Flying Start Challenge

How Do Boats Float?

AIRBUS ATKINS BAE SYSTEMS ROYAL NAVY FLEET AIR ARM MUSEUM GKN AEROSPACE

LEONARDO MBDA SAFRAN

Instructions

- Go through background material
- Complete this activity recording measurements as you go
- Complete data analysis – take care to record your answers neatly and show equations used.
- Send in answers to teacher.
- There is a competition activity at the end!

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Background Material

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LEONARDO HELICOPTERS MBDA MISSILE SYSTEMS ROLLS-ROYCE SAFRAN

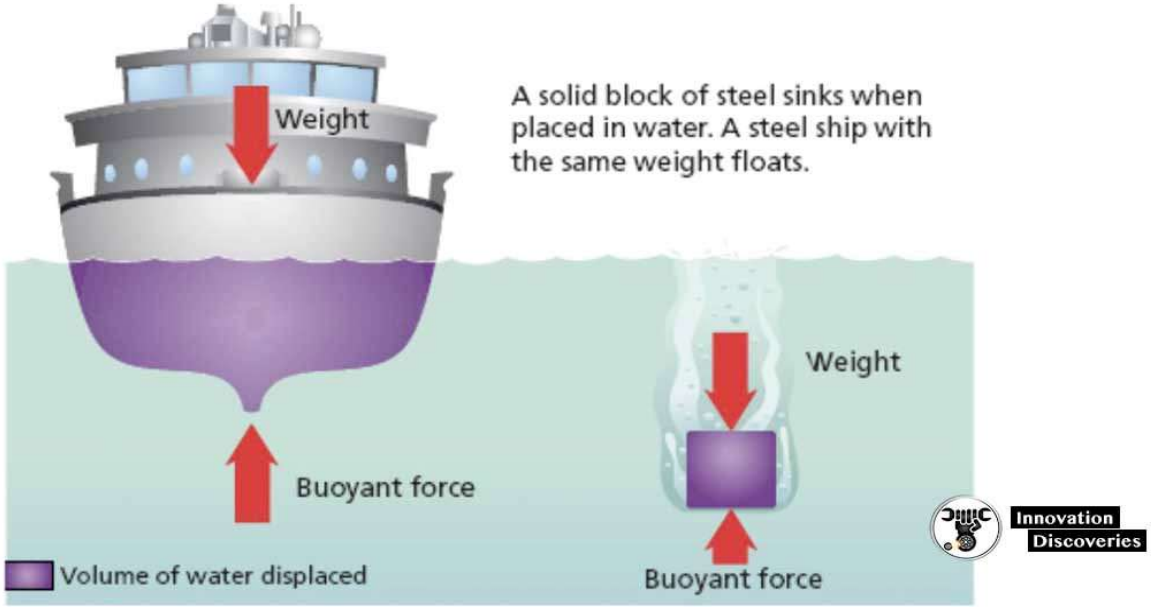
Over 2200 years ago Greek engineer Archimedes sat down in his bath. He noticed how the water level rose as he sunk into the water. Suddenly, in a burst of inspiration, he proclaimed Eureka! Eureka! He had understood that the height of the bath was directly related to the amount of his body which was under water. This is known as Archimedes principle, the volume of water displaced by a body is equal to the volume of the body that is submerged.

Building on this, Archimedes discovered that there is a buoyant force that pushes up on an object when you place it in water. The strength of this force is equal to the weight of water that has been displaced. This also explains why some things float while others sink. Wood floats whereas a stone of equivalent size would sink. This is because the amount of water displaced is only dependant on the size of the wood/stone. As they are both the same size, they both experience the same buoyance force. However, the stone is much heavier meaning it experiences a larger gravitational force. This gravitational force is greater than the buoyance force and therefore the stone sinks.

