GREAT LAKES LEARNING

LESSONS & ACTIVITIES BASED ON THE MONTHLY GREAT LAKES NOW PROGRAM

EPISODE 2210 | WHAT IS AN EFOIL?

CONSTANT SPEED AHEAD

Image Credit: Great Lakes Now

OVERVIEW

This lesson will explore the sport of **eFoiling** and how Newtonian physics can be used to explain the phenomenon of the surfboard moving on the Great Lakes. Students will learn to model constant speed and how balanced forces allow objects to move at constant speeds.

LESSON OBJECTIVES

- **Know** about the recreation water sport e-foiling
- **Understand** how the position of an object moving at a constant speed changes over time
- **Be able to** model the motion of an object traveling with constant speed

WHAT YOU'LL NEED

- Computer or mobile device with Internet access to view video and online resources
- Notebooks and pencils
- Chart paper
- Sticky notes
- Markers
- Lab supplies (see individual activities for a full list)
- Copies of the Student Handouts

INTRODUCTION

What even *is* eFoiling? Think: a speedboat crossed with a hoverboard. The growing popularity of this modern, technologically-enhanced take on the traditional sport of surfing has reached the Great Lakes. Instead of using the waves to move the board, an eFoil is equipped with an electric powered motor, a mast, and a wing. Propulsion from the electric motor gives the board enough speed to lift up above the water, much like a speed boat, giving it the appearance of levitation. But what's most interesting about this technology is that speed control matters greatly, as we are about to see.

This lesson includes multiple activities, including lab activities, that can span the course of several sessions or be adapted to fit the needs of your group's meeting format.

Some prior knowledge* with which students should be familiar includes:

- measurement in the metric system
- unit conversion calculations
- forces and Newton's Laws
- graphing
- unit rates and rate x time = distance
- linear equations (e.g., y=mx+b)

Follow this QR Code or hyperlink to the Episode Landing Page!

Check out our full collection of lessons for more activities related to topics like these.

*****The sequence of these activities is flexible, and can be rearranged to fit your teaching needs.***

NGSS CONNECTIONS

Phenomenon: eFoiling

- 3-PS2-1
- 3-PS2-2
- MS-PS2-2
- SEP-2
- SEP-3
- SEP-4
- SEP-5

During the course of the lesson, students will progress through the following sequence** of activities:

- Class discussion to elicit and activate prior knowledge about surfing
- Close reading of a **photo** with a partner
- Teacher notes on constant speed and balanced forces
- Watch a segment from *Great Lakes Now*
- Class discussion to debrief the video
- Read about surfing on the Great Lakes
- Model the motion of an object moving at a constant speed
- Conduct an experiment to investigate the motion of a block of dry ice

The lesson progresses through three major sections: **launch, activities, and closure.** After the launch of the lesson, you are ready to begin the lesson activities. Once finished with the activities, students will synthesize their learning in the closure. You can select the activities that are best suited for your learners and teaching goals, and then sequence them in a way that makes sense within your learning progression and the scaffolds of the lesson.

If you use this lesson or any of its activities with your learners, we'd love to hear about it!

Contact us with any feedback or questions at: ***GreatLakesNow@DPTV.org***

TEACHER BACKGROUND INFORMATION

by Great Lakes Now Contributor, Gary G. Abud, Jr.

**This information can be presented by the teacher as notes to students at the teacher's discretion.*

Have you ever been in a car that abruptly had to come to a stop? What happened?

You may have noticed a jarring thrust to your body as you moved forward and felt the seatbelt restrain you from getting any closer to the dashboard. That was because of **unbalanced forces** on the car and you. Unbalanced forces can cause the motion of an object—like a car or a person—to change in one of three ways: speed up, slow down, or change direction.

When the forces pushing or pulling on an object are all **balanced**, the motion remains unchanged, or **constant**. That means that the object's speed and direction will continue to be the same until some unbalanced force comes into play.

