Maglev Train/Car

Adapted from The Attraction is Obvious: Designing Maglev Systems

Target Grade: 3rd
Teacher Prep Time: 45 minutes
Lesson Time: 180-240 minutes
Learning Goals:

· Students will design solutions to move a car with objects inside across a given space without the objects falling or the tipping maglev train using engineering practices and properties of magnetism.

NGSS:

- 3-PS2-4 Define a simple design problem that can be solved by applying a scientific idea about magnets.*
- 3-5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

- Disciplinary Core Idea
  - PS2.B Types of Interactions
    - Electric, and magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other.
  - ETS1-A: defining and Delimiting Engineering Problems
    - Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.

- Cross Cutting Concepts
  - Cause and Effect

- Science and Engineering Practice
  - Constructing explanations and designing solutions

Where this lesson fits in:

After completing a unit on magnetism, third grade students are ready to engage in a hand-on problem-solving engineering project to design and create a maglev car (PS2.B). In this lesson, students use the Engineering Design Process to design and "Improve" a small maglev transportation system. Students began the "ask" step of the Engineering Design Process during a previous lesson of this unit as they explored several properties of magnets that are pertinent to the design challenge, including the magnetic force of repulsion, poles, and the factors that affect the strength of magnetic fields. Prior to this lesson, students should create a list of properties of magnet. Students should draw heavily from their knowledge of magnetic properties as they design their maglev transportation systems.

In order for students to have the opportunity of successfully building their maglev vehicle and track, students should have an understanding of symmetry, equal distances, parallel lines and balanced and unbalanced forces.

More advanced students are asked to create a maglev vehicle that both levitates above a track and can (with a gentle nudge) securely carry as many small weights as possible down the track. At the basic level, student may focus instead on simply creating a magnetic vehicle that is able to levitate above the track. . (3-PS2-3),

This project relies on an understanding of magnetism and engineering design process. Students work collaboratively through the steps of the engineering design process to construct, test, and improve maglev cars during the activity(ETS1-A). Students then apply their engineering skill to design car that will bear weight without falling or tipping over. .

Before this activity the teacher should attempt to build a model maglev train using the materials. Students should review how to identify the north or south sides of an unmarked magnet. This requires them to understand that like forces repel and opposites attract (3-PS2-3). They should then expand on this idea by employing repulsion to elevate a panel (car/train) over a section of track. In addition, they should add weight to the panel (car/train) and keep it balanced as it travels a distance.

If desired, a similar design activity can be included using a different car design, rather than flat.

Materials Needed per class:
Chart paper for criteria charting
“Properties of Magnets” chart created in a previous less
Small track box and insert created in previous lesson
1 pair of scissors
1-5 weights (pennies or glass beads)
Engineering Design Process Poster or transparency

Materials Needed per group of 3 student:

