Introduction:

The Teacher Guide is designed to support teachers in teaching with the new Mystery Science Anchor Layer. This is a new feature, and we plan to revise and improve the Anchor Layer based on your feedback! Thank you!

What is the Anchor Layer?

In NGSS instruction, there is a distinction between *anchor* phenomena and *investigative* phenomena. Anchor phenomena are complex phenomena that students need an entire unit, and multiple scientific ideas, to explain. Investigative phenomena are specific, lesson-level phenomena that help students understand smaller conceptual pieces of a larger idea. As students investigate specific phenomena, they can use those learnings to make sense of the anchor phenomenon that guides the unit.

We think of our traditional lessons as investigative phenomena. This new Anchor Layer adds an anchor phenomenon to open and frame the unit. After each lesson, students return to the anchor phenomenon and apply what they've learned to develop increasingly sophisticated models, arguments, explanations or design solutions that help them make sense of the anchor phenomenon.

We've designed the Anchor Layer to be optional for teachers. Teachers can teach our lessons with or without the Anchor Layer.

Storylines:

Storylines provide a coherent overview of how the Anchor Layer unfolds, what students are figuring out at each step, and questions that lead to the next investigation. **View Anchor Layer Storylines**

Before Lessons

I. Anchor Phenomenon
Observe puzzling, complex real-world events explained through scientific evidence

II. Student Inquiry
Make observations and ask questions

III. Initial Student Ideas
Develop initial Conceptual Model, Argument, Explanation, or Design Solution

During Lessons

IV. Investigative Phenomena
Investigate specific real-world events that provide conceptual pieces to a larger idea

V. Student Revision
Revise Conceptual Model, Argument, Explanation, or Design Solution

After Lessons

VI. Performance Task
Demonstrate conceptual understanding in a new scenario

Invisible Forces Anchor Layer

Teacher Guide

TEACHER RESOURCE

Unit Overview

Key Concepts Overview:

- Pushes and pulls are **forces** that cause things to change how they are moving.
- Magnets push and pull at a distance.
- **Friction** is a force that resists sliding motion between two objects.
- Different materials have different strengths and weaknesses when used to push or pull.

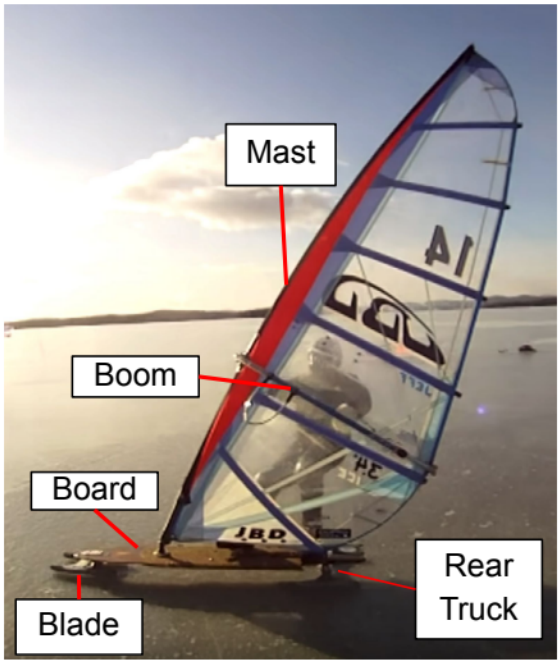
3-Dimensional Alignment		
Crosscutting Concepts	• Structure and Function • Systems and System Models	
Science and Engineering Practices	• Constructing Explanations • Defining Problems / Designing Solutions • Engaging in Argument from Evidence	• Developing and Using Models • Obtaining and Communicating Information
Disciplinary Core Ideas	• **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**
Performance Expectations	• **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-PS2-4. Define a simple design problem that can be solved by applying scientific ideas about magnets.**	• **3-5-ETS1-1. Define a simple design problem...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.**

