



NZAquabots Teaching and Learning Guide

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NZAquabots Teaching and Learning Handbook

This handbook has been designed to support teachers to use the NZAquabots competition to teach their classes about relevant math, science and technology concepts.

We recommend reading through the whole handbook as you may wish to incorporate strategies discussed further in the book at the beginning of your journey.

While information from this handbook can be given to students it has not been designed for students.

Introducing NZAquabots

NZAquabots is an underwater robotics programme for school-aged children based on the Sea Perch programme in the USA. It has been modified to fit the New Zealand culture and education.

NZAquabots is run nation-wide by the charity, Ministry of Inspiration. To learn where regional competitions are run, please go to www.ministryofinspiration.org

Teams are formed from Years 4 – 13 students. The aim is to inspire students, help discover the next generation of Kiwi scientists and engineers, while introducing potential engineering and robotics careers.

Teams work together to build an underwater robot which is capable of completing the year's challenges. These challenges include an obstacle course, and several activities which require collection and delivery of a range of items. Non pool events include; a Factsheet (team poster), quiz presentation to demonstrate what they have learnt and for Nationals (and some regionals) a 5 page technical report.

Curriculum Links

Broadly speaking the NZAquabots competition covers the following curriculum areas. As you move through the book we have suggested ways that you can extend the level for older children. It can also be compacted to deliver to younger children. NZAquabots is a physical thing that can be seen and touched so students can begin to understand quite complex concepts at a relatively young age, so please don't be hesitant if you think that some curriculum links are only for high school students.

	Cross Curriculum Links			
Level	English	Math	Science	Technology
2	<p>Create texts by using meaning, structure, visual and graphophonic sources of information, and processing strategies with growing confidence</p> <p>Construct text that demonstrates a growing awareness of audience and purpose through appropriate choice of context, language and text form</p> <p>Form and express ideas and information with reasonable clarity, often drawing on personal experience and knowledge</p> <p>Organise and sequence ideas and information with some confidence.</p>	Use appropriate units and devices to measure length	Explore everyday examples of physical phenomena such as forces, waves, light, electricity	Develop a plan that identifies the key stages and the resources required to complete an outcome
3	<p>Seek feedback and makes changes to texts to improve clarity, meaning and effect</p> <p>Form and express ideas and information with increased clarity, drawing on a range of sources</p> <p>Use oral, written and visual language to create meaning and effect and engage interest</p> <p>Organise and sequence ideas and information with increasing confidence</p>	Use linear scales and whole numbers of metric units for length, area, weight and angle.	Physical inquiry and physics Communicating in science	Understand that technological outcomes are recognisable as fit for purpose by the relationship between their physical and functional natures

4	Is reflective about the production of own texts, monitors and self-evaluates progress, articulate learning with confidence Constructs text that show an awareness of purpose and audience through deliberate choice of content, language and text form Uses a range of oral, written and visual features to create meaning and effect and sustain interest Organises and sequences ideas and information for a particular purpose and effect	Use appropriate scales, devices and metric units for length, area, angle Convert between metric units, using whole numbers and commonly used decimals	Explore, describe and represent patterns and trends for everyday phenomena such as forces, electricity, light, waves.	Understand that materials can be formed, manipulated, and/or transformed to enhance fitness for purpose of a technological product
5	Seeks feedback and makes changes to texts to improve clarity, meaning and effect Constructs a range of texts that demonstrate an understanding of purpose and audience through deliberate choice of content, language and text form Develop ideas by adding details or making links to other ideas and details Achieves a sense of coherence and wholeness when constructing texts	Convert between metric units using decimals	Identify and describe the patterns associate with physical phenomena found in everyday situations involving, movement, forces, electricity, light and waves.	Understand that technological outcomes are fit for purpose in terms of time and context. Understand the concept of malfunction and how "failure" can inform future outcomes.
6	Uses a wide range of oral, written and visual language features with control to create meaning and effect and sustain interest Achieves a sense of coherence and wholeness when constructing texts	Measure at a level of precision appropriate to the task	Investigate trends and relationships in physical phenomena Investigate how physics knowledge is used in a technological application	

7	Uses a wide range of oral, written and visual language features fluently and with control to create meaning and effect and sustain interest Organises and develops ideas and information for a particular purpose or effect , using the characteristics and conventions of a range of text forms with control		Use physics ideas to explain a technological application of physics	Understand the concepts of redundancy and reliability and their implications for the design, development and maintenance of technological systems
8	Uses a wide range of oral, written and visual language features coherently, fluently and with control to create meaning command interest Organises and develops ideas and information for a particular purpose or effect , using the characteristics and conventions of a range of text forms with control			

Key Competencies

As you work through the NZAquabots competition preparation you and your students will be taking a journey that is about more than just math, science and technology concepts. It is also about building the key competencies to build stronger, more active members of our communities.

Thinking: Students need to explore the ideas that are presented; they need to formulate a clear and articulate description of their learning journey. They need to reflect on what they have created, identify and solve problems. They need to manage their time and tasks, deciding who should do what and when and in what order. They need to investigate why their robot acts and reacts as it does.

Using Language, Symbols and Texts: Students will create a presentation which allows them to articulate their learning journey. They need to investigate concepts and presents those in their own words. They need to use digital technology to create their presentations (either printed or PowerPoint). They need to use effective search words. They need to identify the best way to convey their learning so that it is informative and interesting.

Managing Self: Students need to manage their expectations and their failures. They need to identify the challenge outcomes and work towards that goal. They need to deal with repeated failures. They need to work effectively with others in their team. They need to come up with and stick to a game day strategy. They need to source resources for their attachment and utilise them effectively. They need to investigate why their robot has failed, identify possible causes and fix them.

Relating to Others: Throughout the journey students need to consider their teammates opinions, feelings and emotions. They need to consider how they motivate their teammates, how they criticise and praise teammates. They will reflect on what they can do to change their team dynamic. They need to share their ideas with teammates and with the wider world.

Participating and Contributing: This project allows schools to draw in parents and whanau to help build and design and to support during the competition. Students learn about New Zealand's cultures and others through the challenge themes. They are exposed to new career paths and opportunities.

Getting started – What you Need

Tools

- Eye protection (optional)
- Ruler/tape measure
- Vivid/marker pen
- Hacksaw
- Wire strippers
- Needle nosed pliers
- Electric hand drill
- Fine Sandpaper
- Alcohol wipes
- Vice
- ¼" Drill bit
- 3/32" Drill bit
- Soldering iron
- Craft knife
- Scissors
- Disposable Gloves
- Small magnetic screwdriver

Materials

- 1.8 m or 6x 1 foot lengths ½" PVC pipe
- 10x ½" PVC elbows
- 4x ½" PVC tees
- Pool noodle
- Electrical tape
- Masking tape
- 15 m CAT 5 Tether Cable with RJ-45 Connector Installed on one end
- 3x 35 mm Film canisters, with caps
- 3x 12-Volt DC motors
- 3x Propellers
- 3x 4-40 Threaded propeller shaft Couplers
- 3x 4-40 Tee nuts
- 3x 4-40 Lock nuts
- 1x Super glue
- 1/3x Wax bowl ring
- Monkey Putty

Other Resources

- Newspaper
- Waste paper
- Paper towels
- Electronic device (laptop, tablet)
- Camera
- Coloured paper
- Pens
- Pencils
- Rulers

Curriculum Links:

Level 2: Use appropriate units and devices to measure length

Level 3: Use linear scales and whole numbers of metric units for length

Level 4: Use appropriate scales, devices and metric units for length

Convert between metric units using whole numbers and commonly used decimals

Level 5: Select and use appropriate metric units for length

Convert between metric units using decimals

Level 6: Measure at a level of precision appropriate to the tasks

Key Competencies:

- Using language, text and symbols

Vocabulary List:

- Inches
- Convert
- Measure

Items and equipment you need:

- Tape Measure/Ruler
- Pen
- PVC pipe
- Hacksaw
- Vice

We can now:

- Use a device to measure accurately.
- Guide a teammate through measuring lengths of pipe
- Cut out all our pieces of pipe

Step 1:

Pre-Activities:

- Hand out a range of measuring tools, rules, tape measures etc. Determine what units they measure. Discuss where you start and finish measuring on each of them.
- Practice measuring different objects. Compare and contrast measurements. Discuss how accurate you need to be and why
- Explore the conversion between mm, cm and m. Compare to inches, feet, yards. Convert between cm and inches and km and miles.

Understanding How to Measure Things

Measurement is a key concept in being a useful member of society. You need to accurately measure if you want to make a cake, put up a bookshelf or make sure that your bed fits in your bedroom.



When using a tape measure, we measure from the first tick mark. In this image you can see the first tick mark is right at the beginning.

To read a measuring tape, the big numbers relate to the unit that is written on the measuring tape. In this case the 4 means 4cm. The small tick marks between the three and four relate to a mm.



We measure all the way along until we get to the number we need. We then put a mark on the pipe. We then check that measurement by measuring the other way. So put the metal end of the tape measure on

your pen mark and measure to the end. It should be the same length. If not, erase your mark and try again.



We can measure several pieces onto one piece of pipe. We do this by measuring from the mark we made and measuring along till we make the second mark. We can continue doing this til we run out of pipe.

Converting Measurements

The measurements for your pipe are provided in inches. You will need to convert them into cm.