This property of objects to continue moving in the same way as they had been (or to remain unmoved if they weren't moving in the first place) under conditions with balanced forces is known as **inertia**. Isaac Newton first articulated the **Law of Inertia** (also referred to as **Newton's First Law of Motion**) to describe this phenomenon.

In general, a **force** is any push or pull that one object does to another—no matter how small or large the object. There are two main categories of forces that scientists distinguish: **contact forces** and **non-contact forces**. For example, the floor might be pushing you upward if you are standing on it while talking to a friend—that'd be a contact force—but the force due to gravity from the Earth is pulling you toward the ground—that's a non-contact force. Since these forces are balanced, you remain standing on the ground not really feeling a thing. But if you jump off the ground, now there is nothing pushing you upward, and the unbalanced force due to gravity pulls you toward the ground.

Consider now the feeling you get while traveling in an elevator. When the elevator changes speed as it moves between levels you might feel the floor of the elevator push on you more or less—that difference in feeling "lighter" or "heavier" on an elevator is the result of unbalanced forces that change the speed of the elevator.

Force Diagrams use arrows to show the relative direction and strength of forces. Same size arrows in opposite directions represent balanced forces

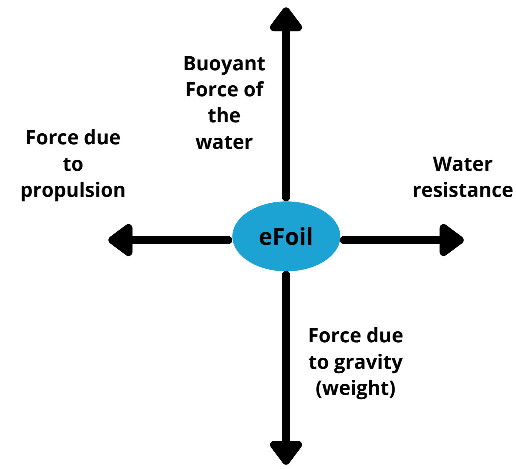

Image Credit: Gary Abud, Jr.

Surfboards and eFoils both require forces to move. The force from the water waves can move a surfboard. However, the electric engine on an eFoil—much like a boat—causes a propeller to spin and push on the water in one direction. The water, in turn, pushes the propeller (and the board attached to it) back in the opposite direction causing it to move. But in order to get the board to lift above the water and move the person on the eFoil forward without tipping over, there needs to be enough force generated from the propeller (and, as a result, more unbalanced force, so more speed) to overcome the resistance from the water on the front of the board. Once the board is out of the water, there is much less resistance and the eFoiling can commence.

After the eFoil gets up to the right speed to hover above the water, maintaining a constant speed means forces are balanced and the rider will feel the same as *any other time* when the forces acting on them are balanced, including when they are at rest. That's why the rider, when eFoiling, can stand calmly atop the board without the board flying out from underneath them—because, due to the balanced forces, it feels just the same as if the board were not moving. Now, of course it is easier said than done to eFoil, but a simple diagrammatic tool can make it conceptually easier to understand.

Force diagrams are a tool used by physicists to illustrate how different forces are pushing or pulling on an object, and with such a diagram, one can better predict and explain the motion of an object. For example, if the diagram shows balanced forces, you can infer the object will be moving at a constant speed in a straight path—even if that speed is 0mph, or stopped entirely.

LESSON LAUNCH

A. Warm Up

The warm up is intended to be structured as teacher-facilitated, whole-group student discussion activities. It helps students to begin thinking about the topic at the center of the lesson.

1. Ask students to list out on a piece of paper five things that come to mind when thinking of **surfing**.
2. Have students pair up with a partner to share their five ideas with each other. If any ideas appear on both lists, have students circle those.
3. Then, engage students in a whole-group discussion to ask them to share any ideas that were circled.
4. Generate a list of the circled ideas.
5. Ask for volunteers to share any ideas that were not circled that they think are really important to include in this topic.
6. Generate a separate list of those ideas.
7. At the end of making the two lists, have students copy down one single list of all the circled ideas and important ideas in their notebooks or on their paper.
8. Ask students individually to rank the ideas in the list from most to least relevant.
9. Ask for some students to share which term should be most relevant and why they think that is. Engage the whole group in discussion to arrive at consensus about the most relevant idea related to **surfing** that they already know about or that came to mind during this exercise.

