ENG

Explanation:

A lens is a piece of glass or plastic having two polished surfaces. One of the surface must be curved. A lens thicker in the centre than at the edge is called a converging lens or convex lens. A lens thinner at the centre than at the edge is called a diverging lens or concave lens. In Fig. 25, lens 1,2 and 3 are converging lens while lens 4,5 and 6 are diverging lens.

When using a thin lens, a mathematical approximation can be used to predict the path of the light passing through it. A ray of light coming from a very distant object, and parallel to the optical axis, will be bent by refraction at the two surfaces of the lens and will cross the optical axis at the focal point (f) of the lens, as shown in Fig. 26. A ray passing through the centre of the lens will pass through the lens undeviated.

The size and location of the image of an object formed by a lens can be found at the intersection of the two rays which is shown in Fig. 27. Ray (a) parallel to the optical axis passes through the focal point (f), Ray (b) passes through the center of the lens undeviated. The image formed is real, smaller than the object and inverted. The image is real because you can see the image on a piece of paper placed at the image location.

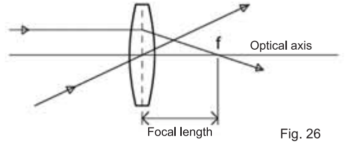


Fig. 26

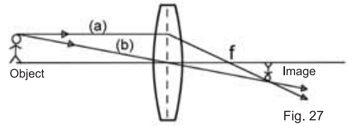


Fig. 27

Activity 8 Concave Lens

We will investigate the characteristics of concave lens.

Material: - 1 Torch (1) - 1 Light guide card (2) - 1 Concave lens (4)

Extra items you will need: - A piece of white paper

Steps:

1. Use the same light guide card as in step 1 of Activity 6. (Fig. 22)
2. Set up the torch, the concave lens and the light guide card on a piece of white paper as shown in Fig. 28. Place the torch at a distance of at least 20mm from the light guide card so that the light will exit as parallel beams after passing through the light guide.


Fig. 28

3. Darken the room and turn on the torch. The light guide will only allow three rays of light to pass through it to enter the concave lens. The beams are diverged after passing through it. See Fig. 29.


Fig. 29

4. Trace the diverged beams with a pencil and extrapolate the lines towards the source. What do you observe?

Explanation:

Similar to the case of convex lens, a ray of light coming from a very distant object, and parallel to the optical axis, will be bent by refraction at the two surfaces of the lens. However, the ray will be bent away from the optical axis and seems to originate from the focal point (f) of the lens, as shown in Fig. 30. A ray passing through the centre of the lens will pass through the lens undeviated.

Since the light is diverged, no real image will be formed. The size and location of the "virtual" image of an object formed by a lens can be found at the intersection of the two rays which is shown in Fig. 31.
Ray (a) parallel to the optical axis is diverted as if it passes through the focal point (f), Ray (b) passes through the center of the lens undeviated. The image formed is virtual, smaller than the object and upright. The image is virtual because you cannot see the image on a piece of paper placed at the image location.

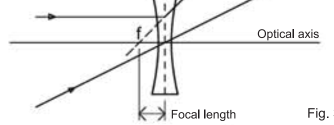


Fig. 30

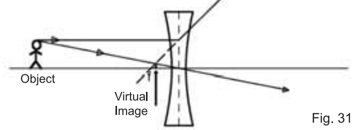


Fig. 31

Activity 9 Convex Lens as Magnifier

In this activity we will make use of a convex lens as magnifier.

Material: - 1 Objective lens (17)

Steps:

1. Make sure you have enough light to read the book or newspaper.
2. Hold the objective lens over the text in the book or newspaper and adjust the distance from very close to very far from the text, as shown in Fig.32.
3. Look through the lens. When the image is the largest without blurring, compare the size of the text with and without the lens.


Fig. 32

Explanation:

The objective lens used is a convex lens. When the object lies between the lens and the focal point, a virtual, upright, and enlarged image is obtained, as seen in Fig.33.

Three rays are included in the figure. Following are descriptions of these rays. A ray (1) leaving the object parallel to the optical axis will bend at the lens and go through the focal point (f). A ray (2) leaving the object going through the center of the lens will be undeviated. A ray (3) leaving the object as if it came from the front focal point of the lens will bend at the lens and travel in a line parallel to the optical axis.

