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TRANSPORTATION IN THE FUTURE LESSON PLANS

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Lesson Plan 1: Maglevs, Maps, and Magnets

This lesson introduces students to the module and the culminating challenge for the module, the Maglevacation Train Challenge. Discussions and video clips are designed to ignite students' curiosity and activate prior knowledge about trains. Social studies activities focus on map reading and a basic understanding of U.S. geography that students apply in choosing a destination for their Maglevacation Trains. In science, students investigate magnets and reflect on how what they learn about magnetism that may be useful as they approach their challenge.

ESSENTIAL QUESTIONS

- How can we use maps to determine a location?
- What region of the United States do we live in?
- How have technological advances affected the performance of trains?
- How do magnets interact with one another and with other materials?
- Why do magnets attract and repel one another?
- What is a testable question?

ESTABLISHED GOALS AND OBJECTIVES

At the conclusion of this lesson, students will be able to do the following:

- Use a map to identify their region, state, county, and town
- Identify and discuss various features of and uses of maps
- Identify the geographic features of their hometown and state
- Calculate distances on a map using the map scale

- Understand that speed affects the time it takes to travel a given distance
- Describe how magnets interact with various materials
- Describe and demonstrate the ways magnetic poles attract and repel one another
- Formulate a testable research question
- Design an investigation and draw conclusions from that investigation

TIME REQUIRED

- 4 days (approximately 45 minutes each day; see Table 3.6)

MATERIALS

Required Materials for Lesson 1

- STEM Research Notebooks (1 per student; see p. 26 for STEM Research Notebook student handout)
- Access to internet technology for showing video clips and for student research
- Classroom map of the United States
- Chart paper (for Know/Want to Know/Learned [KWL] charts)
- Ball
- Magnet
- Assorted materials with varying magnetic properties (e.g., nails, paper clips, pieces of wood, metal washers, fabric, aluminum foil)
- Handouts (attached at the end of this lesson)

Additional Materials for Map Me!

- U.S. road map (1 per group)
- Ruler
- String (3 feet per group)
- Map Me! handouts (1 set per student; attached at the end of this lesson)
- Colored pencils (1 set per student)
- List of potential destinations and student-created lists of information about the destinations (created in Introductory Activity/Engagement phase)

Additional Materials for Magnetic or Not? (per group of 2–3 students unless otherwise indicated)

- Safety glasses or goggles (1 pair per student)
- Pencil
- Piece of string (about 18 inches long)
- Magnet that can easily be tied onto the end of a string
- Ruler
- Magnetic or Not? handout (1 per student; attached at the end of this lesson)

Additional Materials for Magnet Magic (per pair of students unless otherwise indicated)

- Safety glasses or goggles (1 pair per student)
- Nonlatex gloves (1 pair per student)
- 2 bar magnets
- 2 small, round magnets (must be small enough to fit inside the lines of the maze)
- Resealable plastic sandwich bag*
- 3 × 5 index card*
- 1 tsp. iron filings*
- Duct tape to seal bags
- 12 oz. clear plastic cup
- Water to fill cup
- Magnet Magic Maze (attached at the end of this lesson)
- Magnet Magic handouts (1 set per student; attached at the end of this lesson)

*See Preparation for Lesson 1 on page 52 for more details.

CONTENT STANDARDS AND KEY VOCABULARY

Table 4.1 (p. 46) lists the content standards from the *Next Generation Science Standards* (*NGSS*), *Common Core State Standards* (*CCSS*), and Framework for 21st Century Learning that this lesson addresses, and Table 4.2 (p. 48) presents the key vocabulary. Vocabulary terms are provided for both teacher and student use. Teachers may choose to introduce some or all of the terms to students.

TEACHER BACKGROUND INFORMATION

Engineering

Engineering is a topic with which many teachers and students have little experience. Third-grade students may find references to engineers confusing in this module because they may have heard the term used in reference to the railroad engineers who operate trains. In this unit, the term *engineer* is used to denote individuals in the railway engineering profession, which falls under the broad umbrella of transportation engineering. Students should understand that trains are designed by engineers trained in areas such as mechanical engineering, civil engineering, electrical engineering, computer engineering, and even aerospace engineering for high-speed trains. For an overview of the various types of engineering professions, see the following websites:

- *www.nacme.org/types-of-engineering*
- *www.engineeryourlife.org/?ID=6168*
- *www.sciencekids.co.nz/sciencefacts/engineering/typesofengineeringjobs.html*

Geography and Map Skills

Students learn about the basic geography of the United States in this module. They will become familiar with the five regions of the United States—the Northeast, Southwest, West, Southeast, and Midwest—and understand that regions are areas of land grouped according to their location that may have common natural and cultural features. A map of U.S. regions can be found at *http://media.education.nationalgeographic.com/assets/file/us-regions-map.pdf*.

