Mystery science

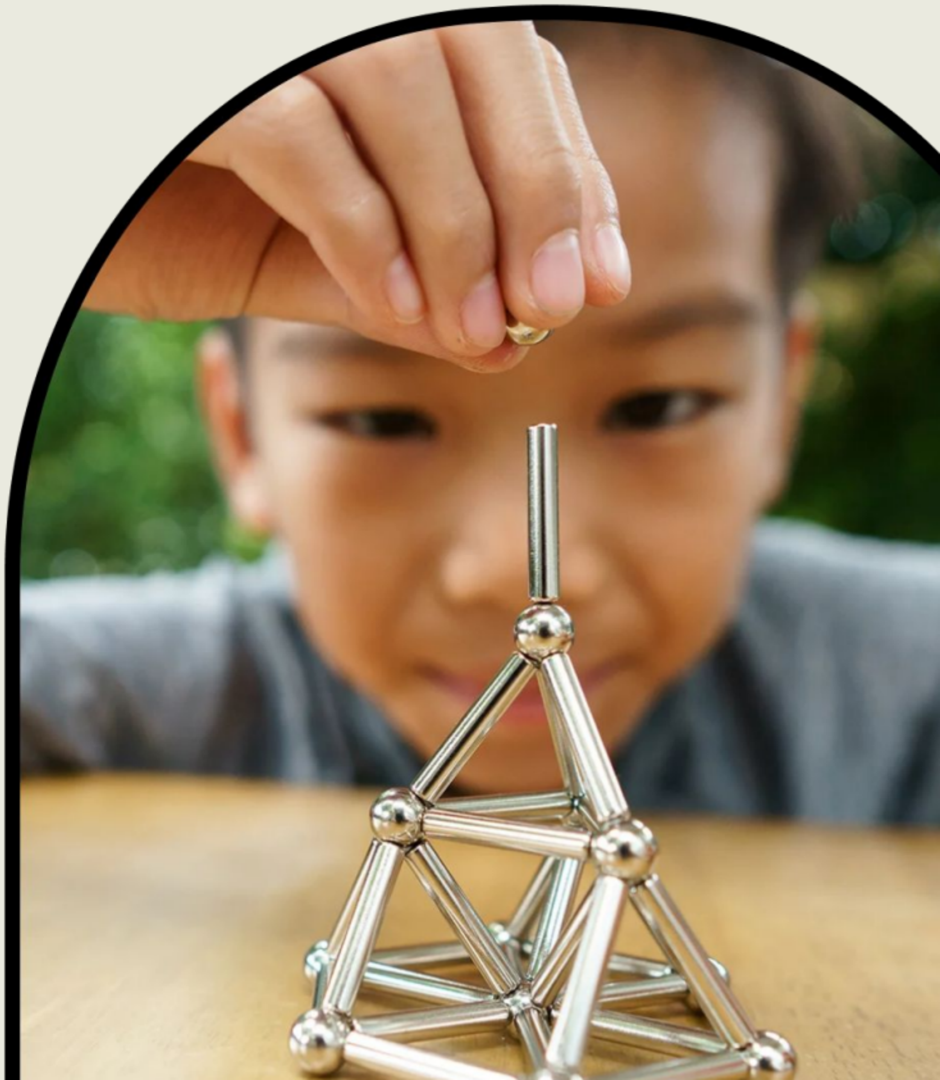
Anchor Layer Teacher Guide

A curriculum companion for Anchor Layer users

Grade 3

Forces, Motion, & Magnets

Unit Web Link • Pacing Guide • Other Units



Unit Summary

In this unit, students explore the forces all around them. They investigate the effects of balanced and unbalanced forces, the pushes and pulls of bridge structures, and the effects of gravity and friction on the motion of objects. Students also explore the power of magnetic forces and design solutions to everyday problems using their knowledge of these forces. Assessments

