STEM ACTIVITY 8
TEACHER NOTES

RESCUE & REHABILITATION

RAF 100
raf100schools.org.uk

EQUIPMENT REQUIRED PER PAIR OF STUDENTS:

- A copy of the STEM student instructions
- Common salt
- Plastic drinking cup or beaker (100 ml or 200 ml)
- Two each of 12cm strips of copper, zinc, tin and aluminium
- 10 cm Magnesium ribbon
- Two crocodile clips and leads
- Sandpaper
- Voltmeter (or multimeter)
- Red LED
- Other LEDs of various colours (if available)

PREPARATION REQUIRED

Before carrying out the activity you may need to download the accompanying video: *Medical Evacuation.*

PHYSICS CURRICULUM LINKS: ELECTRICAL CELLS AND BATTERIES, LEDS.

STEM ACTIVITY: SEA RESCUE LIGHT

In this activity, students make an electrical cell that uses salt water as an electrolyte solution and use it to power an LED.

Introduce the activity by playing the accompanying video: *Medical Evacuation*. Explain that RAF personnel are equipped with rescue beacons on flying suits and dinghies to help rescue helicopters locate them in case they need to be evacuated from the sea. Using sea water to make a cell or battery is one way to ensure that there is reliable power source for a sea rescue light.

Students should follow the STEM activity instructions and add 5g of salt to a cup of water to create a salt solution. They will need to submerge copper and zinc electrodes to complete their sea water cell and then use crocodile clips to measure the voltage (emf) using a voltmeter (see figure 1).

After taking readings with copper and zinc they should then try other electrode combinations. Typical results are shown in the table (figure 2). Their results may differ because the emf generated by a pair of electrodes is highly dependent on the smoothness of their surfaces and any impurities that may be present.

FIGURE 1:
A SEA WATER CELL

Copper and zinc electrodes in a salt water solution.

FIGURE 2:
ELECTRODE PAIRS

Results for 5g of common salt dissolved in 250ml tap water

	Voltmeter reading with electrodes pairs /V				
	Cu	**Sn**	**Zn**	**Al**	**Mg**
Cu		0.28	0.80	0.88	1.77
Sn			0.62	0.29	1.51
Zn				0.30	0.95
Al					1.21
Mg					

RESCUE & REHABILITATION

Once they have determined which electrode pair works best for them, students should use their cell to try to light a red LED. If students are not familiar with LEDs, explain that they are more robust and reliable than a traditional light bulb. However, unlike (incandescent) light bulbs LEDs only work if the voltage is high enough and if they are connected the right way round. An LED is illustrated on the STEM instructions. They need to connect the longer leg of the LED to the positive electrode of their cell. If the legs have been trimmed, they can try it both ways round or look for the flat edge of the LED. The pin nearest the flat edge should be connected to the negative electrode and the other pin should be connected to the positive electrode.

Using a single cell is unlikely to produce a high enough voltage to light the LED. They will need to team up with another pair of students to build a battery. If necessary they can ask more groups to join their team to add more cells until their battery is powerful enough to light the red LED. Remind them that to connect the cells to make a battery they should connect them in series with the negative terminal of one cell to the positive terminal of the next (see figure 3).

If you have different coloured LEDs, students could also investigate how many cells they would need to light these. You could link the need for higher voltages for different colours to the frequency of the light. A blue LED emits light of a higher frequency than a red LED. Higher frequency corresponds to a higher (photon) energy and so a blue LED needs a higher voltage than a red one (see figure 4).

FIGURE 3:
A SEA WATER BATTERY

Three salt water cells connected in series to light a red LED.

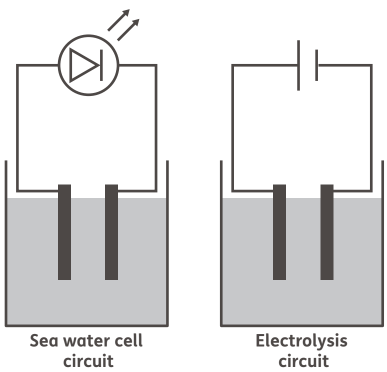
FIGURE 4:
LED COLOURS AND VOLTAGES

The approximate striking voltage for different coloured LEDs

Colour	Striking voltage (at 20mA)
Red	1.8 V
Yellow	2.2 V
Green	3.5 V
Blue	3.6 V

COMPARING TO ELECTROLYSIS

Students may have studied electrolysis in their chemistry lessons. To help them understand the difference you could ask them to sketch circuit diagrams.



