**STEM Curriculum Planning Guide**

This instructional design guide serves as the template for the design and development of STEM units of instruction at the Dayton Regional STEM Center in Dayton, Ohio. The guide is anchored to the *STEM Education Quality Framework* also developed at the Dayton Regional STEM Center.

<table>
<thead>
<tr>
<th>STEM Unit Title</th>
<th>Magnets Like to Move It, Move It!</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic Cluster</td>
<td>Power &amp; Propulsion</td>
</tr>
<tr>
<td>Targeted Grades</td>
<td>2nd</td>
</tr>
<tr>
<td>STEM Disciplines</td>
<td>Science, Technology, Engineering, Math</td>
</tr>
<tr>
<td>Non-STEM Disciplines</td>
<td>Language Arts and Social Studies</td>
</tr>
</tbody>
</table>

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**Section I: STEM Unit Overview**

**Unit Overview**
These scientific investigations will engage students in understanding the force of magnetism and how this force can be used for work. The students will begin the unit by forming generalizations about magnets and their forces through their own knowledge and scientific investigations. The students will explore the variations between different magnet strengths. Finally, the students engineer a system that will utilize magnets to propel and guide a vehicle through a track. Students will use the engineering design process to determine the optimal type and placement of magnets around a predetermined track through testing and synthesis. Students will engage in collecting, analyzing and sharing data throughout this collaborative, inquiry-based unit.

**Essential Question**
1. How can magnetic force be used to do work?
2. How do we collect information and share results?

**Enduring Understanding**
Magnets attract and repel by means of polar charges (polarity). Magnetic force can be used to move or stop an object without touching. Information from a scientific investigation can be quantifiably gathered and shared using measurement and data collection techniques.

**Engineering Design Challenge**
Students will be given a defined pathway in which they will select polar direction and placement of magnets along the route to guide a small vehicle along the path. The students will need to choose the most effective type of magnet and orientation of magnets to propel the car along the path. Students will redesign as needed to improve their track to complete the challenge.

**Time and Activity Overview**

<table>
<thead>
<tr>
<th>Day</th>
<th>Time Allotment</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>45 minutes</td>
<td>The students will take a pretest to assess knowledge, engage in a discussion regarding data collection and representation, and explore magnetism.</td>
</tr>
<tr>
<td>2</td>
<td>45 minutes</td>
<td>The students will test items’ magnetism and test the strengths of different magnets.</td>
</tr>
<tr>
<td>3</td>
<td>45 minutes</td>
<td>The students will engage in an activity to strengthen their understanding of the Engineering Design Process and explore how forces (including magnetic forces) can move objects without touching them.</td>
</tr>
<tr>
<td>4</td>
<td>45 minutes</td>
<td>Engineering Design Challenge</td>
</tr>
<tr>
<td>5</td>
<td>45 minutes</td>
<td>Engineering Design Challenge</td>
</tr>
<tr>
<td>6</td>
<td>45 minutes</td>
<td>Engineering teams will share their results with the class. The class will analyze the results to design one final class track. Students will take the post test.</td>
</tr>
</tbody>
</table>
Pre-requisite Knowledge & Skill

Students should be able to work together in collaborative groups, follow directions, and think critically. Students should be able to make choices based on data and explain their reasons for making those choices.
### Academic Content Standards

