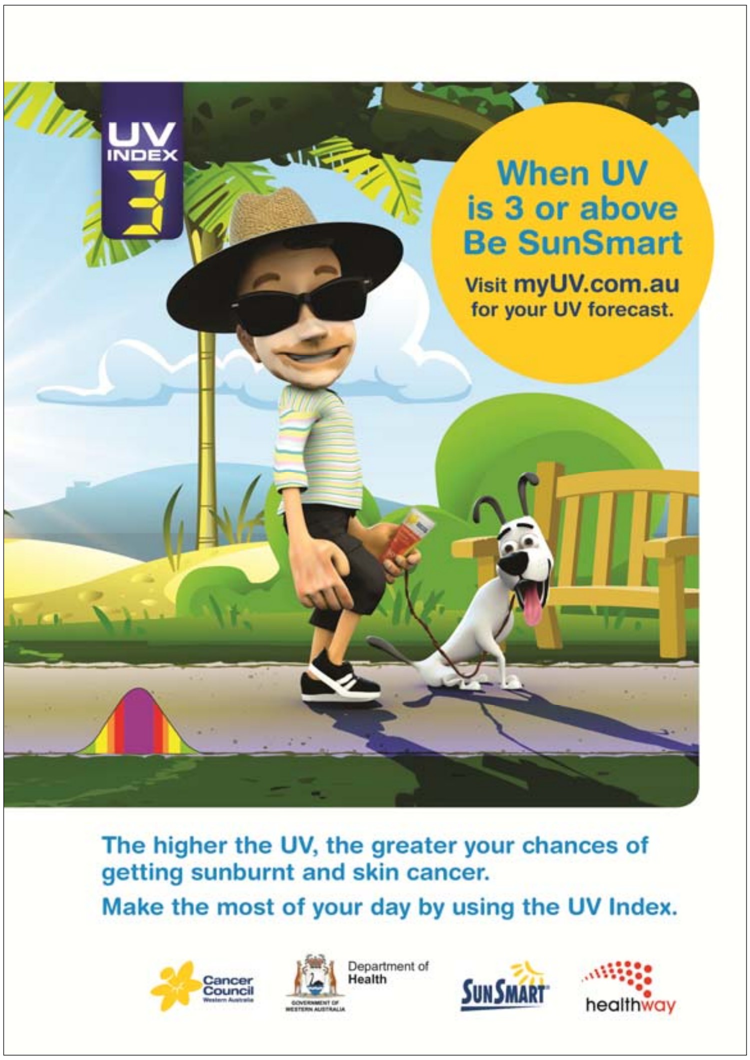
UV Radiation: How do we know it's there if we can't see it?

Primary School learning activities to help students understand the science of light and ultraviolet (UV) radiation.

SunSmart®

Cancer Council Western Australia

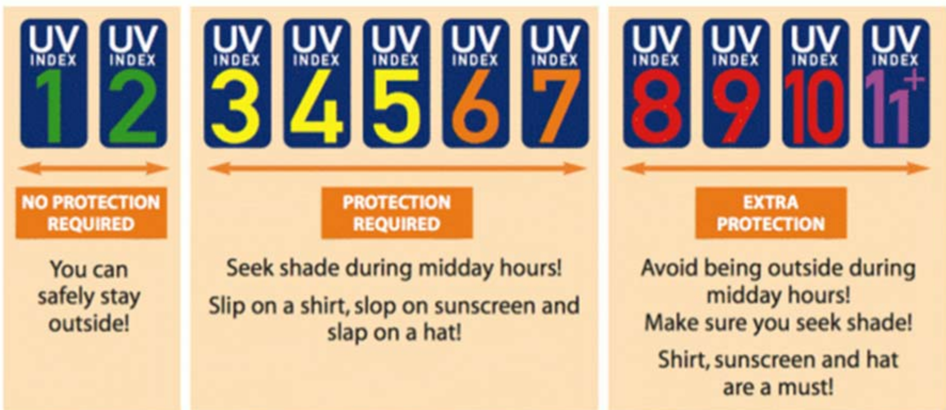
Cancer Council WA's UV Index Campaign



Launched in December 2012, the **UV Index Campaign** is Cancer Council WA's latest skin cancer prevention campaign. It aims to help people understand and use the UV Index to reduce exposure to ultraviolet (UV) radiation from the sun. Exposure to UV radiation, particularly during childhood, greatly increases the risk of developing skin cancer later in life.

Too much exposure to UV radiation can cause sunburn, skin damage and skin cancer. But too little UV exposure can lead to vitamin D deficiency, because the sun is the best source of vitamin D. That's why it is good to watch the UV index. It's safe to get sun under UV3.

The UV Index has been developed by the World Health Organization to communicate the amount of UV radiation reaching the earth's surface. It begins at zero and has no upper limit. The UV Index is often represented as a number line that conveys UV intensity and accompanying actions people should take to protect themselves from the sun (below).



To find out more about the **UV Index campaign** and the UV Index visit myUV.com.au

This resource has been developed by Mark Strickland and Emma Croager, Cancer Council WA, March 2013

UVLearning Activities Overview

This booklet contains eight interesting and interactive learning activities that can be delivered as stand-alone activities or presented as a term's science work. The aim is to help students understand the science of light, with a focus on ultraviolet (UV) radiation.

Learning Activities

- Prism spectrum
- Woods lamp/black light
- Earth-Sun simulation
- Sundial
- Graph the UV Index
- Periscope
- Pin-hole camera
- Polarised light

Prism Spectrum

There is more to light than we can see at first. Why you can get sunburnt on cool days. Why rainbows happen.

Aims

- To introduce the concept refraction and reflection.
- To illustrate that heat and UV are different.
- To introduce the Latin words infra and ultra.
- To demonstrate the visible spectrum (ROY G BIV)

About this lesson

A refracting triangular prism is made from clear material like glass or plastic. When a beam of light is passed through it in a certain way, the light is refracted or split into different wavelengths. This reveals the colours of the spectrum and raises some interesting questions.

Resources

- A prism – these can be purchased online or from the Scitech shop.
- A white screen. This can be a sheet of paper or card (or a white wall or projector screen etc).
- A variety of torches – some LED and some incandescent is best.
- A sheet of thin card.
- Scissors.
- A darkish room helps this lesson greatly.

