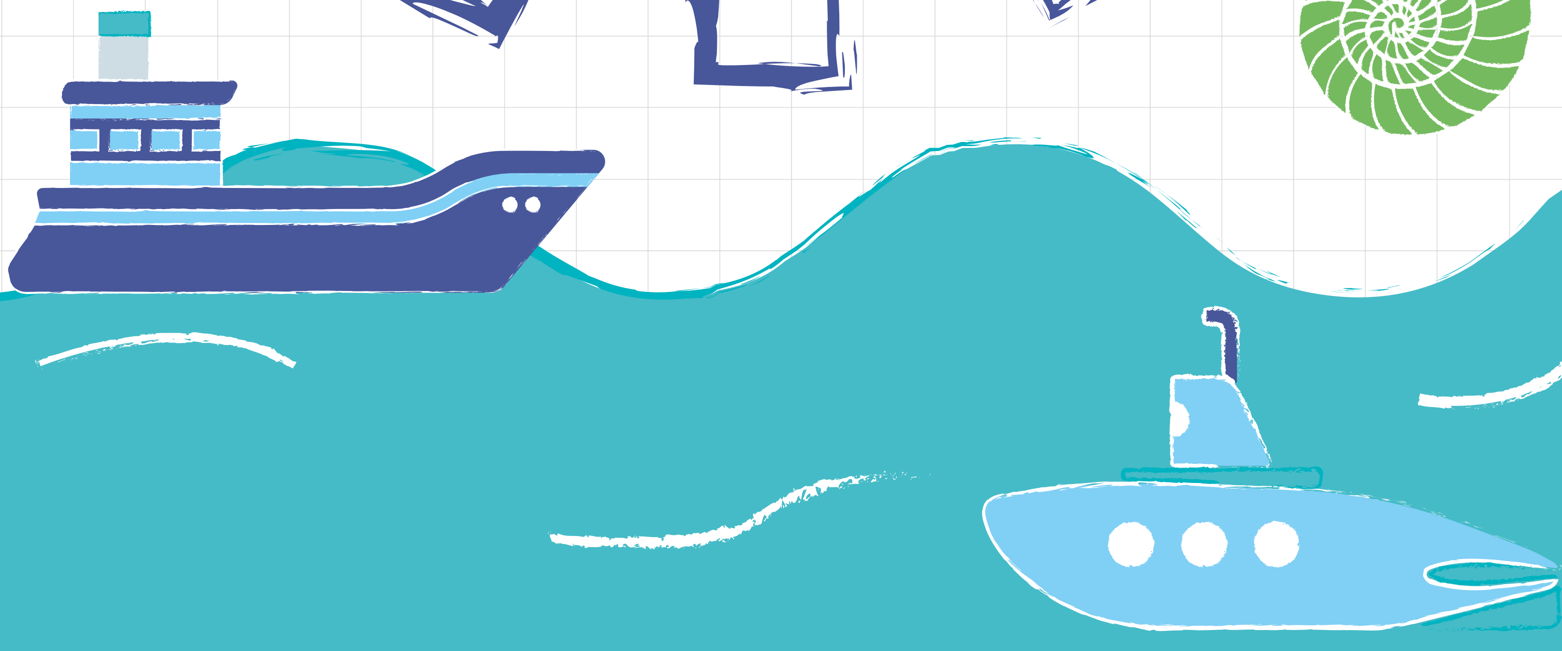
WE DISCOVER, WE GROW
Girlguiding
North West England

BAE SYSTEMS

CLEVER COGS CHALLENGE

MAKING WAVES

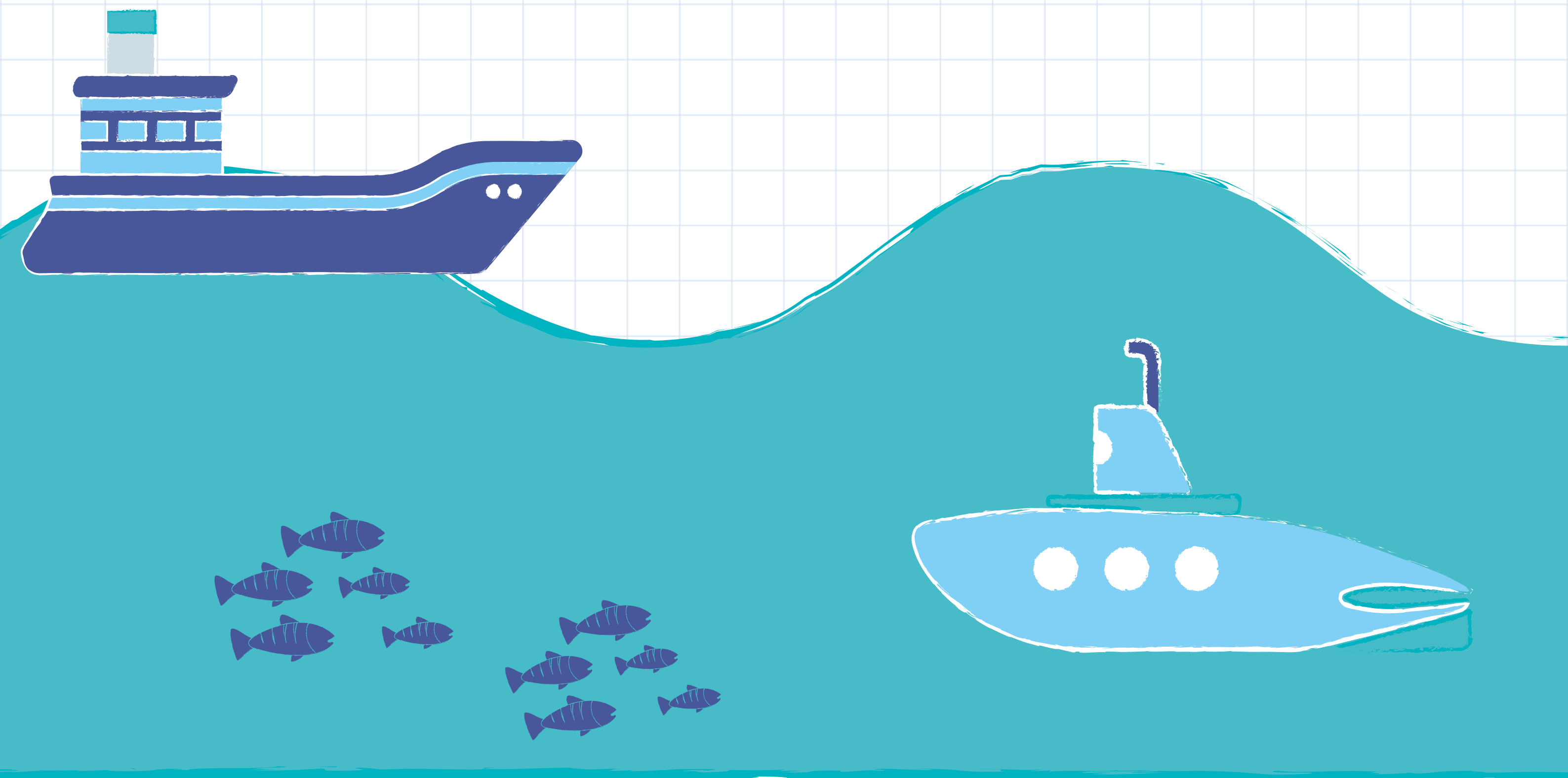


Contents

Introduction

About this Challenge:

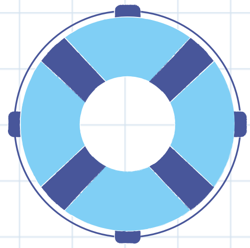
This challenge is an extension of the popular Clever Cogs Engineering Challenge, and is themed around Marine Engineering. It is a little bit different to the previous challenges; in the Making Waves challenge you will follow the activities in order and, at the end, you will use the knowledge and skills you have developed to complete the final activity (building your own submarine!). Each activity will give you a taste of a different kind of engineering that you might find within the field of Marine Engineering. After each activity you'll read about some incredible female engineers who have achieved something amazing in their field! In addition, you will find that each activity has a section giving you an overview of a career path that you could pursue within the field of Marine Engineering, inspiring you to one day become a Hydrographic Surveyor, or maybe even an Inventor!



Oh Buoy!

This activity will teach you about buoyancy and how it applies to ships, submarines, and other water-based equipment and vessels. It will explain the forces acting on a boat, and how the density of the water (using salt) affects the buoyancy. The activity will involve making small boats and using weights to demonstrate how ships float without rolling over or sinking. It will also include adding salt to the water and noting how it affects buoyancy - this is a big consideration for marine engineers when choosing appropriate materials.