Performance Expectations	**Science & Engineering Practices**	**Disciplinary Core Ideas**	**Crosscutting Concepts**
• 3-PS2-1. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object. • 3-PS2-2. Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.. • 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-PS2-4. Define a simple design problem that can be solved by applying scientific ideas 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. • 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. • 3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.	• Planning and Carrying Out Investigations • Developing and Using Models • Asking Questions and Defining Problems • Constructing Explanations and Designing Solutions	• PS2.A: Forces and Motion • PS2.B: Types of Interactions • ETS1.A: Defining and Delimiting Engineering Problems • ETS1.B: Developing Possible Solutions • ETS1.C: Optimizing the Design Solution	• Structure and Function • Cause and Effect • Patterns

Forces, Motion, & Magnets Lesson Flow on Next Page

Forces, Motion, & Magnets Lesson Flow

Anchor Phenomenon

Forces & Engineering
Ice Board

Lesson 1

Balanced & Unbalanced Forces How could you win a tug-of-war against a bunch of adults?

Anchor Connection

Lesson 2

Balanced Forces & Engineering
What makes bridges so strong?

Anchor Connection

Lesson 3

Patterns of Motion, Gravity, & Friction
How high can you swing on a flying trapeze?

Anchor Connection

Lesson 4

Magnets & Forces
What can magnets do?

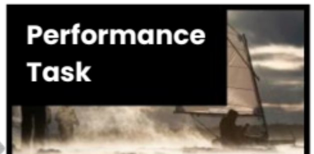
Anchor Connection

Lesson 5

Magnets & Engineering
How can you unlock a door using a magnet?

Anchor Connection

Performance Task



Forces, Engineering
Can you design a new ice board?

Anchor Phenomenon Background

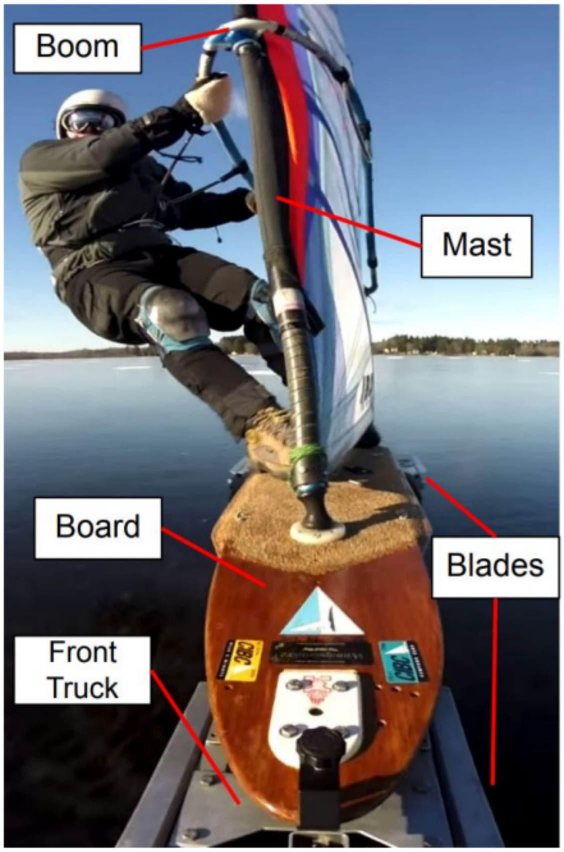
How does the ice board work?

A regular skateboard relies on a human to push it along. Wheels make it move more easily by reducing friction. What would happen if we could reduce the friction even further and we could give it a harder push than any human can provide?

Reducing Friction

The metal skating blades under the board take the place of the wheels that would be on a normal skateboard. They are just like the blades on ice skates. The blades slide very easily forward and backward, but dig in if they are pushed sideways.

The blades are held together to one another and to the board by trucks.



A Stronger Forward Pushing Force

Skateboards are powered by the rider pushing forward; the ice board is powered by the wind!

Sails work the same way that the wing on an airplane does. As air blows over an airplane wing, the air forces the wing up. Sails are like a sideways wing. As air blows over a sail, the air forces the sail diagonally forward and sideways. The rider is always in a tug-of-war with the air that is pushing the sail forward and sideways; this is why the rider has to lean backward and to the other side.

If the blades could slide diagonally on the ice, the board would move diagonally. However, they only easily move forward, so that's the main direction the board moves.

