The Rainbow

It is all a bit odd at the moment with the pandemic keeping us apart from each other. The NHS and all carers are doing their best to help us through these very strange times. Some of us are putting rainbows in our windows to show our support.

It is a fabulous gesture because a rainbow is a beautiful thing on an otherwise miserable, wet day. A ray of sunshine poking through the clouds sending an arc of colours across the sky to brighten our day. Light is a form of energy so again shows brilliant support for the NHS and carers who are giving all their energy to look after us.

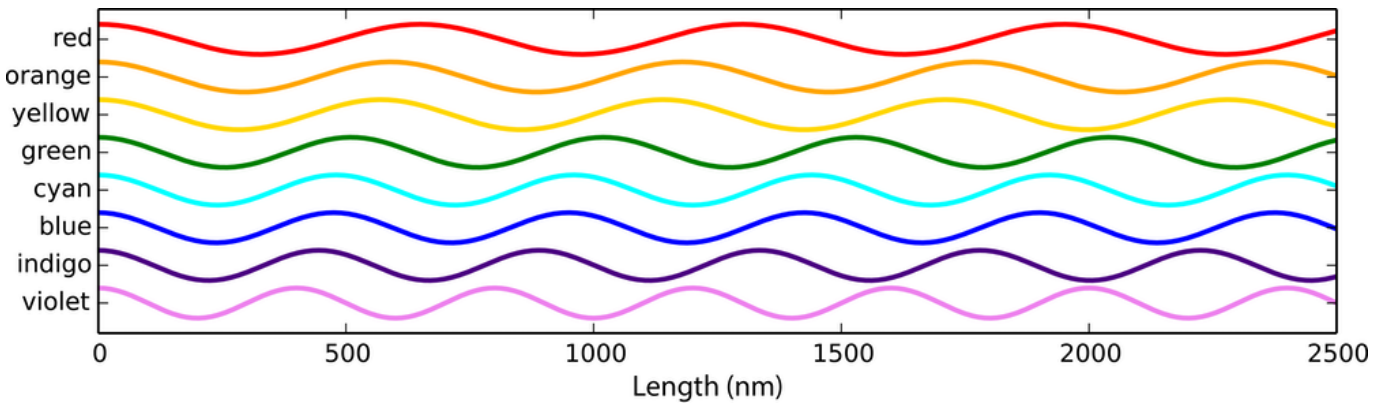
This document will tell you all about how rainbows form and why plus there are 4 simple experiments for you to try at the end of the explanation.

So why do we see rainbows and what are they?

Rainbows occur on days when it is raining and sunny at the same time and they always appear in the part of the sky which is directly opposite the sun. They can occur on days when it is not raining but there has to be water in the air like mist or fog and there has to be light shining from behind the water droplets at the correct angle.

Did you know that a rainbow is in fact a full circle of light but we only see half of that circle because the ground gets in the way?

So why do they occur? Light from the Sun is actually made up of all the colours that you see in a rainbow. Light travels in waves. Look at the picture below and you will see that different colours have a different wavelength.



Wavelength can be measured using the tops (or crests) of the wave.

