

Splitting light, coloured filters, lenses and the eye

Grade 8 science (Year 9 · Class 8) · Lesson

Quick answer: White light is a mixture of colours that a prism splits into a spectrum by dispersion, with violet bent most. Coloured filters absorb all colours except their own. A converging lens bends parallel rays to a focal point, and the eye uses a lens to form an inverted image on the retina.

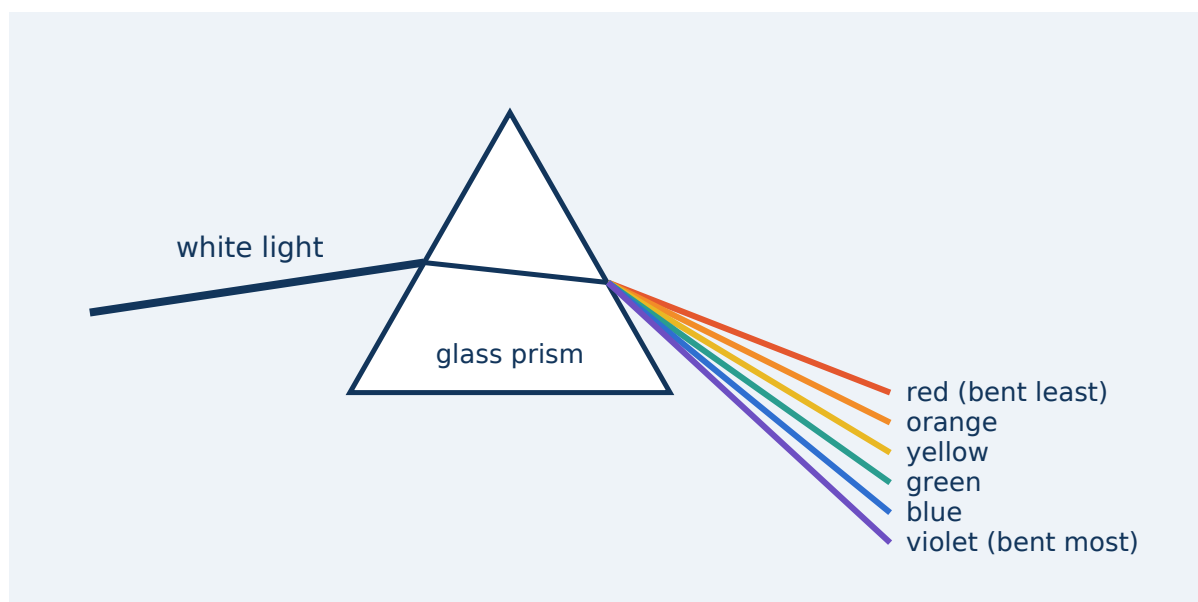
Level: Grade 8 science (Year 9 · Class 8) · **Curriculum:** MS-PS4-2

What happens when white light passes through a prism?

Sunlight and lamp light look white, but white light is a mixture of colours. When it enters a glass prism it slows down and bends. This bending is called refraction. Each colour bends by a slightly different amount, so the mixture spreads out into a band of colours called a spectrum.

Definition

Dispersion is the splitting of white light into its colours because each colour is refracted by a different amount. The order of the spectrum is red, orange, yellow, green, blue, violet. Red light bends least and violet light bends most.



A prism disperses white light. The colours leave in a fixed order, with red bent least and violet bent most.

A rainbow is dispersion on a huge scale. After a monsoon shower in Pune, millions of raindrops act like tiny prisms, and the Sun behind the viewer lights them up. Each colour reaches your eye from drops at a slightly different angle, so you see arcs of colour in order, with red on the outside.