<table>
<thead>
<tr>
<th>Add Standard</th>
<th>Mathematics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grade/Conceptual Category</strong></td>
<td>2.MD.9 and 2.MD.10</td>
</tr>
<tr>
<td><strong>Domain</strong></td>
<td>Measurement and Data</td>
</tr>
<tr>
<td><strong>Cluster</strong></td>
<td>Represent and interpret data.</td>
</tr>
<tr>
<td><strong>Standards</strong></td>
<td>9. Generate measurement data by measuring lengths of several objects to the nearest whole unit, or by making repeated measurements of the same object. Show the measurements by making a line plot, where the horizontal scale is marked off in whole-number units.</td>
</tr>
<tr>
<td></td>
<td>10. Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put-together, take-apart, and compare problems using information presented in a bar graph.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Add Standard</th>
<th>Mathematics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grade/Conceptual Category</strong></td>
<td>2.MD.A.1</td>
</tr>
<tr>
<td><strong>Domain</strong></td>
<td>Measurement and Data</td>
</tr>
<tr>
<td><strong>Cluster</strong></td>
<td>Measure and estimate lengths in standard units</td>
</tr>
<tr>
<td><strong>Standards</strong></td>
<td>1. Measure the length of an object by selecting and using appropriate tools such as rulers, yardsticks, meter sticks and measuring tapes.</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Add Standard</th>
<th>Mathematics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grade/Conceptual Category</strong></td>
<td>2.NBT.B.5</td>
</tr>
<tr>
<td><strong>Domain</strong></td>
<td>Number and Operations in Base Ten</td>
</tr>
<tr>
<td><strong>Cluster</strong></td>
<td>Use place value understanding and properties of operations to add and subtract</td>
</tr>
<tr>
<td><strong>Standards</strong></td>
<td>5. Fluently add and subtract within 100 using strategies based on place value, properties of operations, and/or the relationship between addition and subtraction.</td>
</tr>
</tbody>
</table>
### English Language Arts

**Grade**: 2

**Strand**: Speaking and Listening

**Topic**: Comprehension and Collaboration

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
</table>
| 2.SL.1   | 1. Participate in collaborative conversations with diverse partners about grade 2 topics and texts with peers and adults in small and larger groups.  
a. Follow agreed-upon rules for discussions (e.g. gaining the floor in respectful ways, listening to others with care, speaking one at a time about the topics and texts under discussion).  
b. Build on others’ talk in conversations by linking their comments to the remarks of others.  
c. Ask for clarification and further explanation as needed about the topics and texts under discussion. |
### Social Studies

<table>
<thead>
<tr>
<th>Add Standard</th>
<th>Social Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade</td>
<td>2</td>
</tr>
<tr>
<td>Theme</td>
<td>People Working Together</td>
</tr>
<tr>
<td>Strand (pk-8 only)</td>
<td>Government</td>
</tr>
<tr>
<td>Topic</td>
<td>Civic Participation Skills</td>
</tr>
</tbody>
</table>
| Content Standard | 10. Personal accountability includes making responsible choices, taking responsibility for personal actions and respecting others.  
11. Groups are accountable for choices they make and actions they take. |

### Science

<table>
<thead>
<tr>
<th>Add Standard</th>
<th>Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade</td>
<td>2</td>
</tr>
<tr>
<td>Theme</td>
<td>Physical Science</td>
</tr>
<tr>
<td>Topic</td>
<td>Changes in Motion: This topic focuses on observing the relationship between forces and motion.</td>
</tr>
<tr>
<td>Content Standard</td>
<td>Forces change the motion of an object: motion can increase, change direction or stop depending on force applied</td>
</tr>
</tbody>
</table>
Grade 2

Theme Physical Science

Topic Changes in Motion

Content Standard Forces change the motion of an object: some forces act without touching, such as using a magnet to move an object or objects falling to the ground
<table>
<thead>
<tr>
<th>Add Standard</th>
<th>Fine Arts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade</td>
<td></td>
</tr>
<tr>
<td>Subject</td>
<td></td>
</tr>
<tr>
<td>Standard</td>
<td></td>
</tr>
<tr>
<td>Benchmark</td>
<td></td>
</tr>
<tr>
<td>Indicator</td>
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<table>
<thead>
<tr>
<th>Add Standard</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade</td>
<td></td>
</tr>
<tr>
<td>Standard</td>
<td></td>
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<tr>
<td>Benchmark</td>
<td></td>
</tr>
<tr>
<td>Indicator</td>
<td></td>
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</tbody>
</table>
Assessment Plan

What evidence will show that students have acquired the enduring understandings for this STEM unit?

| Performance Task, Projects | Engineering Design Challenge with scoring rubric  
Final track magnetic design |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Quizzes, Tests, Academic Prompts</td>
<td>Pre- and Post-test: Magnetism and Data Collection</td>
</tr>
</tbody>
</table>
| Other Evidence (e.g. observations, work samples, student artifacts, etc.) | Student-generated data collection  
Student generated T-chart (with modifications)  
Engineering Design Process chart (in student journals)  
Student reflections (in Student Science Journal)  
Magnet Testing page (in Student Science Journal) |
| Student Self-Assessment | Engineering Design Challenge success/redesign  
Student reflections in science journal (Days 1-4) |
## ADISC Technology Integration Model*

