



Lab Summary

The Tech Science Labs: Physics of Roller Coasters

Students design their own roller coasters to learn how engineers prototype and build machines. They also explore kinetic and potential energy, friction, and Newton's 1st and 2nd Laws of Motion.

Grade Levels:

2–8 (can be scaled up for Grades 9–12)

Learning Outcomes:

- Students will demonstrate their knowledge of potential and kinetic energy.
- Students will apply their knowledge of Newton's 1st and 2nd Laws of Motion in the design of their roller coasters.
- Students will gain an understanding of the role of friction in the transfer of kinetic energy.
- Optional: Students will gain an understanding of the concepts of inertia, velocity, and acceleration.
- Optional: Students will design a roller coaster and determine the average velocity a given marble travels.

Estimated Time:

1.5 hours

- Introductory Design Challenge: 20 minutes
- Science Discussion: 20 minutes
- In-depth Design Challenge: 50 minutes (building: 35 minutes, sharing: 10 minutes, clean-up: 5 minutes)

California Science Content Standards Connections:

- Grade 2: Physical Sciences: 1a, 1c, 1d, 1e
- Grade 3: Physical Sciences: 1c, 1d
- Grade 6: Physical Sciences: 3a
- Grade 8: Physical Sciences: 1a, 1b, 1c, 1d, 1e, 1f, 2a, 2b, 2c, 2d, 2e, 2f (optional)
- Grade 9–12: Physics 1a, 1b, 1c, 1d, 1e, 1f, 1g, 1h, 1i, 1j, 1k, 1l, 2a, 2b, 2c, 2d, 2e, 2f, 2g, 2h
- All Grades: Investigation and Experimentation: Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other 3 strands, students should develop their own questions and perform investigations.

The Tech Museum™ Gallery Connections:

The Tech Innovation at Play Gallery:

- "Design a Roller Coaster": Students use a computer program to design and then ride their own roller coaster, while further exploring the forces at play, including friction.
- "Play a New Way with the Everyday": Students design their own track and leverage potential and kinetic energy to direct a ball and make it go where they want.

The Tech Exploration Gallery:

- "Jet-Pack Simulator": Students try to drive a chair in an environment of less friction, battling the forces of inertia and momentum to steer the chair properly.

The Tech Museum™ Gallery Connections (continued):*The Tech Challenge Gallery:*

- “Dynamics Station” (Newton’s Cradle): Students can see how potential energy turns to kinetic energy, and get their hands on Newton’s 3rd Law of Motion.

The Tech Silicon Valley Innovation Gallery:

- “From Math to Magic: Physics of Motion”: Students learn mathematics behind game design as they steer a virtual racer down a hill at top speed and reveal the underlying physical forces at play.

Outside the Group Entrance on Park Avenue:

- “Science on a Roll” (kinetic ball machine): Students can witness an elaborate demonstration of energy in motion and the transfer of energy.

The Hackworth IMAX Dome Theater:

- *Thrill Ride—The Science of Fun*: A white-knuckle adventure that puts your students in the front seat of some of the wildest rides ever created. Exploring the science behind thrill seeking, the film traces the history of thrill rides, from roller coasters to motion simulator rides.

Pre-Visit Vocabulary:

These are words and concepts that we will discuss in the lab. Your students’ lab experience will be enhanced if they are familiar with these terms prior to your visit.

- Energy: “Nature’s way of keeping score.” Measured in joules. Appears in many forms, most of which are ultimately derived from the sun or from radioactivity.
- Mechanical Energy: Energy possessed by an object due to its motion or its stored energy of position. Mechanical energy can be either kinetic energy (energy of motion) or potential energy (stored energy of position).
- Kinetic Energy (KE): Energy of motion. $KE = \frac{1}{2} \text{ mass} \times \text{velocity}^2 = \frac{1}{2} mv^2$. Note that small changes in speed can result in large changes of KE (it’s speed squared!). Net force x distance = KE. Includes heat, sound, and light (motion of molecules).
- Potential Energy (PE): Energy of position; energy that is stored and held in readiness. Includes chemical energy, such as fossil fuels, electric batteries, and the food we eat.
- Newton’s Law of Conservation of Energy: Energy cannot be created or destroyed; it may be transformed from one form into another, or transferred from one place to another, but the total amount of energy never changes.

Advanced Terms:

- Mass: The amount of matter that is contained by an object.
- Velocity (speed): How fast an object is moving. The distance traveled over time.
- Force: An influence on a body, producing or tending to produce a change in movement.
- Inertia: The tendency of matter to remain at rest if at rest, or, if moving, to keep moving in the same direction, unless affected by an outside (or unbalanced) force.
- Newton’s 1st Law of Motion (Law of Inertia): An object at rest tends to stay at rest and an object in motion tends to stay in motion with the same speed and in the same direction unless acted upon by an unbalanced force.

Post-Lab Activity—Make a Hovercraft:

Handout available in The Tech Science Labs

Estimated Time: 25 minutes

Students will create a vehicle that has the ability to travel over various surfaces—including water!

What is the farthest distance you can achieve? Which surface is the most difficult to travel over?

Learning Outcomes:

- Students will be able to describe potential and kinetic energy as it is observed in the hovercraft.
- Students will be able to explain the relationship of friction, force, and energy seen in this activity.