Time required

- 15 minutes.

Instructions

The prism works best when a narrow beam of light is passed through it. You can use a piece of card to achieve this.

1. Cut a short 2mm wide slit in the card (see Figure 1).
2. Fold card so that it stands on the table.
3. Turn torch on and place it behind the slit in the card.
4. Move the torch closer to or further away from the card until you achieve a beam of light with parallel sides coming from the slit.

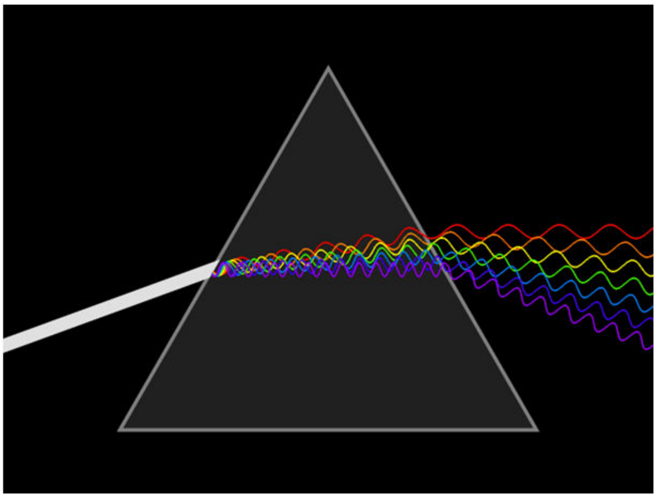
5. Place your prism into the beam of light. Experiment with the position of the prism until you see the beam of light bend ~ 90 degrees.
6. Place your screen in the path of the beam that is coming out of the prism. You should see a spectrum on the screen. If you are using a wall or projector screen, you will need to move the prism and beam of light until you see the spectrum.

Using your prism

You will need to experiment with the positions of the prism, the torch and the screen to achieve a good spectrum. The further away from the prism you place the screen, the wider and fainter the spectrum will be.

What's going on?

Light travels at different speeds in different media. When light enters the prism, it slows down. This speed change causes the light to be bent (refracted) and to travel through the prism at a different angle. The degree of bending of the light's path depends on the angle that the incident beam of light makes with the surface of the prism and also on the refractive index of the prism. (The refractive index of a material describes the degree to which the material bends light). Since different wavelengths – or colours – of light refract at different angles, the prism causes each colour in the white light to be refracted differently and to leave the prism at a different angle, creating an effect similar to a rainbow. See picture below:



With care you should be able to produce a full spectrum from red though to violet. This represents the full range of wavelengths that can be seen by the human eye.
But there is MUCH more light energy here that cannot be seen.

Just beyond the red is the infrared. (Infra is latin for ‘beneath or below’). This is the part of the spectrum that we feel as heat. Infrared light can be seen with night vision goggles and some cameras. Infra redlight was discovered by William Herschell.

At the other side of the visible spectrum just past the violet light is ultraviolet. (Ultra is latin for ‘above or beyond’). Ultraviolet light is the part of the light that causes sunburn and skin damage. You cannot feel it. This demonstration shows us that heat radiation – infrared or IR radiation – and sunburning radiation – ultraviolet or UV radiation – are separate. This is why you can get sunburnt on cool days. UV light was discovered by Johann Ritter.

Extension Activities

- Find out who William Herschel was and how he discovered infrared light.
- Find out who Johann Ritter was and how he discovered ultra violet light.
- What is the difference between reflection and refraction?
- What is diffraction?

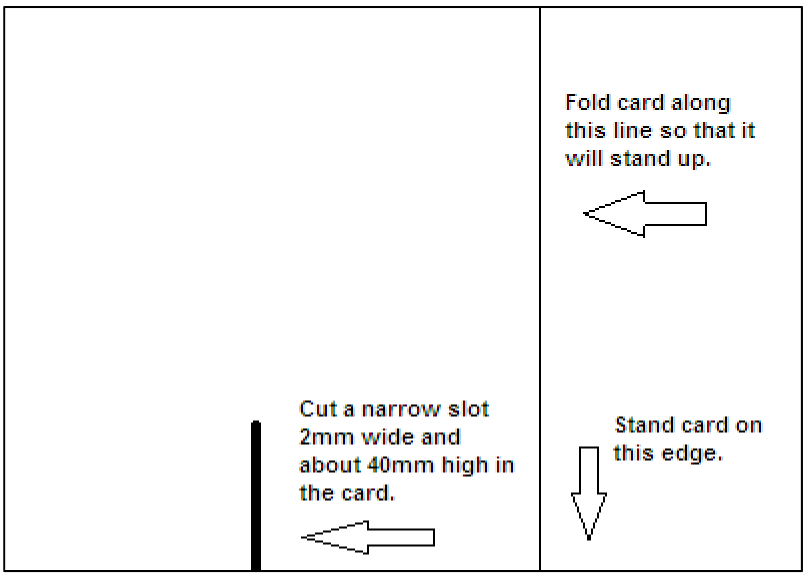


Figure 1. How to cut and fold a card to make a light beam.

Woods Lamp/Black Light

UV is a form of light that we cannot see. We can see its effects though. If UV is strong enough it can cause sunburn and skin damage.

Aims

- To demonstrate that UV light is invisible, but it's effects can be seen.
- To introduce the UV index as a tool for discussing the strength of UV.
- To examine the concept of fluorescence.
- To introduce the UV index as a way to speak about the strength of UV

About this lesson

A Woods lamp is another name for a black light. Black Lights have a filter that blocks most (but not all) the visible light produced by the lamp inside and allows only the UV light to escape. We cannot see this UV light, but we can see its effect on some materials.

Resources

- A black light. These can be purchased from Scitech or online.
- Highlighting pens.
- Samples of different washing liquids.
- A dark room.
- Credit cards.

Time required

- 30 minutes.

Instructions

Depending upon the number of black lights you can obtain, this may need to be conducted as a demonstration to the class.

1. Take a small sample of laundry detergent and smear it on an object or piece of clothing.
2. Use a highlighter to put a small spot on your skin or fingernail.
3. Write something with highlighter on a page.
4. Darken the room and turn on the black light.
5. Shine the lamp on the detergent and the highlighter. Notice that they appear to be bright and easy to see.