<table>
<thead>
<tr>
<th>Type of Integration</th>
<th>Application(s) in this STEM Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Technology tools and resources that support students and teachers in <em>adjusting, adapting, or augmenting</em> teaching and learning to meet the needs of individual learners or groups of learners. Computers with internet access Optional: Electronic white board</td>
</tr>
<tr>
<td>D</td>
<td>Technology tools and resources that support students and teachers in <em>dealing effectively with data</em>, including data management, manipulation, and display. MS Excel Optional: Document camera Optional: Interactive whiteboard</td>
</tr>
<tr>
<td>I</td>
<td>Technology tools and resources that support students and teachers in <em>conducting inquiry</em>, including the effective use of Internet research methods. Maglev train websites MS Excel</td>
</tr>
<tr>
<td>S</td>
<td>Technology tools and resources that support students and teachers in <em>simulating</em> real world phenomena including the modeling of physical, social, economic, and mathematical relationships.</td>
</tr>
<tr>
<td>C</td>
<td>Technology tools and resources that support students and teachers in <em>communicating and collaborating</em> including the effective use of multimedia tools and online collaboration. MS Excel Optional: Skype Optional: Digital camera Optional: Document camera Optional: Video camera Optional: Interactive whiteboard</td>
</tr>
</tbody>
</table>

*The ADISC Model was developed by James Rowley PhD, Executive Director of the Institute for Technology-Enhanced Learning at the University of Dayton*
Career Connections

Career Description

Propulsion engineers use principles of magnetism to investigate moving objects at extremely high speeds. One application may be to launch aircraft or spacecraft. The Materials and Manufacturing Directorate within the Air Force Research Labs at WPAFB employs propulsion engineers for warfighter technology.

Another application of using magnetism to move an object can be found in Maglev (Magnetic Levitation) trains. Mechanical, Electrical and Civil engineers using principles of magnetic theory to design and improve the performance of these trains.

Magnetohydrodynamics (MHD) is the study of the ways in which electric and magnetic fields interact with fluids that conduct electricity. Nuclear engineers apply these principles to design systems that can control power sources for submarines, vehicles and space vehicles.

More Electric Aircraft (MEA) are being developed at Wright-Patterson Air Force Base, using, among other innovations, magnetic bearings to increase reliability, maintainability and supportability. The Materials and Manufacturing Directorate at AFRL are working to develop the magnetic materials necessary to make MEAs possible.
Section II: STEM Lesson Plan

Title of Lesson Day #1

Time Required 45 minutes

Materials
- Pretest (Appendix B) - copy for each student
- Student Science Journal (Appendix C) - copy for each student
- Magnets (bar magnets, circle magnets, square/rectangle magnets, and magnet wands) - one of each magnet for each engineering design team.
- Post-It notes - 4 for each student
- Chart paper or white board space for T-Chart
- "I Have, Who Has?" vocabulary game (Appendix D) - one game set (cards cut out and put in small bag or envelope) for each engineering design team
- Performance Rubric (Appendix F) - copy for each student

Objectives
- Students will identify items that are and are not magnetic.
- Students will identify how magnets repel and attract each other.

Instructional Process

1. Students will take the pretest.

2. Students will engage in a discussion about different types of charts. Look around the classroom and talk about birthday charts, job charts, or other classroom charts. Ask students about the data they show, how data is collected, and the importance of the way it is displayed.

3. Create a T-Chart of items that are and are not magnetic. Start by giving each student four post-it notes. While seated, have the students choose two items in the classroom that are magnetic and two items that are not. Have the students place the post-it notes on the T-Chart on the board or chart paper. (This chart will be revisited later).

4. Show video clip of maglev trains (multiple sites in materials and resources).

5. Place students in engineering design teams of four.

6. Have each engineering design team play the "I Have, Who Has?" vocabulary game. Each team member should have two or three cards. The person with the first card will read their card and ask their question. The person with that card will respond. The students will go through all the cards until they reach the end. Model
the game as an entire class before having the small groups play. Students should play multiple times changing cards with each game. The vocabulary used in the game represents the vocabulary in the Student Science Journals.

