SHOCKWAVES

FROM SINKING SHIPS IN THE BERMUDA TRIANGLE TO WALKING WITH DINOSAURS – DR JOANNA RHODES' LATEST LESSON PLAN IS A TRULY ACTION-PACKED EXPERIENCE...

WHY TEACH THIS?

In this lesson the aim is to use exciting and unusual learning hooks to explore waves with KS3 science students. It is important to give students a good grounding in the fundamental physics of waves ready for them to start KS4 – however it is an opportunity to give students an insight into the more unusual ways we can harness the power of waves or succumb to them. The lesson gives students the opportunity to get active within the classroom using their bodies to model waves. It also links with textiles, art and design by encouraging students to design their own application of fibre optics.

In this lesson we visit the Bermuda triangle and try to sink a ship, then we plan a journey to the centre of the Earth, and back again! And as if that weren't enough excitement we then take a tour around your body and really look back in time – millions of years to the time of the dinosaurs and beyond.

Using interesting and imaginative hooks your KS3 scientists will learn about the physics of waves and some unusual and varied applications of their properties.

Students begin by brainstorming their existing knowledge of waves and visual and kinesthetic learners will especially enjoy the opportunity to model waves using their own bodies in the starter activity. Then it's off to the Bermuda triangle where we use ripple tanks to investigate the way that waves interact with each other. Can you sink the ship with the right pattern of peaks and troughs? The second main activity introduces another property of waves; refraction, with a classic experiment set in the context of discovering what lies beneath the crust of the Earth. As they investigate refraction students learn that waves travel at different speeds in different substances and that earthquakes can tell us about the depths of the Earth we cannot possibly reach.

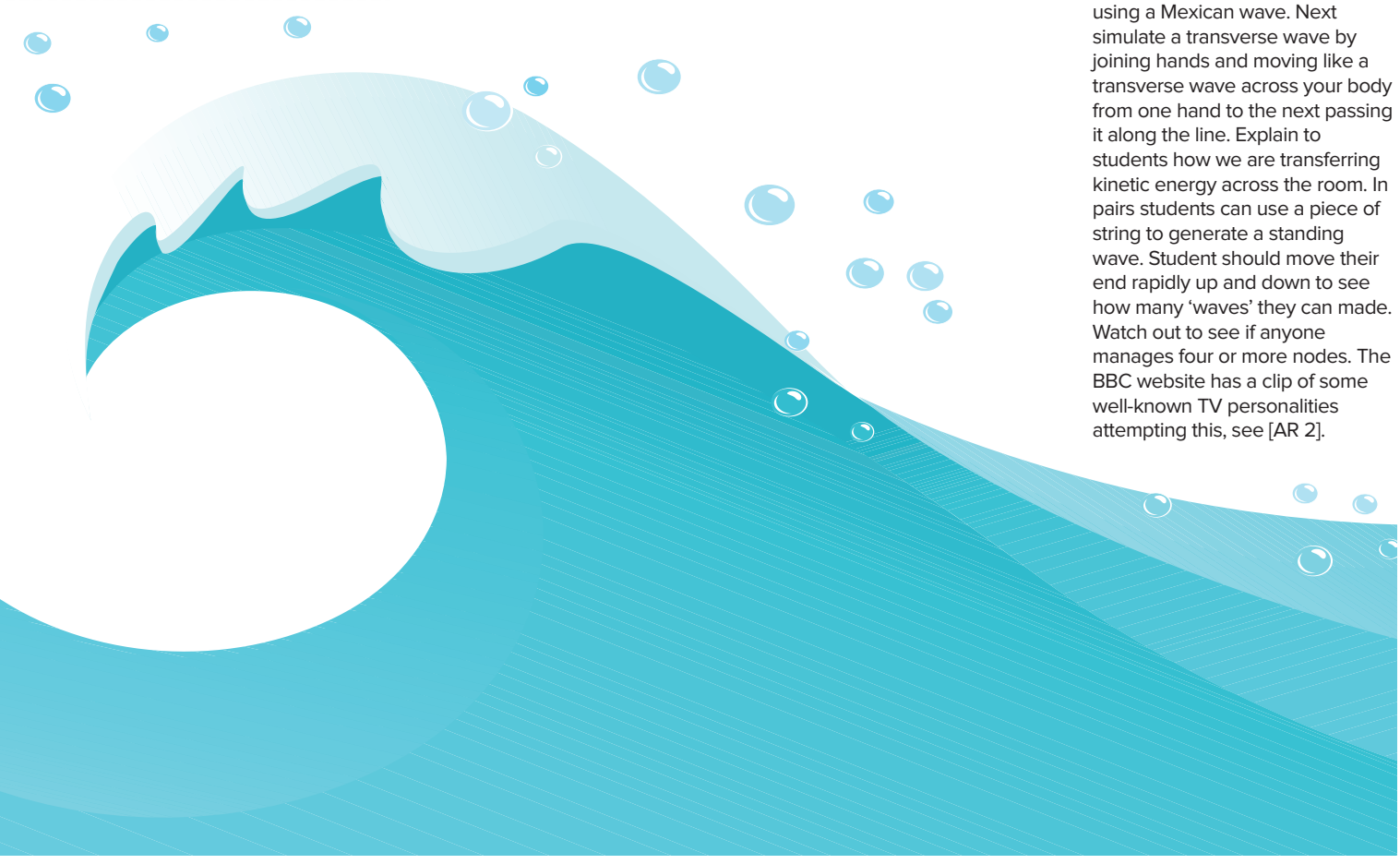
As extension activities students investigate how light waves can be used to investigate remote areas of our bodies and design their own unusual applications of fibre optics. Finally they look at some real light that was given out at the time the dinosaurs were walking on Earth.