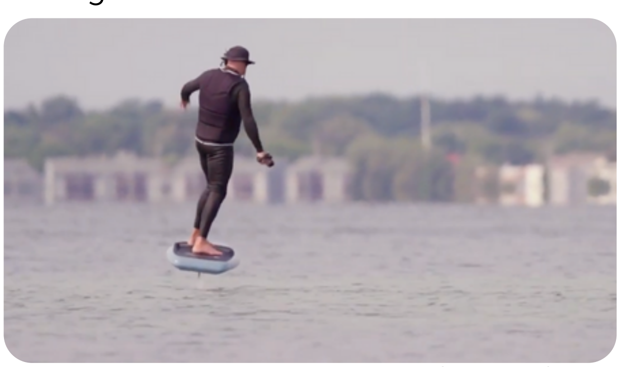

Image Credit: Great Lakes Now

B. Close Reading a Photo

Share, distribute, or display **this photo** so that the whole group can see it. Have students discuss with a partner:

- **What's going on in this picture?**

Then have two sets of partners form a small group and make connections between their partner conversations about the videos and the ideas that came up during the warm up activity about things that came to mind about **surfing**.

C. Bridge to Learning

After the warm-up activity has concluded, help students prepare for the learning that is about to come by doing the following demonstration:

- Take a block of dry ice and put the largest, flattest side of it on the smoothest surface available to you (e.g., a counter top, tile floor, etc.)
- Have a volunteer come up and stand at the opposite end of the surface where you are with the dry ice.
- Both you and the volunteer should have hand protection (e.g., an oven mitt, an insulated glove, or some paper towel)
- Gently push the dry ice toward the volunteer so that it moves slowly, hovering across the surface, and have the volunteer gently stop the block when it gets to them and push it back
- Ask students what they notice and wonder about the block
- Have them draw a diagram of all the forces pushing or pulling on the ice and save these diagrams for a later activity
- **Through discussion, help ensure that their force diagrams are accurate**

D. Background Information Notes

Explain that we are going to build on these ideas and learn more about **forces** in this lesson. Then proceed to give the notes from the **Teacher Background Information**.

ACTIVITY 1: WATCH A GREAT LAKES NOW SEGMENT

This activity is a video discussion of a *Great Lakes Now* episode segment.

First, inform students that they will be watching a *Great Lakes Now* segment discussing the recreation sport of eFoiling on the Great Lakes. During the video they need to jot down four things they took away from the video using the **4 Notes Summary Protocol**.

Then, if students are not already familiar, introduce them to the 4 Notes Summary Protocol, which they will use after they finish watching the video, where they write down one of each of the following notes:

- **Oooh!** (something that was interesting)
- **Aaah!** (something that was an ah-ha moment)
- **Hmmm...** (something that left them wanting to know more)
- **Huh?** (a question they have afterward)

Next, have students watch the segment from episode 2210 of *Great Lakes Now* called **What's an eFoil?**

Last, have students complete their individual 4 Notes Summary and then discuss those in groups of 3-4 students.

***Teaching Tip*: Use the Student Handouts to help students organize their thinking in writing around each of the lesson protocols.**

Post-Video Discussion

After the groups have had time to go over their 4 Notes Summaries, invite a handful of students to share out some of their notes, eliciting at least 1-2 of each of the 4 Notes and listing those somewhere for the whole group to see.

Ask students to turn back and talk with their groups to make connections between the *Great Lakes Now* video and what they remember from the warm-up activities.

How is what we saw in the video related to what we discussed earlier in this lesson during the warm up?

After giving the groups some time to talk, bring the whole group back together for a shareout and discussion of ideas.