7. Give each engineering design team a set of magnets. The students should explore the polarity of the magnets by making them attract and repel each other.

8. Have students reflect on the day's lesson in their Student Science Journal. They can use words, pictures, or both to describe the day's lesson.

**Differentiation**

Help student with identifying and spelling classroom items if needed.
Have students research more information about maglev trains; how they work and why this technology is important.
Give students prompts for journal topics if they struggle with what to write or draw.

**Assessments**

The pretest is used to determine students' prior knowledge.
Reflection Journal Entry will show student knowledge gained during lesson.
Performance Rubric to assess Scientific Knowledge, Journal Content and Team Collaboration.
**Section II: STEM Lesson Plan**

**Title of Lesson**

Day #2

**Time Required**

45 minutes

**Materials**

- Test Kit (paperclip, nut, bolt, washer, metal toy car, penny, nickel, dime, plastic button, quarter, key, scissors, thread, CD, marble, wooden block, Lego, pencil, eraser). - two test kits are needed for each engineering design team
- Student Science Journal from Day #1
- Magnets - 1 per student (wand magnets are recommended for students testing items around room)
- T-Chart from Day #1
- Yard stick, tape measure, rulers- a couple of each per group
- Metal paperclip - one for each student
- Set of four magnets (bar, circle, square/rectangle, wand) - one set for each engineering design team - students will share the magnets as they test strength
- Performance Rubric (Appendix F) - copy for each student

**Objectives**

- Students will identify items that are and are not magnetic.
- Students will determine the strength of different types of magnets.

**Instructional Process**

1. Explain to the students that they will be testing magnets and will be collecting data on objects that are attracted to magnets and those that are not attracted to the magnets.

2. Have the students predict the items that will be attracted to the magnets in the Student Science Journal. Explain to students that this is a prediction and it is okay if they do not predict correctly.

3. When they are finished with their predictions, give each engineering team two Test Kits with 2 magnets. Tell the students that they should work in pairs to test whether or not the objects in the Test Kit are magnetic or not. They should record their results in their Science Journal.

4. After all the engineering design teams have finished their testing ask the class to refer back at the T-Chart they created the day before. Ask the students if they still think all the items they put on the chart are placed correctly. Allow students a chance to change whether or not they believe the objects are magnetic.
5. After changes have been made to the T-Chart give each student a magnet and allow them to test the items in the classroom that they wrote on their post-it notes. When everyone has tested their objects discuss if their hypotheses were correct. If so, what made them think it was magnetic or not magnetic? If they were incorrect what made them think that was the correct answer. This is a good time to correct any misconceptions about all metal items being magnetic. Have students write final results on the T-Chart in their Science Journal.

6. Students will use magnets, paperclips, and rulers to test the strength of different magnets. Give each student a paperclip and a ruler. Give one of each type of magnet to each engineering design team. Have the students predict at what centimeter mark the paperclip will move for each type of magnet. Again, reiterate that these are predictions and it is okay if they are not correct after testing.

7. Teams will select measuring tool and place on the table. Place the paperclip at the end of the ruler at zero. The students will move each magnet one at a time along the ruler starting at 30 centimeters and moving slowly toward zero. Students should record in their journal at what centimeter mark the magnet will cause the paperclip to move. The magnet that attracts the paperclip closest to 30 centimeters on the ruler has the greatest strength. The magnet that attracts the paperclip closest to zero on the ruler has the weakest strength. Students should take turns testing each of the magnets by rotating them around their team.

8. Students should generate a bar graph for this information (See appendix C).

9. Facilitate a class conversation about the invisible force a magnet has to move an object without touching it. Review the associated vocabulary and reflect on the T-Chart for other objects the magnet could be attracted to.

Differentiation

Give support to students that need assistance measuring to the nearest centimeter. Give Engineering Teams different objects to use to test the strength of the magnets. Does using a different item change which magnet is the strongest?

