Kaleidoscope

Create an ever changing world of colour with this classic optical toy you can make in a few minutes.

Age Group: 8yrs + (scissors required)

Method: Group activity (up to 15 per facilitator)

Level: Introductory

Duration: 20 min

Key Learnings: Light travels in straight lines, and flat mirrors will reflect light. When mirrors are placed facing each other, an infinite series of reflections results.

Materials and Equipment

* A4 Cardstock (1 per participant), or a recycled cardboard cylinder 100 – 150mm long (you could use one from inside a toilet roll or kitchen paper)
* Ruler (can be shared between a few participants)
* Scissors (1 per poarticipant)
* Sheet of black paper (1 per participant) as long as the cylinder, or a similar sized piece of black plastic (eg: garbage bag)
* Sheet of stiff acetate transparency film (1 per participant) as long as the cylinder
* Stickytape (can be shared between a few participants)
* Clingwrap (can be shared between participants)
* Mixture of small (<8mm) plastic or glass beads (about a teaspoon full per participant)
* Sharp pencil or biro (something to poke a small hole in the paper)
* Felt pens, coloured pencils or stick ons for decoration (optional)

Preparation

The facilitator should prepare for this workshop by making their own kaleidoscope using the instructions and materials provided. Note critical stages in fixing the device together, and advise the participants accordingly.

Have a rubbish bin ready for the waste card that will be generated.

Recommendations

Depending on the age and skill levels of the participants, they may need assistance in forming a cylinder and taping parts together. It is important to tightly fix the shiny acetate film to the black paper, and fitting the triangle of mirrors inside the tube might require some fine adjustments.

Almost any coloured objects will work inside the kaleidoscope, as long as they move freely. Less transparent items may work if the light is strong enough. You could try using natural materials such as fragments of leaves or small seeds, small coloured stones etc.

Further learning could include designing and constructing a kaleidoscope with two or four mirrors (different patterns will result). Curved mirrors will also change the effect, and could be made by bending the black-backed acetate strips.

Workshop Outline

(5 min) Introduction

Introduce yourself, welcome participants and deal with housekeeping.

Ask participants if they know what happens when they look in a mirror, and then if they have ever looked into two mirrors at once. They might recall that if the angle is correct, an infinite series of reflections is seen.

OPTIONAL: If you have access to a couple of large flat mirrors, you could demonstrate this effect (place the observer between the two mirrors set at an angle to each other so that the observer can look into one mirror and see their reflection in the other). Explain that they will be using this effect to make their device.

(5min) Preparing the cylinder

Find a cardboard cylinder to make the body of your kaleidoscope. The tube from inside a roll of toilet paper works well, and needs less materials than the longer tubes from clingwrap or alfoil. Alternatively, you can make a cylinder by rolling up some stiff card, and taping it together down the long side.

Measure the *inside* diameter of the cylinder, and use this to find the size of the equilateral triangle that fits inside the cylinder.

Measure this = D (inside diameter)

Calculate L (the length of each side) using the formula

FORMULA:

L = D x 0.866

(10 min) Making the mirrors

Cut 3 strips of card as long as the cylinder, and almost as wide as the L you calculated. It is best to cut the strips a millimetre or two narrower than the calculated width, to allow for folding later.

same

= L – 1mm

Cut 3 strips of black paper (black plastic cut from a garbage bag will do, too), and glue or tape them to the strips of card. If you use sticky tape, make the black paper a bit longer than the card, and fold the ends over to tape at the back. Try not to get too much sticky tape on the front (black) side of the strip. Trim the black paper to the size of the card, if necessary.

Cut three strips of shiny plastic transparency film, and tape them on top of the black paper. These will make mirrors when you look along them. Get the plastic sheet as flat as possible (maybe by stickytaping along the edges), but make sure they are no larger than the pieces of card.

Place the three strips black side down, and tape them together lengthwise. Make sure they can fold into a triangle, with the shiny side inwards, without bending (you might need to trim the plastic a bit). The flatter the triangle sides are, the better the final effect will be.

Fold your triangle (with the shiny side inwards), and slide it into the cylinder. You can trim the outer edges a bit to make it fit, but try to get the inner surfaces as flat as possible, with no gaps. It should not be necessary to tape the triangle down the third side, since the cylinder will hold it in place. It is good if the tringle is a millimetre or two past the end of the cylinder.

(10 min) Fitting the ends

Cut a circle of black paper a bit larger than the cylinder, and tape it tightly over one end. It might help to make some radial cuts in the paper to make some flaps that you can fold down the sides of the cylinder for taping. Use a pen or pencil to poke a round hole in the middle of the paper, about 2 – 3 mm in diameter.

Cut a circle of clingwrap (or some other clear soft plastic film) a bit bigger than the cylinder and tape it over the open end. Push the middle of the film down a bit to make a depression in the centre of the triangle. This has to be deep enough to hold some beads and allow them to move around a bit.

Fill the depression with beads, jewels or other small transparent coloured objects. A mixture of large and small beads works well, and a mix of light colours is good. Confetti will not work very well, because it tends to stick to the film – the objects need to be able to roll around a bit. The more beads, the better the result, but leave enough space for movement to occur.

Cut a piece of the stiff transparency film a bit larger than the cylinder, and tape it over the beads. Radial cuts will allow you fold the edges down for taping, but make sure there are no gaps big enough to let the beads fall out.

Hold the kaleidoscope up and point the end with the beads towards a source of light (the brighter the better, but do not aim it at the sun). Look through the small hole and rotate the cylinder to change the pattern you see.

Appendices: Material suppliers (list attached)

Explanation sheet.

How it Works.

You see an object when light bounces from the object into your eyes. From experience, your brain learns to interpret these sensations as a way to locate an object in the world around you – the object appears to be located at the point the light rays are coming from. Because light travels in straight lines, and we have two eyes to give slightly different angles of view, back-tracking to where these two apparent sources coincide allows us to estimate an object’s location in three dimensional space.

Reflected light

When light bounces off a mirror, our brain imagines the incoming light has come directly from a real object, and it concludes that the source of the light is located somewhere *behind* the mirror. This is why things look as far behind a flat mirror as they actually are in front of it.

Reflected light

Imagined light

Light comes from an object in all directions at once – this is why you can still see something even if you move to the side – but we only see the light that comes into our eyes.

When a flat mirror is placed parallel to our line of sight, some of the light we usually do not see coming from the object will bounce off the mirror and into our eyes, and our brain sees an object behind the mirror. We see two objects: one with the light coming directly from the object into our eyes, and another apparently to the side, from the reflected light from the mirror.

Reflected light

Add another couple of mirrors, and we will see four objects: one in the centre, and three around the outside. Arrange the mirrors into an even (equilateral) triangle, and the outside images will be equally spaced around the centre, but because the angles are different, the apparent arrangement of the objects will be slightly different (see [here](http://www.4physics.com/phy_demo/kaleidoscope/kaleidoscope-0.html) for a more detailed explanation). The central view will be brightest though, because this has the most light coming from it.

The view down a kaleidoscope is even more complicated (and theoretically infinite) because each of the mirrors reflects some of the light coming from the object into the *other* mirrors as well. A bit of this light can also be reflected into our eyes, and so we see another series of objects, though fainter than the first set of reflections. Some of this reflected light is also bounced back into other mirrors, making another fainter image, and so on. This continues until the amount of light being reflected is too small to register, and the image gets progressively darker towards the outside of the kaleidoscope until we can no longer make it out.