STARTER ACTIVITY

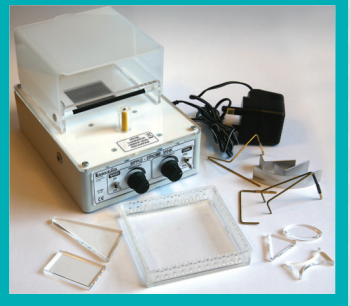
What are waves?

A wave transfers energy from one place to another. Students can begin the lesson with a short brainstorming activity. Can they draw a wave? Where do you see waves? Why are waves important? Higher ability students might even be able to label a diagram of a wave. If you need to provide some differentiated extension activities, you could access an animated oscilloscope [Additional Resource 1] or simply use some laminated cards challenging students to work out the wavelength and frequency using illustrations of different transverse waves.

Now it's time to get up and active. Transfer energy across the room using a Mexican wave. Next simulate a transverse wave by joining hands and moving like a transverse wave across your body from one hand to the next passing it along the line. Explain to students how we are transferring kinetic energy across the room. In pairs students can use a piece of string to generate a standing wave. Student should move their end rapidly up and down to see how many 'waves' they can made. Watch out to see if anyone manages four or more nodes. The BBC website has a clip of some well-known TV personalities attempting this, see [AR 2].



+KEY RESOURCE



Lascells' Ripple-Strobe Tank is a compact and elegant unit for demonstrating reflection, diffraction, refraction and interference. A 10cm tank on a base unit provides the wave generator and light source to project wave images onto the translucent screen which can then be viewed from above.

The LED light source gives super-bright images and can be controlled independently of the wave generator. Three settings give light ON, SYNC and FREE. Sync has wave frequency synchronised to light frequency to give perfectly stationary images. Free gives independent control of the light frequency to give slowly moving images. Supplied with a full set of interchangeable dippers, barriers, refraction plates and plug-top power unit.

