Seeing the Invisible: A Story of Discovery

How do you study something you can't see?

This question has driven science for thousands of years. From ancient ideas about light, to modern particle accelerators, scientists have been building tools to explore an invisible world.

This booklet follows that journey.

Section 1: Light – the oldest mystery

The story begins over 2,000 years ago.

Ancient Greek thinkers debated what light actually is. Later, in the 1600s, scientists like Isaac Newton showed that white light is made of colours. In the 1800s, Thomas Young demonstrated that light behaves like a wave.

Over centuries, experiments with mirrors, lenses, and prisms revealed that light can:

- travel in straight lines

- reflect

- refract (bend)

- spread out into patterns

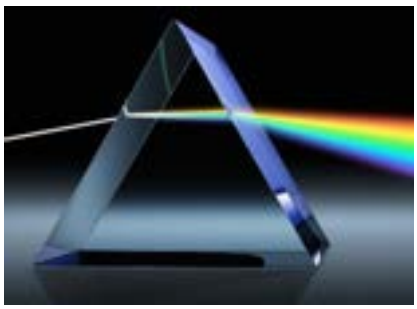
These discoveries didn't just explain how we see—they led to technologies like cameras, microscopes, lasers, and fibre optics.

Even today, scientists are still uncovering new properties of light.

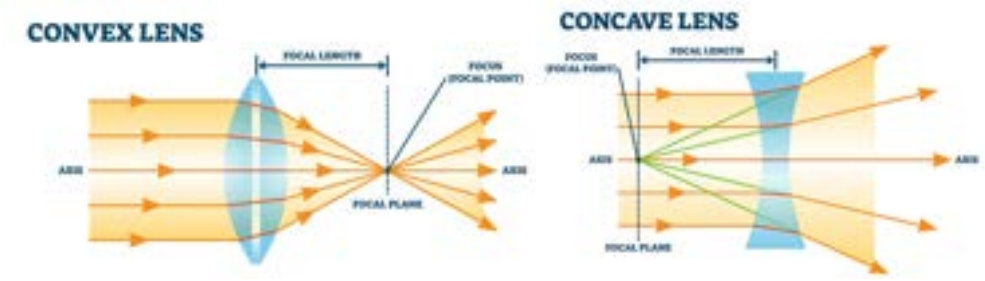
Activity for the section – exploration of optics

Source cube- produces beams of light.

Steering cube – prism that changes the direction of light



Focusing cube – focusing and defocusing lens.



Focusing lens shown on left and defocusing lens on right.

Section 2: Radiation – discovering the atom

By the late 1800s, scientists thought they understood light quite well.

Then something unexpected happened.

In 1895, Wilhelm Röntgen was experimenting in a dark lab when he noticed a strange glow from a nearby screen. Something invisible was passing through the air—and even through solid objects.

He had discovered X-rays.

For the first time, scientists had found a form of “light” that we cannot see.

Radiation from atoms

Just a year later, Henri Becquerel made another surprising discovery.

He found that certain materials could emit radiation **all by themselves**, without any external energy source.

Soon after, Marie Curie and Pierre Curie investigated this further. They discovered new radioactive elements and showed that this radiation was coming from inside atoms.

This changed everything.

Atoms were not solid and unchanging - they had structure, and they could release energy.

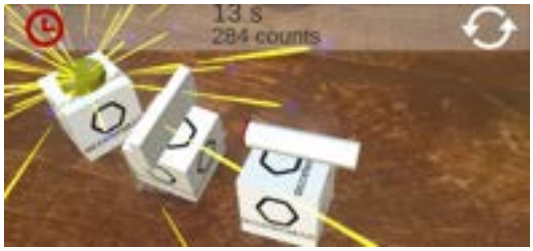
More than just light

As scientists studied radiation, they realised something important:

Radiation is not just light.

There are two main types: Wave radiation (like light and gamma rays) and particles (like electrons)

Source cube – emits radiation. Unlike the beam, this travels in all directions (shown below on left hand side).



Focusing cube – This detects particles (original version looks as on the right in image above, but more recent version is as below).