In this culminating discussion, the goal is to help students make connections between the video segment and what they discussed during the warm up activities earlier in the lesson about what they knew about **surfing.**

Once the discussion finishes, have each student write a "**Sum It Up**" statement in their notebooks. This is a single sentence that captures the big idea of what was just learned.

Have 2-3 students share out their **Sum It Up** statements before concluding this activity.

ACTIVITY 2: READ ABOUT SURFING ON THE GREAT LAKES

The methods of mapping the floor of the Great Lakes have advanced by leaps and bounds over time. From lead sinker plumb line measurements to SONAR, the modern technology shaping Great Lakes bathymetry is nothing short of incredible.

In this activity, students will use a **Think Pair Square Protocol** for discussing what they will read about this very topic.

First, have students partner up and distribute the article **Surfing the Great Lakes** by Sharon Oosthoek from *Great Lakes Now*. Allow time for students to individually read the article, and have them jot down three things they took away from the article using the **Rose Thorn Bud Protocol**—in their notebook or using the handout.

Then, give students time after reading to discuss the article that they read with their partner. Have students share their rose, thorn, and bud with each other, including how those points connect to each other. The pair should come up with a statement to summarize all of their article takeaways.

Next, have two student pairs join up, standing near each other to form the four corners of a square, to discuss the article and what they talked about in their pairs. Encourage them to come to a consensus about which point they found most important or interesting in the article.

Teaching Tip:
If the reading level of the article is going to be tough for some students to read individually, have partners or small groups read the article together aloud while each follows along.

Image Credit: Great Lakes Now

Last, have each group craft a summary statement of the most important point from their discussion and ask for a volunteer in each group to share that key point with the whole group.

As student groups share their most important point, record their ideas on the board and have students copy the list of student ideas down into their notebooks.

Once the shareout is complete, ask students to return to their groups and discuss one last question based on the article:

Based on the article, why does traditional surfing need to be done during colder weather months, but efoiling does not in the Great Lakes?

After giving the groups some time to discuss this question, invite conversation from the whole group to see what consensus can be reached.

Be sure to encourage students to support their claims with evidence and reasoning as they discuss in the whole group.

ACTIVITY 3: MEASURE THE SPEED OF DRY ICE

Image Credit: Gary Abud, Jr.

In this activity, students will conduct an experiment to measure the speed of a dry ice block. Depending on the learners' ages, this could be done as a whole-group activity or completed* in small groups. Either way, start by asking students what two things we need to measure in order to determine the speed of a moving object (e.g., distance and time).

Make a connection to speed limit signs, e.g., "25mph means for every 1 hour (time) driven, a car would have traveled 25 miles (distance)." To make clear this idea, ask students if they need to be driving for an entire hour in order to be traveling at a speed of 25mph. Discuss with them how 25mph is a unit rate based on a measured distance and time ratio that can be used to describe or predict things about motion. For example, if a car were traveling 25mph, ask them to predict how far it would drive in two hours.

Explain to them that because we can't get out on the water and measure the speed of a surfer, they will be conducting an experiment to estimate the speed of a block of dry ice moving across a *surf*ace—get it? The block of ice is going to represent a surfer and help us to model the motion of someone eFoiling. They will need to measure the distance traveled by the block as well as the time as it slides along the surface. Because the dry ice doesn't *actually* touch the surface, it travels at a constant speed, much like someone eFoiling is just above the water.

Materials & Setup **[(See a demonstration here!)]**

- waterproof winter gloves or oven mitts
- blocks of dry ice
- butcher paper & markers
- measuring tape or meter stick(s)
- stopwatch

Set up a strip of butcher paper along the side of the track where the dry ice will move, but not cover the entire surface. Place one or more meter sticks end-to-end along the length of the butcher paper. This will allow you to mark the position at different time intervals (e.g., 1s, 2s, 3s, etc.)

