Waves

Introduction

There are many different types of waves around us and while they may share similar properties, they do have several defining features that enable us to distinguish them from one another. For instance, mechanical waves transport their energy through a medium causing particles to oscillate. There are numerous examples of such waves including sound waves, water waves and even Mexican waves. In contrast **electromagnetic waves**, such as visible light or X–rays, do not require a medium to transport their energy and are therefore capable of travelling through a vacuum. Trigonometric functions, such as sine or cosine, can be used to model waves and are important functions in the field of mathematics. This workshop will focus on the concept of waves from both a physical and mathematical perspective.

Aim of Workshop

This workshop aims to introduce students to the various different types of waves that are found in nature, such as sound waves or ocean waves, whilst also developing a more intuitive understanding of the wave–like trigonometric functions sine and cosine. Furthermore, students will be made aware of the applications of these mathematical tools across a range of physics related disciplines.

Learning Outcomes

By the end of this workshop students will be able to

- Explain, in their own words, the concept of a wave
- Perform basic intuitive addition, subtraction and multiplication of trigonometric functions
- Discuss the widespread application of wave functions in various fields
- Understand the fundamental concepts of wave–particle duality and light polarisation.

Materials and Resources

Both optional: Slinkys, polarisers

Keywords

Wave
a disturbance or a variation which transfers energy from one point to another.

Polarisation
A phenomenon in which waves are limited to a particular direction of vibration e.g. polarised light causes vibrations in a single plane which we see using Polaroid sunglasses.

Superposition
A phenomenon which occurs when two waves meet and interact. Occasionally, such waves can add together to enhance the wave, whereas other times they simply cancel each other out.

Waves: Workshop Outline

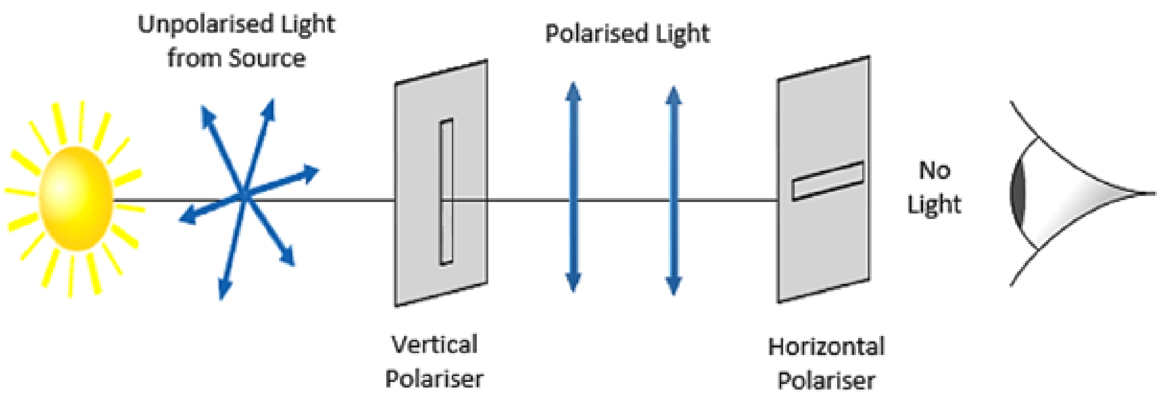
SUGGESTED TIME (TOTAL MINS)	ACTIVITY	DESCRIPTION
10 mins (00:10)	**Introduction to the Concept of Waves**	– Whole class discussion based around the different types of waves found in nature e.g. light waves, seismic waves, ocean waves etc. – ***Note:*** *Alternatively, students can complete activity 1 whereby they are asked to list examples of waves*
5 mins (00:15)	**Mexican Wave**	– "Is it possible to make waves ourselves?" Demonstrate the Mexican wave using the students – "What is the medium?" – "What is being transferred?" – "What does a wave look like if we draw it?" (draw sine or cosine wave on the whiteboard) (Demonstrate the use of Slinkys to provide an example of a mechanical wave)
15 mins (00:30)	**Activity 2 and 3 – Mathematical Waves**	– **Activity Sheet 2:** Students attempt activity on their own before discussing the solutions as a class group – Contrast sine and cosine look like on the whiteboard – "How are they different?" – "How are they similar?" – You may like to ask the students what they think the y–axis scale is measuring. – **Activity Sheet 3:** Students attempt activity 3
15 mins (00:45)	**Superposition and Light Polarisation**	– Explain what is meant by superposition and light polarisation (see **keywords**) – Explain how a polariser works (see **Appendix– Note 1**) – **Activity Sheet 4:** Students complete activity 4 (See **Appendix– Note 2** for solution)