After passing through the lens, the three rays described above will appear to come from an enlarged and upright image. Any other ray leaving the tip of the object will appear to come from the tip of the image after passing through the lens. The three rays used in the illustration were chosen because their paths are always known.

Two rays are actually enough to locate the image, while the third ray is used for an additional check of the location of the image.

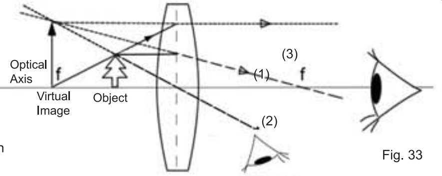


Fig. 33

Activity 10 Handheld Microscope

We use a microscope to view very small objects, the magnification is higher than a magnifier. The most advanced microscopes allow us to study the structure of material down to atomic level!

Material: - 1 Eyepiece tube (19)

Steps:

1. The eyepiece tube (19) has two convex lenses, one at each end. It can use as a microscope. Hold it steadily over the object you want to view and adjust the distance until the image is clear, as shown in Fig. 34. Make sure you have enough illumination on the object in order to view clearly. For example, use the light from the window or illuminate it with a torch.
2. Magnification is the size of the image compared to the size of the object. Try to find out the magnification of this handheld microscope.


Fig. 34

Explanation:

In an optical microscope, as shown in Figure 35, the lens, placed next to the object to be magnified, is called the objective lens. The lens held next to the eye is called the eyepiece. The eyepiece should have a focal length of about 25 millimeters, while the objective should have a focal length of 25 millimeters or less to be suitable for building a microscope. The enlarged image formed by the objective lens is then magnified by the eyepiece, which acts as a magnifier to produce a virtual and inverted image. The net magnification of the entire system is the product of the magnifications of the objective and eyepiece.

Because the image is much larger than the object, it usually requires that the object be brightly lit, or it will be too dark to see well.

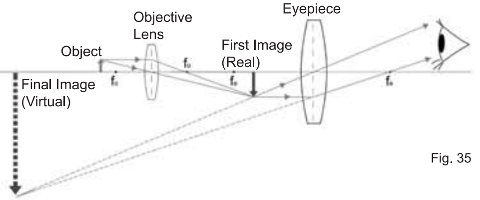


Fig. 35

Activity 11 Make a Pinhole Camera

In this activity you will make a simple pinhole viewer and see how it works.

Material: • 1 Pinhole camera card (14) • 1 Semi-transparent screen (15) •1 Screen frame card (16)

Extra items you will need: • Some glue • Black adhesive tape • A pin

Steps:

1. Fold the Pinhole camera card (14) into a box as shown in Fig. 36.

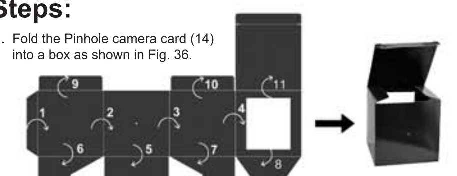


Fig. 36

2. Fold the Screen frame (16) card into a tray shape and glue the semi-transparent screen (15) on top as shown in Fig. 37.

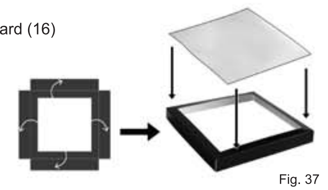


Fig. 37

3. Put the screen of step 2 inside the box as shown in Fig. 38. Close the box and you have a pinhole viewer.

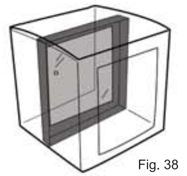


Fig. 38

4. To use the viewer, face the pinhole side of the box towards the scene you want to see. It works well towards a brightly lit object. For example, things under bright sunlight, or other things illuminated by a bright lamp. Move your eye close to the square opening and use you face and hand to block light leaking around the edge. See Fig. 39. You will see an upside-down image on the screen. Adjust the screen position inside the box to change the size of the image. You may experiment with the effect of different hole sizes by covering the hole with a black tape and make a hole with a pin (be very careful not to hurt yourself when using the sharp pin).

