Lights

In this resource students will carry out experiments with prisms, polarising film and 3D cinema glasses to explain some of the interesting properties of light and their applications.

Introduction

Light from light bulbs allows us to see at night, light from the sun provides plants with energy and light from a computer screen lets you to surf the internet.

But there are many more properties of light that people make use of than just the ability to provide us with sight and energy.

What you need:

- Ray box
- Two pieces of polarising film
- Two transparent triangular prisms
- Pairs of realD 3D cinema glasses

Curriculum links

Science: Light waves

This activity should take approximately 1 hour, however allow more time if you are going to complete the extensions.
Dispersion

Start off with a discussion about rainbows and to lead into a discussion of the fact that white light is made up of different colours. Depending on the age of the students, you could discuss wavelengths/frequency.

Get your students to use a prism and a ray of white light to demonstrate that white light can be split into its component colours.

Next they could use two prisms to show that white light can be split up and then recombined again.

A spinning colour wheel could be used if students struggle.

Explanation

This experiment uses the idea that light of different colours (wavelengths) refracts by different amounts.

Therefore white light is split into its separate colours when it enters the prism. Upon exit from the prism, the light refracts again and the colours separate out more.

Using a second prism combines the colours back to white. A prism is necessary rather than a rectangular block because a rectangular block would combine the different colours back to white upon exit from the block.

Some maths

The refractive index is a measure of how much a medium will “bend” light.

The higher the refractive index the more the light will refracted. The light bends because it slows down when it enters a more dense material. Refractive index can be calculated by looking at the ratio between the speed outside and inside of the material.

\[ n = \frac{c}{v} \]

\( n \) = refractive index
\( c \) = speed of light in air = 300000000 m/s
\( v \) = speed of light in the material.

Look at the spectrum you have produced.

- Which colour is refracted most?
- What does this tell you about the speed of red light in glass compared to the speed of blue light?

Some extras

Students can experiment with the refraction by using different angles of incidence and see if they can generate total internal reflection.

Or why not investigate different ways white light can be split into colours, like scattering.

Fill a rectangular tank to three quarters full with water. Add a few drops of milk and mix. How does the light change when you look through the opposite end to the lamp and through the sides of the tank? Use this experiment to explain why the sky is blue and sunsets are red.

Total internal reflection is when all of the light is reflected inside the prism and no light is refracted out.

This is used in telecommunications, endoscopes and automotive rain sensors, which control automatic windscreen wipers.

Viewed through the sides the light should appear blue. This is due to the fat particles in the milk scattering the light. Blue is scattered more than red so blue light will be seen from the sides.

When viewed through the end opposite to the lamp the light will appear red, like a sunset, this is because the blue has been scattered out, leaving only the red light to reach the end.
Polarisation

Give the students two pieces of polarising film. Get them to hold up one piece of film to a light source. Not much should happen other than a reduction in brightness.

Now get them to rotate the second piece of film in front of the first one whilst still holding them up to the light.

Ask them to write down what they notice when they rotate the second film. They should notice that as the film is rotated, the brightness of light transmitting through varies from no light to the same as was transmitted through a single film.

You could alternatively demonstrate this to the whole group by holding the polarising film in front of a projector and rotating the second film to show how much of the image is projected onto the screen.

Get the students to wear a pair of realD 3D cinema glasses and then look in the mirror. Ask them to close one eye and say what they can see. Surprisingly, the student will be able to see their closed eye but not the other one.

A practical use for polarisation is viewing images on LCD screens. You can demonstrate this by removing the polarising film on the display, you will only be able to see the numbers when wearing polarising lens.

Some extras

3D cinema makes use of polarisation of light to create its 3D effect. If students are at the correct level, they could finish this activity by researching how 3D cinema works and how polarisation comes into it.

These experiments exploit a property of light called polarisation.

If light is not polarised the oscillations are in random directions with respect to the direction of propagation.

When unpolarised light travels through a polarising film, only light oscillating in one direction is able to travel through.

Using a second piece of polarising film orientated in the same direction will make no difference to the amount of light passing through. However if it is orientated at right angles to the first piece no light will be able to pass through.

As the second piece of film is rotated between these two orientations, the amount of light passing through will change.

To be able to see in 3D, there needs to be slightly different images for each eye, just like in real life. This is achieved by having two images on the screen, both polarised differently. In basic 3D glasses, each eye has a correctly orientated polarising film on it to only allow the correct image through.

The realD glasses recommended for the activity use a slightly different system using circular polarisation which allows for people tilting their heads but the general idea is the same. The reason the trick with seeing your closed eye works, is that when circularly polarised light reflects off a mirror, it changes its polarisation.
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I am working in the development of sensors based on a combination of optical fibres and nanomaterials, for monitoring of hazardous gas for example ammonia and carbon dioxide. My research work comprises of working in various aspects of optical fibre technology such as working on high power lasers, optical microscopes, spectrometers, electron microscopes, 3-D printers etc.

What do you like about your job?

In my job I am always working at the fore-front of technology. I deal with the latest equipment to find ingenious and smarter ways to solve technical problems.

What does engineering mean to you?

For me engineering means coming up with ingenious solutions to most challenging problems faced by industry and society and making an impact on industry and society.

This is engineering

The image of an engineer that students often have in their heads is one of a person (normally a man) working in a hard hat. Engineering is so much more than that.

Engineering is the designing, testing, manufacturing and improving of products to do something useful. It is the application of science, maths and creative skills to achieve a goal.

Photonics engineers create and improve systems and products that use light to function. The main purpose of the photonics engineering field is to develop new and innovative products for the medical field, telecommunications, manufacturing, and construction.

From light that can cut plastic, to ultra-accurate lasers used in delicate eye surgeries, photonics engineers are responsible for some very big scientific leaps and bounds.

Next steps

The following websites might be of use to you and your students:

What engineering is and careers in engineering
www.tomorrowsengineers.org.uk

Resources
www.raeng.org.uk/education/schools/teaching-and-learning-resources

This site includes more activities like this one as well as longer extended STEM projects.

There are also various teacher networks and ways of collaborating with STEM teachers. Contact the Royal Academy of Engineering to find out more.