Light Box & Optical Set
Article code: QLG003

Description

The complete kit consists of a source of light rays and a set of various optical components that reflect and refract light and colour blend light and allows study of the phenomena of reflection and refraction and a variety of colour experiments, simultaneously permitting measurements and observations, conveniently. The unit operates on 12V AC / DC power rated at 2 to 3 amperes. The light source is located in a specially constructed light box.

Including:
- Set of 5 acrylic prisms
- Set of 3 acrylic cylindrical lenses
- Set of 3 mirrors
- Set of 2 slit plates, black
- Set of 8 color filters
- Set of 8 color cards

The light box comes completely assembled along with an adjustable collimating lens.

Study of Colours: The source-end of the box is fitted with a light bulb and has one front opening and two side openings. The side openings are fitted with two hinged doors, each with a mirror, to reflect the light emanating from these openings. All the three openings have provision to allow the mounting of colour filters (provided in the kit) at their front. With all the three windows having colour filters in place, rotating the hinged side window mirrors, the light beam reflected by them can be swung back and forth to overlap and blend with the fixed center-beam from the front opening. A colorful pattern as a result of colour mixing of the three beams can be easily observed on a screen placed in front of the center-opening at a distance of about 15- 20 cm from the light box.

Study of Reflection & Refraction: The other end of the box also has an opening with a provision for mounting a slit plate or a colour filter. Between the source and the opening is a collimating lens, the position of which can be changed with respect to the light source by means of a knob at the top of the light box to obtain parallel, slightly converging or diverging beam of light, as desired. This beam emerging from the opening can be split into one narrow beam (more suitable for production of spectra) or alternatively one, two, three or four narrow slit rays by mounting the appropriate slit former into the grove provided alongside the window opening.

Setting up the light box:

1. Position the light box on a horizontal work bench surface with the connecting lead facing at the top. The light box has three non-skid feet at the bottom that ensures proper level and stability during operation.
2. Connect the lamp to a low voltage (12V) AC or DC power source through the captive connecting lead provided along with, terminating in a pair of 4mm banana plugs. The power source should have rating of at least 3A. Operating the light box at lower

voltages decreases the intensity of light, whereas operating it at higher voltages than the rated ones significantly reduce the life of the lamp and hence is not recommended.

3. Insert one of the multiple slit formers into the groove provided in front of the window and adjust the position of collimating lens by sliding the knob at the top to obtain a set of parallel rays.
4. Place a plain white sheet of paper in front of the windows, along the path of the rays and adjust its position and height in such a way that the path of rays is clearly visible on the paper.
5. Place the accessory to be used in various positions, depending on the experiment as detailed later on, for performing the experiment.

Light:

Light is electromagnetic radiation within a certain portion of the electromagnetic spectrum. The word usually refers to visible light, which is visible to the human eye and is responsible for the sense of sight.

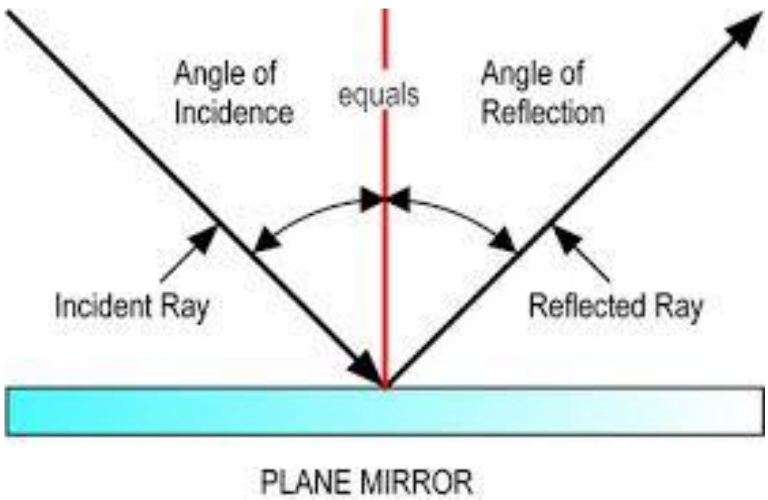
Mirror:

Mirrors are very smooth surfaces usually made of polished metal or silver-coated glass. Mirrors come in a variety of types. Some mirrors have a flat surface while others have a curved surface.