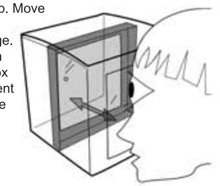


Fig. 39

Explanation:

Light rays from the object pass through the small hole in our pinhole camera. The small hole only allows a little bit of light to enter, and the light that does enter is projected on the semi-transparent screen upside down, as shown in Fig. 40.

Light rays from leaves at the top of the tree must slope down at a steeper angle to pass through the pinhole. These rays hit the bottom of the screen. Rays of light from the base of the tree trunk must slope up to pass through the pinhole. These upward moving rays will hit the top of the screen. Light reflected from every point on the tree must pass through the pinhole this way to hit the screen, thus the tree image is upside-down and left-right reversed.

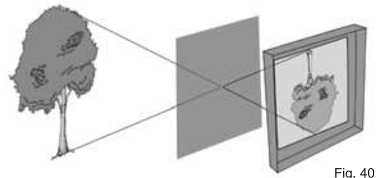


Fig. 40

A pinhole camera is a great example of how our eye works: the "small hole" in our eye is the iris. Light enters the iris and is projected on to the back of the eyeball, the retina. The retina is just like the screen. Everything you see is projected upside-down on the back of your eye! Light receptors on the retina, the rod and cone cells, send this image to our brain which flips it "right side up". The eye itself is a very complicated organ, but the basics of photography and sight are quite simple.

Activity 12 Make a Telescope

We will make a telescope and study the basic principles.

Material: - 1 Objective lens (17) - 1 Eyepiece (18) - 1 Eyepiece tube (19) - 1 Tube ring (20) - 1 Focus tube (21) - 1 Telescope tube (22)

Steps:

1. Install the telescope tube (22) to the objective lens (17) as shown (Fig. 41).


Fig. 41

2. Insert the eyepiece tube (19) into the focus tube (21) as shown in Fig. 42.


Fig. 42

3. Insert the tube ring (20) into the focus tube (21) as shown. (Fig. 43)


Fig. 43

4. Screw the eyepiece (18) on the eyepiece tube (19), see Fig. 44.


Fig. 44

5. Fully insert the focus tube assembled in step 4 into the telescope tube (22), see Fig. 45.


Fig. 45

6. You are done! Look into the eyepiece and adjust the focus by sliding the focus tube in or out until the image is clear (Fig. 46).


Fig. 46

Explanation:

In a telescope, the lens held next to your eye is called the eyepiece and is usually a short focal length lens or a combination of lenses. The lens at the other end of the telescope is called the objective lens. Light from a distant object is focused by the objective lens to form an image in front of the eyepiece. The eyepiece acts as a magnifier and enlarges that image. The magnification of the telescope can be found by dividing the focal length of the objective by the focal length of the eyepiece.

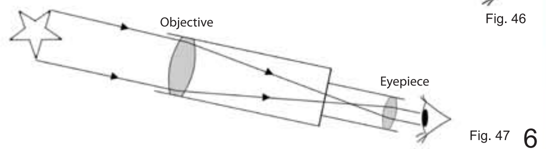
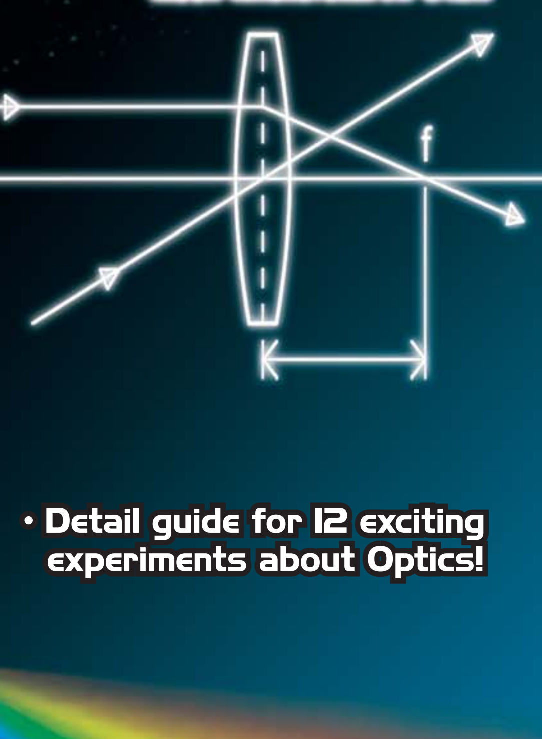


Fig. 47

Science Time™

8+

12 IN 1 OPTICAL EXPERIMENT SET



• Detail guide for 12 exciting experiments about Optics!

