

# **Sail Away: Motion and Forces**

**IEEE ARIZONA SCIENCE LAB**  
[www.arizonasciencelab.org](http://www.arizonasciencelab.org)

## **Workshop Focus:**

The workshop focuses on the principles of Archimedes and of mechanical moments of forces, and their application to watercraft engineering and sailing. Students explore what marine engineers and naval architects do, and work in teams of two to design a sailboat out of everyday objects that can catch a breeze from a fan, stay afloat with a set load, and sail a short distance. Students work in teams of "engineers" to design a boat with a sail structure, test their boat, evaluate the work of other "engineering" teams, and present reflections to the class.

## **Workshop Synopsis:**

The Sail Away workshop not only explores Archimedes principle and mechanical moments of forces and how engineers design watercraft, but also challenges students to work as teams of engineers to develop a watercraft that holds a set weight, captures wind from a fan for power, and can move fast and in a straight line without sinking. Teams design their boats, build them, test them, evaluate the crafts of other teams, and present their project reflections about the activity to the class.

## **Age Levels:**

8 – 15 (grades 4 – 8)

## **Objectives:**

- Learn about density and Archimedes principle

- Learn about mechanical moments of forces
- Learn about marine engineering and sailing principles
- Learn about engineering product planning and design
- Learn about meeting the needs of society
- Learn about teamwork and working in groups

## **Anticipated Learner Outcomes:**

As a result of this activity, students should develop an understanding of:

- Density and Archimedes principle
- Mechanical moments of forces
- Watercraft engineering
- Problem solving
- Teamwork

## **Lesson Activities:**

Students explore Archimedes principle, mechanical moments of forces, what marine engineers and naval architects do, and work in teams to design a sailboat out of everyday objects that can catch a breeze from a fan, stay afloat with a set load, and sail fast and straight. Students work in teams of "engineers" to design a boat with a sail structure, test their boat, suggest and test modifications to their design, evaluate the work of other "engineering" teams, and present reflections to the class.

## **Alignment to Curriculum Frameworks:**

*Note: All Arizona Science Lab workshops are aligned to the National Science Education Standards which were produced by the National Research Council and endorsed by the National Science Teachers Association, and if applicable, also to the International Technology Education Association's Standards for Technological Literacy or the National Council of Teachers of Mathematics' Principals and Standards for School Mathematics. They will also be modified as necessary to be aligned to the Next Generation Science Standards (NGSS) when they are released.*

- **National Science Education Standards Grades K-4 (ages 4-9)**

CONTENT STANDARD A: Science as Inquiry As a result of activities, all students should develop

- Abilities necessary to do scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of the activities, all students should develop an understanding of

- Properties of objects and materials

- Position and motion of objects

#### CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- Abilities of technological design
- Understanding about science and technology

#### CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- Science and technology in local challenges

#### CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- Science as a human endeavor

### • **National Science Education Standards Grades 5-8 (ages 10 - 14)**

#### CONTENT STANDARD A: Science as Inquiry As a

result of activities, all students should develop

- Abilities necessary to do scientific inquiry

#### CONTENT STANDARD B: Physical Science

As a result of their activities, all students should develop an understanding of

- Motions and forces
- Transfer of energy

#### CONTENT STANDARD E: Science and Technology

As a result of activities in grades 5-8, all students should develop

- Abilities of technological design
- Understandings about science and technology

#### CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- Science and technology in society

#### CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- Science as a human endeavor

#### CONTENT STANDARD A: Science as Inquiry As a

result of activities, all students should develop

- Abilities necessary to do scientific inquiry

## CONTENT STANDARD B: Physical Science

As a result of their activities, all students should develop understanding of

- Motions and forces
- Conservation of energy and increase in disorder
- Interactions of energy and matter

## CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- Abilities of technological design
- Understandings about science and technology

## CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- Natural and human-induced hazards
- Science and technology in local, national, and global challenges

## CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- Science as a human endeavor

## • **Standards for Technological Literacy - All Ages**

### The Nature of Technology

- Standard 1: Students will develop an understanding of the characteristics and scope of technology
- Standard 2: Students will develop an understanding of the core concepts of Technology
- Standard 3: Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study

### Technology and Society

- Standard 6: Students will develop an understanding of the role of society in the development and use of technology

### Design

- Standard 8: Students will develop an understanding of the attributes of design.
- Standard 9: Students will develop an understanding of engineering design
- Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving

### Abilities for a Technological World

- Standard 11: Students will develop abilities to apply the design process

## The Designed World

- Standard 18: Students will develop an understanding of and be able to select and use transportation technologies
- Standard 20: Students will develop an understanding of and be able to select and use construction technologies

## Internet Connections:

- TryEngineering ([www.tryengineering.org](http://www.tryengineering.org))
- Virtual Skipper ([www.virtualskipper-game.com](http://www.virtualskipper-game.com))
- SailTrimSim ([www.wb-sails.fi/news/SailTrimSim/TrimSimFrames.htm](http://www.wb-sails.fi/news/SailTrimSim/TrimSimFrames.htm))
- The Physics of Sailing ([www.physclips.unsw.edu.au/jw/sailing.html](http://www.physclips.unsw.edu.au/jw/sailing.html))
- International Sailing Federation ([www.sailing.org](http://www.sailing.org))
- WB-Sails Quest for the Perfect Sail ([www.wbsails.fi/news/98\\_11\\_PerfectShape/Main.htm](http://www.wbsails.fi/news/98_11_PerfectShape/Main.htm))
- ITEA Standards for Technological Literacy: Content for the Study of Technology ([www.iteawww.org/TAA/Publications/STL/STLMainPage.htm](http://www.iteawww.org/TAA/Publications/STL/STLMainPage.htm))
- McREL Compendium of Standards and Benchmarks ([www.mcrel.org/standards-benchmarks](http://www.mcrel.org/standards-benchmarks))
  - A compilation of content standards for K-12 curriculum in both searchable and browsable formats.
- National Science Education Standards ([www.nsta.org/standards](http://www.nsta.org/standards))

## Recommended Reading:

- Introduction to Marine Engineering, Second Edition (ISBN: 0750625309)
- The Complete Sailor: Learning the Art of Sailing (ISBN: 0070571317)
- Toy boats, 1870-1955: A pictorial history (ISBN: 0684159678)

## Materials and Tools:

All materials and tools required for this workshop are provided by the Arizona Science Lab

## Time Needed:

One four hour workshop (inclusive of lunch and restroom breaks).

## ASL Staff Responsibilities:

The ASL staff is responsible for the conduct of the workshop:

- Setting up the workshop
- Presenting the lecture and teaching the science

- Performing the demonstrations
- Provisioning the materials and equipment to the student teams
- Supervising the construction project
- Supporting the students during the construction project
- Supervising the project testing
- Answering student questions about the science, the workshop, or any other related topic
- Cleaning up the workshop after the students have left

### **School Teacher Responsibilities:**

- **Managing the students during the class and the lunch and restroom breaks, and imposing discipline as necessary**
  - The ASL staff is NOT responsible for the class management or for student discipline!
  - **The restroom breaks will require at least one male and one female teacher be present from the school**
- Assisting the ASL staff in the teaching of the science
  - This could comprise asking the students questions about what had just been explained, presenting what had just been explained in another fashion, and so on
  - The ASL staff are not necessarily trained teachers and the school teachers know their students very well, so they can provide valuable insights and help to the ASL staff
- Assisting the ASL staff during the project construction and testing