Reflection of Light:

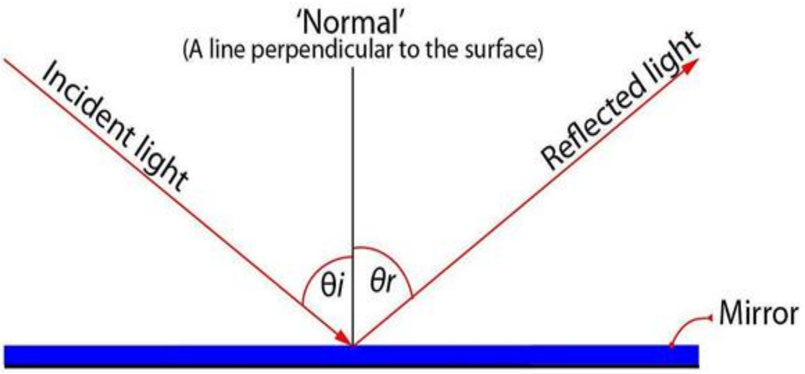
It is the phenomenon of change in the path of light ray without any change in medium.

Here in the diagram a ray of light incident on the plane mirror at some angle called angle of incident with normal. After falling on the mirror the light reflected at the same angle and this angle is called angle of reflection.



Law of reflection:

1. The law of reflection states that the incident ray, the reflected ray, and the normal to the surface of the mirror all lie in the same plane.

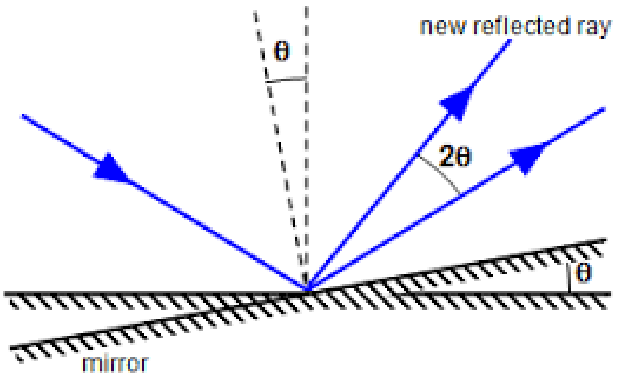


2. Angle of incidence equals angle of reflection

$$\theta_i = \theta_r$$

Effect of mirror rotation:

When a light ray is normal to a mirror it reflects back the way it came.
However, if the mirror is tilted say, through θ° then the reflected light ray rotates through 2θ °.



Experiment 1: Reflection of light using mirror.
Components Required:

- Light Box
- Reflective mirror
- Single slit
- Multiple slit
- Large white sheet (Not Included)
- Power Supply (Not Included)

Procedure:

1. Connect the light box with the power supply.
2. Insert the multiple slit into the slit holder on the light box.

3. Adjust the spacing between 4 rays using the knob on the light box, such that rays should be parallel to each other.
4. Now put a reflective mirror on the white sheet at an angle of 45°.
5. The rays of light undergo regular reflection.

Experiment 2: To study the law of reflection.
Components Required:

- Reflective mirror
- Light box
- Single slit
- Large white sheet (Not Included)
- Power Supply (Not Included)
- Pencil (Not Included)
- Meter ruler (Not Included)

Procedure:

1. Connect the light box with the power supply.
2. Insert the single slit into the slit holder on the light box.
3. Adjust the spacing between rays using the knob on the light box, such that rays should be parallel to each other.
4. Now put a reflective mirror on the white sheet at an angle of 45°.
5. The rays of light undergo regular reflection.
6. Mark the incident ray and reflected ray using pencil.
7. Note the angle of incidence and reflection.
8. Verify the law of reflection from the observed angle.

Experiment 3: Effect of rotation of the mirror on the angle of reflection.
Components Required:

- Reflective mirror
- Light Box
- Slit with 1 line
- Large white sheet (Not Included)
- Power Supply (Not Included)
- Pencil (Not Included)
- Meter ruler (Not Included)

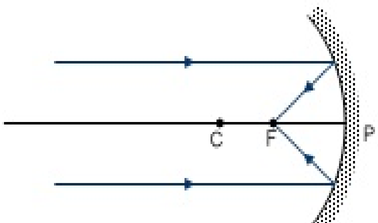
Procedure:

1. Connect the light box with the power supply.
2. Insert the single slit into the slit holder on the light box.
3. Adjust the spacing between rays using the knob on the light box, such that rays should be parallel to each other.
4. Now put a reflective mirror on the white sheet at an angle of 45°.
5. The rays of light undergo regular reflection.
6. Mark the incident ray and reflected ray using pencil.
7. Note the angle of incidence and reflection.
8. Now rotate the mirror at some angle say θ.
9. Again note the angle of incident and reflection.
10. Observe angle of reflection become twice at which the mirror was rotated.