STEM ACTIVITY 8
TEACHER NOTES

RESCUE & REHABILITATION

RAF 100

raf100schools.org.uk

EXTENSION: PROSTHETICS (OPTIONAL)

As an extension, students can carry out independent investigative project and research and design a prosthetic limb.

PHYSICS CURRICULUM LINKS: FORCES AND MOMENTS, DENSITY, MATERIALS

Each student will need a copy of the STEM extension sheet. Explain that before the First World War prosthetic limbs were usually heavy, impractical and made out of wood. With the return of injured soldiers the design of prostheses developed quickly and over time with developments in technology has led to modern prosthetics made out advanced materials (eg carbon-fibre composites).

For their investigative project students should think about the features and functions of a prosthetic limb and the material that it should be made of.

Ask the students to communicate their work and results through a written report, a poster, and/or a presentation to the group. If they complete and communicate over ten hours of self-directed project work, individually or in a team, they may be eligible or for a CREST award.

ABOUT CREST AWARDS

The work undertaken by the students on this project may be eligible for a CREST award. The CREST Awards scheme is the British Science Association's flagship programme for young people. CREST encourages pupils to learn by solving a problem or answering a question, rather than simply following instructions or being presented with information. The emphasis is on the process, not on finding a 'right' answer. If students complete 10+ hours of self-directed project work, individually or in a team, they may be eligible for a CREST Bronze award. If they complete 30+ hours they may be eligible for a CREST Silver award.
Bronze CREST award criteria is available at **crestawards.org/crest-bronze**
Silver CREST award criteria is available at **crestawards.org/crest-silver**

DOUGLAS BADER

Students could research Douglas Bader, an RAF flying ace who lost both legs in an accident in 1931. He had prosthetic limbs fitted and then went on to retake his RAF flight training and fly in combat in Second World War.

Further information: **bit.ly/RAF-Bader**

DESIGN AND FUNCTION

Students should design a prosthetic limb to replace an arm, leg, foot or hand. They will need to think about how it can be attached to a person and how it will perform mechanical functions (eg to mimic a wide range of human functions), or alternatively a specific function such as running, gripping or using tools (eg a fork for eating). They should also to consider the forces that act on the prosthetic and on the person and what affect these may have (eg turning effects or stresses).

SUGGESTED EQUIPMENT

To allow students to make a model of a prosthetic you could provide:

- Cardboard sheets and tubes
- Paper
- Blu-tack (to add mass to different parts of the prosthesis)
- Elastic bands
- Scissors
- Glue
- Paper fastening pins
- Treasury tags

STEM ACTIVITY 8
TEACHER NOTES

RESCUE & REHABILITATION

raf100schools.org.uk

MATERIALS

Students should consider the density of the material they would use to make their prosthetic and think about their own methods for measuring and recording the masses and volumes.

For a more advanced project they could consider other material properties. They could for example do this through practical investigations into how materials stretch or through online searches for modulus of elasticity (Young's modulus) and the tensile strength. They should do this for a number of materials and could use values for biomaterials (eg human bone) as a guide when selecting one for their prosthetic.

SUGGESTED EQUIPMENT

To allow students to carry out a practical investigation into materials you could provide some or all of:

- Blocks material (these do not need to be regular-shaped)
- Top pan balance, Eureka (displacement) can and measuring cylinder
- Wires or 'ribbons' of each material
- Fine-scaled calipers
- Clamps, pulleys, and masses and other equipment to perform stress and strain experiments on the wires or ribbons.

FURTHER INFORMATION

A video showing how to make a cardboard prosthetic arm is available at **bit.ly/RAF-Cardboard**. For density experiments see **practicalphysics.org/measuring-density** and for stress-strain experiments see **practicalphysics.org/stretching-and-force**. Students can find out more about biomechanics at **bit.ly/RAF-Biomechanics** and prosthetic rehabilitation at **bit.ly/RAF-Rehabilitation**. A variety of other web-based prosthetic resources are also available via **openprosthetics.org**.