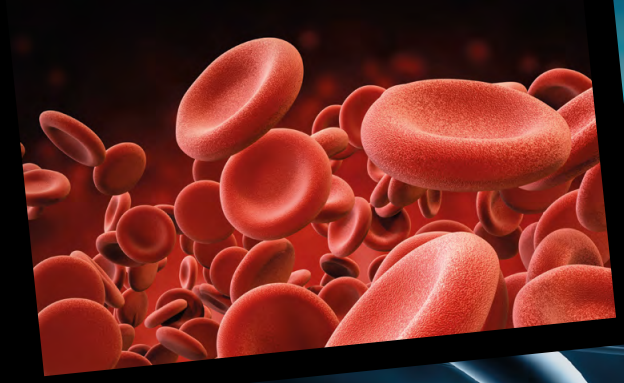
Royal Academy of Engineering

THIS IS ENGINEERING



LIGHT SAVER

Engineering light to help save lives

Teacher Guide

An upper primary and lower secondary STEM-focused resource that gives young learners the opportunity to explore how engineering and science work together in the healthcare service.

Pupils work collaboratively to develop their curiosity and creativity through a series of fun and engaging activities.

ANSWERS FOR TEACHERS

WHAT IS LIGHT?

Time to calculate

Light travels at 300,000 km (300 thousand kilometres) per second and the distance between the earth and the sun is 149,000,000 km (149 million kilometres).

- How many minutes does it take for light to reach us from the sun.
  Approximately eight minutes
- Explain why you think it takes this amount of time. You can write your 'working out' as an equation.
  300,000 km per second x 60 (18,000,000 km per minute) = 18,000,000 km
  Light travels 18,000,000 km in one minute.
  149,000,000 km (distance from the sun) ÷ 18,000,000 km per minute ≈ 8 minutes
  Teacher Tip: speed = distance/time so time = distance/speed

Time to think

The Sun is just one source of light. What other light sources can you think of?

Stars, light bulbs, mobile phones, televisions, lamp posts, lasers, bioluminescence.

The power of 10

All wavelengths are measured by the power of 10. Look at the chart below, can you fill in the gaps?

Calculation	Number		Power	Words	Radiation type wavelength
10 × 10 × 10 × 10 × 10	100,000		**10^{5}**	Hundred thousand	
10 × 10 × 10 × 10	10,000		10^{4}	**Ten thousand**	
10 × 10 × 10	1,000		10^{3}	Thousand	**Radio**
10 × 10	100		**10^{2}**	**One hundred**	
10 × 1	10		10^{1}	Ten	
10 × 0.1	1		10^{0}	One	
1 × 0.1	0.1	$\frac{1}{10}$	10^{-1}	**One tenth**	
0.1 × 0.1	0.01	$\frac{1}{100}$	**10^{-2}**	One hundredth	Microwave
0.1 × 0.1 × 0.1	0.001	$\frac{1}{1000}$	10^{-3}	**One thousandth**	
0.1 × 0.1 × 0.1 × 0.1	0.0001	$\frac{1}{10000}$	10^{-4}	Ten thousandth	
0.1 × 0.1 × 0.1 × 0.1 × 0.1	0.00001	$\frac{1}{100000}$	10^{-5}	Hundred thousandth	**Infrared**

Using the information from the chart you completed above, show the following:

- What is the approximate length of a radio wave in metres? **1,000 m**
- What is the approximate length of a microwave in metres? **0.01 m**
- What is the approximate length of an infrared wave in metres? **0.00001 m**

Stretch and challenge

- What is the approximate length of a wave in the 'visible' spectrum? **0.0000005 m**
- How much longer is a micro wave wavelength compared to an infrared wave? **$10^{-2} \div 10^{-6}$ = 10,000 times longer**

Scale of the universe

Object	Size	The Power of 10	Wavelength
Human	1.7 metres	1.7×10^{0} metres	FM Radio wave
Apollo Lunar Buggy	**9 metres**	**9×10^{0} metres**	**FM Radio wave**
Mount Everest	**8.8 kilometres**	**8.8×10^{3} metres**	**AM Radio wave**
Grain of rice	**5 millimetres**	**5×10^{-3} metres**	**Microwave**
Y-chromosome	**1.5 micrometres**	**1.5×10^{-6} metres**	**Red Light Wave**

Nano-challenge:

How many times smaller is the Apollo Lunar buggy than Mount Everest?
Buggy is 9 metres and Everest is 8.8 kilometres (8,800 metres)
∵ the buggy is approximately 1,000 times smaller than Everest