Note: Student can draw a large circle on the white sheet indicating different angle and placing the accessories in the middle of the circle for performing experiment in better way.

Concave mirror:

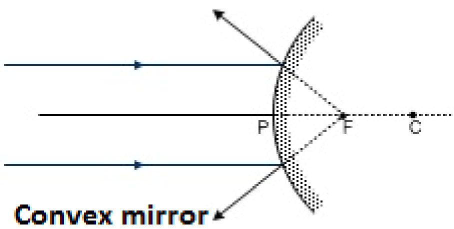
A concave mirror is curved like the inside of the bowl or a spoon. The edges of the mirror curve toward you. Concave mirrors reflect light rays to a point in space called the focus. The focus is in front of the mirror. The distance from the center of the mirror to the focus is the focal length.



Concave mirror

Convex mirror:

A convex mirror is curved like the back of a spoon. The edges of the mirror curve away from you. A convex mirror makes reflected light rays spread out. They seem to come to a point behind the mirror, forming a smaller, and virtual image. Convex mirrors are used on vehicles as the side-view mirrors to help drivers have a wider view of surrounding cars to the side and at the back of the vehicle.



Convex mirror

Experiment 4: To study the reflection from a curved mirror surface and determine the radius of curvature and focal length of circular mirror.

Components required:

- Semicircular mirror
- Parabolic Mirror
- Light Box
- Large white sheet (Not Included)
- Power Supply (Not Included)

Procedure:

1. Connect the light box with power supply.
2. Place the parabolic mirror/semicircular mirror in the middle of the white sheet.
3. Trace the inside concave reflecting surface of the mirror. Carefully, move the mirror around the curve and continue tracing until you have a complete circle. Measure the diameter of this circle along different axis (or directions) and calculate its average diameter.
4. Incident the light from the light box (use multiple slit with light box).
5. The rays of light converge at one point; this point is known as focal point.

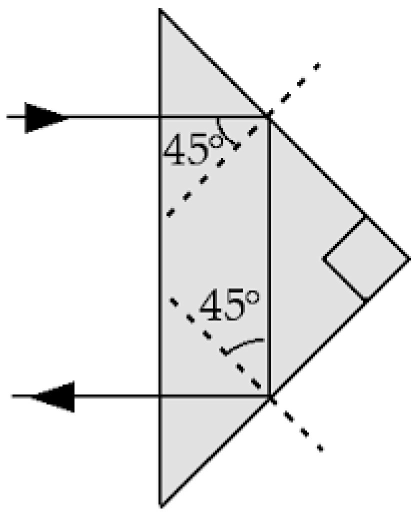
Similarly place a concave lens (of short focal length) in front of the slits to produce diverging rays. Shift the mirror until the reflected rays retrace their paths. The center of curvature is the point where the incident rays appear to diverge from, and the radius of curvature is the distance of the point from the mirror.

Experiment 5: Total internal reflection through a right-angle triangle.

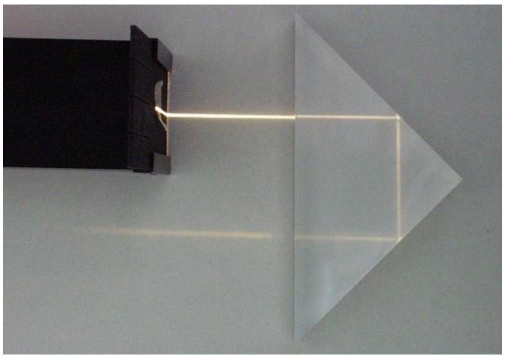
Components Required:

- Light Box
- Right Angle Triangular Block
- Slit With 1 Line
- Large white sheet (Not Included)
- Power Supply (Not Included)

Procedure:



1. Connect the light box with the power supply and insert the slit with 1 line in the light box.
2. Put right angle triangular block in the middle of the white sheet.
3. Incident the ray from the light box on the block normally.
4. As its angle of incident within the block is 45° which is greater than the critical angle, the ray is totally internally reflected and turned through 90° at each reflection as shown in figure.