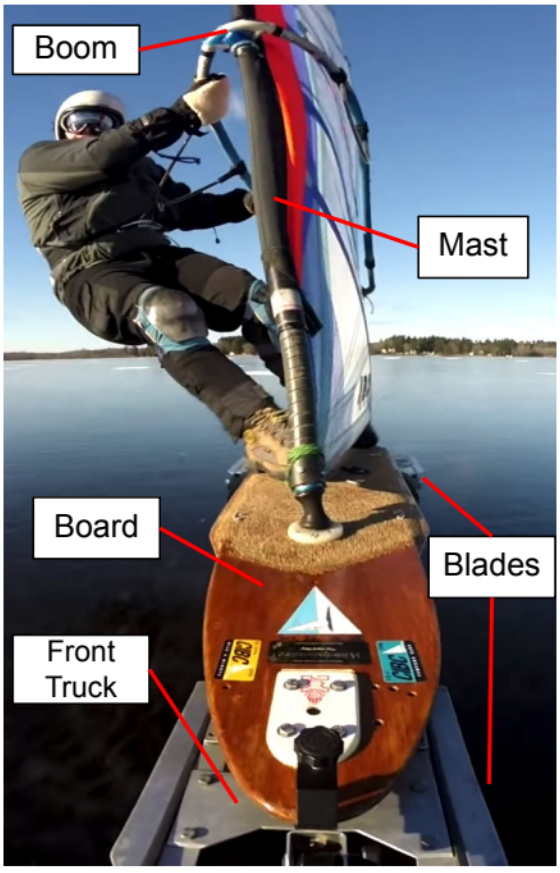
Unit Pacing Guide			
Anchor Phenomenon	0.75 hours	**Lesson 4**	1.5 hours
Lesson 1	1.5 hours	**Lesson 5**	1.5 hours
Lesson 2	1.5 hours	**Performance Task**	1.25 hours
Lesson 3	1.5 hours		
Note: Using Extensions for Lesson 1-5 can extend each lesson up to an additional 2 hours.			

TEACHER BACKGROUND INFORMATION

Anchor Phenomenon Explanation

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.

Invisible Forces Anchor Layer

Teacher Guide

BEFORE LESSON 1

Anchor Phenomenon

I. Anchor Phenomenon

Puzzling, complex real-world events explained through scientific evidence

1. Prepare your classroom for the Anchor Phenomenon lesson:
   a. Create a class See-Think-Wonder chart
   b. Print one copy per student of the Ice Board worksheet
2. Begin the Anchor Phenomenon lesson. The lesson includes visuals and text describing the design of this ice board.

Tip: *The unit anchor phenomenon is a real-world occurrence that motivates students to ask questions and learn more about scientific concepts. Encourage them to investigate throughout the unit.*

II. Student Inquiry

Students make observations and ask questions

1. Pass out See-Think-Wonder charts to students.
2. Students complete the first column *(I see…)* for the images displayed. We recommend using the Think-Pair-Share strategy for this activity.
3. Discuss class responses and write them in your class See-Think-Wonder chart.
4. Repeat Steps 2-3 for the second *(I think…)* and third *(I wonder…)* columns.

Tip: *The chart on the next page provides possible student responses. Use this resource to help you further the See-Think-Wonder discussion with your students.*

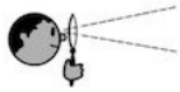
BEFORE LESSON 1

Anchor Phenomenon

II. Student Inquiry (continued)
Students make observations and ask questions

Sample student See-Think-Wonder responses

See-Think-Wonder Chart

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?*

BEFORE LESSON 1 (continued)

III. Initial Student Ideas

Develop initial Conceptual Model, Argument, Explanation, or Design Solution

Students follow the step-by-step directions in the lesson to create an initial explanation of how the ice board works and why certain materials are used in different places on the ice board.

Throughout the unit, students learn new concepts and conduct investigations to help them understand that pushes and pulls explain how the board works. They also begin to understand that different materials work better or worse to meet different needs.

1. When instructed to do so in the Anchor Phenomenon lesson slides, pass out the Ice Board worksheet.
2. Have students write their initial explanation of how the ice board works.
3. Small Group Discussion: Students discuss how the ice board might work.
4. Students then add to their initial thoughts about how the ice board works based on their small group discussion.

