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INVESTIGATING REFRACTION

(Lenses and Telescopes)

Strand/Strand unit

Energy and Forces: Light

Class level

5th/6th

Learning objectives

The child shall be enabled to:

- investigate the refraction of light
- explore how objects may be magnified using simple lens or magnifier

investigate use of lens
design and make model telescopes

(SESE: Science Curriculum, p.85)

Equipment

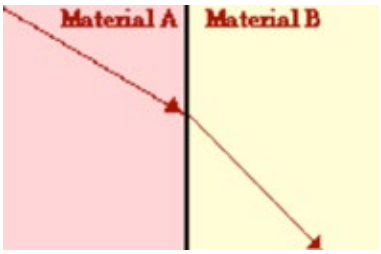
1. Jampot, water, pencil or straw
2. Small convex lenses (1 per child if possible), sheet of white paper
3. Small concave lenses (1 per child if possible), sheet of white paper

   (LENSES WITH 5 cm. DIAMETER AND FOCAL LENGTH 20 cm. ARE CHEAP AND SUITABLE FOR CLASSROOM USE)
4. For model telescope: 2 cardboard tubes (e.g. empty kitchen rolls) – one to slide up and down inside the other; 2 convex lenses – one short focal length (say 5cm.) and one long focal length (say 20 cm.), sellotape.

Preparation

- Collection of materials.
- Children will probably have carried out an activity in a younger class about ***shadows,*** in which they learn that light normally travels in straight lines. If they have not, then this should be done beforehand. Otherwise it may be more difficult to understand the concept of refraction of light.

Background information



Light normally travels in straight lines (think of shadows as an absence of light). This only happens if the light is travelling in the same substance all the time, e.g. through air OR through glass OR through water.

However, if light goes from one medium to another (e.g. from air to glass, from water to air, etc.) it usually bends. This bending of light when it goes from one medium to another is called REFRACTION. It happens because light travels at different speeds in different materials.

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INVESTIGATING REFRACTION

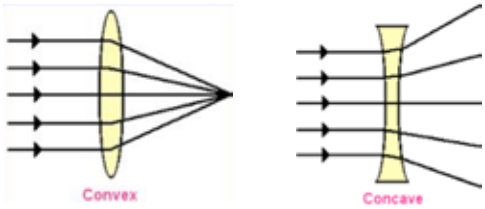
Background information

Lenses are specially shaped pieces of glass or transparent plastic that bend the light travelling through them.

Lenses which are thicker in the middle than at the edges are called CONVEX LENSES. Lenses which are thinner in the middle than at the edges are called CONCAVE LENSES (i.e. they cave in!). They both bend light as it passes through them.

Convex lenses *converge* light that passes through them.

Concave lenses *diverge* light that passes through them.



Telescopes gather up light from distant objects, e.g. stars. They come in all shapes and sizes, from a small plastic tube in a €2 shop to the very powerful giant Hubble Space Telescope which weighs several tons. Galileo made the first telescope in 1609, using a convex lens. This is called a *refracting telescope*. Galileo was able to see mountains and craters on the Moon through his telescope.

(Concave mirrors can also be used to collect distant light. Isaac Newton made the first *reflecting telescope* in 1688. *See DPSM activity 'Investigating Mirrors'*).

Both types are still in use

Our **eyes** contain convex lenses which gather up light coming into them and focus it on the retina, which sends messages to the brain via the optic nerve.

Skills

Experimenting, Observing, Analysing
Designing and Making

Cross –curricular links

MATHS: Estimating, Measuring

Trigger questions

What is a lens?
(Possible response: A specially shaped piece of glass or transparent plastic that can make things look different when you look through them).

Tell me one important difference between a lens and a mirror. Can light pass through both?
(No, light does not pass through a mirror.)

Where do you find lenses?
(Spectacles, cameras, telescopes, binoculars, microscopes.....)

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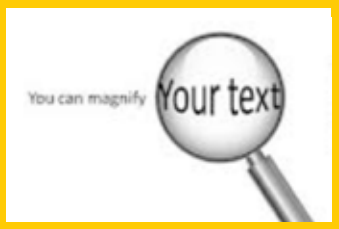
Activities

1. STRAW OR PENCIL IN WATER

Put a straw or pencil in a jampot or glass of water and let it go. Look at the straw from various angles. What do you notice? *(The straw seems to bend at the surface of the water. This effect is called refraction).*

2. INVESTIGATING CONVEX LENSES



This is a magnifying glass or hand lens

A: **Near:** Hold the lens close to some print, e.g. a book or newspaper.
What do you see? *(The image is large and right way up).*

Now look at your friend's eye through the convex lens.
What do you notice?

B: **Further away:** Now hold the convex lens further away from you (at arm's length) and look at something in the distance. What do you notice? *(The image is upside down).*

3. INVESTIGATING CONCAVE LENSES

A: **Near:** Hold the lens in front of some print. What do you see? *(The image is smaller and right way up)*

B: **Further away:** Now hold the concave lens further away from you and look at something in the distance. What do you see? *(The image is still smaller and right way up).*

4. DESIGN AND MAKE A MODEL TELESCOPE

Trigger Questions:

(i) What is a telescope?
(An instrument for making faraway things look much closer.)

(ii) What is the study of stars called?
(Astronomy. It is the oldest science).

Before Galileo invented the first telescope the only way people could study the stars and the Universe was to look at them with just their eyes.

(As telescopes are slightly tricky to make on account of the different focal lengths – which is a second level topic - it may be a good idea for children to follow a prototype first. They can then experiment with designing their own if the school has a variety of lenses of different focal length).

INVESTIGATING REFRACTION

Activities

Slide the narrower tube inside the wider tube. Attach the convex lens with the longer focal length to the end of the wider tube, and the convex lens with the shorter focal length (the bulgier one, which is called the eyepiece because it is the end which you look through) to the end of the narrower tube.