Acceleration cube – These are blocks of material. That particles lose energy to. Shown between particle source and detector on image from app. There are options for a few different materials that cause energy loss at different rates (as shown in your first sample image).

Section 3 –

Once the nucleus was discovered, a new question emerged:

What's inside?

To investigate, scientists built **particle accelerators** - machines that speed particles up to extremely high energies and smash them together.

By studying the results, scientists can:

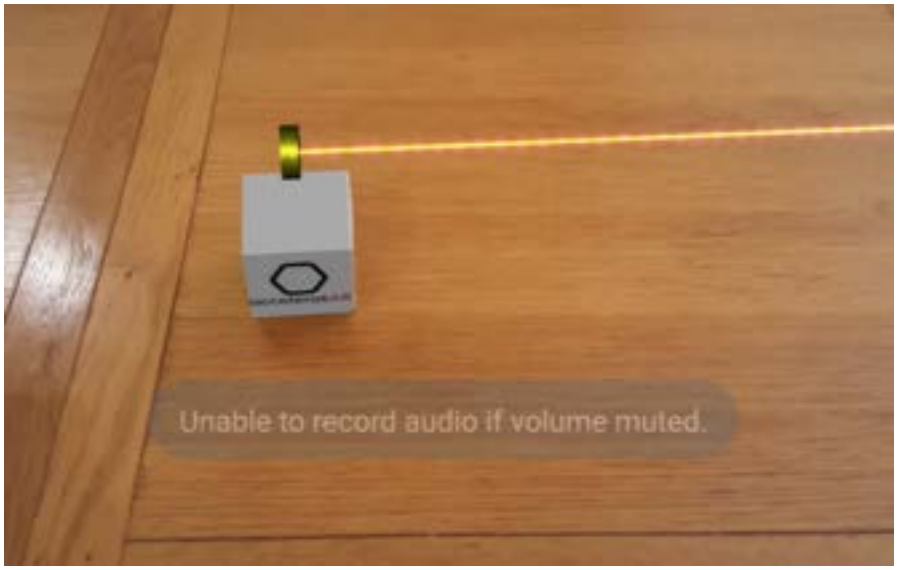
- discover new particles

- test theories about the universe

- understand the fundamental laws of nature

Today, accelerators are used in research, medicine, and industry.

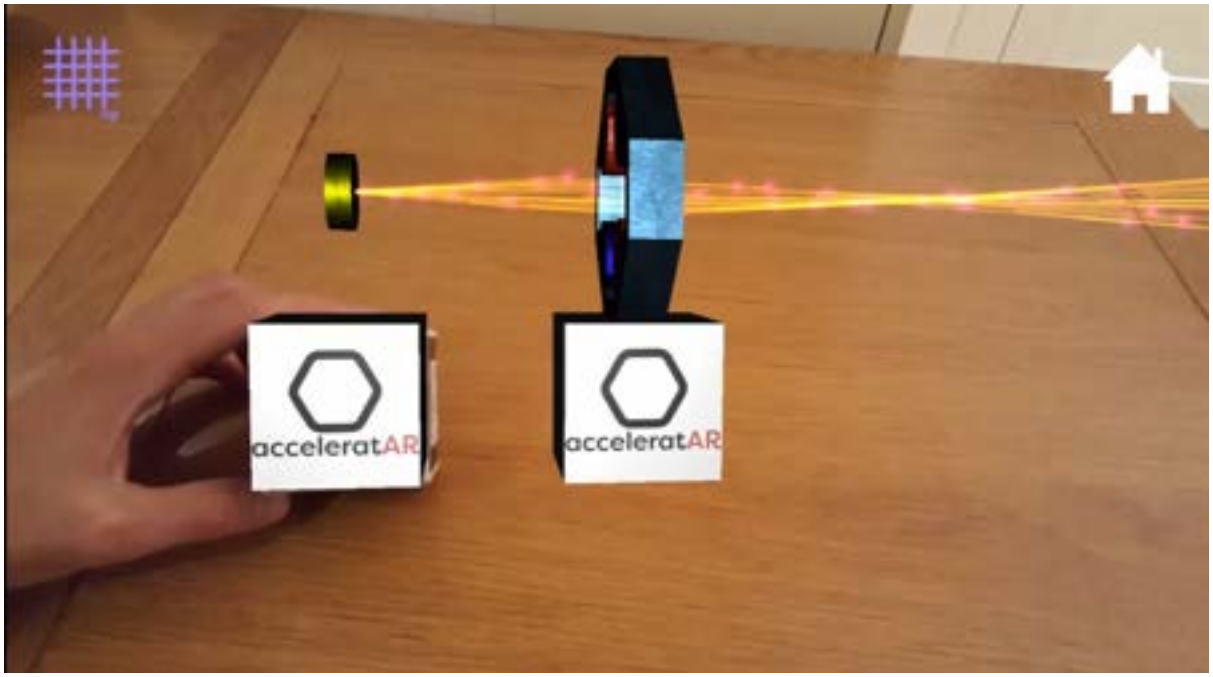
Source cube – creates a beam of particles. These are a little like the light rays in the optics experiment.