Waves Workshop Appendix

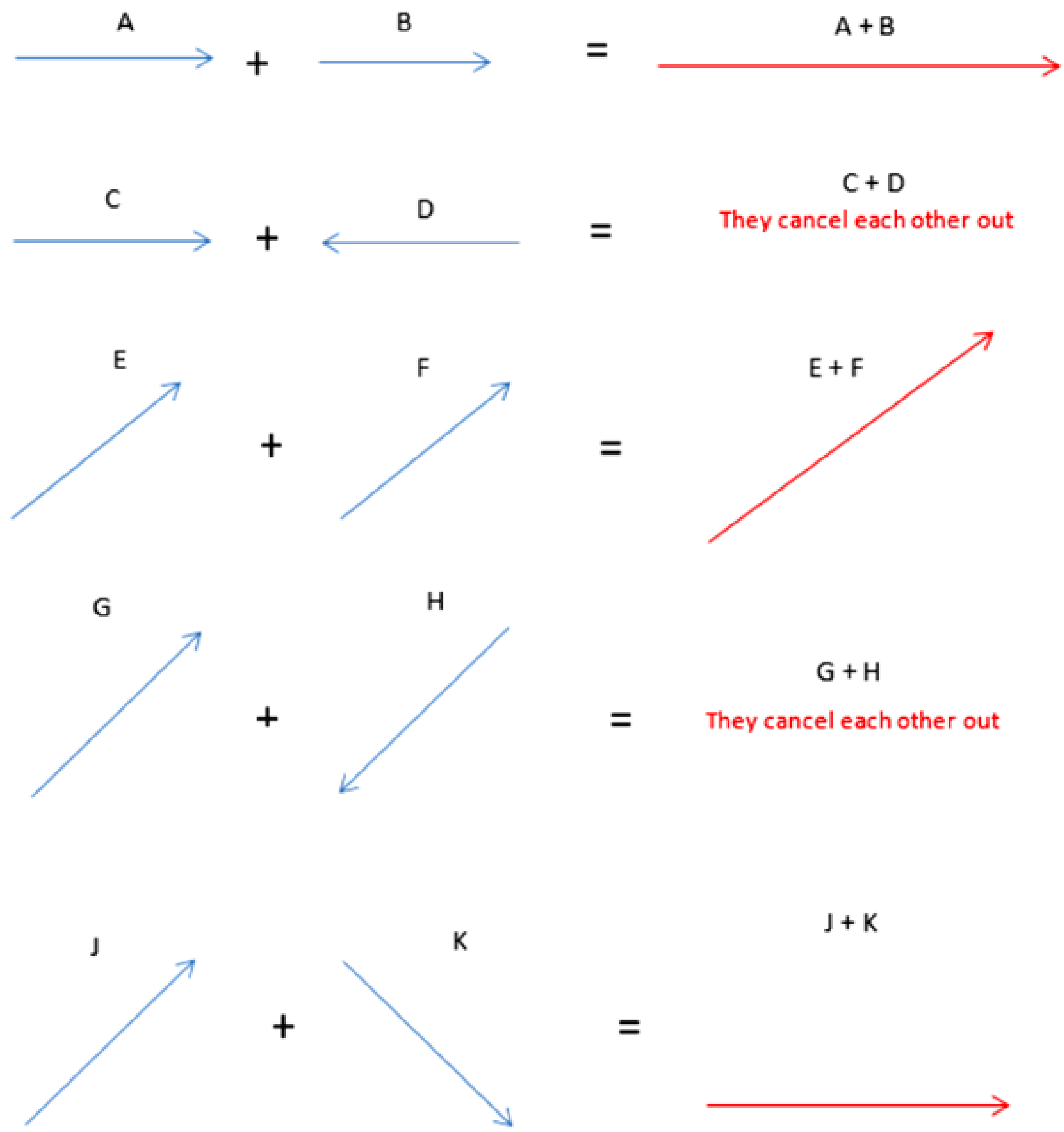
Note 1: How a polariser works

A polariser is a device that only allows light to shine in a particular direction. It can be used to convert light of undefined polarisation (i.e. travelling in lots of directions) into polarised light.

