



Prep: Arrange plenty of space in your room. The teachers may prefer to use the hallway for this activity.

*Cleanup: Allow 2 minutes near end of class for students to try each other's coasters. Then have everyone **gently take apart only their own roller coaster** and clump all the used tape into a giant tape ball*

Start-of-class lecture

- Identify the two parts: the foam tubing (roller coaster track) and marbles
- Demonstrate how the marble can roll in the track
- Show students the construction techniques in 5 minutes or less
- Identify the 4 big mistakes
- Briefly define momentum (a force that keeps something moving in the direction it's already going in), speed (how fast an object is moving), and energy (how much force an object has because it is moving). There are different but related concepts - help students use them correctly.
- Students to work in groups of 4-5 people.

Learning objective:

- Students will comprehend basic physics concepts that are applicable to roller coaster construction, including potential energy, kinetic energy, and momentum.
- Students will apply their understanding of those concepts as they construct and test their roller coaster.
- Through a cycle of building, testing, observing and revision, students will gain an experiential understanding of fundamental physics concepts and the basics of successful roller coaster construction
- Students will also have an unstructured opportunity to hone teambuilding skills as they communicate with their peers during roller coaster construction.

Materials:

- 1" foam pipe insulation from local hardware store (approx. 18ft per group)
- Masking tape (3 rolls shared among all groups)
- Marbles (1 per group)
- Paper cup (1 per group); to be placed at the end of the roller coaster to catch the marble

You can also include elements from around the classroom, like tables, chairs, yardsticks, string, etc.

Starting a roller coaster



Begin by placing a strip of tape on the end of a piece of tubing and affixing it to a smooth, flat surface. Then place another piece of tape across the first piece to secure the tubing in place.

Let your students know that the higher the roller coaster is when it starts, the more energy your marble will have when it begins rolling. More energy means that the students' marble will be able to travel farther and faster.

Connecting track pieces



To connect two pieces of tubing together, lay a piece of tape along the middle of the tube with about half of it hanging off of the end. Pick up the second piece of track and use your finger to press the tape onto it. Use your fingers to smooth out the tape. And finally, tape the underside of the tubes together, too.

It's important to have nice smooth connections. You should definitely emphasize this with students because no matter how awesome the roller coaster looks, if the connections are sloppy, it won't work well.

Secure to a flat surface



Most of the time, your students' roller coasters will need to touch down onto a flat surface like the floor. To secure the tubing to the floor, use two smaller pieces of tape and secure the sides of the roller coaster. Do not tape across the entire tube. Leaving the track clear of tape helps ensure that the marble will roll smoothly.