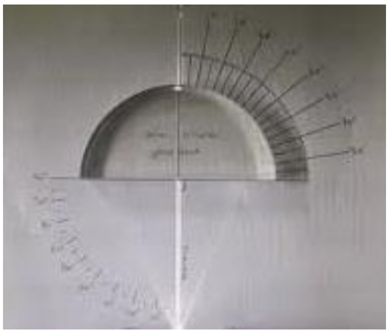


Experiment 6: Refraction and total internal reflection through semicircular block.
Components Required:

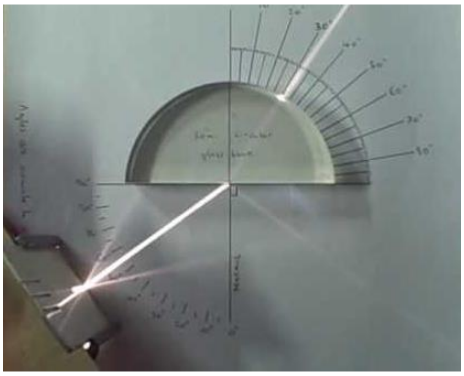
- Light Box
- Semicircular Block
- Slit With 1 Line
- Large white sheet (Not Included)
- Power Supply (Not Included)

Procedure:

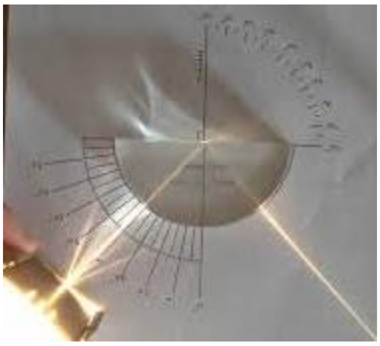
1. Connect the light box with the power supply and insert the slit with 1 line in the light box.
2. Put the semicircular block in the middle of the White sheet.
3. Incident the light normally on the semicircular block, the light passed without deflecting.



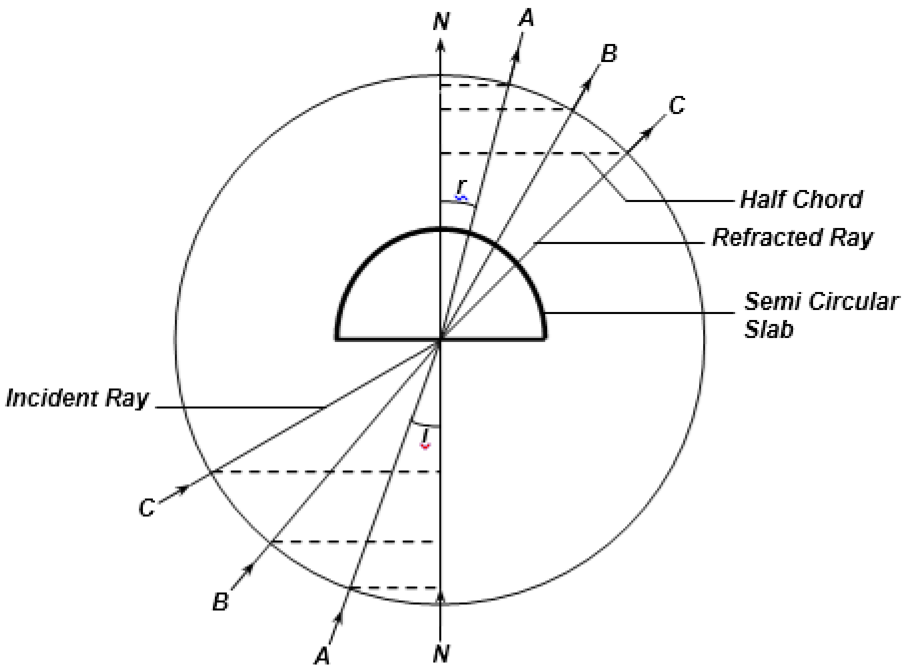
4. Now change the angle of the light box say 30°.
5. Note the angle of refraction through which light is refracted.
6. Note the other refractive angle corresponds to the angle of incident.



