# The A-Maze-ing Marble Roll

**Explore some fundamental laws of forces and motion with this air-powered marble maze.**
**It's harder than you think!**

In this activity, students propose rules about forces and motion based on their observations of how to move a marble through a maze. This serves as a strong base for deeper investigations into Newton's Laws of Motion.

## Tools and Materials

- Foamcore board or a flat table surface (one per table)
- Bendy straws (one per student)
- Meter sticks (one per table)
- Marble (one per table)
- Markers

## Assembly

Create a maze on the foam board using a marker.

- The path should be three to five inches wide.
- The maze should contain no more than three turns.
- The maze should cover the majority of the foam core board.

## To Do and Notice

Using only air blown through the straw, move the marble through the maze. You may use as many team members as you choose.  As you work on this challenge, consider the following:

- What strategies worked best for making the marble move? Consider stopping, starting, and turning, and how and where the force (air being blown) is applied.
- What rules could you make about the relationship between forces and motion based on your observations from this activity?

## What's Going On?

This activity can be surprisingly challenging for students. They might be amazed both by how difficult it is to get the marble going and by how hard it is to stop it. While they probably have some intuitive sense that a force applied to an object can cause it to speed up or slow down, they may not realize the magnitude of the force required. This is especially true when they consider trying to change the motion of the marble once it really gets moving. Because many of students' experiences with objects that roll involve high levels of friction, they often will predict that the marble will slow down "on its own" rather than requiring a force in the opposite direction.

Students may also realize that with low friction, the force does not need to continuously be applied in order to keep the marble moving. Once it is moving, it keeps moving. Again, this might fly in the face of what they already think in high-friction situations such as walking or driving a car.

They may also be surprised by how difficult it is to make the marble turn. Many students think that simply applying a force perpendicular to the current motion will make the marble turn at a ninety-degree angle, but because the marble already has some velocity in a given direction, that additional force will only change the direction slightly. The students will either need to apply the force earlier (start to blow before the turn) OR apply a greater force so the new force will result in the desired change in direction.

## Going Further

For students who need a greater challenge, try to have them create a maze with curves. In order to get the marble to turn, the force has to be applied in the direction of the center of the curve. The force toward the center is called a centripetal force. Students can guide the marble toward the center of the curve by continually applying a large force in that direction as it turns or with many short bursts of air that approximate the continual force. This is a good way to have them think about vector addition and how forces acting in different directions can add up to change the direction of motion.

## Teaching Tips

As students discuss their strategies and rules from the activity, have them chart both the rules and the observational evidence that led them there. Below is a chart with some possible student responses. They will vary depending on the grade level of the student, and they may not be as sophisticated as those listed below at first. The teacher can ask questions about their observations to move them in this direction.

| Rules | Evidence |
|---|---|
| The greater the force, the greater the change in speed (with the same marble). | When we blew harder or more team members blew through their straws, the marble moved faster. |
| To slow down the marble, a force has to be applied in the opposite direction from the marble's motion. | If we didn't blow hard in the opposite direction, the marble just kept going. It seemed like it took as much force to stop it as it did to get it going. |
| Applying a force over a longer period of time results in a greater change in velocity. | Continuously blowing on the marble causes a greater change in velocity—it moves faster when you blow in the direction it is moving and slower when you blow against the direction in which it is moving. Also, when we started blowing earlier, it was able to make the turn, meaning we changed the direction. |

This is an excellent activity to use at the beginning of a unit as students begin to explore the relationships between force, motion, speed, and direction. As they work through additional activities, they can build on this as they wrap their heads around the proportional relationships between force, mass, and velocity.