Equipment:



- Print-out of Appendix A (or this can be done on a computer if virtual)
- Small plastic tub (why not reuse an old takeaway tub?)
- Stones (used for weights - you will need enough to sink your boat)
- A washing up tub or similar filled with water
- Print out of Appendix B1 or B2 (or this can be done on a computer if virtual)
- A variety of small objects that can be put into water (stones, fruit, pen, etc)
- 1-1½ cups of table salt
- Spoon

Estimated Time: 20 minutes

Method:

1. Fill out the boat diagram in Appendix A with the appropriate words. Then, fill out the paragraph of what buoyancy is by matching the words with the right part of the sentence in Appendix B. Show this to your leader when you've finished, and they will check it for you.

2. You should now have an idea of what buoyancy is, and we're going to put this to the test. Put your small plastic tub into the water - see how it floats? Now add a couple of stones into the tub - what happens?

3. Keep adding stones into your tub and see what starts to happen - do you think it's going to sink, or topple over?

4. As you add weights to your 'boat', you are increasing the overall weight of your boat. Look at your diagram to see where this force applies to your boat.

5. As the weight of the boat is greater than the buoyancy of the boat, the boat will sink. You can watch this happen as you add more and more weight to your boat. Keep a log of how many stones you add to your boat to make it sink.

6. Now, remove your boat and all of the stones, and add the salt to the water - stir it until it is dissolved.

7. Now try the experiment again, and compare how many stones it takes to sink your boat compared to the first time. Do you think the water is more dense or less dense than without the salt? Can you explain the results?

Keep it Simple!

If you think the main activity is a little too challenging for your group (i.e. young Rainbows), try a simplified version below.

1. Fill out the boat diagram in Appendix A with the appropriate words. Then fill out the paragraph of what buoyancy is by matching the words with the right part of the sentence in Appendix B. Show this to your leader and they will mark it for you.

2. You should now have an idea of what buoyancy is, and we're going to put this to the test! Look at the table provided in Appendix C, and list three objects in your table (these have to be objects you have access to and that can put into water without damaging them). Then, have a think about whether your items will sink or float, and why you think that. Fill out the first column of your table with what you think will happen.

3. Now you get to test them out! Take it in turns to test each of your objects to see if they float in water. Record the results in your table and see how many you get right. Read the paragraph you filled out in Step 1 for some information on why some objects float and some sink

Take it Further:

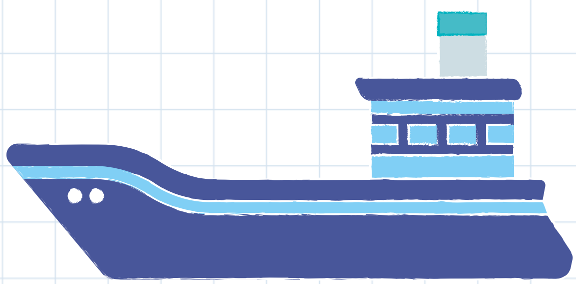
To take this activity a step further, complete the main activity, but this time try the second part of the experiment in stages - adding salt in stages and making a record of how many stones it takes to sink it each time. This will involve a bit of analysis where you can create a table of your results.

How has adding the salt to the water changed how the boat sits in the water? Do you think it has affected the buoyancy, and why?

How this relates to Engineering:

Archimedes' principle states that the buoyant force that is applied on an object immersed in a fluid is equal to the weight of the fluid displaced by the object. This simply means that if you fill a bath to the very, very top and then drop a rubber duck in, the rubber duck will displace (move) some water to make room for it (and you'll have a wet floor!). The amount of water that has been displaced is equal to the volume of the rubber duck. So, the rubber duck will only float if the weight of the water that the rubber duck displaced weighs more than the rubber duck. However, if you drop a brick into the bath, the brick weighs more than the amount of water that it displaced, and therefore the brick would sink. Look up buoyancy online to learn more about it!

Marine Engineers or Naval Architects have to consider the effects of buoyancy when they design boats. They have to think about the materials they use, and the size and shape of the hull (the bottom of the boat) so that the boat will float and not sink



Guidance for Leaders:

The ‘Keep it Simple!’ part of this activity has been created to provide a slightly easier version if you think your group might struggle with the main activity. It still teaches about the concept of buoyancy, but in a slightly simpler way.

The ‘Take it Further!’ part of this activity has been created to provide a more challenging additional part to the activity. This just furthers the girls’ understanding of buoyancy by comparing the different salt solutions, and would be most suited to Rangers or older Guides.

The aim of this activity is to teach the girls about the concept of buoyancy and the forces acting upon a boat. The additional element of density has been added to the experiment through adding salt to the water. Adding salt to water increases its density. Buoyancy is directly proportional to density, so by increasing the density, the buoyant force also increases. This means by adding salt to the water, the ‘boat’ will be more inclined to float, and you will see that it will be able to withstand more weight before sinking as opposed to the water without any salt added.

This is why swimming in dense salt water (i.e. the Dead Sea!) makes you float so much when swimming in it!

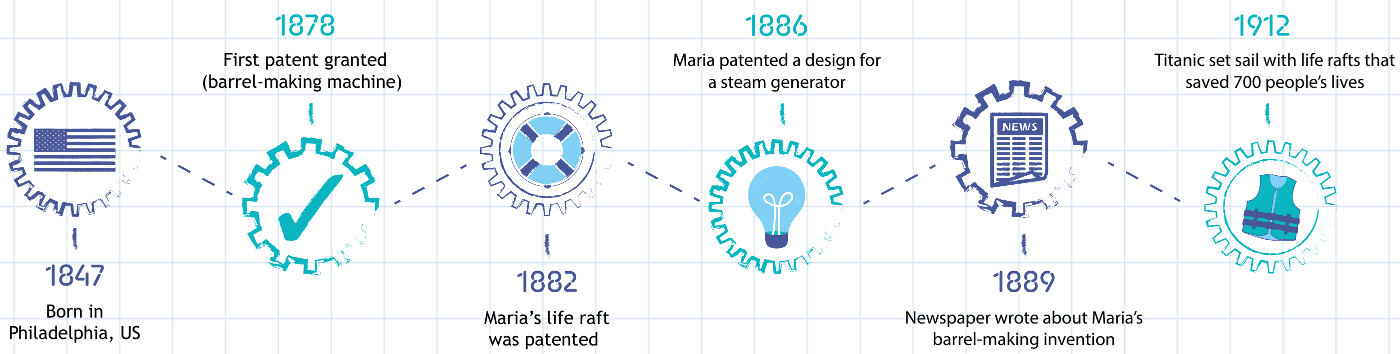
Inspiring Female Engineer: Maria Beasley

Maria was an Inventor who was born in 1847 in the United States. She was known as an ‘engineering dynamo’ for inventing really amazing products over her lifetime; many of which were machines. She secured 15 patents for her inventions, which ranged from foot warmers to one of the world’s most significant inventions - the life raft.

One of Maria’s first inventions was a barrel-making machine, which she received recognition for making a fortune from in the local newspapers. Maria then went on to obtain two patents for life raft designs, which would go on to save many lives in the years following. Prior to Maria’s life raft design, life rafts were simply planks of wood which people held onto to stay afloat. Maria is said to have saved millions of lives with her invention.

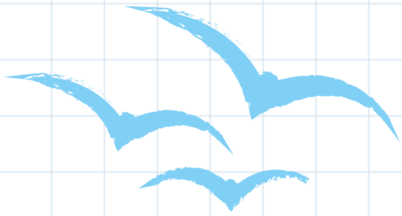
Maria’s life raft design was used on the RMS Titanic, where around 700 passengers were saved using the 20 life rafts on board.

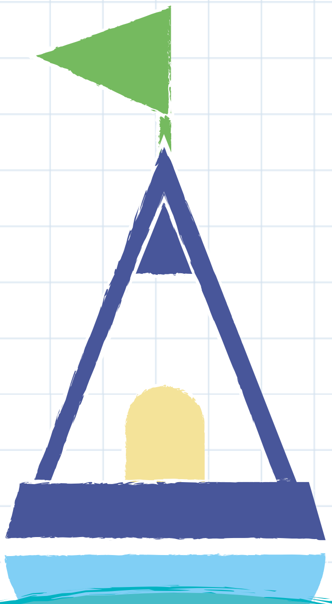
Timeline:



Career: Inventor

There are many different ways of becoming an Inventor. It's not as straightforward as some other career paths, because it relies on your creativity and ability to turn your imagination into a product. Inventors often have other jobs on the side to support themselves whilst they try out new inventions and creations. A good idea might be to join a start-up business to learn what it's like to start up your own business and work in that environment. A more education-focussed route would be to undertake education in Industrial Design or Product Development. You can study courses in these subjects at university and complete a Bachelor's Degree and even a Master's Degree. If you have a love of computers and technology, you might want to look into studying to become a Computer and Research Scientist. Another route you could take is to apply for an internship at an Industrial Design or Research company, to gain some real-life experience. There might even be apprenticeships on offer, which give you the opportunity to gain qualifications while working and gaining experience in the field.

