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3.1 What floats your boat?

Lesson outcomes

At the end of this activity students will be able to:

- design and construct a plasticine model that can float.

What ideas might your students already have?

- Students may not think that there is a single explanation for why floating and sinking.
- Students may believe that different explanations relate to different contexts; such as light things will float, the depth of water affects how well something floats.

Teacher content information

This is a simple and engaging activity that will, hopefully, draw student thinking towards the importance of shape in determining whether something will float or not. Using small weights to test the effectiveness of their plasticine boat serves two purposes. Firstly it provides a bit of competitive excitement to the activity. It also provides a simple example of how a piece of technology can be evaluated for its effectiveness.

Lesson plan

What to use:

Each GROUP will require

- one piece of plasticine
- large container of water
- a set of small masses, such as small washers.

What to do:

Step 1: Roll your piece of plasticine into a ball and check whether it will float.

Step 2: Now re-shape the plasticine so that it DOES float.

Step 3: Test how many weights your boat can carry before sinking. How did this compare with other groups in the class?

Step 4: Draw a sketch of your floating plasticine boat in your Notebook.

Discussion:

In your ***Notebook*** write an explanation of why you think the plasticine was able to float in its new shape, while it sank when it was in a ball.

Remember, that this is the **same** piece of plasticine.

In your ***Notebook*** draw a sketch of your boat with arrows showing what forces you think are acting on it.

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3.2 Density

Lesson outcomes

At the end of this activity students will be able to:

- Experimentally determine the density of a material.

What ideas might your students already have?

- Students tend to concentrate on weight or size rather than combining these into a new concept of density.
- Students believe that heavy things sink.
- Students find ideas that involve a ratio difficult to work with.

Key vocabulary

Density

Teacher content information

This is activity appears to investigate experimentally a relationship that is totally obvious. But many students at this level find this relationship surprising even if the y have been taught the definition of density and done practice calculations. The *Student Guide* includes the story of Archimedes and the gold crown. The historical veracity of this story is very questionable, but is included here because there is no doubt that Archimedes did develop an explanation for buoyancy, which is covered in the next activity.

The link between mL and cm^3 is an important one to emphasise, and also that 1.0 mL of pure water has a mass of 1.0 g by definition.

Lesson plan

What to use:

Each GROUP will require

- a set of masses of the same material but different sizes. These could be made from plasticine. They need to be of a size that can fit into the measuring cylinder.

An alternative material to use could be large lead sinkers.

- electronic balance for weighing objects up to 500 g.
- 100 mL measuring cylinder

What to do:

Step 1: Carefully weigh each of your masses. Note that you will have measured the mass of each one, measured in grams (g).

Step 2: Now measure the volume of each mass by placing it in the measuring cylinder and noting how much water was displaced. You will need to have sufficient water in the cylinder so that the object can be totally immersed. You will have measured the volume in mL (which are equivalent to cm^3)

Step 3: Calculate the density of each of your masses using the formula provided.

Step 4: Draw up a table of your data.

Step 5: Draw two graphs to illustrate your data. The graphs should show what happens to both the mass and the density as the volume changes.

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Discussion:

1. What happens to the mass of the objects as the volume increases?
2. What do you notice about the density of your different masses?
3. If one of the masses was cut exactly in half;
   a) what would happen to its mass?
   b) what would happen to its volume?
   c) what would happen to its density (m/V)?
4. Other groups in your class may have used a different material. How do their results compare with yours?

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3.3 Buoyancy: forces in balance

Lesson outcomes

At the end of this activity students will be able to:

- demonstrate that any object that is lowered into water loses weight.
- represent weight and buoyancy force of a floating object using appropriate force arrows.

What ideas might your students already have?

- Students may not be familiar with the concept that water can exert a force on a solid object. They may think of buoyancy in terms of the water simply getting in the way of the floating object.
- Students believe that heavy things sink.

Key vocabulary

Buoyancy

Teacher content information

Buoyancy is an upwards force, or up thrust, exerted by a fluid that opposes the weight of an object. In a column of fluid (and this is true of both gases and liquids) pressure increases with depth as a result of the weight of the overlying fluid. The pressure at the bottom of an object is slightly greater than the pressure at the top of the same object. This pressure difference produces a net upwards force that is called buoyancy. It is surprising that such small differences in depth can produce such a significant effect. It turns out that the magnitude of that force is equivalent to the weight of fluid that has been displaced (Archimedes' Principle). This is a simple, but powerful, observation. It is not, however, immediately obvious why this should be true. The mathematics behind it is somewhat complex (but reasonably explained in the Wikipedia article on Buoyancy). Even the atmosphere exerts a buoyancy force that is observable when a helium filled balloon floats. The buoyancy effect on our bodies is small, but does make us slightly lighter than we would be in the absence of air.

Lesson plan

What to use:

Each GROUP will require

- large container or sink half filled with water
- large ball (hollow)
- spring balance or force measurer
- two masses tied to a string (one that would sink and one that would float e.g. ping pong ball and golf ball)

What to do:

Step 1: Try to push the ball under the water. What do you observe? (in this case your observation might be based on feel rather than sight).

Discussion:

1. Was it hard to 'sink' the ball?
2. Did you feel a force pushing the ball upwards?

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Step 2: Attach the object that would float to the spring balance or force measurer, and make a note of its weight.

Step 3: Now lower it slowly into the water until it stops sinking. What weight is recorded on the spring balance?

Step 4: Now attach the object that would sink to the balance and record its weight. Lower it slowly into the water until it is completely submerged. Has its weight reduced?