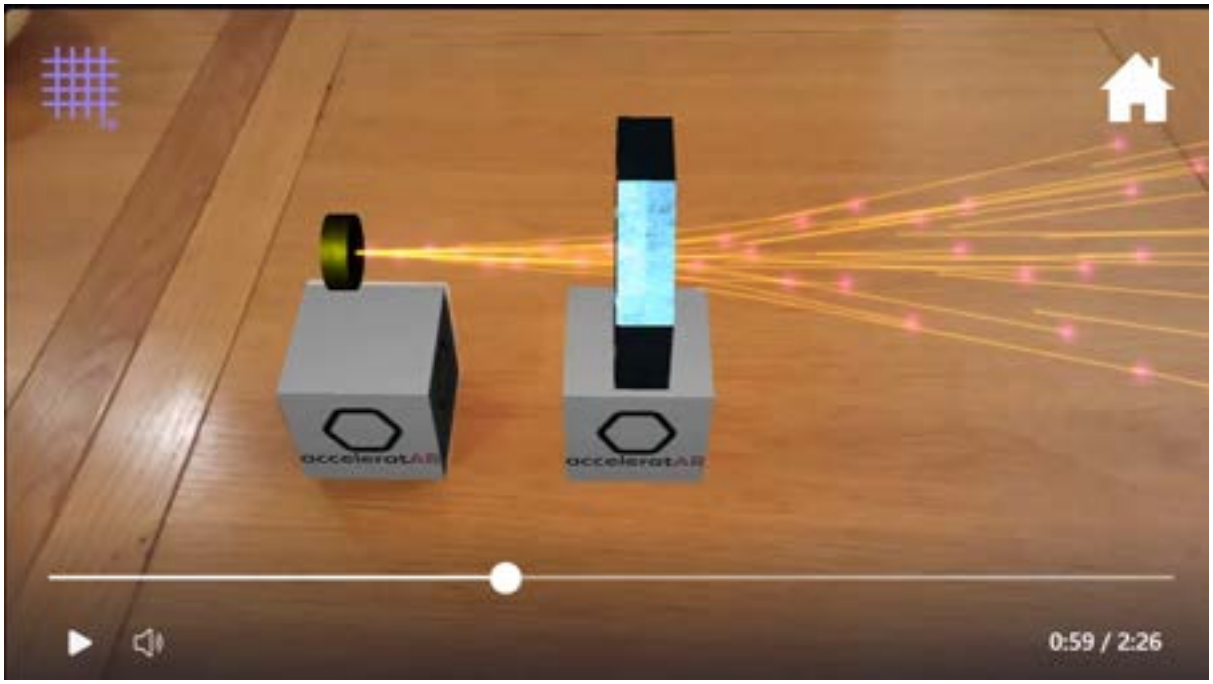
Focusing cube – These magnets are often compared to glass lenses for optics. The difference is that they can only focus in one plane. You need two magnets (with one rotated relative to the other to focus in both planes). Details below.