Density is used to understand how different materials would perform. Density is the mass per unit volume of an object, or how much stuff is in a certain space. For example, a sponge is not very dense. Now imagine a stone the same size as the sponge, the stone has a higher density – there is more matter packed into the same volume. If the density of an object is less than that of water, the object will float. The equations for density is as follows:

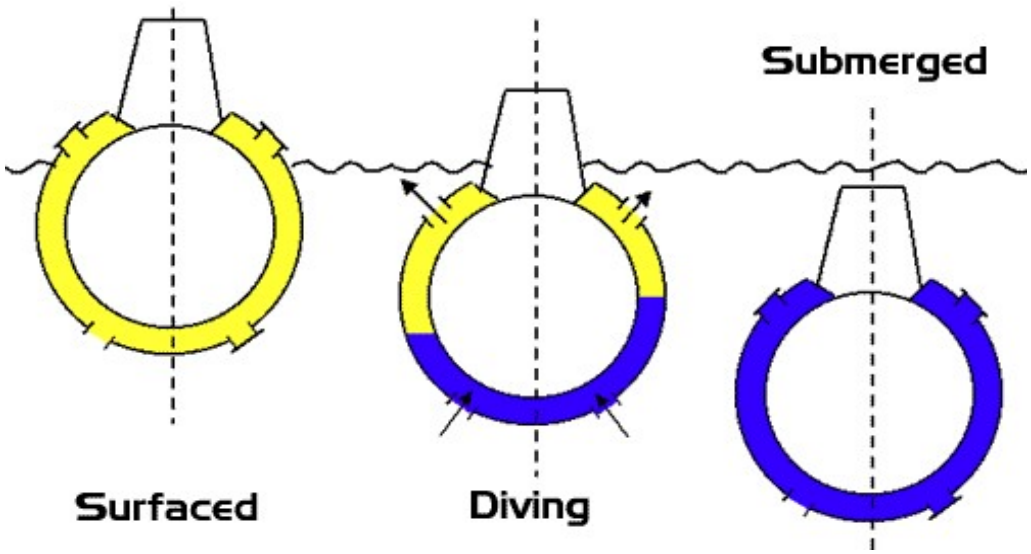
$$density = \frac{mass}{volume}$$

Using this knowledge, we can now discover how metal ships are able to float despite being made of very dense material. Materials more dense than water can float if they displace the same weight of water as they weigh. This is achieved by the ship's hull. The ship's hull is designed to displace more water than it weighs and does this by increasing its volume as you can see in the image below. Because the volume has increased, the density of the ship is much less than the density of the solid cube of metal meaning the ship floats.


Weight
A solid block of steel sinks when placed in water. A steel ship with the same weight floats.
Weight
Buoyant force
Volume of water displaced
Buoyant force
Innovation
Discoveries

Extra Insight!

Submarines float and sink by changing its density. To sink, the submarine pumps sea water into ballast tanks. This increases the amount of mass contained in the submarine. As the volume of the ship has not changed, the density increases to more than that of water. This means that the buoyancy force becomes less than that of gravity and thus begins to sink beneath the waves. To re float the submarine, the seawater in the ballast tanks is pumped back into the sea which acts to reduce the mass of the submarine which makes the density lower than the density of water. Thus now, with the gravitational forced reduced, the buoyancy force is once again larger causing the submarine to rise out of the sea.


Submerged
Surfaced
Diving

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Activity

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Materials

- Towels/kitchen roll
- Large, preferably clear, bowl/container (e.g. washing up bowl, measuring jug, etc.)
- Tap water (Be careful not to get it on your laptop/tablet!)
- Aluminium foil
- Ruler
- Pen
- Scissors
- Permanent marker/felt tip/sharpie
- Notebook
- Camera

Setting Up

1. Spread out the towel/kitchen roll over a hard work surface.
2. Fill the bowl or container about two-thirds full of tap water and put it on the towel/kitchen roll.
3. Using a pen and ruler measure out a 25cm x 25cm square of aluminium foil.
4. Use the scissors to cut out the square.
5. Repeat steps 3 & 4 3 more times.
6. Create a table like the one on the next slide.