6. Shine the black light on the credit cards. You might notice markings that are only visible in UV light. Master cards have the letters MC hidden in them as a security device.
7. Look up the UV Index at www.myuv.com.au Learn to read it.

Using your Woods lamp

The level of UV radiation produced by black lights is very, very low. This experiment will not put the children at risk of UV-related skin damage. You can demonstrate this with a UV meter – if you have a Cancer Council Regional Education Officer in your town/region, you can ask to borrow their UV meter.

What's going on?

When ordinary light strikes an object it simply bounces off and we see ordinary colours as a result. When UV light strikes some objects, they absorb the light and immediately reradiate it at a slightly longer wavelength. This makes it visible. When things do this they are said to fluoresce.

Fluorescence has many practical applications, including mineralogy, gemology, chemical sensors (fluorescence spectroscopy), fluorescent labelling, dyes, biological detectors, and, most commonly, fluorescent lamps.

The UV Index is a scale that describes the strength of the UV light reaching the ground.
The higher the number, the stronger the UV. Scientists tell us that when the UV index is 3 or more that our skin can be damaged by UV. This damage causes sunburn and, over many years, can lead to skin cancer.

Extension Activities

- What is the difference between fluorescence, luminescence and phosphorescence?
- Why don't we see items fluorescing in normal daily life? After all, the UV Index tells us UV can be very strong.
- UV and visible light are both part of the electromagnetic spectrum. Radio waves, X-rays, gamma rays, microwaves and infrared light are also part of the electromagnetic spectrum. Try to find a diagram that shows where they all fit on the spectrum.
- Find out what the term 'wave length' refers to.

Earth-Sun Simulation

The angle of the earth to the sun creates the seasons. The intensity of the sun changes due to this angle. UV levels remain fairly constant from day to day despite changes in local weather on the ground.

Aims

- To introduce the angular relationship between the earth and the sun.
- To illustrate the effect that the angle has on the light that strikes the earth's surface.
- To illustrate why the earth has seasons.
- To demonstrate that UV is fairly constant despite changes in local weather from day to day.

This helps students to understand that sun protection can be required on cool days.

About this lesson

A correct understanding of the earth-sun relationship is useful in helping us to understand the seasons and the variations in the length of days, months and years. It also helps to dispel common myths such as 'It is hotter in summertime because the earth is closer to the sun.'

Resources

1. A light bright light source to simulate the sun (eg. a camping lantern or table lamp without the shade on).
2. A hand held torch.
3. A ball to simulate the earth. A basketball is OK. A Styrofoam ball that you can push a pencil through is even better.
4. A darkish room.

Time required

- 30 minutes.

Instructions

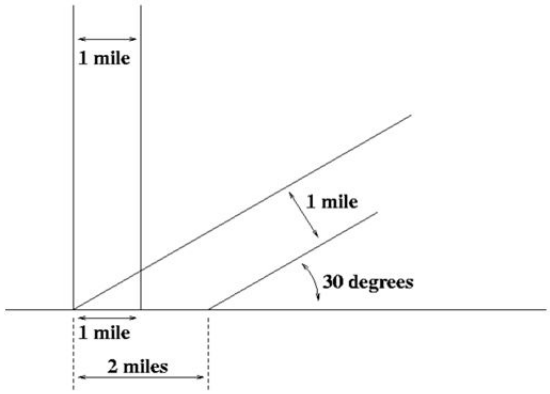
1. If you are unfamiliar with this topic – view this excellent animation. http://esminfo.prenhall.com/science/geoanimations/animations/01_EarthSun_E2.html
2. Take a torch and shine it directly at the ground (ie perpendicular to the ground) Ask students to note how bright the pool of light is and how large the pool of light is.
3. Now, holding the torch at the same height above the ground, shine the torch at the ground at an angle of 45 degrees. Ask students to note how bright the pool of light is now, and how large the pool of light is. They should notice that the light is much-less bright and that the pool of light is much bigger.
4. Point out that the light source has not changed, but that the strength of the light on the ground has varied a great deal because the angle changed from 90 to 45 degrees.
5. On a basketball (or other earth analogue) mark the Equator, the North Pole and the South Pole. Then draw in Australia.
6. Place the lamp that will simulate the sun in the centre of the room.
7. Draw or otherwise mark out a large circle around the sun lamp to show the orbit of the earth around the sun.
8. Estimate an angle 23.5 degrees with the students.
9. Have a student stand on the circle that represents Earth's orbit, holding the basketball so the Poles are tilted at an angle of 23 degrees. Ask the student to rotate the basketball to simulate a day. Notice where Australia is when the sun is shining on it.
10. Now have the student walk to the other side of the orbit. (Simulating the passing of six months). Repeat the rotation of the Earth (Step 9) and note the difference in the position of Australia when the sun is shining on it.
11. Point this out to the students and ask them which one represents summer and which one is winter time.
12. Repeat the exercise but this-time hold the earth with the axis vertical. Note that the amount of light striking Australia does not change in this situation.

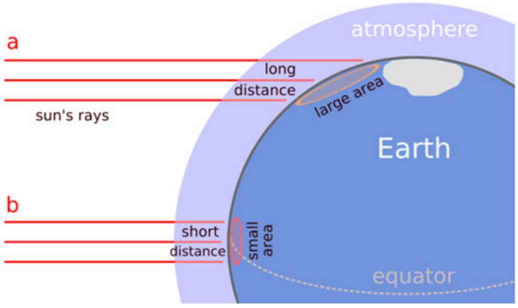
About the Earth-Sun relationship

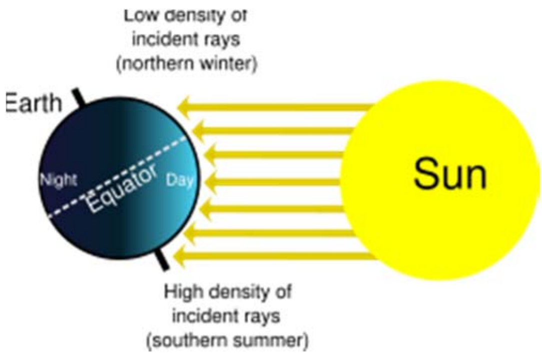
The axis of the earth is tilted at 23.5 degrees from vertical. This means that, in our summer time, the southern hemisphere is tilted so that the sun strikes the ground almost vertically at midday. So the sun's energy is concentrated onto a small area that gets very hot.

