# How Much Weight Can Your Boat Float?

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|---|---|
| Areas of Science | Aerodynamics & Hydrodynamics (http://www.sciencebuddies.org/science-fair-projects/project-ideas/aerodynamics-hydrodynamics) |
| Difficulty | |
| Time Required | Short (2-5 days) |
| Prerequisites | None |
| Material Availability | Readily available |
| Cost | Very Low (under $20) |
| Safety | No issues |

## Abstract

Have you ever wondered how a ship made of steel can float? Or better yet, how can a steel ship carry a heavy load without sinkir little "boats" out of aluminum foil to investigate how their size and shape affects much weight they can carry and how this relates t

## Objective

Determine how much weight can be supported by boat hulls of various volumes and how this relates to the density of water.

## Credits

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### Sources

This project is based on:

- Junior Engineering, 1997. *Buoyancy.* Utah State University. Retrieved December 29, 2006.


## Cite This Page

General citation information is provided here. Be sure to check the formatting, including capitalization, for the method you are using and upd

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## Introduction

You know from experience that if you drop a steel bolt in a bucket of water that it will sink like a rock to the bottom. On the other h
can float. How does it work?

What determines whether an object floats or sinks? It is the **density** (**mass** per unit **volume**) of the object compared to the densit
than the fluid, it will sink. If the object is less dense than the fluid, it will float. If the object has the same density as the fluid it will n

With a steel-hulled ship, it is the shape of the ship's hull that matters. On an empty ship the hull encloses a volume of air so that t
below.

**Equation 1:**

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

The ship floats because its density is less than the **density of water**. But when cargo or other weight is added to the ship, its den

**Equation 2:**

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

If too much cargo or weight is added to the ship, the density of the ship becomes greater than the density of water, and the ship s
thrown overboard in a hurry or it is time to abandon ship!

Archimedes discovered that an object placed in water **displaces** a volume of water. If the object is floating, the amount of water t
much as the object. The displaced water creates an upward force on the object, called **buoyancy**. The strength of this upward ac
weight of the water that is displaced. Whether an object sinks or floats depends on its density and the amount of water it displace
force.

In this hydrodynamics science project you will make boat hulls of various shapes and sizes using simple materials (aluminum foil
weight can be supported by these hulls and how this relates to the density of water. Can you predict how many pennies each of y

## Terms and Concepts

- Density
- Mass
- Volume
- Density of water
- Displacement
- Buoyancy

### Questions

- What is density?
- How can the density of something, like a boat, be changed?
- If a boat is sinking because it has too much cargo, how does its density compare to the density of water? What about its d

## Bibliography

Here are some good background resources on buoyancy and how heavy objects float in water:


- Wikipedia contributors. (2013, January 16). *Buoyancy.* Wikipedia, The Free Encyclopedia. Retrieved January 22, 2013, frc *title=Buoyancy&oldid=533387673* *(http://en.wikipedia.org/w/index.php?title=Buoyancy&oldid=533387673)*
- *ScienceLine*. (n.d.). *How does a boat float if it's heavy?* University of California, Santa Barbara. Retrieved January 22, 201 *http://scienceline.ucsb.edu/getkey.php?key=2673* *(http://scienceline.ucsb.edu/getkey.php?key=2673)*


Here is an article to get you thinking about what happens if the fluid in which the object is immersed has a density lower or higher


- Phillips, T. (2005). *Rainbows on Titan*, National Aeronautics and Space Administration (NASA), Science News. Retrieved I *https://science.nasa.gov/science-news/science-at-nasa/2005/25feb_titan2* *(https://science.nasa.gov/science-news/science-at-nasa/2005/25feb_*


The following link shows you how to make a Cartesian Diver experiment:


- Wikipedia. (2009). *Cartesian diver.* Retrieved January 11, 2018, from *https://en.wikipedia.org/wiki/Cartesian_diver* *(https://en.v*


For help creating graphs, try this website:


- National Center for Education Statistics, (n.d.). *Create a Graph*. Retrieved June 2, 2009, from *http://nces.ed.gov/nceskids/* *(http://nces.ed.gov/nceskids/createagraph/)*


## Materials and Equipment

- Aluminum foil
- Cellophane tape, such as the common Scotch® tape brand
- Optional: Permanent marker
- Metric ruler *or* dry rice kernels and either a metric measuring cup or graduated cylinder
- A sink, tub, bucket, or dishpan
- Water
- Pennies (at least 200, depending on the size of your boat hulls)
- Optional: Paper towels or rag
- Calculator
- Lab notebook

