



# Science Kit #1: Year of Light

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# Science Kit #1: Year of Light

## Summary

This project was developed by Peter Musk for the Queensland National Science Week Committee for distribution to regional libraries and loan to schools in 2015.

The goal was to produce a self-contained set of 6 workshop kits with sufficient materials and instructions for 15 participants. Each workshop involved exploring an aspect of the science of light.

## Materials

[A list of materials for each workshop kit, with alternative suppliers and costs is here:](#)

materials\_cost\_and\_suppliers.docx

Some materials and simple tools were not included in the kit, and these are identified in the documentation for individual workshops.

[The contents of each kit for re-stocking are listed in this document:](#)

light\_box\_kits\_contents.docx

## Instructions

### 1: Bending light

Optic fibres can make light bend around corners, and when you look at your legs in a swimming pool, you can see how the light bends when it goes through the water, too.

- Age Group: 6yrs +
- Method: Group activity (up to 15 per facilitator)
- Level: Introductory
- Duration: 25 min

Key Learnings:

Light travels in straight lines, but when it shines into different materials it changes speed. If it enters the new medium at an angle, the light ray gets bent, and different colours bend differently. If the angle is too shallow, the light will be reflected (like glare from a window pane).

**Materials and Equipment**

- Opaque cup (1 per participant)
- Small flat object that does not float (a coin or washer) (1 per pair)
- Water
- 100mm square flat acrylic mirror (1 between three participants)
- Shallow tray (1 between three participants)
- A4 White paper or card (1 between three participants)
- Clear plastic bottle (with a lid)
- Black paper or plastic (enough to cover the bottle)
- Torch
- Scissors
- Stickytape
- Convex lens

**Preparation**

The facilitator should prepare for this workshop by using the instructions and materials provided to complete the tasks. Note critical angles and sources of light for viewing and advise participants accordingly. Have a rubbish bin ready for the waste that will be generated, and a bucket for the water.

**Recommendations**

The activities in this set are all brief. Be prepared to move things along reasonably quickly, but consider having time at the end for participants to return to things that have caught their interest.

Further learning could include adding coloured cellophane between the light source and some of the demonstrations to see how this alters the effects.

**Workshop Outline****(5 min) Introduction**

Introduce yourself, welcome participants and deal with housekeeping.

Ask participants if they have ever tried to grab something underwater, and whether they had a problem with locating the thing they were reaching for.

Explain that these activities will help them understand why they had a problem.

**(5 min) The invisible washer**

Distribute cups and ask the participants to form pairs. Give each pair a

washer, and have one member fill their cup with water. The participant with the empty cup puts the coin or washer at the bottom of the cup, and places it on the table. They then adjust their line of sight (by

moving their head up or down) so they can no longer see the coin over the edge of the cup.

While the viewer holds steady, their companion slowly pours water into the cup. At some point, the object will appear to the viewer.

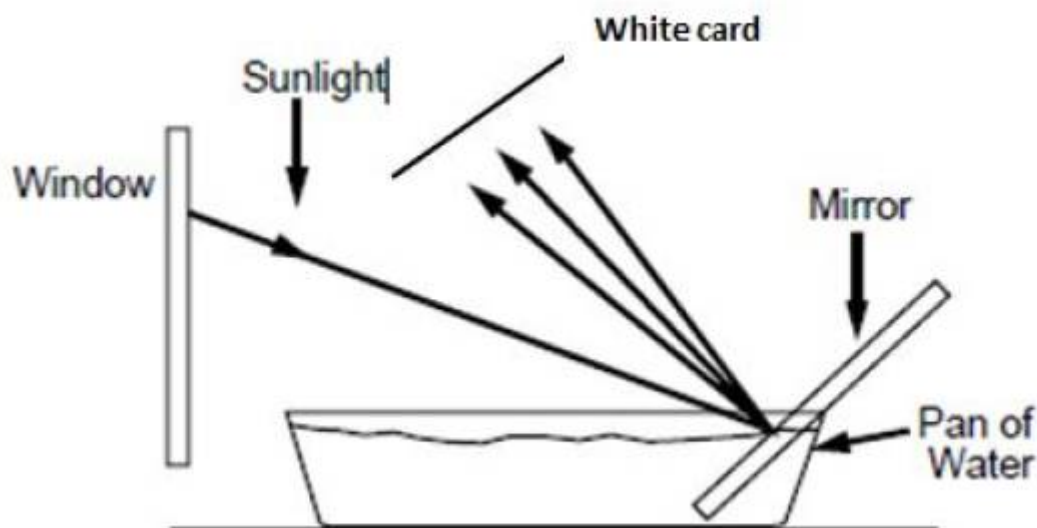
*Explanation:* You see the object in the bottom of the cup because light is reflected from the object into your eyes. When this light is going from water into air, it changes direction, and is bent at an angle. When the height of the water gets to the right level, the light from the object is bent into from your eye, and you can see it.

