LIGHT ENERGY

Learning outcomes

By the end of this theme, students will be able to:

- explain the phenomenon of reflection of light
- define terms related to reflection
- state the laws of reflection
- use the laws of reflection to explain the formation of images by plane mirrors
- describe the characteristics of images formed by plane mirrors
- state the value of the speed of light
- define primary colours
- describe the formation of secondary colours by the addition of primary colours
- explain how the observed colour of an object is based on the reflection, transmission and absorption of light
- explain the concept of colour subtraction

Warm-up

Encourage students to complete the *Get going* section given at the beginning of the chapter.

LESSON PLANS

GUIDELINES TO TEACH

Introduction

Ask students:

You have studied that light is a form of energy. Can you imagine the Earth without the Sun? Would it be possible for life to exist on the Earth?

- Give a short introduction to light mentioning its straight line propagation, the process behind vision, image formation and so on.

Ask students:

Since light travels in straight line, what will happen if you place an object in its path?

Reflection of light

- List and explain the three things that can happen when an obstacle is placed in its path, which are the results of *rectilinear propagation* (straight line) of light.
- Classify objects according to how they allow light to pass through them.

- Define and explain the processes of *reflection*, *transmission* and *absorption* of light with examples from everyday life.
- Clarify that these processes take place because of the rectilinear (straight line) propagation of light.

Ask students:

You have studied what reflection is. Do all objects reflect light equally?

Regular and irregular reflection

- Point out the role of the nature of the surface in the process of reflection.
- With the help of the figure, given in the coursebook, distinguish between *regular* and *irregular* (or diffused) reflection.
- Distinguish between the images formed due to regular and irregular reflection.

Real and virtual images

Ask students:

What do you see when you look at a mirror? Have you heard of the phrase 'mirror image'? What does it mean?

- Help students recall of the pinhole camera that formed an image of an object on a screen.
- Explain that an image that can be caught on a screen is called a *real image*.
- Demonstrate it with an optical bench in the class.
- Ask students if their image on a mirror can be caught on a screen.
- Point out that the image formed by the mirror in a vehicle also cannot be caught on a screen.
- Now inform students that there are two kinds of images, *real* and *virtual* and ask them to distinguish between the two based on the discussion so far.

Terms related to reflection

- Using the figure, given in the coursebook, explain the new terms associated with reflection.
  - **Incidence:** Indicates something like a ray of light hitting a surface
  - **Incident ray:** Indicates a ray of light travelling towards a reflecting surface
  - **Reflected ray:** The ray of light returning from a reflecting surface after incidence
  - **Normal:** It is the perpendicular to the reflecting surface at the point where incident ray strikes
  - **Angle of incidence:** It is the angle between the incident ray and the normal to the surface where the incident ray strikes the surface
  - **Angle of reflection:** It is the angle between the reflected ray and the normal at the point of incidence

The laws of reflection

- List and explain the two laws of reflection.
- Demonstrate the activity, given in the coursebook, in class to prove the laws of reflection.

Ask students:

What is the angle of incidence when the incident ray falls along the direction of the normal to the surface?

What is the angle of reflection when the incident ray falls along the direction of the normal to the surface?

Plane mirrors

- Define a *mirror as a flat reflecting surface*.
- Describe the constitution of a plane mirror.
- Share the information from 'Know more' and introduce convex and concave mirrors.
- Ask students to examine the mirrors of a vehicle and determine whether they are plane, concave or convex.
- Also ask them to justify their conclusion.

Image formation by a plane mirror

Ask students:

You look at the mirror every day. Can you describe the characteristics of the image you see it? Is the image virtual or real?

- Describe the process of *lateral inversion*.
- Tell students why the image is a virtual image and give them an indication about the distance of the image formed from the mirror.

Characteristics of the image formed by a plane mirror

- List and explain in depth about all the characteristic features of the image formed by a plane mirror.
- Share the information provided in 'Spotlight'.
- Through the activities '*To verify the location of the image formed by a plane mirror using a ray diagram*' and '*To verify the size and orientation of the image formed by a plane mirror using a ray diagram*', given in the coursebook, introduce the idea of ray diagrams and explain how ray diagrams can be used to determine the distance and size of an image.

Uses of plane mirrors

Ask students:

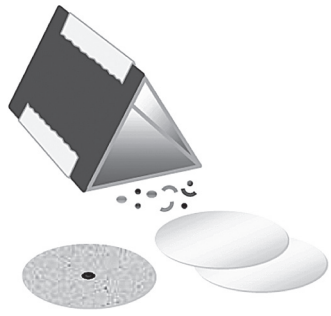
Can you suggest some uses of plane mirrors?