From 1 minute 7 seconds:

A particle beam passes through a quadrupole magnet. From this side, the beam appears to have been focussed a short distance after the magnet:



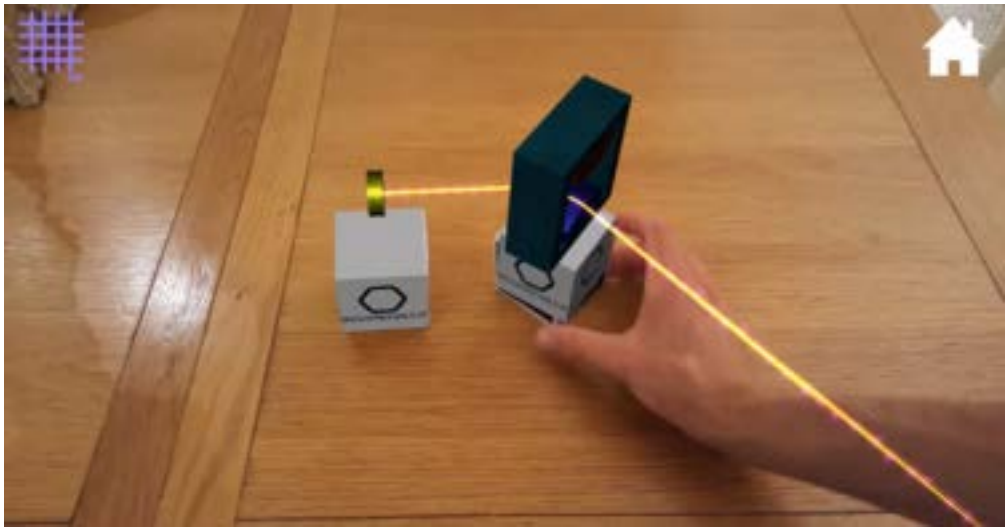
If looked from above, the beam looks to have been defocussed:



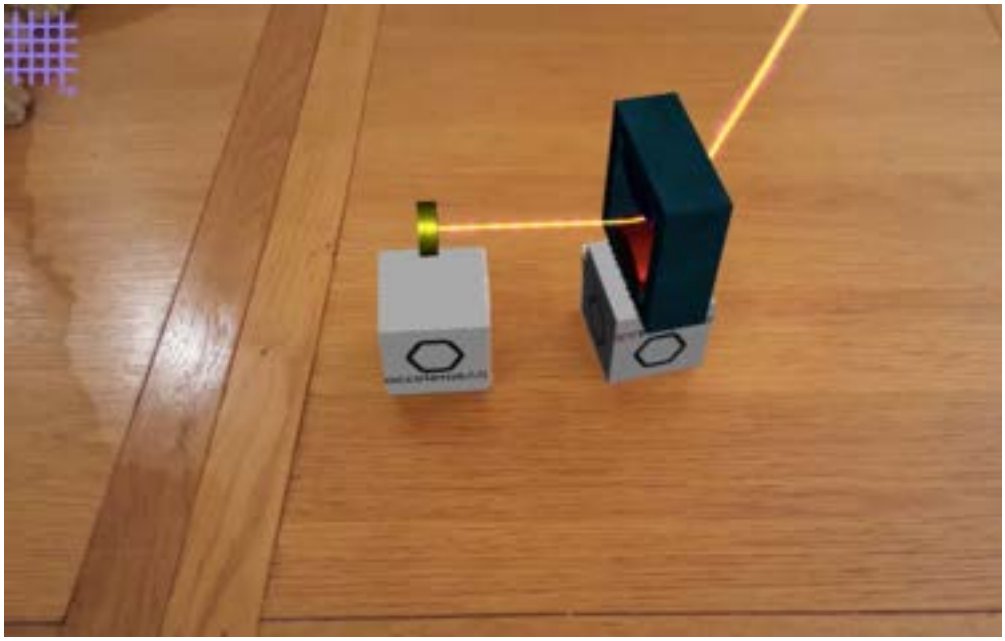
It takes two magnets to focus the beam along both the vertical and horizontal axis.