This is why when you look at something under water, it appears to be further from to you than it actually is, because your brain is used to light travelling directly to you in a straight line, and the light has actually been bent towards you as it left the water.

### **(5 min) Bending light into a rainbow**

Distribute the mirrors, and shallow trays to each group of three participants. Place the shallow tray near a window or other light source, and hold the

mirror at an angle as the tray is filled with water (see diagram below). Hold the white card as shown, and a rainbow will be seen.



*Explanation:* The rays of light are bent as they enter and leave the water, but different colours are bent to varying degrees. This effect makes the colours spread out, and results in the rainbow effect. Similar effects are seen when light passes through fishtanks, hanging crystals or even the edge of a

plate of glass.

Try placing a sheet of coloured cellophane between the window and the dish of water, and the rainbow will disappear because only a single colour of light is being affected.

**(5 min) Bending light around a corner (requires a darkened room for best viewing).**

Pierce a hole in the top of the plastic bottle using the scissors, or some other sharp tool, the rounder the hole the better.

Use stickytape to cover the outside of the bottle with black paper, but leave the bottom clear. If you can cover the top of the bottle too (but not the

lid), the effect will be better.

Fill the bottle with water, and screw on the lid. Now take the bottle and the torch into a darkened room, and place the torch on the bottom of the bottle so

the light shines through the water. Hold the bottle horizontally, and squeeze: the water will make an arc, and the light bend with it.

*Explanation:* The light is travelling through the water, parallel to the edges of the bottle. If the angle of the arc of water is not too great, the light inside the water skims off the boundary with the air surrounding it, and is reflected along inside the stream of water. This is the same effect that causes light to glare off a partly opened window, or a pool of water, even though these are transparent.

This effect is used in optic fibres, to trap light inside a thin cylinder of glass.

**(5 min) Bending light with a lens**

Hand around the lens provided and allow participants to examine it. It is helpful to have some printed material at hand that can be viewed through the lens.

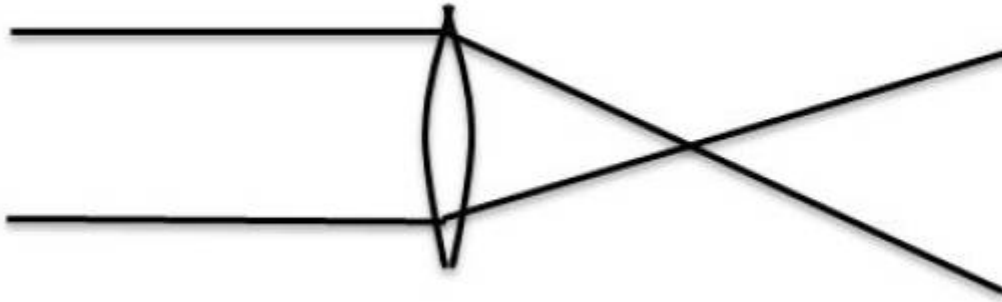
If the lens is moved closer or further away from the object being viewed, the image will move in and out of focus. At the right distance, the lens will act

as a magnifier.

Move to a window and hold the lens vertically, so the incoming light is focussed through it. Get an assistant to hold a piece of white paper or card about

20cm behind the lens, and observe that an image of the view outside the window is formed on the paper (move the paper slowly back or forwards to bring the

image into focus). Is the image the right way up? Does this change if the paper is moved?



