

Physics of Sailing Educator Guide

Watch it online <http://www.kqed.org/quest/television/the-physics-of-sailing>

TV story length 9:31 minutes

QUEST SUBJECTS

Life Science **Biology**
Health
Environment

Earth Science **Geology**
Weather
Astronomy

Physical Science **Physics**
Chemistry
Engineering

PROGRAM NOTES

We know that a sailboat can travel with the wind, but what really makes a sailboat move? Join the QUEST crew aboard a sailboat in San Francisco Bay to learn about the physics of sailing.

In this story you'll find...



- ⦿ examples of the physics of sailing.
- ⦿ demonstrations of how lift works.
- ⦿ an explanation of Bernoulli's principle.

CA SCIENCE STANDARDS

Grade 8

Motion

1 (a, d, e) Position is defined in relation to a reference point; velocity is described by direction and speed of an object; changes in velocity are due to changes in speed, direction or both.

Forces

2. (b, e) When an object is subject to multiple forces at once, the result is the cumulative effect of all the forces; when forces on an object are unbalanced, the object will change its velocity.

Grades 9-12

Motion and Forces

1. (b) When forces are balanced, no acceleration occurs.

Conservation of Energy and Momentum

2. (f) An unbalanced force on an object produces a change in its momentum.

TOPIC BACKGROUND

To make a sailboat move, you need both wind and water, in addition to a sail, of course! When a sailboat sails downwind, wind blows into and pushes against the boat's sails. Because the wind is faster than the boat, the air pushing into the sails is decelerated. As the sails push back against the wind, the wind pushes forward on the sails and the boat moves. But working with just the sail and the wind in this way, the boat will move slowly and only in the direction the wind carries it. To really make a sailboat move quickly, a sailor needs to know how to harness aerodynamic and hydrodynamic lift force. Bernoulli's principle is a scientific principle stating that as the speed of a moving fluid or gas increases (or decreases), the pressure within the fluid decreases (or increases). It's the guiding principle behind the physics of lift.

By sailing closer to the wind, a boat will generate more aerodynamic lift. To move around the sails, the wind will have to change direction. This creates a change in wind velocity and harnesses lift force. But instead of being fully forward of the boat, the force is now primarily sideways on the boat. This means that the sailboat will move sideways if left unchecked.

This is where the keel comes into play. Unlike the keel in other kinds of boats, a sailboat keel is typically very large and uses the forward momentum of the boat to generate hydrodynamic lift and counter the lateral force coming from the air interacting with the sail. Instead of lying flat or nearly flat against the boat hull, a sailboat keel drops down into the water beneath the boat like a large rudder. When the boat moves sideways, the keel must push a lot of water sideways. Like the interaction between the wind and the sail, the water resists the push from the keel to generate lift. Because of the similar roles the keel and sail play in generating lift, the keel on a sailboat is sometimes regarded as a "second sail." Between the sail and the keel, a boat generates enough lift to accelerate forward. In fact, in this way a sailboat can even move faster than the wind! When moving, a sailboat generates its own wind, often called apparent wind or relative wind. This is the flow of wind acting upon the sail. The faster a boat travels, the more of this kind of wind occurs and the more force there is acting upon the sails. This means greater acceleration, and the boat will travel faster than the true wind speed. Many modern, extreme design sailboats and larger skiffs are built especially with this purpose in mind -- to sail faster than the wind.

VOCABULARY

Physics

physical properties, interactions, processes or laws

Aerodynamics

the study of objects moving relative to gases, particularly the interaction of moving objects with the atmosphere

Lift

the force resulting from air passing by a sail or water passing by a centerboard or rudder

Accelerate

to change the velocity of

Velocity

the distance traveled divided by the time taken

Pressure

force applied uniformly over a surface, measured as force per unit of area

Keel

the principal structural center of a boat that runs lengthwise from front to back, to which the frame is attached

Force

any influence that can impose a change of velocity on a material, either producing or preventing motion

PRE-VIEWING

- What do you already know about sailboats and sailing?
- What do you think physics has to do with sailing?

VIEWING FOCUS

NOTE: You may choose to watch the television segment twice with your students: once to elicit emotional responses and get an overview of the topic and again to focus on facts and draw out opinions.

- How has our understanding of sailing changed over time?
- What is lift and how is it achieved in sailing?
- What forces are at work on a moving sailboat?
- How can a better understanding of the laws of physics help sailors and boat builders make and sail better, faster boats?

