep it removable for experiments where the balls need to roll off.



9

Post the question

Print the question 'Which position gets the ball to the bottom the quickest?' and fix it to the side of the support.

**THE PHYSICS****How it works**

A ball released high on the curve has farther to go, but it starts on a steeper part of the track, so it accelerates harder and reaches a higher speed. A ball released low has a short trip but a gentle slope and a slow start.

On a curve shaped like part of a circle, these effects nearly cancel. The ball behaves like the bob of a pendulum whose string is as long as the radius of the curve, and a pendulum takes nearly the same time to swing down to the bottom whether it is pulled back a little or a lot.

The match is not perfect. For a 25 degree arc, a release from the top takes about one percent longer than a release from near the bottom, which is far too little to hear. A curve called a cycloid would make the times exactly equal.

Because the balls roll, they move more slowly than a sliding object would, but both balls are slowed by the same proportion, so the comparison still works.

GO FURTHER

Variations

- Straight-track comparison: build the same device with straight diagonal tracks. On a straight incline, the ball released higher takes noticeably longer.
- Ball-size race board: two straight twin-rail tracks on a slope show that different-sized balls roll down together when the rail spacing is in the same proportion to each ball's diameter. Students can also notice that the smaller ball spins faster, and race brass against aluminum balls.
- Galileo's track and the high road, low road tracks use the same shelving-track construction.

IF IT DOESN'T WORK

Troubleshooting

IF THIS HAPPENS

One track is always faster.

Using it

- Read the question on the side aloud and ask students to vote for a letter before testing.
- Release two balls together from different letters and listen for the clicks as they hit the stop.
- Try every pair of letters. Then ask why the higher ball doesn't win or lose.
- Connect it to a pendulum: swing a bob with small and large pulls and time ten swings each.
- Remove the stop block and use the track for speed measurements at the bottom from each letter.

TRY THIS

The curves are not identical or one track is rougher. Swap the balls to check, then re-sand and polish the slower track.

IF THIS HAPPENS

The balls arrive at very different times.

TRY THIS

Check that you are using only a modest section of the circle (about 25 degrees). A much larger arc makes high releases noticeably slower.

IF THIS HAPPENS

The balls jump at the joints or screws.

TRY THIS

Make sure the screw heads sit below the rolling surface and the track lies tight to the wood.