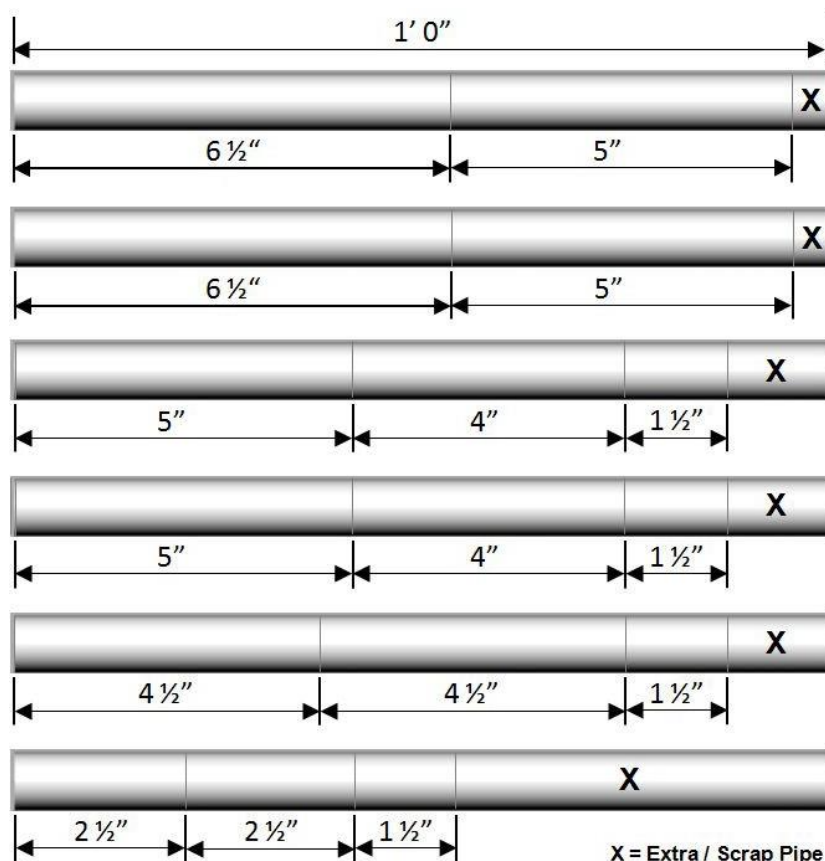
Measure out your pipe

When you have measured your pipe it is HIGHLY recommended that you write the size in INCHES on the pipe. Make the mark on the pipe quite long so you can see where to cut.

List of Pieces you need

Use the check list to make sure you have measured out all your pieces of pipe.

- | | |
|---|--|
| <input type="checkbox"/> Two Pieces – 6.5" (16.5 cm) long | <input type="checkbox"/> Four Pieces – 5" (12.7 cm) long |
| <input type="checkbox"/> Two Pieces – 4½" (11.4 cm) long | <input type="checkbox"/> Two Pieces – 4" (10.2 cm) long |
| <input type="checkbox"/> Two Pieces – 2½" (6.4 cm) long | <input type="checkbox"/> Four Pieces – 1½" (3.8 cm) long |



ADULT - check that each group/team has all the pipes correctly measured and labelled before proceeding.

Review Health and Safety for Using Hacksaws:

- Put the pipe into the vice
- Ensure that the line to cut is approximately between 2cm and 5cm from the edge of the vice
- Keep hands away from the blade
- Make straight cuts with the blade – keep the blade straight
- Rest your other hand on the vice to provide balance
- Have teams cut all their pipe pieces out. Get them to double check that they have all the right pieces.
- NB: if pipes are 1cm out they are ok, if they are several centimeters out they need to be recut

COMMON ERRORS

- Students will measure the inches as cm instead e.g. 6.5cm = 6.5"
- Students will try to arrange the measurements in a different way than the pipe diagram
- Students will forget to measure a piece of pipe
- Students will measure a measurement on top of another one, i.e. 16.5cm with a 10cm marked on it as well

Review and Reflection Prompts

Encourage students to regularly review what they have learnt, how they worked as a team and what they, personally can do to make things better, what they would do differently next time. This is a key step in the design process.

- How did you work well as a team – what did you do?
- What could you do to make things better next time?
- What went wrong? – why?
- What went well? – why?
- What can I do now (WALT)?
- Which image captures the feeling from this step?
- What can I add to our presentation?
- Anything else to share or discuss at this stage?

Ideas to go further – for senior students or students who have participated before

- Design your own robot. Consider the size, area, volume and shape
- Sketch out a design which includes measurements of lengths and angles of connections
- Determine the width of the PVC pipe to be used
- 3D design and print your connectors

Curriculum Links:

Level 2: Build their language and develop their understanding of the many ways the natural world can be represented

Explore every day phenomena such as forces

Seek and describe simple patterns in physical phenomena such as floating and sinking

Level 3: Explore, describe and represent patterns and trends for everyday examples of physical phenomena such as forces

Level 4: Explore, describe and represent patterns and trends for everyday examples of physical phenomena such as forces

Level 5: Identify and describe the patterns associated with physical phenomena found in simple everyday situations involving forces and movement.

Level 6: Investigate trends and relationships in physical phenomena such as forces and movement

Investigate how physics knowledge is used in a technological application

Key Competencies:

- Relating to others

Vocabulary List:

- Density
- Buoyancy
- Mass
- Weight
- Volume
- Chuck
- Fluid

Items and equipment you need:

- Drill
- Large drill bit
- Elbow connectors
- Vice
- Masking Tape

Step 2:

Pre Activities:

- Go to Bunnings/Mitre 10 and compare and contrast different saws, drills and drill bits. Investigate what they are used for and why
- Investigate why the Titanic sank. Compare this to the Wahine disaster
- Take several water tight plastic containers and drill different sized holes, compare with many holes of the same size, which sinks faster?
- Test different shapes and materials to see what floats and what doesn't. Can you make a shape which floats out of a material that sinks?
- Show students the pipe connections but don't give the names. What would they name this kind of connection?
- Investigate the names for other pipe connections – why are they called that?

Understanding How Tools Work

To insert a drill bit, turn to open the jaws of the drill.

Insert the drill bit into the jaws – move it as far as it will go and hold it straight. Turn the chuck to tighten the jaws.



Squeeze the trigger on the drill while holding the chuck – this will feel a bit weird but acts as an uber tightener. If you don't do this the drill bit will eventually fall out.

The electric drill works when the trigger is pressed down. The more the trigger is pressed the faster the drill bit will turn. You need to press down onto the drill so that your weight makes the drill move through the material you are drilling. Otherwise all you will do is make a small dip in the pipe.

Official Names for Pipe Connections



Figure 1: This is an elbow connector Figure 2: This is a T connector

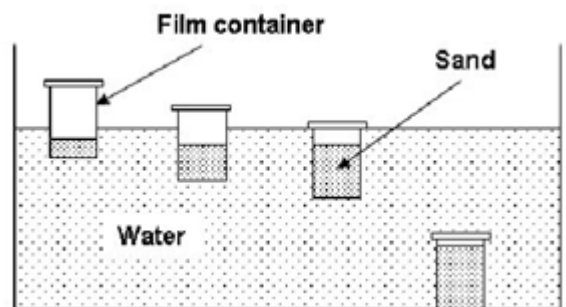
Understanding How Things Sink



Things float when they are “positively buoyant” or less dense than the fluid they are sitting in.

What does that mean? Fluid is a fancy word for water (or oil or Coke). Density means how much stuff is in one spot. For example if you have a rock and a sponge the same size, one will float (hint the sponge) and one will sink.

We divide the mass (what we normally call weight) by the volume (size) and if there is a small mass then we have a small density. If we weighed the sponge it would weigh less because it's full of holes and air, while the rock is full of rock, so it's heavier. This is why a boat will float, until it has holes in it. The holes allow water to fill up the boat and NOW the boat is heavier than before because water is heavier than air.



Drilling Holes in Your Elbows

Place the elbow in the vice with one of the end pointing up towards the sky. Tighten the vice. Place the drill bit into the open end and drill through the end until you make a hole.

Review Health and Safety for Using Drills:

- Never drill anything in your hand
- Always use the vice
- Press down as you drill
- Press the trigger slowly till the bit has gripped
- Keep hands out of the way
- Take finger off the trigger immediately if you feel unsafe or the drill slips
- Hold the drill vertically and slowly press the trigger. When the drill bit has really dug into the pipe then speed up the drill. Ensure that you press down so the drill drills into the pipe
- Stop once it has gone through the pipe.

COMMON ERRORS

- Placing the elbow upside down
- The drill bit falls out
- They drill through both sides of the elbow

Review and Reflection Prompts

Encourage students to regularly review what they have learnt, how they worked as a team and what they, personally can do to make things better, what they would do differently next time. This is a key step in the design process.

- How did you work well as a team – what did you do?
- What could **you** do to make things better next time?
- What went wrong? – why?
- What went well? – why?
- What can I do now (WALT)?
- Which image captures the feeling from this step?
- What can I add to our presentation?
- Anything else to share or discuss at this stage?

Ideas to go further – for senior students or students who have participated before

- Investigate how many holes your robot will need and where they should be best placed
- Create an explanation video for why your robot will sink appropriately, ensure that you refer to the forces at work and if you can, create the calculations that prove it

Curriculum Links:

Level 2: Build their language and develop their understanding of the many ways the natural world can be represented

Explore every day phenomena such as forces

Seek and describe simple patterns in physical phenomena such as movement

Level 3: Explore, describe and represent patterns and trends for everyday examples of physical phenomena such as forces movement

Level 4: Explore, describe and represent patterns and trends for everyday examples of physical phenomena such as forces

Level 5: Identify and describe the patterns associated with physical phenomena found in simple everyday situations involving forces and movement.

Level 6: Investigate trends and relationships in physical phenomena such as forces and movement

Investigate how physics knowledge is used in a technological application

Key Competencies:

- Relating to others

Vocabulary List:

- Force
- Velocity
- Friction
- Motion

Items and equipment you need:

- Motors
- Electrical Tape
- Scissors

We can now:

- Connect our motors to the cable
- Explain how motors make our robot move and the effect of water on our motors

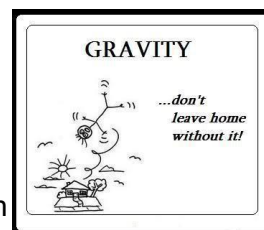
Step 3:

Pre activities:

- Push a car along a smooth surface, a carpeted surface and a ramp. On which does the car move faster? Why?
- Take a bucket of water outside and spin it around vertically (like a windmill) – why does the water stay inside?
- What happens when you place your phone in water? Why?
- Investigate how Samsung and Apple have created “waterproof” phones
- Create a waterproof container for an object and test it

Understanding How Things Move

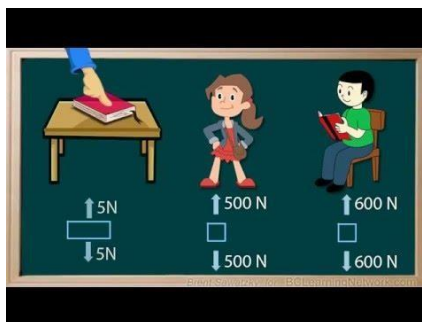
Objects in our world move because of things called forces. There are all kinds of forces. A force is a big word for pushing or pulling.