Setting Up

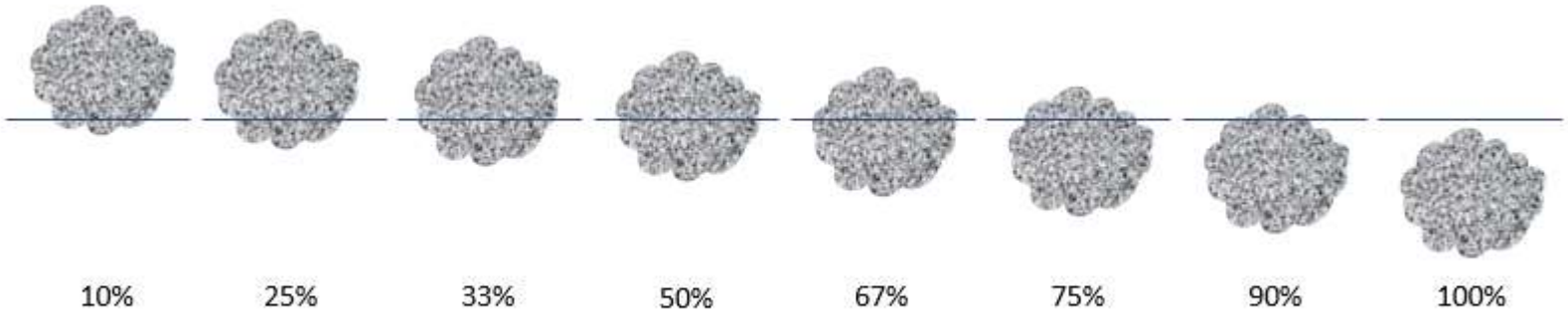
Diameter (cm)	Amount of the Ball Under the Water (%)			
	Sheet 1	Sheet 2	Sheet 3	Average

Experimenting

1. Take your first sheet of aluminium foil and mark each corner with the felt tip pen so that you can see the corners later.
2. Pull the corners of the sheet together and crumple the sheet into a loose ball approximately 6 cm in diameter (Try to keep the corners together).
3. Measure the actual diameter of the aluminium ball and note this in the top of the row of sheet 1.
4. Gently set the ball in the water. NOTE: To avoid the ball filling up with water place the ball in the water so that the coloured corners you marked earlier are at the TOP.

Experimenting

5. Write down how much of the ball is underwater, using the following diagram as a rough guide. If you have a clear container it may help to move down so that you are at eye level with the ball.



Experimenting

6. Remove the ball from the water, shake out any water and dry it on the towel.
7. Now crumple the same aluminium ball a little more tightly to a diameter of roughly 5 cm. If you go too small gently pull the ball apart to be bigger.
8. Repeat steps 3-7, crumpling the ball slightly smaller each time until the ball sinks or you can't make it any smaller. If you're struggling to make it any smaller you could gradually stand on the ball to make it smaller.
9. Repeat steps 1 – 8 for the other two sheets of aluminium foil.

Analysing the Data

- Calculate the average percent of the ball submerged for each diameter, write these in your table. Marks for making an attempt. [2 marks]
- Plot a graph with the diameter of the aluminium balls on the x-axis and the average percent submerged on the y-axis. Marks for a neat and readable graph. [2 marks]
- Did the balls sink? If so at which diameter?
- At which diameter did the balls have the lowest density?
- At which diameter was the density of the balls roughly equal to the density of the water? [2 marks]
- Can you calculate the density of the water? [2 marks]
- Make sure to hand in you Table, Graph and answers to your teacher.

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Competition

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Who can make the best boat?

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Aim

In this experiment we will see who can make the best boat out of aluminium foil.
You will each design and build a boat out of aluminium before competing to see who's can hold the most weight.

Materials

- Aluminium foil
- Ruler
- Tape
- Pen or pencil
- Towel or kitchen roll
- Pennies (or anything small you know the weight of or can weigh)
- Calculator
- Bucket/tub/sink/bath
- Water
- Camera

Design and Build Your Boat

1. Cut out a 25cm x 25cm square of aluminium foil.
2. Cut 10cm of tape.
3. Design your boat using only the aluminium foil and the specified length of tape. There is an example in the picture or feel free to design your own. Marks will be awarded for creativity.
4. Make sure to think about:
   a) What makes a boat float?
   b) How will adding weight effect the performance of your boat?
   c) Are there any real life examples that you can take inspiration from?
   d) Why is a speed boat so different to a cargo ship? Which performs a similar job to your boat?

Test Your Boat

Be sure to have your camera ready to film/photograph your experiment.

1. Place your boat in the tub/sink/bath full of water.
2. Begin placing pennies/weights into your boat.
3. Record the number of pennies/weights your boat can hold before it sinks and send a picture/video of your boat holding this weight to your teacher.
4. Calculate the weight your boat held, either from weighing the load or using online values. Make sure to weigh the load when dry.
5. Submit the weight your boat held to your teacher, with photos or videos. Marks will be given on the weight held.

Lesson Reflection

- Can you outline the details of the Archimedes Principle?
- Can you explain how this principle causes objects to float?
- How do you calculate density?
- How do submarines use this principle to sink?
- How did surface area of your boat affect its ability to float?
- What did you find happened when the weight on your boat was increased?