Maglev Train/Car

Adapted from The Attraction is Obvious: Designing Maglev Systems

Download the entire unit as a preview at
http://www.eie.org/eie-curriculum/curriculum-units/attraction-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 hands-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 begin the "ask" step of the Engineering Design Process during a previous lesson of this unit as they explore 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 build a model using the materials for trouble shooting purposes, but not for showing students. 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 a flat card.

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

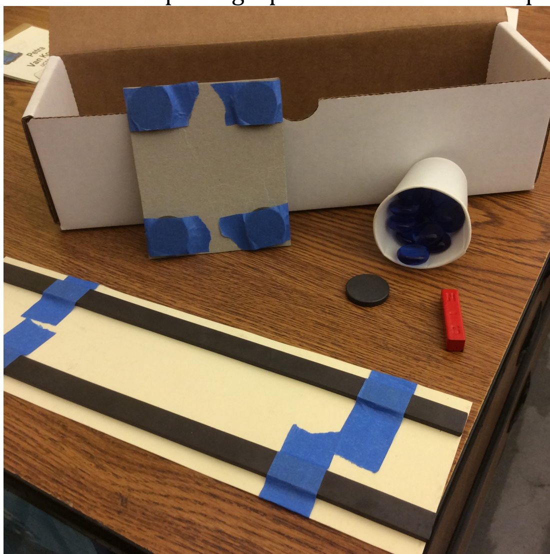
Materials Needed per group of 3 student:
1 bar magnet, with poles labeled,
2 magnets, ring, approximately 1" (2.5 cm) in length
5-7 magnets, disc, approximately ¾" (1.9 cm) in length
1 piece of high energy flexible magnet (http://zigmystermagnets.com/product-category/low-high-energy-flexible-material/flexible-magnetic-strips/page/2/), strip, approximately ½" (1.3 cm) wide, each 12" (30.5) long, or as long as the track box
1 rectangle of non-corrugated cardboard, approximately 4" x 3.5" (10.2 x 6.85 cm)
1 cups, paper, 3 or 5 ounces (88.7 to 147.9 ml)
1 Cardboard box 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
weights (pennies or glass beads)
For students with engineering experience, add a 3 x 4" rectangle, so that they have to decide which rectangle would work best.

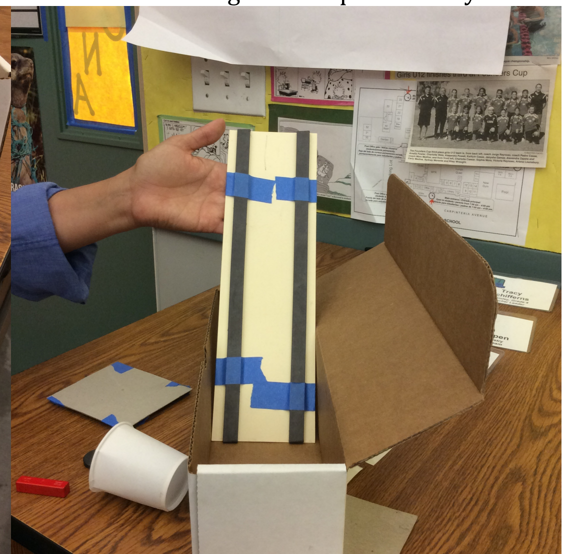
Teacher Prep:

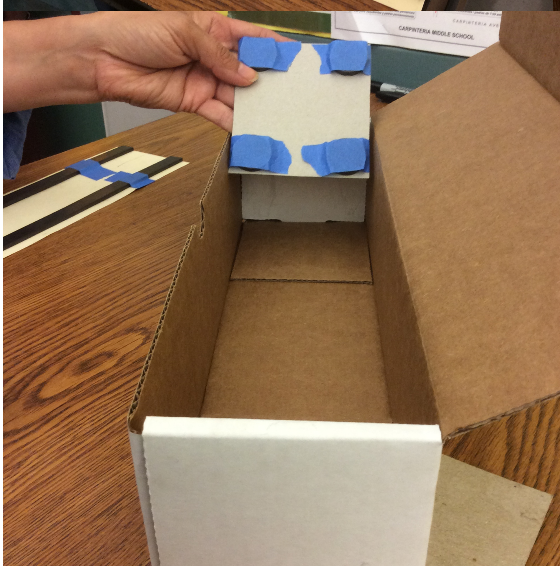
1. Teachers should read background information on maglev trains:
   Kevin Bonsor "How Maglev Trains Work" 13 October 2000.
   HowStuffWorks.com.
   <http://science.howstuffworks.com/transport/engines-equipment/maglev-train.htm>
   8 July 2016
2. Print 1: *Guided Question*
3. Print one *Design Process* 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. Fill the cardboard box with the following materials:
   1 bar magnet
   - 5 disc magnets
   - 1 paper "Dixie" size or smaller
   - 1 piece of high energy flexible magnet, strip
   - 1 insert (prepared in step 5)
   - 1 piece of non-corrugated cardboard, approximately 3 ½ x 4" square
   - 1 copy of Intervention Design Piece

Note: Design pieces were made at http://drawisland.com/#drawing

See the photographs below for an example of a successful maglev transportation system.

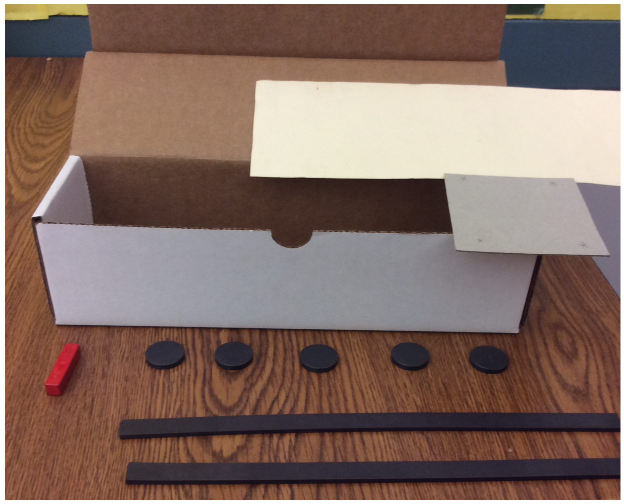






20 minutes	Have students seated in groups of 3 **Phenomenon:** Distribute a pencil and two ring magnets. Ask student to make the magnets interact. Students should demonstrate repulsion and/or attraction. Ask students: “How can we get the magnets to repel?” and “What do we need to do to get the ring magnets to levitate?” Can they locate the poles 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 “Is possible to identify the north or south poles on a ring magnet? 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 make a card levitate above magnet strips, so that the card will freely move back and forth above the track?* Tell students that they have an opportunity to design their own maglev transportation system- Just as they have in Japan. Show a picture of a maglev train or a short maglev video. 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 via levitation 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. · 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. · Display the "The Engineering Design Process" on a projector. 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. Lay materials out on a front table. Show students each of the materials that they will have access to and ask them what property the material possesses. Do not distribute the materials yet. • 1 bar magnets • 5 or 7 disc magnets (students may use fewer) • 1 paper cup and weights • 2 pieces of high energy flexible magnet, strip long enough to fit the box

	• 1 piece of manila folder to fit in side the track box (insert) • 3 ½ x 4" rectangle of 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. First, they will design their own and then they will collaborate with a team. **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? Note: You may want to share a short video so that students know what a Maglev train is but do not share details about how they work. • What constraints exist? Distribute one bag or box 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. **Imagine:** Students individually complete the imagine sheet using the prompts below • 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? **Plan:** Ask students to share their design and discuss the above questions with a group of 2-4 students. Distribute the materials and only hand out weights when students have successfully made their card levitate about the track. As a group review the best thought out design pieces. As a team, have students list the materials used and draw a picture of the panel on the "Engineering Design" Team Plan 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 reminding student thinking to the task.* *What is your goal? (Expected Response: We will make a vehicle that will levitate across a space without tipping)* *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?]* After students have a team plan, 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. • They may use their hands to start the vehicle but then the vehicle should move on its own. • Remind them to follow their design plan. • Test the design • *Did the system transport the weight?* • *What parts worked well? How do you know?* • *What didn't work* Teacher Note: If students get stuck, use the "Intervention piece" with their individual group". Remind them that they need to use their knowledge of parallel lines, alignment, balanced and unbalanced forces in order to make the vehicle move. They need to use their knowledge of magnets as listed in the poster for example, Sometimes students flip magnets or add magnets to the track, which will add places with stronger magnetic fields along the They need to reflect on the process and write in their thoughts before they forget on the "team plan" page. Ask groups to share out their systems. Have a class discussion about which systems held the weight the longest and what patterns they noticed. 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. Have students to record.