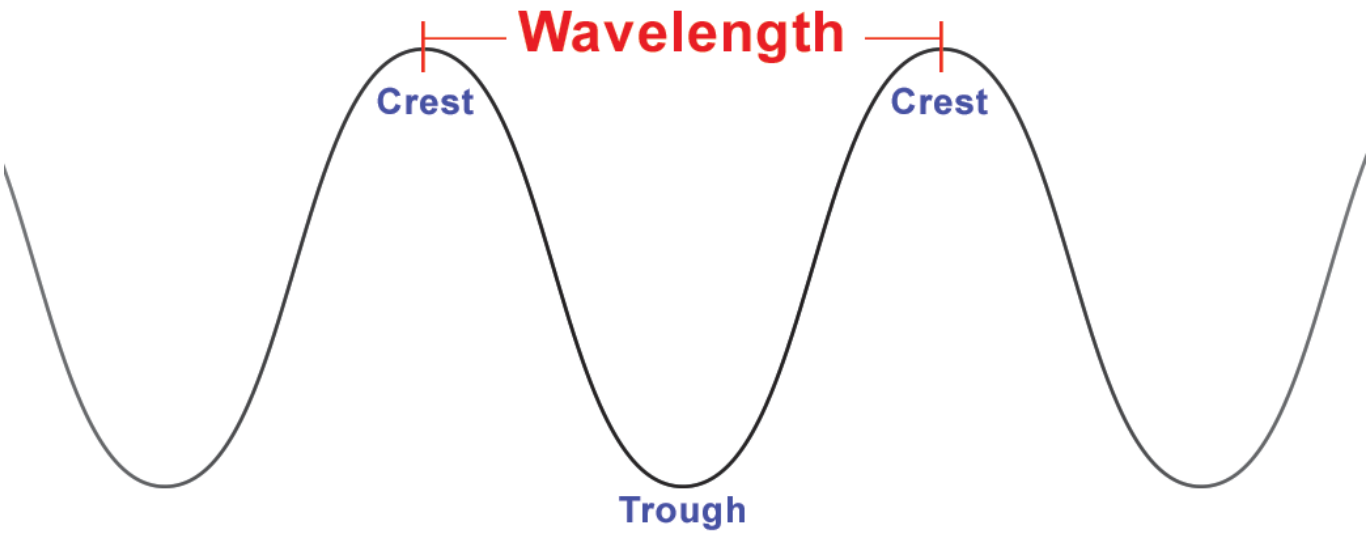
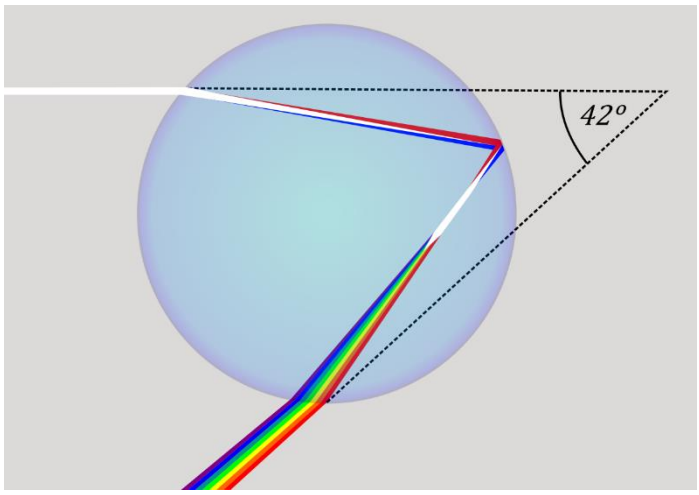