Forces are always pushing and pulling on you. They keep you with your feet on earth and your scooter in motion.

Gravity is the force which keeps you on earth and magnetic force is used in rollercoasters.

There are 6 kinds of forces.



Normal force – this stops the book on the table from falling through the table. It is the water pushing back when your NZAquabot sits on the water.

Applied force – the force when you pick something up.

Frictional force – the force that occurs when two surfaces come into contact with each other. This is what slows your car down when it is on the carpet.

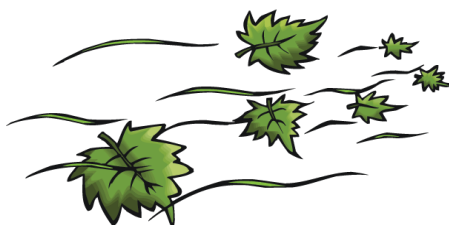


Tension force – the force that is in the power lines, when a cable or wire is tied to two opposite walls or objects.

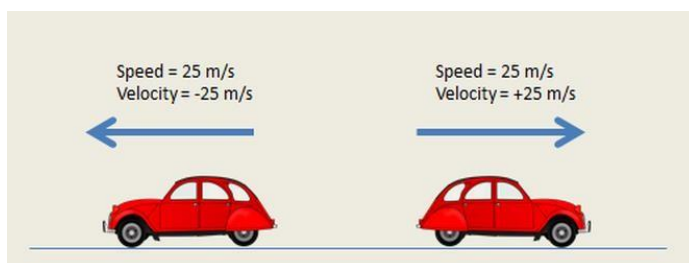


Spring force – this force is in a slinky, or a rubber band.

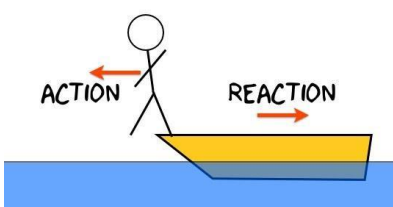
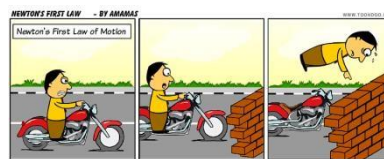
Resisting forces – things like wind and air. They move things along – sometimes they can slow you down, like when you walk into the wind or they can speed you up, if the wind is behind you.



Velocity is a big word that means your speed in a direction.



Newton's first law of motion says an object in motion will remain in motion unless acted on by an outside force. This means your car will keep going forward unless it meets something that stops it, like friction or an applied force (running into a wall).



Newton's second law of motion says that a force acting on an object will change its velocity by either changing its speed, direction or both. This means that when your car hits the wall it will either slow down, change direction or both. AND this is true for the wall.

Newton's third law of motion says that every action has an equal and opposite reaction. This means that when you fire a gun, as the bullet leaves the barrel, there is what is called kickback as the gun moves backwards. You can apply these laws and force knowledge to explain why your robot moves through water.

Understanding How to Waterproof and Why

When we put electrical things in water, we discover that they stop working. This is not due to the water itself. In fact, it is due to the impurities (specifically salt) in the water. In fact if you have 100% distilled water you could put your working cellphone into the water and it would still work. (Don't try that at home just in case.)

Because the water we put our motors into is not pure we need to ensure that our motors are waterproofed. Waterproofing is about keeping water out. Anywhere that there is a crack or a gap, with enough pressure, water can get in.

The most common way to waterproof is using glue. We can use tape, seals, rubber or anything like that, but the idea is to seal off the gaps. Using tape to seal off part of our motors is the first step in waterproofing them.

Tape Up Your Motors



Use your marker to colour in the gold connector that is next to the red dot.

Use the electrical tape to tape all-round the side of the motors. Then cutting pieces of tape, tape across the top of the

motor. Tape across the bottom of the motor so that the wax cannot get in.

COMMON ERRORS

- Colouring in both gold connectors
- Not taping the top of the motors
- Layering more than one layer of tape

Review and Reflection Prompts

Encourage students to regularly review what they have learnt, how they worked as a team and what they, personally can do to make things better, what they would do differently next time. This is a key step in the design process.

- How did you work well as a team – what did you do?
- What could **you** do to make things better next time?
- What went wrong? – why?
- What went well? – why?
- What can I do now (WALT)?
- Which image captures the feeling from this step?
- What can I add to our presentation?
- Anything else to share or discuss at this stage?

Ideas to go further – for senior students or students who have participated before

- Work out the velocity of your robot
- Can you create a device or attachment that will enhance your motor speed or velocity?

Curriculum Links:

Level 2: Build their language and develop their understanding of the many ways the natural world can be represented

Explore every day phenomena such as electricity

Seek and describe simple patterns in physical phenomena such as electricity

Level 3: Explore, describe and represent patterns and trends for everyday examples of physical phenomena such as electricity

Level 4: Explore, describe and represent patterns and trends for everyday examples of physical phenomena such as electricity

Level 5: Identify and describe the patterns associated with physical phenomena found in simple everyday situations involving electricity.

Level 6: Investigate trends and relationships in physical phenomena such as electricity

Investigate how physics knowledge is used in a technological application

Key Competencies:

- Managing self

Vocabulary List:

- Electricity
- Electrons
- Circuit
- Voltage
- Amps

Items and equipment you need:

- Ethernet cable
- Wire strippers
- Scissors/craft knife

We can now:

- Connect our motors to the cable
- Explain how electricity moves around the circuit

Step 4:

Pre activities:

- Create a diagram that shows how electricity gets to your light
- Use a lemon to turn a light on, compare to a potato and other fruit and vegetables
- Explore electricity with squishy circuits
- <https://www.makerspaces.com/squishy-circuits/>
- Create circuit diagrams with TinkerCAD
- <https://www.tinkercad.com/circuits>

Understanding Electricity and Your Wires

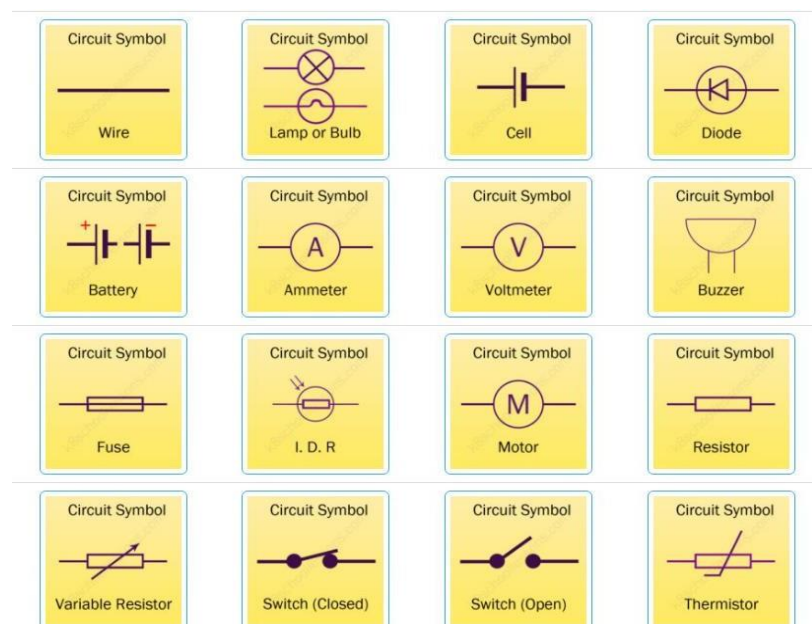
What is electricity? Electricity is a type of energy that is created by electrons moving from one place to another.

For our lights (or motor) to work we need a complete circuit.

This will allow the electricity to follow from the start to the finish. Think of it like water in a pipe. If the pipe doesn't connect all the way round, then water will spill out on the floor.

Electricity flows from the positive to the negative through the different parts in the circuit. If the circuit only goes to the battery/power then it will short circuit. For us, this means that it will spark, or blow a fuse in the controller.

These are some symbols used to create circuit diagrams. It is often a good idea to draw out what the circuit will look like before you create it. This will reduce the chances of a short circuit.



Electricity has several ways of measuring it. First is voltage. Voltage measures the pressure that makes the electron flow. You can think of it like how steep the river is. A very steep river is no worse than a very flat river. So voltage is not the dangerous part of electricity.

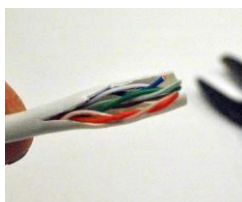
Second is current which measures how many electrons are flowing, measured in amps. You can think of this like how much water is in the river. More water is more dangerous than less water. So amps is the measure of electricity that will kill you.

Understanding Ethernet Cables

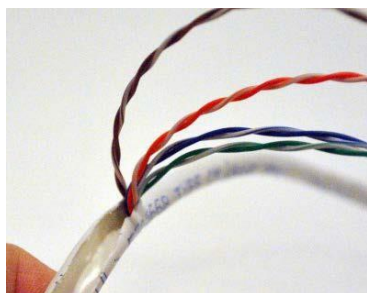
Ethernet cables are the cables that carry information from your computer to the world via the internet. Your data is converted into electrical pulses (like Morse code) and sent out. Our motors run based on an electrical signal that is sent from the controller when different buttons are pressed.

Strip Your Wires

Use a craft knife to gently cut through the plastic, like gutting an eel. Continue for about 50cm. Then peel the plastic off and cut the plastic off.



Use the wire strippers to cut through the Ethernet cable to expose the four wires inside.



Cut the brown one off at the same point you cut the plastic off. We do not need this wire.

Strip the coloured plastic off each of the cables so that approximately 2cm of copper wire is exposed.

COMMON ERRORS

- Cutting all the way through the copper wire
- Stripping too much of the plastic off the copper wire
- Not stripping enough of the plastic off the copper wire
- Only having one strand of copper wire
- Cutting off any wire except the brown one

Review Health and Safety for Using Craft Knives:

- Never cut anything in your hand
- Hold the cable in place with your fingers
- Cut away from you
- Cut small pieces at a time
- Move your fingers out of the way

Review and Reflection Prompts

Encourage students to regularly review what they have learnt, how they worked as a team and what they, personally can do to make things better, what they would do differently next time. This is a key step in the design process.