First, practice the procedure with a demo. Have everyone watch as two volunteers move the dry ice back and forth with gloves on. Make sure to push the block slowly so there is enough time to record its position at different time intervals. Have another person with a stopwatch going. Once you've practiced pushing the block to move in as straight a path along the track as possible, practice having the stopwatch reader call out "now" each second on the second while another volunteer practices putting an imaginary dot along the track at the location of the front edge of the block on the butcher paper near the meter stick. After everyone is feeling comfortable with the procedure, you're ready to begin collecting data.

Next, conduct several trials. The stopwatch can be going before the block begins moving. Once the block is released, the timer calls out "now" every second on the second while the marker makes a dot on the paper near the meter sticks where the front edge of the dry ice is every second until the block reaches the other side. Label each dot as the second it was recorded (e.g., "1s" "2s" etc.) With different colored markers, repeat the procedure a few more times to get more data.

Then have students analyze the spacing between the dots for each trial. Ask them what they notice? They should point out that the dots are evenly spaced apart, signifying the block is moving at a constant speed once it is released. Have students record the position marking on the meter stick for each dot at each second in a data table with time in seconds as one column and position in centimeters as the other.

Last, use the data from the table, determine how far the block traveled in total distance from the first to last measurement, how much time passed, and generate a unit rate in cm/s.

**Note: If concerned about students handling dry ice, this experiment can be done using video footage. Have a person recording the entire scene in one frame without moving the camera such that the meter stick measurements could be read by the viewer.*

ACTIVITY 4: MATHEMATICALLY MODELING CONSTANT SPEED

In this activity, students will complete a graphing exercise to mathematically model the motion of an object moving at a constant speed.

Materials Needed:
- graph paper
- dry ice data in tabular form from Activity 3

Begin by having students partner up and obtain one of the data sets from the dry ice speed experiment. Ensure that different pairs of students are working with different data sets. This will be important later to drive home the point that the block was moving at a constant speed no matter how fast it was moving when pushed with different amounts of force.

First, have students construct a position vs. time graph and plot their data points from the table. They will need to scale the axes with position in cm on the y-axis and time in seconds on the x-axis. The intervals of each axis will depend on the ranges for the data in their measurements. They should draw a best-fit line for their graph.

Next, have the students determine the amount of distance traveled from second to second by finding the difference between the positions at each time. Have them list those differences (e.g., calculated distances) out in a separate table that shows time and distance. Ask them to discuss what they notice about the distance vs. time data compared to the position vs. time data. They should jot down some observations to share later during the discussion.

Then, have students average their distances and divide it by the time interval (e.g., 1 second) that was associated with each. This is the average speed of the dry ice block in cm/s.

Last, have students find the slope of their best-fit line with units of the slope in the calculation (e.g., cm/s), and also determine the y-intercept value (with units) for their best fit line. Using these two calculated values, students should write a linear equation (e.g., y=mx+b) that represents the line of best fit (including units).

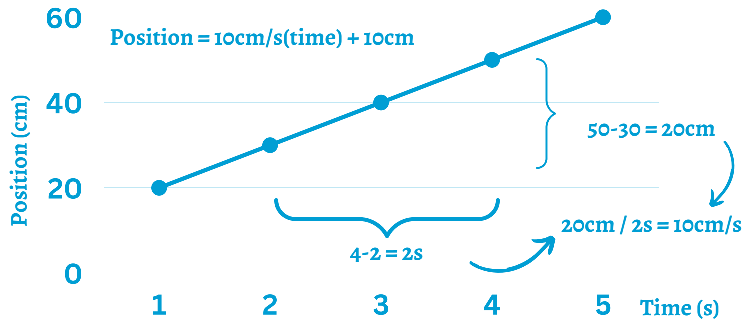

Image Credit: Gary Abud, Jr.

Discussion

Using large dry erase boards or chart paper, have students summarize their analysis of the data by displaying their data table, graph, and linear equation to be able to show the class.