Activity Guide

NO. 28802

12 in 1
Optical Experiment Set
Activity Guide

WARNING!

Only for use by children over 8 years old. To be used solely under the strict supervision of adults that have studied the precautions given in the experimental set. Not suitable for children under 36 months because of small parts – choking hazards. This toy contains functional sharp edge on plastic mirrors. Use with care and only under supervision of adult.

Do not view sun through telescope, lens, or magnifier as serious injury to the eyes may result.

IMPORTANT:
Keep these instructions. DO NOT DISCARD.

1. Only adults should install and replace batteries.
2. Alkaline batteries are recommended.
3. If the device has not been used for a long time, remove the batteries.
4. Do not use rechargeable batteries.
5. Do not mix old and new batteries.
6. Do not mix alkaline, standard (carbon zinc) or rechargeable (nickel cadmium) batteries.
7. Exhausted batteries are to be removed from the toy.
8. Non-rechargeable batteries are not to be recharged.
9. The supply terminals are not to be short-circuited.
10. Only batteries of the same or equivalent type as recommended are to be used.
11. Batteries are to be inserted with the correct polarity.
12. Do not dispose of batteries in fire, batteries may explode or leak.
13. Batteries may explode or leak if misused.

Batteries required: 2 x 1.5V AAA (Not included)

If at any time in the future you should need to dispose of this product please note that Waste electrical products should not be disposed of with household waste. Please recycle where facilities exist. Check with your Local Authority or retailer for recycling advice.(Waste Electrical and Electronic Equipment Directive)

Components:

1. 1 Torch
2. 1 Light guide card
3. 1 Convex lens
4. 1 Concave lens
5. 1 Prism
6. 1 Red filter
7. 1 Green filter
8. 1 Blue filter
9. 1 Periscope Card
10. 5 Plastic Mirrors (34mm x 125mm)
11. 1 Magic coin safe card
12. 1 Magic coin safe inner card
13. 1 Plastic mirror (89mm x 125mm)
14. 1 Pinhole camera card
15. 1 Semi-transparent screen
16. 1 Screen frame card
17. 1 Objective lens
18. 1 Eyepiece
19. 1 Eyepiece tube
20. 1 Tube ring
21. 1 Focus tube
22. 1 Telescope tube
23. 1 Eyepiece
24. 1 Removable cover
25. 2 Plastic tube parts (Left,right)
26. 1 Object chamber
27. 1 Plastic disc
28. Colour beads

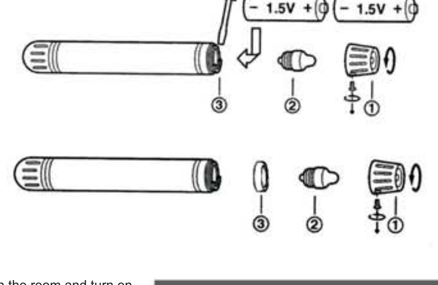
Fig. 1

Activity 1 Light and Colour

Materials: - 1 Torch(1) - 1 Light guide card(2) - 1 Prism(3)
Extra items you will need: - A piece of white paper

Using the Torch - Switch on the torch by turning the knob at the end to the ON position.
Battery Installation / Replacement (Batteries are not included)

1. Turn the front part of torch anticlockwise and detach it from the body as shown.
2. Remove the light bulb with the metal ring from the body.
3. Use a screwdriver to lever the white plastic ring out.
4. Insert 2 AAA batteries into the torch body, noting polarity requirements.
5. Attaching plastic ring, light bulb with metal ring and front part back to the torch body.



Replacing Light Bulb
The torch requires one (3V, 0.2A, type TL-3) light bulb.

1. Turn the front part of torch anticlockwise and detach it from the body.
2. Remove the old light bulb with the metal ring from the body.
3. Detach the old light bulb from the metal ring by turning it anti-clockwise.
4. Screw the new light bulb in the metal ring by turning it clockwise.
5. Attach the light bulb with the metal ring back to the body.
6. Put the front part back into the torch by turning it clockwise

Steps:

1. Cut a narrow slit at the single white line on the light guide card. (Fig. 2)

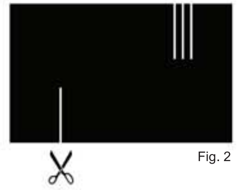


Fig. 2

2. Set up the torch, the prism and the light guide card on a piece of white paper as shown in Fig. 3. Place the torch at a distance of at least 20mm from the light guide card so that the light will exit as a single beam after passing through the light guide.


