

MACGILLIVRAY FREEMAN'S
**DREAM
BIG**
ENGINEERING OUR WORLD

GRADE 3:

MAGLEV TRAIN



Grade level: 3

Lesson length: 85 minutes

Most forms of transportation rely on fuels that come from oil, called fossil fuels. This type of fuel can be expensive because it comes from a source that is not renewable (the less there is of it, the more precious it is, and the more expensive it becomes). Fossil fuels can threaten our environment because they must be extracted from the earth and they pollute our air.

Thus, engineers are working to make transportation systems more green. Students will learn about one method as they design a train that can move three feet without making physical contact with the track. Magnetism provides the force required to levitate the train over the tracks, reducing the energy required to move the train.

In the Film

Transportation in the modern world is becoming a challenge as the population continues to grow beyond the capacity of the highways that once allowed civilization to flourish and expand. Today's engineers are working on new innovations, like bullet trains and the futuristic Hyperloop, to move people and goods more quickly, more safely, and with less dependence on fossil fuels.

NGSS Disciplinary Core Ideas

3-ESS3-1 Crosscutting Concepts

Influence of Engineering, Technology, and Science on Society and the Natural World

Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks (fossil fuel consumption), and meet societal demands (greater mass transit).

NGSS Engineering Practices

3-PS2-3 Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.

3-PS2.B Types of Interactions

Objects in contact exert forces on each other.

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.

Dream Big: Engineering Our World is a film and educational project produced by MacGillivray Freeman Films in partnership with the American Society of Civil Engineers and presented by Bechtel Corporation. The centerpiece of the project is a film for IMAX and other giant screen theaters that takes viewers on a journey of discovery from the world's tallest building to a bridge higher than the clouds and a solar car race across Australia. For a complete suite of *Dream Big* hands-on activities, educational videos, and other materials to support engineering education, visit discovere.org/dreambig. The *Dream Big* Educator Guide was developed by Discovery Place for the American Society of Civil Engineers. ©2017 American Society of Civil Engineers. All rights reserved. Next Generation Science Standards ("NGSS") is a registered trademark of Achieve. Neither Achieve nor the lead states and partners that developed the Next Generation Science Standards were involved in the production of this product, and do not endorse it.

Key Words/Vocabulary

Fossil fuel: An energy source that is produced through the million-year decomposition of dead organic material, such as trees and animals.

Attractive force: A force that attracts objects toward each other.

Repelling force: A force that pushes two or more objects away from each other.

Magnetic force: The attractive or repulsive force that exists between two bodies that contain a magnetic charge.

Materials

Per class:

- ☐ Track Assembly Instructions sheet
- ☐ Track template
- ☐ Video capture device (optional)

Per student:

- ☐ Bar or disc magnets
- ☐ Paper

Per group:

- ☐ Paper
- ☐ Pens or pencils
- ☐ Cardstock paper
- ☐ Scissors

- ☐ 6 inches of magnetic tape
- ☐ 4 disc magnets
- ☐ 4 bar magnets
- ☐ 1 foot of tape
- ☐ Washers for weight during testing
- ☐ Preassembled train track:
 - ☐ Cardboard
 - ☐ Track template
 - ☐ Scissors or box cutter
 - ☐ Strong tape
 - ☐ Magnetic tape
 - ☐ Glue gun or glue

Teacher Prep Notes

Preassemble track segments beforehand. You will find a template for tracing with the Track Assembly Instructions sheet (included later in this lesson plan). You can build just a couple as a class set for testing or build one track per group. The tracks are reusable.

Cheap and varied magnets can be sourced online from common vendors like Amazon or from your local craft store.

Be prepared to discuss how magnets work. You will also give a basic overview of how the maglev train in Japan uses magnets to float and accelerate trains. (For quick reference: web-japan.org/kidsweb/hitech/maglev).