Display all the groups' summary boards for everyone to see and engage the whole group in a discussion about the data. Elicit a few select groups to answer each question based on the features of their summary board that you see. Help students to use the information on their board to support their claims as they answer and discuss the following questions:

- **How does the slope value from your best-fit line compare to the average speed calculated earlier?** *(these values should be very close to one another)*
- **What does the y-intercept value from the graph tell us about the block of dry ice during the experiment?** *(it tells us the position of the block at the 0s point in time)*
- **What conclusions can we all draw about the motion of the block in each experiment?** *(It was moving with a constant speed every time)*
- **Where would the block be after 30sec?**

Conclude this discussion by revisiting the force diagrams of the dry ice from earlier in the lesson. Be sure to name the object that is doing the pushing or pulling for each of the forces on the diagram and note which forces are balanced out by any others. Help students to see that the forces are balanced on the block of dry ice. Tie this to the motion of the dry ice to help students make the connection that **when forces are balanced, objects move with a constant speed in a straight path.**

LESSON CLOSURE

After the conclusion of all the activities, help students to make connections* between everything they did in the lesson and what they learned overall.

A. Free Recall

Group students in pairs or triads (e.g., in groups of 2-3 partners) and distribute the **Free Recall Protocol handout**, Alternatively, you can have students do this in their notebooks. Set a 3-min timer and have students generate a list of everything they can remember learning about in this lesson related to the central topic of the lesson. This doesn't have to be in depth, just whatever each group can call to mind. Have them draw lines between any terms that relate to one another. After the timer finishes, give groups a chance to volunteer to share aloud 2-3 things from their free recall lists and any of the connections that they made with those. Jot down any ideas that come up multiple times during the shareout for the whole group to see.

B. Lesson Synthesis

Give students individual thinking and writing time in their notebooks to synthesize their learning, by jotting down their own reflections using the **Word, Phrase, Sentence Protocol.**

In the Word-Phrase-Sentence Protocol, students write:

- A **word** that they thought was most important from the lesson
- A **phrase** that they would like to remember
- A **sentence** that sums up what they learned in the lesson

Image Credit: Great Lakes Now

C. Cool Down

After the individual synthesis is complete, students should share their synthesis with a partner.

After sharing their syntheses, have students complete a **3, 2, 1 Review** for the lesson with their partner, recording in their notebooks or, optionally, on exit ticket slips to submit, each of the following:

- **3 things** that they liked or learned
- **2 ideas** that make more sense now
- **1 question** that they were left with

Invite several students to share aloud what they wrote in either the synthesis or 3, 2, 1 Review.

Lastly, ask one student volunteer to summarize what has been heard from the students as a final summary of student learning.

**Optionally here, the teacher can revisit the learning objectives and make connections more explicit for students.*

***Teaching Tip:* Use the Student Handouts to help students organize their thinking in writing around each of the lesson protocols.**

NAME: ______________________

A Word, Phrase, Sentence Protocol

What is a **word** that you thought was most important from this lesson?

What is a **phrase** that you would like to remember from this lesson?

What is a **sentence** that sums up what you learned in this lesson?

3, 2, 1 Review Protocol

What are **3 things that you liked or learned** from this lesson's activities?

-
-
-

What are **2 ideas that make more sense** now to you?

-
-

What is **1 question that you were left with** after this lesson?

-

NAME: ______________________

Free Recall Protocol

With 1-2 partners, generate a list of everything you can remember learning about in this lesson related to the central topic of the lesson. Draw lines between any terms that relate to one another.

NAME: ______________________

4 Notes Summary Protocol

OOOH!

Something that was interesting to you

AAAH!

Something that became clearer; an "ah-ha" moment

HMMM...

Something that left you wanting to learn more

HUH?

Something you questioned or wondered

Sum It Up Statement:

Summarize your group discussion about your 4 Notes Summaries below:

NAME: ______________________

Think Pair Square Protocol

THINK

Write down your own individual ideas

PAIR

Summarize what you and your partner discussed

SQUARE

Summarize what your group discussed

NAME: ______________________________

Rose, Thorn, Bud Protocol

ROSE

Something that "blossomed" for you in your learning

THORN

Something that challenged your thinking or was difficult to understand

BUD

Something that's new and growing in your mind — a "budding" idea