What are Colours?

Colour is all around us. The natural world is full of vivid colours. Painters and printers use *pigments* (paints or inks) to produce colours for us to admire. In art you learn how to mix pigments to make different colours. In science you see how the *primary colours* of light can be combined to give other shades. You may know that the primary colours of light are different from those for pigments. As we work through this topic, we will see how colours come about, explore the differences between objects that are coloured because they emit light and objects that are coloured as they reflect light. We will explore how primary colours work for light and for pigments and discuss how a scientific understanding of colour relates to other subjects, such as art.

First thoughts

What do you think colours are?

In the box below, write down a short description of what you think colours are. Don't worry about being scientific or technical, just write your immediate reaction to the question: '*what are colours*'?

Now imagine that you are a painter (artist) or a decorator or a clothing designer. Try and put yourself in the position of someone who works with colours all the time. If you were in that situation, what do you think colours would mean to you? What might be that person's understanding of colour? In the box below, write down what you think their reaction to the question *'what is colour?'* might be.

Now think about everything that you may have read or discussed in science classes about the nature of light and colour. In this final box, write down what you think is the scientific understanding of colour. Don't worry about being completely correct at this time; just try and summarise what you know about colour from the scientific point of view.

Rainbows and prisms

Figure 1: A double rainbow as seen in Finland.

List the colours found in a rainbow, in order from bottom to top, as seen in Figure 1:

Order of colours in a rainbow:

In 1672, Isaac Newton published the results of a famous experiment that he had carried out in the late 1660s. He arranged for a thin strip of sunlight to hit a piece of glass (nowadays we use a *prism*) and on the other side of the glass he placed a screen so that the light from the glass would illuminate the screen. Without the glass, the sunlight lit up a thin streak on the screen. With the glass, a range of colours, rather like a rainbow, could be seen.

Figure 2 shows a modern version of this experiment using a prism. Note that the colours are the same as those in the rainbow and appear in the same order.

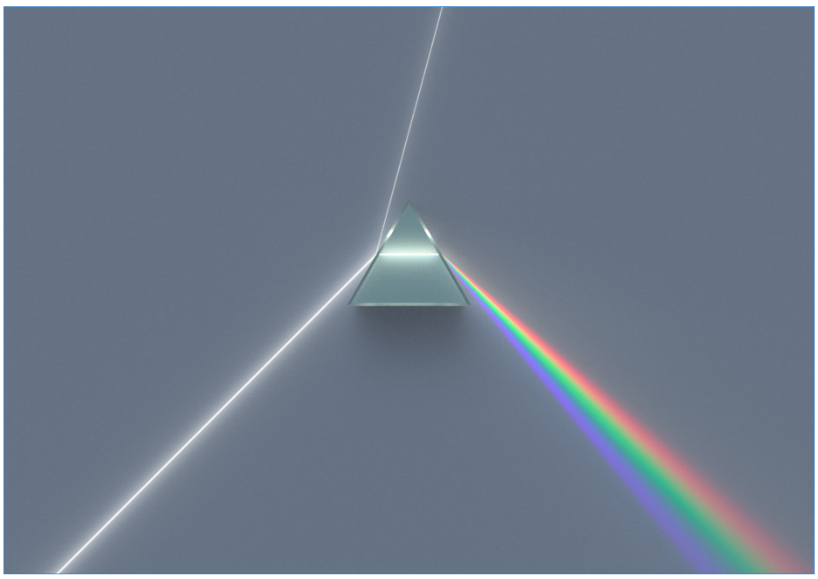

Figure 2: A modern version of Newton's famous experiment.
(image credit: Sigget via Wikkimedia commons, CC3.
https://creativecommons.org/licenses/by-sa/3.0/deed.en)

Newton's experiment strongly suggests that what we see as *white light* is actually all the different colours in the rainbow mixed together. We will see exactly how this works in a later lesson. The question now is: what makes one colour of light different from another?

Sounds and music

In music you learn that sounds have different *pitches* and *volumes:*

- Pitch of a sound – how *high* or *low* the sound is;
- Volume[1] – how *quiet* or *loud* the sound is.

A piano is a musical instrument that has a keyboard: a row of black and white keys (see Figure 3). The colours are used to help pick out different notes that can be played.

[1] The same word, volume, can also be used to indicate the size of an object

Figure 3: The keyboard of a grand piano.

At the right-hand end of the keyboard, the notes are *high-pitched* and at the left-hand end the notes are *low-pitched*.

Before they had electronic devices to help, people used to tune pianos (make sure that the notes were at the right pitch) by using *tuning forks*.

Each tuning fork makes a sound with a specific pitch, so you listen to the fork and a note from the piano and then adjust the piano until they sound the same pitch.

Figure 4: A tuning fork for the musical note E.

Looking at the selection of tuning forks provided, what do you notice about the difference between a high-pitched tuning fork and a low-pitched one?

Difference between a high-pitched fork and a low-pitched one:

If you watch a tuning fork in slow motion, you can see that the arms wave back and forth. Physicists say that the arms of the tuning fork are *vibrating* and the faster the vibration, the higher the pitch of the sound:

- High pitched sound – fast vibrations
- Low pitched sound – slow vibrations

Every sound is made by some object vibrating and the speed of these vibrations makes the pitch of the sound. In order to be more quantitative, we use the *frequency* of the vibrations:

- Frequency – number of complete vibrations in one second

Humans can hear a wide range of frequencies. You will hear a demonstration of a loudspeaker vibrating at different frequencies:

Lowest frequency of vibration that I could hear = ...vibrations per second

Highest frequency of vibration that I could hear = ...vibrations per second

The unit used for vibrations per second is Hertz (Hz).

Fill in the blanks in the following:

One........................per second is the same as ....Hz

100 vibrations........................is the same as 100........................

Sound travels through the air as *waves*. We often see ripples across the surface of a pond. Sound waves are different from water waves as sound waves in air travel as changes in the pressure of the air. However, the waves have the same frequency as the vibrations that produced them.

While a musician talks about the pitch of a note, a physicist would say that each pitch has a specific frequency. The tuning fork in Figure 4 has a frequency of 659 Hz.

Light

Light travels as waves, but of a very different sort from those in sound and water. Just as sound waves have loudness and pitch, so light waves have *brightness* and *colour*:

- Brightness – how much the light will illuminate an object;
- Colour – the frequency of the light: red light has a low frequency; blue light has a high frequency.

Just as notes of different pitch are spread across the keyboard of a piano, so the colours of light are spread across the rainbow.

So, here is one answer to the question: *what is colour?*

Scientifically: the colour of light is the frequency of the light waves involved.

While this is a very good start, it can't be the total answer to the question, as some things need further thought:

What is the colour of an object that reflects light?

Are the colours black and white also frequencies of light?

Lesson summary

- The frequency of a wave is the number of vibrations every second.
- Frequency is measured in Hertz, Hz.
- A high-pitched sound has a high frequency (many vibrations per second).
- A low-pitched sound has a low frequency (not many vibrations per second).
- Humans can generally hear sounds between 20 Hz and 20 000 Hz.
- Light is a type of wave and so has a frequency.
- The different colours of light correspond to different frequencies.