Anchor Phenomenon: Ice Board
Forces & Engineering

Anchor Phenomenon
10 mins

Guided Inquiry
15 mins

Hands-On Activity
10 mins

Wrap Up
2 mins

Anchor Phenomenon Lesson Overview

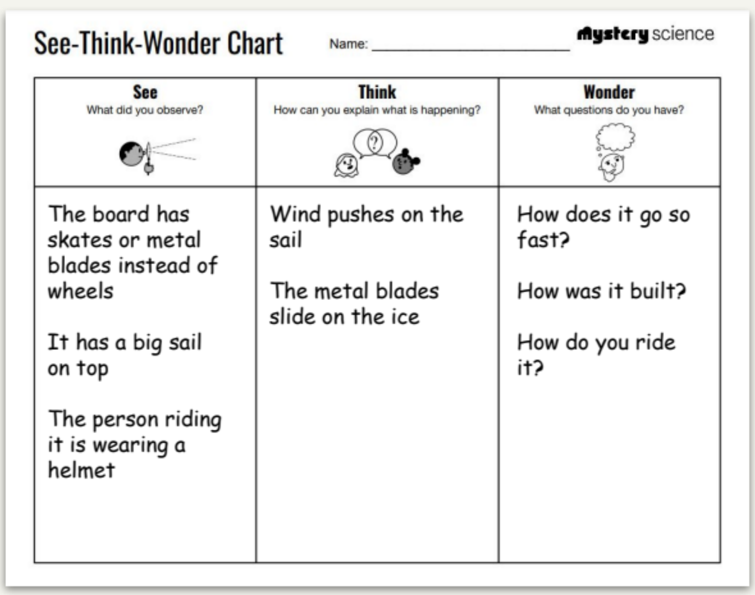
Note: This lesson is part of this unit's Anchor Layer. If you have the Anchor Layer turned on, we recommend teaching all lessons in the remainder of this unit in order.

The anchor phenomenon for this unit is a skateboard that has been modified to work on ice and be powered by the wind.

During the introduction, students generate observations and questions about the phenomenon and create an initial conceptual model to explain how the ice board works.

Student Work Samples & Notes

Students will gather clues during and after each lesson in this unit to help them improve their explanation. It is important to encourage students to recognize that even if they don't know the perfect answer yet, they are going to learn a lot throughout the unit and will have an opportunity to change or add to their first explanation.



See-Think-Wonder Chart Name: ____________ mystery science

See What did you observe?	Think How can you explain what is happening?	Wonder What questions do you have?
The board has skates or metal blades instead of wheels It has a big sail on top The person riding it is wearing a helmet	Wind pushes on the sail The metal blades slide on the ice	How does it go so fast? How was it built? How do you ride it?

Lesson 1: How could you win a tug-of-war against a bunch of adults?
Balanced & Unbalanced Forces (pg 1 of 2)

Exploration
20 mins

Hands-On Activity
45 mins

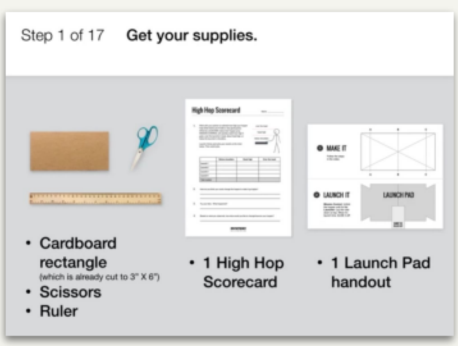
Anchor Connection
15 mins

Assessment
20 mins

Overview

In this lesson, students will see that by learning to think about pushes and pulls — forces — they can accomplish extraordinary things!

In the activity, Hopper Popper, students make a folded piece of cardboard jump high in the air, propelled by the pulling force of a rubber band. They discuss the forces involved in making this "Hopper Popper" jump.



Activity Notes

In this activity, each student will make their own Hopper Popper, but we suggest they work in pairs when they launch their poppers. Some teachers choose to have students wear safety glasses for this activity since Hopper poppers can hop high!