*Explanation:* The light coming from the object being viewed is bent as it passes from the air into the glass of the lens, and again as it moves from the glass back into the air. Because the surface of the glass is curved, the bending focuses the rays of light onto a single point (the focus of the lens). If a viewing screen is placed beyond this point, the rays of light cross over, and the image will be inverted (as shown in the diagram below)

### Resources

[A printable form of these instructions is here:](#)

bending\_light.docx

[Cutfiles for the mirrors are here:](#)

98mm\_mirror.cdr

## 2: Colours

We see millions of colours every day, but how does the white light from an LED or the yellowish light of the sun make that possible?

- Age Group: 5yrs + (some cutting with scissors)
- Method: Group activity (up to 15 per facilitator)
- Level: Introductory
- Duration: 25 min

**Key Learnings:** White light is actually made up of many different colours, and this is shown when light of different colours is mixed together.

### Materials and Equipment

- Spinner template (1 per participant)
- Scissors (1 per participant)
- Ruler (1 per participant)
- Cotton twine (0.75 - 1m per participant)

- Coloured felt pens
- 3 small torches
- Baking paper (1 A5 sheet)
- Stickytape
- Red, blue and green cellophane
- White surface (card or paper is OK)

### Preparation

The facilitator should prepare for this workshop by making their own spinner using the instructions and materials provided. Experiment with getting the spinner to work – putting your fingers through the loop, holding it tight enough to make the disc stand up, and rolling the disc towards you to start a twist in the twine before gently pulling your hands apart. When the twine becomes an open loop, relax your hands and let the momentum of the spinner twist the twine in the opposite direction. As the spinner slows down, begin to apply gently and increasing pressure outwards to increase the spin. Repeat rhythmically to build speed.

Have a small object at hand (eg: an eraser, a matchbox, a bulldog clip) to make shadows with the coloured light from the torches. Participants can be encouraged to guess what colour shadows they will see with individual colours, and different combinations.

The coloured light works best in a darkened room, but if this is not available, then it is possible to use a large cardboard box to make a darkened viewing area. Consider how participants will observe the effects if using a box – crowding may be an issue. Have a rubbish bin ready for the waste card that will be generated.

### Recommendations

Depending on the age and skill levels of the participants, it might be wise to have a couple of extra copies of the template at hand if cutting errors make completion impossible. The spinner works best if adjacent colours are contrasting, and a variety of colours is used.

Further learning could come from considering why mixing coloured paints produces a muddy grey, rather than white (reflected colours, from pigments, appear because the pigments absorb all colours except the one reflected. Mixing enough pigments means that eventually all the colours in white light will be absorbed, and the mixture looks dark.) Stage effects using coloured lights and shadows could be illustrated.

### Workshop Outline

#### (5 min) Introduction

Introduce yourself, welcome participants and deal with housekeeping.

#### (10min) Combining colours

Ask participants if they have ever seen a rainbow, and explain that this shows that sunlight contains all the colours we see (and some we can't).  
Begin

with the demonstration, and get some participants to assist in cutting up the cellophane and black paper.

Cut 3 squares of baking paper a bit larger than the end of the torch, and a similar sized piece of each of the three colours of cellophane. Place one coloured piece of cellophane over each torch, and sticky tape it in place, making three torches that each shine a different colour. Place a piece of baking paper over the cellophane on each torch, and sticky tape it in place (this helps to diffuse the light).

In a darkened room (or other dark space), shine the torches onto a white surface (a piece of paper will do) to demonstrate that they produce a single colour. Now shine two torches simultaneously on the same spot, and observe what happens when the light combines.

Try different combinations of colours, and finally all 3 (a white spot should result), showing that white light is made up of different colours combined.

An additional activity would be to place a small object in front of the white surface, and shine different coloured light onto it. This time, look at the shadows.

### **(10 min) Make a colour spinner**

Hand out spinner templates, and cut them to make a circle.

Each section is then coloured in with a different colour. Doubling up is OK, but make sure adjacent segments are different. As far as possible, do not leave

any white spaces.

Use a pen or sharp pencil to punch two holes at the spots marked, about 5 – 10 mm each side of the centre of the circle. The holes need to be big enough for

the twine to pass through.

Cut a piece of twine about a metre long for each participant (smaller pieces may be better for younger groups). When doubled, the twine should stretch

loosely between outstretched hands.

Thread the twine through the holes, and tie the ends. Keep the knot at a distance from the spinner, so it can move freely.