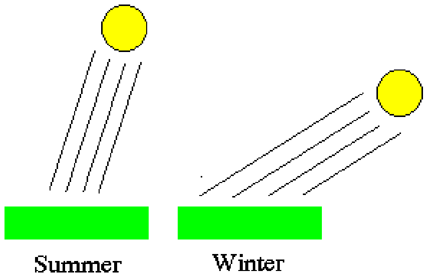
During our winter time, the southern hemisphere is tilted so that the sun strikes the ground at a significant angle. This spreads the sun's energy over a much wider area and reduces the maximum temperature that we experience.

See the following illustrations:









If the angular tilt did not exist we would not have seasons.

What's going on?

You can see that tilt of the earth is very important in determining the intensity of the radiation (sunshine) that reaches the ground. This in turn, varies the intensity of the various components of the solar radiation such as the UV energy and the IR (infrared) energy that reach the ground.

Extension activities

Look at the other planets and moons in our solar system.

- Would they also have seasons? Can you find one that would not have seasons? (Hint: if the axis is tilted it has seasons)
- What would the seasons be like on Uranus?

Sundial

As the sun moves across the sky during the day, shadows become longer and then shorter. When your shadow is shorter than you are, the sun is strongest so you burn quickest.

Aims

- To highlight the sun moves across the sky in a regular way and that it can be tracked.
- To investigate how shadow length changes during the day.

About this lesson

Understanding how the sun moves across the sky and how this movement affects shadows can help understand why UV levels change during the day.

Resources

- Sunny area with a level, flat surface.
- Stick 750 – 1000mm in length. A cricket stump or broom handle size is ideal.
- Large flower pot. Only used to support stick if it cannot be supported any other way.
- Clock or watch with second hand.
- Chalk, paint or markers (eg milk bottle tops) as appropriate.
- Measuring tape, ruler or blackboard ruler.
- Hats, sunscreen for everyone outside if UV is above 3.

Time required

Day 1

- 10 minutes initially, then 1 min every hour between 9 am and 4 pm for observation and recording of data.

Day 2

- 10 mins on day two to mark out and consider the SunSmart zone.

Instructions

Day 1

1. Locate a suitable area with all day sun exposure and a hard, level, flat surface.
2. If required, fill the flower pot with soil and place it in the centre of your area.
3. Push the stick (called a gnomon) into the soil in the flower pot and ensure that it is as vertical as possible.

4. Alternatively, just push your gnomon into the ground.
5. The gnomon should now be casting a shadow.
6. Using the clock to monitor the time, come back and mark the end of the gnomon's shadow precisely on the hour, every hour.
7. Place markers every hour between 9 am and 3 pm.

Day 2

8. Using an appropriate marker such as the blackboard ruler and chalk, or string lines, have some students draw lines connecting the hour marks and the base of the gnomon. Then, using a different colour chalk, shade in the area of the sundial that represents the 'peak' SunSmart hours (10 am to 3 pm). Discuss the result with the students.
9. Visit the sundial several times on Day 2 and use it to estimate the time.

What's going on?

The shadows cast by the gnomon each hour are different lengths. This is because, as the earth turns under the sun, the angle of the sun's rays changes. This causes a change in the length of the shadow.

If you do this activity in the summer time and then again in the winter time, your sundial hour markers will be in a different place. This is because the Earth is tilted on its axis at 23.5 degrees and the sun appears higher in the sky in summer time than it does in winter. This changes the sun's angle to the gnomon and causes the shadows to be in different places.

We need to be SunSmart for some hours of the day – when the UV is above 3 – and not in others. This is because when the sun is highest in the sky and is shining almost straight down, UV levels are highest. This is because the sunlight (including the UV radiation) passes through less atmosphere and is more intense because of this.

We need to take extra care to be SunSmart in the middle of the day, even when it does not feel hot. This is because UV radiation causes sun burn but does not carry heat energy. We cannot see or feel UV radiation, so if the UV is above 3 our skin can be damaged and burn without ever feeling hot.

Extension Activities

- Work with the local council to construct a permanent SunSmart sundial in the local community.
- Prepare a presentation about their SunSmart sundial and deliver it to other classes in the school, or community groups such as senior citizens or other schools.
- Students could do this activity at home with brothers/sisters, parents and grandparents.

Graph the UV Index

UV light (or radiation) varies in strength. The UV Index (UVI) is a global standard for describing the strength of UV radiation. The UV index is used to create UV forecasts that can help to keep us safe in the sun.

Aims

- To introduce the concept of a UV forecast.
- To demonstrate that past experience can help to predict future events.
- To demonstrate that the same information can be presented in a variety of ways.

About this lesson

Records of previous UV Index levels are very useful in helping to forecast future UV levels. The Bureau of Meteorology (BoM) and Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) work together to record and predict future UV levels. This information is used to create the UV Bell Curve, also known as the UV Alert forecast. This tells us what strength we can expect the UV to be at various times of the day. We can use this information to help us decide if we need sun protection or not.

In this lesson, students will choose a location and record, then graph, the UV index level as it changes over the course of a week. They will then use this information to predict the UV index for the next day.

Real time UV measurements are only available for Australian capital cities and selected other locations. For the purpose of this lesson, the student can choose to monitor the UV in any location for which there is data. They might like to choose a location at the same latitude as the city/town they live in.

Resources

- A computer connected to the internet.
- Materials to make a paper chart or a copy of Excel on a computer.

Time required

- 20 minutes initially, then a few minutes each day for observation and recording of data. Then time to discuss results and make predictions about a week later.

Instructions

1. Log on to www.myuv.com.au and find the current UV for Perth. Click on the 'Your UV Forecast' page and look at the bell curve forecast diagram.
2. Log on to http://www.arpansa.gov.au/uvindex/realtime/index.cfm and http://www.arpansa.gov.au/uvindex/realtime/antarctic_rt.htm to see the real-time UV for other locations.
3. Record the UV level and the time of day once every hour. Do this for 5 days.
4. Graph the results. A line graph showing the five days results would be simple and clear, but children can experiment with different graph formats to find one that may be more useful. Excel makes this easy.
5. Use your completed graph to predict the UV index at the same times for the next day.