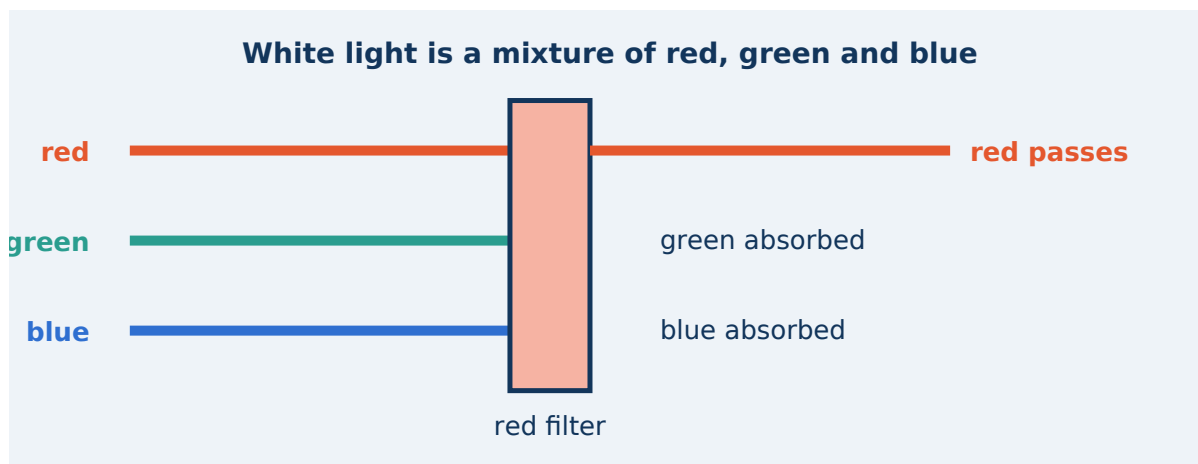
How do coloured filters and coloured objects work?

Red, green and blue are the primary colours of light. Mixing lights adds colours: red + green makes yellow, green + blue makes cyan, red + blue makes magenta, and all three together make white. A filter does the opposite job: it takes colours away.

Definition

A coloured filter is a transparent material that transmits some colours of light and absorbs the rest. A red filter transmits red light only. A yellow filter transmits red and green, because red + green looks yellow.

Filter	Colours transmitted	Colour absorbed
Red	red	green and blue
Green	green	red and blue
Blue	blue	red and green
Yellow	red and green	blue
Cyan	green and blue	red
Magenta	red and blue	green



A filter only removes colours. It never adds light that was not already in the beam.

Key law

An object has the colour of the light it reflects. It absorbs the other colours. White objects reflect all colours and black objects absorb nearly all of them.

Worked example

A yellow banana is lit only by blue light. **Data:** a yellow object reflects red and green and absorbs blue. **Method:** the beam contains blue only, so the banana absorbs all of it and reflects nothing. **Answer:** the banana looks **black**.

Common mistake

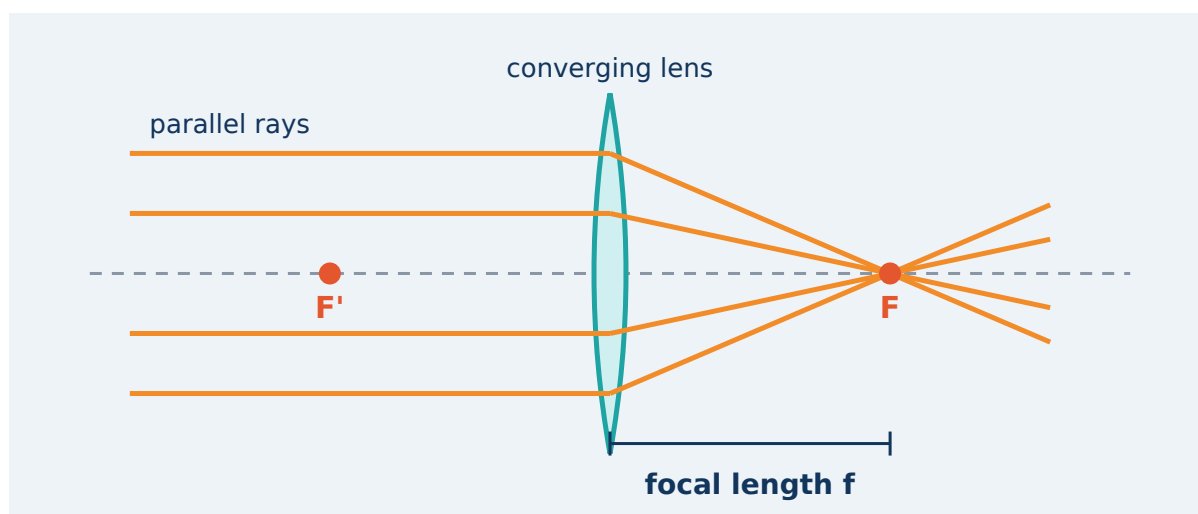
Students often say a coloured filter adds colour to white light. A filter only removes colours. A red filter makes a beam redder by absorbing the green and blue, so the beam also becomes dimmer.