Find the smallest creature visible to the naked eye. **Dust mite**

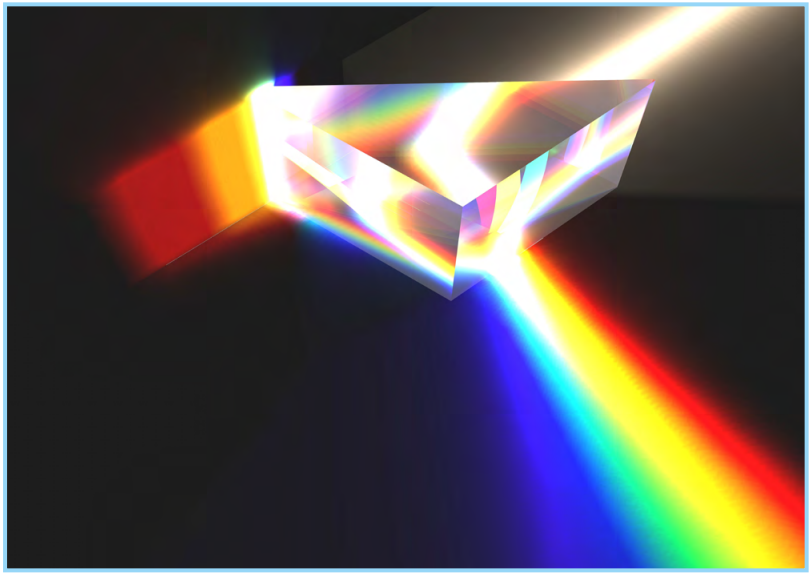
Find the smallest thing visible to an optical microscope. **Virus**

The visible light spectrum

- How many nanometres (nm) is the slice of orange? Write this down in words? **100 million**
- How long is the grain of salt in centimetres (cm)? **0.1 cm**

Pencil case object	Measurement (cm)	Measurement (nm)
Pencil	**17**	**170,000,000**
Full stop made by pencil	**0.1**	**1,000,000**
Rubber	**4**	**40,000,000**
Sharpener	**3.5**	**35,000,000**

BEHAVIOUR OF LIGHT



Absorbing the light challenge

Why do you think black objects radiate more heat? **They absorb more energy, thus emitting more heat**

Absorption spectra

What do you notice about the green light the eye can see and the line on the absorption spectra graph? **Green light has the lowest absorption**

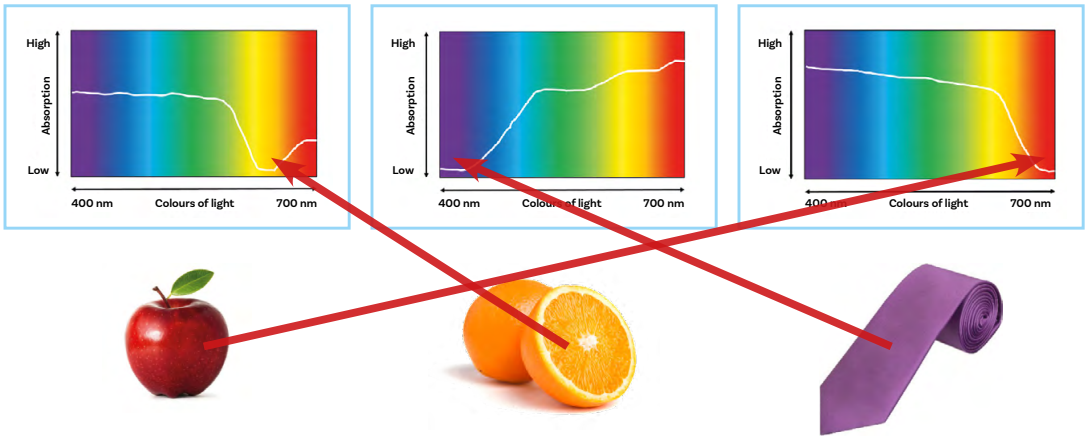
Time to experiment

When we add blue dye to the water in the glass, the behaviour we are investigating is absorption. The blue dye absorbs all the other colours and only allows blue light to pass through.

When we add the milk to the water, the behaviour we are investigating is scattering. Fat globules are suspended in the milk liquid and scatter light in different directions. This is why you can't see through milk. So when we shine the torch into the milk, some of the light will be scattered back to you.