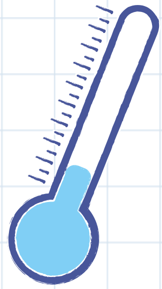




Brrrrr-illiant Engineering

This activity will encourage you to consider the extremely low temperatures associated with marine engineering (particularly at depth) and to explore some of the solutions which can allow engineers to build components which can withstand these very low temperatures. You will use a bucket of ice water to simulate the ocean, and will try using different insulating materials to see how these can provide protection against the low temperatures. This activity will introduce the idea of using nature to inspire new engineering solutions, by encouraging you to think about how animals such as penguins and polar bears survive in such low temperatures.

Equipment:



- Washing up bowl/bucket
- Ice (enough to half fill the bowl/bucket – about half a bag of supermarket ice)
- Sandwich bag
- Water
- Print out of the table below

Selection of insulating materials, for example: scrunched up paper, towel, cotton wool, foam, felt or material, a warm glove etc.

Estimated Time: 30 minutes

Method:

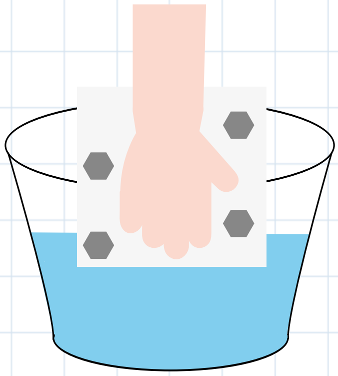
1. Fill the bucket or bowl half full with water and add the ice.

2. Complete the table below with a list of the insulating materials that you have selected. Decide how you're going to rate the temperature inside the bag - you could use anything from emojis to numbers!

3. Make sure that you do one experiment without any insulating material in the bag - this is called a control experiment.

Insulating Material	Temperature inside the bag
[EXAMPLE] Scrunched up Paper	❄ ❄ ❄ ❄ ❄
None	
Material 1	
Material 2	
Material 3	
Material 4	
Material 5	
Material 6	

4. Get started with your experiment! Fill your sandwich bag with one of the insulating materials. Once it's filled place your hand inside the bag and then put your hand into the bucket of water and ice! Rate how cold or warm your hand feels inside the bag and record your findings in the table.



5. Once you have tested all of your materials, as a group discuss which insulating material worked the best. Could this material be used on submarines? If not, can you think of a similar material which might work?

Keep it Simple!

For Rainbows, why not introduce the idea of animals in the arctic to get them really excited about this activity. Take along some pictures of animals like polar bears and arctic wolves, and ask them to think about what stops them from getting cold. You could use this to introduce the idea of insulation, and how some materials keep you warmer than others, before starting the experiment.

Take it Further!

You could use a thermometer to measure the temperature inside the sandwich bag to make the experiment more accurate. For Rangers, why not ask them to do some research into different types of systems that might be used on a submarine or submersible vessel. How do submariners breathe whilst under water? Where does fresh water come from for drinking?

Guidance for Leaders:

The girls may find it difficult to think of insulating materials to begin with - anything that can fit inside a plastic bag can be used as an insulating material; from scraps of fabric to left over paper. For younger sections you may need to explain what we mean by 'insulating' or 'insulator'. You could try coupling this activity with the Hot or Cold UMA to get the girls thinking about what makes them warm or cold.

How this Relates to Engineering:

Temperatures in the ocean can vary hugely. In some areas the water can be as cold as 4° C, and the temperature gets colder the deeper you go. Marine Engineers need to consider the effect that the water temperature might have on the product they are designing - particularly in the case of submarines where people have to be able to live for a long period of time whilst submerged in water. Materials can also behave differently at different temperatures - for example oil can become thicker and more viscous at lower temperatures. This means that it moves a lot more slowly - more like treacle than water. This could have an impact on different systems that might be built in to the product.

Inspiring Female Engineer: Ayanna Howard

Ayanna Howard is a specialist in computer engineering and robotics. In 2008 she worked on a project to develop robotic rovers to explore Antarctica and catalogue the changes in ice cover. The robots are called ‘SnoMotes’ and they are based on children’s snowmobiles. Ayanna and the research team designed a programme for the SnoMotes which allows them to navigate based on very small cracks in the ice. SnoMotes can also communicate with each other, and even contain a code allowing them to ‘vote’ on where they should travel to next. These SnoMotes can be used to gather data to better understand how climate change is affecting areas which are very difficult for humans to access due to extreme weather conditions.

Timeline:

1993
Graduated from Brown University with a degree in Engineering

1994
Completed a Master’s degree in Engineering

1999
Completed a PhD in Engineering

1999-2005
Worked at NASA’s Jet Propulsion laboratory

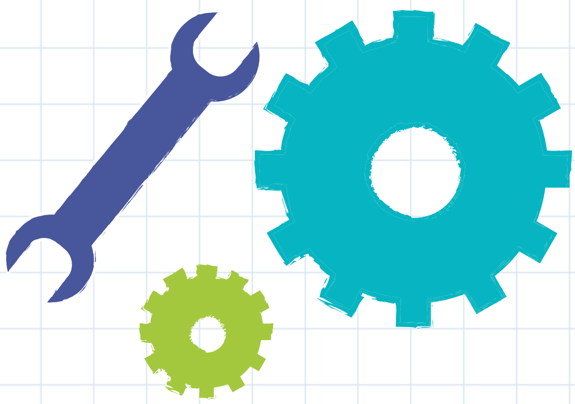
2005
Started her own laboratory at the Georgia Institute of Technology. Created the research group HumAns

2008
The SnoMote programme is internationally recognised

2013
Founded the organisation ‘Zyrobotics’, which produces educational products for children with special educational needs and disabilities

Career: Robotics Engineer

Robotics Engineering is all about using cutting-edge technology to create a product or system which solves an engineering problem. Robotics Engineering is a very wide-ranging field; you could work on anything from creating self-driving cars to developing new medical instruments to improve healthcare, or even creating robots which can be used in outer space! There are lots of different ways to become a robotics engineer - if you enjoy maths, problem solving and computer technology, this could be the career for you. There are robotics specific courses available at university - but you could also study broader degree courses such as Mechatronics, Computer Science or Mathematics. There are also college courses and apprenticeships available, for example studying a HNC in Electrical or Electronic Engineering or an apprenticeship in Software Development. If you study A-Levels/Scottish Highers be aware that a degree apprenticeship might also be an option - where you are sponsored by a company to complete a relevant degree whilst also working and gaining valuable experience in your field.



Fun with Fossilisation

This activity is all about exploring the immense pressure that exists at the bottom of the ocean. You will make your own fossil using home-made salt dough. Leaders will be encouraged to talk to you about the way in which fossils form, and will encourage you to think about how much weight the water must have to cause this process to occur.

Equipment:

To Make the Salt Dough (enough for a group of 6):

- 1 cup of plain flour
- Half a cup of table salt
- Half a cup of water
- Large bowl

To Make the Fossils:

- Rolling pin
- Round or square biscuit cutter
- Small dinosaur toys, stamps or similar

Miscellaneous/Tools:

- Spoon
- Tray lined with parchment/baking paper OR airtight container

Estimated Time: 30 minutes

Method:

1. Mix the flour and salt in the large bowl. Then, slowly add the water, stirring continuously, until the mixture forms into a dough which sticks together.

2. Tip the mixture out onto a surface sprinkled with a little bit of flour. You might want to do this on baking paper or a chopping board because it could get messy! Split the dough into six pieces and take one piece each - this is enough to make one fossil.

3. Using the rolling pin, roll out your piece of dough until it is about a centimetre thick. Use the biscuit cutter to cut out a square or round piece of dough

4. Press your chosen dinosaur toy, stamp or something similar into the dough so that it forms an impression in the dough. Gently remove it and check that you are happy with the imprint left behind.

5. Your fossil is now ready to be baked! Since it could take some time to bake the fossils and your unit might not have cooking facilities, place your completed fossils onto a baking tray lined with parchment paper (or into an airtight container). Ask your leader nicely if they would mind taking the fossils home to bake in their oven ready for next week (they will need around 45 minutes to bake, although depending on how thin the dough has been rolled they might take less time. Look for the dough changing colour/becoming solid).

Keep it Simple!

If you're worried about the mess from the salt dough, why not make up some batches of salt dough ahead of the meeting? You could give everyone a piece of baking parchment or similar to work on, to help contain the mess.

Take it Further!

Leaders - after you have baked the salt dough fossils, why not bring them back to the next meeting to be painted! You could run a mini archaeological dig instead of handing out the fossils. Put all of the fossils into a large tray and cover them with sand. Bring a selection of small paint brushes along and get the girls to pretend they are archaeologists, carefully unearthing their finds!

