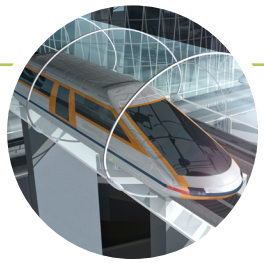
Engineering an Electromagnetic Train

A Carolina Essentials™ Activity



Overview

This physics inquiry activity asks students to engineer the fastest "train." Students are given a length of copper wire, AA batteries, and neodymium magnets and are asked to engineer a magnetic train that travels through a copper coil. The activity can be used to visually introduce electric and magnetic fields or as a summary engineering design challenge. Students can work in pairs or small groups, and all materials are reusable.

Physical Science, Physics
Grades: 9–12

Your Engineering Problem

How can we move people quickly and minimize burning fossil fuel?

Essential Question

How can magnetic and electric fields be used to engineer a vehicle?

Investigation Objectives

1. Engineer a device that can transport a battery like a train car.
2. Maximize the speed of the train car.

Next Generation Science Standards* (NGSS)

HS-PS2-5. Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations • Plan and conduct an investigation individually and collaboratively to produce data to serve as a basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.	**PS2.B: Types of Interactions** • Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Continued on the next page.

TIME REQUIREMENTS

PREP	ACTIVITY
30 min	30–90 min

Teacher Prep: 30 min
Student Activity: 30–90 min

SAFETY REQUIREMENTS

No PPE is required for the activity.

MATERIALS (PER GROUP)

Copper wire, 12 ft (16, 18, or 20 gauge)

2 batteries, size AA

4 neodymium magnets, $^1/_2 \times {}^1/_4$ in

Stopwatch or smartphone

Metric ruler or measuring tape

Wire cutters

HELPFUL LINKS

Making Audio Speakers from Household Materials

Making Magnetic Slime

REFERENCE KITS

Carolina® Introduction to Electromagnetism

Engineering an Electromagnetic Train

A Carolina Essentials™ Activity

Teacher Preparation and Disposal

Precut the 12 feet of copper wire prior to the activity. Check batteries for signs of corrosion and properly dispose of any cored batteries. All materials can be reused.

Student Procedure

1. Construct a data table that identifies the variables you are changing (independent), the variables you are holding constant (controlled), and the variables you are measuring (dependent).

Teacher Preparation and Tips

1. The only variable that must remain constant is the length of copper wire. The number of coils (length of track), number of batteries (1 or 2), and number and placement of magnets (1–4) can all vary. Time and length of track must be measured to calculate speed.

Analysis and Discussion

1. Describe your final design, explain how it works, and use evidence to make a claim that it was the best design.
   Student answers will vary with design; electromagnetic fields must be included in the explanation. Highest speed obtained should be correlated to best design.

2. Identify the variables that were the most impactful on the final design, and supply evidence for the variable impact on the design.
   Student answers will vary with design.

TEACHER NOTES