Image courtesy NASA

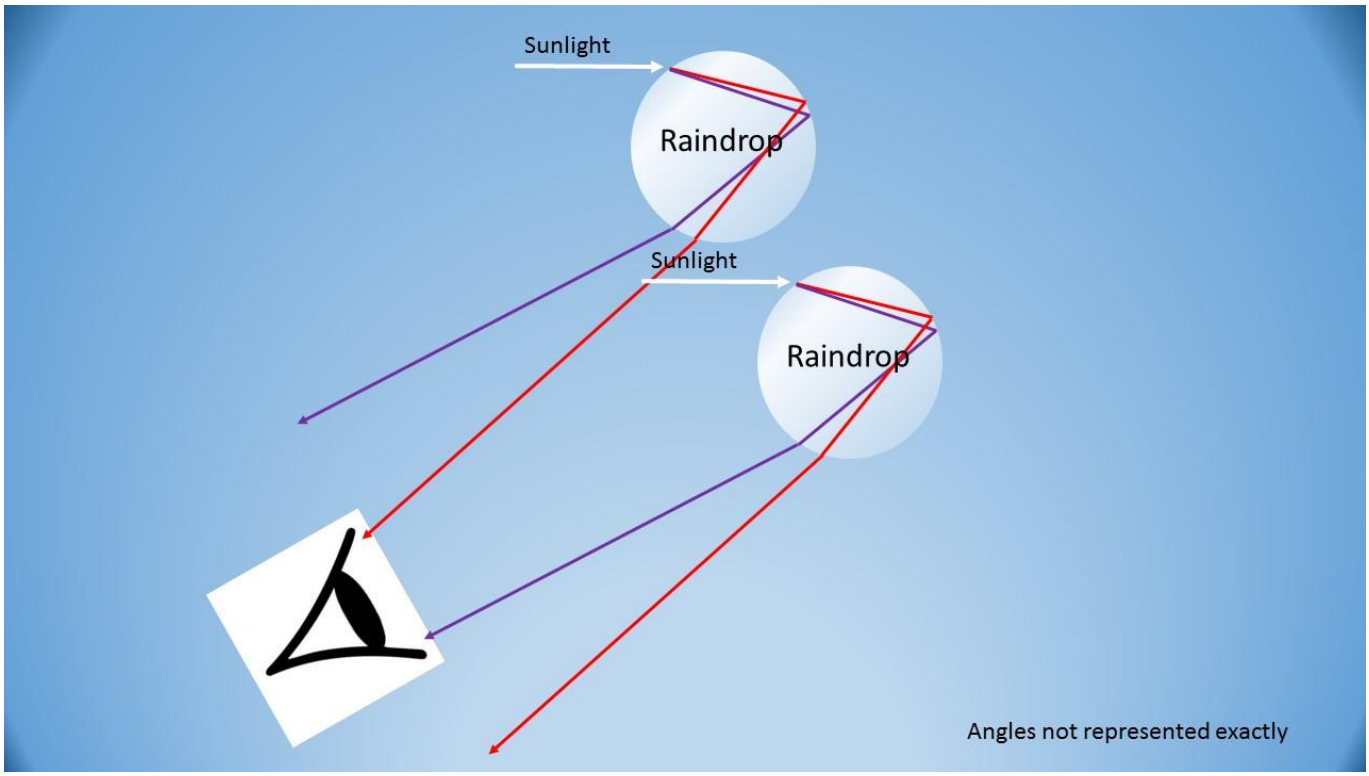
You can now see that red light has a longer wavelength than blue light. The length of the waves also tells you how much energy the light has. Blue light goes up and down (oscillates) more times per second than red light; it has more energy and a shorter wavelength than red light.

To get a rainbow, light has to pass through a raindrop (or droplet of water). Now, raindrops are denser than air so when light goes from air into the denser raindrop it slows down a bit. When it does this the light bends (changes direction). This is called refraction. Blue light actually travels more slowly in a raindrop than red light so it will bend more sharply than red light and because this happens white light gets split up into all its component colours. This is called dispersion.