For all media see:

- Segment Summary Student Sheet
http://www.kqed.org/quest/downloads/QUEST_SegSum_StudentSheet.pdf
- Personal Response Student Sheet
http://www.kqed.org/quest/downloads/QUEST_PersResp_StudentSheet.pdf

QUEST, PBS and NPR LESSON PLANS and RESOURCES

NOTE: Resources from the Teachers' Domain collection require a fast and free registration.

Aerodynamics: What Causes Lift? Teachers' Domain

<http://www.teachersdomain.org/resource/phy03.sci.phys.mfw.airfoil/>

This media-enhanced essay from NOVA offers another explanation of lift, based on Newton's third law of motion.

Here Comes Bernoulli PBS Chasing the Sun

http://www.pbs.org/kcet/chasingthesun/resources/resources_lesson_1.html

In this lesson, students will gain an understanding of Bernoulli's principle and learn how air pressure affects a plane's ability to fly.

Sailing Dragonfly TV

<http://pbskids.org/dragonflytv/show/sailing.html>

What is the fastest sailing direction: with the wind, with the wind but at an angle, or into the wind? This episode of Dragonfly TV investigates the speed of sailing.

Science of Sports: Speed Sailing PBS Scientific American Frontiers

http://www.pbs.org/safarchive/4_class/45_pguides/pguide_405/4545_ss.html

This **In the Classroom** teaching guide offers two activities designed to help students test the physics involved with creating high-speed, wind-powered craft.

Faster Than Sound NOVA

http://www.pbs.org/wgbh/nova/teachers/activities/2412_barrier.html

This classroom activity from NOVA Teachers gives students the opportunity to better understand the concept of aerodynamic lift by participating in and explaining hands-on demonstrations based on the Bernoulli effect.

Discuss the Physics of Sailing on the QUEST Blog QUEST

<http://www.kqed.org/quest/blog/2008/09/30/producers-notes-physics-of-sailing/>

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Exploratorium
www.exploratorium.edu

Girl Scouts of Northern California
www.girlscoutsbayarea.org

Golden Gate National Parks Conservancy
www.parksconservancy.org

The J. David Gladstone Institutes
www.gladstone.ucsf.edu

Lawrence Berkeley National Laboratory
www.lbl.gov

Lawrence Hall of Science
www.lawrencehallofscience.org

Monterey Bay Aquarium
www.mbayaq.org

Monterey Bay Aquarium Research Institute
www.mbari.org

Oakland Zoo
www.oaklandzoo.org

The Tech Museum of Innovation
www.thetech.org

UC Berkeley Natural History Museums
<http://bnhm.berkeley.edu/>

U.S. Geological Survey
www.usgs.gov

MORE EDUCATIONAL RESOURCES FOR USING QUEST MULTIMEDIA TO ENHANCE 21st CENTURY SKILLS IN TEACHING AND LEARNING

Why Use Media in Science Education?

www.kqed.org/quest/downloads/QUEST_Why_Media_08-09.pdf

- “As science educators, we know how important critical thinking and new technology skills are in the scientific community...” (read more).

Science Multimedia Analysis

www.kqed.org/quest/downloads/QUEST_Science_Multimedia_Analysis_08-09.pdf

- “By increasing students’ awareness of the intersections between media and science, we give them the tools to think like scientists...” (read more).

How to Use Science Media for Teaching and Learning

http://www.kqed.org/quest/downloads/QUEST_Media_Tips_08-09.pdf

- If we consider all forms of media “texts” from which students gather information, we can use similar literacy strategies to engage them in video, audio, blogs and Explorations. Once students have obtained information from multiple media sources, how do they share what they have learned? Through their own media-creation projects, of course!

Using Google Maps to Create Explorations

http://www.kqed.org/quest/files/download/52/QUEST_ExplorationCreation.pdf

- Do you like the science hike Explorations on the QUEST site? Use this place-based educational guide for educators and group leaders to create similar science-based maps with youth.

OTHER WAYS TO PARTICIPATE IN QUEST



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KQED 88.5 FM San Francisco &
89.3 FM Sacramento
Mondays at 6:30am and 8:30am



WATCH

KQED Channel 9
Tuesdays at 7:30pm

Major funding is provided by the National Science Foundation, the Gordon and Betty Moore Foundation, the Richard and Rhoda Goldman Foundation, and The Amgen Foundation. Additional support is provided by the S. D. Bechtel, Jr. Foundation, the William K. Bowes, Jr. Foundation, Ann S. Bowers - The Robert Noyce Trust, the Dirk and Charlene Kabcenell Foundation, and the Vadasz Family Foundation.