About the UV Index

It will be useful for students and teachers to know that the following facts.

- The strength of UV radiation changes throughout the day. It is weakest in the morning and late afternoon and strongest when the sun is directly overhead. This is called **Solar Noon**.
- UV radiation also varies from place to place. This tends to be by latitude. Places that are close to the equator have higher UV levels, whereas places near the poles have lower UV. See this website http://www.bom.gov.au/wa/uv/index.shtml
- UV varies according to the season. Summer UV is higher than winter UV in the same location.
- UV varies on a daily basis depending upon cloud cover and ozone cover.
- Despite all these factors, average clear sky UV levels are quite predictable for a given place and time.

What's going on?

We know that some UV radiation is essential for good health since UV radiation provides our bodies with most of the Vitamin D that we need. We also know that too much UV is bad for us. It causes skin damage and skin cancer. Damage from UV cannot be undone and is cumulative. Therefore it is very important that we learn to understand when UV will be good for us and when UV will harm us. The UV index provides us with this information.

Scientists and dermatologists advise that skin damage begins to occur when the UV index level is 3 or more. If we are outside then, we need to wear sun protective clothing and sunscreen.

Extension Activities

- Try to find other factors that cause variations in UV level.

- See if you can locate other ways to show the UV forecast – apart from the bell curve.
- Can you find out what the UV index is outside the earth's atmosphere?

Useful reference

Liley, JB and McKenzie RL (2006) Where on earth is the highest UV?

https://www.niwa.co.nz/sites/default/files/import/attachments/Liley_2.pdf

Periscope

Light, including UV light, reflects from surfaces. This means that we can still get burnt while we are in the shade.

Aims

- To demonstrate that light travels in straight lines.
- To demonstrate that light can bounce off surfaces and continue travelling.
- To demonstrate a practical use of angular measurement.

About this lesson

Essentially, periscopes let us see around corners. Submarines and military tanks both use periscopes to allow those inside to see out. Real periscopes use optical lenses and digital sensors and can magnify as well as see in infra-red wavelengths. Our periscopes will use mirrors.

Resources

- Sheets of light card. Manila folders are perfect - 1 for each student.
- Paper glue.
- Sticky tape.
- Scissors.
- 2 plastic mirrors – these can be ordered from BCJ Plastics, Osborne Park, 9443 8600 or Superline Plastics, Kewdale, 9353 2383 Order silver acrylic mirror, cut to squares 49 x 49 mm. 2 per student.
- Periscope template. See following page.

Time required

- 45 minutes.

Teachers will need to decide how to provide each child with the template. Older students can measure and rule it up themselves on blank card. Younger students may need a pre-printed copy.

Instructions

1. Cut out the periscope body from the template.
2. Using a ruler to get sharp straight edges, fold the template along the lines shown.
3. Glue the tabs in place to create the body for your periscope.
4. Place a mirror into the viewing window at one end of the periscope.
5. Set the mirror to a 45 degree angle and tape in place. (Hint – you will know when you have a 45 degree angle because you will be able to see the other end of the periscope body.)
6. Place a mirror in the viewing window at the other end and tape in place.

Using your periscope

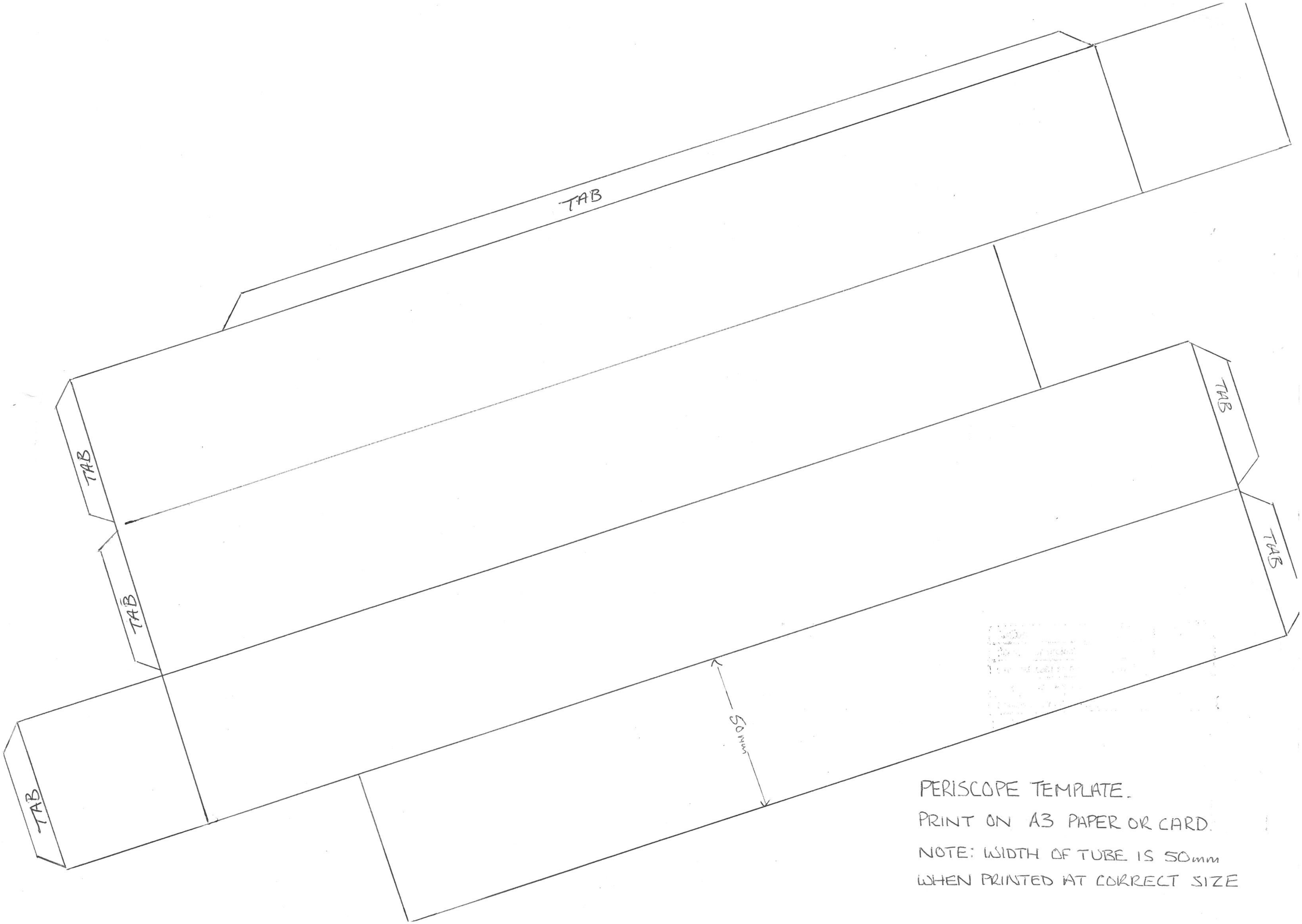
Remember you can use your periscope to see over things and also to see around corners.