Assessments

Accuracy of student measurements during strength testing recorded in Student Science Journal.
Final data in T-Chart
Performance Rubric to assess Scientific Knowledge, Measurement, Journal Content and Team Collaboration.
### Section II: STEM Lesson Plan

<table>
<thead>
<tr>
<th>Title of Lesson</th>
<th>Day #3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time Required</td>
<td>45 minutes</td>
</tr>
<tr>
<td>Materials</td>
<td>Student Science Journals from previous days&lt;br&gt;&quot;I Have, Who Has?&quot; vocabulary game (Appendix D) - one game set for each engineering design team&lt;br&gt;Lesson Kit (1/4 cup rice, cotton ball, pompom, straw, 3x5 index card) - one kit per engineering design team&lt;br&gt;Magnet wand - one for each student&lt;br&gt;Sheet of white construction paper (at least legal size recommended) - one for each engineering design team&lt;br&gt;Markers&lt;br&gt;Performance Rubric (Appendix F) - copy for each student</td>
</tr>
<tr>
<td>Objectives</td>
<td>Students will be able to recall and restate the Engineering Design Process.&lt;br&gt;Students will utilize different forces to move objects.&lt;br&gt;Students will record and compare data.</td>
</tr>
<tr>
<td>Instructional Process</td>
<td>1. Students should play the game &quot;I Have, Who Has?&quot; with their engineering design team. They should go through the game one or two times. Students should be more familiar with the vocabulary. Let the students know they will be referring to repel, attract, magnet, force, and gravity in today's activity. If they play more than one time it is recommended to change cards each time.&lt;br&gt;2. Using the poster found in Appendix A, introduce the Engineering Design Process (EDP). Describe each step of the process. Use the following example to help you define the process and explain it to the students.&lt;br&gt;Example: There are two villages, Daytona and Cincinattia, that are separated by a very wide and deep fast moving river. Daytona has a doctor, but Cincinattia does not. The citizens are tasked with engineering a solution that allows the doctor in Daytona to easily move between the two villages. First, the citizens need to define the problem. What is the problem? Think of what is happening between the two villages. What questions or challenges exist? Once the problem is defined, the villagers need to think of potential solutions, this may include villagers doing research and collecting data so that the better understand the challenge or barriers for their success. Next villagers design possible solution(s). These possible solutions include prototypes to investigate the success of their idea or to share</td>
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</table>
design information with other villagers. One of the suggested solutions that a group of citizens designed was a slingshot that the doctor could use to fly across the river. However, sometimes the dummy used for testing landed on its head or lost its equipment in flight. After testing the design, the citizens realized that it was not a safe and consistent method of getting the doctor across the river. Since this idea didn't work, the citizens needed to re-design their idea. The decided that instead of the doctor flying across the river, they would try and go under the river in a tunnel. After testing their idea, they found that the test tunnel would have to be very deep as the shallower kept filling with water, when they dug deeper they hit rock which they could not dig through. The citizens decided to re-design again and thought about a method where the doctor can walk across the river. They designed something they called a bridge made out of wood. While designing their bridge they realized that they would have to build giant structures on both sides of the bridge to support it across the water because they could not put posts in the middle of the river. These citizens designed a cantilever bridge as their solution. This bridge design was strong enough and long enough to allow the doctor to cross between the two villages. Success was achieved, though lots of team work, thinking, designing, and testing!

Note: Some students will need the opportunity to not only hear about and see the EDP but will also profit from writing down the different steps. The "fill in the blank" sheet in their Student Science Journal is not designed as an assessment but rather as part of the introduction process. Refer students to the EDP poster. Have student find the EDP poster in their Student Science Journal. Instruct student to fill in the missing words on the EDP Poster in their Student Science Journal. Students can role play the example if time permits.

3. Introduce the day’s activity with the question, "How can we use force to make objects move without touching them?"

4. Give each team a lesson kit and instruct them that they will try to move the materials in their kit without touching them directly. The only materials the students can touch are the magnets and the straw, but they cannot touch the other materials with the magnet or the straw.

5. Give each group a large sheet of white paper and marker. Instruct children that they will use this paper to record the different ways they moved the materials using the tools provided. All students should write or draw the results on the paper. If children have some difficulty getting started, give them some prompts: Can you use air to move the rice (pompom, cotton ball)? How could you use the straw? How could you use one magnet to move the other? Could you use two magnets to push the rice (pompom, cotton ball)? Give students 10-15 minutes to investigate the material properties.