There are various types of maps. Students may be familiar with road maps and online mapping websites such as Google Maps. Other types of maps include topographic maps, relief maps, political maps, and weather maps. Road maps are the primary map resource used in this module, although topographic maps may be used as well. The U.S. Geological Survey (USGS) provides a number of educational resources for working with maps. These excellent aids for supporting your students' basic map-reading skills can be found at *http://education.usgs.gov/primary.html#geoggeneral*.

Career Connections

As career connections related to this lesson, you may wish to introduce the following:

- *Geographer:* Geographers study the Earth's natural land formations and human society, with a focus on the relationship between these phenomena. In particular, they study the characteristics of various parts of the Earth, including physical characteristics and human culture. Many geographers work for the federal government. Teaching and field research are other areas in which geographers work. For more information, see *www.bls.gov/ooh/life-physical-and-social-science/geographers.htm.*

- *Cartographer:* Cartography is a subset of geography. Cartographers interpret geographic information and create maps and charts. Many cartographers have backgrounds in geography and civil engineering. For more information, see *www.bls.gov/ooh/architecture-and-engineering/cartographers-and-photogrammetrists.htm.*
- *Photogrammetrist:* Photogrammetrists use aerial photographs, satellite imagery, and other images to create maps or drawings of geographic areas. This field is closely related to cartography. For more information, see the above website as well as *www.wisegeek.com/what-are-photogrammetrists.htm.*

Trains

The focus in this lesson is on train travel, and teachers should access students' prior experiences and current understanding and perceptions. Students will have had varying experiences with train travel. This may depend on where they live, since passenger train travel is much more prevalent in the Northeast than in some other parts of the country such as the Midwest, where freight trains are more common. Showing the class video footage of modern train technology may influence students' perceptions.

This module focuses more specifically on maglev train technology. *Maglev* is a term that combines the words *magnetic* and *levitation* and is used to refer to modes of transportation in which the vehicle (typically a train) travels without touching the ground, using magnets to provide lift and forward movement. For more information about maglev train technology and a proposal to provide a maglev train between New York and Washington, D.C., see the following websites and YouTube video:

- *http://science.howstuffworks.com/transport/engines-equipment/maglev-train.htm*
- *www.wsj.com/articles/campaign-for-floating-train-to-connect-new-york-and-washington-gathers-pace-1413976169*
- *www.youtube.com/watch?v=aIwbrZ4knpg*

Magnets and Magnetism

Most third-grade students have had hands-on experience with magnets and thus some understanding of magnetism, but they may also have some conceptual misunderstandings about how magnets work. Teachers should be ready to provide additional content information about magnetism throughout the unit.

Magnetism, as the term is used in this module, can be defined as the force of attraction or repulsion of materials, typically metals such as iron, steel, and nickel. More simply, it refers to the ability of objects to attract iron. The alignment of electrically charged particles within a substance causes magnetism. Magnetism can be permanent or temporary. Permanent magnets are those in which the magnetism is a physical characteristic of the substance. Temporary magnetism results when an object is moved by a permanent magnet and typically disappears when the permanent magnet is removed.

Magnetic objects create a magnetic field, which is the space around the magnet in which the magnetic force exists. Opposing magnetic forces are produced at each end, or pole, of a magnet. When a magnet is suspended (with no friction), it will automatically orient itself so that one pole points north and one south, and thus, the ends are labeled the north and south poles. If you work with multiple magnets, opposite poles will attract each other, and like poles will repel each other. For instance, if you lay two magnets on a table so that opposite ends are together, they will be drawn together, but if you place them so that the two south poles (or north poles) touch, they will separate. A good way for students to remember this is to use the phrase "opposites attract." The poles of a magnet are not visually distinguishable as either north or south; however, if you place a magnet beside a compass, the needle that points toward the Earth's north will move toward the magnet's south pole, allowing you to distinguish between north and south poles.