- How did you work well as a team – what did you do?
- What could **you** do to make things better next time?
- What went wrong? – why?
- What went well? – why?
- What can I do now (WALT)?
- Which image captures the feeling from this step?
- What can I add to our presentation?
- Anything else to share or discuss at this stage?

Ideas to go further – for senior students or students who have participated before

- Create a circuit diagram of the motors, controller and battery
- Solder the controller PCB together
- Determine the voltage and amperage for the circuit

Curriculum Links:

Level 2: Build their language and develop their understanding of the many ways the natural world can be represented

Explore every day phenomena such as electricity

Seek and describe simple patterns in physical phenomena such as electricity

Level 3: Explore, describe and represent patterns and trends for everyday examples of physical phenomena such as electricity

Level 4: Explore, describe and represent patterns and trends for everyday examples of physical phenomena such as electricity

Level 5: Identify and describe the patterns associated with physical phenomena found in simple everyday situations involving electricity.

Level 6: Investigate trends and relationships in physical phenomena such as electricity

Investigate how physics knowledge is used in a technological application

Key Competencies:

- Thinking

Vocabulary List:

- Terminal
- Film Canister

Items and equipment you need:

- Film canister
- Ethernet cable
- Drill
- Battery
- Controller

We can now:

- Test our motors
- Explain why our motors go

Step 5:

Pre activities:

- Show students a film camera and the film from one. See if they can work out what it is
- Use film canisters to create rockets using vinegar and baking soda
- Create a pinhole camera

Understanding What Film Canisters Are

Film canisters were used to store the film from older cameras. It keeps them safe and they are water tight.

Press the lid onto the canister and hold the canister at the bottom on the table.

It is important that the hole is drilled exactly in the middle of the canister, to allow the motor shaft to go through.

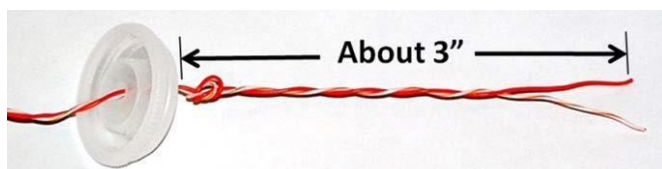
Drill gently through the lid using a small drill bit. Turn the canister over and drill through the bottom. Repeat for all the canisters



Review Health and Safety for Using Drills:

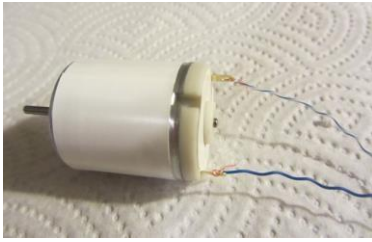
- Never drill anything in your hand
- Press down gently as you drill
- Keep hands out of the way
- Take finger off the trigger immediately if you feel unsafe or the drill slips
- Press the reverse switch to pull the drill out of the hole

Take the cable that you have stripped and slide the paired colours through the hole in the lid. Make sure the lid will still close. There should be about 5cm of cable inside the lid, then tie a knot on the inside of the lid.



COMMON ERRORS

- Threading the wires through the wrong way
- Only drilling one part of the canister
- Using the big drill bit



Take the stripy cable and twist it around the gold connector that is NOT coloured in.
Take the solid cable and twist it around the connector that is coloured in.
Make sure NO plastic is touching the gold connectors

Connect all the motors. Plug the ethernet cable into the controller. Connect the black alligator clip to the black terminal on the battery and the red alligator clip to the red terminal on the battery.
Test your motors all work.

Troubleshooting if my motors don't go:

If none of the motors go

- Have you connected the alligator clips correctly?
- Try a different controller
- Try a different battery

If one/two motors don't go:

- Is the copper wired twisted/connected?
- Is there plastic touching the gold connectors?
- Have you connected the solid to the connector that was coloured in?
- Are both wires connected?

Review and Reflection Prompts

Encourage students to regularly review what they have learnt, how they worked as a team and what they, personally can do to make things better, what they would do differently next time. This is a key step in the design process.

- How did you work well as a team – what did you do?
- What could **you** do to make things better next time?
- What went wrong? – why?
- What went well? – why?
- What can I do now (WALT)?
- Which image captures the feeling from this step?
- What can I add to our presentation?
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Ideas to go further – for senior students or students who have participated before

- Explain what would happen if you connected the red alligator clip to the black terminal
- Explain why there is a plastic cover on the alligator clips
- Solder the controller cable to the alligator clip
- Explain what a short circuit is

Curriculum Links:

Level 2: Build their language and develop their understanding of the many ways the natural world can be represented

Explore every day phenomena such as electricity

Seek and describe simple patterns in physical phenomena such as electricity

Level 3: Explore, describe and represent patterns and trends for everyday examples of physical phenomena such as electricity

Level 4: Explore, describe and represent patterns and trends for everyday examples of physical phenomena such as electricity

Understand that materials can be formed, manipulated, and/or transformed to enhance fitness for purpose of a technological product

Level 5: Identify and describe the patterns associated with physical phenomena found in simple everyday situations involving electricity.

Level 6: Investigate trends and relationships in physical phenomena such as electricity

Investigate how physics knowledge is used in a technological application

Key Competencies:

- Managing self

Vocabulary List:

- Solder
- Melting point
- Weld

Items and equipment you need:

- Soldering iron
- Solder
- Ethernet Cable
- Motors
- Battery
- Controller

We can now:

- Test our motors
- Explain how electricity passes through the soldered connection
- Explain why plastic in the connection will stop the motors working

Step 6:

Pre activities:

- Explore different melting points of metals
- Investigate the different properties of different metals, what are they used for and why
- Compare the difference between welding and soldering
- Visit a welder at work

Metals have different properties which make some good for conducting electricity. Silver and gold are excellent conductors of electricity. This is because there are more free electrons in them. They can bounce around passing the electricity on. Some metals melt at low temperatures such as lead (which means you can melt old lead figurines at home) or aluminum. This is why fizzy drink cans will melt in your home fire (don't try this at home). Some have very high melting points so we can use them when we are working with high temperatures – such as iron can be used as material in making fireplaces and ovens. This is important for us because when we solder we are melting a metal and using it to join two metals together. Unlike welding, we can solder two different metals together. We need something that will melt at a low temperature and will conduct electricity. This will help the electricity pass from our controller through to the motors. We use solder because we need the connection to be strong and not come apart.

Solder your connections

We are going to solder the connection between the ethernet cable and the motors.

Line up the copper connection and the wire (ensuring that there is NO plastic between these) and rest the solder on the connection.

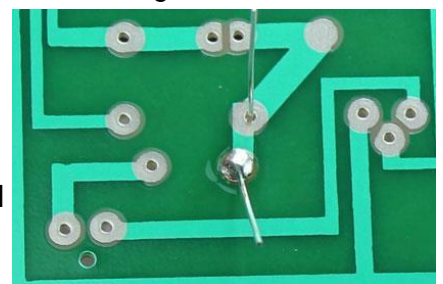
Bring the soldering iron down into contact with the solder. Feed the solder in as it melts. Ensure that the soldering iron is in contact with the copper connection.

If the solder sticks, simply touch the soldering iron to it and it will melt.

A good solid connection should look like a smooth volcano. Check that the connection is soldered around the whole copper connection. Repeat for all the wires/copper connections.

COMMON ERRORS

- Holding the soldering iron off the connection
- Not feeding the solder in
- Only soldering a small bit of the connection



Review Health and Safety for Using Soldering Irons:

- Wait until the soldering iron has heated up
- Always put the soldering iron back into the stand if you are not using it (that includes when adjusting the motors or solder)
- If helping stay on the opposite side of the person's writing hand,
i.e. if you are helping a left handed person stay on their right hand side
- Keep a length of around 10cm of solder
- Wash your hands after soldering
- Never touch the soldering iron anywhere other than the handle
- Never muck around with the soldering iron
- Hold the soldering iron like a pencil

Test all the connections to make sure that the motors go.

Troubleshooting IF my motors don't go:

If none of the motors go

- Have you connected the alligator clips correctly?
- Try a different controller
- Try a different battery

If one/two motors don't go:

- Is the copper wire soldered?
- Is there plastic touching the gold connectors?
- Are both wires soldered?

Review and Reflection Prompts

Encourage students to regularly review what they have learnt, how they worked as a team and what they, personally can do to make things better, what they would do differently next time. This is a key step in the design process.

- How did you work well as a team – what did you do?
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- What went well? – why?
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Ideas to go further – for senior students or students who have participated before

- Explain the difference between welding and soldering
- Explain why plastic being soldered into the circuit might cause the circuit to fail
- Solder the PCB controller together
- Focus on a quality solder connection

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Investigate how physics knowledge is used in a technological application

Key Competencies:

- Relating to others

Vocabulary List:

- Thrust
- Buoyancy
- Hydrodynamics
- Fluid
- Drag

Items and equipment you need:

- Film canister
- Ethernet cable
- Drill
- Battery
- Controller

We can now:

- Put the robot together
- Explain why we pool noodle
- Explain why the front of the robot is the front

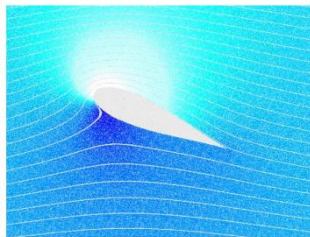
Step 7

Pre activities:

- Test and evaluate a variety of materials (clay, tinfoil, plastic) which floats best? Create a floating boat out of each of the materials and test again.
- Create a rubber band boat – do different rubber band sizes (both fatter and longer) make a difference to how fast or far it goes? (<https://thekidshouldseethis.com/post/how-to-make-a-popsicle-stick-and-rubber-band-paddle-boat>)
- Try different rubber band boat designs – have a flat nose, a pointed nose, which design works better and why?

Understanding Hydrodynamics

Hydrodynamics is how objects move in liquids (in our case, water). Some designs move faster through water. It is the same principal that helps things to fly in the air.



When water comes into contact with a curved surface it will follow that surface. This leads to less drag (or water resistance).