7. Now further increase the angle of incident say 45^o (which is greater than the critical angle for acrylic), the ray of light gets reflected back into the block to show the phenomenon of the total internal reflection as shown in the figure below.



Complete the following observation table.



Ray	Angle of Incidence (i)	Angle of refraction (r)	Difference (i-r)	Ratio $\frac{i}{r}$	Length of Half Chord i (hc-i)	Length of Half Chord r (hc-r)
A						
B						
C						
D						
E						
F						

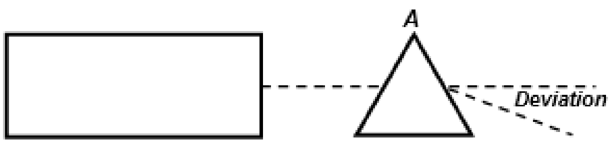
Experiment 7: To study the double refraction, angle of minimum deviation using equilateral prism.

Components Required:

- Light Box
- Equilateral Triangle prism
- Single slit
- Large white sheet (Not Included)
- Power Supply (Not Included)

Procedure:

1. Select equilateral triangular (60° 60° 60°) prism and position it in front of the light box.
2. Aim a single ray of light on to one face of the prism in such a way that it is almost parallel to the face adjacent to the incident face (as shown in Figure).



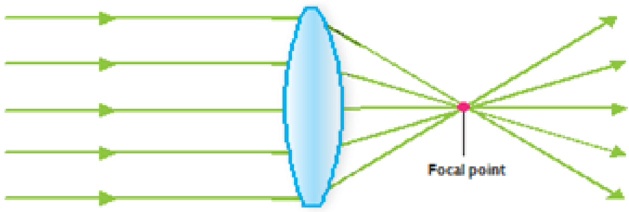
3. Mark the rays and the prism position.
4. Carefully, rotate the prism to make the incident ray strike the incident face at different angle of incidence with respect to the normal to the face, but striking the face at the same point of incidence.
5. Repeating the same procedure as above, find the position of the prism corresponding to which you get minimum deviation of the ray with respect to the direction of incident ray striking the outer face of the prism.
6. Repeat this experiment with 45°, 90° and 30° angle at position A (using different prisms) and in each case, find the angle of minimum deviation.
7. Mark the incident ray and refracted ray using pencil on white sheet.
8. Find the angle of minimum deviation using the formula

$$\mu = \frac{\sin(A + \frac{D}{2})}{Sin\ (A/2)}$$

The angle A is called angle of the prism, D is the angle of minimum deviation.

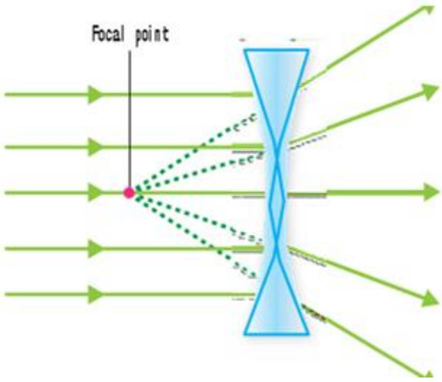
Convex Lens:

Convex lenses are thicker in the middle than at the edges. A thicker convex lens will bend light more than a thinner, less curved lens. The diagram shows how a convex lens refracts light rays. The rays are bent so they come together at a point behind the lens—the focus. A convex lens that is thicker and more curved has a shorter focal length than one that is thinner and less curved.



Concave Lens:

Concave lenses are thinner in the middle than at the edges. The diagram shows how a concave lens refracts light rays. Notice that the light rays do not come together at a focus. Instead, the rays are bent and spread apart as they pass through the lens. Light rays passing through a lens always bend toward the thickest part of the lens. Light waves bend toward the thick center in a convex lens. They bend out toward the thick edge in a concave lens.



Experiment 8: To study refraction and radius of curvature of biconvex lens.

Components Required:

- Biconvex Lens small
- Biconvex lens large
- Large white sheet (Not Included)
- Pencil (Not Included)

Procedure:

1. Place the thinner lens on a white sheet of paper
2. Trace the curve of the perimeter of one side of the thinner lens surface on a sheet of plane paper. Move the curved surface of the lens along this trace, thereby extending this tracing a number of times until it forms a complete circle. Measure the diameter of the circle and compute its radius.