Time to calculate

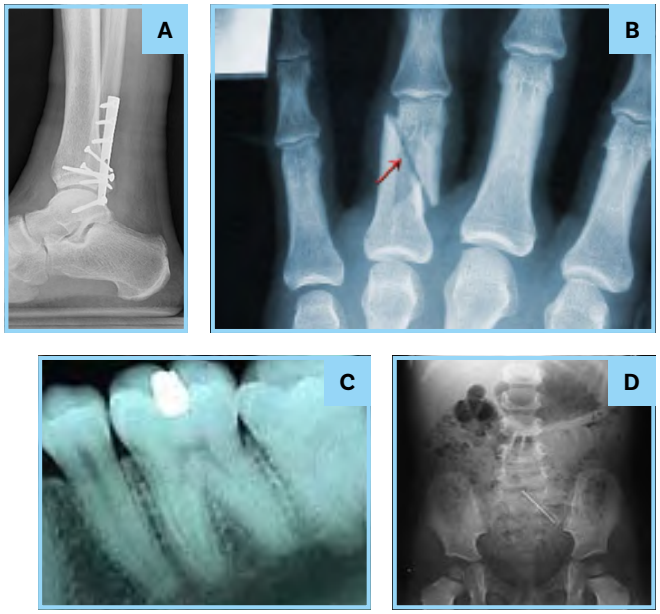
Match the objects (right) to the correct absorption spectra graph.



LIGHT AND THE BODY

Role of the radiologist

Diagram A – Foot with metal plates
Diagram B – Hand with broken finger
Diagram C – Metal filling in a tooth
Diagram D – Swallowed a needle



Transmission through the body

Shine a torch onto your fingers. What do you notice?

Your hand lights up a red colour as all the other colours in the spectrum are absorbed and only red light can travel through our body.

Time to think

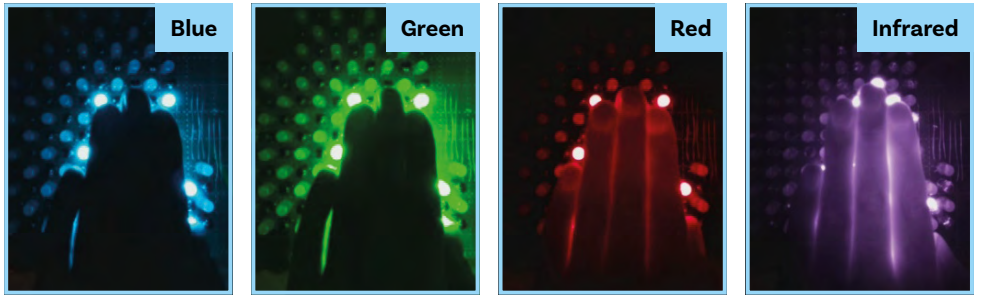
Look at the image to see which colours of light travel through the body and which don't. What do you think will happen if you shine different coloured light through your fingers?

Why do some colours travel through the body?

The body is made up of lots of components including water, blood, fat, proteins and collagen. They have different colours and therefore different absorption spectra.

**Water makes up around 60% of the body and it is transparent,
because it transmits visible light.**

The optical window (which is between 600 and 1,000nm) allows a range of colours to travel through the body. This region includes red, which is why our hands glow red when white light shines through it. It also includes infra-red, which is invisible to us but can be detected with cameras.



LIGHT AND THE BRAIN

Absorption Spectra

Identify the green light (550 nm) dotted line. Which statement is correct?

- HbO_2 absorbs more green light than Hb
- **Hb absorbs more green light than HbO_2**
- Both HbO_2 and Hb absorb the same amount of green light

Now identify the purple light (400 nm) line. Which statement is correct?

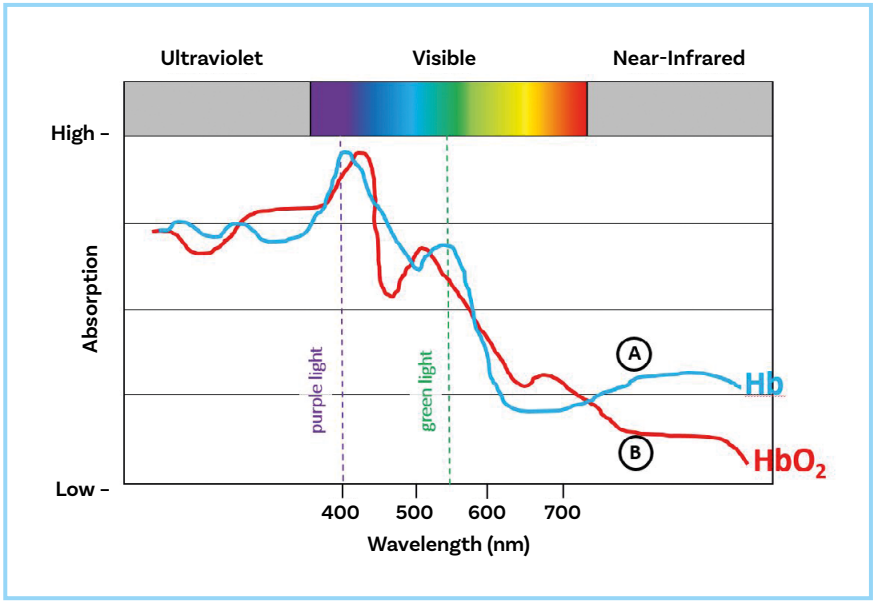
- HbO_2 absorbs more purple light than Hb
- Hb absorbs more purple light than HbO_2
- **Both HbO_2 and Hb absorb the same amount of purple light**

Now look at point A and B on the graph. Which of these statements is correct?