Drag is what slows an object down. You can increase the force you use (thrust) to move forward to decrease the effects of drag. However with NZAquabots we can't increase the thrust as we would need to replace the motors (which we can't do), so we need to reduce drag by changing the shape of the object.

Shape		Drag Coefficient
Sphere		0.47
Half-sphere		0.42
Cube		1.05
Streamlined Body		0.04
Streamlined Half-body		0.09

Measured Drag Coefficients

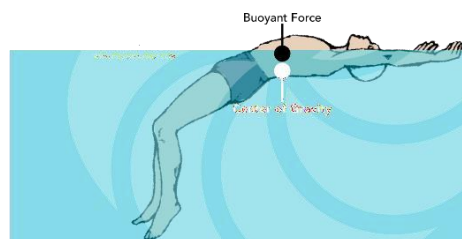
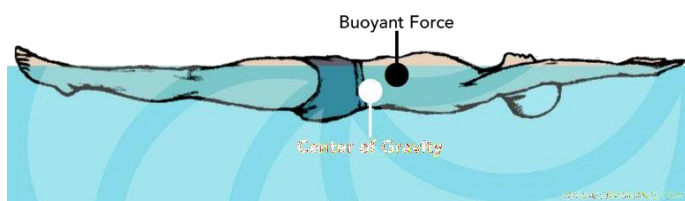
Understanding Buoyancy – How Things Float

Buoyancy is also affected by how much of that stuff is all in one place. For example, if you stand on a nail then all of you is pressed down on that one point. It will hurt (and if you're unlucky the nail will go through your foot).



If you lie down on a bed of nails then all of you is spread out across all the nails and so it doesn't hurt (it prickles a little).

In water this means that something with a bigger surface area (shape) pushes against the water, the water pushes back. The more shape it has the more water pushes back and so it floats.



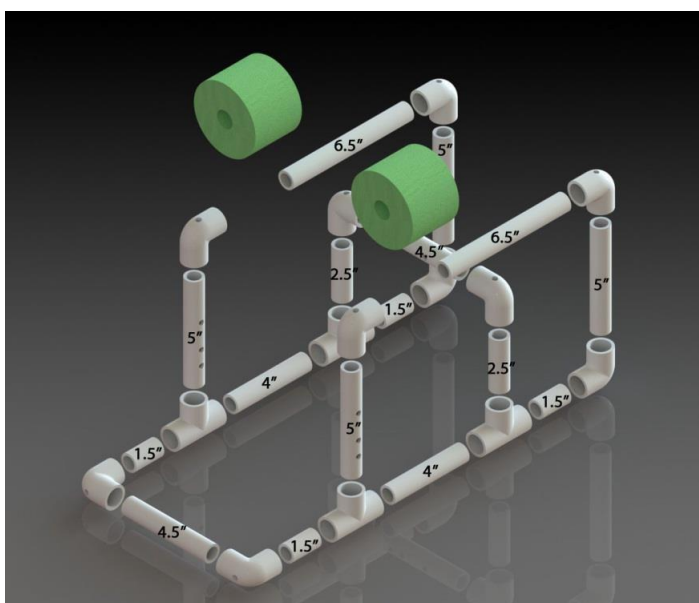
Building Your Robot

Use the image below to put your robot together. Make sure that you press each join together firmly so that it doesn't fall apart. Once you have tested your robot in the pool for the first time you can then superglue joints together if you need/want to.

COMMON ERRORS

- Discovering that pipes are not the same length
- Not putting the pool noodle on

You need to label each pipe with the inches measurement so that you can easily put the robot together. The pipe may need to be firmly pressed through the pool noodle depending on the size of the pool noodle hole.



Review and Reflection Prompts

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- What could **you** do to make things better next time?
- What went wrong? – why?
- What went well? – why?
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Ideas to go further – for senior students or students who have participated before

- Explain why your chosen design (or chosen front) is more hydrodynamic
- Hypothesis how much pool noodle you will need to cut off later
- Explain how the pool noodle provides buoyancy
- Explain how the shape of the pool noodle will affect hydrodynamics
- Test different pool noodle shapes to reduce drag and still ensure neutral buoyancy

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Investigate how physics knowledge is used in a technological application

Key Competencies:

- Relating to others

Vocabulary List:

- Waterproof
- Hydrophobia
- Molecule

Items and equipment you need:

- Toilet wax
- Motors
- Film canisters
- Paper towels
- Gloves
- Battery
- Controller

We can now:

- Test our motors
- Explain why our motors will not get wet once in the water

Step 8

Pre-activities:

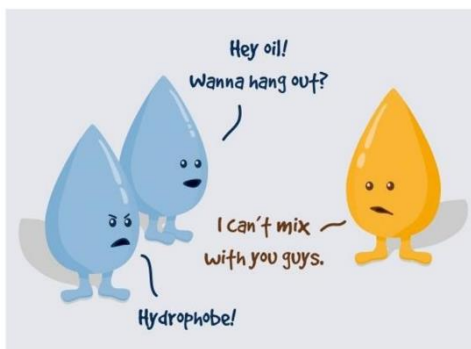
- Try to combine vegetable oil and water, shake the container and see what happens
- Combine vegetable oil, water and dishwashing liquid, shake the container and see what happens
- Put oil, coloured water in a bottle and add an effervescent antacid (like Berocca) and see what happens

Understanding how to waterproof – oils and water

Oil is considered to be hydrophobic. This means that it repels water. This is why you cannot mix oil and water.

Their molecules cannot link together and so they separate.

The wax that we use to waterproof the motors is oil based. That's why it feels greasy when we touch it with our hands and why it doesn't quite come off when we wash our hands. We need to wipe it off or use soap. Soap molecules (the tiny things that make up everything) link with water and with oil.



We can use the idea of hydrophobia to create a spray that would make water repel off our clothes or anything that we sprayed it on. This can mean we can design clothes that never need to be washed. Sweat is water based so this spray

would repel sweat.

Review Health and Safety for Using Toilet Wax:

- Put gloves on
- Keep gloves on until the final test and the lid on the canisters is closed
- Make sure that there is paper under your working area
- Don't eat or taste the wax

Toilet Wax for Motors

Take a ball of wax and put it around the end of the motor with the shaft. You should put enough wax on to the thickness of one adult finger.



Gently push the motor into the canister so the shaft pokes through the hole – you may need to turn the motor a little to line the shaft up correctly. Press the motor down until the shaft fully pokes out of the canister.

Test the motor still works.



Curl up the cable and add wax to the top of the canister to hold

the cable in. Fill the top of the motor and press the lid on. There should be no cable hanging out the sides and no empty space between the wax and the lid. Test the motor to make sure it still works.

COMMON ERRORS

- Not enough wax
- Too much wax
- Wax on the sides of the motors
- Solder connection is broken while putting the wax on/motor into the canister

Troubleshooting if my motors don't go:

If none of the motors go

- Have you connected the alligator clips correctly?
- Try a different controller
- Try a different battery

If one/two motors don't go:

- Remove the wax and check the connection is still soldered

If motors go slowly:

- Hold the controller down for forwards or backwards until the motor moves fast (the wax needs be loosened from the shaft).

Monkey Putty

This is your last line of defense to waterproof your motors. The monkey putty is the little black lump.

Place some around the lid of the canister where the cable goes into it. This stops the water running down the cable and into your motor.

Place the final amount around the end of the cable where it meets in the Ethernet cable.



This stops the water running up your Ethernet cable and into your controller.

COMMON ERRORS

- Putting putty on the grooves in the lid, not around the cable
- Putting the putty around the propeller shaft
- Not putting putty on the Ethernet cable end

Review and Reflection Prompts

Encourage students to regularly review what they have learnt, how they worked as a team and what they, personally can do to make things better, what they would do differently next time. This is a key step in the design process.

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- What could **you** do to make things better next time?
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- What went well? – why?
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Ideas to go further – for senior students or students who have participated before

- Have students select their own waterproofing materials and test these
- Explain why the wax gets “stickier” the more it is worked with
- Determine in which situations the waterproofing will not work

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Investigate how physics knowledge is used in a technological application

Key Competencies:
Managing self

Vocabulary List:

- Kort nozzle
- Pitch
- Drag

Items and equipment you need:

- Propellers
- Shaft
- Nut
- Hex bolt
- Vice
- Pliers
- Superglue

We can now:

- Put the propellers together
- Explain how the propellers move our robot forwards

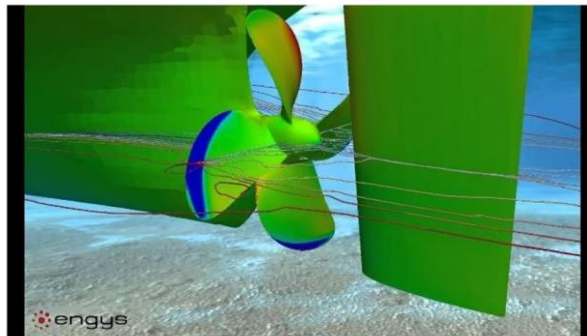
Step 9

Pre-activities:

- Investigate whether different propeller sizes, propeller shapes and number of propellers – which make your Aquabot go faster? Record and discuss your results
- Research a Kort nozzle
- Create different sized Kort nozzles

Thrust

Earlier we discovered how things move, looking at forces and Newton's law. In order to go forwards we need to push backwards and this is how propellers work. Propellers work like a screw. As they turn they push water behind them which makes you move forward.



The angle of the propeller blade is called the pitch. This angle will help decide how fast you move forward. A steeper angle will mean that it will go faster, but will require more effort to turn. Just like walking up a steep path, you walk a shorter distance but it's harder.

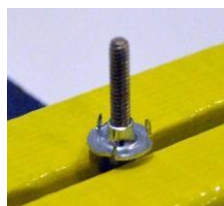
As a propeller turns in water we also have to consider the drag that it creates. The bigger the surface the more drag. It is a balancing act between the right angle to go faster and the right angle to reduce drag.

A Kort nozzle is a way of putting a cover around the propeller that makes it more efficient. It works for ships that need high thrust and travel at low speeds, like our NZAquabots. We do need to consider the extra drag created by this attachment as well.