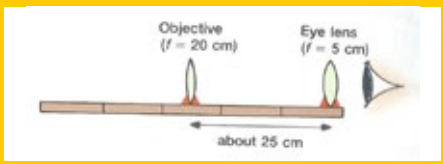
While looking through the eyepiece, slide the inner tube back and forth slowly inside the outer tube until you see a sharp image in the distance. What do you notice about the image? *(It is upside down).*

Why is it upside down?
(Because the first lens which the light meets collects the light from far away and turns the image upside down - remember when you held your convex lens at a distance from you. Then the lens near your eye magnifies this image, without turning it the other way up – remember when you held the convex lens near you.)

N.B. There is quite a narrow field of view in this model telescope, but it is the principle on which a real telescope is based.

You can experiment with the principle of this activity , without using tubes, by holding convex lenses of different focal lengths in the air at different distances apart – with the shorter focal length lens nearer your eye, as above. *(suggested by Frances McCarthy, Blackrock Castle Observatory, Cork).*

Another simple tubeless method to illustrate the principle of the refracting telescope is to set up the following arrangement, using a ruler, plasticine and the two convex lenses (5 cm and 20 cm focal length) approximately 25 cm. apart.



Analysis/Conclusion

What in general do you notice when you look at objects through lenses?
(The objects can look bigger or smaller, right way up or upside down, depending on the type of lens and the distance from it).

Safety

1. **Mind your eyes! <u>Do not look directly, or through lenses, into the sun or bright lights.</u>**
2. **Convex lenses can concentrate sunlight into one small area and could cause a fire on a hot day.**

Follow-up activities

WATER AS A MAGNIFYING GLASS

1a) **Drop of water**

Equipment: Small piece of clear plastic, a page of print, water, pencil or dropper.

Activity: Place a drop of water on clear plastic (using a pencil or dropper). What shape is the drop? Holding the plastic tight, place it over some writing. What do you notice?. Does this remind you of any type of lens you used? *(Convex).* What shape is a drop of water? *(Curved).*

Move the plastic nearer to and then away from the print. What do you notice?

INVESTIGATING REFRACTION

Follow-up activities

WATER AS A MAGNIFYING GLASS

1b) **Bottle of water**

Equipment: clear bottle of water, page of print.

Look at a picture or writing through a clear bottle of water. What do you notice? Does this remind you of any particular type of lens? *(Convex)*

Question: What shape was the water in the above two activities, to produce the magnification? *(Curved: convex).*

2. **"MAGIC COIN"** is a fun activity, based on refraction, for children working in pairs.

Equipment: Jug or jar of water, empty carton (butter cartons work well), coin, blutack.

Place a coin on the bottom of the butter carton and secure it with blutack. One child looks at the coin and moves his/her head back until the coin is JUST OUT OF VIEW. The other child pours water into the carton slowly. What does the first child see?

The children then reverse roles. What happens? Why do you think this happens?

Children Can:

1. Investigate spectacles: do they bulge in or out in the middle, i.e. are they convex or concave? What happens to the print if they hold the spectacles close to some print?
2. Try to 'catch a light'!

(a) using a convex lens: hold a convex lens towards a light (sun or artificial) and, with a sheet of white paper in the other hand, try to focus the light (i.e. to where it is the smallest and brightest) to a sharp point onto the paper, by moving either the paper or lens.

Convex lens

MATHS: (i) Estimate the distance between the lens and the paper.

(ii) (working in pairs) measure the distance between the lens and the paper (this distance is called the 'focal length', which is in the second level curriculum).

Concave lens

(b) using a concave lens *(This is not possible because a concave lens bends light in the other direction, i.e. it diverges the light).*

3. Try to predict which type of lens is contained in their eyes, to gather up light coming into them and focus it on the retina (the part of the eye which tells the brain what it sees).

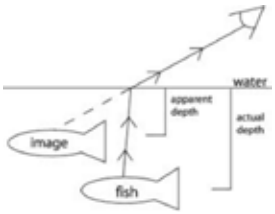
Shut their eyes and gently feel the outside of their eyelids with their clean fingers (CAREFUL! GENTLY!). What type of lens do they feel?

INVESTIGATING REFRACTION

Did You Know?

1. Short-sighted people wear spectacles which have lenses that are thinner in the middle, i.e. concave.

   Long-sighted people wear convex lenses. The lenses bend the light to form a sharp image on the retina (the part of the eye that sees).



2. Water can look a lot shallower than it actually is, because of refraction. Because light which is reflected off say a fish in water, bends when it reaches the surface, your eye assumes light travels in straight lines and sees the fish nearer the surface than it actually is.

   Have you noticed that when you paddle in water your legs appear to be shorter than their actual length? *(This is for the same reason).*

   SAFETY in the water! So refraction is important to think about before you jump into water – it might be much deeper than you think!

3. A fresnel lens (named after a Frenchman called Fresnel, who invented it) is a special type of convex lens – a very powerful one, which is used in lighthouses to send out extra strong beams. *(See DPSM activity 'Make a Lighthouse' – using an ordinary bulb in glass).*

Useful Websites:

For more about telescopes have a look at http://www.kidsastronomy.com/telescopes.htm

Another activity, using just one convex lens, can be found at https://www.exploratorium.edu/science_explorer/pictures_from_light.html

At www.bco.ie read about a partnership between Blackrock Castle Observatory, Cork and a primary school in the San Francisco Bay area, America, where the first robotic telescope project will be sited.

Maths and Space: A flying saucer containing aliens is about to invade! Try shooting it down using a laser beam at different angles, at http://www.innovationslearning.co.uk/subjects/maths/activities/year6/angles/game.asp