- Discuss about the different uses of plane mirrors as looking mirror, reflecting glass in cookware, and in kaleidoscope and periscope.
- Share the content of 'Know more' and describe a periscope.

Activity: Ask students to construct a kaleidoscope.

Aim: To make a kaleidoscope

Materials needed: three rectangular plane mirror strips about 15 cm long and 4 cm wide, two pieces of thick clear plastic or glass, thick chart paper, small pieces of coloured glass (for example, from broken bangles) and beads



Making a kaleidoscope

Method:

1. Join the mirror strips to form a prism as shown in the figure.
2. Wrap the chart paper around the prism and tape it in place.
3. Poke a small hole in a piece of cardboard. Close one end of the prism with it and tape it firmly.
4. Tape a piece of clear plastic to the other end of the tube.
5. Place the pieces of glass on this piece of plastic.
6. Tape the other pieces of plastic over it such that there is just enough space for the pieces of coloured glass to move arround.

Peep through the hole you made in the piece of cardboard. Rotate the kaleidoscope to see a variety of interesting patterns.

Speed of light

Ask students:

Observe at home how long it takes for the electric bulb to glow after you turn the switch on.

- Point out the huge magnitude of speed of light.
- Write down the number with unit on the board.
- Underline the fact that it is the highest speed known to humans.
- Tell them that when light has to travel very large distances, it takes finite time.
- Point out that it takes a little more than 8 minutes for sunlight to reach the Earth (so we are getting the light that the Sun radiated more than 8 minutes ago) and 1.3 s for moonlight to reach the Earth.
- Bring to their attention the fact that light does not travel with the same speed in all media.
- Share with them the data on the different speeds of light in different media.
- Briefly explain light pollution and its effects, as given in 'Eco corner'.
- Use **Stop and check** for a quick recap.

Colours

- Describe the process of vision and the mechanism of appearance of different colours.
- Explain about spectrum and VIBGYOR with the help of figure '*The spectrum of sunlight*', given in the coursebook.
- Discuss about rainbow and the order in which the colours occur in the spectrum.

Addition of colours

Primary colours

- Write on the board RBG and inform students that these are the first letters of primary colours.
- With the help of diagram, given in the coursebook, explain why *red*, *blue* and *green* are called primary colours.
- Point out the white region in the middle and explain that the three primary colours mixed in equal amount will produce white light. (That is why they are called primary colours.)

Secondary colours

- Indicating the regions of *yellow*, *magenta* and *cyan*, explain secondary colours as equal mix of two of the primary colours.
- Ask students how many secondary colours are possible from the three primary colours.
- Ask them to name the three secondary colours and their composition.
- Discuss the activity '*To study the addition of primary colours*', given in the coursebook. (If possible, demonstrate it.)
- Inform students that all other colours we see around us can be obtained by *additive colour mixing*—mixing primary colours in different proportions.

Complementary colours

- Define complementary colours.
- List some complementary colours.

Uses of additive colour mixing

- Describe the process behind colour vision in human beings and the three different types of cone-cells.
- Indicate that a similar process is used in TV, computer and mobile screens.
- Only difference is that instead of cone cells, there are pixels in these screens.
- Define pixels as minute dots that glow with different levels of brightness to produce different shades of colours.

Colours of objects

Ask students:

Have you ever thought about how different objects appear in different colours?

- Describe the mechanism behind the colours of objects.
- Distinguish between the colour appearance of opaque and transparent objects.
- Point out that the apparent colour (not actual colour) of an object depends upon the colour of the light falling on it also.

White light falling on opaque objects

- Use the figure '*Objects of different colours viewed under white light*', given in the coursebook, effectively for the following discussion.
- List and describe the different processes that can take place when white light falls on an object, depending on the ability of the object to absorb or reflect different components of white light.
- Point out why we see so many different shades of colours around us.

Coloured light falling on opaque objects

- Using the figure '*A red object viewed under different lights*', given in the coursebook, explain the effect of coloured light in deciding the apparent colour of an object.
- Clearly explain when an object would appear black under a coloured light.
- Provide sufficient examples.
- Share the information given in 'SciTech'
- Use **Stop and check** for a quick recap.

Subtraction of colours

- Using the figure '*A yellow object viewed under different lights*', given in the coursebook, explain that colours other than primary colours can be viewed as obtained through subtraction of colours just as they can be thought of as addition of colours.
- Discuss all the examples given in the coursebook.