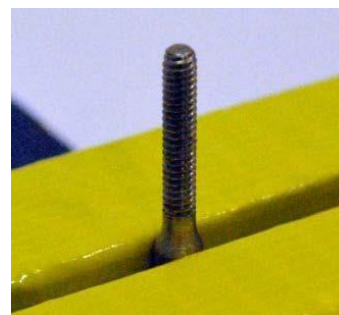


Putting Your Propellers Together

Put the threaded coupler into the vice with the thread face up.

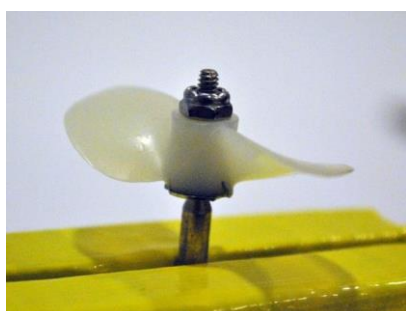


Screw on the nut (which has the points on it) all the way to the bottom. Make sure the points are facing upwards (like in the diagram on the left).



Place the propeller onto the coupler with the groove facing down.

Screw on the nut. NB: It is VERY IMPORTANT that the nut is screwed down until it can go no further. The propeller should NOT spin freely.



COMMON ERRORS

- Putting the propeller on upside down
- Not screwing the nut on tight enough
- Testing the motors before 10 mins
- Not cleaning the shaft

When this is done, ensure that the motor shaft is clear of all wax – use an alcohol wipe to clean it. Next run the sandpaper up and down the motor shaft to roughen in. Again, clean the shaft with an alcohol wipe – not the same one as before get a new one so that no wax goes onto the shaft. Drip a couple of drops of superglue into the hollow end AND onto the shaft. Slide the coupler onto the shaft all the way down.

Leave to dry for at least 10mins before testing.

Review and Reflection Prompts

Encourage students to regularly review what they have learnt, how they worked as a team and what they, personally can do to make things better, what they would do differently next time. This is a key step in the design process.

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- What could **you** do to make things better next time?
- What went wrong? – why?
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Ideas to go further – for senior students or students who have participated before

- Have students create and test Kort Nozzles for their motors
- Create and test different propellers (these cannot be used in the competition)
- Create a simulation that explains Newton's third law, the forces at work and thrust for their motors

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Investigate how physics knowledge is used in a technological application

Key Competencies:

- Relating to others

Vocabulary List:

- Hydrodynamics
- Thrust
- Drag

Items and equipment you need:

- PVC pipe robot
- Controller
- Battery
- Motors
- Tape
- Scissors

We can now:

- Put our robot in the water
- Explain why our motors are placed where they are

Step 10

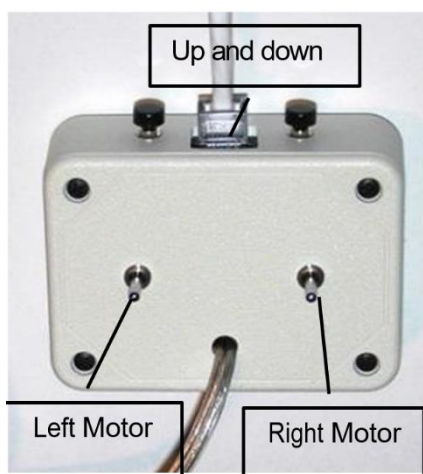
Pre-activities:

- Take the rubber band boats your created earlier and test where the best place to put the rubber band is
- Investigate where boats and submarines locate their motors and why

Reviewing Hydrodynamics

Remember that hydrodynamics is about how objects move through a liquid (in this case water). When we move an object through water, the placement of the motors can increase or decrease the drag based on where we position them. The position of the motors can also determine how effective their thrust is. For example motors placed on the bottom in the middle of the Aquabot might allow the robot to turn quicker but they might not allow the robot to move as fast.

Test your motors to determine which motor is connected to the up and down buttons on the controller, the left and the right.



Ensure that the left motor is attached to the left of the Aquabot and the right to the right side.

For your motors to be effective you need to determine the best location for your motors. For the left and right motors, you need to decide if they will be inside the Aquabot or outside the Aquabot.

Then you need to choose where on the vertical you will attach them. It is important that the motors are level with each other so that you can turn accurately.

COMMON ERRORS

- Not testing which motor is which
- Putting the motors on the front of the robot
- Putting the motors on backwards

It is best to attach your motors with tape to start with. You can later attach them with cable ties or stay with tape. Tape is easier to remove if you choose to move your motors after testing.

Review and Reflection Prompts

Encourage students to regularly review what they have learnt, how they worked as a team and what they, personally can do to make things better, what they would do differently next time. This is a key step in the design process.

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Ideas to go further – for senior students or students who have participated before

- Have students test and record the effect of different positions for the motors
- Have students test the up/down propeller facing up and facing down and record their results
- Students can use physics to explain why their selection is the most effective position
- Create a diagram that shows the forces being exerted and calculate the forces

Curriculum Links:

Level 1: Outline a general plan to support that development of an outcome, identifying appropriate steps and resources

Level 2: Develop a plan that identifies the key stages and the resources required to complete an outcome

Level 3: Undertake planning to identify the key stages and resources required to develop an outcome. Revisit planning to include reviews of progress and identify implications for subsequent decision making

Level 4: Undertake planning that includes reviewing the effectiveness of past actions and resourcing, exploring implications for future actions and accessing of resources, and consideration of stakeholder feedback to enable the development of an outcome

Level 5: Use planning tools to support and justify planning decisions that will see the development of an outcome through to completion

Key Competencies:

- Thinking
- Managing Self

Vocabulary List:

- Design Process
- Engineer
- Brainstorm

Items and equipment you need:

- Device
- Internet access
- Paper
- Pen/Pencil

We can now:

- Apply the Design Process
- Explain the design process

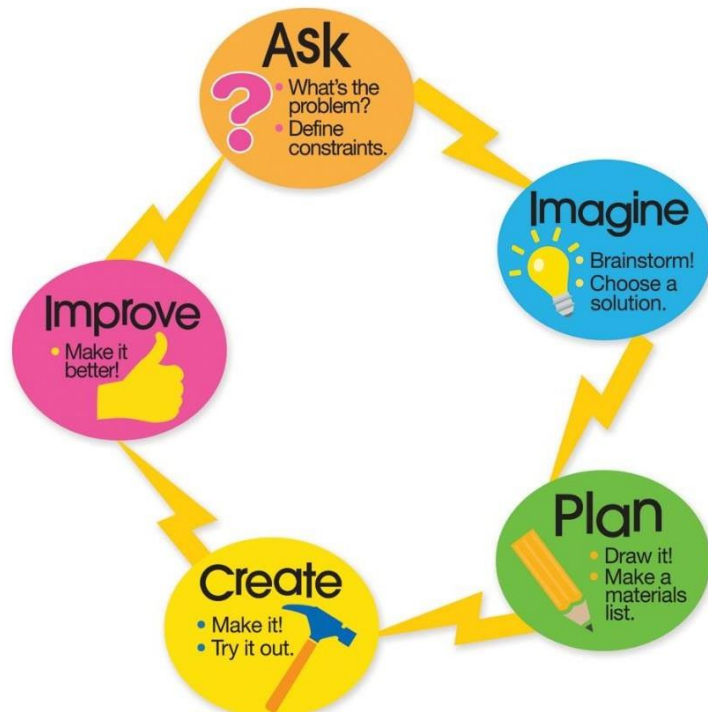
Step 11

Pre-activities:

- Find different examples of the design process
- Visit an engineer and discuss how they use the design process at work
- Use the design process to create a way to allow an egg to be dropped from a height without breaking
- Investigate different materials and their weights. Explore how they would work in the water and the advantages and disadvantages of each. Consider factors such as weight and drag in your investigations. You could use wood/chopsticks/plastic netting/chicken wire
- Create your Aquabot in TinkerCAD – make sure it is to scale

The Design Process

The design process is a way of thinking that people like engineers and programmers use to solve a problem. Everything in our lives can be defined as a problem, whether it's making life better or fixing an issue. The design process gives guidelines so that we can move from a problem to a solution. The design process is a circle because we can always make things better.



Ask

The first step is to define the problem. Here you need to review the different challenges. What does your robot have to do?

What are the constraints? This means the rules that you have to operate in. For example, you are not allowed to attach a camera to your robot. That is a constraint. Another constraint is that your robot needs to fit in a 31cm by 46cm x 46 cm box.

Read through the rules, challenges and marking schedule

Summarise these and explain them to someone else

Create a couple of examples of the objects that your Aquabot may have to collect

Imagine

Now that you know what you are aiming for, you need to come up with a range and variety of ways that you could complete the mission.

To start with put all your ideas down.

Now review these ideas, which are realistic, what materials might you need to make it happen, which ones would be the most effective and why?

Select two or three of the best ideas and use these in the next step.

Plan

Create a list of what materials you need – do you need wire, mesh, plastic, metal? Perhaps collect a couple of different material options so that you can have different choices to test.

Sketch out what your attachment might look like – put measurements on the sketch

Use TinkerCAD to create a 3D model of your robot and attachment – you might be able to 3D print this

Create

Make your attachment. Test it out with your examples that you made of the objects. Feel how heavy it is.

Attach it to your robot and test (more info in the next step)

Create different versions of your attachment using the different materials and the different ideas you had.

COMMON ERRORS

- Not reading the description of the challenges
- Not reading the scoring charts
- Making the attachment too long
- Making the attachment too heavy

Improve

Once you have tested your attachment (see next step), improve it. Consider making it from a different material, positioning it differently, using your pool noodle flotation differently, and measure to make sure your robot is still complying with the rules.

Finally, if it doesn't work go back and imagine, plan and create again.

Review and Reflection Prompts

Encourage students to regularly review what they have learnt, how they worked as a team and what they, personally can do to make things better, what they would do differently next time. This is a key step in the design process.

- How did you work well as a team – what did you do?
- What could **you** do to make things better next time?
- What went wrong? – why?
- What went well? – why?
- What can I do now (WALT)?
- Which image captures the feeling from this step?
- What can I add to our presentation?
- Anything else to share or discuss at this stage?