What's going on?

Light normally bounces off an object at the same angle that it strikes it. By setting our mirrors at 45 degrees we can get the light to bounce down the periscope tube, hit the bottom mirror and then bounce into our eyes. Have the students draw the path a light ray takes through the periscope.

Extension Activities

- Try making a longer periscope with a mailing tube. (Hint - You may need bigger mirrors)
- Find out how long real periscopes are and what they can do.
- Try joining two periscopes together.
- Search for pictures that show reflections.
- Find out how mirrors are made and what different kinds of mirrors there are.



PERISCOPE TEMPLATE.

PRINT ON A3 PAPER OR CARD.

NOTE: WIDTH OF TUBE IS 50mm WHEN PRINTED AT CORRECT SIZE

Pin-hole Cameras

The first cameras were very basic. You can make a simple version of them with some cardboard, foil and tape, but the big question is 'Why is everything upside down?'

Even though we cannot see UV with our eyes, we can take pictures with false colour UV cameras. We know UV is real.

Aims

- To demonstrate that light travels in straight lines.
- To introduce the concept of a lens and that a pin-hole can act as a simple convex lens.
- Students will understand that a camera is a device that captures light. There are different types of cameras.

About this lesson

Pin-hole cameras usually consist of a sealed box with a pin-hole on one side and some film or photographic paper on the other side to record the image. Here we'll make a pin-hole camera that doesn't use film, so you'll see the image but not record it. Using tracing or greaseproof paper instead of film you can test the theory of pinhole projection for yourself and view the world upside down.

Resources

- Cardboard mailing tubes (1 for each student), **or**
- Sheets of A4 card (1 for each student).
- Extra A4 card to make the Pin Hole camera screen shade (1 per student).
- A pin (or straightened paperclip).
- Aluminium foil.
- Greaseproof paper.
- Strong tape (preferably opaque/not clear).
- Scissors.
- Magnifying glass.
- Strong elastic bands (2 for each student, optional).

Time required

- 10 to 45 minutes depending on method chosen to make camera body.

If using cardboard mailing tubes, teachers will need to pre-cut sections of mailing tube before the lesson. Almost any length of tube will work but good results are obtained when tube length and diameter are equal. Experiment with different lengths.

Instructions

1. Decide on method to construct camera body – can use tubes for younger students and template for older students, or tubes if less time for activity.
2. **10min build time.** Use pre-cut cardboard mailing tube sections for camera body (go to Step 4).
3. **45 min build time.** Use the template included with this lesson to build the camera body (go to Step 7).

4. **For cardboard mailing tube version**. Cut a section from the end of the cardboard tube. This **length** of this section **should not be less than the diameter of the tube**. Take the short, cut section of tube and cover one open end with foil. Wrap tape around tube to hold in place (or use a strong elastic band). Cover the other end of this tube with tracing paper. Carefully fold the paper down over the tube to avoid wrinkles and creases in the paper. Tape this in place (or use a strong elastic band).
5. Place the camera foil side down on the table. Now take the remaining piece of cardboard tube and stand it on the tracing paper end. Tape in place. (This becomes the screen shade).
6. Turn the camera over, and use pin to carefully make small hole in the centre of the foil.

7. **For template version**, print template onto light weight card (or print template on A4 paper and glue to card).
8. Cut out template from card. Remember to cut out the small window in the wall too.
9. Fold and glue, or tape, the box into shape. When it is finished you will have a small box that is open at one end, with the window opposite the open end.
10. Place window-side down on table and tape a piece of foil so it tightly covers over the window in the bottom of the box. (Hint – It may be easier to do this before the box is glued or taped together, but make sure the foil is on the inside of the box).
11. Now cut a piece of tracing paper to fit over the open end of the box. Tape in place.
12. Using a pin, carefully make a small hole in the middle of the foil.

Using your camera

Take your pin-hole 'camera' outside and look through the viewing hole. You should be able to see the world upside down on the greaseproof paper. If you can't see anything, try making the hole a bit bigger until you get an image on the paper. Experiment with different sized holes to find out which size gives the best effect. The hole is called the aperture: the bigger the aperture, the brighter the image. But as it gets bigger, the picture gets more out of focus.

What's going on?