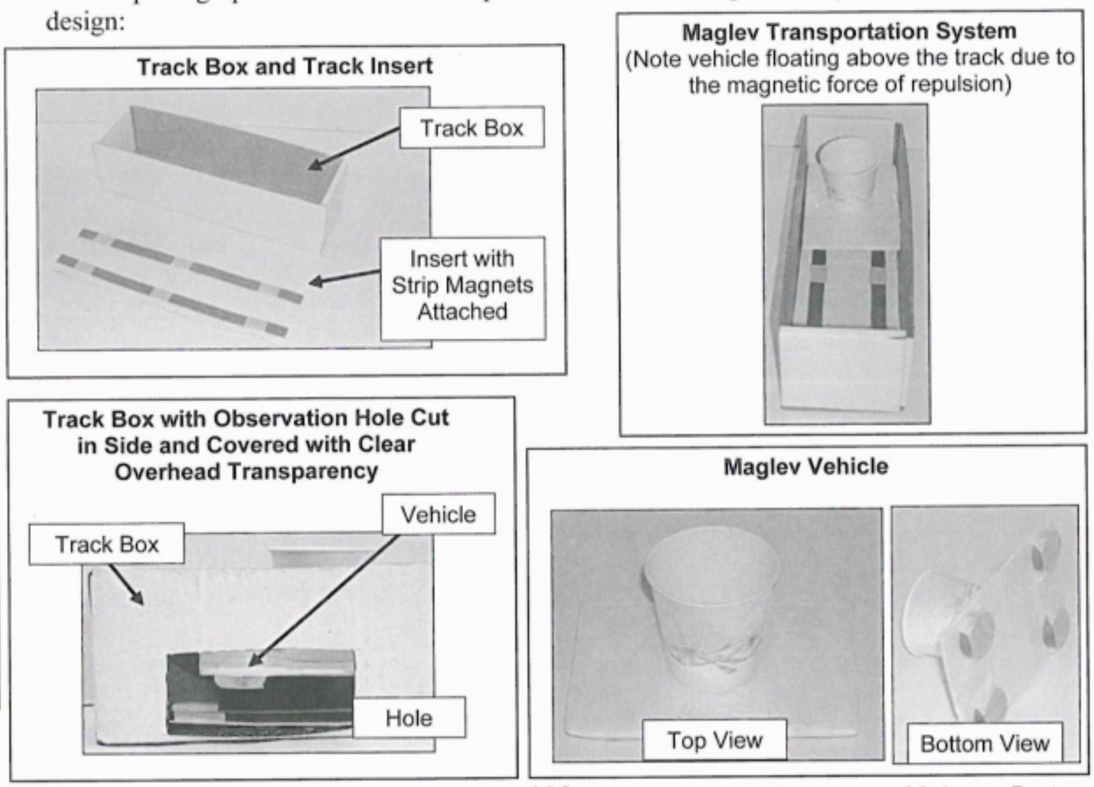
- 1 bag, plastic, clear, resealable 1 gallon (3.8L)
- 2 magnets, bar, with poles labeled,
- 2 magnets, ring, approximately 1” (2.5 cm) in length
- 2 magnets, disc, approximately ¾” (1.9 cm) in length
- 1 piece of high energy flexible magnet: http://zigmystermagnets.com/product-category/low-high-energy-flexible-material/high-energy-magnetic-strip/
  Cut to approximately ¾” wide, each 12” (30.5) long, or as long as the track box. Do not buy strips at Home Depot or a discount store, they will not work.
- 2 squares of folder, manila, file, approximately 4” x 3.5” (10.2 x 6.85 cm)
- 1 rectangle of non-corrugated cardboard, approximately 2” x 2” (5.1 x 5.1 cm)
- 2 cups, paper, 3 or 5 ounces (88.7 to 147.9 ml)
- 1 Cardboard storage type BCW 800 (14x 3 ¾ x 2 ¾) (14 x 3 3/4 x 2 ¾), https://www.amazon.com/Bundle-BCW-Corrugated-Cardboard-Storage/dp/B0014179G2/ref=sr_1_3?ie=UTF8&qid=1466790855&sr=8-3&keywords=bcw+800+count+card+storage
- Scissors
- 1 roll of Blue Painters (Masking) tape
- For students with engineering experience, add a 3 x 4” rectangle

Teacher Prep:

1. Read background information on maglev trains:
   Kevin Bonsor "How Maglev Trains Work" 13 October 2000.
   HowStuffWorks.com.
   <http://science.howstuffworks.com/transport/engines-equipment/maglev-train.htm>
   8 July 2016
2. Print 1: *Guided Question*
3. Print one *Design Process* sheet per student.
4. Prepare a sample track
5. Cut the insert to fit the box (students will potentially have difficulty with sizing)
6. Cut 10 pieces of high energy flexible magnet, strip each as long as the track insert you created for the sample track.
7. Create plastic bags of sample materials. Include samples of the following materials (enough so that students can manipulate the “Imagine” using the materials, but not construct with them):
   - 2 ring magnets
   - 1 bar magnet
   - 5 disc magnets
   - 2 paper cups
   - 1 piece of high energy flexible magnet, strip
   - 2 pieces of manila folder size of the bottom of your track to use as an insert
   - 2 pieces of non-corrugated cardboard, approximately 3 ½ x 4” square

5. Consider your students and how to best facilitate this lesson. If students might become frustrated, you may want to provide students with pre-made track using two pieces of strip magnet similar to the diagram below or pre-cut vehicles.
Note: Design pieces were made at http://drawisland.com/#drawing

- See the photographs below for an example of a successful maglev transportation system design:



Transportation Engineering: Designing Maglev Systems 106 © Museum of Science, Boston Duplication Not Permitted

20 minutes	Have students seated in groups of 3 **Phenomenon:** Distribute a pencil and two ring magnets. Ask student to make the magnets interact. Students should demonstrate repulsion and/or attraction. Ask students: “What causes the magnets to attract?” “What causes the magnets to repel?” Ask students if they can locate the poles are on the ring magnets. [ESR: The poles are on the flat sides of the magnets.] Ask student if they can identify the north or south poles of the magnet. [ESR: no, they aren’t labeled] Ask student if it is possible to identify the north or south poles. If so, how? [ESR: Yes, a labeled magnet is required. When the north end is near the pole, it will attract or repel the bar magnet. Like charges repel, opposite charges attract.] **Beginning Thoughts**

	· Introduce the design challenge of the maglev system Post the Guiding Question for students: *How can we use our knowledge of properties of magnets, the Engineering Design Process, and to creativity to design a maglev transportation system?* · Tell students that they have an opportunity to design their own maglev transportation system- Just as they have in Japan. Explain that the maglev system will require two main parts; the track and the vehicle. The goal is to create a levitating vehicle that safely transports materials above the length of the track when given a push. · Guide students in a discussion about the role of a transportation engineer, confirming that they are concerned with designing and improving technologies that safely and efficiently move objects or people from one place to another. · Show students the picture of the maglev train. · Hold a criteria discussion: **How we will know whether the objects were transported safely?** [ESR: The don't tip over. They don't fall. They make it to the other side] **How will we know whether the objects transported being transported efficiently?** [ESR: The more weights we carry, the fewer trips need to be made.] **How will we measure success?** [ESR: the number of weights the system designs are able to transport and whether they are tipped or shaken out of the vehicle.] Record student ideas concerning criteria. · Today, students will take the role of transportation engineer. Show students how to build their maglev track onto the manila insert, which they can fit into the bottom of the box. The placement of the tracks on the template is very precise but students can and should work to correctly place the. Also, students must be aware of the orientation of the poles of both the magnets they choose to use in their design and of the track. Use the marked bar magnets to confirm the orientation of the poles. Students must use their knowledge of parallel lines and math in this instance. · Distribute the handout "The Engineering Design Process". Review the Engineering Design Process.: The engineering design process is a series of steps that engineering teams use to guide them as they solve problems. The design process is cyclical, meaning that engineers repeat the steps as many times as needed, making improvements along the way.
40 minutes	**Maglev Lab-** · Distribute the handouts and a plastic bag Lay materials out on a front table or put these materials inside the box that will be your track. Show students each of the materials that they will have access to and ask them what property the material possesses. • 2 ring magnets • 1 bar magnets

- 5 or 7 disc magnets (students may use fewer)
- 1 paper cup
- 2 pieces of high energy flexible magnet, strip
- 1 piece of manila folder to fit in side the track box
- 1 pieces of foam tray, approximately 2 x 2" square or non-corrugated cardboard

· Tell students that they will get 20 minutes to design a panel that levitates over the track. The panel that they make will eventually hold weight.

Ask the question:

- How can we use our knowledge of magnets, the Engineering Design Process, and creativity to design a maglev transportation system? (On the poster)
- What have others done?
- What constraints exist?

Distribute one bag of materials per group.

Ask groups to **imagine** and discuss the possibilities:

- Imagine a design. What are some possible maglev transportation systems?
- Brainstorm ideas remembering that the two parts must interact

Plan

- On the track, where will you place the magnets? Where will you place the magnets on the vehicle
- What kind of magnets will you use?
- How will you arrange the poles of the magnets?
- How will the vehicle hold the weights?

The can use any of the above materials. Have students list the materials used and draw a picture of the panel on the "Engineering Design Plan Process worksheet. Then have each group explain their designs and why they think their car will be effective.

[Teacher note: This is a good place to break if you are working in multiple sessions.
If you took a break, begin by realigning student thinking to the task.
What is your goal?
What process are you using to design your maglev transportation system
What is the system
What are the parts of the maglev transportation system that you are designing?
How will you know if you maglev transportation system design is successful?]

Give students 20 minutes to **create**. They will want to fiddle with the design as they build it but remind them that they have a limited time to produce their system. They will have time to modify it and record their second design during the "Improve" phase.