Fig. 3

3. Darken the room and turn on the torch. The light guide will only allow a ray of light to pass through to enter the prism. Adjust the angle of the prism so that the light beam strike it at an angle.The light is separated into different colors when it exits the prism. See Fig. 4.

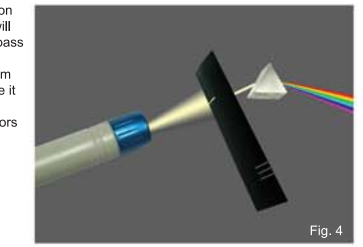


Fig. 4

Explanation:

White light or sunlight is not made up of a single “white” colour. In fact, it is the result of the combination of a spectrum of colours. Our modern understanding of light and color begins with Isaac Newton (1642-1726) and a series of experiments that he publishes in 1672. He is the first to understand the rainbow — he refracts white light with a prism, resolving it into its component colors: red, orange, yellow, green, blue and violet. Newton let a beam of sunlight pass through a glass prism and observed the white light spectrum. In a vacuum, light of all colours travels at the same speed. When light passes through a material, such as glass or water, the red light at one end of the spectrum travels faster than the violet light at the other end of the spectrum. This difference in speed causes a change in the direction of light when going from air to glass and from glass to air. This change of direction is called refraction, and is greater for violet light than for red light. The speed of light in the glass depends on the color; thus we get a continuous band as in the rainbow.

Activity 2 Light Filter

Material: - Red, Green, Blue Filter(6,7,8) - 1 Torch(1)
Extra items you will need: - A piece of white paper

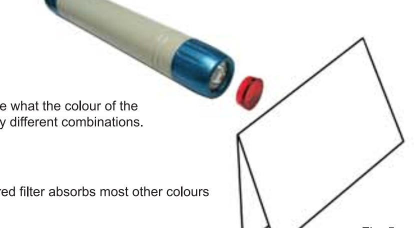


Fig. 5

Steps:

1. Place a filter in front of the torch and turn it on. Allow the light to fall on a piece of white paper. Note what the colour of the light will become. Combine two coloured filters. Now combine three colours. Experiment with many different combinations.

Explanations:

Filters subtract or absorb some colours while allowing other colours to pass through. For example, a red filter absorbs most other colours but transmit red light, making it appear red.

Activity 3 Reflection of Light

In this activity, you will find out the law of reflection.

Material: - 1 Mirror (34mm x 125mm)(10) - 1 Torch(1) - 1 Light guide card(2)
Extra items you will need: - A piece of white paper (about 300mm x 210mm)
- Enough modeling clay to hold up the mirror and light guide card on a tabletop
- A protractor for measuring angles - A ruler

Steps:

1. Use the same light guide card (with a narrow slit) as in activity 1. (Fig. 2)
2. Set up the flashlight and the light guide card on a piece of white paper as shown in Fig. 6. Use some modeling clay to hold the light guide card in place. Turn on the torch so that a narrow beam of light emerges from the slit and runs along the tabletop.

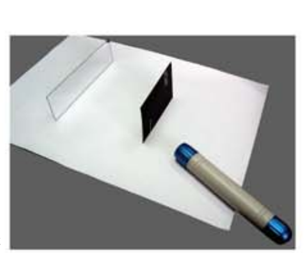


Fig. 6

3. Using the clay, place the mirror so that the beam of light strikes the center of the mirror.
4. Use the ruler to trace the pathway of the beam to and from the mirror. You may need to dim the light to observe the beam clearly.
5. Label the incidence beam and the reflective beam. (Fig. 7)

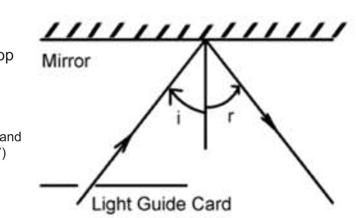


Fig. 7

6. Using a protractor, measure these angles (i, r) in degrees. How do they compare? Record your results in Table 1 below.
7. Repeat the experiment four additional times, changing the angle of incidence with each trial.