6. After engineering design teams have had time to work with the materials, instruct teams to identify which strategies worked to move materials and which did not work.
to move materials. How did they use the magnets? Could they use the magnets to move the rice, pom pom or cotton ball? Why or why not? Note for teachers: Students may report blowing through the straw, waving the 3x5 card, or using the repelling force of 2 magnets to make the materials move.

7. Instruct students to individually record through drawing or writing at least one of the propulsion strategies that worked and one that did not work in their personal science journal. If time permits, let each group report out to the class at least one of the strategies they used and how successful they were at moving the rice, pompom or cotton ball.

Differentiation

Provide support for writing strategies in journals for students that need writing support.

Assessments

Engineering Design Worksheet
Team posters of strategies for moving items.
Individual Science Journal entries
Performance Rubric to assess Scientific Knowledge, Journal Content and Team Collaboration.
### Section II: STEM Lesson Plan

<table>
<thead>
<tr>
<th>Title of Lesson</th>
<th>Day #4 and #5</th>
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<tbody>
<tr>
<td>Time Required</td>
<td>45 minutes (each day)</td>
</tr>
</tbody>
</table>

**Materials**

- Magnets - 20 small 1 inch diameter and 1/4 inch thick ring magnets per engineering design team
- Wand Magnet - one per engineering design team
- Black Line Master of track (Appendix G) - one per engineering design team
- Vehicle (see Appendix E for assembling before lesson) - one per engineering design team
- 20"x30" Foam Board - one third laminated section of track per engineering design team (Appendix G)
- Optional: Safety Goggles - one pair per student
- Masking tape
- Performance Rubric (Appendix F) - copy for each student

**Objectives**

Students will utilize the Engineering Design Process to design a track using magnetic poles to move a vehicle without touching it. Students will record, analyze, and use data to inform redesign decisions.

**Instructional Process**

1. Before the lesson, the teacher will need to assemble one vehicle for each engineering team. See Appendix E. Also attach the final challenge track to the foam board for each group. Student hint: Magnetic placement for design should be on the underside of the track. This emphasizes the force without touching.

2. Introduce the student roles. Place this information on the board or poster for student reference. All students will be the Data Manager, taking data. The Construction Engineer will help team members design or think of ways to use the tools to make the materials move. The Data Manager will collect the data and record (write or illustrate/draw) on the poster board the different ways or strategies used to move the materials. All team members will record data in their individual science journal. The Test Engineer will test and assist other team members as they test the different ways to make the materials move with the tools provided. The Project Manager will help keep the team members on task and report to the whole group.

3. Introduce students to the vehicle they will be using. Inform teams that their first challenge will be to get the vehicle to move in a straight line across the desk without touching it, using a wand. Pose the questions, how can we use polarity of magnets to propel the car?
4. Have the Construction Engineer tape 2 pieces of straight track on the top of their desk or flat, level working surface (an uneven or non-level surface will make the challenge more difficult). The team will practice moving their vehicle along the track.

5. Data will be recorded in student science journals. Students will record the data in their journals.

6. The students can also try to see if they can get the vehicle to turn instead of moving in only a straight line. Have students push the vehicle toward a magnet and use that magnet to push the vehicle in another direction.

7. Have the Project Manager from each team share their results with the class. Discuss results. How did you get your vehicle to move? What didn't work? What worked well? At this point students should record their results for Day #4 in their Student Science Journals.

8. The teacher will give a preview demonstration of how to keep the magnets in place on the foam board that will be used for the next part of the challenge.
   a. Show the students how to tape the magnets on the board. It is okay for the tape to cover the magnets. The vehicle will need to move across the path without touching it. Brainstorm ideas within the group as to how this could happen. You may need to work with the groups to determine the best way to secure the type of magnet they choose to use in their design.

9. Have the students brainstorm in their journal their ideas for the track.

10. After they have all had a chance to write their individual ideas. Give students time to share ideas with their engineering design teams.

11. At this point engineering design teams should work on placing their magnets and begin to record information. The teacher should move from group to group making sure students are correctly recording information. Three times should be recorded for the the design and the results should be graphed on the first graph in the Student Science Journal.

12. At the end of the Engineering Design Challenge each group should have three times recorded for each design. They should have magnet tracings in orange, red and blue on their foam board. Each student should complete the reflection page in their Science Journal. Engineer Design Teams will need their data and foam boards for Day 6.