Crosscutting Concepts: Structure and Function, Systems and System Models

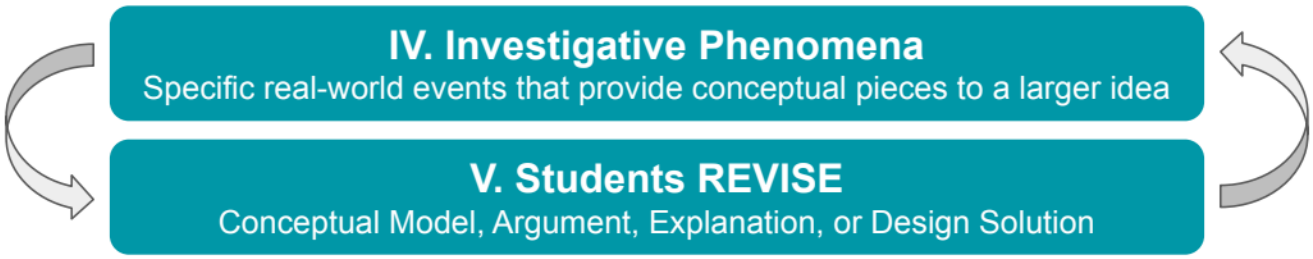
- This is a great opportunity to reinforce the crosscutting concepts of **systems** and **structure and function**.
- Each individual **structure** on the ice board serves one or more **functions** that causes it to work the way that it does.
- A **system** is a group of related parts that interact with one another. All of the parts of the ice board work together.

Matrix of Crosscutting Concepts in NGSS

Invisible Forces Anchor Layer

Teacher Guide

DURING LESSONS



1. Teach the lesson (Investigative Phenomenon).
2. **Anchor Connection (after Activity):**
   a. After the Activity of each lesson, continue advancing through the slides to the Anchor Connection.
   b. Discuss the **Anchor Phenomenon Connection** questions.
   c. Revise the Ice Board worksheet to include new information learned in each lesson.

Lesson *(Investigative Phenomenon)*	**During the Anchor Phenomenon Connection slides, guide students toward these ideas:**	**If they haven't already, students can update their explanations and/or drawings by:**
Lesson 1: How could you win a tug-of-war against a bunch of adults? 3-PS2-1	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.	• Adding 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). • Adding arrows showing the rider pushing the board forward with their feet.
Lesson 2: What makes bridges so strong? 3-5-ETS1-1 3-5-ETS1-2 3-5-ETS1-3 Foundational for 3-PS2-1	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.	• Adding where the special ropes are that attach to the ice board rider's waist.

DURING LESSONS

Continued from page 8

Lesson *(Investigative Phenomenon)*	**During the Anchor Phenomenon Connection slides, guide students toward these ideas:**	**If they haven't already, students can update their explanations and/or drawings by:**

Lesson 3: How high can you swing on a flying trapeze?
 	
3-PS2-2
	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.
		• Adding where the friction should be high:
		  ○ Between boots and the board
		  ○ Between gloves and the handle
		
		• Adding where the friction should be low:
		  ○ Between the blades and the ice

Lesson 4: What can magnets do? 3-PS2-3 3-PS2-4	Complete the 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.*
Lesson 5: How can you unlock a door using a magnet? 3-PS2-3 3-PS2-4 3-5-ETS1-1 3-5-ETS1-2 3-5-ETS1-3	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.	• 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.

AFTER LESSONS

Performance Task Lesson

VI. Performance Task

Students demonstrate conceptual understanding

The performance task is an opportunity for students to apply their conceptual understanding to a new scenario. In this performance task, students will use what they've learned in the unit to design a wind-powered vehicle.

Crosscutting Concepts:
Structure and Function

- This is a great opportunity to reinforce the crosscutting concept of **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.**

Matrix of Crosscutting Concepts in NGSS

Crosscutting Concepts:
Systems and System Models

- This is a great opportunity to reinforce the crosscutting concept of **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.

Matrix of Crosscutting Concepts in NGSS

1. Prepare in advance
   a. For each student, print one copy of both pages of the Ice Board Designer worksheet.
   b. Print one page of ice board rider cutouts for every three groups. Each page has three cutouts.
   c. To start, each group will need 4 note cards, 4 paper clips, and 4 tape strips. You can give students more supplies to make it simpler, and fewer supplies to make it more challenging.

2. Begin the Performance Task Lesson, which includes a review of the:
   a. Anchor phenomenon
   b. Unit key concepts (*page 3 of Teacher Guide*)

3. Begin Activity Step-by-Step
   a. Have students get into groups of 2-3.
   b. Follow the instructions in the step-by-step slides.