For information about magnets and compasses, see the following websites:

- *http://science.howstuffworks.com/magnetism-channel.htm*
- *www.livescience.com/38059-magnetism.html*
- *www.nde-ed.org/EducationResources/HighSchool/Magnetism/twoends.htm*

COMMON MISCONCEPTIONS

Students will have various types of prior knowledge about the concepts introduced in this lesson. Table 4.3 (p. 52) outlines some common misconceptions students may have concerning these concepts. Because of the breadth of students' experiences, it is not possible to anticipate every misconception that students may bring as they approach this lesson. Incorrect or inaccurate prior understanding of concepts can influence student learning in the future, however, so it is important to be alert to misconceptions such as those presented in the table.

Table 4.3. Common Misconceptions About the Concepts in Lesson 1

Topic	Student Misconception	Explanation
Magnetism	All metals are magnetic.	The only naturally occurring magnetic metals are iron, cobalt, and nickel.
	All magnets are solids.	Magnetic fields can be created in space by electric currents.
	Large magnets exert a stronger magnetic field than small magnets.	The size of a magnet and its magnetism are not necessarily related. The substances that compose the magnet, not its size, determine its magnetic force.
Maps*	Map symbols directly represent their referents.	Symbols may be abstract and may not be a true physical representation of the feature. For example, blue on a map does not always indicate water, a triangle does not always indicate a mountain, and green areas do not always indicate trees. The map legend provides a key for symbols.

*For more information on misconceptions students might have about maps, see the National Geographic report Spatial Thinking About Maps: Development of Concepts and Skills Across the Early Years at *http://nationalgeographic.org/media/spatial-thinking-about-maps.*

PREPARATION FOR LESSON 1

Review the Teacher Background Information, assemble the materials for the lesson, and preview the videos recommended in the Learning Plan Components section below. Prepare plastic sandwich bags with iron filings and index cards inside for the Magnet Magic activity, and seal the bags securely with duct tape. Students should not open these during the activity, as iron filings can be hazardous if they get into the eyes or are inhaled or swallowed. Consult the safety data sheet that accompanies the iron filings for full information. Be sure to wear safety glasses and non-latex gloves at all times when handling filings. Use caution when handling sharp objects such as tacks or nails, as they can cut or puncture skin. Wash hands with soap and water after handling the filings and completing the activity.

Have your students set up their STEM Research Notebooks (see pp. 25–26 for discussion and student instruction handout).

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LEARNING PLAN COMPONENTS

Introductory Activity/Engagement

Connection to the Challenge: Begin each day of this lesson by directing students' attention to the driving question for the module and challenge: How can we create a plan and build a prototype for a maglev train to carry passengers to a vacation destination? Hold a brief student discussion of how their learning in the previous days' lessons contributed to their ability to create their plan and build their prototype. You may wish to hold a class discussion, creating a class list of key ideas on chart paper, or you might have students create a notebook entry with this information.

Social Studies Class: Social studies is one of the driving content areas behind this interdisciplinary unit of study and therefore may be used as an opportunity to launch the module. Begin the lesson by asking students how many of them have ridden on a train. Find out what students know and think about train travel by asking them questions such as the following and recording their responses (you may wish to create a KWL chart for this):

- Did you ever see a train?
- What do you think the train was carrying?
- Have you ever ridden on a train? (allow students to share personal experiences)
- Do you think that many people in the United States travel on trains?
- How fast do you think trains can go?
- Do you think that trains could go faster than they do now?
- Where can you go on a train?
- How are trains powered? Do they use gas like cars, electricity, or something else?
- Can you board a passenger train in our town?

Introduce modern trains by showing a video about futuristic transportation. (Relevant videos can be found on YouTube by searching for "future of transportation technologies"; one example is "Hyperloop and Future Transport Technology" at *www.youtube.com/watch?v=YHiKjJEFY6A*). After watching the video, ask students what they learned about trains. What were they surprised about? Can they identify some of the ways trains have changed over the years? Enter this information in the KWL chart.

Tell students that they will be working as train design engineers in this module. They will be challenged to create a Maglevacation Train. Use the Maglevacation Train Challenge graphic (p. 157) to introduce students to the challenge. Hold a class brainstorming