Table 1

Test	Incident Angle (i)	IReflected Angle (r)
1		
2		
3		
4		
5		

Explanations:

As we look around the room, we see most objects by the light that is diffusely reflected from them. Diffuse reflection of light takes place when the surface of the object is not smooth. The reflected rays from a diffusely reflecting surface leave the surface in many different directions. When the surface is smooth, such as the surface of glass or a mirror, then it can be easily demonstrated, as in the experiment above, that reflected rays always obey the law of reflection:

The angle of incidence is equal to the angle of reflection. **r = i**

Activity 4 Make a Periscope

You will make a simple periscope and see how it reflects light.
Material: - 1 Periscope card (9) - 2 Plastic Mirrors (34mm x 125mm) (10)

Steps:

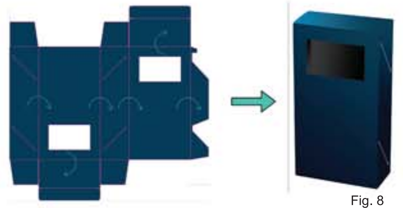


Fig. 8

1. Fold the periscope card into a box as shown in Fig. 8.
2. Insert both plastic mirrors (remove the protective film first) into the slit as shown in fig. 9. The reflective side of the mirrors should face each other.

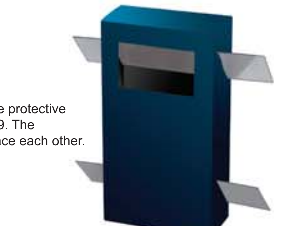


Fig. 9

3. You are done. Look into one of the mirrors and you will see the object in front of the other mirror.

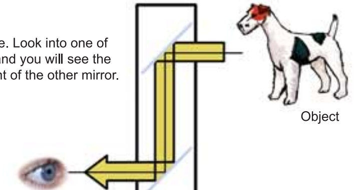


Fig. 10

Explanations:

A periscope is an optical instrument that uses a system of prisms, lenses, or mirrors to reflect images through a tube. Light from a distant object strikes the top mirror and is then reflected at an angle of 90 degrees down the periscope tube. At the bottom of the periscope, the light strikes another mirror and is then reflected into the viewer’s eye. This simple periscope uses only flat mirrors as compared to the periscopes used on submarines, which are usually a complex optical system using both lenses and mirrors.

Do you think the periscope will work if the mirrors were at some angle other than 45 degrees?

Activity 5 Make a Magic Coin Safe

You will make a magic coin safe and see how it works.
Material: - 1 Magic coin safe card (11) - 1 Magic coin safe inner card (12) - 1 Plastic mirror (89x125mm) (13)

Steps:

1. Fold the Magic coin safe card (11) into a box as shown in Fig. 11.

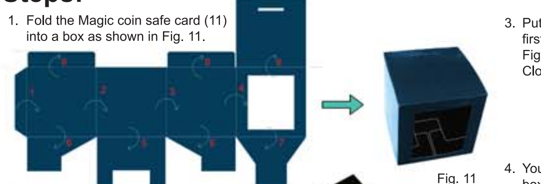


Fig. 11

2. Insert the inner card (12) to cover the bottom part of the safe. The black side with some dot pattern should face upwards. See Fig. 12.

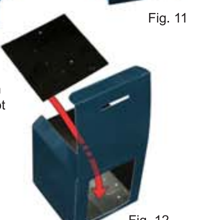


Fig. 12

3. Put the plastic mirror (remove the protective film first) diagonally inside the safe as shown in Fig. 13. The reflective side should face downwards. Close the box.


Fig. 13

4. You are done. When you look at the safe from the front, you will see an empty box. Try inserting a coin through the slot on the top. Can you find it?

Explanations:

The coin seems to disappear because it is hind behind the mirror. The mirror is not visible when view through the opening at the front. It reflects the bottom card and produces an illusion of the rear wall.See Fig. 14.

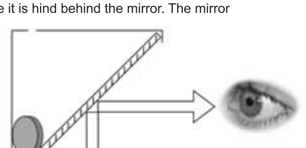


Fig. 14

Activity 6 Make a Kaleidoscope

In this activity you will make a simple kaleidoscope and see how it reflects light.

