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LEVEL 2 CAMBRIDGE NATIONAL IN SCIENCE

R072/02/RB How scientific ideas have developed

PRE-RELEASE RESOURCE BOOKLET

JUNE 2015

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INSTRUCTIONS TO CANDIDATES

- This Pre-release Resource Booklet contains the article required to answer Question 1.
- Take this booklet away and read it through carefully.
- Spend some time looking up any technical terms or phrases you do not understand.
- For the examination on **5 June 2015** you will be given a fresh copy of this booklet, together with a question paper.
- You will **not** be able to take your original copy into the examination with you.

INFORMATION FOR CANDIDATES

- This document consists of **4** pages. Any blank pages are indicated.

INSTRUCTION TO EXAMS OFFICER / INVIGILATOR

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Communicating with waves

Sound waves

People have communicated using sound waves for thousands of years. Sound makes waves in the air so that the molecules move closer together (compressions) and further apart (rarefactions), as shown in **Fig. 1**.

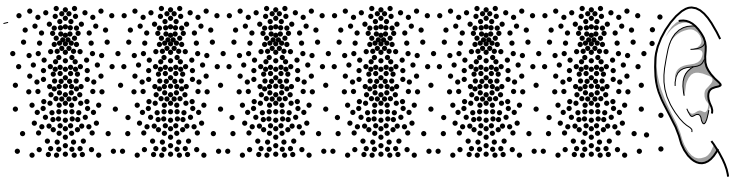


Fig. 1

Sound waves can travel through the air and through other substances like water. They cannot travel through space where there is no air.

Measuring the speed of sound in air

Experiment 1
Sachin stands 50 metres from a wall and claps his hands (**Fig. 2**). The sound bounces back from the wall as an echo. Les stands next to him and uses a stopwatch to measure the time between the clap and the echo.

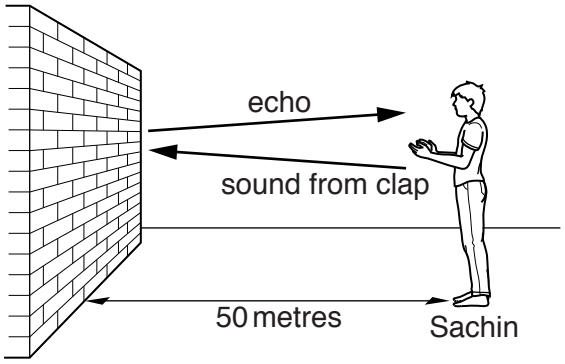


Fig. 2

He does the experiment 5 times and here are his results:

Time between clap and echo in seconds				
0.40	0.38	0.44	0.36	0.37

Table 1

Experiment 2
Les uses a mobile phone to record the clap and the echo. A microphone records the vibrations in the air and these can be displayed on a computer screen, as shown below in **Fig. 3**.

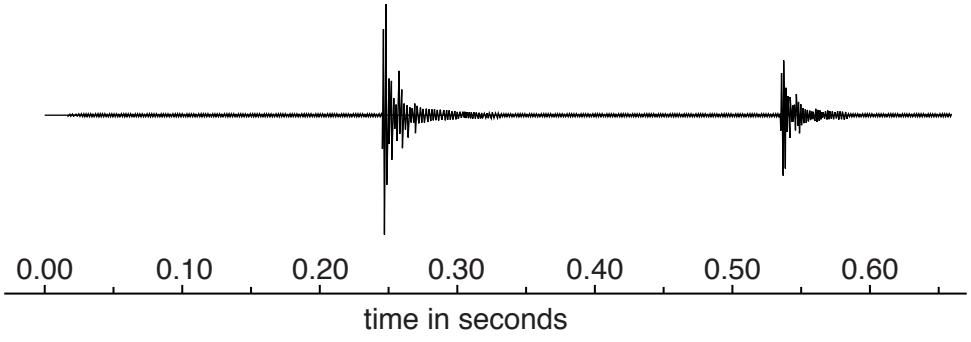
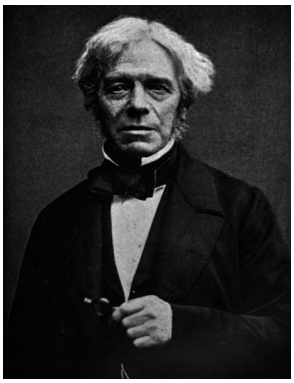


Fig. 3

Discovering electromagnetic waves

In 1831, Michael Faraday showed that an electric current can affect a magnet nearby. He suggested that there were 'invisible lines of force' around the wire and the magnet. His ideas were widely published. Many other scientists did not accept them as he had not explained them mathematically.