1. Take a polariser and hold it up to the light. Notice how the light only appears to be going in the one direction.
2. Take a second polariser and hold it at a 90–degree angle in front of the first polariser. Notice how no light can pass through this time. This is due to the fact that the first polariser is positioned vertically and the second one is now positioned horizontally. Thus the initial polarised light, travelling in the direction of the first polariser, cannot pass through the second.



Note 2: Superposition activity sheet solutions:



Sources and Additional Resources

http://www.physicsclassroom.com/class/waves/Lesson–1/Categories–of–Waves

https://phet.colorado.edu/

Waves: Activity Sheet 1

Physical Waves

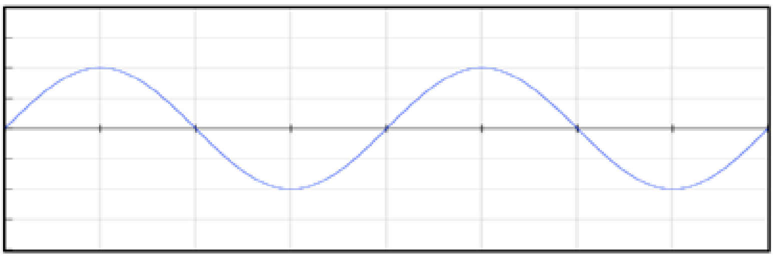
In the physical world, waves are found in many different forms. Physicists define a wave as a transfer of energy and there are many examples of waves in the world around us. See how many examples of the different types of waves you and your group can come up with...

Waves: Activity Sheet 2

Mathematical Waves

Waves exist in the mathematical world too. In fact, waves can be manipulated using maths. Sketch, in the empty boxes, what you think a new wave would look like if you were to add the two given waves together. Use your instinct here!

A:



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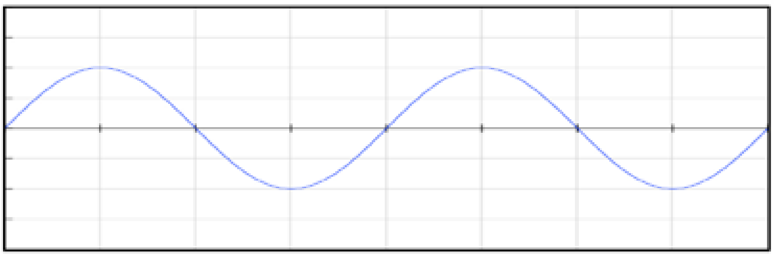

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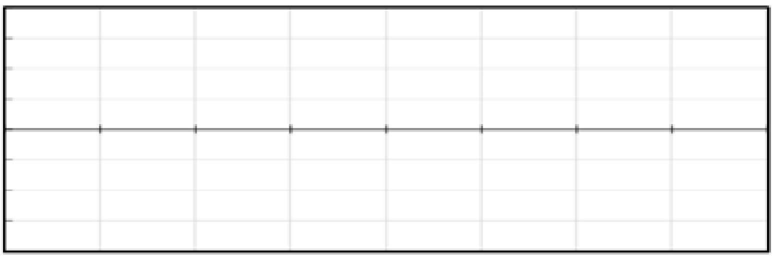
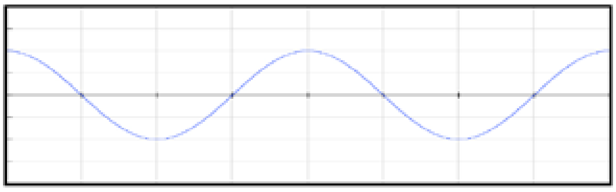


Waves: Activity Sheet 2

C:



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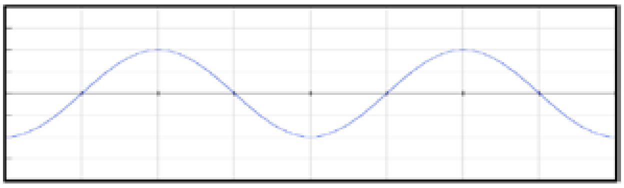