Guidance for Leaders:

Really encourage the girls to get creative with this activity. The salt dough mixture is very straightforward to make so most of the creativity lies on how they design and decorate their fossils. For older girls why not try drawing the design freehand using a cocktail stick or similar? You could show the girls some images of amazing fossils which have been found for inspiration!

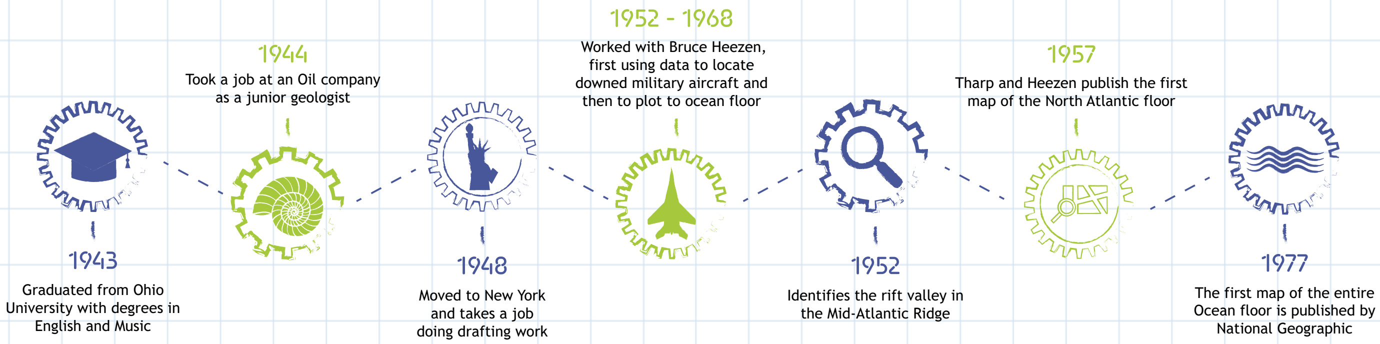
How this Relates to Engineering:

One of the biggest challenges that marine engineers face when they are designing products like submarines or underwater vehicles, is water pressure. Water is very heavy - think about how heavy a bucket of water is if it's filled to the very top. When you travel deep underwater, you have the weight of all the water that's above you pushing down on top of you. At very shallow depths you won't notice water pressure - though you might have experienced your ears popping when you are in the deep end of a pool - this is an effect of water pressure. At the kind of depths submarines or underwater vehicles travel at, water pressure can be strong enough to crush equipment! Water pressure is also one of the factors which can help to form fossils of dinosaurs at the bottom of the ocean - the weight of the water pressing down can compact sediment into the dinosaur remains, eventually creating a rock-like fossil.

Inspiring Female Engineer: Marie Tharp

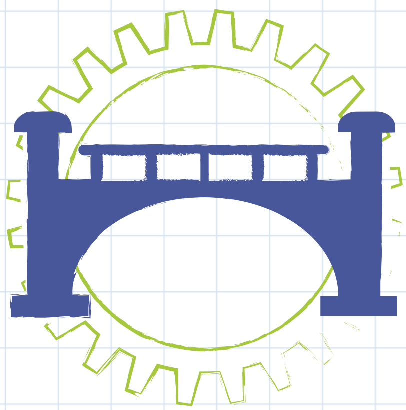
Marie Tharp was a geologist based in America in the 1940/1950s who, alongside her colleague Bruce Heezen, created the first ever detailed map of the floor of the Atlantic Ocean. They also discovered a ‘rift valley’ along the Mid-Atlantic Ridge which directly lead to the theory of ‘plate tectonics’ becoming widely accepted. Marie Tharp faced significant challenges in her career due to her gender. For example, when developing the map of the Ocean floor she had to rely completely on data gathered by her colleagues as Women were not allowed on ships at the time. When Marie discovered the presence of the rift valley on the Mid-Atlantic Ridge and realised that it supported the theory of plate tectonics, her discovery was called ‘girl talk’ and was dismissed. Plate tectonics is now a widely accepted scientific theory. To this day, many of the papers that Marie Tharp published with her male colleague do not have her name on.

Timeline:



Career: Geotechnical Engineer

Geotechnical Engineering is actually a sub-section of Civil Engineering (cast your mind back to the balloon towers in the original Clever Cogs badge pack!). Geotechnical Engineers often work on major construction projects, like building a new bridge, dam or reservoir. When these major constructions are designed/built it is important that the impact on the surrounding area/environment is considered. For example, is the ground strong enough to support the foundations of such a large structure? Could there be flooding in the area because of the new structure? Is the area at risk of earthquakes? Some universities offer degrees in Geotechnology specifically, but courses in Geology, Geophysics or Civil Engineering could also be relevant. If you would prefer to go straight into the world of work you could consider taking a job as an Engineering Technician in a development role, and then work towards specialising in Geotechnical Engineering. Some colleges also offer relevant courses for post-GCSE/National 5s students such as Environmental Science or Geology.



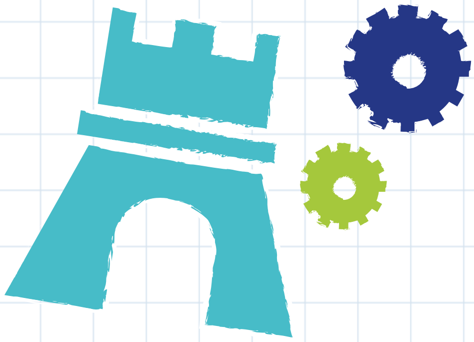
Sandcastles in the Sea

Everything is made of materials; from the steel in a ship to the rubber in undersea cables. Therefore, understanding how materials are made-up and interact with each other is incredibly important in all aspects of engineering. In this activity, you will be making your own kinetic sand and ocean putty, and exploring some of the basic concepts of Material Science and Engineering, such as density, viscosity and elasticity.

Ocean Putty:

Equipment:

- 150g Cornflour
- Water
- 120ml Washing up liquid
- Mixing bowl
- Measuring jug
- Weighing scales
- Spoon x 2
- Food colouring (blue if possible)
- Eco-friendly glitter (optional)
- Air-tight box or plastic zipped bag
- Plastic gloves (optional)



Estimated Time: 15 minutes

Method:

1. Pour 120ml of washing up liquid into a mixing bowl (your putty will become the same colour as the washing up liquid you chose to use).

2. Add a few drops of food colouring to the mixture if you wish to change the colour.

3. Add glitter to your bowl and stir until the colour is even and the glitter is spread throughout the washing up liquid.

4. Next, mix in 150g of cornflour using a spoon until it comes together to form a putty.

5. Add a tiny splash of water to the mixture and knead the putty together, until it becomes firm. It will still be sticky and gooey, but shouldn't be wet or watery. If you added too much water then just add some more cornflour

6. Now you can play with the putty - you can stretch it, ball it up and bounce it.

7. Once you've finished playing with your putty, you can store it in a plastic zipped bag or air-tight box and place in the fridge. Remember that all putty will dry out eventually even if stored in an air-tight container.

Kinetic Sand (Makes enough for a group of 6):

Equipment:

- 750g Play sand
- 100g Cornflour
- 1tsp Bicarbonate of soda
- 1tsp Baking powder
- 1/2 tbsp Washing up liquid
- Splash of water
- Measuring jug
- One large mixing bowl
- Spoon x 2
- Air-tight box or plastic zipped bag
- Knife (Optional – to cut the sand)
- Plastic gloves (optional)
- Food colouring (optional)

Estimated Time: 15 minutes

Method:

1. Place the play sand in the large mixing bowl.

2. Add the cornflour to the sand and mix together using a spoon.

3. In a measuring jug, mix the washing up liquid with a tiny splash of water (try not to froth it up too much).

4. Add the soap mixture to the sand in the bowl and mix thoroughly using the spoon.

5. Knead the sand for a while until it comes together. It should form a Play-Doh like consistency - you'll know it is ready when you can form it into a solid ball and cut it easily with a knife. Go very carefully with the water - it's easy to add too much and make a paste! If your mixture is too dry just add the water in tiny splashes.

6. Now you can play with your sand; cutting it and shaping it to form a solid shape.

7. Once you've finished playing with your kinetic sand, you can store it in a plastic zipped bag or air-tight box. Remember that all kinetic sand will dry out eventually even if stored in an air-tight container. If this happens you can add a few drops of water and mix well to re-use the sand.

Guidance for Leaders:

These activities are quite messy so it might be worth covering the work area with sheets or newspapers to protect the area. The girls also might want to wear gloves when creating their putty or kinetic sand. Food colouring may stain so the girls should wear old clothes or aprons to protect their clothing.

How this Relates to Engineering:

Substances like putty are part of a class of materials called polymers. Like other molecules, polymers are compounds, but they are large and may contain tens of thousands of atoms. Compare this to water, which contains only three atoms. A good way to visualise the difference between small molecules and polymers is to think of the size difference between a crystal of salt and a strand of spaghetti. Like the strand of spaghetti, polymers are long chains of molecules strung together. These strands can also be tangled up to create a giant mess of polymer chains.