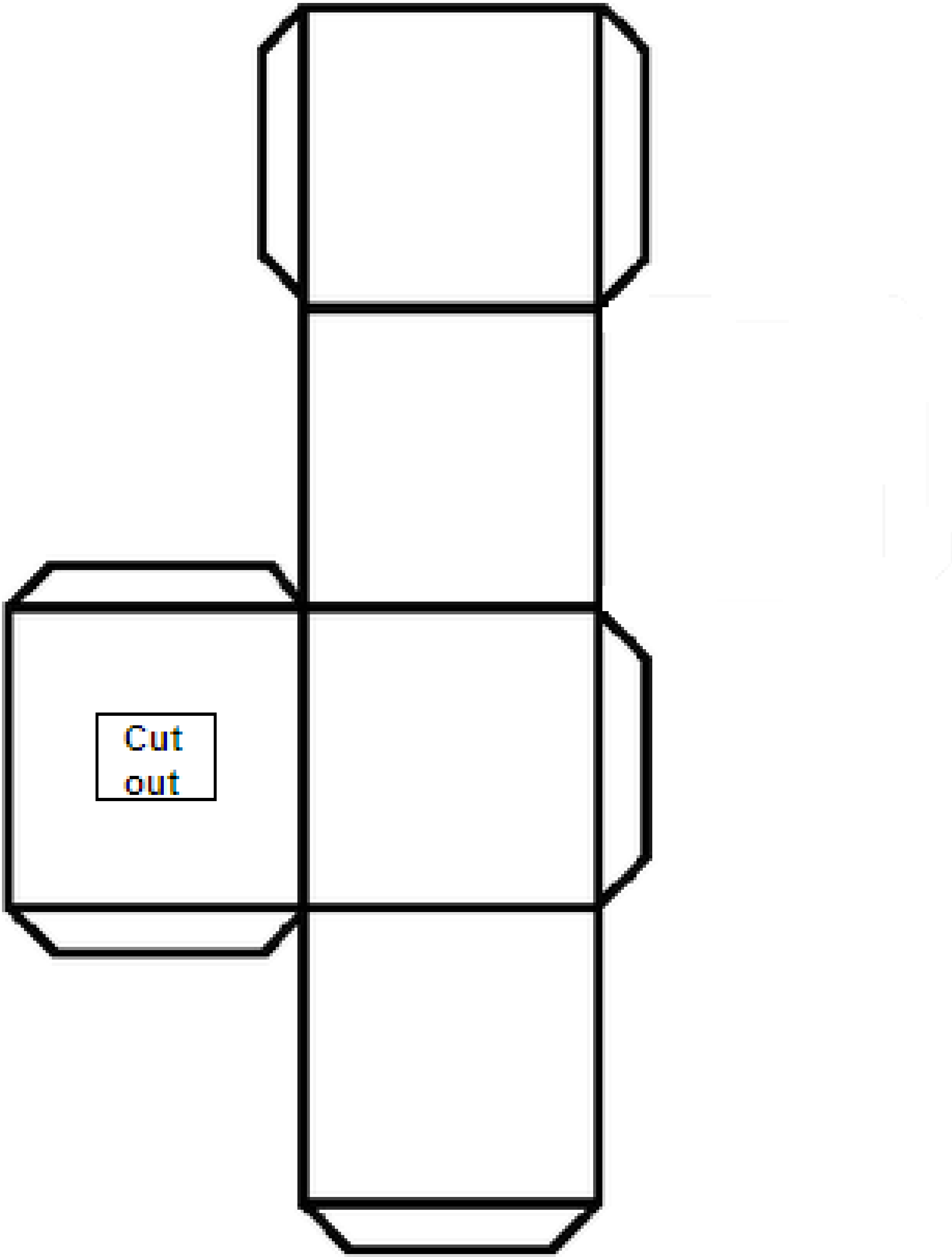
Light travels in a straight line unless it's diverted, so light travelling from the base of an object will travel in a straight line through the hole and hit the top of the screen. This is why the image appears upside down. The pin hole is acting as a simple convex lens. If you hold a convex lens magnifying glass at arm’s length and look through it, you will see that it also inverts the image.

Extension Activities

- Investigate ray diagrams for convex and concave lenses.
- Investigate how film cameras used to work.
- Investigate how digital cameras work.
- Investigate false colour UV pictures of the sun.

It can be expensive and tricky to process film or use photographic paper, but you might like to try converting your pinhole viewer into a camera.
Be careful, as the film or photographic paper must not be exposed to the light - load the camera in a dark room and keep the pin hole covered until you are ready to take your picture.

Pin Hole Camera Template



Polarised light

Along with wavelength, and phase, polarization is one of the fundamental characteristics of light. This lesson looks at what polarization is and some ways we can use this behavior of light to our advantage.

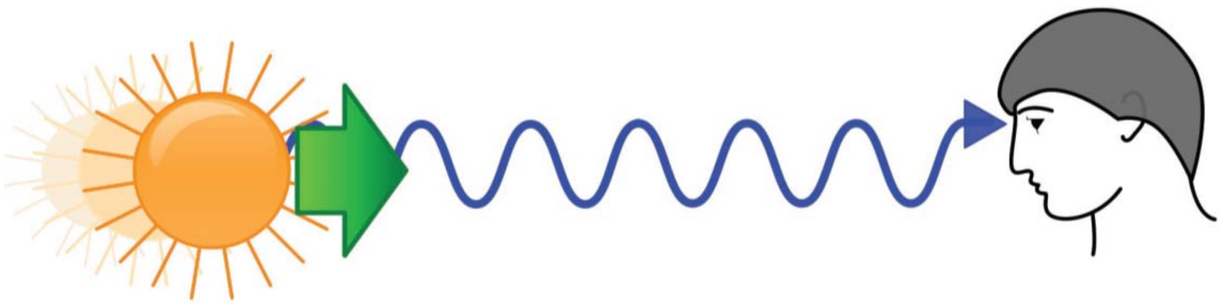
Aims

- To demonstrate and investigate the wave concept of light using polarisation.
- To investigate how polarised sunglasses work.

About this lesson

Light sometimes behaves as a wave and sometimes as particles. In this lesson we will think of it as a wave.

When light travels as a wave, it looks like this.



Notice that as this wave travels from left to right, its wave pattern is up and down (vertical). Scientists call this wave pattern the direction of vibration. Now, in normal light, not all the light rays vibrate vertically. Some vibrate horizontally. In fact, light rays can vibrate on any angle as they travel.

If you are having trouble understanding this, it might help to imagine a light ray coming straight at you. A light wave that is vibrating vertically will be like a car travelling on a straight but hilly road. It will move vertically up and down over the hills and valleys as it moves towards you.

A light wave that is travelling towards you in a horizontal vibration would be like a snake, slithering towards you by swishing its body left and right as it moves along.

Some sunglasses are described as having polarised lenses. What does this mean and are they better than ordinary sunglasses? Non-polarised sunglasses block some light. Polarised sunglasses are also designed to block some light, but they block glare as well. How?

Children work in groups of three or four for this activity. It is ideal to have two pairs of polarised sunglasses for every group.

Resources

- Polarised sunglasses.
- A variety of transparent plastic objects. CD cases and clear plastic rulers are ideal.
- Flat computer screen (LCD).
- Clear sticky tape (not cloudy magic tape).

Time required

- 30 minutes.