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# How Much Weight Can Your Boat Float?

https://www.sciencebuddies.org/science-fair-projects/project-ideas/Aero_p020/aerodynamics-hydrodynamics/how-much

(http://www.sciencebuddies.org/science-fair-projects/project-ideas/Aero_p020/aerodynamics-hydrodynamics/how-much-weight-can-your-boat-float)

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## Experimental Procedure

1. Use the aluminum foil and tape to construct at least five boat hulls with different sizes and shapes.
    a. Try building some different boats using the same amount of aluminum foil for each.
    b. Also try building some different boats using different amounts of aluminum foil.
    c. Some different shapes you could try include making the hulls have two pointed ends (like canoes), like the ones on rectangular (like a *rectangular prism*), like the ones on the right in Figure 1.

d. You can fold or even cut the aluminum foil if you wish to obtain the desired shape.
e. Make sure the hulls are not too large to fit in the sink, tub, bucket, or dishpan you will be using.
f. Make finishing touches to the boat hulls so that they are ready to test.
    i. Make sure there are no leaks!
    ii. Make sure the hulls seem to hold their shape. If they do not, try adding a little tape to make them stronger.
    iii. Flatten the bottoms of the hulls.
    iv. Try to make sure each hull's rim is the same height going all around the edge of the hull. In other words, mal of any of the hulls.
g. Assign a number (1 to 5) to each boat hull. You could do this by using a permanent marker to label each hull with a each hull in your lab notebook. However you do it, just be sure you have a way to identify each hull by a number.

**Figure 1.** Some different boat hull shapes you could make include boat hulls that have two pointed ends, like the ones on the square or rectangular, like the ones on the right in this image.

2. Calculate the volume of each boat hull. Below are two alternative methods you could use. (Or, you could use both method method is more accurate?)
    a. Ruler Method
        i. If the hull is a rectangular prism, use the ruler to measure the length, width, and height of the hull in centimet Equation 3 below.

        **Equation 3:**

        ii. If parts of the hull are rectangular prisms but other parts are curved or angled, measure the (imagined) parts calculate the volume of each part, and add up the volumes to get the total volume for each hull.
            1. Use *triangular prisms* to approximate any areas of the hull that are curved or angled. Calculate the vc

2. Calculate the volume of any rectangular prism parts by using Equation 3 above.

iii. If the entire hull is a triangular prism, calculate the volume by using Equation 4.

iv. In your lab notebook, record the volume for each hull in a data table like Table 1 below.

**Equation 4:**

½

b. Dry Rice Method

i. Carefully fill the boat hull with dry rice. The rice should be level with the top of the hull.

ii. Being careful not to damage the hull, move the dry rice into the measuring cup (or graduated cylinder).

iii. Gently shake the cup to level the rice.

iv. Read the volume of the dry rice, in milliliters (mL).

1. If this is all of the rice that was in the boat hull, then this is the volume of your boat hull.
2. If there is still rice left in the hull, empty the rice from the measuring cup and fill it with rice from the hu notebook, keep track of the amount of rice that you have filled the measuring cup with. The total amo volume of the hull.

v. In your lab notebook, record the volume for each hull in a data table like Table 1 below.

1. Record the volume in cubic centimeters ($cm^3$). Cubic centimeters are the same as milliliters.

| Boat hull | Volume (in $cm^3$) | Number of Pennies it Supported | Weight it Supported (in grams) | (i |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |

**Table 1.** In your lab notebook, create a data table like this one to record your measuremer

3. Measure the buoyancy of each boat hull.

a. Fill the sink, tub, bucket, or dishpan with some water.

i. The water level should be deeper than the height of the boat hulls so that they are able to sink.

b. Carefully float one of the hulls in the container of water.

c. Gently add one penny at a time. To prevent the hull from tipping, carefully balance the load as you add pennies (lef starboard, fore and aft, if you are feeling nautical).

d. Keep adding pennies until the boat finally sinks.

e. Count how many pennies the boat could support before sinking (i.e., the penny that sank the boat does *not* count).

f. In the data table in your lab notebook, record how many pennies the boat could support.

g. Repeat steps 3b to 3f until you have tested each hull.

i. Only use dry pennies. If you run out of dry pennies, you may need to use paper towels or a rag to dry some,

h. For each hull, convert the number of pennies it could support to grams. Do this by multiplying the number of pennie single penny in grams). Record this in the data table in your lab notebook.