3. Repeat the procedure using the thicker biconvex lens.
4. Each of the radius of the circle is called the radius of curvature of the respective lens used to draw that circle.
5. Calculation:
6. Focal length of lens can be calculated by knowing the factor refractive index of the material of the lens (μ), radius of curvature of the two curved surfaces of the lens (R_1 and R_2) and the focal length of the lens (f)

$$\frac{1}{f} = (\mu - 1)(\frac{1}{R_1} + \frac{1}{R_2})$$

Experiment 9: To determine the focal point and focal plane of biconvex lens.
Components Required:

- Light Box
- Biconvex Lens small
- Biconvex lens large
- Slit With 3 Line
- Large white sheet (Not Included)
- Power Supply (Not Included)

Procedure:

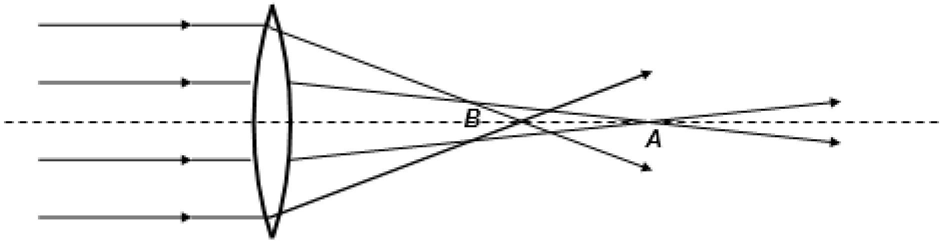
1. Position a biconvex lens in front of the light box and mark its outline.
2. Allow a pair of parallel rays to fall on it such that the incident rays are parallel to the axis of symmetry of the lens. Mark the incident and emergent rays and the focal point.
3. Adjust the light box so as to project the parallel rays at a small angle to the axis of symmetry of the lens but aimed at the center of the lens. Again mark the rays and focal point. Repeat the same procedure with rays angled at the center of lens from the other side of the axis of symmetry.
4. Again repeat the procedure by adjust the rays to strike the center of the lens at a larger angle from either side of the axis of symmetry.
5. Join all the focal points (Foci) obtained above with a line.
6. The plane at which parallel rays incident to the lens at any angle meet is called the focal plane of the lens.

Experiment 10: To determine the spherical aberration in biconvex lens.
Components Required:

- Light Box
- Biconvex Lens small
- Biconvex lens large
- Slit With 4 Line
- Large white sheet (Not Included)
- Power Supply (Not Included)

Procedure:

1. Allow four parallel rays to strike a convex lens (as shown in Figure), parallel to its axis of symmetry. The inner two and outer two rays meet at different foci. This defect is called spherical aberration.



2. In the figure the parallel rays striking the lens near the edge are bent to a nearer focus, B, than those passing through near the center, which meet at A. The magnitude of the defect, represented by AB in the diagram, is shown greatly exaggerated.

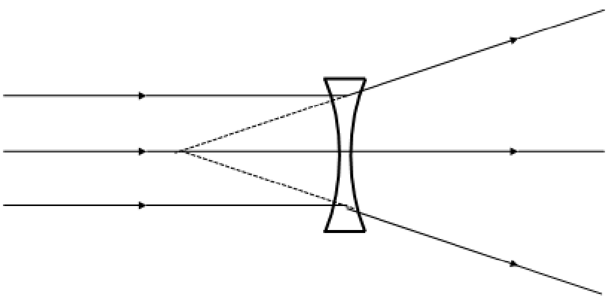
Experiment 11: To study the refraction through biconcave lens.

Components Required:

- Light Box
- Biconcave Lens
- Slit With 3 Line
- Large white sheet (Not Included)
- Power Supply (Not Included)

Procedure:

1. Select the lens which has two hollow faces curving in towards each other, making it thinner at the center than at the top or bottom. Such a lens is called bi-concave lens.
2. Allow a set of four parallel rays of light to fall on the lens parallel to its axis of symmetry. Mark the lens position and the incident and emergent rays.
3. You will observe that after refracting through the lens, the rays are diverging away from each other. Remove the lens and extend the emergent rays back through the lens position towards the light box (as shown in Figure).



Primary Colour:

Red, Green, Blue are primary colours. When red, green and blue color are mixed or added together with the proper intensity, white (W) color is obtained.

The mixing together (or addition) of two or three of these three primary colors with varying degrees of intensity can produce a wide range of other colors.