Supplies for Open-Ended Exploration (Optional):
At the end of the activity, we suggest that students change one variable to see how this affects their Hopper Popper. For this open-ended exploration, we have included extra chipboard, construction paper, and extra rubber bands of different thicknesses. The Teacher Tips printout will help you guide students during this open-ended exploration.

Anchor Connection on Next Page

Lesson 1: How could you win a tug-of-war against a bunch of adults?

Balanced & Unbalanced Forces (pg 2 of 2)

Exploration
20 mins

Hands-On Activity
45 mins

Anchor Connection
15 mins

Assessment
20 mins

Anchor Connection

Pushes and pulls cause things to move.

When the wind blows, the sail catches the wind's push. The person riding the ice board is in a tug-of-war with the sail. Just like in the tug-of-war in this lesson, the rider's feet push forward when they pull back on the sail. This forward push from the rider's feet is what makes the board move forward.

Students revisit the explanation and/or drawing that they worked on during the Anchor Phenomenon. They should understand that the person riding the ice board applies pushes and pulls to the ice board to work against the wind and make the board move.

Students can revise their explanation and/or drawing by adding in arrows showing the rider pulling the sail back, and the air pushing the sail forward (if you want to be detailed, have the students make the length of the arrows equal to show that the strength of each force is equal). Students may also add arrows showing the rider pushing the board forward with their feet.

Connecting Storyline Question

How is the person riding the board able to keep holding it?

Lesson 2: What makes bridges so strong? (pg 1 of 2)
Balanced Forces & Engineering

Exploration
22 mins

Hands-On Activity
30 mins

Anchor Connection
15 mins

Assessment
20 mins

Overview

In this lesson, students will learn about real-life bridge design.

In the activity, Paper Bridge Engineering, students will use their knowledge of forces to build a strong bridge that supports as many pennies as possible -- using only paper.

Activity Notes

We suggest students work in pairs.

Prepare With Some Engineering Inspiration:
We recommend you watch this video of Doug & Pat from the Mystery Science team modeling how to build and improve a bridge. If your students get stuck, you can use this video for inspiration. Our Teacher Tips printout also provides suggestions for guiding students when they are building bridges.

Anchor Connection on Next Page

Lesson 2: What makes bridges so strong? (pg 2 of 2)
Balanced Forces & Engineering

Exploration
22 mins

Hands-On Activity
30 mins

Anchor Connection
15 mins

Assessment
20 mins

Anchor Connection

Some materials (such as ropes) are strong when being pulled, but very weak when being pushed. Some materials (such as the sand underneath roads) are very strong when being pushed but very weak when being pulled. Some materials (such as steel) are strong both when being pushed and pulled.

One of the jobs of scientists and engineers is to choose the right material for the right job.

Students revisit the explanation and/or drawing that they worked on during the Anchor Phenomenon. They should understand that certain materials on the ice board help the person riding it to push or pull in certain ways to make it move.

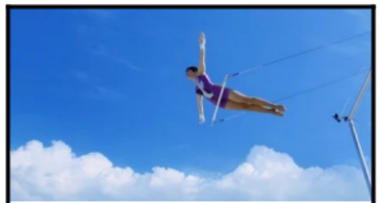
Students can revise their explanation and/or drawing by adding where the special ropes are that attach to the ice board rider's waist.

Connecting Storyline Question

How is the ice board able to move so fast?

Lesson 3: How high can you swing on a flying trapeze?

Patterns of Motion, Gravity, & Friction (pg 1 of 2)



Exploration
10 mins

Hands-On Activity
35 mins

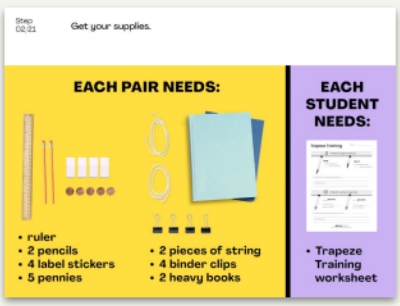
Wrap-Up
15 mins

Anchor Connection
20 mins

Overview

In this lesson, students investigate the patterns of motion exhibited by a trapeze.

In the activity, Trapeze Tester, students build a model trapeze. They make observations and take measurements of the motion of that model and use that data to predict the motion of a real trapeze.