Discussion:

3. By how much did the weight of the objects decrease?
4. Where do you think this weight went?
5. Do you think the level of the water rose?

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3.4 Free body diagrams

Lesson outcomes

At the end of this activity students will be able to:

- represent multiple forces acting on an object using a free body diagram.

What ideas might your students already have?

- Students should now be familiar with the idea of representing a force using an arrow, where the size and direction of the force are represented by the length and direction of the arrow.
- Students may be unsure about where to place the arrow on their diagrams.

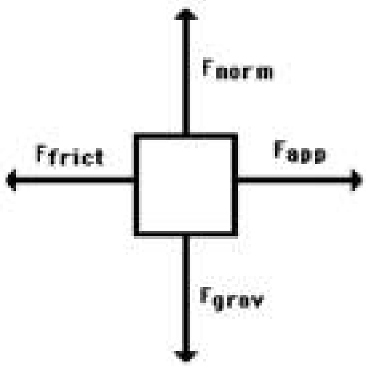
Key vocabulary

Free body diagram

Teacher content information

A free body diagram shows all the forces acting on a single object. The term 'free body diagram' is often not included in the teaching of forces at this level even though students are often required to place multiple force arrows on a diagram to represent multiple forces acting. There is no great conceptual leap in identifying that there is a scientific term for such diagrams. An important feature of free body diagrams is that the tail of the force arrow be placed as close as possible to where the force acts. Students will often place the arrow head in this location to indicate where the object is being pushed.

The end result should be a diagram with multiple force arrows showing the different forces acting on one object. The free body diagram is a fundamental instrument used by physicists and engineers to describe the force interactions in any situation. It can be a very simple representation, as shown in this diagram.



Some forces are worth a particular mention. A normal force is one acting from a surface onto an object resting on it. The size of the normal force will be equal in size to the force of the object pressing on it (possibly its weight if it is lying horizontally) and they are always perpendicular to the surface in question. The force of friction is a horizontal force exerted by any surface that is experiencing a force due to some other surface applying a horizontal force to it. If there is not horizontal component to any force between the two surfaces then there is no force of friction occurring (eg if a book is simply lying on a table. If someone attempts to slide the book across the table then there will be a frictional force occurring, whether or not the book moves). Friction is sometimes referred to as a force that opposes motion, but this is not strictly correct. If an object is changing direction the force of friction will relate to the direction the object is accelerating rather than the direction of its current motion. An object at rest may be experiencing many forces including static friction. The force of gravity is one that acts on all objects and is generally shown acting either from the centre or the bottom of the object directly downwards.

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Lesson plan

What to use:

Each STUDENT will require:

- access to the student *e-Notebook* or worksheet printed from the ***Notebook***.

What to do:

Students complete the exercise in the ***Notebook*** followed by the *Student Digital* activity.

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3.5 Seesaws

Lesson outcomes

At the end of this activity students will be able to:

- carry out an experiment to show that a 1st order lever can multiply force or distance, and changes the direction in which the force acts.

What ideas might your students already have?

- Students will have an intuitive idea of how a seesaw works and will behave under different conditions.

Key vocabulary

Lever, effort, load, fulcrum

Teacher content information

This activity draws on the experiences that many students will have had with seesaws to explore a scientific idea. Students should notice that this simple lever can change the magnitude of a force and distance through which it acts, and change the direction in which a force is applied. They should also discover, or reinforce their understanding, that where the output force of lever is increased then distance is decreased, and vice versa. This is a simple consequence of the conservation of mechanical energy in this system; work in equals work out, where work is defined as F.d. This energy relationship is further explored in the Year 8 unit *Energy*.

Lesson plan

What to use:

Each PAIR will require:

- a pencil
- piece of paper
- 30 cm ruler
- 10 washers

What to do:

Step 1: Place the pencil flat on the table top and balance the ruler on top of it.

Step 2: On your piece of paper draw a number line so that zero is in the middle and lines up with the pencil (the fulcrum).

Step 3: Put one washer on the 10 cm mark and try to balance it with a stack of two washers on the other side.

Step 4: Now try to balance three washers with two washers.

Step 5: Can you find a rule that allows you to predict where to place the washers?

Discussion:

- Was there a pattern to your results?
- Did you find a general rule?

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3.6 Levers around us

Lesson outcomes

At the end of this activity students will be able to:

- describe the different outputs, and examples, of 1st, 2nd and 3rd order levers
- identify everyday objects that act as levers.

What ideas might your students already have?

- Should now understand that concept that a lever can multiply force and distance, but that a larger output force is associated with a smaller output distance and vice versa.

Key vocabulary

1st order lever, 2nd order lever, 3rd order lever

Teacher content information

All levers either change force and distance, or change the direction in which a force acts, or both. Only a 1st order lever can change the direction in which a force acts. 2nd order levers always produce a larger output force but over a proportionally smaller distance. 3rd order levers always produce a smaller output force but over a proportionally larger distance. These characteristics can be related quite well to a geometrical interpretation using similar triangles.

Lesson plan

What to use:

Each STUDENT will require:

- *Science by Doing* ***Notebook***

What to do:

Step 1: In your ***Notebook***, place labels on these three useful devices showing the EFFORT, LOAD and FULCRUM.

Step 2: For each example, indicate whether it is;

Multiplying force
Multiplying distance
Changing the direction of the force.

Also identify whether each one is a 1st, 2nd or 3rd order lever.

Step 3: Now look at the images provided in the ***Notebook*** and explain which order lever is used in each situation.

Locate the fulcrum, load and effort in each case.