13. Each student should complete the redesign page in their Student Science Journal.
Differentiation

Students may need to see an “order of events” within this experiment and be able to check off each activity that occurs. Example: a simple overview of what is expected for this lesson. Students with fine motor difficulties, may need larger push pins or balls of silly putty or play dough that could be placed behind the bar magnets. As an extension, the students could design their own matchbox cars with magnet placement. Use tape to test where you want the magnets to go and when the students are satisfied the teacher can hot-glue the magnets to the car.

Assessments

Science journal entries explaining what worked and what did not work.
Data collection in journals.
Teacher observations as to how students were working together in assigned groups. (See Appendix D).
Performance Rubric to assess Scientific Knowledge, Graphing, Engineering Design Challenge, Journal Content and Team Collaboration.
Performance Rubric to assess
Student redesign journal page will assess individual student knowledge gained in the Engineering Design Challenge.
Section II: STEM Lesson Plan

Title of Lesson  | Day #6
--- | ---

Time Required  | 45 minutes

Materials  
- Student Science Journals from previous days
- Each team's final trace designs
- White Board or chart paper for notes
- Performance Rubric (Appendix F) - copy for each student
- Post-test (Appendix B) - 1 copy for each student

Objectives  
Students will present and analyze results from each engineering design team to design another track using data from all design teams.

Instructional Process  
1. Each group will be given a chance to show how their track works by moving the vehicle from point A to point B. Below is a suggestion for how to guide each group's presentation.
   - The Construction Engineer will explain how they decided upon their magnet placement and show the foam board design.
   - The Test Engineer will explain what problems led them to their final design.
   - The Data Manager will share the results of their data record sheet, show the graph from the science journal, and indicate where the magnets were placed.
   - The Project Manager will show their final track design and demonstrate one run of the vehicle on the track.

2. Repeat the process for each group. As the groups are presenting, the teacher will make a chart on the board of each group's best time.

3. After the presentations, the teacher will use the data chart on the board to lead a discussion about a possible redesign. The class will create one track that would move the vehicle in the quickest time. Below are some sample questions you could use in your discussion.
   - What parts of their design made their vehicle travel the fastest? The magnet placement? The way they held their wand magnet?
   - Are there any suggestions for changes to this track that would make a vehicle travel faster?

Using information from the class discussion, redesign a class track to get the best
Did this track move the vehicle the fastest? If so, why? If not, why not? What can still be changed. Discuss on the redesign process can go on and on as new ideas are tried.

- Are there any suggestions for changes to this track that would make a vehicle travel faster?

4. Administer post test

Have guiding questions ready for groups or students that need support with public speaking. Students could use presentation software or SmartBoard graphing tools to present their information.

Teachers can discuss optimizing design costs and have teams engineer a design to use the least materials (magnets and tape). This discussion can focus on economic considerations for consumer and producer as well as finite resources.

Leave materials out and available to students to try during independent time.

Performance Rubric to assess Scientific Knowledge, Engineering Design Challenge, and Team Collaboration.

Students will take the post-test to assess knowledge of standards.
Section III: Unit Resources

Materials and Resource Master List

Printable Resources
- Engineering Design Process (Appendix A) - copy posted in room for reference
- Pretest (Appendix B) - copy for each student
- Student Science Journal (Appendix C) - copy for each student
- "I Have, Who Has?" vocabulary game (Appendix D) - one game set for each engineering design team
- Performance Rubric (Appendix F) - copy for each student
- Black Line Master of track (Appendix G) - one per engineering design team

Lesson Resources
- Magnets (bar magnets, circle magnets, square/rectangle magnets, and magnet wands) - one of each magnet for each student will be used throughout the lessons.
- Post-It notes - 4 for each student
- Chart paper or white board space for T-Chart
- Test Kit (paperclip, nut, bolt, washer, metal toy car, plastic button, penny, nickel, dime, quarter, key, scissors, thread, CD, marble, wooden block, Lego, pencil, eraser) - two test kits are needed for each engineering design team
- Yard stick, measuring tape, rulers - a few per engineering design team
- Metal paperclip - one for each engineering design team
- Lesson Kit (1/4 cup rice, 1/4 cup birdseed, cotton ball, pompom, straw, 3x5 index card) - one kit per student
- Sheet of white construction paper (at least legal size recommended) - one for each engineering design team
- Markers/ white board markers
- Vehicle (see Appendix C for assembling before lesson) - one per engineering design team
- 20"x30" Foam Board - each team gets a laminated 1/3 piece of the foam board 'track'
- Safety Goggles - one pair per student
- Masking tape (about 6 feet per engineering design team)
- Maglev video websites mentioned in Lesson 1:

Key Vocabulary

Attract - to pull toward

Data - information that helps you make a decision.