Find out more at education.scichem.com, call 01902 402 402, or email customerservices@scichem.com

MAIN ACTIVITIES

1 – A visit to the Bermuda Triangle

Every so often an enormous wave rises out of the ocean, it could be 60 or 100ft high, but this is not a tsunami. A rogue wave is defined as any open-ocean wave that is abnormally larger than the waves around it. Such freak waves have been hypothesised as the cause of disappearances in the Bermuda triangle, but how are they caused? For the science behind it there is an engaging website and clip you can share with the class from Livescience.com [AR 3]. In the activity students will use ripple tanks to investigate waves and how they interact which each other through constructive and destructive interference. Can you made a rogue wave to sink a model ship?

Ripple tanks are a powerful tool that can help students visualize wave behaviour in general. They are relatively inexpensive but if you don't have one it is straightforward to make your own as described by the Mathematics and Science Center [AR 4]. This website also describes some interesting and exciting experiments including reflection, refraction and interference. Further detail can be found on the Nuffield Science website which describes a broad range of activities including examples that can be used to stretch and challenge your more able students [AR 5]. Ripple Tank Free is an app on the Apple App store that allows you to experiment with ripples [AR 6], a similar Android app can be downloaded

called Loughborough Wave Lab [AR 7]. Can you re-create the theory in your own real ripple tank?

Students can get even more out of the activity by recording their waves. Does your school have access to a slow motion camera or can you slow down a video to watch what happens when two perpendicular waves collide? Provide materials for students to design and make small paper boats to investigate the impact of large and rogue waves caused when the wave fronts interact with each other forming constructive interference and deep troughs that characterize destructive interference. Another fun activity is to make a harbor for your ship and investigate the effect of a single or double gap in the harbor wall. How do the waves behave in your own fishing village?

Independent learning ideas

Ask students to select one of the following activities to look at in more detail:

- **Explore the Science of Surfing**

Research the physics involved in surfing on ocean waves.

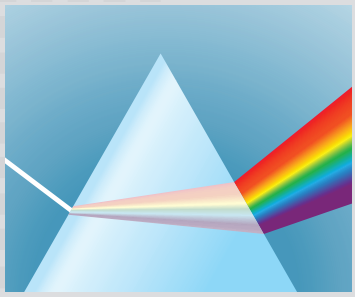
- **Explore the Art of Waves**

Research how waves are depicted by artists in different paintings. How do artists capture and express the features, motion, and "colour" of waves?

2 – Journey to the centre of the Earth

A Journey to the Centre of the Earth is a classic 1864 science fiction novel by Jules Verne. The story involves a descent into the Icelandic volcano Snæfellsjökull, encountering many adventures, including prehistoric animals and natural hazards, before eventually coming to the surface again in southern Italy, at the Stromboli volcano. It is not currently possible to penetrate below about 25% of the thickness of the crust so how do we know what lies beneath? The answer comes from waves, which can penetrate through the Earth and emerge the other side much as we imagine we can do on the beach with a bucket and spade. The waves we use are generated by Earthquakes and are called P-waves and S-waves, but how can they tell us what the inner Earth is made of?

Begin by showing students



beakers with a range of objects sticking into them, ask students to observe the way this can make a pencil look broken or an object be in a different position on the bottom of beaker. Then demonstrate the reversing arrow as shown in this video from Mocomi [AR 8]. Refraction is due to the way light bends as it travels through different substances as it changes speed. If the refractive index of two substances is identical, light will travel through them at the same speed, which can render the object invisible [AR 9].

Using ray boxes or homemade ray boxes [AR 10] in a darkened classroom to investigate the way light changes direction as it passes through different substances such as glass, pyrex plastic and water. In a very generalised way, from the angle we can determine the substance. Try stacking two or three different substances together to simulate earthquake waves traveling through the Earth and back out. As you can see the light will come out in a different place depending on the combination of substances it travels through. Sensors all over the world pick up earthquakes and the location where refracted waves leave the Earth some having traveled all the way through. Students can investigate further using 'Refractive' a free refraction app available on the Apple Appstore [AR 11].

They can also investigate P-waves and S-waves using a seismometer [AR 12], which is available on iphone and android and responds to movements such as shaking the device on the table. Challenge students to work out which motion gives rise to P-type waves and which gives rise to S-type waves.