- Once students have their materials together, have them create their maglev system.
- Remind them to follow their design plan.

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- Test the design
  - *Did the system transport the weight?*
  - *What parts worked well? How do you know?*
  - *What didn't work*

Ask groups to share out their systems. Have a class discussion about which systems held the weight the longest and what patterns that they notice about these plans.

Looking at the solutions that everyone came up with. What were the most effective solutions and why? Create a list of improvements.

It is now time to improve. Give time for students to tinker with their system. Have them record their improved system.

Final discussion topic:
Ask students: In order for an engineer to design this maglev train, what science concepts do they need to know?
Create a list of concepts to post and for students to record.

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Resources

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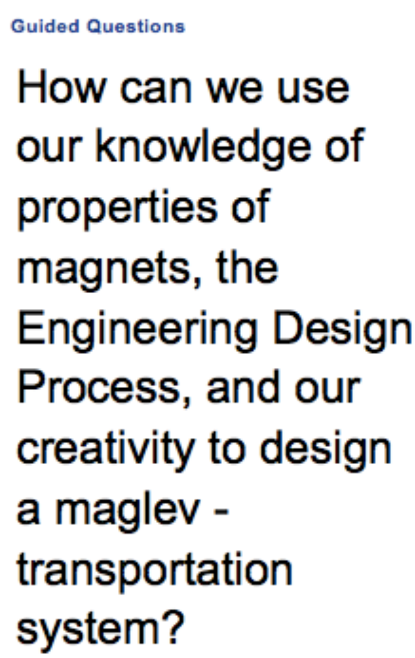

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The Engineering Design Process

Adapted from Engineering is Elementary

To solve engineering problems, engineers follow a series of steps called the "Engineering Design Process."

A Five-Step Process: Because the EiE Project serves young children, they've created a simple Engineering Design Process (EDP) to guide students through our engineering design challenges. This EDP has just five steps and uses terms children can understand.

ASK: What is the problem? How have others approached it? What are your constraints?
IMAGINE: What are some solutions? Brainstorm ideas. Choose the best one.
PLAN: Draw a diagram. Make lists of materials you will need.
CREATE: Follow your plan and create something. Test it out!
IMPROVE: What works? What doesn't? What could work better? Modify your design to make it better. Test it out!
Note that the EDP is a cycle—

Take a moment to watch one of our EiE Spotlight videos about the EDP. Visit their Video Collection for more videos and other useful video resources.

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Properties of Magnets

- All magnets have two poles
- Like poles repel
- Opposite poles attract
- Magnetic field surround magnets and can affect other objects what are within the field.
- The magnetic force of attraction and repulsion can be intensified by increasing the number of magnets (and therefore increasing the magnetic field).
- Placing non-magnetic items (such as manila folder, Styrofoam, or tape) in between magnets does not affect their magnetic fields.
- The magnetic field travels through (rather than around or is insulated by) many materials.

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Engineering Design Maglev System: Imagine

Brainstorm your plan here. Collaborate once everyone in your group completes their individual plan. Include;

- What does the maglev vehicle look like?
- How will you arrange the magnet poles to interact?
- Where will you place the magnets on the vehicle and the track?

Imagine your plan.

x class set

Engineering Design Maglev System: Team Plan

- Explain your your design to your group
- Collaborate on one.

Draw your design.

After you finish building, think about what worked and what didn't. Go around the group, what is one thing that went well.

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What is one thing you had a challenge from?

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Did your system transport weights safely? ____________

How many weights did your system transport? ________

x clas set

Engineering Design Maglev System: Improve

Make modifications and record your latest version.

Did your system transport weights safely? ____________

How many weights did your improved system transport? ___

How did you improve your system design? ____________

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Were your improvements successful? How do you know?

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What parts of your system worked well? How do you know?