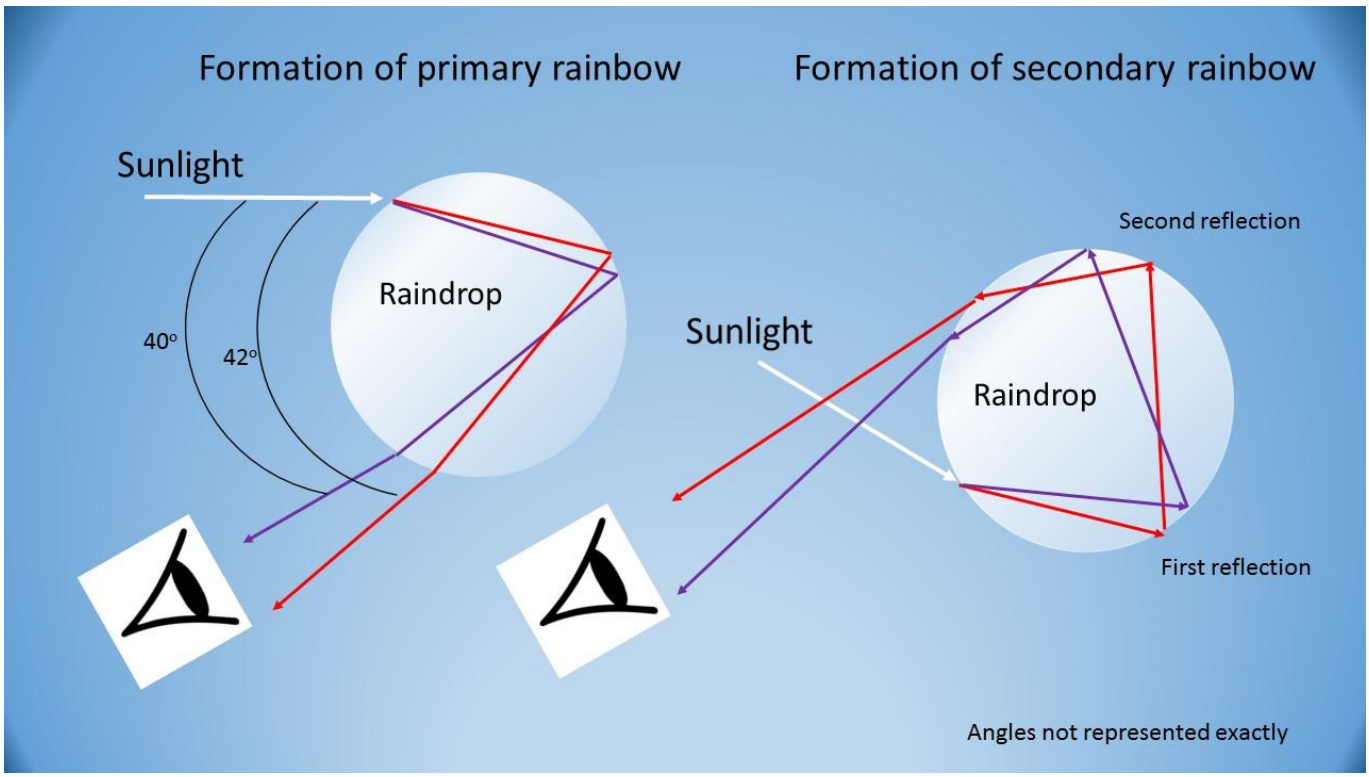
When the light hits the back of the raindrop some of it passes straight back into the air (not shown on the diagram) but this light is not very intense and so doesn't actually form a rainbow. The rest of the light is reflected off the back of the raindrop (see the diagram). When it leaves the raindrop the light bends again as it passes back into the air and this is what forms the rainbow that we can see.

It does get a little more complicated! Although each raindrop produces the full spectrum of visible light, we only see one colour from each raindrop. It's all a matter of angles. Red light comes into our eyes at an angle of 42° and blue light comes in at a less steep angle of 40°; all the other colours come into our eyes at the angles in between. So we see red light from raindrops higher up and blue light from raindrops lower down – red on top and blue underneath!



Not all of the light leaves the raindrop, some of it gets reflected inside the raindrop again and this light can form a double rainbow.

The secondary rainbow is fainter than the primary because more light escapes from two reflections compared to one and because the rainbow itself is spread over a greater area of the sky.



Can I make my own rainbow?

Experiment 1: Using a glass of water

What you will need

- A glass of water about ¾ full
- White paper
- Sunshine or if you haven't got a sunny day experiment with a torch.

Health & Safety

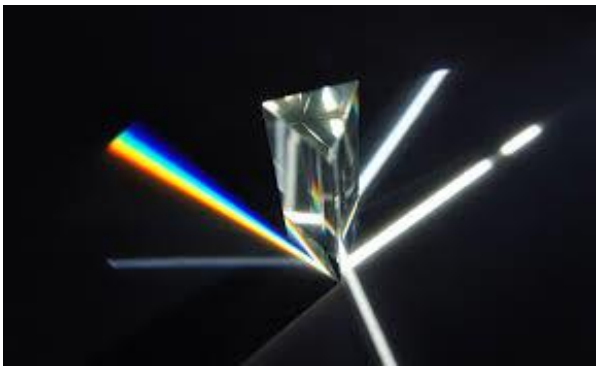
- Take care not to spill the water on the floor. If you do spill some water, wipe it up quickly so nobody slips over.
- Take care not to break the glass.