Part of what makes polymers interesting is that each polymer has unique properties and behaviours. Some polymers are stretchy, some are sticky and some are hard. Many familiar and commonly used polymers are synthetic, but there are also naturally occurring polymers, including cellulose, starch, proteins, silk, chitin and rubber.

Kinetic sand is sand that is coated in a specific type of polymer, called silicone oils. Silicone oils have unique properties in that they can be liquids that flow freely, or semisolids that flow slowly in the absence of pressure, and therefore act like rubbery solids under stress.

With kinetic sand, the polymer chains within the silicone oil make the sand particles stick together so you can form them into a ball. However, the ball will slowly flatten out over time. But the silicone-oil-coated sand particles stick only to each other, not to other surfaces. This is why kinetic sand doesn’t seem “sticky” and is easy to clean up.

Inspiring Female Engineer: Ingy Abdekarim

Ingy Abdekarim was born in Alexandria, Egypt, where she grew up and still lives today. Ingy wanted to become a Marine Engineer, however, at this time, Egyptian women were not accepted into the field. Ingy decided to pursue her dream career anyway and went on to study Maritime Engineering at the Arab Academy of Science and Technology (AAST). Ingy admitted that one of the struggles with her studies was that some of her classmates and teachers did not take her seriously enough.

After two years at AAST, Ingy confronted the director of the Marine Engineering department and convinced him to enable her to join the sector after her studies. At the age of 24, she became the first Egyptian woman to complete these studies and graduated with a distinction of excellence.

Ingy began her career in petroleum resources at her father’s company and then went onto work at a company specialising in the inspection and securing of ships. In 2018, Ingy decided to join Exxon Mobile Egypt - a company in the gas and oil sector - and she became the first woman to join their operational team.

Timeline:

2013
Started studying Marine Engineering at the Arab Academy of Science and Technology

2016
At the age of 24, Ingy became the first female Marine Engineer to graduate from Arab Academy of Science and Technology in Egypt. She graduated with a Distinction of Excellence

2016
Ingy began working at her father's company, specialising in petroleum resources

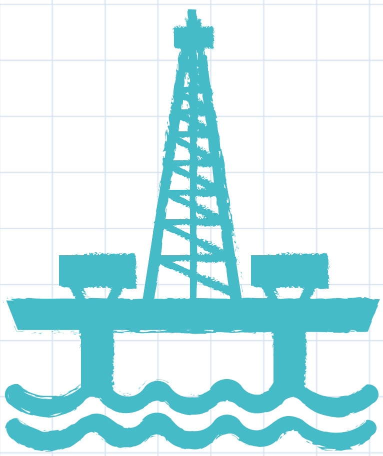
2018
Ingy became the first woman to join the operational team at Exxon Mobile Egypt

Career: Marine Engineer

Marine Engineering is all about the design, manufacturing, testing and maintenance of boats, ships, oil rigs and other marine vessels/structures. Marine Engineering also includes Oceanographic Engineering which is the study of physical and biological aspects of the ocean. Engineers in this field often research and collect data about the ocean and study how the environment of the ocean impacts on the marine structures, such as oil rigs or wind farms.

Marine Engineers use principles from Electrical & Mechanical Engineering, as well as Computer Science, and apply them to design and develop marine vessels and their systems, as well as operating them on-board. Marine Engineers can also carry out hands-on engineering tasks and are responsible for the operation of active boats. If you want to pursue a career in this field then you could go on to become Naval Architect, Marine Engineer, Environmental Engineer or Petroleum Engineer.

One of the routes you could chose to gain some hands-on experience is through on-the-job training, usually in the form of an apprenticeship. Many companies offer apprenticeships now; these could be in Marine Engineering, Mechanical/Electrical Engineering, Offshore Engineering, Naval Architecture or Oceanographic Engineering. Some companies that offer these apprenticeships include Energy Companies, Private Ship Builders, Marine Shipping Companies and the Royal Navy, to name a few. Some companies will sponsor you to complete a HNC or a Bachelor's degree in Engineering, which will provide you with the opportunity to gain real work experience whilst undertaking your studies. Another option would be to attend university first to achieve a degree in one of the related subjects and then begin your career as a graduate. Then you could go onto specialise into your preferred career.



Motion in the Ocean

Structures that sit on the ocean floor must deal with the extreme conditions and forces that act upon them. In this activity, you will build your own wind turbine and replicate the ocean environment around you. You will then test the stability of your structures in these conditions, and discover some of the fundamentals of Mechanical and Civil Engineering.

Equipment:

- 2L Clear plastic bottle
- 4 Small balloons
- Scissors
- Adhesive putty
- Sticky Tape
- Paper Straws
- Large container or bathtub - filled with water.

Estimated Time: 30 - 45 minutes

Method:

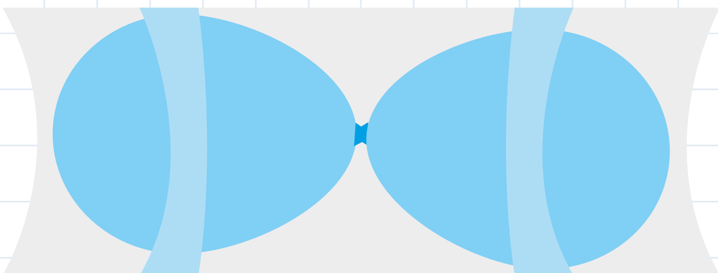
Please note: Build the floating platform and wind turbine separately.

Floating Platform:

1. Using scissors, cut a rectangle (roughly 15cm x 20cm) from the side of a large bottle- this will be the base of your platform. The base should curve downwards when in the water.

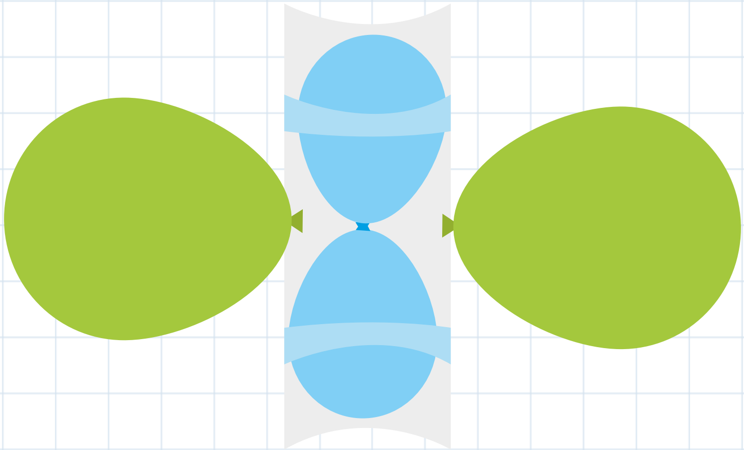
2. Blow up two balloons slightly (they must be able to fit under the curve of your plastic base), tie the ends, and then tie the two ends together to form a figure-8.

3. Place the two balloons (tied together) underneath your platform and then wrap the two widest points with sticky tape to secure the balloons and base together. This will act as the "ballast" to the platform which provides buoyancy and upwards force, and which counteracts the weight of the turbine. Please see the image below:



4. Blow up two more balloons fully and tie the ends together.

5. Attach the larger balloons to the underside of the long edges of the platform using sticky tape, so that they stick out of the sides. These two balloons provide stability to the platform - the forces acting upwards on the sides stop the platform from rolling over in the water. Please see the image below:



Wind Turbine:

1. Use four paper straws to create a pyramid, then put a ball of adhesive putty at the top to keep them all together.

2. Attach four more balls of putty to the end of each of the straws.

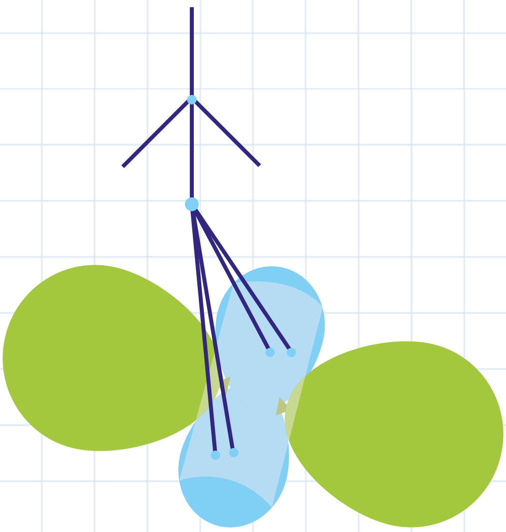
3. Place a fifth straw coming out of the top of the pyramid and put another ball of putty at the top.

4. Use the scissors to cut down three straws to just over half their original length.

5. Place these three straws coming out of the top of the structure like the blades of a wind turbine.

Test your Structure:

1. Carefully place your wind turbine on top of the floating platform, remembering to press down the putty at the ends of the straws to make sure it sticks to the platform. Yours should look similar to the image below.