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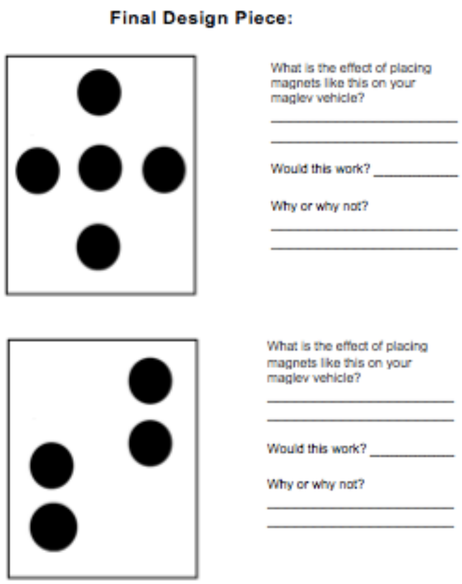
x class set



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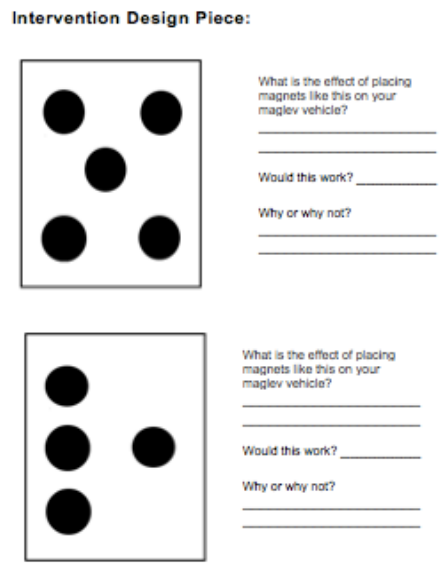

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Additional Resources

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Transrapid Maglev Video

https://youtu.be/aCEeH12Iw7w

Shanghai's Transrapid Maglev Guideway https://youtu.be/I-U7s6KpKwg

Guided Question

How can we use our knowledge of properties of magnets, the Engineering Design Process, and our creativity to design a maglev - transportation system?

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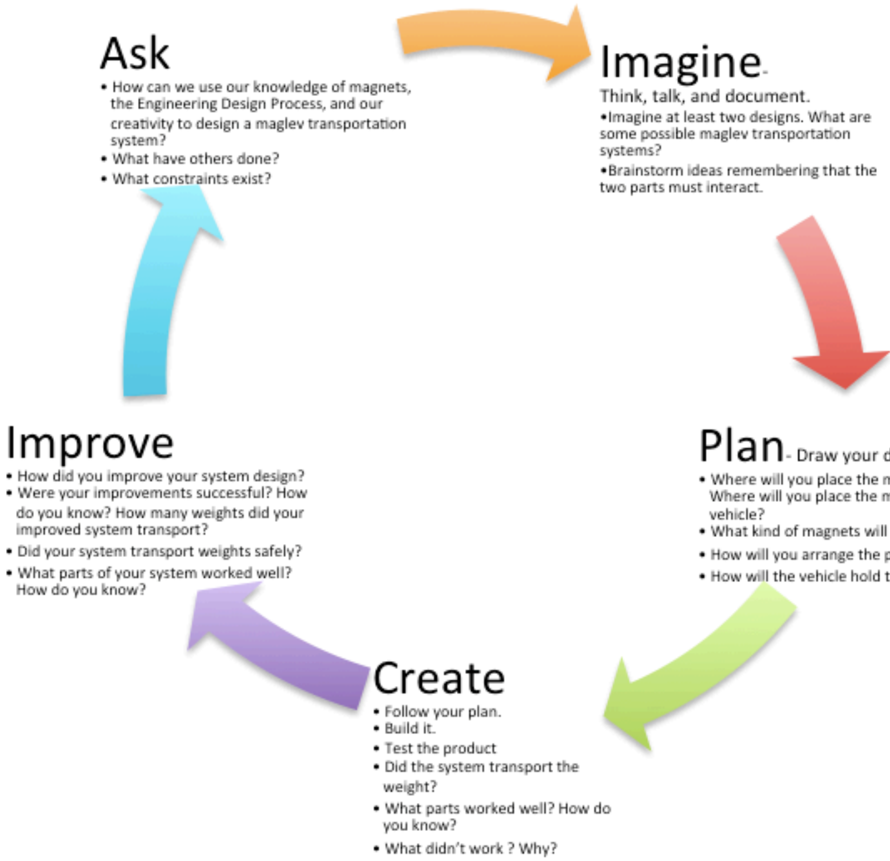

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How many weights did your improved system transport?___

How did you improve your system design? _______________

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Were your improvements successful? How do you know?

