EQUIPMENT BUILD PLAN

MOTION & FORCES

Giant See-Through Tumbling Toy

The traditional tumbling toy hides its rolling ball inside a wooden tube. This large classroom version stands 30 inches tall and has clear plastic sides, so students can see how the ball's movement shifts the center of gravity and keeps the body flipping from peg to peg. Swappable bodies (a single steel ball, an hourglass of BBs, or a tube of liquid soap) change the rhythm.

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

DIFFICULTY	BUILD TIME
Advanced	6-8 hours over two or three sessions
COST	SAFETY
About $25-40	Adult build / supervision
GOOD FOR	
Teachers, Makers	

What it shows

A wooden body somersaults end over end down a pair of notched rails, and the clear sides let everyone watch the steel ball inside that makes it happen.

Key ideas: center of gravity, torque, rotation about a pivot, potential to kinetic energy

Safety (Adult build / supervision). This is a woodworking build using a jigsaw or saber saw, a drill press or drill, and a table saw or band saw to rip the rails. An adult should do all cutting and drilling, with eye protection and hearing protection. Clamp work pieces; never

hold small parts by hand near a blade. Once built, the toy is safe for students to operate.

CONSTRUCTION

Build it

Materials

- [ ] **Steel ball, 1 in diameter** · 1
  Other sizes work; size the body to the ball
- [ ] **Hardwood for the body, slightly thicker than the ball** · About 2 in x 6 in
  About 1 in taller than the ball is wide
- [ ] **Clear plastic sheet (acrylic or polycarbonate)** · Two pieces the size of the body
- [ ] **Small screws** · 4-6
  To hold the plastic sides on
- [ ] **Wood dowel, 1/4 in** · About 4 in
  Cut into two pivot pegs
- [ ] **Hardwood board, 1 in thick** · About 3 ft long
  Ripped into two 1/2 in wide rails after the notches are cut
- [ ] **Wood for two bases** · Two pieces about 10 in x 3 in
  Dimensions are not critical
- [ ] **Wood for uprights and spacer blocks** · As needed
  Heights are found by testing
- [ ] **Bolts with flat heads** · 4
  To join rails to uprights
- [ ] **Short dowel pieces, drilled one size smaller than the bolts** · 4
  Used as wooden 'nuts'
- [ ] **Wood screws and wood glue** · As needed

Tools

- Jigsaw or saber saw
- Drill or drill press with 1/4 in bit and a Forstner or spade bit the size of the ball
- Saw for ripping a board lengthwise (table saw or band saw)
- Countersink bit
- Clamps
- Screwdriver
- Sandpaper
- Hammer and two nails (for the spacing jig)
- Cotton swab (for applying glue in holes)

1

Size the body to the ball

The body must be slightly wider than the ball and about 1 in taller. For a 1 in ball, Bruce's body is 6 in long with an inside chamber about 5 1/4 in long.

2

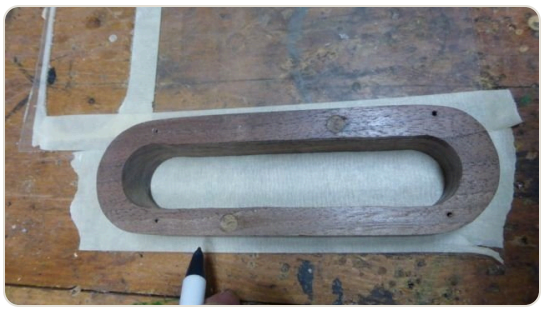
Cut out the chamber

Draw the rounded outline and the inner chamber on the wood. Drill out each end of the chamber with a bit the size of the ball, then remove the wood in between with a jigsaw. Cut the outside shape and sand it smooth.

3

Make the clear sides

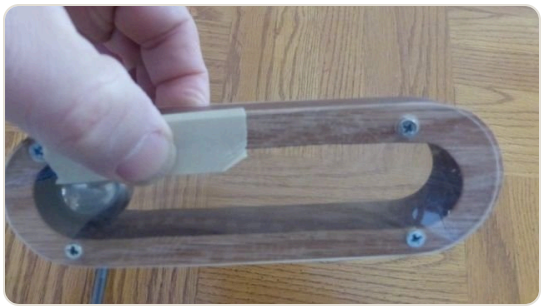
Trace the body onto two pieces of clear plastic. Leave the masking film or a layer of masking tape on the plastic so the line is easy to see, then cut them out.



4

Enclose the ball

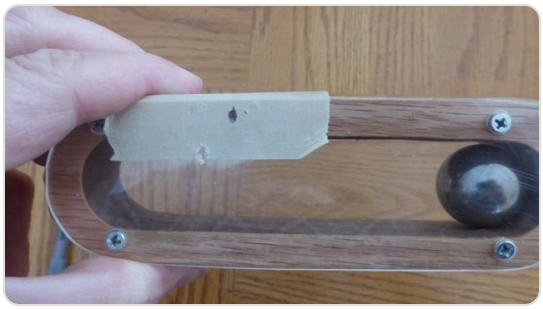
Put the ball in the chamber and screw a plastic side on each face of the body.



5

Find the peg position

Tape over the approximate peg spot near one end and balance the body there on a finger with the ball resting in that short end. Move the spot until the long, empty side is just slightly heavier than the short side holding the ball. Mark it carefully and test several times.



6

Drill the two peg holes

Drill a 1/4 in hole all the way through at the mark. Measure the same distance from the other end, on the opposite side, and drill the second hole.