Ideas to go further – for senior students or students who have participated before

- Demonstrate how your attachment affects your buoyancy and hydrodynamics
- Explore what SCRUM and AGILE are
- Keep an Engineering journal which records all your design successes and failures
- Use the Design Process, SCRUM and AGILE to design your own Aquabot
- Visit a company who use SCRUM or AGILE

Step 12

Curriculum Links:

Level 2: Build their language and develop their understanding of the many ways the natural world can be represented

Explore every day phenomena such as electricity

Seek and describe simple patterns in physical phenomena such as electricity

Level 3: Explore, describe and represent patterns and trends for everyday examples of physical phenomena such as electricity

Understand that technological outcomes are recognisable as fit for purpose by the relationship between their physical and functional natures

Level 4: Explore, describe and represent patterns and trends for everyday examples of physical phenomena such as electricity

Understand that materials can be formed, manipulated, and/or transformed to enhance fitness for purpose of a technological product

Level 5: Identify and describe the patterns associated with physical phenomena found in simple everyday situations involving electricity.

Understand that technological outcomes are fit for purpose in terms of time and context. Understand the concept of malfunction and how "failure" can inform future outcomes.

Level 6: Investigate trends and relationships in physical phenomena such as electricity

Investigate how physics knowledge is used in a technological application

Key Competencies:

- Thinking

Vocabulary List:

- Neutral buoyancy
- Buoyancy

Items and equipment you need:

- Robots
- Craft knife
- Battery & Controller
- Attachment

We can now:

- Practice with our robot
- Complete our presentation
- Explain why we removed pool noodle

Pre-activities:

- Review how things float
- Review how things move

Reviewing Buoyancy and Design Process

Remind students that the pool noodle helps the robot to float. That when we put the robot in the water we want to achieve neutral buoyancy. This means that it sits just below the water (with the up/down propeller under the water). It should easily go down and up. It should not sink and it should not be impossible to go down.

Remind students that adding attachments will affect the buoyancy of the robot. It might make it heavier, meaning it will need more pool noodle to float. It might also mean the robot tilts as it moves up and down, particularly if it is collecting objects. This can be adjusted by adding/moving where pool noodle is placed.

Testing in the Water – First Visit

The aim of the first visit is to achieve neutral buoyancy. They need to fully submerge the robot and wait til the bubbles are gone. Then see if it sinks/floats and can go up/down. They then need to take pool noodle off – SAVE the pool noodle for later.

Repeat this process.

IMPORTANT, every time they

MUST fully submerge the robot. Eventually they will have cut off almost 1/3 of the pool noodle.

They can cut the pool noodle lengthwise or vertically, they can experiment and consider the effect on hydrodynamics.

COMMON ERRORS

- Cutting off too much pool noodle
- Not fully submerging the robot
- Placing a very heavy attachment on the front/back
- Propellers fall off (wait 10 mins with superglue usage)

Testing in the Water – Second Visit

The aim of the second visit is to achieve neutral buoyancy WITH an attachment and ensure that when picking up objects the robot is balanced.

Remember to fully submerge the robot when testing buoyancy. Teams may need to add additional pool noodle or reposition pool noodle.

Testing in the Water – Third and Subsequent Visits

The aim for the third and any subsequent visits is to practice collecting objects and navigating the obstacle course.

Students should ensure that they take photos and video of their practices and note changes they make based on their tests.

Review and Reflection Prompts

Encourage students to regularly review what they have learnt, how they worked as a team and what they, personally can do to make things better, what they would do differently next time. This is a key step in the design process.

- How did you work well as a team – what did you do?
- What could **you** do to make things better next time?
- What went wrong? – why?
- What went well? – why?
- What can I do now (WALT)?
- Which image captures the feeling from this step?
- What can I add to our presentation?
- Anything else to share or discuss at this stage?

Ideas to go further – for senior students or students who have participated before

- Predict how much pool noodle will need to be used using physics
- Compare the actual to your prediction
- Remove the pool noodle in a way that makes your robot more hydrodynamic

Curriculum Links:

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Level 4: Explore, describe and represent patterns and trends for everyday examples of physical phenomena such as electricity

Level 5: Identify and describe the patterns associated with physical phenomena found in simple everyday situations involving electricity.

Level 6: Investigate trends and relationships in physical phenomena such as electricity

Investigate how physics knowledge is used in a technological application

Key Competencies:

- Thinking

Vocabulary List:

- Refraction
- Density
- Medium

Items and equipment you need:

- Robot
- Controller
- Battery
- Items to collect

We can now:

- Explain why it's hard to collect items from the bottom of the pool

Step 13

Pre-activities:

- Draw two arrows on paper facing the same way. Slowly lower the paper behind a full glass of water (<http://coolscienceexperimentshq.com/light-refraction/>)
- Use different shaped lens to shine lights through
- Shine light through a prism
- Create rainbows using spray bottles

Understanding Light Refraction

When you start to practice with your robot underwater you will soon discover that just because you think you are close to an object doesn't mean you actually are. In fact you will find that navigating underwater can be trickier than it looks. This is because of a phenomena called refraction.

Light travels in straight lines.

When light passed from one medium (like air) into a denser medium (something that is thicker than air, like water) the light slows down. This causes

the direction of the light to change. It does not bend, but refracts away from the line it was on.

If light goes from a dense medium (from water) into something less dense (like air) then the light will speed up. It will refract in the opposite direction.

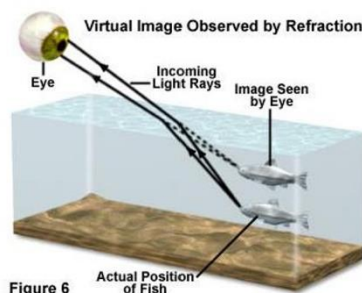
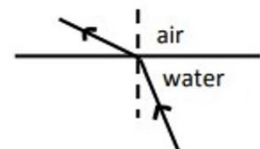


Figure 6

We struggle to touch the item underwater because our eye tracks back from the image in a straight line, forgetting that the light has refracted and so the actual image is lower. It will take practice to get used to driving to where the object is in reality

rather than where it appears.

Light refraction is a key component of how microscopes and telescopes work as well as understanding rainbows.

Testing Further

Practice makes perfect... and the more practice you have at the pool collecting objects and navigating through objects the better you will get at predicting where the objects actually are underwater.

COMMON ERRORS

- Not practicing picking things up
- Not practicing driving through objects

Please note that you CAN NOT attach a camera to your robot. You can however, attach ultrasonic or other such sensors (providing sensors and receivers are below the \$20 threshold).

Review and Reflection Prompts

Encourage students to regularly review what they have learnt, how they worked as a team and what they, personally can do to make things better, what they would do differently next time. This is a key step in the design process.

- How did you work well as a team – what did you do?
- What could **you** do to make things better next time?
- What went wrong? – why?
- What went well? – why?
- What can I do now (WALT)?
- Which image captures the feeling from this step?
- What can I add to our presentation?
- Anything else to share or discuss at this stage?

Ideas to go further – for senior students or students who have participated before

- Investigate the effect of waves on light refraction
- Create a device or lens that can help you navigate underwater more easily
- Calculate the relative index of refraction
- Create a diagram which shows the critical angles of the light refraction

Curriculum Links:

Level 2: Build their language and develop their understanding of the many ways the natural world can be represented

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Level 4: Explore, describe and represent patterns and trends for everyday examples of physical phenomena such as electricity

Level 5: Identify and describe the patterns associated with physical phenomena found in simple everyday situations involving electricity.

Level 6: Investigate trends and relationships in physical phenomena such as electricity

Investigate how physics knowledge is used in a technological application

Key Competencies:

- Participating and contributing

Items and equipment you need:

- Laptop/device
- Internet access
- Links from the challenge

We can now:

- Answer basic quiz questions about the topic

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Step 14

Pre-activities:

- Visit a scientist or museum that covers the topic
- Have a guest speaker come in and talk about the topic
- Introducing the topic

Students should ensure that they have read and viewed the given links as a bare minimum. They can create questions to test each other's knowledge, they could create a video to tell the story to someone else. They should choose the parts of the story that most intrigued them or key knowledge that they didn't know before, to present as part of their overall presentation.

It should not be a significant part of their presentation (no more than 2mins max) and should be integrated into their whole presentation rather than tacked on at the end.

COMMON ERRORS

- Not reading the provided links
- Putting too much theory into the presentation
- Just adding a slide at the end

Review and Reflection Prompts

Encourage students to regularly review what they have learnt, how they worked as a team and what they, personally can do to make things better, what they would do differently next time. This is a key step in the design process.

- How did you work well as a team – what did you do?
- What could **you** do to make things better next time?
- What went wrong? – why?
- What went well? – why?
- What can I do now (WALT)?
- Which image captures the feeling from this step?
- What can I add to our presentation?
- Anything else to share or discuss at this stage?

Ideas to go further – for senior students or students who have participated before

- Create a storybook or an ebook to tell the stories to year 1 & 2 students
- Create a promotional video for the event showcasing the stories

Curriculum Links:

Level 2: Construct text that demonstrates a growing awareness of audience and purpose through appropriate choice of context, language and text form,

Form and express ideas and information with reasonable clarity, often drawing on personal experience and knowledge

Organise and sequence ideas and information with some confidence.

Level 3: Seek feedback and makes changes to texts to improve clarity, meaning and effect

Use oral, written and visual language to create meaning and effect and engage interest

Level 4: Is reflective about the production of own texts, monitors and self-evaluates progress, articulate learning with confidence

Organises and sequences ideas and information for a particular purpose and effect

Level 5: Seeks feedback and makes changes to texts to improve clarity, meaning and effect

Develop ideas by adding details or making links to other ideas and details

Achieves a sense of coherence and wholeness when constructing texts

Level 6 - 8: Uses a wide range of oral, written and visual language features fluently and with control to create meaning and effect and sustain interest

Organises and develops ideas and information for a particular purpose or effect, using the characteristics and conventions of a range of text forms with control

Key Competencies:

- Using language, symbols and text

Vocabulary List:

- Design Elements
- Design Principles

Items and equipment you need:

- Device
- Internet access
- Images

We can now:

- Present our learning journey

Step 15:

Pre-activities:

- Do 30 second impromptu speeches on a range of topics
- Watch inspiring speakers, what do they do?
- Watch awful presentations, what do they do?
- Have students sit in the "hot seat" for 2mins and tell a story to a small group, receive and give critical feedback
- Film students presenting and have them analyse their presentation
- Have students write 30 second speeches and have someone else present them. Both parties should give feedback

The Presentation

Delivering a good quality presentation is not difficult, mainly because so many presentations are not good.