ADDITIONAL RESOURCES

[AR1] ANIMATED OSCILLOSCOPE
tinyurl.com/tsshockwaves
[AR2] BRIAN COX "A NIGHT WITH THE STARS"
tinyurl.com/tsshockwaves2
[AR3] ROGUE WAVES – CAUSES AND CONSEQUENCES
tinyurl.com/tsshockwaves3
[AR4] MAKING A RIPPLE TANK
tinyurl.com/tsshockwaves4
[AR5] NUFFIELD SCIENCE RIPPLE TANK EXPERIMENTS
tinyurl.com/tsshockwaves5
[AR6 RIPPLE TANK FREE
tinyurl.com/tsshockwaves6
[AR7] LOUGHBOROUGH WAVE LAB
tinyurl.com/tsshockwaves7
[AR8] REVERSING ARROW MOCOMI
tinyurl.com/tsshockwaves8
[AR9] DISAPPEARING ROD MOCOMI
tinyurl.com/tsshockwaves9
[AR10] MAKE A RAYBOX BY EHOW
tinyurl.com/tsshockwaves10
[AR11] REFRACTIVE
tinyurl.com/tsshockwaves11
[AR12] ISEISMOMETER
tinyurl.com/tsshockwaves12
[AR13] CHANDRA
tinyurl.com/tsshockwaves13
[AR14] BBC HISTORY OF THE EARTH
tinyurl.com/tsshockwaves14

SUMMARY

Inner space

Imagine being able to travel to parts of your body and beam back images of damage or disease without needing to operate. Although we don't use mini-submarines or robots yet, we do use another property of waves, a special case of refraction called total internal reflection to beam back images through a small flexible tube. The special flexible tubes contain fibre optics and an even make the light travel around sharp corners on the way back to the monitor where the doctors can clearly see what is happening inside you. Bundles of fibre optics can be purchased quite cheaply by the metre for example from Starscape.co.uk; give students a design challenge to come up with an innovative use of the fibre optics and a light source. My students have come up with a classroom to classroom Morse code communicator and some have combined their science with artistic talents to come up with magical costumes and football shirts with sponsorship that lights up when the person scores a goal.

INFORMATION CORNER

ABOUT OUR EXPERT

Dr Joanna L. Rhodes M.Chem, D.Phil, MRSC is a teacher of science at Shelley College, Huddersfield.

STRETCH THEM FURTHER

'WATCHING' WITH DINOSAURS

EVEN LIGHT, WHICH TRAVELS AT 3 X 108 MS-1, TAKES TIME TO GET FROM A TO B; ABOUT 8 MINUTES FROM THE SUN TO THE EARTH AND MUCH LONGER FROM ALL THE OTHER STARS IN OUR GALAXY AND BEYOND. THIS MEANS THAT BY THE TIME THE LIGHT REACHES US IT MAY HAVE BEEN TRAVELLING FOR MANY YEARS. WHEN WE FOCUS A TELESCOPE ON THE MOST DISTANT STARS THE LIGHT HAS BEEN TRAVELLING TO US FOR MILLIONS OF YEARS. WE CAN EVEN SEE BACK IN TIME AS FAR AS 2.5 MILLION YEARS WITH THE NAKED EYE WHEN WE LOOK AT THE ANDROMEDA GALAXY. IN THIS EXTENSION ACTIVITY, ASK STUDENTS TO USE THE INTERNET TO FIND A GALAXY THAT CORRESPONDS IN DISTANCE WITH EACH GEOLOGICAL ERA OF THE EARTH AND TO DESIGN THEIR OWN TIMELINE CHART. EXAMPLES INCLUDE THE ANDROMEDA GALAXY FOR THE QUATERNARY PERIOD AND THE COMA CLUSTER FOR THE CARBONIFEROUS PERIOD. A GOOD WEB RESOURCE TO USE IS THE CHANDRA WEBSITE [AR 13] FOR GALAXIES AND THE BBC HISTORY OF THE EARTH WEBSITE FOR GEOLOGICAL ERAS [AR14].