Activity Notes

We suggest students work in pairs.

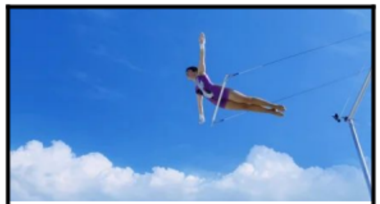
The trapeze model will need to hang from the side of a desk or table. We suggest that students move their chairs and sit or kneel on the floor to be able to more closely observe the movement of the model.

Cut the string so that each piece is about 2 feet (~61 cm) long. Each pair of students will need two pieces of string.

We suggest building one of the trapeze models prior to student testing to ensure that your materials work together. If the string is too thick, the suggested binder clip size won't be able to hold these in place. You may need to adjust the type of string you use or you can try using larger binder clips.

Anchor Connection on Next Page

Lesson 3: How high can you swing on a flying trapeze?
Patterns of Motion, Gravity, & Friction (pg 2 of 2)



Exploration
10 mins

Hands-On Activity
35 mins

Wrap-Up
15 mins

Anchor Connection
20 mins

Anchor Connection

Friction is one of the keys to making the ice board work well. The runners (the metal blades on the ice) are designed to have as little friction as possible when moving forward.

The boom that the rider holds onto and the board where the rider stands are both designed to have as much friction as possible.

Students revisit the explanation and/or drawing that they worked on during the Anchor Phenomenon. They should understand that for the ice board to work, it needs to have very high friction in some places, and very low friction in others.

Students can revise their explanation and/or drawing by adding where the friction should be high:

- Between boots and the board
- Between gloves and the handle

And adding where the friction should be low:

- Between the blades and the ice

Connecting Storyline Question

Could the ice board be used to take a long trip?

Lesson 4: What can magnets do? (pg 1 of 2)
Magnets & Forces

Exploration
1 min

Hands-On Activity
25 mins

Wrap-Up
14 mins

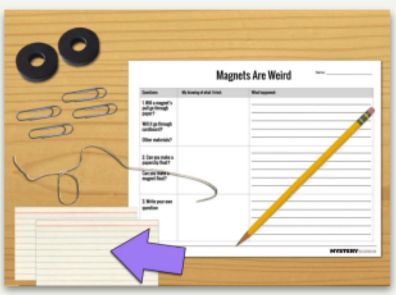
Anchor Connection
20 mins

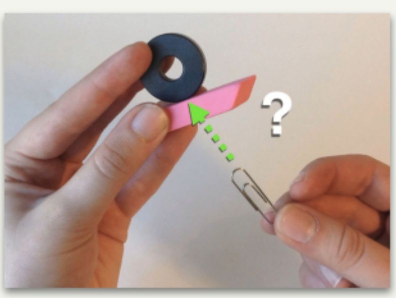
Assessment
20 mins

Overview

In this lesson, students will explore the surprising properties of magnets and experiment with an invisible force that acts at a distance.

In the activity, Magnet Discovery, students use ring magnets and common objects to discover the push and pull of magnets and how magnets attract certain types of metals.





Activity Notes

The test items should include some metals that are attracted to magnets, some metals that are not, and some non-metal items. At a minimum, students should examine one item from each of these categories. You may want to set up a test item station so that students can explore multiple items from each category.

Before class, cut up the string so that each student can have some for their experiments.

Teacher Tip

Magnets are fragile, so be careful. If you smack them against each other too hard, they will break. We trust you'll be gentle with them, but just in case, it can't hurt to wear safety goggles

Anchor Connection on Next Page

Lesson 4: What can magnets do? (pg 2 of 2)
Magnets & Forces

Exploration
1 min

Hands-On Activity
25 mins

Wrap-Up
14 mins

Anchor Connection
20 mins

Assessment
20 mins

Anchor Connection

In the anchor connection, students will complete a reading about compasses.

This lesson gives students an opportunity to explore magnets and it serves as an introduction to the next lesson when they are using magnets to engineer a solution to a problem. As a result of this lesson being an introduction to the next lesson, students will not make a significant connection back to the anchor phenomenon.