To Do

Determine the Problem or Question to Solve: 15 minutes

1. Before watching the IMAX movie *Dream Big*, give students an overview of what they are about to experience. This film is about engineering and the ways that engineering can inspire, challenge, and enrich our lives. Give students the following questions to think about as they watch the film:
 - How is transportation shown and talked about in the film?
 - What role do engineers play in shaping our future modes of transportation?
 - What are some of the trends you see with future transportation?
2. Debrief as a whole class after viewing the film. Allow students to reflect on the guiding questions you gave them.
3. If necessary, remind students of some of the current challenges we face regarding transportation. These include too many vehicles on the roads, which causes traffic; safety concerns; and using fossil fuels, which pollute the air, water, and ground.
4. Introduce the design challenge. Sixty years ago, there weren't nearly as many people as there are today. When suburban neighborhoods were built around a city center, people could comfortably and safely travel back and forth to work each day. But as populations have increased, so have the number of cars on the road. Today we face long commutes in slow traffic, back and forth between our jobs and homes. Unfortunately, some public transportation services, like buses, are bogged down with the same challenges. Engineers are working now to develop solutions to these challenges. One of the methods of transportation being reimagined is trains. Imagine a train that can travel incredibly fast, yet be safe and consume very little energy from fossil fuel sources—or none at all. Today you will reimagine the way trains work and the potential they may have as a future form of public transportation.

Research and Gather Information: 20 minutes

1. First, give students time to experiment with magnets. Have bar or disc magnets available. Ask students to arrange the magnets so that they can hold a piece of paper in between them. Then ask the students to arrange the magnets so that they push away from each other. Explain the concepts of magnetic force having a negative and positive end (magnetic polarity). Demonstrate the repulsion of positive-positive and negative-negative interactions and the attraction of positive-negative interactions.
2. Students should attempt to float or hover an object with the bar or disc magnets. Note the challenges of doing this. The magnets will flip over so that the opposite sides attract and attach to each other, for example, or the magnets will fly away to the side rather than stay suspended.
3. Give a basic overview of how the maglev train in Japan uses magnets to float and accelerate trains. (For quick reference: web-japan.org/kidsweb/hitech/maglev).



Plan a Solution: 15 minutes

If students are unfamiliar with the concepts of criteria and constraints in engineering, take the time now to introduce these two key ideas. Engineers look at challenges through the lens of criteria (what does my device have to do?) and constraints (what are the limitations I face in making, testing, and using the device?). Spend some time as a whole class brainstorming the criteria and constraints of this particular engineering challenge.

Divide students into groups of three. Give each group a preassembled track and basic train platform (the piece of cardstock). Based upon their experimentation and research, tell groups to design and draw a magnet configuration that they believe will allow the train to float along the track. Give students a variety of options to choose from for magnetic materials, such as disc magnets, magnetic tape, and bar magnets.

Make It: 15 minutes

Instruct students to assemble the train and test it on the track. They should start building according to their plan, but they should not be surprised if they have to keep experimenting in order to create a functional floating train. Visit each group and review how their experiments shaped their overall design and plan. If students are making mistakes, let the mistakes happen. Avoid offering solutions; instead, encourage students to keep trying and allow their ideas to evolve.

Test: 15 minutes

To test their trains, have each group float their device along the track. Allow students to add washers, one at a time, to see how much weight their train can hold. Optional: make videos of the different tests to compare the trains afterward.

Evaluate: 10 minutes

Ask students to reflect on the following questions, and talk about their responses as a class:

1. Did your train float magnetically?
2. Was your train able to carry any washers?
3. What part of your design contributed to its successes?
4. What part of your design contributed to its failures?
5. What could you change to make your train better able to carry a heavy load?



Taking It Further

Allow students to reiterate and create a new design that they feel addresses the failure point of their previous design, and then test the new design.

Explore how civil engineers are overcoming transportation issues (mountains and inclement weather) by designing and building new tunnels like Switzerland's Gotthard train tunnel that opened in 2016.

Watch YouTube videos about magnetic tracks/trains and their capabilities.