- **HbO_2 absorbs less red light than Hb**
- Hb absorbs less red light than HbO_2
- Both HbO_2 and Hb absorb the same amount of purple light

Therefore, which blood type is redder in colour? **HbO_2**

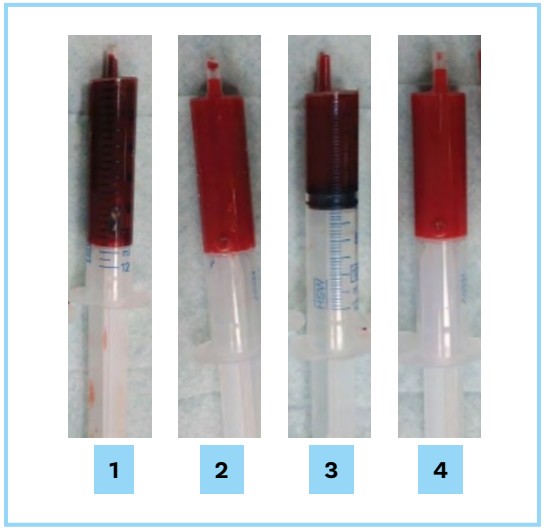
Why is blood red? **Blood does not absorb the red light of the spectrum**



Time to investigate

Look at the colour of the blood in each syringe.

- Which one is filled with the least oxygenated blood? **3**
- Which one is filled with the most oxygenated blood? **4**



Time to calculate

- **Baby A** has an oxyhaemoglobin count of 45 units and a deoxyhemoglobin count of 5 units.

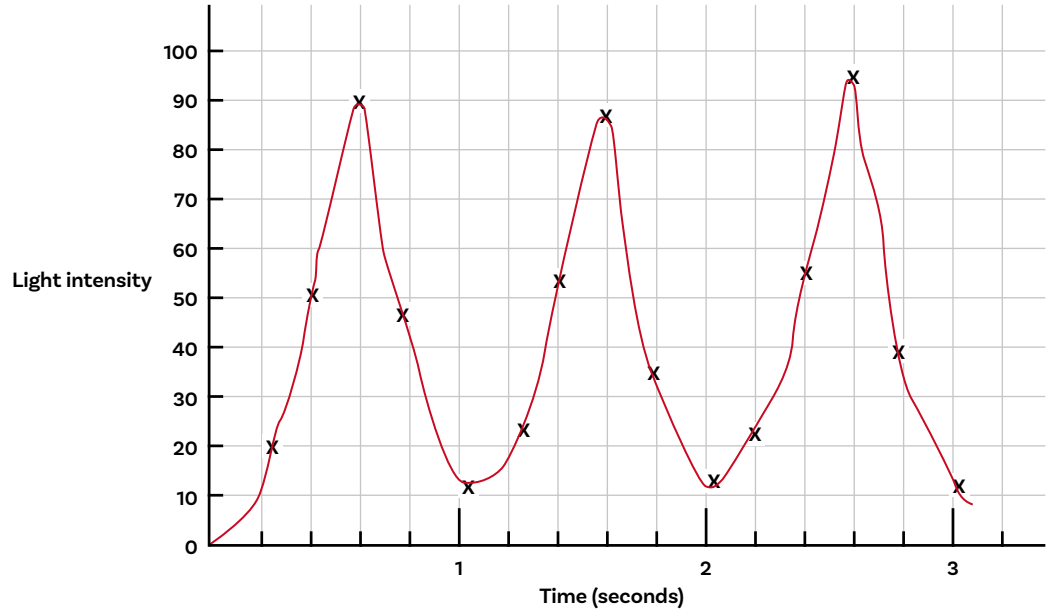
$$\frac{45}{45+5} \times 100\% = 90\%$$

- **Baby B** has an oxyhaemoglobin count of 36 units and a deoxyhaemoglobin count of 9 units.

$$\frac{36}{36+9} \times 100\% = 80\%$$

∵ **Baby B is in more need of medical treatment**

FINGER ON THE PULSE



What is the patient's heart rate per minute?

60 beats per minute (bpm).
One wave in a cycle every second.

Royal Academy of Engineering

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