Connecting Storyline Question

Could a compass be used on the ice board to know where you're going?

Lesson 5: How can you unlock a door using a magnet?
Magnets & Engineering (pg 1 of 2)

Exploration
17 min

Hands-On Activity
35 mins

Wrap-Up
3 mins

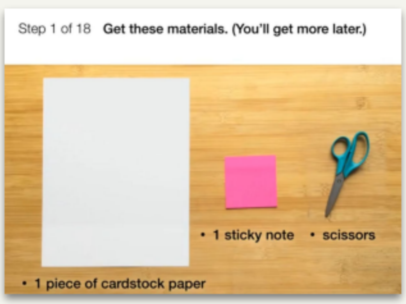
Anchor Connection
20 mins

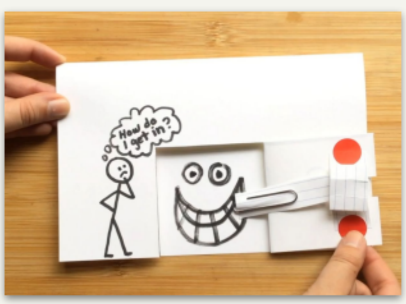
Assessment
20 mins

Overview

In this lesson, students investigate magnetic attraction and repulsion.

In the activity, Invent a Magnetic Lock, students apply their scientific ideas about magnets to create a useful product: a magnetic lock that can open a paper door. Students engage in the engineering design process to test and improve their designs.





Activity Notes

Sort materials into two piles. Each student will first make a paper door using cardstock, scissors, and a post-it note. Then, students will design a lock for their door using a magnet, paperclip, paper fastener, stickers, and index cards. You may want to sort your materials into two piles for easier distribution.

Be prepared for some troubleshooting. See our lesson page's prep instructions for detailed pictures and instructions for troubleshooting.

Anchor Connection on Next Page

Lesson 5: How can you unlock a door using a magnet?
Magnets & Engineering (pg 2 of 2)

Exploration
17 min

Hands-On Activity
35 mins

Wrap-Up
3 mins

Anchor Connection
20 mins

Assessment
20 mins

Anchor Connection

Magnets push and pull on things from a distance. The Earth itself is a giant magnet, so we can use compasses anywhere on Earth to detect which direction we are pointing.

Students revisit the explanation and/or drawing that they worked on during the Anchor Phenomenon. They should understand that designing a mount that will hold a compass in an easily visible spot will make navigation easier for the ice board rider.

Students can revise their explanation and/or drawing by adding a way to mount a compass on their ice board; this could be by attaching it to the mast, or adding an extra stand in front of the mast to hold it up, or attaching it down on the board, or anything else.

Connecting Storyline Question

How might an even more advanced ice board look that would be usable for longer voyages?

Performance Task: Can you design a new ice board?
Forces, Engineering

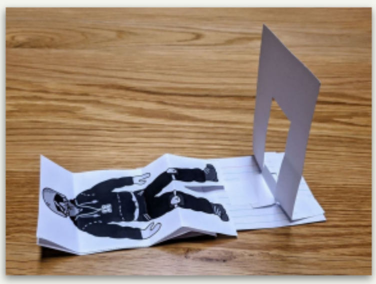
Unit Review
25 mins

Hands-On Activity
50 mins

Overview

In this performance task, students will design new versions of the ice board that have to meet a specific set of design constraints.

They will then build models of the ice board based on their designs.



Performance Task Notes

We recommend having students work in groups of two to three. Each individual student will need one copy of each page of the Ice Board Designer worksheet. Each group will need one cutout of the ice board rider, as well as a pack of the supplies listed in the supply calculator above.

You can put the supplies for each group and a cutout of the ice board rider into an envelope or plastic bag before class to make it easier to hand them out.

See the lesson page for examples of student work and more extension ideas.

Crosscutting Concepts

Structure and Function: The way an object is shaped or structured determines many of its properties and functions. Each individual structure on the ice board serves one or more particular functions.

Systems and System Models: A system is a group of related parts that interact with one another. All of the parts of the ice board work together with one another.