4. Calculate the density of each hull right before sinking.

a. For each hull, divide the number of grams it could support by its volume. This will give you the hull's density in gram
b. Record your results in the data table in your lab notebook.

5. Make a line graph of buoyancy. To do this put the weight supported by the boat (in grams) on the y-axis and the boat hull v each boat on your graph.
   a. You can make a graph by hand or use a website like Create a Graph (http://nces.ed.gov/nceskids/createAgraph/) to make a grap
6. Make a bar graph of the density of each hull before sinking. To do this put the density before sinking (in grams per cm³) on the boats (on the x-axis).
7. Analyze your graphs.
   a. What do your results tell you about the relationship between buoyancy (amount of weight a boat can support) and v
   b. The density of the hulls right before sinking should roughly be the same as the density of water. (*Tip:* Reread the In are unsure of why this is.) Based on the results in your bar graph, what do you think is the density of water?

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(http://www.sciencebuddies.org/science-engineering-careers/engineering/marine-architect)

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(http://www.sciencebuddies.org/science-engineering-careers/engineering/materials-scientist-and-engineer)

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What makes it possible to create high-technology objects like computers and sports gear? It's t Materials scientists and engineers develop materials, like metals, ceramics, polymers, and com their designs. Materials scientists and engineers think *atomically* (meaning they understand thir design *microscopically* (at the level of a microscope), and their materials are used *macroscopic* heat shields in space, prosthetic limbs, semiconductors, and sunscreens to snowboards, race c materials scientists and engineers make the materials that make life better. Read more (http://www careers/engineering/materials-scientist-and-engineer)

## Variations

- You roughly calculated the density of water in this science project, but your calculation could be made even more accurate your density calculation, develop a way to more accurately determine the density of water, such as by including the weight than pennies to measure how much weight the hulls can carry, and more accurately determining the volume of the hulls. H the actual density of water?
  - *Tip:* To calculate the average weight of a small item, you can use a scale to find out how much 10 or 20 of the items average weight by dividing the total weight by the number of items you weighed.

- In this science project you investigated the density of water, but what about the density of other liquids? Think of some oth like to test the density of, such as cooking oil, liquid detergent, or snow. Check with an adult first to make sure it is alright f science project. Make sure *not* to use any dangerous chemicals, such as household cleaning solutions! If you do not want it with water or use a small container (just wide enough to fit your boat hull in) and fill it so it is just a little deeper than the h with water, keep track of how much you diluted them by. What are the densities of other liquids and semisolids? How do th
- It would be difficult to bring a bathtub to the science fair in order to demonstrate your project, but there is a nice demonstra clear plastic soda bottle—see the Wikipedia link in the Bibliography in the Background tab.
- Use other materials for building the boat hulls. For example, waxed half-gallon cartons (for milk or juice) can be cut open a waterproof material. To make folds to create the desired hull shape, first score the material with a blunt stylus—the classic a great shape for this. Keep the cap on and use it to score the waxed paperboard before folding.
- Here is a "thought experiment" for more advanced students to try. NASA's Cassini spacecraft sent the European Space Ag Saturn's moon, Titan, where it found evidence that the surface contains large bodies of liquid methane (Phillips, 2005 (https:/ nasa/2005/25feb_titan2)). On Earth, methane ($CH_4$) is typically not liquid at all, and is known most commonly as 'natural gas.' On −179°C, water would be solid and methane is a flowing liquid. What is the density of liquid methane? How does the densit density of water? If your boat could float 100 pennies in water, how many pennies would it support (on Earth) in a containe experiment you could do would be to re-do the experiment with a liquid that has a density different than that of water. Cool the difference in density is not nearly as dramatic as for liquid methane, it is a lot easier to obtain and safer to work with! H in vegetable oil (measured by the number of pennies it can support) compare to its buoyancy in water?

## Ask an Expert

The Ask an Expert Forum is intended to be a place where students can go to find answers to science questions that they have be If you have specific questions about your science fair project or science fair, our team of volunteer scientists can help. Our Expert make suggestions, offer guidance, and help you troubleshoot.

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