2. Place the entire structure in a bathtub or large container – it should float without assistance.

3. Now use your hand or shake the container to make some waves! How well does your wind turbine stay up? Have a think about how you could make it more stable if you were to repeat the activity. What made the platform float? Make sure to have a read of the 'How it relates to Engineering' section for more information.

Keep it Simple!

If you want to simplify this activity, you could build the platform with no wind turbine on top. This will still give you an opportunity to learn about the buoyancy and stability of floating objects.

Take it Further!

If you'd like to challenge yourself further, why not try out a few different wind turbine base designs and see how the structure affects the stability of the wind turbine when floating in the water. Also, try changing the size of/adding/removing balloons to see how this affects the buoyancy and stability of the platform.

Guidance for Leaders:

The younger girls may need some assistance with cutting up the plastic bottle using the scissors, as a hole will be required to be made to cut the bottle. If you are supporting Rainbows or Brownies with this activity, encourage them to think about how a wind turbine becomes less stable as it becomes taller, and how they can keep their tall tower stable, such as via the use of a larger base.

How this Relates to Engineering:

Wind turbines utilise mechanical and electrical technology to transform the potential energy of wind into electricity. The force of the wind turns the wind turbine, which spins the rotor of a generator and produces electricity. On land, there are more structures in the way that alter the way the wind impacts the turbines, however, at sea, the wind speeds are greater and not obstructed. One of the challenges faced by Engineers today is to build more robust structures that can withstand waves and move with the motion, rather than break.

There are various methods for securing wind turbines and structures in the ocean - they can either be drilled into the sea floor, attached to the sea floor with tension lines (tension leg platform) or they can be floating structures (spar-buoy platform) which aren't attached to the seabed, but potentially kept within a boarder so they don't float away.

A spar-buoy uses a ballast submerged below the surface of the water with a turbine fitted to the top of the structure which is lighter than the weight of the ballast, which creates buoyancy and allows it to float – this is very similar to the wind turbine you have just created.

Engineers need to build stable wind turbines and structures at sea, as they are subjected to harsher conditions. Common materials used for the wind turbines include steel and fibreglass; the steel makes a stable tower, and the fibreglass blades are light enough to catch the wind but not to break with high wind speeds.

Inspiring Female Engineer: Emeline Veit

Emeline Veit grew up in the south of France, in Sumene and attended an Engineering school at ENSTA Bretagne where she studied Hydrography and Oceanography. She went onto complete a Master's degree in Marine Geophysics as well as internships in Canada, Korea and Hawaii and is now a Hydrographic Surveyor.

She spends half the year living and working on a 100m offshore vessel in the North Sea - it is her job to find unexploded ordinances (UXOs) which are explosives such as land mines and naval mines that haven't exploded for many decades, most likely left over from World War II. Emeline and her team are responsible for finding and destroying any UXOs that are in the way of the cable routes and piling for offshore wind turbine farms. Their team use remotely operated vehicles (ROVs) which are underwater robots that are operated by the team onboard, and Emeline is the navigator. As well as finding UXOs, Emeline and her team work on dredging projects and building islands.

When Emeline isn't working, she enjoys living on her sailboat with her husband and sailing around the world. She admits this has given her many skills that she can apply to her job too.

Timeline:

- **2013** Internship with Comité
- **2014** Internship with Boskalis
- **2015** Internship at University of Hawaii at Monoa where she studied and produced a report on the impact of groundwater depletion on spatial variations in the sea level change during the past century
- **2015** Graduated from the Engineering School at ENSTA Bretagne with a degree in Hydrography and Oceanography
- **2015** Graduated from IUEM Plouzané with a Master's degree in Marine Geophysics
- **2015** Started working as a Surveyor at Boskalis
- **2019** Started working as a Freelance Hydrographic Surveyor

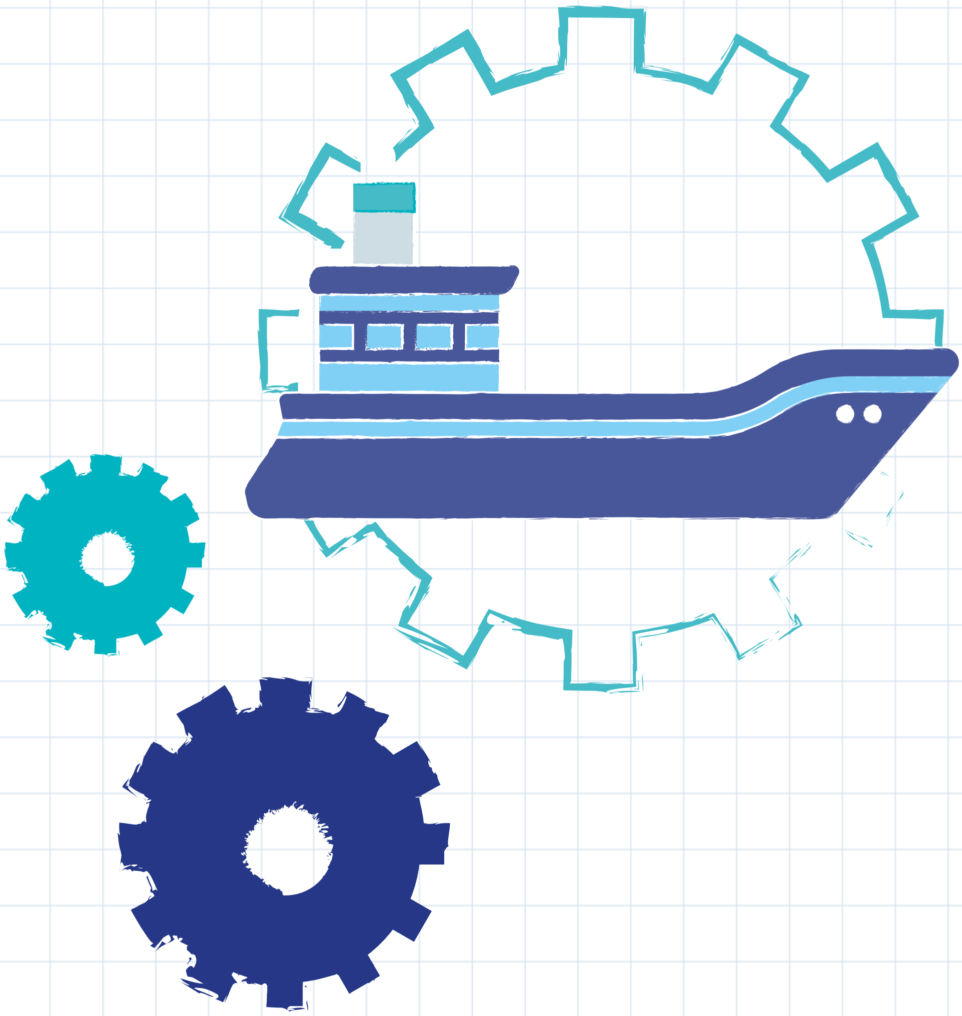
Career: Hydrographic Surveyor

Hydrographic Surveyors, also known as Hydrographers, use technology to produce detailed plans of the seabed, as well as ensuring that marine resources are maintained and explored in a sustainable manner. Their role involves collecting scientific data and mapping the underwater structure of seabeds and inland bodies of water to show their depth, shape and contours. This is incredibly important information for marine vessels as they require accurate maps and charts to ensure they sail in deep enough waters to avoid becoming grounded.

Hydrographic Surveyors also locate offshore resources such as oil and gas and lead projects on the positioning of offshore wind farms, coastal works, dredging, oil rigs and underwater cables. They carry out surveys using specialised lasers or remotely operated vehicles to determine the structure of the seabed and ensure that it is clear of any objects that could cause problems during construction work.

Most Hydrographic Surveyors complete either a Bachelor's or Master's Degree in a STEM-related subject – but most commonly in either Hydrographic Surveying, Marine Sciences, Civil Engineering, Environmental Engineering or Geology. After this, Chartership is available through the Royal Institute of Chartered Surveyors. Another route to this career is through an apprenticeship with a company specialising in Hydrographic Surveying, or a relevant subject, either from the age of 16 after GSCEs/National 5s, or 17/18 after A Levels/Highers.

On-the-job learning in the form of apprenticeships is also available from certain institutions and companies, such as Offshore Energy Companies (Oil, Gas & Wind Farms), Marine Structure Manufacturers (Manufacturers of Wind Farms, Underwater Cables or Robots) or the Royal Navy. In most cases, they will fund your education, which will enable you to achieve a HNC/degree alongside gaining real work experience.