Resources

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Guided Question

How can we make a card levitate above magnet strips, so that the card can freely move back and forth above the track?

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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.
• A magnetic field surrounds a magnet 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.

x1 (for posting)
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Engineering Design Maglev System: Imagine

On your own, brainstorm your plan here. Can you design a maglev transportation system?

Remember and consider:

• Your track will be designed so it fits in the bottom of the box.
• Which magnets might be used to create your track ?
• How will you place the magnets so that they will repel a vehicle?
• Where will you place the magnets on the vehicle so it levitates?

Imagine and create your personal plan here.

Draw arrows to show repulsion or attraction.

x class set
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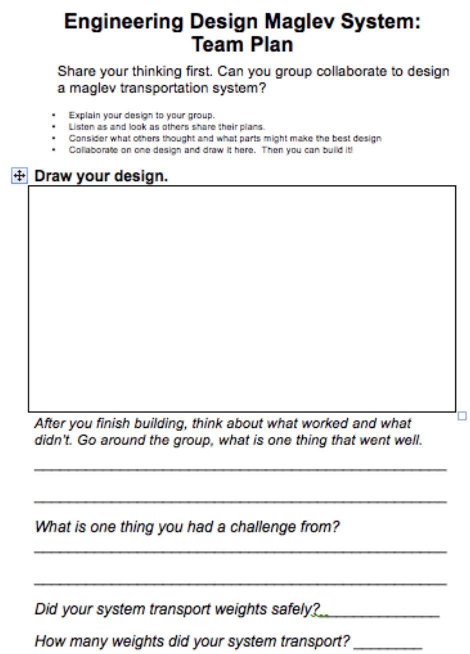

Engineering Design Maglev System: Team Plan

Share your thinking first. Can you group collaborate to design a maglev transportation system?

- Explain your design to your group.
- Listen as and look as others share their plans.
- Consider what others thought and what parts might make the best design
- Collaborate on one design and draw it here. Then you can build it!

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.

What is one thing you had a challenge from?

Did your system transport weights safely?

How many weights did your system transport?

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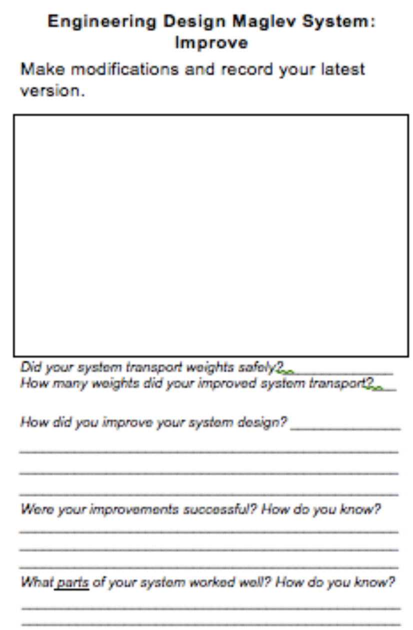

Engineering Design Maglev System: Improve

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?

Were your improvements successful? How do you know?

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

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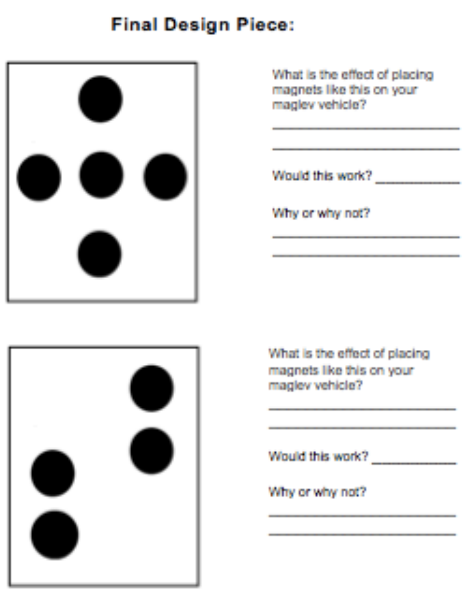

Final Design Piece:

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

Would this work?