7

Glue in the pegs

Use a cotton swab to coat the inside of each hole with glue and push in the 1/4 in dowel pegs so they stick out evenly on both sides.

8

Make a notch-spacing jig

Every notch on the rails must be the same distance apart. Mark that spacing on a scrap of wood and drive two nails through it at the marks. Screw a second strip to the scrap as a depth guide against the edge of the rail stock.

9

Mark the notches

Work on the full 1 in thick board so both rails are made at once. Press the jig to mark the first hole, move the first nail into that mark, press again to mark the next, and work down the whole board.

10

Drill and cut the notches

Drill a 1/4 in hole at each mark so the pegs seat in a rounded bottom. Draw lines from the edge of the board to each hole and cut the notches with a saber saw. Sand them, then rip the board lengthwise into two matching rails 1/2 in wide.

11

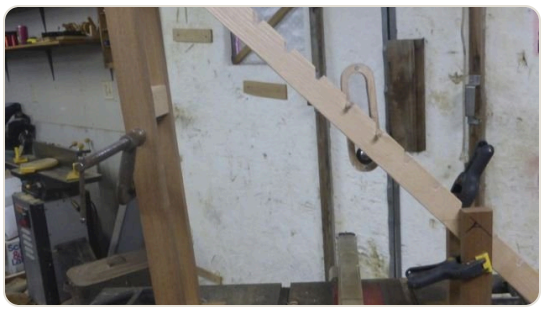
Build the bases

Each base is a board about 10 in x 3 in with a block screwed on from underneath. Make the block just wide enough to hold the rails slightly farther apart than the body is thick.

12

Set the rail angle by testing

Clamp the rails to temporary uprights and try the body at different angles until it tumbles steadily but not too fast. The low end must be high enough that the body never hits the floor. Mark the final positions while clamped.



13

Drill the rails together

Tape the two rails together and drill the bolt holes through both at once so they match exactly. Brace the tall upright with a second block halfway up.

14

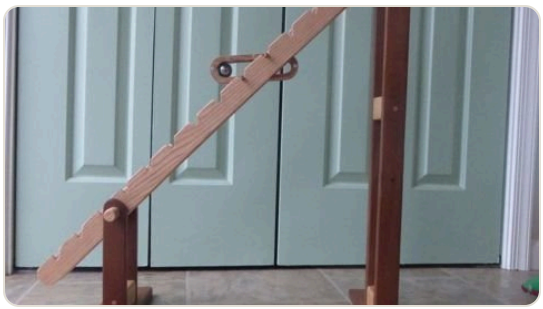
Bolt it together

Countersink the holes on the inside faces so the bolt heads sit flush and can't catch the body. Instead of metal nuts, use short dowel pieces drilled one size smaller than the bolt; twist them on to tighten.

15

Final test

Set the body upright in the top notch and let it go. Bruce drilled two sets of holes in the tall upright: the upper set makes a steeper track and a quicker tumble, the lower set a slower one.



THE PHYSICS

How it works

Standing upright on its lower peg with the ball at the top, the body has a high center of

Using it

gravity that is not directly over the peg. Gravity produces a torque that turns the body over around that lower peg.

As the body swings past horizontal, the chamber tilts downward and the ball rolls to the other end. That end now hangs below the peg, so the body keeps swinging, and the other peg drops into the next notch down the rails.

The peg that was the pivot is now the upper peg, the ball is at the bottom, and the body swings back up past upright. The cycle repeats, with the support switching from peg to peg each half turn.

Each flip lowers the body one notch. The gravitational potential energy lost on the way down is what drives the motion and makes up for friction at the pegs.

- Ask students to predict what would happen if the ball were glued in place, then show them the clear body and let them explain why the moving ball matters.
- Pause the toy at each stage and have students mark where the center of gravity is relative to the supporting peg.
- Switch the rails between the upper and lower holes and time the trip down. Discuss why a steeper track runs faster.
- Compare bodies: a single steel ball, an hourglass of BBs, and a tube of liquid soap. Which one tumbles most smoothly and why?
- Have students build a small paper or soda-bottle tumbler (see the Tumbling Toy experiment page) and then compare it with this large version.

GO FURTHER

Variations

- Hourglass tumbler: replace the single ball with a load of BBs in an hourglass-shaped chamber for a cascading effect. Small wood pieces inside slow it even more, but can jam the BBs and stop the toy.
- Liquid tumbler: replace the ball with a clear tube of liquid dish soap. It takes about 20 seconds to drain to the other end, so each step is very slow.
- Traditional small toy: under a foot tall with a hidden ball, made from a hollow wooden tube.

IF IT DOESN'T WORK

Troubleshooting

IF THIS HAPPENS	TRY THIS

The body stops after one or two flips.	Steepen the rails, or recheck the peg position. The empty side must be slightly heavier than the ball end when balanced at the peg.

IF THIS HAPPENS	TRY THIS
The body tumbles too fast and jumps off the rails.	Use the lower set of holes to make the track less steep, and check that the notches are deep enough to hold the pegs.

IF THIS HAPPENS	TRY THIS
The body drifts sideways or rubs.	The notches on the two rails are not matched. Re-cut them, or make sure the rails were drilled together and the bolt heads are flush.

IF THIS HAPPENS	TRY THIS
The pegs bind in the notches.	Sand the notches and the round hole at their base so the pegs pivot freely.

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