Consider the audience – two judges who have to listen to 30 – 40 teams present almost the same material.

Consider the medium – PowerPoint/computer or poster

The judges can read faster than you can talk, so ensure that what they are seeing isn't just what you are saying. Tell them a story, a story that tells what you have learnt through this journey. Tell them about the problems you came up against, the new things you learnt and how they relate to your robot. Tell them why you have designed your robot the way it has been... and support that with some research or evidence. Tell them about how you worked as a team, how you decided who would do what job, what issues did you run into and how you fixed them.

Make sure you have covered the following points. You don't necessarily need a separate slide for each one

COMMON ERRORS

- Writing paragraphs on each slide
- Talking to the floor
- Only one person knows the presentation
- Talking only about theory

- Title—Name of the NZAquaBot Project or Team
- Team—tell the judges about the team. Include team members, teacher/coach, and volunteers.
- Building Process and Challenges—Describe the process the team went through designing and building the NZAquaBot include any challenges faced or lessons learned by the team during the design, construction, design priorities, and testing phases.
 - Research completed on design and/or scientific principles- buoyancy, refraction, propulsion, etc.
- Modifications—describe and justify any modifications

- Trials—describe the trials performed and how the NZNZAquabots was adjusted after the trials.
- Cost Documentation—Receipts or other proof of additional costs incurred in building the NZNZAquabots. This should include the itemized cost of additional items purchased or equivalent value of donated items in a simple table. Receipts should be kept in an envelope and clearly marked with team name, item and cost. NOT NEEDED IN PRESENTATION IF YOU SPENT LESS THAN \$10

The presentation:

Teams will enter the room by themselves (coaches, parents are allowed to watch but may not communicate with the team).

They should take a laptop with them if using Powerpoint, Prezi etc. There should be no assumption that there will be a projector, computer or TV.

They need to set up where the judges can see the screen.

Team will tell their story, with all members of the team being involved equally. Judges will ask questions and team members will answer.

Team members must share the answering and not talk over the top of each other.

The presentation time is 10mins in total and should cover all the topics listed earlier. Teams should bring their robot in with them to use as a reference during their presentation.

Top tips for PowerPoint:

Limit animations and slide transitions – if you must use them, use the same style throughout

Limit the number of fonts – max of 3 throughout the presentation (No comic sans or novelty fonts)

Use bullet points and images – aim for 12 words or less per slide

Use images that are personal to your team

Have a theme – the same background, colours and fonts on each slide

Use colours that complement each other

Explore using Prezi, PowToon or other options instead of using PowerPoint or Google Slides

Factsheet

This prepares teams for Internationals. Teams will prepare and submit a ONE page A4 sheet which summarises their team, experience and their robot.

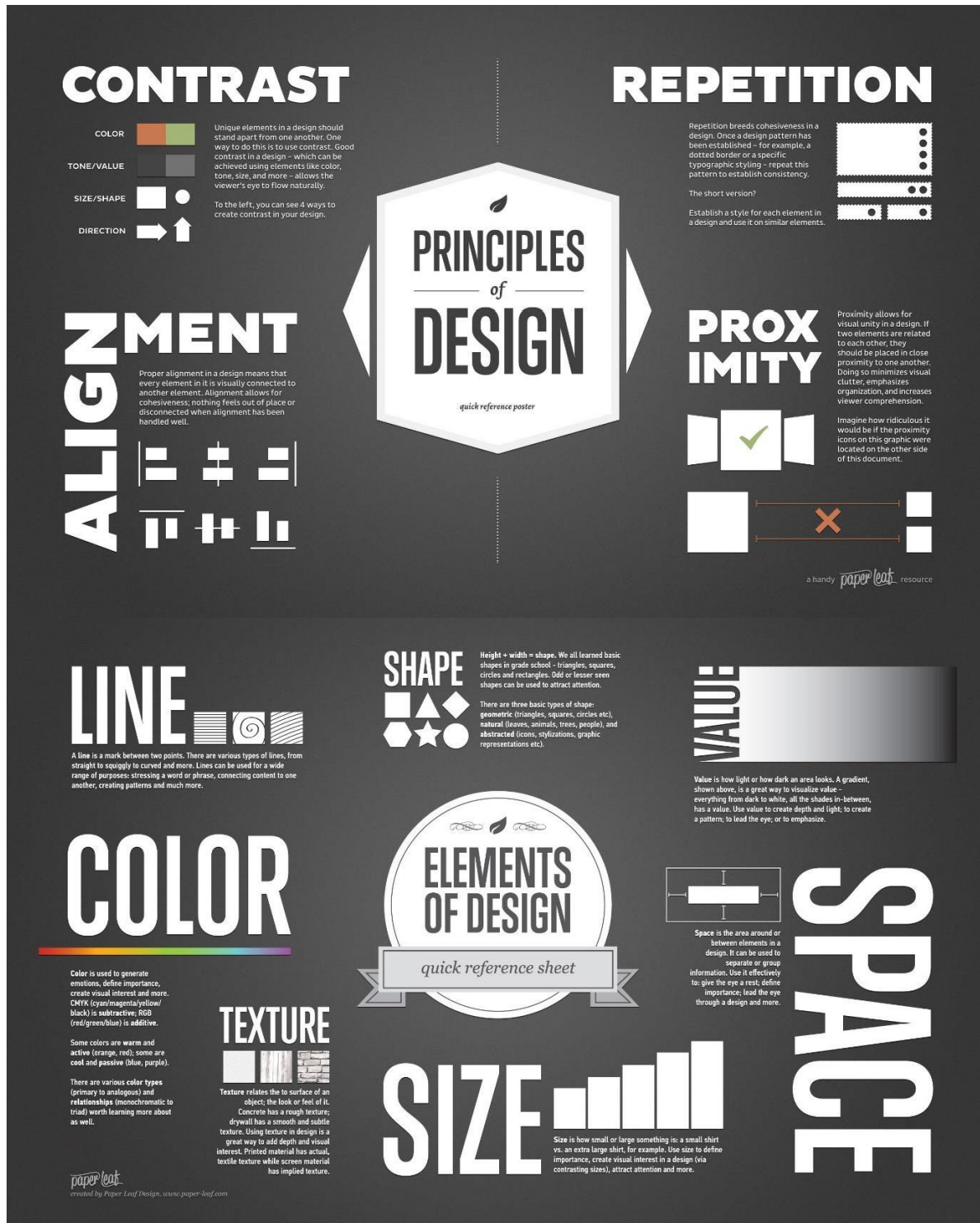
It MUST include:

- Team name and school/organization
- An image of their robot
- A 100 word overview of their design
- Number of years participating in NZAquabots
- 50 words for “Our Aquabot is unique because...”
- 50 words for “Our biggest learning this year is....”
- An image of their team
- Names and year levels of team members
- Names of mentors/coaches and their organisations/relationship to students

Factsheets MUST be submitted 1 week prior to the competition

Design Elements and Principles:

The design principles and elements are useful to help you develop a design that is pleasing. Check that your finished design enhances rather than distracts from your story. Test your design by presenting it to an audience. Listen to their feedback and make changes.



Review and Reflection Prompts

Review and reflection after the competition allows students to reflect on what they have learnt, how they can improve next time and is a good habit to cultivate.

- How did you work well as a team – what did you do?
- What can I do now (WALT)
- How did your presentation go?
- What did you see at the competition that you liked – why?
- What would you do differently next time?

Ideas to go further – for senior students or students who have participated before

- Explore using video as a means of presentation
- Consider using a more storytelling approach rather than presentation
- Present your presentation to your school, sponsors or supporters
- Consider keeping an engineering journal and presenting that, rather than a presentation

Credits and Acknowledgements

Photos and images

Step 1:

Image 1 – protoolreviews.com Image 2 – shutterstock.com Image 3 – youtube.com

Image 4 – familyhandyman.com Image 5 – Sea Perch Build Manual Image 6- clipart-library.com

Step 2:

Image 1 – ehow.com Image 2 – wikihow.com Image 3 – youtube.com Image 4 – ebay.com

Image 5 – pvcfittingsonline.com Image 6 – easyscienceforkids.com Image 7 – education.vic.gov.au

Step 3:

Image 1 - <https://archive.org/details/GravityCartoon> Image 2 – youtube.com

Image 3 – studiosguy.com Image 4

Image 5 -

Image 6 – tes.com Image 7 – pinterest.com Image 8 – wired.com

Image 9 – Sea Perch Build Manual

Step 4:

Image 1 – k8schoollessons.com

Image 2 – Sea Perch Construction Manual Image 3 - Sea Perch Construction Manual

Step 5:

Image 1 - Sea Perch Construction Manual Image 2 - Sea Perch Construction Manual Image 3 - Sea Perch Construction Manual

Step 6:

Image 1 – manufacturingstories.com

Step 7:

Image 1 – en.wikipedia.org Image 2 – ozanerhansha.github.io Image 3 – youtube.com

Image 4 - entertainment.howstuffworks.com Image 5 - aqua4balance.com

Image 6 – aqua4balance.com

Image 7 - Sea Perch Construction Manual

Step 8:

Image 1 – thoughtco.com

Image 2 – worldofbiochemistry.blogspot.com Image3 - Sea Perch Construction Manual

Image 4 - Sea Perch Construction Manual Image 5 - Sea Perch Construction Manual

Step 9:

Image 1 – revolv.com Image 2 – gcaptain.com

Image 3 - Sea Perch Construction Manual Image 4 - Sea Perch Construction Manual Image 5 - Sea Perch Construction Manual

Step 10:

Image 1 - Sea Perch Construction Manual Image 2 - Sea Perch Construction Manual

Step 11:

Image 1 – dowlingsmagnets.com

Step 13:

Image 1 – http://www.nobraintoosmall.co.nz/html/Level1_physics/NCEA1_physics_waves.html

Image 2 – Olympus-lifescience.com

Step 15:

Image 1 – j6design.com.au Image 2 – visme.co

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