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What <u>parts</u> of your system worked well? How do you know?

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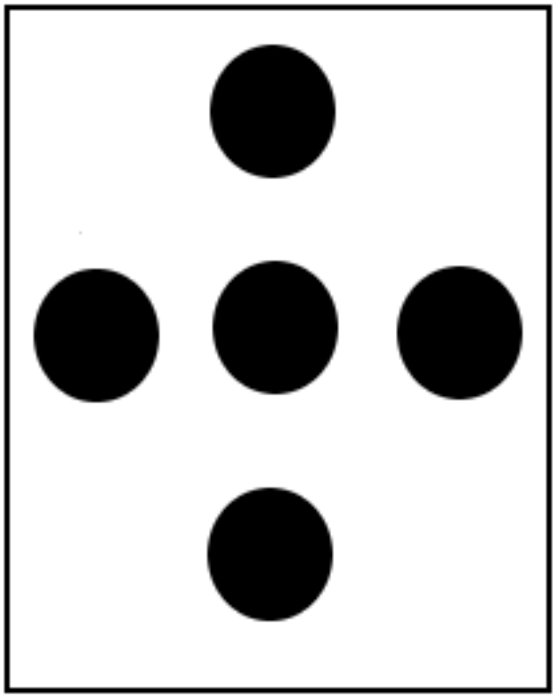
Final Design Piece:



What is the effect of placing magnets like this on your maglev vehicle?

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Would this work? ____________

Why or why not?

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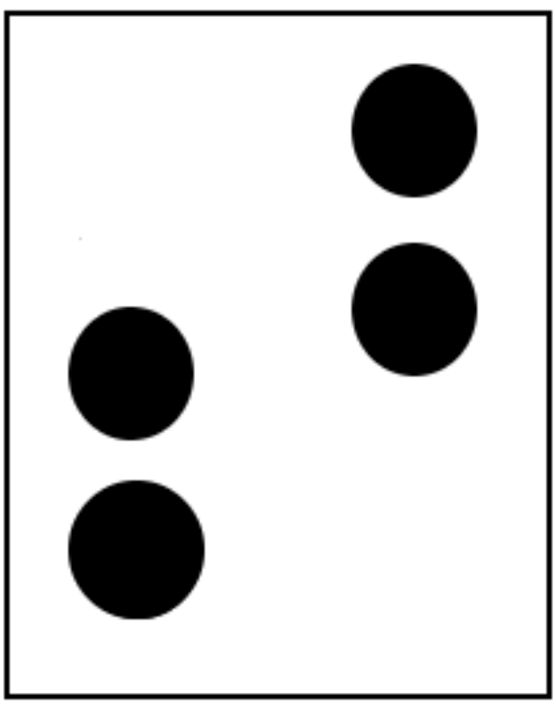

What is the effect of placing magnets like this on your maglev vehicle?

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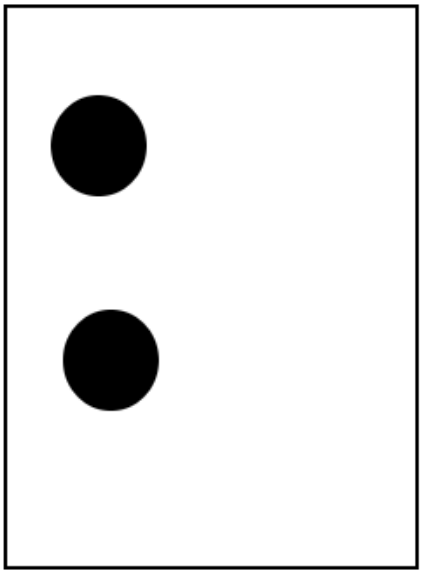
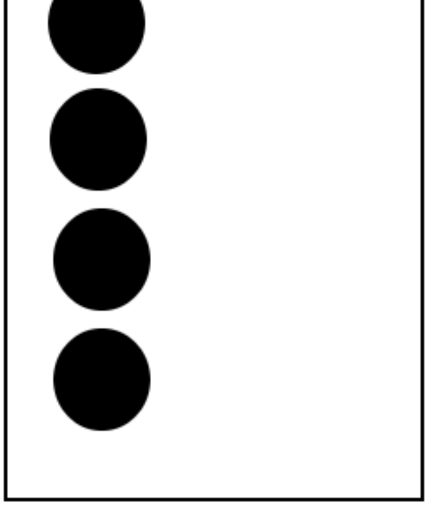


What is the effect of placing magnets like this on your maglev vehicle?

