Collisions - Facilitator guide

Learning objective

Predict a hidden shape by looking at trajectories of marbles that bounce off it.

Science concepts

Trajectories, Particle collisions, Radar, Reflection of a particle from a flat surface

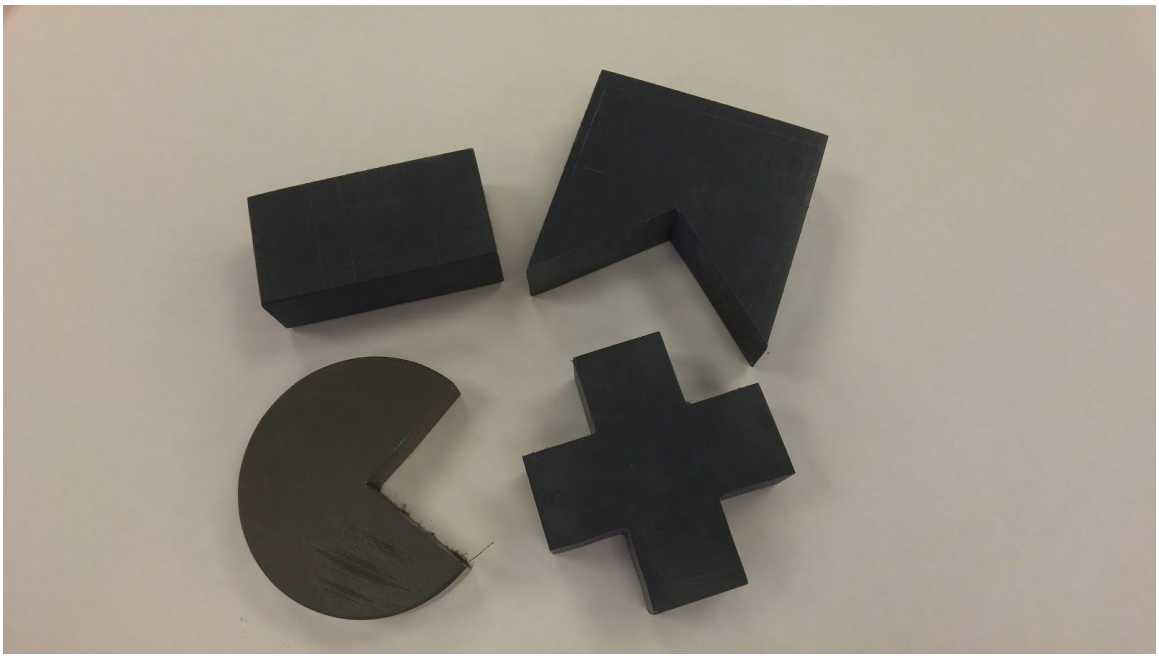
Materials

Note: alternative materials are listed in the appendix.

One setup viewed from the top, includin paper, hula hoop, marble, and shape hidden by vinyl record.

Per group:

- 1 hula hoop
- 1 vinyl record with velcro on the back
- 1 or 2 marbles
- Pencils or markers



A few shapes made of PVC.

Per class:

- Tape
- PVC shapes with velcro on the top
- Roll of paper (at least as wide as the hula hoop)

Preparation:

- Prepare sheets of paper to go under each setup. Students will collect data by drawing trajectories on this paper.
- Move chairs and tables out of the way (unless tables are very large, this activity is best done on the floor.)
- Make sure you have access to a board, otherwise stick up a sheet of paper.
- For each group, put down a sheet of paper, the shape with the hiding disk, the hoop around, a marble and a pen. Sticky tape can be used under a shape to stop it from moving.

Lesson plan:

1. **ENGAGE**
    a. Tell the students that we are going to follow the scientific procedure: thought, experiment design, data collection, data analysis, and prediction.
    b. Ask students: “what is the smallest thing you can think of?” Lead them towards the atom, and tell them how small the atom is by saying that the numbers of atoms in a marble is close to 10 with 23 zeros on the right.

c. Tell them that because atoms are so small it is difficult to see them - even with a microscope, an individual atom is invisible. One way to learn more about the atoms is to shoot other atoms at a material and see how they bounce off, like Rutherford did 100 years ago.

d. Tell them that we are going to do this experiment but with marbles instead of atoms.

e. Ask them to guess the correct trajectories for different situations (see student worksheet for examples) and probe their intuition and make sure they are able to predict a simple reflection on a flat surface. You may want to use a tennis ball to demonstrate. Draw the results on the board.

2. **EXPLORE**
    a. Stick the shapes to the vinyl records. Set up sheets of paper on the floor with one of shapes for each group of students, surround the hidden shape with the hoola hoop.

    b. Tell the students that their goal is to guess what their shapes are by shooting marbles and drawing the trajectories on the paper (you can assign roles, one thrower, one drawer and switch between them).

    c. If the students are struggling to predict the shapes, draw the different possibilities on the board.

    d. Once a group has determined their shape, attach a new shape to their vinyl disc and have them try again. Reserve some of the more challenging shapes for groups that finish quickly.

3. **EXPLAIN**
    a. Come back to what was discussed at the beginning, and tell them that the researchers at CERN are using machines to launch particles against each other so they can learn what they have inside.

    b. You may also talk about other scattering techniques such as sonar, radar or X-rays.

    c. Summarize the activity: “You can learn a lot by observing collisions! Today you learned about how scientists (doctors, engineers, etc.) use collisions to learn about materials or atoms that they can’t see directly. You were able to use a model - our hidden shapes - to show how it works.”

4. **EXTEND:**
    a. Discuss what would happen if the marble was larger than the dimensions of the shape. Would you be able to tell where the edges are very well?

    b. Explain that depending on what they are trying to observe, scientists will need to choose the thing they are launching to be the right size.

Students drawing trajectories in the Collisions activity. Image credit: Gabriel Kocher 2015.

Acknowledgements

This module was created by Anabelle Chuinard and Gabriel Kocher.

Appendix: Alternative materials

Alternative materials for constructing this module:

- Use cardboard circles to hide the shapes.
- Cut cardboard into strips that are about 1.5 or 2 times as wide as the marble. Glue these into a shape, and attach to the circles to hide. You may need to tape down so they do not shift when hit with a marble.