Under Pressure

This activity is the final activity in the pack and aims to put into practice some of the other topics learned, such as buoyancy, pressure changes and wave disruption. In this activity you will make a model submarine in small groups, using a few basic items. You will test your submarine in a tub of water; inflating and deflating by blowing through plastic tubing into a balloon, thus moving the submarine up and down. You should be able to talk about buoyancy and how it applies in this activity, including how the addition of salt to the water would affect the buoyancy. You will be asked to create a poster in your groups about your submarine, including why you made it the way you did, what you learned, and what knowledge from previous activities helped you.

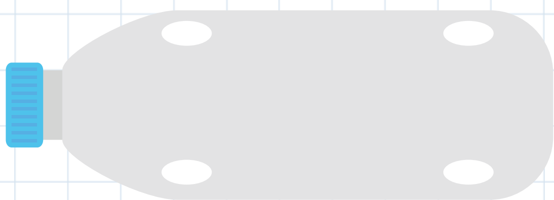
Equipment:

- A bath or large tub - the key is for it to be at least 0.5m deep
- A 2L plastic water bottle
- A balloon
- Plastic tubing, approx. 1m in length (search “plastic tubing“ on Amazon)
- Sticky tape
- Elastic band
- Scissors/skewer
- Some stones/weights/coins
- Paper for posters
- Colouring pencils/pens/decorating materials

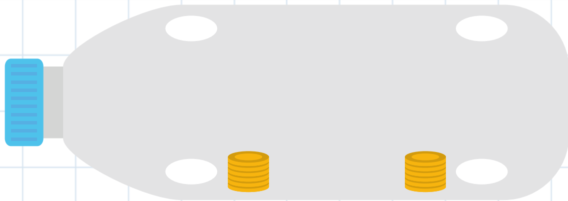
Estimated Time: 30- 45 minutes

Method:

1. First, cut some holes in your plastic bottle as shown in the below diagram. You will need 2 small holes on the top, and 2 on the bottom. Ask for help from your leader if this is too tricky.



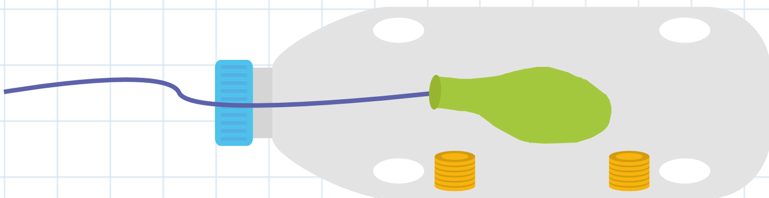
2. Stack some coins/weights together and tape them to the bottom of your bottle, next to where the holes are. See the diagram for further information.



3. Make a small hole in the bottle cap using a sharp pair of scissors or a skewer. Please ask an adult to do this for you as it can be tricky.

4. Insert one end of the plastic tubing into the balloon. This should be a nice snug fit so if it’s not use some sticky tape or an elastic band to secure it.

5. Feed the other end of the plastic tubing through the hole in your bottle cap. You might need to make the hole a little bigger if the tubing doesn’t fit, but be careful not to make the hole too big, as you want it to be a very snug fit.



6. Place the balloon inside the bottle and screw the lid back onto the bottle, so that the tubing is coming out of the lid as shown in the diagram.

7. Test out your connections by blowing the balloon up using the tubing. If this doesn’t work, your connection between the tubing and the balloon isn’t air-tight enough.

8. Now, put your submarine into the water (keeping the free end of the tubing out of the water) and let the submarine slowly fill up with water. You should place it so that the weights are at the bottom. The water will come in through the holes in the bottom and the top, and the submarine will eventually sink.

9. Now try blowing up your balloon! Your submarine should come to the surface when the balloon is inflated, and sink again when you let the air out of the balloon.

10. It may take some trial and error to get your submarine to work properly. You might want to tweak the design to make it work better - you are now the engineer, so give it your best try to get it to work!

11. After you're finished testing your submarine, make a poster detailing what you've learned from this activity, and also what you've learned from the other activities in the pack. Think about all of the different kinds of engineering that have been in this pack and what sort of jobs you could do in the field of Marine Engineering. Can you remember what buoyancy means from activity one? Show your poster to your group once you are finished.

Keep it Simple!

This activity may be too difficult for younger age groups, so to simplify it you could make up some bottles of water, with varying levels of water within them, in advance of the meeting. Put each of them into the tub of water and notice how each one behaves. Use this as an opportunity to recap what has been learned through the previous activities, and quiz the girls on some of the topics covered (e.g. buoyancy). Then ask them to complete the poster as mentioned in step 10.

To help them with their posters, explain the basic principles of how a submarine manoeuvres through the water (see How this Relates to Engineering!).

Take it Further!

Challenge the groups to steer their submarine to different depths. Assign one of them the role of 'Captain' and the rest of the group will be the Crew. The Captain should give out commands for how the submarine should behave, and the Crew should try to achieve this by manoeuvring their submarine through the water. Examples are given below.

Surface! - this command means bring the submarine up to the surface so that it is visible above the surface of the water. This should be done slowly so that the Crew on-board don't get seasick!

Periscope depth! - this command means bring the submarine close to the surface of the water but without breaching the surface of the water (this will be a very tricky one to achieve!) You could even ensure the girls have attached periscopes to their submarine prior to this so that they can try and get only the periscope out of the water.

Deep dive! - Get the submarine to dive to the bottom of the tank of water (but not sitting on the bottom!).

Guidance for Leaders:

This activity is a tricky one, so the girls might need more support than for the other activities. If the submarine is tipping over, it means there are not enough weights attached to the bottom. If it does not float when the balloon is blown up, it means there are too many weights attached to the bottom. You might find it's a bit of trial-and-error to get it just right.

How this Relates to Engineering:

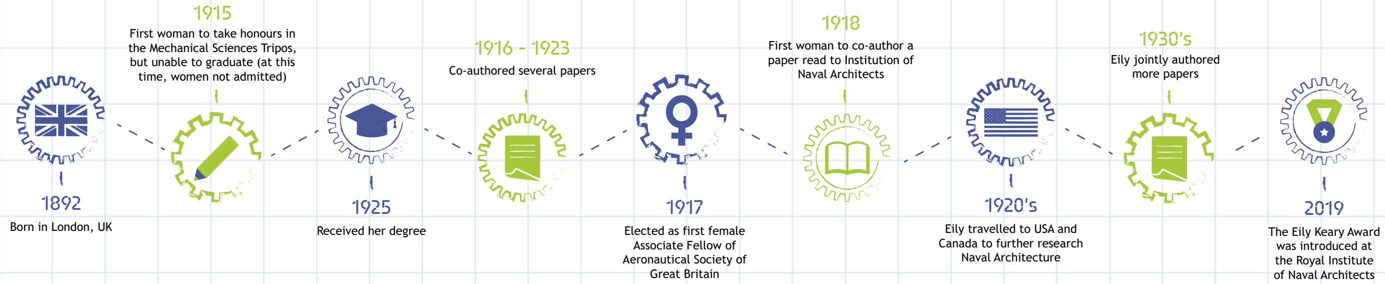
Submarines sink and float using the same principles as described for the buoyancy activity (Activity 1 – Oh Buoy!). For the Submarine to float, it has to weigh less than the amount of water it displaces. This means it has to be designed so that, when it has no water on-board, its weight is not too heavy (otherwise it will sink), but also not too light (otherwise it will topple over)! For a submarine to dive underwater, it has to take water on-board to make it heavier. A submarine will bring water on-board using something called Ballast Tanks. Once the submarine has taken enough water into its Ballast Tanks to make it heavy enough to sink, it will start to slowly sink. This is when it gets clever – as the density of the water changes as the submarine goes deeper and deeper, the submarine has to adjust how much water it is carrying on-board to stop it from sinking to the bottom. Sometimes this means it has to get rid of some water whilst it is already underwater! To do this, a submarine has powerful air canisters that blow water out of its tanks (like your balloons). This is also how it rises to the surface. The submarine can also use its hydroplanes (like aeroplane wings, but a bit shorter) to move up and down in the water.

Inspiring Female Engineer: Eily Keary

Eily was born in 1892 in London, and was a Naval Architect, a Mechanical Engineer, and an Aeronautical Engineer. She was the first woman to co-author a paper read to the Institution of Naval Architects (now Royal Institute of Naval Architects (RINA)) in 1918, called ‘The effect of the longitudinal motion of a ship on its statical transverse stability’. Eily went on to jointly author more papers which were presented to various Naval Architect and Marine Engineering institutes.

In 1917, Eily was elected as the first female Associate Fellow of the Aeronautical Society of Great Britain (now Royal Aeronautical Society). After WW1, Eily became one of the first three women Associates of the Institution of Naval Architects (now RINA). In 2019, RINA introduced an annual award named after Eily – The Eily Keary Award.