Would this work? ______

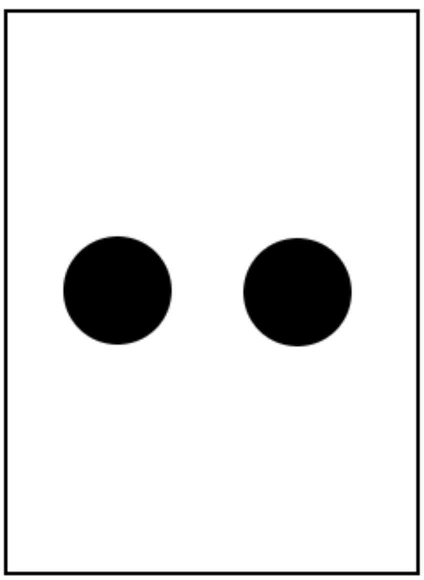
Why or why not?



What is the effect of placing magnets like this on your maglev vehicle?

Would this work? ______

Why or why not?

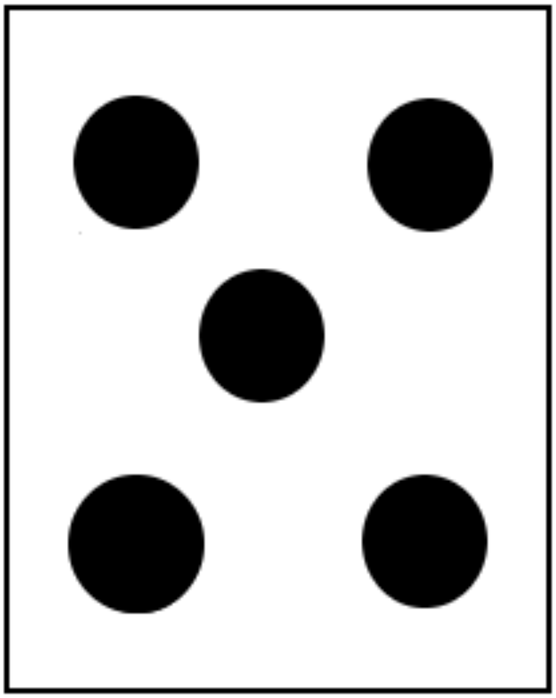


What is the effect of placing magnets like this on your maglev vehicle?

Would this work? ______

Why or why not?

Intervention Design Piece:



What is the effect of placing magnets like this on your maglev vehicle?

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Would this work? ____________

Why or why not?

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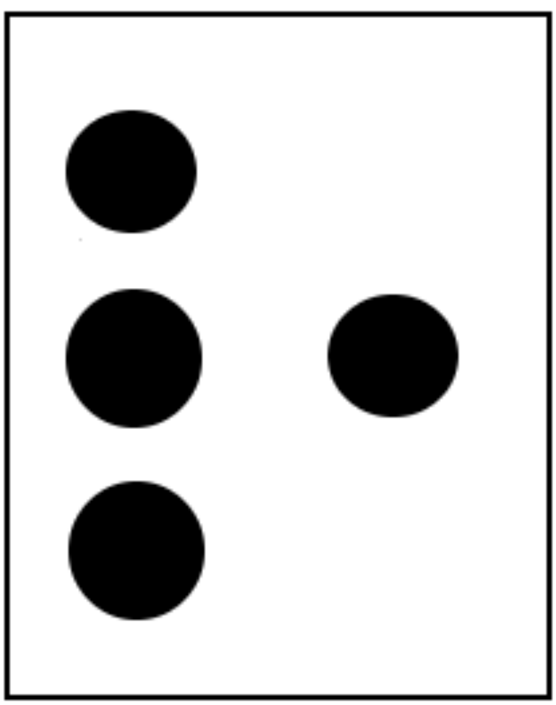

What is the effect of placing magnets like this on your maglev vehicle?

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