Michael Faraday

James Clerk Maxwell

After Faraday's death, James Clerk Maxwell worked out a series of equations. These showed that electric and magnetic fields can travel together as waves. They can travel through space where there is no air.

Other types of electromagnetic waves

Maxwell's equations suggested that there would be other types of electromagnetic waves. From 1886, Heinrich Hertz experimented with electromagnetic waves. He made the first equipment to broadcast and receive radio waves. Asked about his discovery, Hertz said:

> "*It's of no use whatsoever. This is just an experiment that proves Maxwell was right – we just have these mysterious electromagnetic waves that we cannot see with the naked eye. But they are there."*

All electromagnetic waves travel at the same speed in a vacuum. Each wave has a wavelength and a frequency. Different types of wave have different wavelengths (**Table 2**). Waves with shorter wavelengths have higher frequencies and carry more energy.

Type of wave	Wavelength in cm
Radio waves	>10
Microwaves	0.01 – 10
Infra-red	0.00007 – 0.01000
Visible light	0.00004 – 0.00007

Table 2

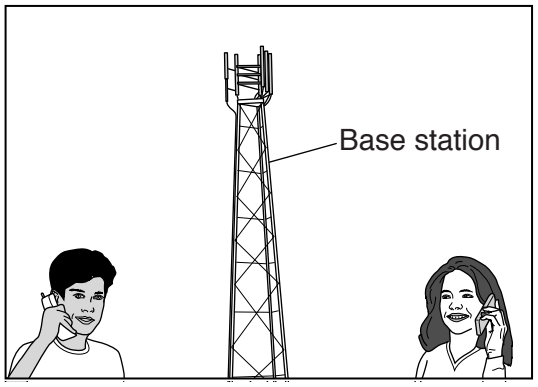
Using waves

Radio: Just like light, radio waves usually travel in a straight line. Some can be reflected from part of the atmosphere.

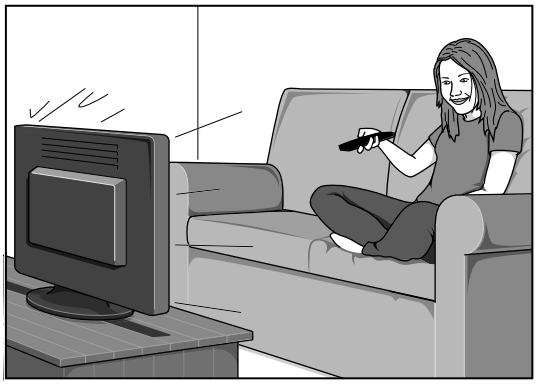
A radio works when a presenter speaks into a microphone. The sound waves are converted into electromagnetic radio waves. A transmitter sends these waves through the air to your radio. The radio receives these waves and converts them into sound waves. The radio gives out sound waves so that you can hear what the presenter said.

Lots of different radio stations can be transmitted at once. Each station uses a different wavelength.

Mobile phones: The mobile phone works like a two-way radio, exchanging messages with a base station. If a mobile used radio waves, the antenna would have to be much larger, so microwaves are used instead. Many different mobile phones can use the same base station at the same time.



Remote controls: These use infra-red waves to pass a simple message to the TV. Remote controls only work over a short distance because the waves spread out and become much weaker. However, the remote control sometimes works when pointed at the ceiling.



Optical fibres: The landline telephone network uses optical fibres to pass data rapidly over long distances. Telephone calls or internet data can be encoded onto electromagnetic waves which pass along flexible glass fibres. The glass fibres allow the waves to be carried much further than they would be in air.