Light Comes in Waves

Many forms of energy travel through space in waves, and light is one of them. When waves collide, interesting things happen

Age Group: 6yrs +

Method: Group activity (up to 15 per facilitator)

Level: Introductory

Duration: 30 min

Key Learnings: Light energy comes in waves with different spaces between their peaks depending on the colour of the light. When these waves meet, we can see the effects.

Materials and Equipment

* 2 x 150mm squares of clear acrylic plastic
* A4 sheet of black paper
* Stickytape
* Clean, new pencils (2 per participant)
* Candle or other point source of light (a single bulb, not a tube)
* 150mm squares of flyscreen (2 per participant)
* 3-D glasses (1 per pair)
* 120x120 acrylic mirror (1 per pair)

Preparation

The facilitator could prepare for this workshop by using the instructions and materials provided to observe the desired effects. Note critical stages (such as preparing the thin slit, and finding an appropriate viewing angle and light source), and advise the participants accordingly.

Have a rubbish bin ready for any waste that will be generated.

Recommendations

Since this activity consists of some quick demonstrations, and a single simple construction activity, consider the sequence of events. Participants may become bored with too much explanation, and it will be necessary to move on to the hands on work relatively quickly.

This topic is also conceptually complex, and it is not important to achieve deep understanding, especially with younger groups. Refer interested participants to online explanations rather than frustrating too many group members with details.

Workshop Outline

(5 min) Introduction

Introduce yourself, welcome participants and deal with housekeeping.

Ask participants if they know about waves and where they have seen them (water waves are a good analogy). Explain that the waves they see are caused by energy moving through the medium (wind acting on water, for example), rather than the movement of the medium (does every wave at the beach wash them in to the shore, or are they just lifted up and down?). When the energy reaches the edge of the medium, it can be absorbed (like a wave on the beach) or reflected (like a wave in the bath or a swimming pool).

The experiments they will do show what happens when light waves interact.

(5 min) When waves are squeezed between two surfaces

Prepare the acrylic sheets (if not already done) by removing the protective covering, cleaning them with some methylated spirits, and taping them together around the edges. Cut out a piece of black paper the same size as the acrylic, and tape it to the back.

Hold the plates together under a light with the black paper underneath, and squeeze with your thumbs. Swirling coloured patterns can be seen that move and shift as the pressure you apply is varied.

Explanation: The coloured areas appear where light waves reflecting from the surface of the acrylic interact with waves that have passed through the plastic and been reflected from the bottom sheet. Different colours of light have their peaks different distances apart, so when the gap varies slightly, different colours are affected.

If the gap between the sheets is just right (half a wavelength – less than a thousandth of a millimetre), the waves bouncing from the bottom have their peaks where the waves bouncing from the top have their troughs, and they cancel out. This colour is removed from the light you see, and only the remaining colours of light are visible (so the red areas have lost their blue light, for example).

(10 min) When waves are squeezed through a slit

Wrap a single layer of stickytape around one of the pencils, about 1 – 2 cm from the end. Stand about a half a metre from the light, hold the pencils vertically, squeezing them together and hold them about 2.5cm from your eye. Now look at the light through the slit, just below the stickytape, and you should see a line of light perpendicular to the slit. If you hold the pencils horizontally, the line should become vertical.

Looking closely, you can see that this line of light is made up of dots of light that will move apart as you squeeze the pencil harder. You might see that they have coloured edges.

Explanation: the effect is caused by waves of light cancelling each other out (to make the black areas) just like in the first example, or doubling up to make bright spots. As the waves pass through the narrow slit, they bend around the edge of the slit and fan out. How much they bend varies with the colour of the light (or the distance between the peaks of the waves). The different amount of bending explains the coloured areas you might see.

(5 min) When waves are filtered through a mesh

Hold the two pieces of flyscreen together and look through them at a white surface (a piece of paper will do). Now move the top sheet gently from side to side (rubbing works), or rotate it, and notice the patterns of wavy lines that appear. Try flexing one of the screens, too. You can use one piece of screen, if you work with a partner. Hold the screen and shine a bright light through it. Get your partner to hold a piece of white paper or card behind it. Start with the paper touching the screen, and slowly move it away, maybe changing the angle. You should see the same sort of patterns as the screen interacts with its shadow on the paper.

Explanation: What you are seeing are called Moire patterns. The black lines of the top screen overlap either black or clear areas in the screen below, and your eye sees the whole effect as a single pattern. Changing the relationship between the black and white areas even slightly will make a new pattern.

These patterns can be seen anywhere that a mesh or repeating pattern of lines interacts with itself, or its shadow, in screens, open weave fabrics and even wire fences.

(5 min) Sifting waves through a filter

Ask the group how many have been to a modern 3-D movie, and if the recall having to wear special glasses to see the effect. Explain that the glasses work by sending a slightly displaced image to each eye, which your brain combines to make things look 3-D. Unlike old fashioned 3-D glasses, which used different coloured filters to separate the images, modern technology uses polarising filters to separate the images.

Hand out the 3-D glasses, and ask how their vision changes when they put them on (a reduction in brightness will be observed). Things get dimmer because the glasses only let part of the available light through (see explanation below).

Hand out the mirrors, and ask participants to close one eye while they observe their reflection (they should see that one lens of the glasses is dark, and through the other lens they will see the closed eye).

Explanation: Coloured filters sift out light according to the wavelength (the distance between the peaks of the waves). Polarised filters sort out light according to the direction of the wave, as shown in the diagram below. In natural light the waves wiggle at all angles – up and down, side to side, and every way between.

A beam of light viewed head-on, Polarising filter Filtered light

showing waves coming at a beam, with

variety of angles wave in one direction

Polarising filters reduce the total incoming light (hence the reduction in intensity), because they only let light through that is wiggling in one direction. (Cinema 3-D glasses actually use a more complicated phenomenon, called circular polarisation, which you can read about [here](http://en.wikipedia.org/wiki/Polarized_3D_system) and [here](http://en.wikipedia.org/wiki/Circular_polarization).)

When you look at your eyes in the mirror through the glasses, you see the light that has gone from your face, through the glasses and then onto the mirror. This light is reflected from the mirror, and must travel back through the glasses to get into your eye and be seen. The light travelling from your face near the open eye has gone through a filter, but when it is reflected from the mirror, the angle of the wave is changed. When this light gets back to the glasses, it will no longer pass through the lens in front of the open eye, so this lens appears black in the image. The light travelling from your face near the closed eye is twisted in the opposite direction, and will now pass through the lens over your open eye, so you can see what is beneath this lens: your closed eye.

Appendices: Materials suppliers list (attached)