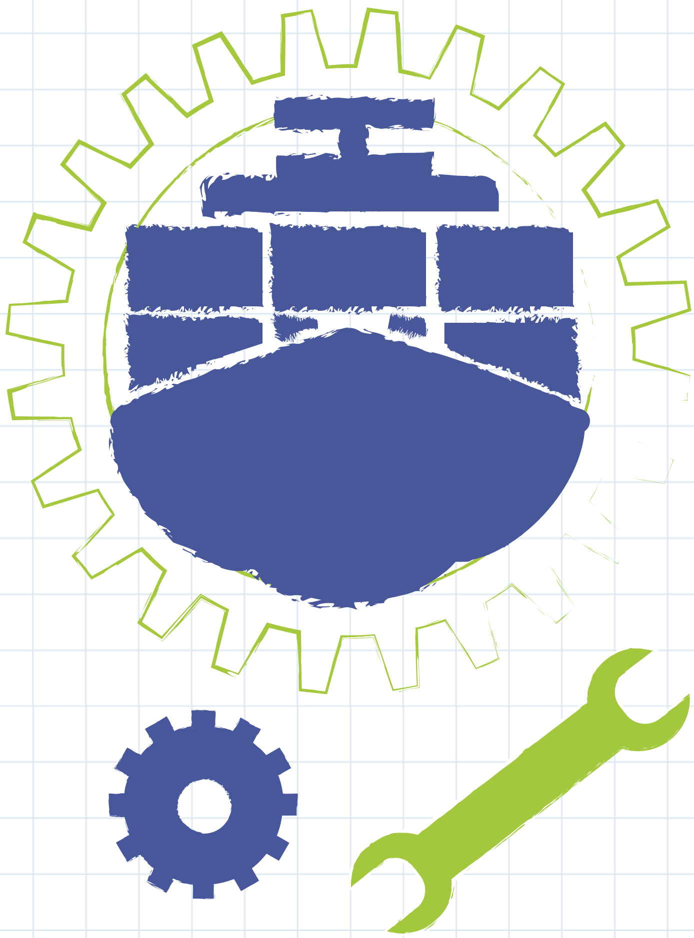
Timeline:



Career: Naval Architect

There are many ways to become a Naval Architect, and even through the university route there are many options you could take. You could study Naval Architecture itself, and gain either a Bachelor's or a Master's degree in Naval Architecture. There are also other options in Higher Education - you could study Aeronautical Engineering and then choose to go into Naval Architecture afterwards. This is because the principles of Engineering that apply to an aeroplane also apply to a ship or submarine (such as air/water flow over the body of the vehicle). Another option would be to study Ship Science or something similar. All of these options at university would equip you with the skills you need to go into Naval Architecture once you graduate.

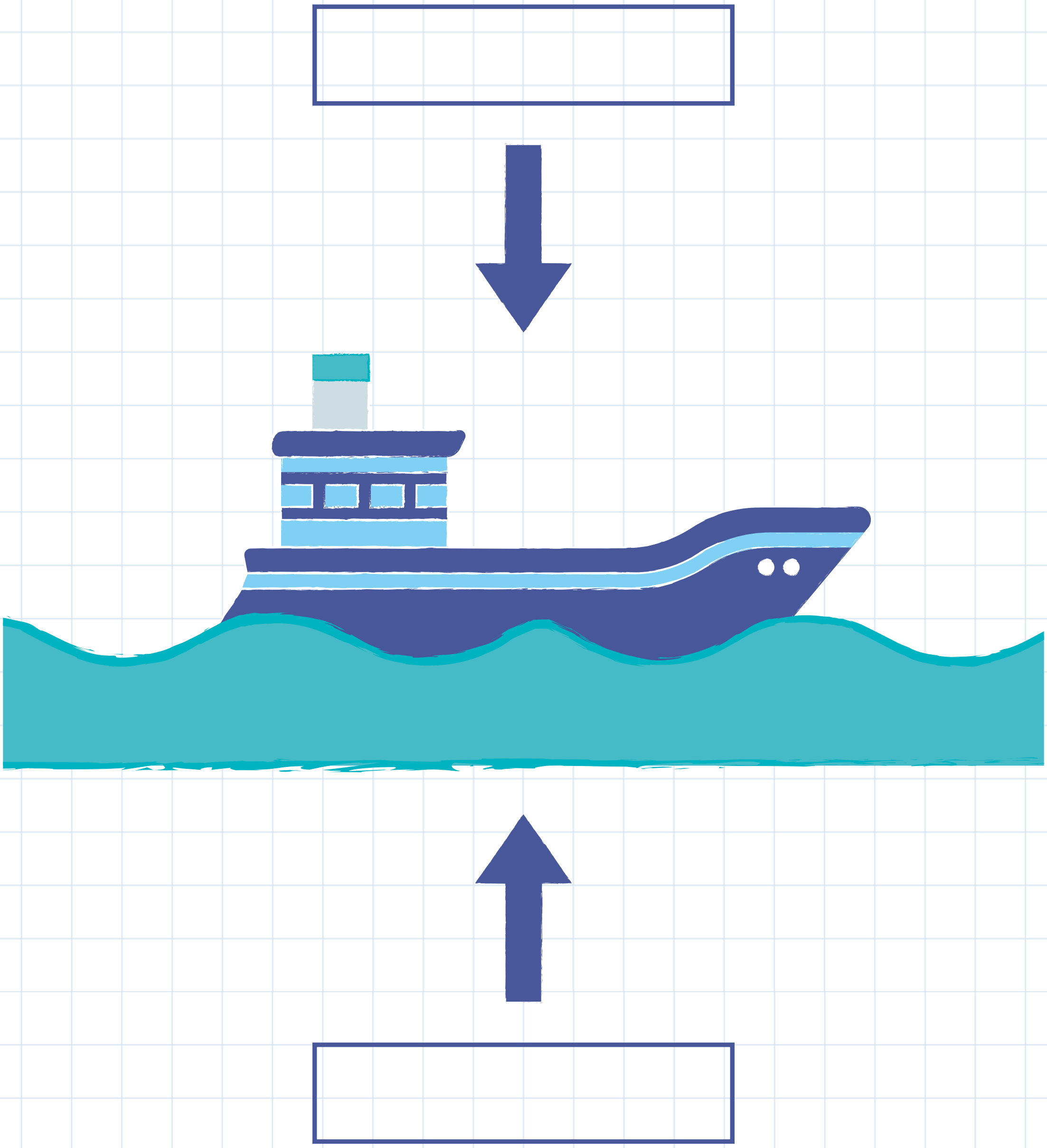
Another route you could take to becoming a Naval Architect would be to undertake an apprenticeship. Many Engineering and Maritime companies offer apprenticeships at different levels – some start at the age of 16 after GSCEs/National 5s; some start at the age of 17/18 after A Levels/Highers. Apprenticeships would give you the opportunity to study for your qualifications at the same time as working part-time in an organisation. The apprenticeship route takes longer to gain your qualifications, compared to going straight to university, but you get the advantage of working alongside and gaining some real work experience.



Appendix A:

Match the correct words to the correct boxes in the diagram:

Weight
Buoyancy



Appendix B1: Rainbows & Brownies: What is Buoyancy?

______________ is what makes something sink or float. If an object is _________, it will sink. If it is ___________, it will float. The reason big boats float is because they have lots of ______ trapped inside, which makes them float (like when you hold your breath under water!).

Word Bank:

heavy buoyancy air light

Appendix B2: Guides & Rangers: What is Buoyancy?

Buoyancy is what makes something float in water. When you put an object into water, it has to push some water out of the way to make room for it. For something to float, it must be less dense than water it has pushed out of the way. You can work out how dense something is by looking at how much room it takes up (its volume) compared to its mass (how much it weighs). When a boat sits in water, it pushes some water out of the way. The reason boats float is because their total volume (including all of the air that makes up the inside of the boat) is lighter than the water that it has pushed out of the way. Therefore the boat is less dense than the same volume of water.

Buoyancy is a force acting ____________ on a boat in when it is sitting in water. For a boat to float in water, it must be _______ dense than the water pushed out of the way by the boat. If the boat is ______ dense than the water, it will sink. If the water is more dense (______ water), the boat is _______ likely to float. This is why you float when you go swimming in salty water!

Word Bank:

salt   upwards   more   less   more

Appendix C:

Object	Sink or Float (before testing)	Sink or Float (after testing)
1		
2		
3		

We would love to hear about your unit's engineering journey and to share your experience on our Girlguiding North West England website and social media pages, in the press, online and in our promotional material, so that our members of all ages, potential members and potential supporters can be inspired by everything you've done.

Share your story with us by emailing northwesthq@girlguidingnwe.org.uk.

Once available, badges will be available to purchase from the Girlguiding North West England online shop: https://shop.girlguidingnwe.org.uk/

We value your feedback so that we can continue to improve our challenge packs. Please spare a few minutes to complete the short survey upon completing the challenge.

https://www.surveymonkey.co.uk/r/RQRHV99