Put a finger of each hand through the ends of the loop, and twist it a



bit (try rolling the spinner towards you along the table or floor as you hold the string). Now pull your hands apart gently, and the twist will make the spinner rotate. Relax the tension when the loop opens to allow the momentum of the spinner to wind the twine in the opposite direction. As the spinner begins to slow, apply outward pressure again, and repeat the process as the spinner builds speed.

Look at the spinner as it rotates – you should see it turn white when spinning rapidly, and may catch a glimpse of the colours as it slows down.

*Explanation* When you look at the spinner, light is reflected into your eyes, and you see the colours that are not absorbed by the pigments. Different cells in the eye respond to different coloured light, and the brain has learned to interpret this as seeing particular colours. When the spinner is rotating rapidly, different colours are reflected into your eyes so fast that all the different receptor cells are responding at the same time, and the brain interprets this as the colour white. This explains how we see white as a colour, even though it is actually made up of light of all the colours of the rainbow.

## Further Resources

### 3: The Colour White

[A printable form of these instructions is here:](#)

the\_colour\_white.docx

[Additional templates for making the colour spinner are here:](#)

colour\_spinner\_a4\_template.docx

[and here:](#)

colour\_spinner\_a3\_template.docx

[Here are some examples of alternative spinners that can be used:](#)

spinners.zip

### 4: Kaleidoscope

[Instructions are here:](#)

kaleidoscope.docx

[Cutfiles for the mirrors are here:](#)

acrylic\_mirrors.zip

## 5: Light comes in Waves

[Instructions are here:](#)

light\_comes\_in\_waves.docx

## 6: Periscope

[Instructions are here:](#)

periscope.docx

[Additional A3 template is here:](#)

periscope\_a3\_template.pdf

## 7: Spectroscope

[Instructions are here:](#)

spectroscope.docx

[Additional template is here:](#)

spectrometer\_template.pdf

[Cutfiles for the CD sections are here:](#)

cd\_cutter.zip

## Materials suppliers list

materials\_cost\_and\_suppliers.docx

### Additional Instructions

[A set of instructions were prepared for a version of these workshops that relied on students rotating through various activities, without direct instruction. The table-top instructions are here:](#)

sequential\_workshop\_instructions.zip

## Boxes

This project required a single container capable of holding the 6 workshop kits, and robust enough to be delivered to regional libraries. A design was developed for a laser cut box with a hinged lid and branding that could be made from 4mm ply.

[Cutfiles for the box are here:](#)

swivel\_lid\_box.zip

## Production notes

### Critical Success Factors

[Which of the critical success factors does this Prototype target? For more details see](#)

SLQ-Strategic-Plan-2016-20

### Enable Access

- ☒ [✓ peter, 2017-03-29] Provide life skills and early childhood literacy programs
- ☐ Increase free access to digital content
- ☒ [✓ peter, 2017-03-29] Strengthen Queensland library infrastructure and discovery platforms

### Engage Community

- ☐ Grow the State's historical collection of Queensland culture and heritage
- ☒ [✓ peter, 2017-03-29] Engage with communities of interest through dedicated centres of engagement
- ☒ [✓ peter, 2017-03-29] Facilitate the community's use of and interaction with content

### Build Capability

- ☒ [✓ peter, 2017-03-29] Build capacity within our communities of interest
- ☐ Generate new revenue sources
- ☒ [✓ peter, 2017-03-29] Position our workforce for the future

## Delivering of The Edge Promises

Aside from the SLQ Strategic Plan, there is The Edge's commitments to the community and the lens we look at it through. Here are a few more check boxes for you to answer

**This empowers creative experimentation across...**

- ☐ Art?
- ☒ [✓ peter, 2017-03-29]Science?
- ☒ [✓ peter, 2017-03-29]Technology?
- ☐ Enterprise?

**It will inspire...**

- ☒ [✓ peter, 2017-03-29]Whimsy?
- ☐ Nostalgia?
- ☒ [✓ peter, 2017-03-29]Curiosity?
- ☒ [✓ peter, 2017-03-29]Awe?

**Feedback**

1. Response from libraries was good - more applied than there were boxes to distribute
2. Restocking was an issue. No budget was available for this and regional libraries did not have the capacity.

Solution: Lists of suppliers were included with each kit for users to purchase their own materials.

3. Cutting CDs was messy - polycarbonate smokes and sputters in the laser.

Solution: try a score and snap approach next time.