Why or why not?

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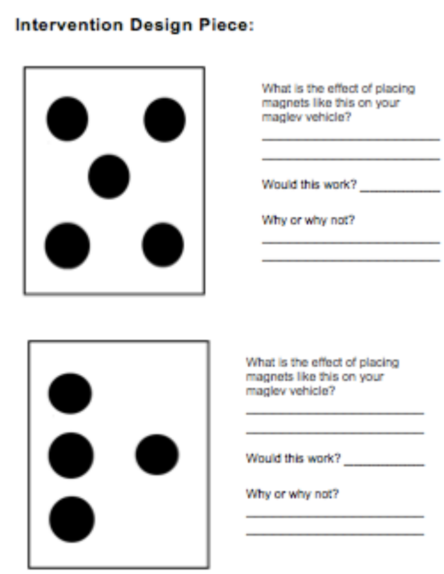

Intervention Design Piece:

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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/l-U7s6KpKwg

Guided Question

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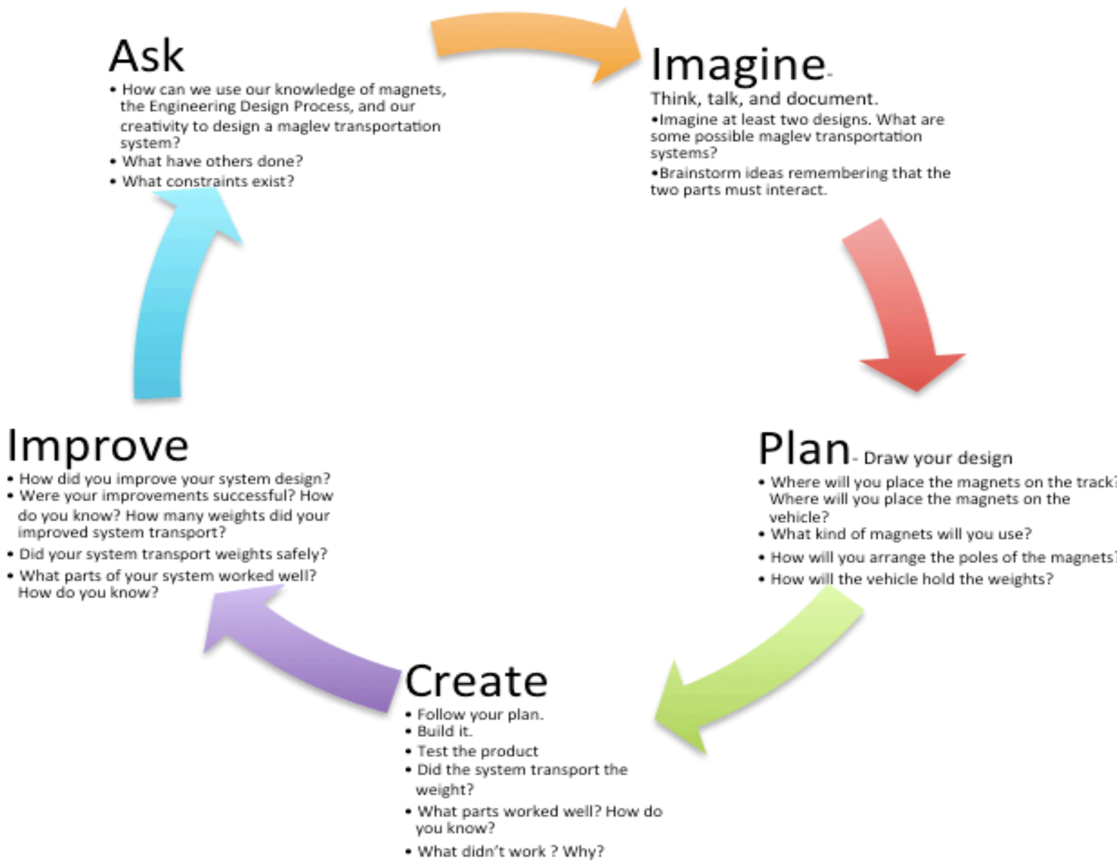

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*Did your system transport weights safely?*_______________

How many weights did your system transport? _________

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Have a class discussion. Make modifications and record your latest version here.