Energy - the ability to do work

Engineer - a person who uses science and math to solve problems
Engineering Design Process- the steps an engineer or person takes to solve a problem

Ferromagnetic- a substance containing iron or nickel attracted to a magnet

Force- strength or power exerted upon an object

Gravity- a force that pulls towards the earth

Magnet- a piece of material (such as iron or steel) that is able to attract certain metals (www.learnersdictionary.com)

Polarity- the state of having magnetic poles

Poles- opposite ends of a magnet

Repel- to push away

Technical Brief

Man has used many forms of energy to create movement. Wind energy has moved sail boats, gasoline engines have powered automobiles, electric motors power large locomotives, and magnetic power may move cars and trains of the future. Simple magnets have both North and South polarity. The principle of like charges can be used to repel and move an object. If the magnetic force is powerful enough, large objects can be moved at high speeds.

The earth itself acts as if it contains a large magnet in its center. There is a magnetic field surrounding the earth. The earth has a magnetic North and South Pole. This characteristic allows a compass to point to the direction of the magnetic north pole. Every atom has a central core called a nucleus. Moving around the nucleus, like planets around the sun, are even smaller particles called electrons. The electrons carry a electric charge, and there motion makes an electric current. In most atoms, the electrons spin in different directions and their magnetic fields cancel each other. But in atoms of magnetic elements, such as iron and nickel, the fields do not cancel each other. These magnetic atoms are sometimes called atomic dipoles. Materials which contain many atomic dipoles can be magnetized. These materials are called ferromagnetic because atomic magnets were first discovered in iron, and ferrum is the Latin word for iron.

An electromagnet is a temporary magnet formed when electric current flows through a wire or other conductor. Most electromagnets consist of a wire wound around an iron core. This core is made from magnetically soft iron that loses its magnetism quickly when the electric current stops flowing through the wire.

Magneto Rheological Fluid (MR Fluid) is a liquid that has iron particles within the
liquid. As the liquid approaches a magnetic field, the substance thickens in response. These fluids are used to create better shock systems in military vehicles. Video: https://www.youtube.com/watch?v=SBXQ-6uI8GY

Safety and Disposal

Students should not ingest magnets or place any other materials in their mouths. Magnets can be wrapped in duct tape before use to avoid breakage. Chipped or broken magnets should not be used. Students can wear safety goggles during the engineering design challenge and while using magnets.

References

Books:
Experiments with Magnets: Salvatore Tocci
What Makes a Magnet: Franklin M. Branley and True Kelley
What Magnets Can Do: Allen Fowler
Magnets: Anne Schreiber
Magnets: Pulling Together, Pushing Apart: Natalie M. Boyd
Thomas Edison for Kids: His Life and Ideas: Laurie Winn Carlson
Amazing Magnetism: Rebecca Carmi and John Spears
Earth is Like a Giant Magnet: Janice Pratt VanCleave

Magnet websites and videos:
http://www.neok12.com/Magnetism.htm
http://science.howstuffworks.com/magnet.htm
http://www.internet4classrooms.com/science_elem_magnets.htm
http://www.sciencekids.co.nz/

Where to buy magnets:
http://www.radioshack.com
http://apexmagnets.com
http://www.amazon.com
http://www.magnet4sale.com/AlNiCo-Bar-Magnets/

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Section IV: Appendices

Appendix A - Engineering Design Process
Appendix B - Pre and Post Test and Answer Key
Appendix C - Student Science Journal
Appendix D - "I Have, Who Has?" vocabulary game
Appendix E - Instructions for Vehicle Assembly
Appendix F - Performance Rubric
Appendix G - Track Template