Steering cube-

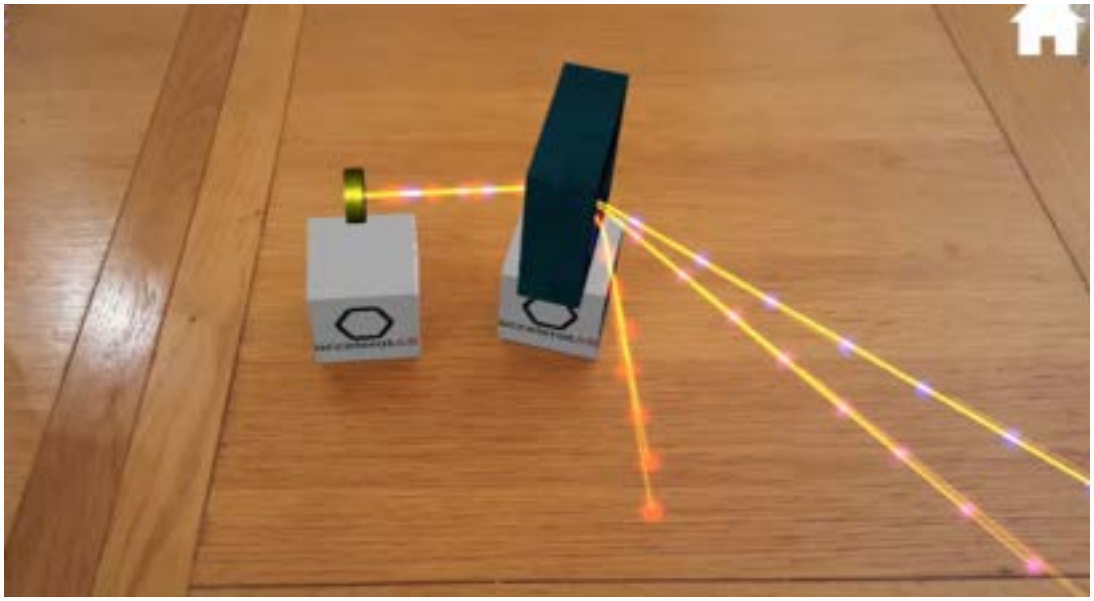
The direction in which a particle moves depends on the direction of the magnetic field. Below, south pole of magnet on bottom:



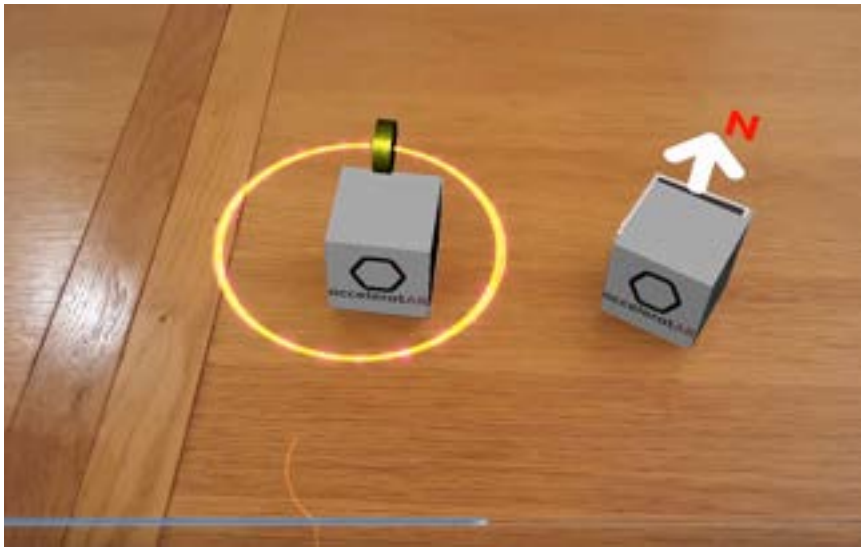
North pole on bottom:



The amount by which the particle is steered depends on the strength of the field, like light through a prism. Below, three different energy beams are input:



If magnetic field is the same everywhere, then particles travel in a circle:



Accelerating cube – Accelerates particles using electric fields.