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*How many weights did your improved system transport?*___

How did you improve your system design? ______________

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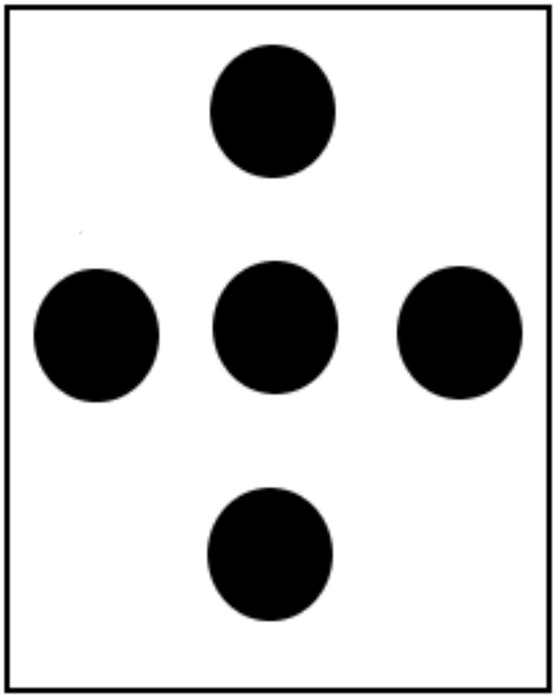
Final Design Piece:



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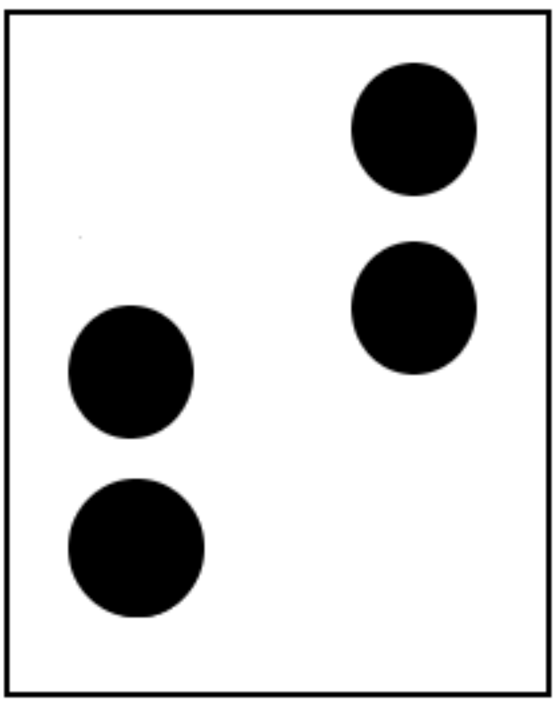

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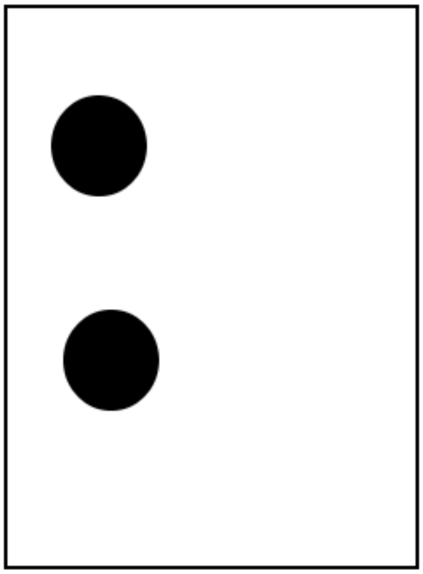