Filters

- Define a colour filter and point out that these filters are used frequently in dance performance to give the impression of multiple colours to the costume of the performer.
- With the help of the figure '*Subtraction of colours*', given in the coursebook, explain the working of filters.
- Using the figure '*Subtractive colour production*', given in the coursebook, discuss the process of subtractive colour mixing and contrast it against additive colour mixing.
- Point out some applications of subtractive colour mixing, as given in the coursebook.
- Share information from 'Know more' and 'Career watch'.

LIGHT ENERGY

Stop and check

1. reflected 2. regular 3. reflection 4. laterally 5. virtual

Stop and check

1. red 2. black 3. green 4. black 5. black

Checkpoint

A. 1. b, the incident ray and the normal 2. d, 40° 3. c, it can be captured on a screen
4. c, 120 cm 5. d, 0° 6. c, 30° 7. d, 90° 8. a, vacuum 9. b, red and green
10. c, blue 11. c, red and yellow

B. 1. regular 2. normal 3. behind 4. coating 5. 3×10^8 m/s 6. complementary
7. green 8. magenta 9. cyan 10. blue

C. 1. False 2. False 3. False 4. True 5. False 6. True 7. True

D. 1. When parallel rays of light fall on a smooth and polished surface, the reflected rays also remain parallel forming clear sharp images. This is known as *regular reflection*. On the other hand, when light is reflected from a rough and dull surface, the reflected rays get scattered in all direction resulting in a dull and diffused image. This process is known as *irregular reflection*.
2. An image that can be caught on a screen such as the image formed by a pinhole camera is called *real image*. If the image cannot be caught on a screen, it is called a *virtual image*.

E. 1. A ray of light travelling towards a reflecting surface is known as the incident ray.
2. The ray of light coming back from a reflecting surface after hitting it is known as the reflected ray.
3. An imaginary line perpendicular to the reflecting surface at the point of incidence is known as the normal.
4. The angle between the incident ray and the normal is known as the angle of incidence.
5. The angle between the reflected ray and the normal is known as the angle of reflection.

F. 1. The two laws of reflection are:
   i. The incident ray, reflected ray and the normal at the point of incidence, all lie in the same plane.
   ii. Angle of reflection is equal to the angle of incidence.
2. Plane mirrors are made by coating one surface of a plane glass plate with a highly reflecting substance such as aluminium or silver.
3. Plane mirrors are used as looking glasses. They are also used in solar cookers to reflect sunlight onto the cooking vessel.
4. The left and right sides of the object are interchanged in the image formed by a plane mirror. This is known as lateral inversion.
5. The primary colours used in additive colour mixing are red, green and blue.
6. Yellow, magenta and cyan are the secondary colours. They are obtained by combining any two primary colours in equal proportion.
7. Magenta reflects red and blue colours and absorbs green colour.
8. The bead will appear as blue in blue light because that is the colour it reflects when white light is incident on it.

G. 1. Fix a sheet of paper on a table and draw a straight line *AB* on it. Mark the centre of the line as *O* and draw perpendicular to the surface at *O*. Draw another line denoting the incident ray. Fix two pins at *P* and *Q* along the line a little distance apart. Place a mirror vertically along line *AB* and look at the mirror with one eye such that the two pins will be seen as one in the reflection. Fix two other pins *R* and *S* such that they are along a line and seen as a single pin. Remove the mirror and the pins and draw a line to *O* along *R* and *S* which will indicate the reflected ray. Measure the angles between the incident ray and the normal and the reflected ray and the normal. It can be seen that both are same. (*Diagram: Refer to the coursebook.*)

2. Fix a sheet of paper on a table and draw a straight line *AB* on it. Mark the centre of the line as *O* and draw perpendicular to the surface at *O*. Draw another line denoting the incident ray. Fix two pins at *P* and *Q* along the line a little distance apart. Place a mirror vertically along line *AB* and look at the mirror with one eye such that the two pins will be seen as one in the reflection. Fix two other pins *R* and *S* such that they are along a line and seen as a single pin. Remove the mirror and the pins and draw a line to *O* along *R* and *S* which will indicate the reflected ray. Extend the line farther into the back side of the mirror. Draw perpendiculars to *AB* from *P* and *Q* such that they intersect the extended line at *P*' and *Q*'. Now measure *OP*, *OP*', *OQ* and *OQ*'. It can be seen that *OP* = *OP*' and *OQ* = *OQ*'. This way we can find out the position of the image formed by a plane mirror and also prove that the image is formed at equal distance from the mirror as the object. (Diagram: Refer to the coursebook.)

3. The major characteristics of the image formed by a plane mirror are:
   - The image is erect and has the same size as the object.
   - The left and right sides of the image are interchanged compared to the object.
   - The image formed is a virtual image.
   - The image in the mirror is at the same distance behind the mirror as the object is in front of it.

