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 pass 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 aluminium. 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.

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:

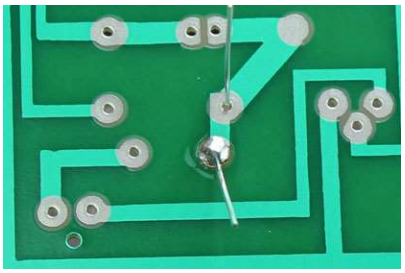
1. Wait until the soldering iron has heated up
2. Always put the soldering iron back into the stand if you are not using it (that includes when adjusting the motors or solder)
3. If helping stay on the opposite side of the person's writing hand, i.e. if you are helping a left handed person stay on their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

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.



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

Troubleshooting IF my motors don't go:

1) If none of the motors go
- Have you connected the alligator clips correctly?
- Try a different controller
- Try a different battery

2) 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?
- 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

- 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:
- 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:

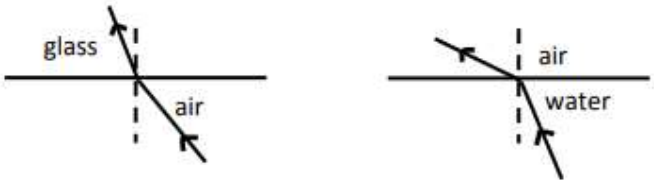
Pre-activities:

- **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.

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.

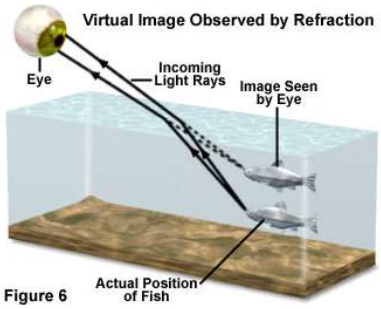


Figure 6

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.
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).

COMMON ERRORS

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

Review and Reflection Prompts

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- What could **you** do to make things better next time?
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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