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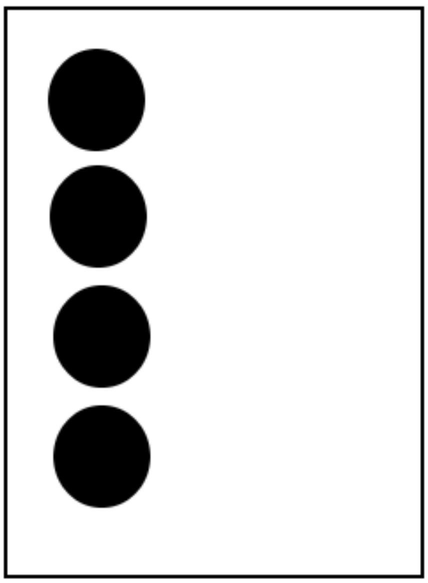

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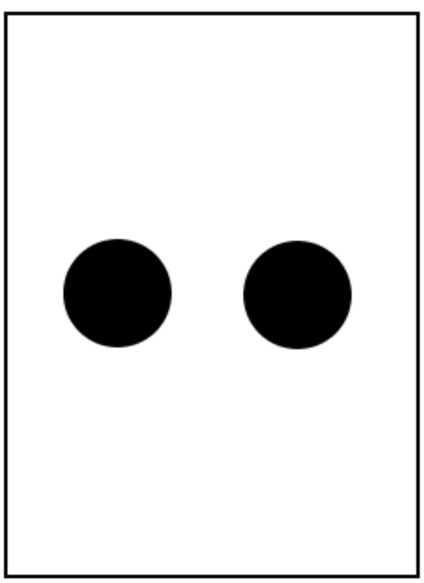

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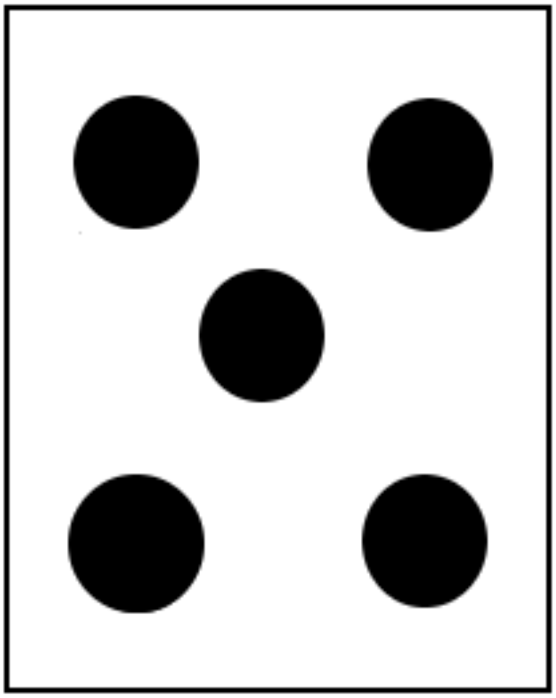

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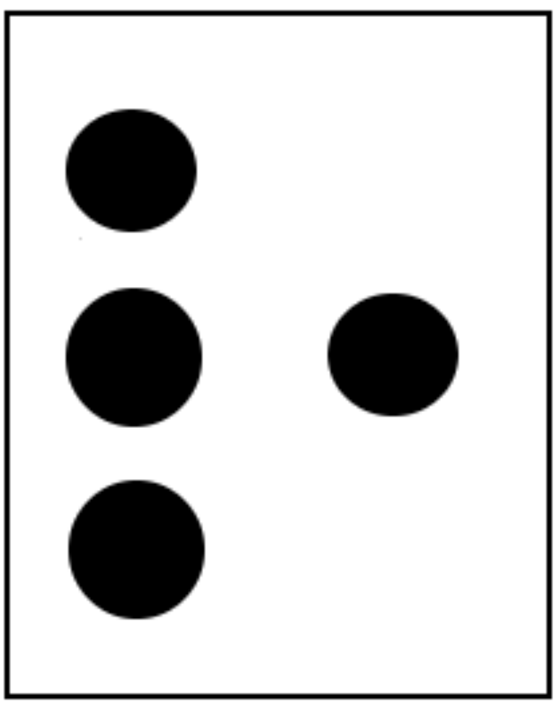

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