How does a converging lens bend light?

A converging lens is thicker in the middle than at the edges. Rays of light travelling parallel to its principal axis are refracted towards each other and cross at one point.

Definition

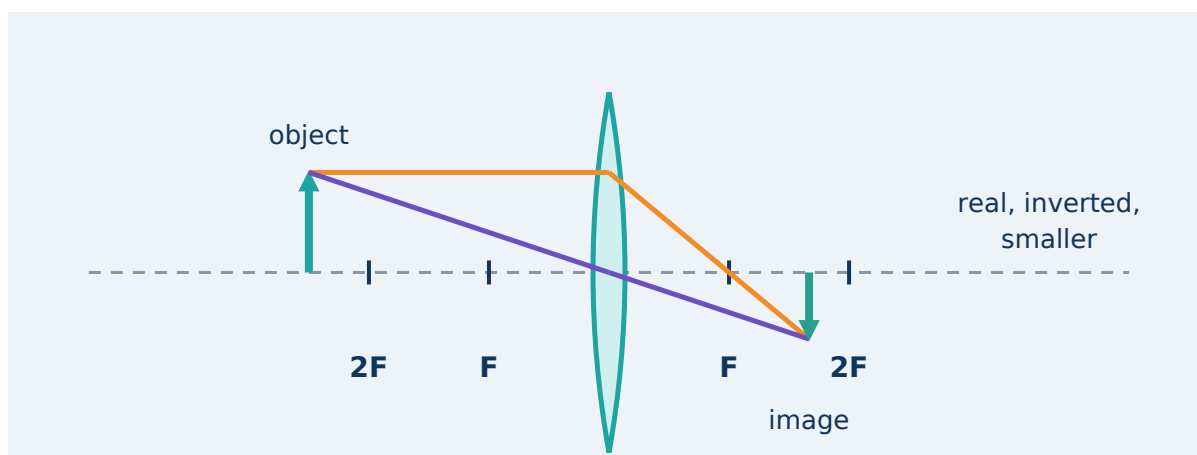
The focal point F of a converging lens is the point where parallel rays meet after passing through it. The focal length f is the distance from the centre of the lens to F . A fatter lens bends light more strongly and has a shorter focal length.



Parallel rays meet at the focal point. A lens has a focal point on each side.

What kind of image a lens makes depends on where the object stands. A real image forms where rays actually meet, so it can be caught on a screen. A virtual image only seems to come from behind the lens, and no screen can show it.

Object position	Image formed
Beyond $2F$	real, inverted, smaller
At $2F$	real, inverted, same size
Between F and $2F$	real, inverted, larger
Closer than F	virtual, upright, larger (magnifying glass)



Two rays are enough: one parallel to the axis that bends through F , and one that goes straight through the centre of the lens.

