



Solar Boats

Lesson 3: What is Force?

AUTHOR: Carol Patrick

DESCRIPTION: Students will build a barge out of tin foil and describe the forces acting on it. The barge itself is designed only with the constraints that passengers within the barge will not get wet, allowing for students to experiment with different shapes and densities as they construct their boats. This simple design challenge has a competition built within it to allow for students to make direct observations of components of their peers' boats that led to success in the actual testing phase. Through the development of these boats, they will discuss Isaac's Newton's 3 Laws of Motion and that different forces act on objects.

GRADE LEVEL(S): 4, 5, 6

SUBJECT AREA(S): Science, energy, motion, acceleration, resistance, friction, gravity, thrust, force, Laws of Motion, buoyancy

ACTIVITY LENGTH: 1.5 hours

LEARNING GOAL(S):

Students will identify the Laws of Motion and learn about the forces acting on the system. There are multiple forces acting on a boat, some of these forces include, acceleration, friction, gravity and thrust. High-level concepts that students will be able to apply to their own design:

- Acceleration is the increase in the rate of speed that the boat moving through the water
- Friction exists between the water and the boat and resists motion
- Gravity acts on all objects on earth
- Thrust is the forward force of the propeller moving through the water
- Buoyancy is the force of water is that which pushes the boat toward the surface and is measure using the displacement of water.

NEXT GENERATION SCIENCE STANDARDS:

- 4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.
- 4-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.
- 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.
- PS2-1 Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.
- PS2- 2 Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

STUDENT BACKGROUND:

Students should have a basic understanding of types of energy and energy transfer and transformation. These concepts are worked with and should be assessed in the first two lessons of this unit, with students identifying different types of energy transfer.

EDUCATOR BACKGROUND:

There are two primary forces acting on this science experiment. The first force is gravity. Gravity is trying to pull the tin foil and pennies downward. The force of buoyancy is pushing the boat toward the surface.

The gravitational force is determined by the weight of the tin foil and the weight of the pennies in the boat. The force of buoyancy is the weight of the water displaced by the boat. Your boat will continue to float as long as the force of buoyancy is greater than the force of gravity and you do not overload the boat so it will tip over or leak.

Additionally, you could discuss friction and acceleration with your students using this activity, however, there needs to be motion simulated through pushing the boats on your own and relating these terms to this motion (friction slowing the progress of the boat and acceleration being the increasing speed of the boat as more force is added).

Materials List (30-person class)

- Aluminum foil
- Marbles
- Large tub or basin

Vocabulary

- **Acceleration:** Increase in the rate of speed of an object.
- **Friction:** The resistance that one surface or object encounters when moving over another.
- **Thrust:** a force that produces motion, for example the change of momentum of a fluid in a jet engine, rocket engine, or propeller.
- **Gravity:** the force that attracts a body toward the center of the earth, or toward any other physical body having mass.

- **Buoyancy:** the tendency of a liquid to cause less dense objects to float or rise to the surface.
-

Lesson Details

Activity 1 – Science Olympiad Barge Building Activity

This is a simple Science Olympiad activity found online (<http://www.soinc.org>) under Science Olympiad's Sample K-6 Events. Students will create simple boats from aluminum foil that can carry a load (we used pennies).

- Ask students to draw a design of their cargo boat (barge).
- Students will make a prediction of how many pennies the cargo boat can hold.
- Students will then shape their boat to match their design.
- Students will test it in a small body of water.
- They will have a chance to redesign as necessary.
- After testing students will come together to reflect on this exercise.

Activity 2 – Comparing Boats to Cars

- Go through Isaac Newton's Laws of Motion, if students are unfamiliar with them. Great website for students to write the 3 Laws of Motion: <http://teachertech.rice.edu/Participants/louviere/Newton/>
- Pass out a **Box and T Chart** and give students time to compare forces acting on a boat versus on a car. When using this attached tool, there ensure that students are writing the differences for forces acting on cars on one side of the bottom chart, and boats on the other. Discuss in class together, making sure students see there are similar forces on both a boat and car.
- Possible formal assessment: Laws of Motion Quiz
- Watch video of speed boat to get students excited: <https://peterkaphysics4-5.wikispaces.com/Lauren+McNelis>

References

Barge Building. Science Olympiad Activity. See https://www.soinc.org/sample_k6_events#barge

Isaac Newton's Laws of Motion. Houston TeacherTECH archives.
<http://teachertech.rice.edu/Participants/louviere/Newton/>

McNelis, Lauren. Speeding Boat Moving Through the Water. UMPHysics Picture of the Day.
<https://peterkaphysics4-5.wikispaces.com/Lauren+McNelis>