What you need to do

1. Go to a sunny window.
2. Hold the glass of water above the paper – what do you see?
3. If you cannot see anything it may not be sunny enough or you may need to change the position of your water. Try holding the glass at different heights and angles above the paper to see if it makes any difference.

Can I make a rainbow using other things?

You can make the visible spectrum of colours that you see in a rainbow using different things.



In the 1660s, English physicist and mathematician Isaac Newton experimented with sunlight and prisms. He passed sunlight through a prism and produced the 7 colours we see in the rainbow. He called this a spectrum. Some other scientists thought that it was the prism that was causing the coloured lights. However, Newton proved that it was the sunlight (white light) that was causing the colours because he used another prism and made white light again.

Experiment 2: Using a prism

What will you need?

- A prism
- A bright torch
- A piece of white paper or card or a white wall
- A piece of card with a slit in it to cover the front of your torch

Health and safety

- Take care when you make the slit in the piece of card. You may need an adult to help you. I used a sharp knife and made one straight cut.

What you need to do

1. Give yourself enough space on a flat surface. It is best if it is dark too because the spectrum will stand out more. For this experiment I used my kitchen floor.
2. Place the card with the slit over the end of the torch. Tape it in place if it keeps falling off.
3. Simply set up the experiment as in the diagram and play around with moving the prism and forming spectra.

Experiment 3: Using crystals

What will you need?

- Crystals
- A bright torch or sunshine
- A piece of white paper or card or a white wall (optional)

What you need to do

1. Play! Have fun twirling the crystals around in the light. You can hang crystals in a window and they will cast beautiful 'rainbows' all around the room.

So what is happening with the prism and the crystals?

Similar to water, the glass in the prism and the crystals is denser than air and this cause the white light to refract and disperse into the colours of the visible spectrum.

Experiment 4: Using a CD

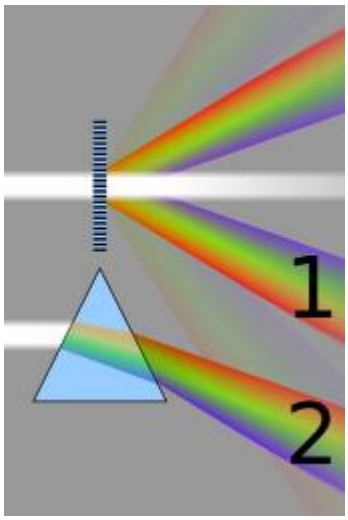
What will you need?

- CD
- A bright torch or sunshine
- A piece of white paper (optional)

What you need to do

1. Play! Have fun producing the spectra in your CD. Move the CD around and see what happens. Try to get the spectra to reflect off the CD onto the piece of paper.

So what is happening with the CD?



This is a little different from the water, the crystals and the prism. You cannot pass light through a CD it reflects light off its surface. So why do we see the spectrum of colours? A CD or DVD is made up of thousands of tiny spiral grooves. When white light hits the CD, each groove diffracts light in all directions (number 1 in the diagram). Diffraction like refraction (number 2 in the diagram) splits white light into the visible spectrum. Remember light travels in waves! When these light waves reflect off the surface of the CD some waves overlap and interfere with each other. Sometimes the waves add together making a bright colour and sometimes the waves cancel each other out and the colour is lost.

The study of using the spectrum in science is called spectroscopy. It is extremely important in astronomy and can tell astronomers an awful lot about what they are looking at. This is a NASA article about spectroscopy in astronomy. https://imagine.gsfc.nasa.gov/science/toolbox/spectra1.html