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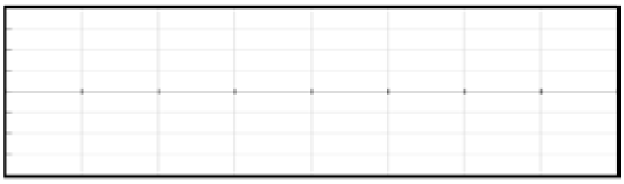
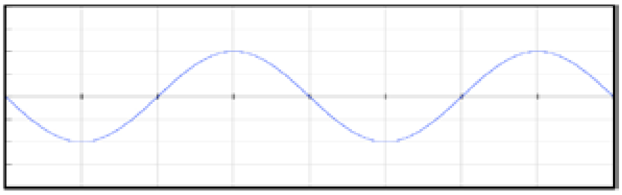


E:



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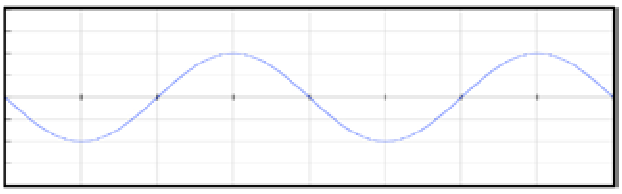
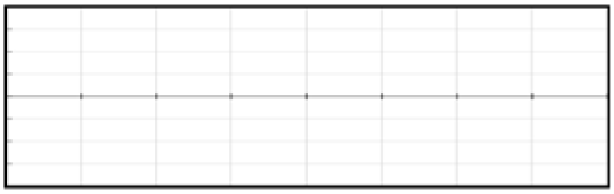


E + F:

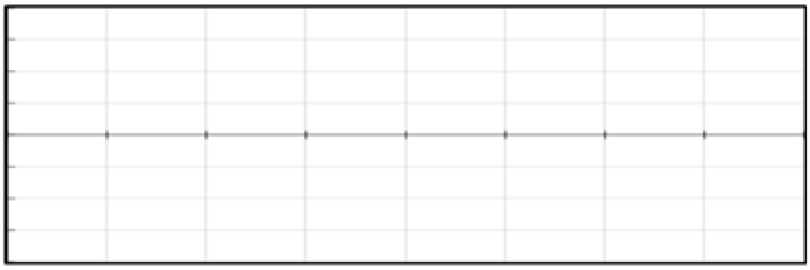


E - F:

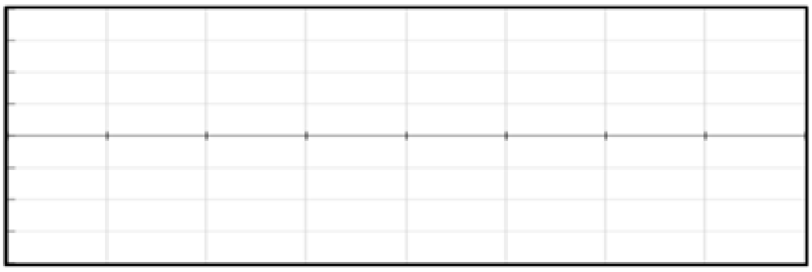
Waves: Activity Sheet 3

Now that we have seen what Sine and Cosine look like, try to figure out what it might look like if you multiply these waves by a number. If you think you don't know, guess!

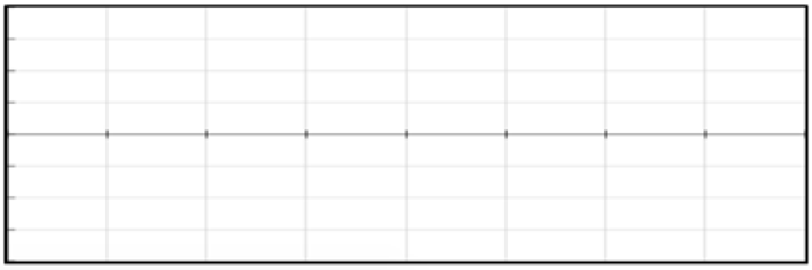
$2\sin$:



$\frac{1}{2}\cos$:



$-2\sin$:



Waves: Activity Sheet 4

Polarised Waves

In Activity 3, we learned that we can add mathematical waves together to make new waves, and that we can break bigger waves up into a collection of smaller waves. We can do this with physical waves too, for example light waves. These light waves are polarised in a certain direction. By learning how to add directions, we can understand the idea of polarisation more intuitively.