Instructions

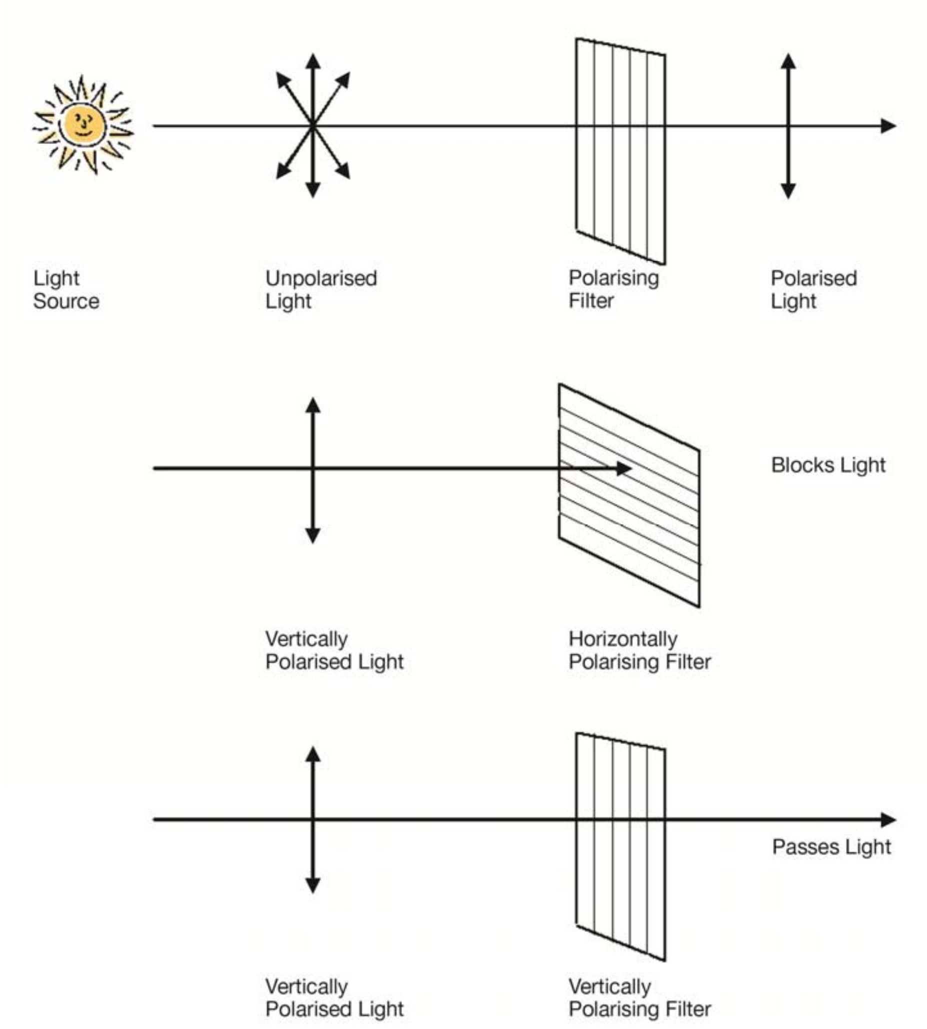
1. Working in groups, ask two students to put on a pair of sunglasses and face each other. They will be able to see through the sunglasses worn by the other person. Then ask both the students to tilt their heads to the right. They will find that the lenses of the other person's sunglasses go completely black. Ask them to experiment with different angles of head tilt and discuss/record what happens.
2. Next, ask the students to sit in front of the computer screen wearing their sunglasses. Have them hold one of the plastic objects up in front of the screen and look at it. They should notice that the plastic is now filled with a rainbow of colours. Ask them to rotate the object and describe what they see. This works best when the screen is white, eg use a blank Word document on the screen.
3. Finally, give the children a strip of sticky tape about 30 cm long. Ask them to hold this in front of the screen while they wear the sunglasses. Have them hold the tape still and tilt their heads. Then ask them to keep their heads still and rotate the tape. Ask them to discuss/record what happens.

What's going on?

Although you can't see it, the lenses in the sunglasses are made up of many closely spaced bars. These bars block out all the light rays, except the ones that are vibrating in the same plane as the bars. Scientists say the lenses in the sunglasses are acting as 'polarising filters'. That means that the light passing through the sunglasses is all vibrating in the same direction or plane. You could think of the lenses as gates. Only the light that lines up with the gaps in the bars can squeeze through.

Only the light rays vibrating vertically can pass through the vertical gaps in the gate (filter).

When there are two gates (filters) that are not aligned, all light is blocked. The polarised light coming through the first filter is blocked by the second filter because it is set in the horizontal direction which stops vertically polarised light.



This explains why the lenses of the sunglasses go dark as the children face each other and tilt their heads.

The light that comes out of the computer monitor (LCD) is polarised. When you hold a clear plastic object in front of it and look at it with sunglasses on, you see a pattern of rainbow colours in the plastic. The colours are caused by the polarizing filters blocking some frequencies of light and letting others pass to your eyes.

The sticky tape has the amazing ability to 'refract' polarised light 90 degrees. It is not a polarising filter itself, it just twists the light that passes through it. That explains why the light coming through the sticky tape behaves in reverse to the light from the rest of the screen.

That's all great but what is glare and how do polarised lenses stop it?

Normal light rays vibrate in all directions, but once light has been reflected by a surface this can change. In reflected light, many of the light rays vibrate in the same plane as the reflecting surface. This concentration of light rays in one plane is often called glare.

Much of the glare people are exposed to comes from horizontal surfaces (for example, a lake, snow or a highway). If you wear sunglasses with polarised lenses set to the vertical plane or to 45 degrees, most of the horizontally polarised light (glare) is blocked for you.

Testing polarised sunglasses for polarisation.

How can you tell if a pair of sunglasses is polarised or not? You know that they are polarised when you buy them, because there is a sticker on them labeling them as such. The only other way to know is to put one lens of a pair of sunglasses over another and rotate them. If they darken and then lighten, the lenses are both polarised. If there is no change in the lenses, one pair is definitely not polarised; the other pair may or may not be.

Extension Activities

- The word *polarise*, means to break into opposing factions. For example,
    - Why do you think it is used to describe this behaviour of light?
- What is the difference between ‘light’, ‘glare’ and ‘UV radiation’?
- Compare polarised light with laser light.
- Find out about polarisation in DC electricity.
- Find out how ‘phase’ and ‘wavelength’ relate to light.