Document your students' work through our social media outlet: #dreambigfilm

TRACK ASSEMBLY INSTRUCTIONS

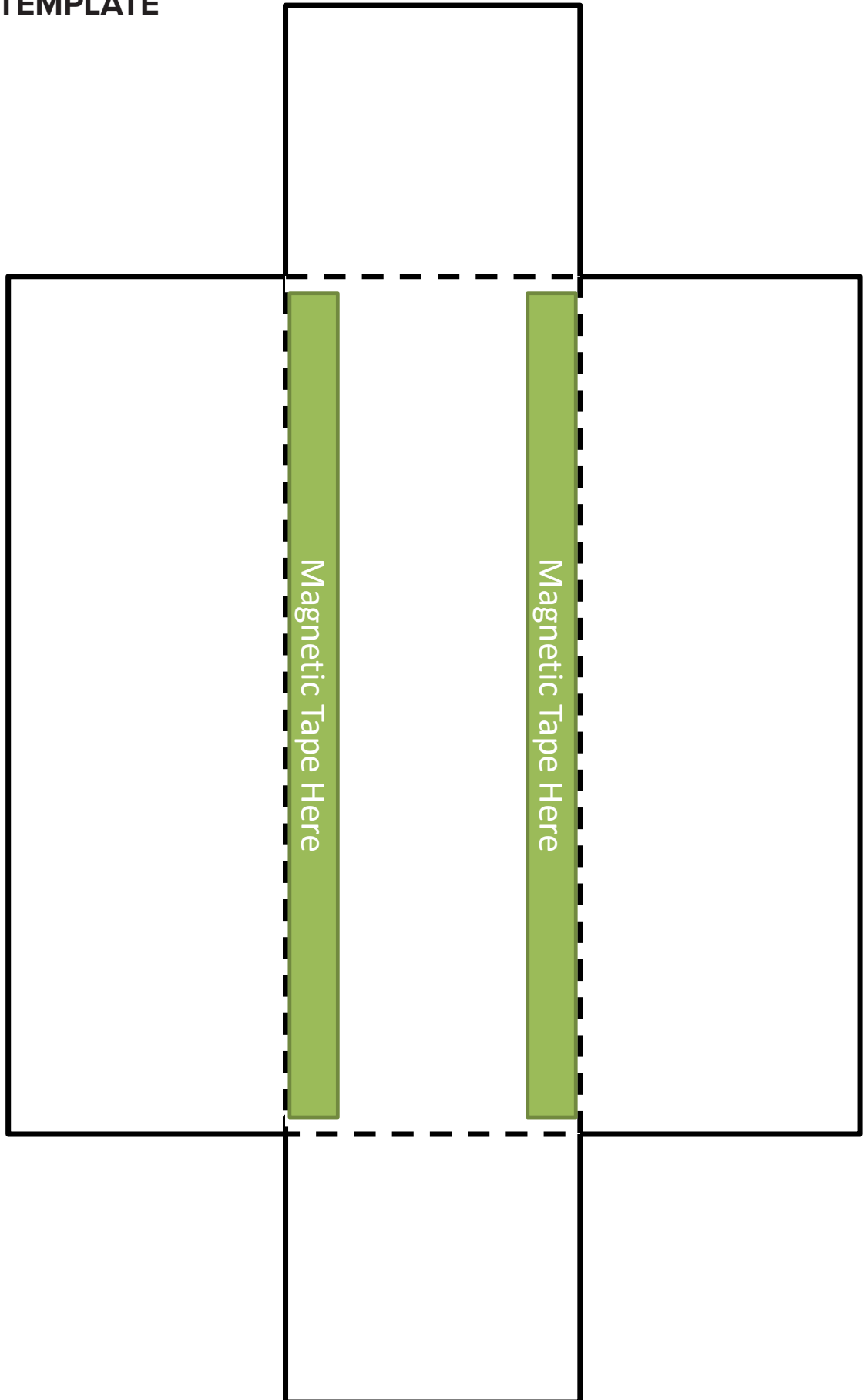
Obtain cardboard. Use the template (included as a separate sheet) for exact dimensions. Trace the cut lines with scissors or a box cutter. Fold the cardboard along the dotted lines. Tape the sides together with strong tape.

On either long side of the track, measure out a length of magnetic tape that would run from end to end. Use a glue gun to glue down the magnetic tape along the leftmost and rightmost sides of the top of the track.

Give students a piece of cardstock paper cut to the size of the width of the track. This will serve as the “train” for them to tape magnets onto in order for the train to float suspended above the magnetic tape on the track.

Hints: If you would like, you can have students create an actual train boxcar to place on top of the cardstock. Another option is to place an empty paperclip box on top of the cardstock and allow students to add washers, one at a time, to see how much weight their floating magnetic train can hold.

TRACK TEMPLATE



DREAM BIG VIDEO SERIES ***WATCH WHO'S IN THE DRIVER'S SEAT: AUTONOMOUS VEHICLES***

Go behind the scenes at Google X and other companies to discover how self-driving cars are engineered. Meet the teams who love the creative problem solving this challenge requires. Go to discovere.org/dreambig/media-assets and visit Educational Webisodes.