Formula

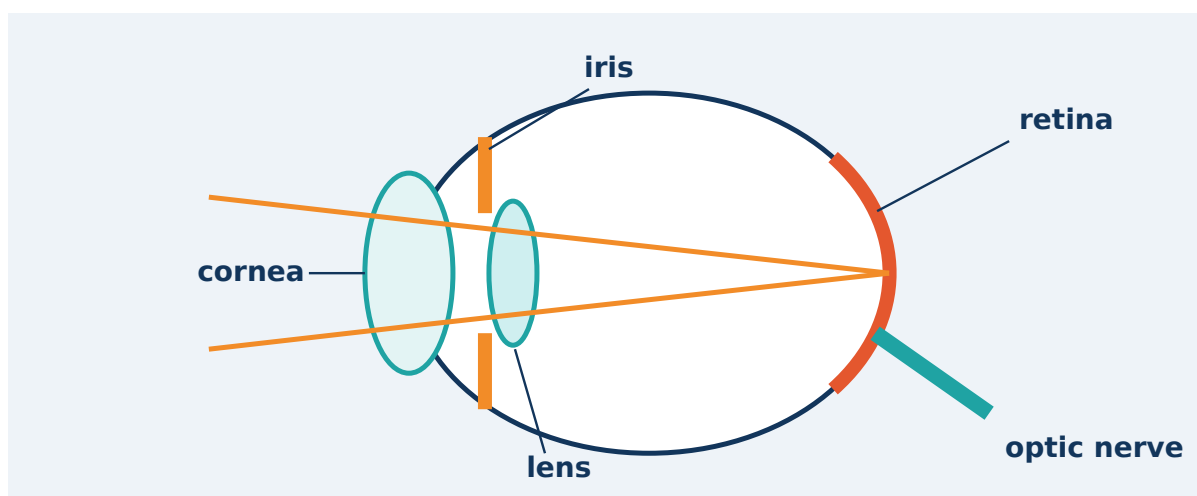
$M = h_i \div h_o$. M is the magnification (no unit), h_i is the image height and h_o is the object height, both in the same unit.

Worked example

A magnifying glass shows an ant 1.5 cm long. **Data:** object height 1.5 cm, image height 4.5 cm. **Method:** $M = 4.5 \div 1.5$. **Answer:** $M = 3.0$, so the image is three times as large.

How does the human eye make a picture?

The eye works like a tiny camera. Light enters through the transparent cornea, which does most of the bending. It passes through the pupil, the hole in the coloured iris, and then through the lens, which fine-tunes the focus. The lens makes a small, real, inverted image on the retina, the layer at the back of the eye that holds light-sensitive cells. Cone cells detect colour in bright light, and rod cells work in dim light. The optic nerve carries electrical signals to the brain, which turns the image the right way up.



The cornea and the lens focus light so that a sharp image forms on the retina.

The iris controls the size of the pupil. In bright light it makes the pupil smaller so less light

enters, and in dim light it makes the pupil larger. Muscles also change the shape of the lens, making it fatter to focus on near objects and thinner for far ones.

Lina's tip

Draw only two rays from the top of the object: one parallel to the axis that bends through F, and one straight through the centre of the lens. Where they cross is the top of the image.

Key points to remember

- Dispersion order: red, orange, yellow, green, blue, violet; red bends least.
- A coloured filter transmits its own colours and absorbs the rest.
- An object's colour is the colour it reflects.
- Magnification $M = \text{image height} \div \text{object height}$.
- The eye forms a real, inverted image on the retina.

Splitting light, coloured filters, lenses and the eye: frequently asked questions

Why does a prism split white light into colours?

Glass slows each colour of light by a slightly different amount, so each colour is refracted through a different angle. Violet slows most and bends most, while red bends least.

Why does a green leaf look black in red light?

A green leaf reflects green light and absorbs red light. Pure red light contains no green, so the leaf reflects almost nothing and looks black.

What is the focal length of a lens?

It is the distance from the centre of a converging lens to its focal point, where parallel rays meet. A stronger, fatter lens has a shorter focal length.

What is the difference between a real and a virtual image?

A real image forms where rays actually cross, so a screen can display it. A virtual image only appears to come from behind the lens and cannot be shown on a screen.

Why is the image on the retina upside down?

A converging lens always gives a real, inverted image of a distant object. The brain learns to interpret the signals from the optic nerve so the world looks the right way up.