Secondary Color:

- Red color and green color add together to produce yellow (Y) color
- Red color and blue color add together to produce magenta (M) color
- Green color and blue color add together to produce cyan (C) color

Yellow, Magenta and Cyan are called secondary colour.They can be produced by the addition of equal intensities of two primary colors.

Complementary Colors:

Any two colors that when mixed together in equal intensities produce white are said to be **complementary colors** of each other.

Complementary Colors :

- Red and Cyan
- Green and Magenta
- Blue and Yellow

Experiment 12: Color Observation- colours of objects.

Components Required:

- Light Box
- Color Cards
- Color filter set
- Power Supply (Not Included)

Procedure:

1. Close the side-openings (use the mirrors) and one by one, place the filters in the center-opening and observe the colour on the screen in front of it. This will familiarize you with the various colours.
2. Next place the colour cards, included in the kit, on the screen and observe their colours in lights of different colours 9obtained after filtering from the colored filters in front of the light box).
3. The colour of an object is explained by stating that the white light is composed of many colours and that a white object reflects all the colours.
4. A red object absorbs all the colours except red, which it reflects, making the object appear red. If however, red is completely filtered from the incident light falling on the object, by using other colored filters (say cyan), the red object should absorb the incident colour as transmitted by the filter (cyan) and should reflect nothing. Check your observations against this theory.

Note your observations in the table given below.

Colour of light falling on Plate → Colour of Plate ↓	White	Red	Magenta	Orange	Yellow	Green	Cyan	Blue	Violet
RED									
MAGENTA									
ORANGE									
YELLOW									
GREEN									
CYAN									
VIOLET									
BLUE									

Next, illuminate the various colour cards with white light and observe them through coloured filters by holding the filters close in front of your eyes.

Tabulate your results in a similar manner

Colour of Filter Used → Colour of Plate ↓	White	Red	Magenta	Orange	Yellow	Green	Cyan	Blue	Violet
RED									
MAGENTA									
ORANGE									
YELLOW									
GREEN									
CYAN									
VIOLET									
BLUE									

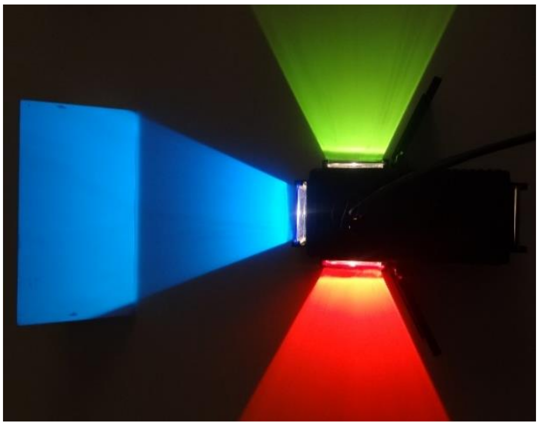
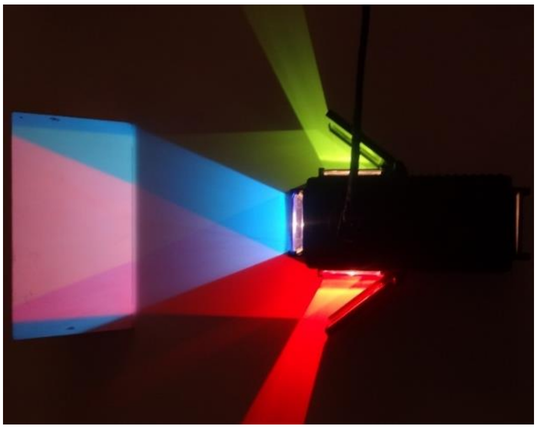
Experiment 13: Additive effect of primary color.

Components Required:

- Light Box
- Color Filter Set
- Screen (Not Included)
- Power Supply (Not Included)

Procedure:

1. Connect the light box with the power supply.
2. Insert 3 color filters in the 3 slits of the light box.
3. The light of different color emerges out from the 3 sides of the light box.
4. Now adjust the position of mirror attached with the ray box such that 3 colored light rays emerge onto the screen placed in front of the light box.
5. Emerging portion of 3 primary colors will be of white color.

Similarly perform the experiment using secondary colors.

Note: Students can perform a series of other experiments using this kit under the provision of teacher. The images used in this kit are only for reference make your own observation for each experiment.