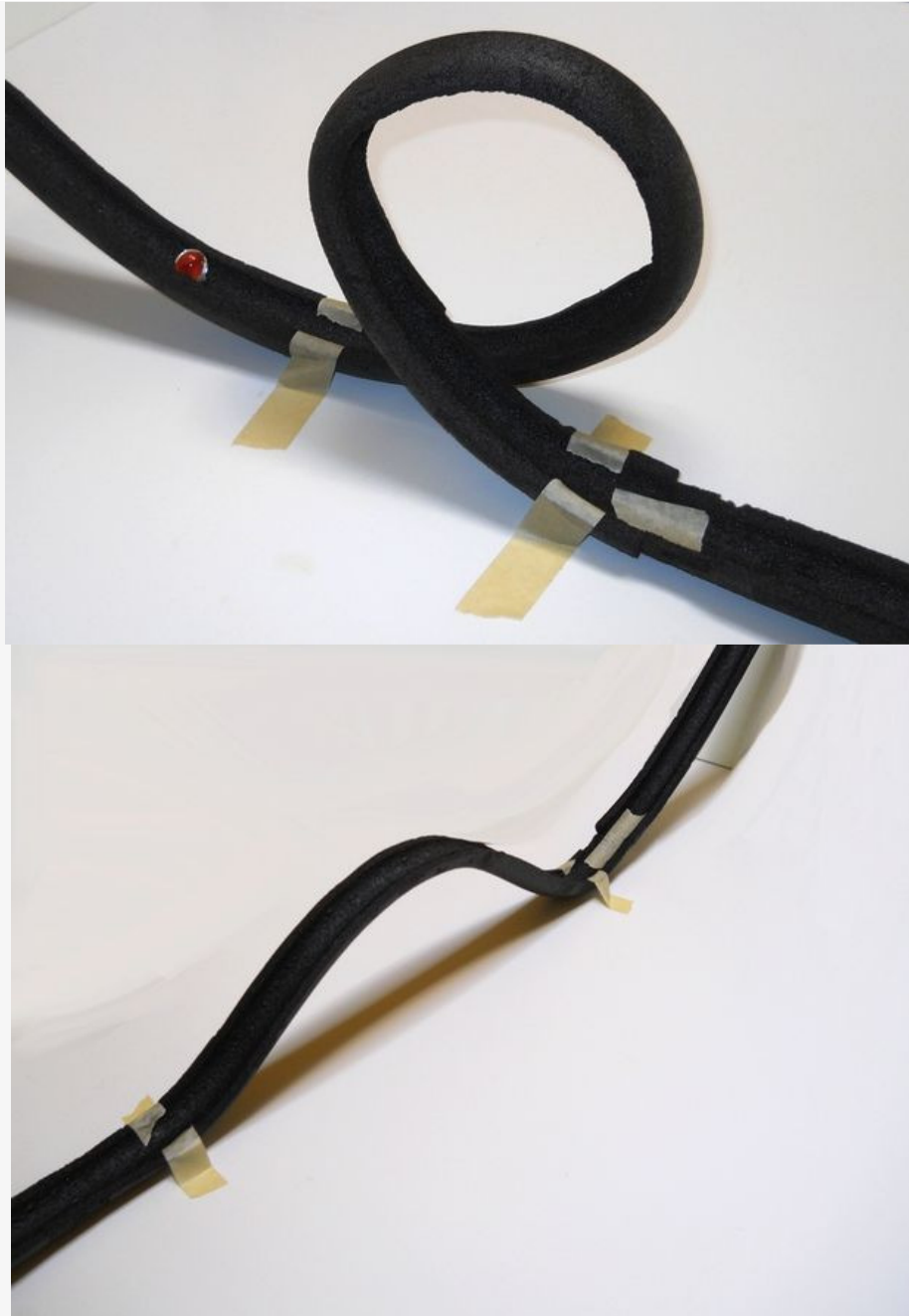
Turning the track



And finally, show your students how to make turns. The track must be turned on its side if the marble is travelling even moderately fast. In roller coaster construction, this is called 'track banking.'

This is a good opportunity to explain the negative effects of momentum. A marble travelling forward will continue moving in that direction because of its momentum. If a curved track is not banked, the marble may fly off of the edge of the track. However banking the track allows the marble to run along the 'bottom' of the track. Once the turn is complete, the track should be straightened out.

Make it awesome!



Now for the fun stuff! A roller coaster that just goes in a straight line can be fun, but I find it much more satisfying to include exciting elements.

Loops can be created by securing the track to a flat surface, then bending the track upside down and securing the other end. You can explain that loops work because of centripetal force. Centripetal force is like momentum: it's when an object wants to keep moving forward, except that it's forced into a circular path.

Hills can be made by securing the track to a flat surface, then lifting the middle of the track up and securing the other end. This is another good opportunity to illustrate the negative effects of momentum. If the hill is too small and the marble is travelling too fast, the marble's momentum will carry it up the hill and then continue its trajectory off the track.

4 big mistakes and how to avoid them

1. Bad connections. Remind the students that the tape needs to be smoothly applied.
2. Not enough energy. Marbles have a limited amount of energy, so encourage the students to plan their roller coaster according to how much energy the marble has. Start the coaster high and test regularly.
3. Too much momentum. Remember, momentum is the force that keep the marble going in the direction it's currently moving. Sudden turns or drops that do not account for the marble's momentum may result in the marble flying off of the track.
4. Not enough testing. This is the biggest mistake. Emphasize the importance of constant testing. Always test a new addition. Always test before adding onto the roller coaster. If the marble is falling off of the track halfway through, then everything that is built after that point won't matter until the problem is fixed. Experiment, observe, and make corrections!

Safety, tips, and troubleshooting

- Do not allow your students to run. It's easy to get hurt while diving for a runaway marble or tripping over a low-lying track piece. It's also easy to disrupt a precisely configured roller coaster, and running students may bump into tables/chairs/etc that are connected to a roller coaster.
- Toward the end of class, make an announcement: everyone has permission to try anyone's roller coaster. It's fun!
- When it comes time to clean up, do not allow your students to frenetically demolish their own roller coasters. Track pieces can be ruined, and it leads to other reckless behavior. Instead, tell them to carefully take the tape off of the track pieces from *their own roller coaster* and turn it into a giant tape ball. For whatever reason, kids love making tape balls.