Material: - 1 Eyepiece (23) - 1 Removable cover (24) - 2 Plastic tube parts (Left,right) (25)
- 3 Plastic mirrors (10) - 1 Object chamber (26) - 1 Plastic disc (27) - Colour beads (28)

Steps:

1. Combine the plastic tube parts (25) together. (Fig. 15)

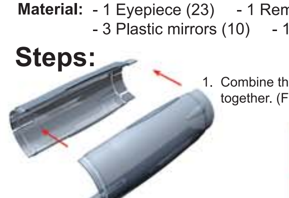


Fig. 15

2. Put the three plastic mirrors (10) into the plastic tube with the three reflective sides facing inwards. Remember to remove the protective film from the mirror first. Note that the mirror edges should stay at the notches at the mouth of the tube which hold them in position (Fig. 16).

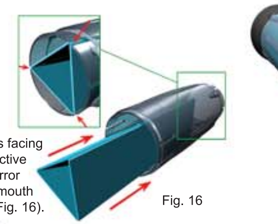


Fig. 16

3. Join the eyepiece (23) with the assembled parts. Note that the eyepiece has a tooth that fit with the notch of the tube as shown. (Fig. 17)


Fig. 17

4. Remove the protective film from the plastic disc (27). Put it into the object chamber (26). (Fig. 18)

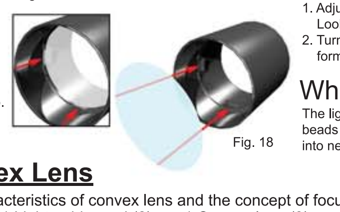


Fig. 18

5. Combine the two assembled parts together as shown. (Fig. 19)

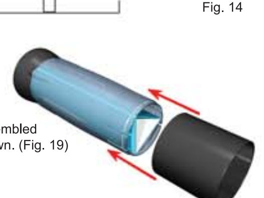


Fig. 19

6. Put the colour beads (28) into the chamber part. Or you can put other small objects you like to create different patterns. Make sure there is space inside the chamber for the objects to move freely. (Fig. 20)

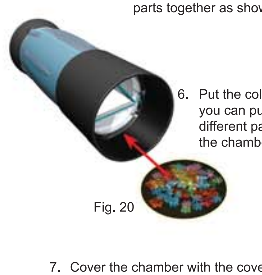


Fig. 20

7. Cover the chamber with the cover (24). (Fig. 21)

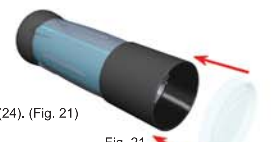


Fig. 21

Looking through the Kaleidoscope

1. Adjust the eyepiece so that the pattern of the colour beads can be clearly seen. Looking at a light helps.
2. Turn the tube slowly, the rolling colour beads will be reflected in the mirrors, forming different interesting patterns.

What happens?

The light bounces back and forth between the mirrors. The reflection of the coloured beads makes beautiful patterns. When you shake the kaleidoscope, the beads move into new positions to create a different pattern.

Activity 7 Convex Lens

We will investigate the characteristics of convex lens and the concept of focus.
Material: - 1 Torch (1) - 1 Light guide card (2) - 1 Convex lens (3)
Extra items you will need: A piece of white paper

Steps:

1. Cut three narrow slits at the white lines on the light guide card. (Fig. 22)


Fig. 22

2. Set up the torch, the convex lens and the light guide card on a piece of white paper as shown in Fig. 23. Place the torch at a distance of at least 20mm from the light guide card so that the light will exit as parallel beams after passing through the light guide.

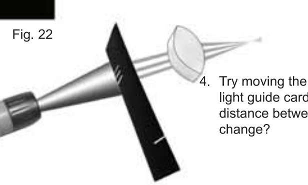


Fig. 23

3. Darken the room and turn on the torch. The light guide will only allow three rays of light to pass through it to enter the convex lens. The beams are converged at the focus of the lens after passing through it. See Fig. 24.


Fig. 24

4. Try moving the lens closer or further from the light guide card. Does the focal length (the distance between the focus point and the lens) change?

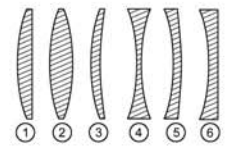


Fig. 25