4. The perceived colour of an object is dependent on the colour of the incident light. The colour of an object is the colour that it reflects from all the colours of light that is incident on it. The object absorbs all other colours. If the incident light does not contain the colour an object reflects, then it will appear dark. A red object will appear black if seen in green or blue light. Similarly, a green object will appear black if seen in blue or red light. An object with cyan colour which is a mix of green and blue colours will appear black in red light, blue in blue light, green in green light and cyan in white light.

5. The green leaf will appear to be black in red light, green in green light, yellow light and cyan light. The leaf appears green because it absorbs or subtracts all other colours from incident light other than green. So it subtracts red light and appear black in red light. When green light falls on it, the leaf reflects it fully. Since yellow light is a mix of red and green, the green leaf subtracts red and reflects green. Similarly, cyan being a mix of green and blue, the green leaf subtracts blue colour and reflects green. Hence the leaf will look green in all these cases.

Think and answer

1. There are many reflecting surfaces around our homes like the painted compound walls and walls of the neighbouring houses, leaves of plants, surface of the Earth and so on. Every object around us reflect some amount of sunlight which enter our houses and we get a combination of all these reflected lights. Since there are objects of many different colours around us, we get the experience of white light inside our homes.
2. When two mirrors are placed parallel to each other with an object placed in between, the image of the object will be formed in each of the mirrors. The image formed in one mirror will act as a second object for the other mirror. Similarly for the other mirror also. This second image will act as the third object and so on. In general, if the two mirrors are perfectly parallel, uncountable number of images will be formed this way.
3. Sunlight consists of potentially harmful radiation like ultraviolet rays. Long exposure to these rays can cause cataract and macular degeneration of the retina leading to loss of vision. By blocking UV rays and other intense radiations, sunglasses protect our eyes from the harmful effects of sunlight. It also prevents sunburn to the cornea.

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Answer the questions.

1. Why do we use frosted glass as window panes?

   Ans: While frosted glass panes allow light to enter the room in a diffused way preventing intense lighting and thus excessive heating of the room. Frosted glass pane also prevents sharp images reaching on lookers from outside. Due to its irregular surface, it scatters the light rays passing through it in all directions.

2. What are complementary colours? Give two examples.

   Ans: If a pair of colours produce white colour on mixing, they are called complementary colours. Examples are green and magenta, and red and cyan.

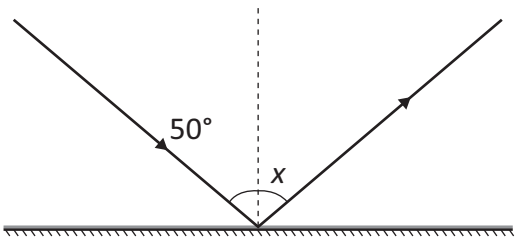
3. What is the mechanism of colour vision? Why are some animals colour blind?

   Ans: The colour vision in animals is due to colour sensitive cone cells in the retina. In humans, there are three cone cells, one for each primary colour. The brain mixes the colour information received from these cells to have colour vision. In some animals, there are only two cone cells with reduced sensitivity. Such animals remain colour blind, even though some other animals have colour vision.

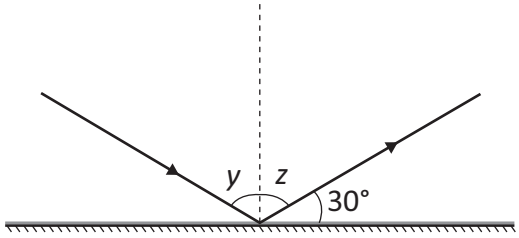
LIGHT ENERGY

1. Find the angles marked x, y and z.

a.



b.



2. Give examples of:

a. Two things that are transparent: _____

b. Two objects that reflect light: _____

c. Two man-made objects that emit light: _____

d. Two surfaces that cause diffuse reflection: _____

WORKSHEET

3. Fill in the blanks.

a. A _____ image is one that can be caught on a screen.

b. The image formed by a plane mirror is _____ .

c. An object appears _____ when it absorbs all colours contained in the light falling on it.

d. An object appears _____ when white light falls on the object and it reflects all three primary colours.

e. In a spectrum, _____ forms the bottom most band and _____ forms the top most band.

ANSWER KEY FOR THE WORKSHEET

LIGHT ENERGY

1. a. $x = 50^\circ$ b. $y = z = 60^\circ$

2. a. glass, air
b. a mirror, a shiny metal plate
c. glowing bulb, burning candle
d. wall, rough paper
(*Other relevant examples may also be accepted*.)

3. a. real b. virtual c. black d. white e. violet, red